EUROPEAN TELECOMMUNICATION STANDARD

I-ETS 300 131

November 1994

Second Edition

Source: ETSI TC-RES

Reference: RI/RES-03015

ICS: 33.060.20

Key words: CT2, CAI

Radio Equipment and Systems (RES); Common air interface specification to be used for the interworking between cordless telephone apparatus in the frequency band 864,1 Mhz to 868,1 MHz, including public access services

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

Contents

Foreword

This Interim European Telecommunication Standard (I-ETS) has been prepared by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI) and has been adopted having undergone the ETSI standards approval procedure.

Parts of this I-ETS were prepared by the British Standards Institution (BSI), by the United Kingdom Department of Trade and Industry (DTI) and by those companies listed in annex H. It contains information and copyright material, the property of these organisations. The connection of equipment specified here to the Public Switched Telephone Network (PSTN) is covered in prETS 300 001 [1].

Every I-ETS prepared by ETSI is a voluntary standard. This I-ETS contains text concerning the type approval of the equipment to which it relates. This text should be considered solely as guidance, and does not make the I-ETS mandatory.

The I-ETS includes two types of requirement: those that are required in all units; and those that are optional in a unit, but shall be implemented in the specified manner if provided. The specifications of parts one and two are requirements unless otherwise stated. The specifications of part three are optional unless otherwise stated. The specifications of part four are requirements unless otherwise stated. The tests specified in part five shall be passed by all units where the tested feature is provided.

This document is the second edition of I-ETS 300 131. Equipment conformaing to the first edition, I-ETS 300 131 (April 92), will interwork with equipment conforming to the second edition.

There are some mandatory requirements in the second edition which may not be met by equipment conforming to the first edition. Details of such amendmets ans transitional arrangements are recorded in annex E. These changes do not affect interworking.

References to the first edition may therefore be treated as references to the second edition.

Annexes A to D, annex J, annexes M to N and annex R of this I-ETS are normative. annexes E to H and K to L and annex P are informative.

Announcement dates	
Date of latest announcement of this I-ETS (doa):	28 february 1995

Introduction

This I-ETS covers the minimum performance requirements for fixed and portable radio units used with the second generation cordless telephone (common air interface) CT2 (CAI) service operating in the band 864,100 MHz to 868,100 MHz.

This I-ETS is intended to allow a user to migrate from one cordless telephone environment (public or private; public access, domestic or PBX) to another without having to change, or having to purchase additional, radio equipment.

The I-ETS is divided into five main parts:

Part 1: The radio interface (clause 4): This part covers the minimum radio frequency performance requirements including channel frequencies, modulation and channel selection.

Part 2: Signalling layers one and two (clauses 5 and 6): There are three layers of signalling requirements for the radio units. The first two layers are detailed in this part.

Signalling layer one covers aspects such as time-division duplexing, data multiplexing, link initiation and handshaking. This layer allows systems to obtain mutual synchronisation over a digital synchronisation channel and provides bi-directional data channels for digital signalling data and digital speech data.

Signalling layer two covers the signalling channel protocols, message formats, error detection, error correction and message acknowledgement. This layer allows systems to communicate over an established link using data and signalling channels which are established and maintained free from interference where possible.

Part 3: Signalling layer three (clause 7): This part defines the structure of and attaches meanings to messages. Part of the message space is undefined in order to accommodate future expansion of services and facilities.

Part 4: Speech coding and transmission (clause 8): This part specifies the requirements for the digital coding and transmission of analogue speech information.

Part 5: Parametric and system tests (clauses 9 to 11): This part specifies the tests required to verify that a system conforms to this standard.

1 Scope

This I-ETS specifies the technical requirements for equipment known generically as common air interface second generation cordless telephones or CAI CT2. This equipment is intended to convey digitally-encoded speech with associated digital signalling, via a radio frequency channel, to and from the Public Switched Telephone Network (PSTN), possibly via a private network. Protocols for the transmission of non-speech data, as a secondary service, are also covered by this I-ETS.

This I-ETS specifies the requirements for:

- generation and interpretation of digital speech;
- generation and interpretation of digital data;
- generation and interpretation of digital control signalling;
- the means by which the two ends of a cordless link become and remain synchronised; and
- the means by which the specified data structures are modulated onto one of a number of specified radio frequency carriers.

The speech performance characteristics defined in this I-ETS typically conform to ETS 300 085 [7], which specifies the overall performance between the handset acoustic interface and a Pulse Code Modulation (PCM) digital network interface. The deviations from ETS 300 085 [7] are limited to the consequences of non-PCM coding and transmission delay.

These additional features are not included in ETS 300 085 [7], but are likely to occur in a CT2 system: analogue interface, loudspeaking and hands-free operation, tandeming with a mobile radio network. Headsets are not covered by the present specifications.

For the CT2 systems which connect to the PSTN via an analogue interface, the document includes the basics on which national specifications can be built, referring to prETS 300 001 [1] (which specifies the connection of terminal equipment to the PSTN via a 2-wire analogue interface).

This I-ETS covers the technical requirements considered necessary to ensure that:

- minimum interference is created to other users of the RF spectrum; and
- there exists a defined minimum degree of interworking between the portable and fixed parts of a cordless telephone apparatus, allowing users, in possession of a compliant Cordless Portable Part (CPP) and if so authorised, to make and receive telephone calls from any compliant public or private Cordless Fixed Part (CFP).

Equipment covered by this I-ETS is of the following types:

- apparatus intended for voice telephony and or data use;
- CPPs and CFPs with internal or external antenna, and with or without an external RF connector;
- CPPs containing one or more RF transceivers; and
- CFPs containing one or more RF transceivers and capable of operating simultaneously with one or more CPPs.

2 Normative references

This I-ETS incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this I-ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] prETS 300 001: "Attachments to Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN (Candidate NET 4)".

[2] CCITT Recommendation G.823 (1988): "The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy".

[3] CCITT Recommendations Q.921 (1988): "Integrated Services Digital Network (ISDN) user-network interface, data-link layer specification".

[4] CCITT Recommendation Q.931 (1988): "Integrated Services Digital Network (ISDN) user-network interface layer 3 specification for basic call control".

[5] CCITT Recommendation T.50 (1984): "International Alphabet No.5".

[6] CCITT Recommendation G.721 (1988): "32 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)".

[7] ETS 300 085: "Integrated Services Digital Network (ISDN): "3,1 kHz telephony teleservice; Attachment requirements for handset terminals (T/TE 10-06) (Candidate NET 33)".

[8] CCITT Recommendation G.122 (1988): "Influence of national systems on stability, talker echo, and listener echo in international connections".

[9] CCITT Recommendation G.132 (1988): "Attenuation Distortion".

[10] CCITT Recommendation G.223 (1964 with amendments): "Assumptions for the calculation of noise on hypothetical reference circuits for telephony".

[11] CCITT Recommendation G.714 (1988): "Separate performance characteristics for the encoding and decoding sides of PCM channels applicable to 4-wire voice frequency interfaces".

[12] CCITT Recommendation P.51 (1993): "Artificial mouth".

[13] CCITT Recommendation P.64 (1993): "Determination of sensitivity/frequency characteristics of local telephone systems to permit calculation of their loudness ratings".

[14] CCITT Recommendation P.79 (1988): "Calculation of loudness ratings".

[15] CCITT Recommendation G.711 (1972 with amendments): "Pulse Code Modulation (PCM) of voice frequencies".

[16] CCITT Recommendation P.76 (1988): "Determination of loudness ratings; fundamental principles".

[17] CCITT Recommendation G.113 (1988): "Transmission Impairments"

[18] ISO 3 - 1973: "Preferred numbers - Series of preferred numbers".

[19] CCITT Blue Book (1988), Volume V, Supplement 13: "Noise Spectra".

[20] ISO 2022: "Information processing - ISO 7-bit and 8-bit coded character sets - Code extension techniques".

[21] ISO 639 (1988): "Code for the representation of names of languages".

[22] CCITT Handbook on Telephonometry; ITU, Geneva 1987.

[23] CCITT Recommendation P.57 (1993): "Artificial ear".

[24] CCITT Recommendation O.132 (1988): "Quantizing distortion measuring equipment using a sinusoidal test signal".

[25] ETS 300 086 (Jan 1991): "Technical characteristics and test conditions for radio equipment with an internal or external RF connector intended primarily for analogue speech".

[26] CCITT Recommendation V.24 (1988): "List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)".

[27] EIA 422-A-78: “Electrical characteristics of balanced voltage digital interface circuits”.

[28] EN 41003 (May 1991): “Particular safety requirements for equipment to be connected to telecommunications networks”.

[29] CCITT Recommendation X.25, Blue Book, Vol.VIII.1, 1988.

[30] CCITT V-SeriesRecommendations, CCITT Yellow Book, Vol.VIII.1, 1981.

3 Definitions and abbreviations

For the purpose of this I-ETS, the following definitions and abbreviations apply.

3.1 Definitions

active mode: Any mode of operation of a CFP or CPP in which the CFP or CPP is transmitting only or transmitting and receiving.

communication state: The phase of a call between link set up and link termination.

handover: The re-routing of a call in progress via a different RFP.

idle mode: Any mode of operation of a CFP or CPP which is not the active mode.

layer 3 message: A sequence of one or more layer 3 information elements transmitted in 1 or more packets.

link supervisory message: A Layer 2 message transmitted in one packet.

PACKET: Layer two entity comprising ACW and any following DCWs transmitted as a single unit over which the signalling protocol may operate.

3.2 Abbreviations

ACW	Address Code Word
ADPCM	Adaptive Differential Pulse Code Modulation
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
ALR	Automatic Location Registrations allowed indicator in CIS codewords
AM	Amplitude Modulation
ARQ	Automatic repeat request
AUTH_KEY	Authentication function identifier
AUTH_NO	Authentication function to be used
AUTH_PREF	Preferred CPP Authentication function
AUTH_REQ	Authentication Request Information Element
AUTH_RES	Authentication Response Information Element
AUTH2_REQ	Alternative Authentication Request Information Element
AUTH2_RES	Alternative Authentication Response Information Element
B channel	32 kbit/s Speech or Data Channel (in CT2)
BAS_CAP	Base Capabilities Information Element
BASET	Base Type
BCD	Binary Coded Decimal
BER	Bit Error Ratio
BID	Base Identity code
BLB	B channel Loopback Bit
CAC	Channel Access Criteria
CAI	Common Air Interface
CC	Channel Control Information Element
CCITT	International Telegraph and Telephone Consultative Committee
CFP	Cordless Fixed Part
CHANGE_SLOT	Change slot information element
CHAR	Character Information Element
CHM	Channel Marker bit pattern
CHMF	Channel Marker bit pattern sent by CFP
CHMP	Channel Marker bit pattern sent by CPP
C/I	Carrier/Interference Ratio
CIC	Codec Identity Code
CIS	CFP Information and Status codeword
CIS_IDENTIFIER	Reserved value of MIC used in CIS codewords
CKEY	Encrypted KEY
Code Word No	Indicates Number of Octets in Last Code Word
CPP	Cordless Portable Part. Note that CPP=CRE if the CPP has no TIM capability and that CPP=CRE+TIM if the CPP has a TIM capability.
CRC	Cyclic Redundancy Check
CRE	Cordless Radio Equipment
CT2	Second Generation Cordless Telephone
CTA	Cordless Telephone Apparatus
D channel	Signalling channel (in CT2)
DCAP	Display Capability
DCE	Data Communications Equipment
DCFP	Data Cordless Fixed Part
DCPP	Data Cordless Portable Part
DCW	Data Code Word
DISP	Display Information Element

DL_ESTABLISH_IND	Data Establish Indication
DL_ESTABLISH_REQ	Data Establish Request
DTE	Data Terminal Equipment
E-CKEY	Expected CKEY
E-KEY	Expected Key
EKEY 1,2,3	GPID/KEY data fields in KEY_ALLOC
ENC	Encryption bit in KEY_ALLOC
Endwrd	Indicates Last Code Word of a Packet
EPID	Encryption PID
ERP	Ear Reference Point
FA	Feature Activation Information Element
f_c	Nominal Channel Centre Frequency
FCR	Fast channel change on re-establish bit
FEC	Forward Error Correction
FFEC	Framing and Forward Error Correction
FI	Feature Indication Information Element
FSK	Frequency Shift Keying
FT	Format Type bit
GPID	Global PID
HIC	Handset Identity Code
HSSC	High Speed Signalling Capability
I/S	Information/Supervisory Type Packet
IA5	International Alphabet Number 5
ICI	Incoming Call Indication in CIS codewords
ICOM	CFP Intercom Capability
ID	Identity Code (generic name for PID,LID)
ID_LOST	Handshake-lost code word
ID_OK	Handshake-ok code word
IDLE_D	D channel Preamble pattern
IE	Information Element
INCZ	Increment ZAP field control bit
INIT	Initialisation Information Element
IRI	In Range Indication bit in CIS codewords
ISDN	Integrated Services Digital Network
ISO	International Standards Organisation
KEY	Personal Key Number
KEY_ALLOC	Key registration data information element
KP	Keypad Information Element
L3_end	Indicates Last Packet of a Layer 3 Message
LAI	LOCAL_AREA_IDENTIFIER
LAN	Language preference bit
LAPR	Link Access Protocol for Radio
LCI	LOCAL_CELL_IDENTIFIER
LD	Loop Disconnect
LID	Link Identification Code
LINK_GRANT	CFP Acknowledgement Assigning Call Reference ID
LINK_REQUEST	Link Status Request to seize Link
Lmest	Sidetone Path Loss
LOCAL_AREA_IDENTIFIER	Local Area Identifier in CIS codewords
LOCAL_CELL_IDENTITY	Local Cell Identity in CIS codewords
LPI	Landline Physical Interface
LR_PARAMS	Location Registration Parameters information element
LRC	LID change on re-establishment bit
LRGP	Loudness Rating Guard-ring Position
LS(0/1)	Link Status bits
LSB	Least Significant bit
LSTR	Listener SideTone Ratio
LT_POLLING_LID	Location Tracking Polling LID, auxiliary LID transferred using the polling LID information element

LR_POLL_LID	Location Registration Poll LID, auxiliary LID transferred using LR_PARAMS information element
MANIC	Manufacturer Identity for CFP and CPP
MB	Message Buffer Size
MF	Multiple Frequency
MIC	Manufacturer Identity Code
MMI	Man-Machine Interface
MODEL	Manufacturers CPP model identity code
MRP	Mouth Reference Point
MSB	Most Significant bit
MUX1.2	Signalling Multiplex Mode 1 (two-bit signalling)
MUX1.4	Signalling Multiplex Mode 1 (four-bit signalling)
MUX2	Signalling Multiplex Mode 2
MUX3	Signalling Multiplex Mode 3
(r)	Receive Sequence Number
(s)	Send Sequence Number
NA	Network authentication bit
NAR	Network authentication request
NET_AUTH_REQ	Network authentication request information element
NET_AUTH_RES	Network authentication response information element
NLP	Non Linear Processor
NO_POLL	Number of polled CPPs Information Element
NPSS	Normal Power Secondary Service
NTTA	Network Terminating and Testing Apparatus
OARAC	On Air (de-)Registration Acknowledge Information Element
OPSIC	Operators Identification Code
OTAR_NO	Decryption algorithm to be used
P/F	Poll/Final bit (0 = Unacknowledged Operation; 1 = Acknowledged Operation)
PAD	Packet Assembler/Disassembler
PAR_REQ	Parameter Request Information Element
PAR_RES	Parameter Response Information Element
PAR_SET	Parameter Set Information Element
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PERIOD_OF_SERVICE	Period of location registration granted in LR_PARAMS information element
PERIOD_UNIT	Units of PERIOD_OF_SERVICE
PI	Protocol Identifier
PID	Portable (CPP) Identification Code (=MIC + HIC)
PLL	Phase-Locked Loop
POLLING_LID	Polling LID information element
PSTN	Public Switched Telephone Network
PWR	Power level indication in CIS codewords
QDU	Quantization Distortion Unit
RAND	Random Number used in generating CKEY
REJ	Indicates Rejection of a Received Packet
REJ'	Local state variable (packet rejection)
Rem	Indicates Number of Octets in Last Code Word
RES	Response bit (NO_POLL)
RF	Radio Frequency
RFP	Radio Fixed Part
RFU	Reserved for future use
RLR	Receiving Loudness Rating
RLRH	Handset Receiving Loudness Rating
SABM	Set Asynchronous Balanced Mode; Layer two link protocol initialisation command. Unless otherwise stated, SABM refers to either the basic or extended form of the message.

SABM_ACK	Layer two acknowledgment to SABM. Unless otherwise stated, SABM_ACK refers to either the basic or extended form of the message.
SCA	Standard Control Authority (contact the CAI Secretariat, see annex H)
SELV	Safety extra low voltage
SIG	Signal Information Element
SLOT_IDENTITY	Slot identification field
SLR	Sending Loudness Rating
SLRH	Handset Sending Loudness Rating
SLT	Slot identity bit
SPL	Sound Pressure Level
SR	Signalling Rate bit
SRA	Signalling receiver availability indicator in CIS codewords
SRc	Signalling Rate Capability
SRE	Synchronous re-establishment bit
SRr	Signalling Rate Request
SSP	Secondary Service Power level
SSR	Secondary Service Re-establish
STMR	Sidetone Masking Rating
SUP	Supervisory Packet
SYN channel	Synchronisation channel
SYNC	Synchronisation word (in SYN channel)
SYNCD	Synchronisation word for D channel
SYNCF	Synchronisation word from CFP (in SYN channel)
SYNCP	Synchronisation word from CPP (in SYN channel)
Tbid	CPP BID detect from CHM time (19 ms)
TCA	Traffic channel receiver availability indicator in CIS codewords
Tcfp	CFP processing time (18 ms max)
Tclr	Timer awaiting acknowledgement to a clear down request (1,00 s to 1,04 s)
TCLw	Weighted Terminal Coupling Loss
TCOS	Terminal Class Of Service
Tcpp	CPP processing time (6,2 ms max)
Tdata0	Period for which a data call may last after initial data call establishment before channel re-assessment is required
Tdata1	Period for which a data call may last following a channel re-assessment before a further channel re-assessment is required
Tdata2	Maximum period, prior to expiry of Tdata0 or Tdata1 when FI 5,x,0 may be sent
TDD	Time-Division Duplex
TERM_CAP	Terminal Capabilities Information Element
Tf	CFP Handshake Period
Tfcyc	CFP MUX2 minimum transmit time (1,4 s)
Tfdetect	CFP LINK_GRANT transmit to ID_OK detection time from CPP (100 ms)
Tfmax	CFP Link Establishment Timeout when due to incoming ringing (5 s or as otherwise determined on a country by country basis by prETS 300 001 [1])
Tfmax2	CFP Link Establishment Timeout when NOT due to incoming ringing (15 s)
Tfnolr	Time for which CFP should wait for reception of acceptable LINK_REQUEST codewords in MUX3 during link re-establishment on the same channel. (1,6 s to 1,8 s)
Tfpres	CFP poll response timer (1,00 s to 1,04 s)
Tftx	CFP link set up LINK_GRANT Transmission time (56 ms to 84 ms)
tgain	Transmit Power Level Control bit
Thlost	Link Re-establish time (10 s)
Thrx	ID handshake receive time (1,00 s to 1,04 s)
Thtx	ID handshake transmit time (400 ms)
T_max_cis_per	Maximum period between CIS codewords during CIS transmissions (12 ms)
Tmin_re-establish	Minimum period between link re-establishments. Tmin_re-establish shall be 300 ms for MUX1.4 and MUX2 and 600 ms for MUX1.2.

Tp	CPP Handshake Period
Tpcyc	CPP MUX3 minimum transmit time (750 ms)
Tpgrant	Timeout for receipt of LINK_GRANT after detection of SYNCF during link establishment and re-establishment (50 to 100 ms)
Tpid	CPP PID detect from BID time (384 ms)
Tpmax	CPP call set up time (5 s)
Tpoll	CPP poll detection re-trigger time (1,00 s to 1,04 s)
Tptxlr	The period for which the CPP shall transmit LINK_REQUEST code words in MUX3 on a given channel during link re-establishment on the same channel. (not less than 1,6 s)
Trate	Code word transmit rate time (50/100 ms)
Trcw	Timeout period after which re-establishment on the same channel shall occur if valid SYNCD or valid code words are not received. (300 ms to 1,1 s)
Trcw2	CPP and CFP received code word timer, for synchronous re-establishment; 300 ms for MUX2 and MUX1.4, 600 ms for MUX1.2
TRD	Terminal Registration Data
TRD_ALLOC	Terminal registration data information element
Trees	CFP IDLE_D transmission timer, 400 ms for MUX2 and MUX1.4 transmissions, 700 ms for MUX1.2 transmissions.
T_rr_min	Minimum period between successive relocation registration requests from a CPP (15 s)
Trtx	Re-transmission time (66/320/600 ms)
Tsrlg	CFP synchronous re-establishment transmission timer, 300 ms - 750 ms.
Tsrlgmax	Maximum value of CFP synchronous re-establishment transmission timer, 750 ms.
TYP	EPID/KEY bit in KEY_ALLOC
U	Locking/Non-locking Shift Indicator
UI	Un-acknowledged Information message
V(r)	Local State Variable (Receive)
V(s)	Local State Variable (Send)
ZAP	"Zap" field used with INC ZAP to disable handsets

4 Radio frequency interface

4.1 General

Clause 4 covers the minimum RF performance and RF system requirements for cordless telephone equipment which permit, by radio means, some or all of the functions of a normal telephone apparatus and comprises one or more single PSTN line fixed parts, one or more antenna systems, and one or more cordless portable parts. Test conditions for parameters defined in this clause are specified in clause 9.

NOTE: In clause 4, communication is taken to be the CFP and CPP interchanging either control, or speech, or both.

4.2 Channel frequencies

4.2.1 Channel centre frequencies

In countries where the frequency band is available, the channel centre frequencies for the forty CT2 channels shall be 864,050 MHz + (0,100 x n) MHz, where n is the channel number, lying in the range 1 to 40 inclusive. The first channel (channel number one) lies at 864,150 MHz and the last (channel number forty) at 868,050 MHz.

4.2.2 Channel frequency accuracy

The channel frequency accuracy required of both the CFP and CPP transmitters shall be ±10 kHz maximum difference between the nominal and actual channel centre frequencies over supply voltage and temperature ranges. AFC may be used in the receiver at both CFP and CPP but may only be linked to control the transmitter centre frequency at the CPP.

4.2.3 Rate of change of transmit centre frequency

The maximum rate of change of transmit centre frequency at both CFP and CPP shall not exceed 1 kHz/ms, except for the specific cases of switching of the CPP transmitter from MUX3 to MUX2 and for channel changing.

4.2.4 CTA access

The CTA shall have access to all radio channels defined in subclause 4.2.1.

4.3 Signalling strategy

The supplier shall declare that the signalling strategy complies with each subclause of 4.3.

4.3.1 CTA access

The CTA shall have access to the full number of allocated channels and make use of any free channel when signalling to establish a communication channel.

4.3.2 Signalling whilst in the communication state

Signalling whilst in the communication state shall be limited to the same radio channel as is used for communication.

4.3.3 Signalling outside the communication state

Signalling outside the communication state shall only be allowed for the purposes of subclauses 4.4 and 6.8 and limited in duration by the requirements of subclauses 4.9.2 and 6.8.

4.4 Dynamic channel allocation strategy

The supplier shall declare that the signalling strategy complies with each subclause of 4.4.

4.4.1 Incoming calls

When an incoming call is detected by the CFP it shall choose a free channel over which to signal, using its handshake, to the CPP. The CPP upon detection and recognition of this handshake shall respond on this chosen channel with a signal using its handshake. The CFP, upon detection and recognition of this response, shall in conjunction with the CPP establish the communication link.

If the above link establishment is unsuccessful then the CFP may make re-attempts, sequentially, on the subsequent free channels. These re-attempts shall be restricted to using a maximum of five free channels and shall be constrained by the requirements of subclauses 4.4.4 and 4.9.2.2.

4.4.2 Outgoing calls

When a CPP is requested to make an outgoing call it shall choose a free radio channel over which to signal for a maximum period of 5 s, using its handshake, to the CFP. The CFP, upon detection of this matching handshake shall respond on this chosen channel with a signal using its handshake. The CPP, upon detection and recognition of this response, shall in conjunction with the CFP establish the communications link.

If the above channel acquisition is unsuccessful then the CPP may make re-attempts, sequentially, on the subsequent free channels. These re-attempts shall be restricted to using a maximum of five free channels and shall be constrained by the requirements of subclauses 4.4.4 and 4.9.2.1.

4.4.3 Channel selection strategies

Manufacturers shall use such selection strategies as to ensure random utilization of the radio channels defined in subclause 4.2.1.

4.4.4 Free channel

The primary usage of CT2 CAI is for voice telephony. The radio interface may also be used for other purposes. These secondary uses include CIS transmissions (subclause 6.8.2) and data services. Different free channel selection algorithms apply for primary and secondary services. All uses not specified as secondary services in the text of this document may be considered as primary services.

4.4.4.1 Free channel selection for primary services

The decision as to whether a channel is free shall be made on the basis of intermittent or continuous monitoring for a period of time between 200 ms and 2 s. If intermittent monitoring is used the decision shall be based upon a minimum of five distributed samples which should be taken such that the peak level over a period sufficient to cover both halves of a MUX1 or MUX2 frame is recorded. Monitoring shall be performed to a nominal resolution of 6 dB or better over this period. The decision on whether a channel is free shall be considered valid only during the period of 2 s immediately following the end of the monitoring period.

A free channel is defined as the following:

1) any channel with a local field strength below an absolute maximum of 40 dB relative to 1 µV/m; or

2) where all channels are above 40 dB relative to 1 µV/m, then any channel which has the lowest field strength of all channels defined in subclause 4.2.1 as measured, by intermittent or continuous monitoring, to a nominal resolution of 6 dB or better,

but may exclude any channels on which an unsuccessful attempt has been made to establish communications for that call. If an externally synchronised RFP or nested RFP is able to make a valid free channel assessment in the transmit window then the RFP should exclude from its free channel assessment any channels which on a basis of at least one sample per channel, record a peak level of 79 dBµV/m or greater in its transmit window. Alternatively where the channel usage of all the synchronous RFPs in a network or nest are known then those channels which are reported as locally in use should be excluded.

4.4.4.2 Free channel selection for secondary services

The CFP or CPP shall select a free channel for secondary service in accordance with the channel selection criteria in subclause 4.4.4.1; however, further restrictions for channel selection shall apply:

1) a channel shall not be selected if the local field strength is measured above 56 dB relative to 1 µV/m;

2) a channel may only be selected for transmission at the low power level (see subclause 4.5.1.3) if the measured field strength on both the selected channel and the immediately adjacent channels does not exceed 56 dB relative to 1 µV/m. If a secondary service channel assessment occurs during a communications link, and a SABM_ACK with NPSS = 1 (see subclause 6.5.6.6) has been received by the CPP, the CPP shall not select a channel which is only available for low power use.

3) a channel may only be selected for transmission at the normal power level if the measured field strength on both the selected channel and the immediately adjacent channels does not exceed 50 dB relative to 1 µV/m.

For CFPs only, the above two thresholds may be varied to suit local operating conditions, but the values used shall not exceed those specified above by more than 3 dB.

NOTE: There is only one adjacent channel for channel numbers 1 and 40.

4.5 Radio transmitters

4.5.1 RF power

4.5.1.1 Maximum RF power

The transmitter carrier output power or effective radiated power (see subclause 9.3.1) under normal test conditions and under extreme test conditions shall not exceed 10 mW.

4.5.1.2 Minimum RF power

At nominal design operating voltage the normal carrier output power or effective radiated power (see subclause 9.3.1) under normal test conditions shall not be less than 5 mW for a CPP or CFP, and not less than 6,3 mW for a public access CFP. Annex E contains recommendations concerning interim arrangements for minimum RF power.

4.5.1.3 Output power at low power setting

Output power at the low power setting (see subclause 4.5.3.4) shall be lower than the output power level at the normal power setting. The difference in output power between the two power levels shall be 16 dB ±4 dB and shall be independent of the absolute power level chosen for normal power output.

4.5.2 Modulation

The modulation employed shall be 2-level FSK shaped by an approximately Gaussian filter to meet the requirements of subclause 4.5.5. The peak frequency deviation under all possible data patterns shall lie between 14,4 kHz and 25,2 kHz.

A binary 1 shall be encoded as a frequency higher than the carrier frequency (f_c+ f); a binary 0 shall be encoded as a frequency lower than the carrier frequency (f_c - f). f_c is the RF carrier frequency and f is the deviation.

The designation of the specified emission, according to article 4 of the Radio Regulations is 100KF7WCT.

4.5.3 Adaptive transmitter power strategy

The supplier shall declare that the signalling strategy complies with each subclause of 4.5.3.

4.5.3.1 General

The adaptive transmitter power strategy during communications may vary the transmitter power by up to 20 dB in a CPP and any CFP. This shall only be used when the received field strength is above 90 dB relative to 1 µV/m and shall not alter the operation of any other part of the CTA.

4.5.3.2 CPP only

If the adaptive transmitter power strategy is used only in the CPP, then both a reduction and increase in transmitter power shall be allowed.

4.5.3.3 CPP and CFP

If the adaptive transmitter power strategy is used in both the CPP and CFP, then transmitter power shall not be increased during a call without re-establishing that the radio channel is free in accordance with subclause 4.4.4.

4.5.3.4 Power level changes

The CPP shall be capable of switching its RF output power level between two settings: normal and low power. If the CPP originates or re-establishes a call using a channel selected for primary service (4.4.4.1) it shall set its power level to normal. If the CPP establishes or re-establishes a call using a channel selected for secondary service (4.4.4.2) it shall set its power level according to the secondary assessment criteria. When responding to polls in CIS transmissions (see subclause 6.8.2.2) the CPP shall use the power level indicated in the CIS codewords. At all other times the CPP shall only change its RF output power level in response to a power control message (subclause 6.5.6.1) or a secondary service channel availability message (6.5.6.7.1) transmitted by the CFP. All RF output level changes shall conform to the requirements of subclause 4.5.3.

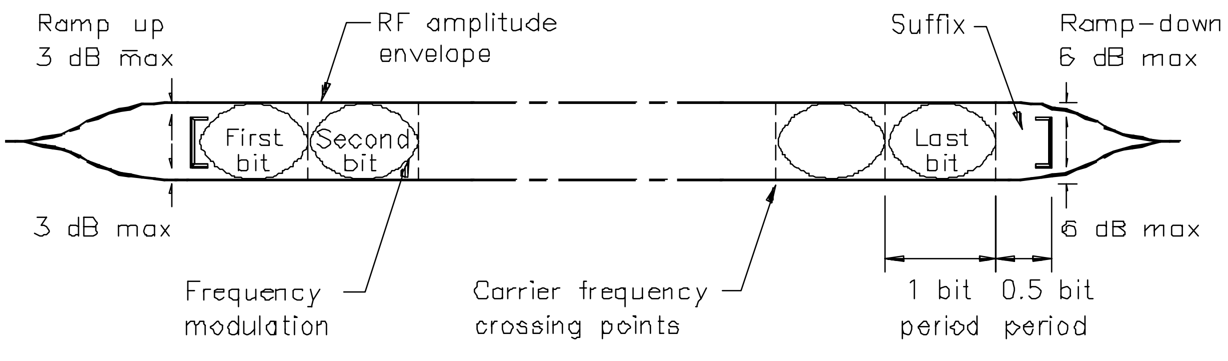
4.5.4 Transmitter burst envelope

4.5.4.1 Amplitude

The amplitude of the RF envelope at the start of the first valid bit to be transmitted shall be within 3 dB of the final amplitude of the burst, as shown in figure 1.

The amplitude of the CPP RF envelope 2 bit periods prior to the start of the first bit to be transmitted shall be less than -60 dB relative to the amplitude of the transmission. Annex E contains recommendations concerning interim arrangements for the CPP ramp up time.

The amplitude of the CPP RF envelope 3 bits periods after the end of the final bit to be transmitted shall be less than -60 dB relative to the amplitude of the transmission. Annex E contains recommendations concerning interim arrangements for the CPP ramp down time.



NOTE: The signal frequency during ramp-up, suffix and ramp-down may lie anywhere between the upper deviation limit

Figure 1: Data packet within RF envelope

4.5.4.2 Dispersion effects

In order to allow for the effects of dispersion in channel filters, the amplitude of the transmitted signal during the period of 0,5 data bit after the end of the normal transmitted data shall be maintained to within 6 dB of the amplitude obtaining during the transmission of normal data, as shown in figure 1.

4.5.4.3 Guard time

During the guard time between transmitting and receiving, no additional information is present. The signal frequency during ramp-up, suffix and ramp-down may lie anywhere between the specified deviation limits.

4.5.4.4 Synchronisation of transmitter burst envelopes

Where external synchronisation ports are provided to synchronise the transmitter burst envelopes of a CFP or CT2 system, the transmitter burst envelopes shall conform to the specifications given in annex N, subclause N.2.2.

4.5.5 Adjacent channel power (narrow band)

The adjacent channel power under either normal or extreme test conditions shall not exceed 10 µW when integrated within a bandwidth of 80 kHz ± 5%.

4.5.6 Out of band power arising from transmitter transients

The power level of any switching transient at a frequency separated by 100 kHz from the nominal frequency shall not exceed 2,5 µW and those by 500 kHz from the nominal frequency shall not exceed 1 nW.

4.5.7 Intermodulation attenuation

This requirement applies to transmitters/receivers to be contained (nested) in a single enclosure or a single unit containing two or more transmitters/receivers which are not separable.

The effective radiated power of the intermodulation products measured in a 10 kHz bandwidth shall not exceed 4 nW.

4.6 Radio receivers

4.6.1 General

Equipment shall meet the requirements of either subclauses 4.6.1.1 or 4.6.1.2. Subclause 4.6.1.3 shall apply to equipment without integral or supplied antennas.

4.6.1.1 CTA including three or more RFPs

The radio receivers in any CFP comprising part of a CTA which includes three or more RFPs which are contained within the same enclosure and/or which utilise a common antenna or antennas or antenna connection port or ports shall comply with subclauses 4.6.3, 4.6.4 and 4.6.5. Informative annex E contains recommendations concerning interim arrangements for equipment covered by subclause 4.6.1.1

4.6.1.2 Other CTAs

The radio receivers in the CPP or CPPs and in any CFP (other than those described in subclause 4.6.1.1) comprising the CTA shall comply with subclauses 4.6.3, 4.6.4 and 4.6.5. Informative annex E contains recommendations concerning interim arrangements for equipment covered by subclause 4.6.1.2.

4.6.1.3 CTAs without integral or supplied antenna

In the case of equipments without integral or supplied antennas, assessment of compliance to subclauses 4.6.1.2 and 4.6.1.3 may be based upon measurements made by application of signals to the termination point provided for non-integral antennas. The termination point shall have an impedance of nominally 50 ohms. In this case, the conversion factor of 0 dB relative to 1 µV/m (0 dBµV/m) being equivalent to -134 dBm (referring to a lambda/2 dipole with 2,2 dB of gain over the isotropic radiator) shall be used to convert the stated field strengths to absolute signal levels.

The conversion factor is derived by substituting F = 866 MHz in the following equation:

$$E(dB\mu V/m) = P(dBm) + 20\ LogF(MHz) + 75$$

4.6.2 Sensitivity

The receiver sensitivity (see subclause 9.5.7 for test method) shall be defined at a bit error ratio of 1 in 1000 or better in both the B (speech data) and D (signalling data) channels (see subclause 5.2). Annex E contains recommendations concerning interim arrangements for receiver sensitivity.

4.6.2.1 Receiver sensitivity for CFP or CPP using an integral or supplied antenna

The radio receiver sensitivity shall be at least 40 dBµV/m.

NOTE: It is recommended that this be achieved by ensuring that the radio receiver sensitivity is typically 34 dBµV/m or better.

4.6.2.2 Receiver sensitivity with a 50 ohm connector

The radio receiver sensitivity shall be -100 dBm or better at the antenna connector. A sensitivity of - 94 dBm at the antenna connector shall be allowed for a system employing a multi-channel passive combiner/splitter.

4.6.3 Interference rejection

4.6.3.1 Unmodulated interfering carrier signal

The communications state, once established between the CFP and CPP shall be maintained when the receiver of the CFP or CPP is receiving a wanted signal from its associated CPP or CFP at a signal strength equal to that specified in subclause 4.6.2 for the receiver sensitivity plus 5 dB and when an unmodulated interfering carrier signal is introduced at any frequency within the ranges and at the corresponding field strengths (dBμV/m), power levels (dBm - see subclause 4.6.1.3) or the interferer to wanted signal ratios (dBc) listed below in table 1:

Table 1: Unmodulated interfering signals

Frequency Range(s)	Extreme conditions	Nominal conditions
25 MHz to 800 MHz	120 dBμV/m	123 dBμV/m
800 MHz to 850 MHz 890 MHz to 4 GHz	117 dBμV/m	120 dBμV/m
850 MHz to 860 MHz 872 MHz to 890 MHz	110 dBμV/m	113 dBμV/m
860 MHz to 863 MHz 869 MHz to 872 MHz	45 dBc	48 dBc
863 MHz to f_c - 300 kHz f_c+300 kHz to 869 MHz	35 dBc	38 dBc
f_c-300 kHz to f_c - 200 kHz f_c+200 kHz to f_c + 300 kHz	30 dBc	33 dBc
f_c-200 kHz to f_c-100 kHz f_c+100 kHz to f_c+200 kHz	20 dBc	20 dBc
f_c-100 kHz to f_c+100 kHz	-20 dBc	-20 dBc

where f_c is the nominal frequency of operation.

The signal from the associated CPP or CFP and the interfering carrier wave are assumed to have the same polarisation.

Annex E contains recommendations concerning interim arrangements for interference rejection.

4.6.3.2 Modulated asynchronous interfering signal

The communications state, once established between the CFP and CPP shall be maintained at a BER of 1 in 1000 or better when the receiver of the CFP or CPP is receiving a wanted signal from its associated CPP or CFP at a signal strength equal to that specified in subclause 4.6.2 for the receiver sensitivity plus 10 dB and when a modulated asynchronous interfering signal is introduced, modulated in any manner that meets this specification, at any channel and at the corresponding field strengths (dBmV/m) or the interferer to wanted signal ratios (dBc) listed below in tables 2 to 4. In these tables, W is the wanted channel. The signal from the associated CPP or CFP and the interfering carrier are assumed to have the same polarisation. See subclause 9.5.8.2 for method of measurement.

Table 2: Modulated interfering signals

Frequency Range(s)	Extreme conditions	Nominal conditions
860 MHz to W - 4 W + 4 to 872 MHz	90 dBµV/m (-44 dBm)	93 dBµV/m (-41 dBm)

Table 3: Adjacent channel rejection

Channels	Extreme conditions	Nominal conditions
W + 3 and W - 3	34 dBc	37 dBc
W + 2 and W - 2	25 dBc	28 dBc
W + 1 and W - 1	0 dBc	0 dBc

Table 4: Co-channel rejection

Channel	Extreme conditions	Nominal conditions
W	-18 dBc	-15 dBc

4.6.4 Blocking due to spurious responses

If any part of the CTA fails to meet the requirements of subclauses 4.6.3.1 or 4.6.3.2 only due to a maximum, in each case, of ten spurious responses to, respectively, unmodulated or modulated carrier wave signals at discrete frequencies in the range 25 MHz to 4 GHz, of which three shall be at a field strength of not less than 80 dB relative to 1 µV/m and the remaining such responses at a field strength of not less than 100 dB relative to 1 µV/m, then the CTA shall be deemed to meet the requirements of subclauses 4.6.3.1 and 4.6.3.2.

For the purposes of this subclause a spurious response is the failure of the communications state between a CFP or CPP and its corresponding CPP or CFP due to the introduction of interfering radio signals, at any frequency within a continuous band of width 1 MHz or less and of which the centre frequency varies with the channel of operation selected by the CTA, and at a lower field strength than that given as the limiting value in subclauses 4.6.3.1 or 4.6.3.2 for that frequency equal to the centre frequency of this band.

4.6.5 Intermodulation response rejection

The communications state, once established between a CFP and one of its associated CPPs, shall be maintained without interruption when the CFP or CPP is receiving a signal from this CPP or CFP at a signal strength of 45 dB relative to 1 µV/m and when two interfering signals are introduced, each of which generates a signal strength of 85 dB relative to 1 µV/m at the antenna of the CFP or CPP (each modulated as described below) in each of the following cases (where f_c is the frequency of operation):

a) at frequencies of f_c+ 400 kHz and f_c+ 800 kHz;

b) at frequencies of f_c - 400 kHz and f_c - 800 kHz;

c) at frequencies of f_c+ 400 kHz and f_c - 400 kHz.

The interfering signals shall each bear continuous data modulation similar to that produced by the CPP or CFP. The data modulating the interfering signals shall not, either separately or when combined in any way, simulate the handshake code required to maintain the communications state between the CPP and CFP.

Annex E contains recommendations concerning interim arrangements for intermodulation performance.

4.7 Combined radio transmitter/receivers

4.7.1 Adverse power supply conditions

The adjacent channel power and spurious emission limits specified shall not be exceeded under normal and under adverse power supply condition.

4.7.2 Spurious emissions of the combined transmitter/receiver

The power of any spurious emission in the frequency ranges specified in table 5, when the equipment is in the active mode, shall not exceed the values listed in table 5.

The bandwidth of the measurements are specified in subclause 9.4.1.

Table 5: Spurious emissions

Frequency range	Maximum level (active mode)	Maximum level (idle mode)
100 kHz to 862 MHz	4 nW	2 nW
862 MHz to 864,1 MHz	250 nW	2 nW
864,1 MHz to 868,1 MHz	250 nW	0,2 nW
868,1 MHz to 890 MHz	250 nW	2 nW
890 MHz to 1000 MHz	4 nW	2 nW
1000 MHz to 10,7 GHz	1 µW	20 nW
10,7 GHz to 12,75 GHz	20 nW	4 nW

Annex E contains recommendations concerning interim arrangements for spurious emissions.

4.8 Termination of the communication state

The supplier shall declare that the signalling strategy complies with each subclause of 4.8.

4.8.1 Clear down signal sequence

Any action for the deliberate termination of the communication state shall initiate an interchange, over the RF link, of a clear down signal sequence.

4.8.2 Cessation of RF activity

Any action for the deliberate termination of the communication state shall, within 1 s, cause the cessation of RF activity in the CPP and that part of the CFP with which it is in communication.

4.8.3 Off-line timing

Where only one CPP is in communication with the PSTN, any action for the deliberate termination of the communication state shall cause that part of the CFP with which it is in communication, and which was on-line to the PSTN, to go off-line to the PSTN within 1 s.

4.9 Channel scanning

The supplier shall declare that the signalling strategy complies with each subclause of 4.9.

4.9.1 Available channels

The CTA shall have access to all radio channels defined in subclause 4.2.1.

4.9.2 Response times

The response times given in subclauses 4.9.2.1 and 4.9.2.2 shall be for the following conditions:

a) full availability of free radio channels to the service;

b) any possible group of three adjacent radio channels, below a field strength of 40 dB relative to 1 µV/m and the remaining channels carrying speech traffic, with the same modulation format as the CTA at field strengths of 50 dB relative to 1 µV/m.

4.9.2.1 Outgoing

The interval between the CPP initiating a communication link, and the establishment of that communication link to the CFP shall not exceed 5 s.

4.9.2.2 Incoming

The interval between a CFP having sufficient information to determine which CPP(s) are to be polled and the poll response from the CPP(s) (if enabled) shall be less than 5 s.

4.10 In-communication channel switching

4.10.1 Capability

All CFPs and CPPs shall support in-communication channel switching. Annex E contains recommendations concerning interim arrangements for channel switching capability.

4.10.2 Channel change delay

A CTA in the communication state shall not change channels before 3 s of handshake has been lost (see subclauses 5.4.5 and 5.5) due to poor RF link conditions.

The following exceptions shall apply:

- CFPs which have physically separate RFPs which are controlled from a common point and which can ensure that in-communication channel switching between RFPs does so on a free channel (see subclause 4.4.4) at the new RFP may, subject to subclause 6.5.6.4, send an UnSpecified_Channel_Re-establish message or a Specified_Channel_Re-establish message without reference to loss of handshake. Similarly, if a CFP meeting the above conditions receives a Same_Channel_Re-establish message (subclause 6.5.6.4) from a CPP it may begin MUX2 transmissions on a different channel without reference to loss of handshake;

- a CPP which has received extended SABM_ACK with the FCR bit set (see subclause 6.5.6.6) and which has not received a command to re-establish on a specified channel (see subclause 6.5.6.4) may, under the conditions for re-establishment (see subclause 5.4.4), select one or more channels on which to attempt re-establishment without reference to loss of handshake and subject to the provisions of subclause 4.4.4 (see subclause 5.4.5.1, 3));

- CFPs which have physically separate RFPs which are controlled from a common point and which have set-up a link for synchronous re-establishment (see subclause 5.4.6) may under the conditions for re-establishment in subclause 5.4.6 send a MUX3_UnSpecified_Channel_Re-establishment message (see subclause 6.5.6.4) without reference to loss of handshake;

- a CPP which receives a MUX3_UnSpecified_Channel_Re-establishment message (see subclause 6.5.6.4) may select one or more channels on which to attempt re-establishment without reference to loss of handshake and subject to the provisions of subclause 4.4.4 (see subclause 5.4.5.1, 4));

- where a synchronous re-establishment (see subclause 5.4.6) on the same channel occurs, a CFP may change to a different RF channel after the expiry of Tsrlg (see subclause 5.4.6.1);

- a CFP or a CPP may send a Secondary_Service_Re-establishment message without reference to loss of handshake. A CFP may send a MUX3_Secondary_Service_Re-establishment message without reference to loss of handshake.

  NOTE: Subclause 5.5.1.6 still applies during in-communication channel switching.

4.11 Controls

Those controls, which if maladjusted might increase the interfering potentialities of the equipment, shall not be easily accessible, in particular any control which may cause the equipment to operate outside the permitted frequency limits specified in the other parts of clause 4.

4.12 Synthesisers and PLL systems

Where synthesisers and/or phase-locked loop systems are utilised for carrier generation, precautions shall be taken to ensure that any lack of synchronisation does not cause deviation outside the permitted frequency limits specified in the remaining parts of clause 4.

5 Signalling layer one

CT2 signalling layer one specifies methods for the following:

- the time-division duplexing of data;

- the multiplexing of data onto the TDD structure;

- two-way digital link initiation;

- handshaking.

Operation of CT2 CAI layer one is primarily designed for point to point communication, but multi-point operation is allowed, during the call set up phase for multiple ringing of CPPs. Multiple response resolution from CFPs providing the same service is also provided.

5.1 Data structure and timing

Four different burst structures (MUX3, MUX2, MUX1.4 and MUX1.2) are defined in subclause 5.2. Briefly, however, this I-ETS supports the use of a transmission burst length during speech communication mode of either 68 bits or 66 bits at 72 kbit/s. This is repeated every 144 bits (2 ms) with an interleaved receiving window of up to 68 bits. Since the speech channel (B channel) occupies 64 of the bits in a burst, systems equipped to cater for the 68-bit burst length can signal, in the presence of the speech channel, at twice the rate of those that handle 66-bit bursts only. Eight or twelve bits of guard time remain per burst frame for burst lengths of 68 bits and 66 bits respectively.

5.1.1 Data rate

The nominal data rate shall be 72 kbit/s with a tolerance of ± 50 ppm at the CPP and ± 50 ppm at the CFP. The data clock may have drift and jitter up to the limits specified for the CCITT Recommendation G.823 [2] table 1, 64 kbit/s interface, but this does not override the long term frequency accuracy specified above.

5.1.2 Time-division duplexing

Normal speech and data communication takes place in Time-Division Duplex (TDD) mode with a guard band between transmit and receive periods (figure 2). The guard band ensures that sufficient time remains at the beginning and end of a transmitted burst for the transmitted power to rise and decay without violating the AM splash requirements of subclause 4.5.6, and for the receiver to be enabled sufficiently in advance of the expected return burst.

Time-division duplex using the frame shown in figure 2 (in MUX1.2, MUX1.4 or MUX2) is the normal operational state except in the case where the CPP is initiating the link, when transmission from the CPP is not constrained to the burst frame structure (see subclause 5.2 for full details).

5.1.3 Master-slave relationship

In the communication state, the CFP shall act as master for frame, burst and bit synchronisation. The CPP shall synchronise its frame, burst and bit clocks to the signals received from the CFP.

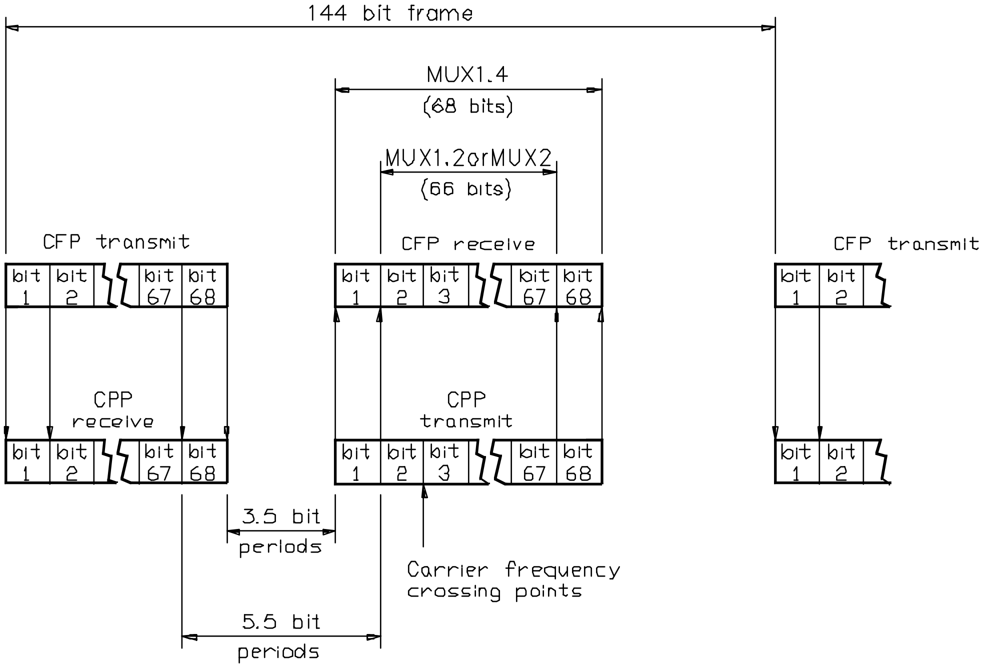


Figure 2: Transmission duplexing

5.2 Sub-channel multiplexes

A CT2 CTA exchanges data in a TDD mode with an instantaneous data rate of 72 kbit/s. Under various situations up to three sub-channels have to be multiplexed within the available data bandwidth. These are:

- a signalling channel (the D channel);
- a voice/data channel (the B channel);
- a burst synchronisation channel (SYN channel) used for bit and burst synchronisation.

According to the requirements of a particular situation or function, the proportion of the main channel bandwidth allocated to each of the above sub-channels may vary, and a sub-channel may be absent in some circumstances. Each different allocation of sub-channel bandwidths is termed a multiplex. Three multiplexes (known as multiplexes one, two and three) are used. They are illustrated in figures 3, 4 and 5 respectively and described in subclauses 5.2.2 to 5.2.4 below.

5.2.1 Channel Markers (CHM) and synchronism markers (SYNC)

Multiplexes two and three are used in situations where a CTA may have not yet gained burst synchronism. Special bit patterns are used in the SYN channel in order to mark an RF channel where a link set up attempt is being made and/or to mark a particular time within the multiplex period in order to allow CTAs to gain burst synchronism. The patterns are all of 24-bit length and chosen to yield low auto-correlation and low cross correlation with other frequently-occurring bit patterns.

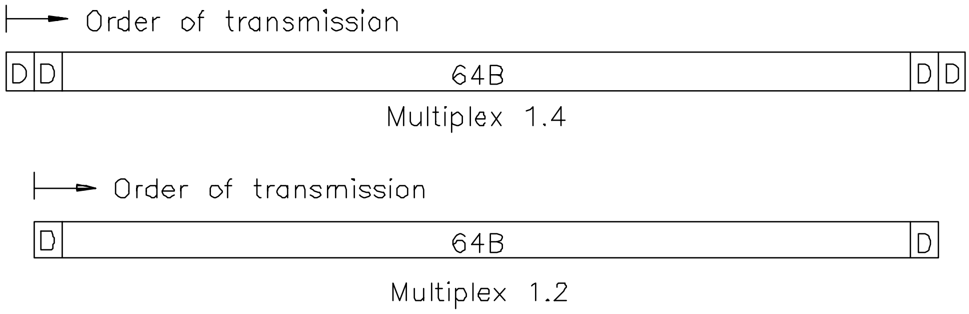
Patterns called CHM are used to mark transmissions within a CTA which is attempting to initialise a radio link and also to mark a particular time within the multiplex. Patterns called SYNC are used when a link has already been established. Details of the usage of CHM and SYNC are covered further in subclauses 5.3 and 5.4.

The CHM bit pattern sent by the CFP (specifically CHMF) is the bit-wise inverse of the CHM pattern sent by the CPP (specifically CHMP). Similarly SYNC sent by the CPP (SYNCP) is the bit-wise inverse of that sent by the CFP (SYNCF). CPPs which expect to see CHMF or SYNCF are therefore unable to recognise marker patterns from other CPPs, and CFPs are unable to recognise marker patterns from other CFPs. The bit patterns for SYNCP, SYNCF, CHMP and CHMF are given below:

	msb (sent last)					lsb (sent first)	
CHMF	1011	1110	0100	1110	0101	0000	(BE4E50H)
CHMP	0100	0001	1011	0001	1010	1111	(41B1AFH)
SYNCF	1110	1011	0001	1011	0000	0101	(EB1B05H)
SYNCP	0001	0100	1110	0100	1111	1010	(14E4FAH)

5.2.2 Multiplex one

Multiplex one is invoked from multiplex two by means of a layer three channel control message (see subclause 7.2.6). Multiplex one (figure 3) is used bi-directionally over an established link to carry the D and B-channels. The SYN channel is nonexistent in this multiplex and therefore should burst synchronisation be lost, it cannot be recovered without re-establishing the link (see subclauses 5.4.4, 5.4.5 and 5.4.6). If the B channel source is disconnected, the input to the B channel scrambler (see below) shall be all zeros.



NOTE: the burst is repeated every 144 bits (2 ms).

Figure 3: Multiplex one

Multiplex one supports both the 68-bit and 66-bit burst structure (referred to as MUX1.4 and MUX1.2 for signalling with four bits or two bits respectively). The raw data rates in this multiplex are 2,0 kbit/s (MUX1.4) or 1,0 kbit/s (MUX1.2) for the D channel and 32,0 kbit/s for the B channel. All CTAs shall support at least MUX1.2. Support for MUX1.4 shall be optional, it shall be used only if both ends of the CTA support the higher signalling rate.

Data bytes in the D channel are aligned in this multiplex so that bytes always start on a frame boundary (figure 6). The alignment of the data in the B channel specified in subclause 8.3.

In MUX1.4 the valid transmitted data bits in a burst are numbered 1 to 68. At the CPP antenna the start of transmission of valid data bit 1 of MUX1.4 shall occur 3,5 bit periods ±0,25 bit periods after the end of valid data bit 68 has been received (also measured at the CPP antenna).

In MUX1.2 the valid transmitted data bits in a burst are numbered 2 to 67. At the CPP antenna the start of transmission of valid data bit 2 of MUX1.2 shall occur 5,5 bit periods ±0,25 bit periods after the end of valid data bit 67 has been received (also measured at the CPP antenna).

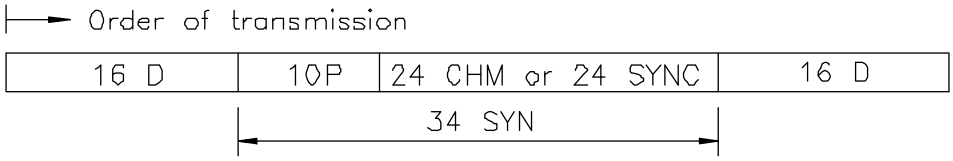
In order to ensure reasonably random bit sequences in MUX1.2 and MUX1.4, the following bits shall be inverted in the 64 bits of the B channel within each 2 ms frame:

03, 04, 06, 09, 14, 16, 18, 19, 20, 22, 23, 27, 28, 29, 30, 31,
34, 35, 37, 40, 45, 47, 49, 50, 51, 53, 54, 58, 59, 60, 61, 62.

NOTE: These bit numbers refer to the 64 bits of the B channel and not the burst bit numbers (bit 1 is the first transmitted bit of the B channel). All other bits shall remain non-inverted.

5.2.3 Multiplex two

MUX2 (figure 4) is used to carry the D and SYN channels for link establishment and re-establishment. The B channel is nonexistent in MUX2. MUX2 is used prior to a switch to MUX1 by means of a layer three message (subclause 7.2.6).



NOTE: The burst is repeated every 144 bits (2 ms).

Figure 4: Multiplex two

MUX2 carries the D channel at a data rate of 16,0 kbit/s and the SYN channel at an overall rate of 17,0 kbit/s. The SYN channel consists of ten bits of preamble (one-zero transitions) followed by a channel marker (CHMF) or synchronism marker (SYNC: either SYNCF or SYNCP).

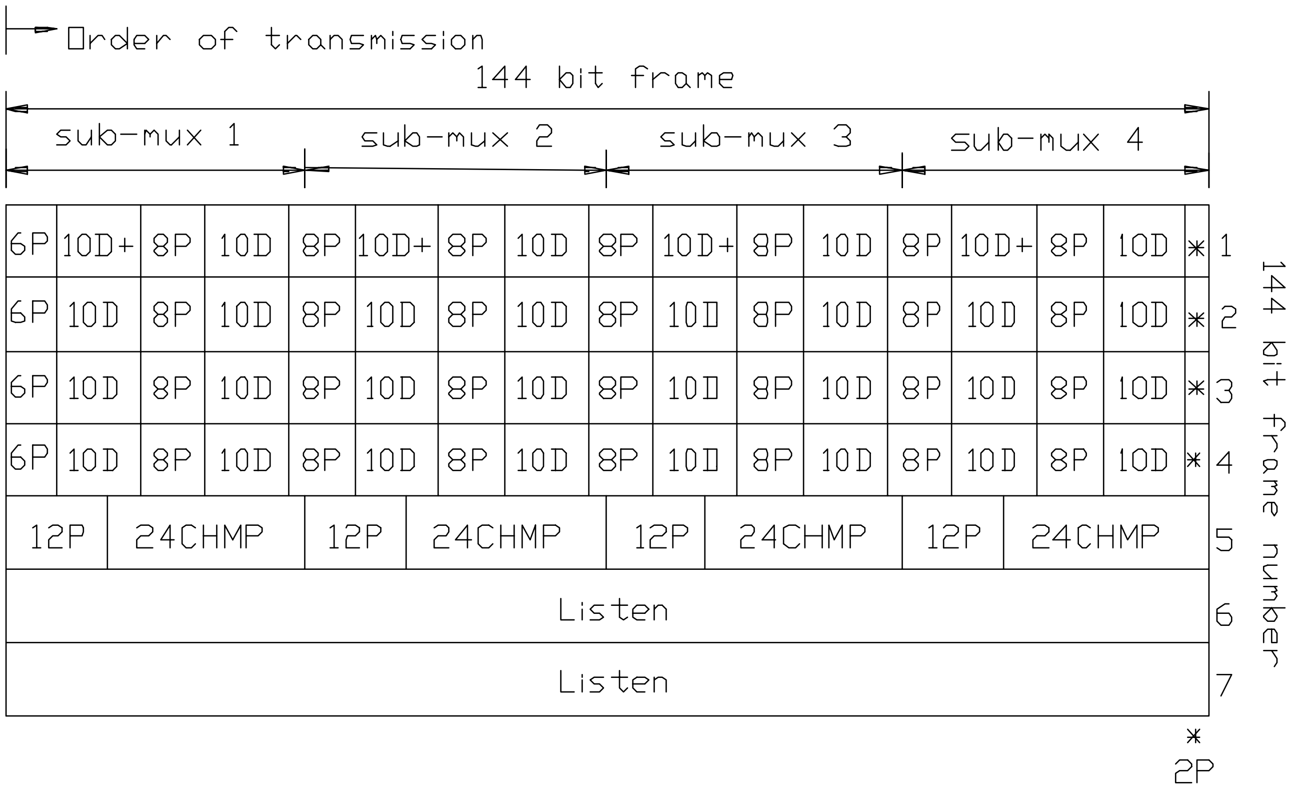
The use of CHM or SYNC in the SYN channel is covered in subclauses 5.2.1, 5.3 and 5.4.

Data bytes in the D channel are aligned in this multiplex so that the D channel synchronisation word, SYNCD, (see subclause 6.3) occurs as the first 16 bits in the D channel after the SYN channel (figure 6). The alignment of the data in the SYN channel is specified in figure 4.

In MUX2 the valid transmitted data bits in a burst are numbered 2 to 67. At the CPP antenna the start of transmission of valid data bit 2 of MUX2 shall occur 5,5 bit periods ±0,25 bit periods after the end of valid data bit 67 has been received (also measured at the CPP antenna).

5.2.4 Multiplex three

MUX3 (figure 5), carrying the D and SYN channels, is used for link establishment and re-establishment in the direction CPP to CFP. The B channel is nonexistent in MUX3.



NOTE 1: Transmission is continuous for five frames, then off for two.

NOTE 2: The 20 bits of D channel preamble are repeated in each of the four sub multiplexes before D changes.

NOTE 3: P is preamble in the SYN channel.

NOTE 4: The D channel synchronisation word (SYNCD) always begins at the start of slots marked +.

Figure 5: Mutliplex three

MUX3 repetitively transmits for 10 ms and receives for 4 ms. Responses from CFPs in MUX2 are detected during the receive slot. During transmission each sub-channel (D and SYN) is further sub-multiplexed by repetition four times over. This scheme enables the CFP (which in multiple-link systems is constrained to fixed receive slots) to be able to receive one of the sub-multiplexes of the SYN and D channels from the CPP.

The sub-multiplexed D channel comprises 20-bit words split into 10-bit sections surrounded by preamble in order to avoid CHM/SYNC emulation. The SYN channel contains a 12-bit preamble followed by a 24-bit CHMP.

Once the CFP has locked to the SYN channel of one sub-multiplex and recognised the correct ID in the corresponding D channel, the CFP shall then attempt to re-initialise the link (from its own end), using MUX2 with SYNCF in the SYN channel.

Data bytes in the D channel are aligned in this multiplex so that the D channel synchronisation word, SYNCD, (see subclause 6.3) occurs as the first sixteen bits in the D channel after the listen window. The alignment of the data in the SYN channel is specified in figure 5.

The MUX3 transmission shall be in accordance with the transmit envelope specified in figure 1.

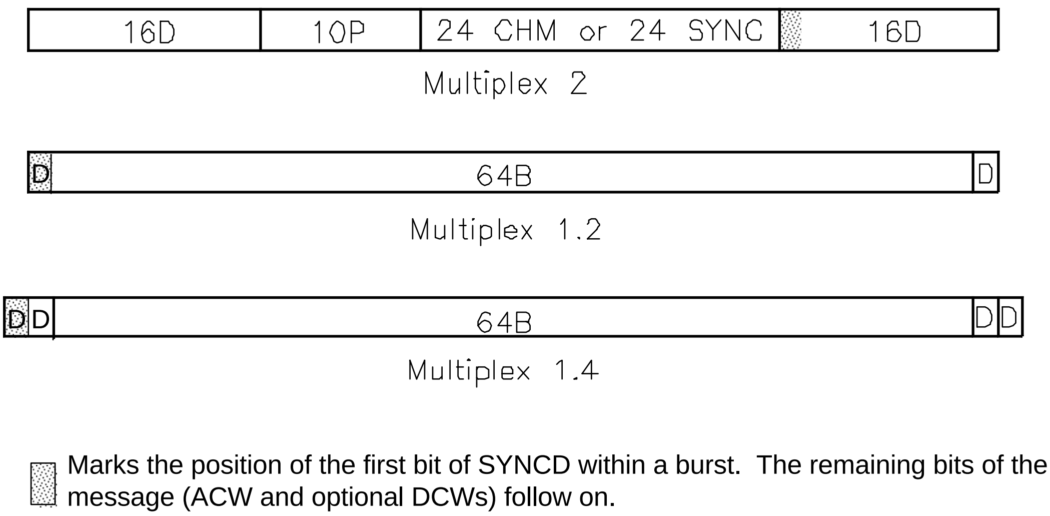


Figure 6: Signalling channel byte alignment

5.3 Calling channel detection

Calling channel detection operates in one of two ways depending upon the unit which originates the call request.

The two possibilities are that the CFP (master) originates the call which is then detected at the CPP (slave); or that the call originates at the CPP (slave) and is detected at the CFP (master). The CPP shall track the CFP bit timing clock once a link is established.

5.3.1 Calling channel detection at the CPP

The CPP expects to receive information formatted in MUX2. The process of calling channel detection on a single channel is shown in figure 7 and the sequence is as follows:

1) On command from the CPP control system, the RF synthesiser begins to switch to the new channel and eventually settles on the new centre frequency and begins receiving.

2) The presence of D (or SYN) channel data from the CFP allows any AGC system to settle. During preamble the system gains bit synchronisation and then detects the CHM in the SYN channel of MUX2 from the CFP (CHMF in this case). D channel decoding then starts. Should CHMF not be detected within a suitable receive window then another channel may be examined.

3) Only when CHMF has been correctly detected and a recognised ID found in the D channel, (LID and PID fields, see subclauses 6.4.3, 6.4.4 and 6.4.5), may a response be transmitted using MUX2 with SYNCP in the SYN channel and the contents of the LID and PID fields reflected back to the CFP.

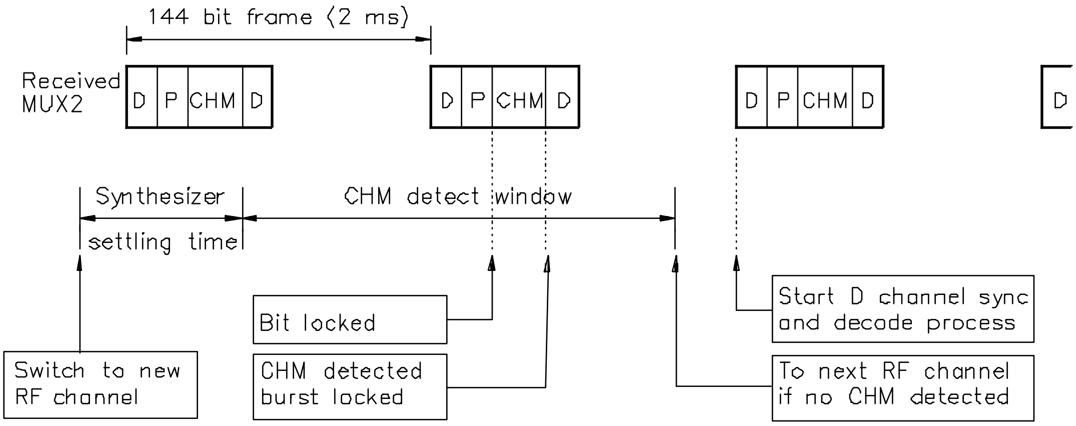


Figure 7: Calling channel detection and burst sync. at the CPP

Channel scanning continues until either a valid incoming call is detected and established or the user initiates an outgoing call.

5.3.2 Calling channel detection at the CFP

The CFP expects to receive information formatted in MUX3. The process of CHM detection is similar to that above except that the receive window is known, a priori, since the CFP acts as the frame timing master:

1) On command from the CFP control system, the RF synthesiser begins to switch to the new channel and eventually settles on the new centre frequency and begins receiving.

2) The presence of D (or SYN) channel data from the CPP allows any AGC system to settle. During preamble the system gains bit synchronisation (temporarily acting as a slave for bit timing) and then attempts to detect CHMP in the SYN channel of MUX3. This is transmitted every seventh 144-bit cycle. D channel decoding then starts. Should CHMP not be detected within a suitable receive window then another channel may be examined.

3) Only when CHMP has been correctly detected and a recognised link end point identification code found in the D channel LID field (see subclause 6.4.5), may the link be re-initialised from the CFP using MUX2 with SYNCF in the SYN channel, and with the CPP's own PID and a call reference value (assigned by the CFP) in the LID field. At this point the CFP re-gains master status for bit timing. The processing time for the CFP to decode the MUX3 information field and start sending SYNCF in MUX2 shall be less than Tcfp (18 ms, and recommended to be less than 4 ms to minimise the risk of response collision).

Channel scanning may continue until either a valid outgoing call is detected or the PSTN initiates an incoming call.

5.4 Link set up and establishment

Upon identification of the RF channel upon which a call is taking place and verification of compatible link-end identification, digital link set up can occur.

5.4.1 Link set up from CFP to CPP

Action at the CFP: When a link needs to be established to a CPP (e.g. in response to an incoming call indication), the CFP shall acquire a free RF channel and begin transmitting (and receiving) in MUX2 over that channel (with CHMF in the SYN channel and with PID and BID or LID in the D channel). The transmission shall last for a minimum of 1,4 s (Tfcyc) unless either a response from a recognised CPP is received (see subclause 6.6.7), or the link establishment timeout expires (Tfmax or Tfmax2 see (iii), below), or the link establishment request ceases. The three possible eventualities are:

1) the link is established when the CFP accepts a response from the target CPP with the correct ID code before the expiry of the transmit time;

2) no recognised response is received before the expiry of the transmit time. In this case a new RF channel may be selected and a further link set up attempt may be made on the new channel;

3) the link establishment is subject to a timeout period. In the case of incoming ringing, the timeout Tfmax shall be used. Tfmax shall be restarted on each detection of incoming ringing and is of sufficient length to cover the specified maximum quiet period of ringing cadence. Its value shall be 5 s (or as otherwise determined on a country by country basis by prETS 300 001 [1]). If no incoming ringing is detected for this timeout period, then link establishment shall cease. All link establishment attempts other than those initiated by incoming ringing detection shall cease when either the link establishment attempt ceases, or where this cannot be determined, after a timeout period not exceeding Tfmax2 (15 s).

Action at the CPP: The CPP should normally check every channel periodically for the presence of CHMF. On detection of CHMF in the SYN channel and a matching PID in the D channel, the CPP shall respond using MUX2 with SYNCP in the SYN channel and either:

1) the PID and LID fields reflected back in the D channel; or

2) the PID field reflected back and the poll decline LID in the D channel (see subclause 6.4.5.1, NOTE 3 and subclause 6.4.5.5).

5.4.2 Link set up from CPP to CFP

Action at the CPP: When a link needs to be established to a CFP, the CPP shall acquire a free RF channel and begin transmitting in MUX3 (with CHMP in the SYN channel and PID, LID in the D channel) and listening for MUX2 over that channel. The transmission cycle period shall last for a minimum of 750 ms (Tpcyc) unless either a response from a recognised CFP is received (see subclause 6.6.6), the link establishment timeout expires (Tpmax), or the link establishment request ceases. The three possible eventualities are:

1) A one-way link is established when the CFP has detected the CHMP from the CPP and checks PID, LID.

   The CFP then replies using MUX2 with SYNCF in the SYN channel, for a period between 56 ms and 84 ms (Tftx).

   The CPP shall synchronise to the SYNCF of MUX2 during its receive slots in MUX3. Immediately the CPP has detected SYNCF from a CFP, it shall cease transmission of MUX3 and shall continue to receive the transmission from the CFP in MUX2. The processing time for the CPP to stop transmission of MUX3 when SYNCF in MUX2 has been detected shall be less than Tcpp(6,2 ms). On detection of the first SYNCF pattern a timer Tpgrant (50 to 100 ms) should be started by the CPP. If the PID is subsequently detected in a LINK_GRANT code word (see subclause 6.4) before the expiry of Tpgrant, the CPP shall respond in MUX2 with SYNCP in the SYN channel and halt timer Tpgrant. If PID is not detected in a LINK_GRANT code word before the expiry of Tpgrant, then MUX3 transmission of LINK_REQUEST code words should resume for the remainder of the transmission cycle or until a further SYNCF is detected, when Tpgrant should be re-started.

For an initial link establishment, the CPP may acquire a new channel before re-starting MUX3 transmission following the expiry of Tpgrant. In the case of a link re-establishment a new channel may not be selected except as specified in subclause 5.4.5.

2) No recognised response is received before the expiry of the transmit time. In this case a new RF channel may be selected and a further link set up attempt may be made on the new channel. This may be repeated for a total of five channel attempts.

3) If a period of 5,0 s (Tpmax) expires before a link is successfully established, no further link set up shall be attempted until the initiation of a new call attempt.

Action at the CFP: The CFP should normally check every channel periodically for the presence of CHMP. On detection of CHMP in the SYN channel and a suitable end point ID in the LID field of the D channel, the CFP shall respond using MUX2 with SYNCF in the SYN channel and PID plus a link reference ID in the LID field of the D channel, for a period of between 56 ms and 84 ms (Tftx).

5.4.3 Set up collision resolution

There are situations under which set up collisions may occur. These are:

1) **call deadlock**: a situation can exist where the CFP can be trying to establish a link to an associated CPP on RF channel X when the CPP is also trying to establish a link to the CFP on channel Y. Each end therefore may never get a response for a period of up to Tpmax. This may be overcome by the CPP reverting to channel scanning.

2) **response collision**: a CPP which has requested a given service will cause responses from all CFPs which provide this service and are in range. The probability of both initial and repeated collision of such responses is minimised by all CFPs starting their channel scanning algorithms at a random channel number and so generating a random time at which the CPP's call will be detected.

If a collision does occur, the CPP will continue to call using MUX3 for the normal calling period and then select a new channel. CFPs, alerted by the failure of the CPP to respond in MUX2 to their MUX2 broadcasts shall re-scan for the CPP and in doing so shall re-start their channel scanning algorithms from randomly determined channel numbers.

5.4.4 Link re-establishment on the existing channel

Re-establishment may be used to re-synchronise the two ends of a CT2 link which have lost synchronisation. It may also be used to hand-over a call between different RFPs of a CT2 system.

Two methods of re-establishment are specified in this I-ETS. Synchronous re-establishment (see subclause 5.4.6) is not mandatory but shall be the preferred method if it is supported. The re-establishment technique described in subclauses 5.4.4 and 5.4.5 shall be used if either the CPP or CFP (or both) do not indicate support for the synchronous method of re-establishment. If both indicate support for synchronous re-establishment, then the method described in subclause 5.4.6 shall be used.

The CPP and CFP should maintain a received code word timer Trcw (300 ms < Trcw < 1,1 s) that is started at link set up and subsequently re-started on each reception of a good codeword or a valid SYNCD. The point of link set up shall be defined as the time of reception of a LINK_GRANT codeword at the CPP and the time of the subsequent reception of a ID_OK codeword at the CFP.

Link re-establishment on the same channel:

1) shall be triggered upon reception of a Same_Channel_Re-establishment message (see subclause 6.5.6); or

2) should be triggered upon the expiry of Trcw and the subsequent transmission, as soon as possible, of at least one Same_Channel_Re-establishment or MUX3_Same_Channel_Re-establishment message subject to subclause 6.5.6.4; or

3) shall be triggered if the reliable detection of loss of synchronisation has occurred and the subsequent transmission, as soon as possible, of at least one Same_Channel_Re-establishment message or MUX3_Same_Channel_Re-establishment subject to subclause 6.5.6.4; or

4) shall be triggered after a minimum of three seconds loss of handshake and the subsequent transmission, as soon as possible, of at least one Same_Channel_Re-establishment or MUX3_Same_Channel_Re-establishment message subject to subclause 6.5.6.4; or

5) shall be triggered upon reception of a MUX3_Same_Channel_Re-establishment message (see subclause 6.5.6.4) provided the CPP has signalled SRE capability in extended SABM (see subclause 6.5.6.5).

   NOTE: After three seconds loss of handshake, re-establishment is not limited to the same channel (see subclauses 4.10 and 5.4.5.1).

Link re-establishment shall be permitted only after a period of at least Tmin_re-establish from a previous link establishment or re-establishment.

5.4.4.1 Action at the CPP

On link re-establishment on the same channel, the CPP shall immediately switch to MUX3 and, using the current link reference in the LID field (see subclause 6.4.5), shall transmit fixed format LINK_REQUEST code words (see subclause 6.4) in MUX3 with CHMP in the SYN channel, for a period of at least Tptxlr (1,6 seconds) or until SYNCF is detected (see subclause 5.4.2 i).

After expiry of Tptxlr and a minimum of 3 seconds loss of handshake, the CPP may attempt link re-establishment on a re-selected channel (see subclause 5.4.5.1)

5.4.4.2 Action at the CFP

On link re-establishment on the same channel, the CFP shall cease transmission and shall wait for reception of a LINK_REQUEST code word (see subclause 6.4) in MUX3 containing the PID of the CPP and the current link reference in the LID field. If after a period Tfnolr (1,6 s < Tfnolr < 1,8 s), the CFP has not received a suitable LINK_REQUEST code word, then the CFP should attempt link re-establishment on a re-selected channel (see subclause 5.4.5).

5.4.5 Link re-establishment on a re-selected channel

5.4.5.1 At the CPP

Link re-establishment on a re-selected channel at the CPP:

1) may occur after link re-establishment on the same channel has failed (see subclause 5.4.4) and after 3 seconds loss of handshake has occurred. The CPP shall acquire a free channel (preferably different from the current channel) in accordance with the requirements of subclause 4.4.4.

2) shall occur immediately after reception of a Specified_Channel_Re-establishment message (see subclause 6.5.6). The CPP shall change channel without any band assessment.

3) may occur without reference to the loss of handshake timer (see subclause 4.10.2) on a free channel selected in accordance with the requirements of subclause 4.4.4 under the conditions for same channel re-establishment provided:

    a) no message to re-establish on a specified channel has been received (see (ii)) and

    b) the FCR bit in extended SABM_ACK has been received set (see subclause 6.5.6.6).

    c) at least one MUX3_UnSpecified_Channel_Re-establishment message has been transmitted (see subclause 6.5.6.4).

4) may occur without reference to the loss of handshake timer (see subclause 4.10.2) on one or more free channels selected in accordance with the requirements of subclause 4.4.4 upon receipt of a MUX3_UnSpecified_Channel_Re-establishment message (see subclause 6.5.6.4).

5) shall occur after synchronous establishment has failed (see subclause 5.4.6).

Action at the CPP: using a re-selected channel, the CPP shall transmit using the current link-reference in the LID field (see subclause 6.4.5), fixed format LINK_REQUEST code words (see subclause 6.4) in MUX3 with CHMP in the SYN channel for at least Tpcyc. If the channel re-establishment is still unsuccessful, and the link re-establishment is subject to subclause 5.4.5.1 (i) or (iii), then the CPP may make re-attempts on re-selected free channels subject to the constraints of subclause 4.4.4. The re-establishment process shall terminate when the link is successfully re-established or when the handshake timeout (Thlost) matures (see subclause 5.5.1.6).

5.4.5.2 At the CFP

Link re-establishment on a re-selected channel shall occur after link re-establishment on the same channel has failed (see subclause 5.4.4). The CFP shall begin scanning all 40 channels.

Action at the CFP: the CFP shall continuously look for the MUX3 transmission from the CPP containing CHMP in the SYN channel and containing a LINK_REQUEST code word with the current link reference in the LID field and the CPP identity in the PID field. The CFP shall cease link re-establishment on a re-selected channel when the link is successfully re-established or when the handshake timeout (Thlost) matures (see subclause 5.5.1.6).

5.4.6 Synchronous re-establishment

Synchronous re-establishment is an alternative method of re-establishing a link. This method shall be used if both the CPP and CFP indicate support for this feature in the exchange of extended SABM and extended SABM_ACK messages (see subclause 6.5.6) at link set up. In all other circumstances the re-establishment shall occur as detailed in subclauses 5.4.4 and 5.4.5.

The CPP and CFP shall maintain a received code word timer Trcw2 that is started at link set up and subsequently re-started on each reception of a good code word or a valid SYNCD. The point of link re-establishment shall be defined as the time of reception of a LINK_GRANT code word at the CPP and the time of the subsequent reception of a ID_OK code word at the CFP.

Link re-establishment:

1) shall be triggered upon reception of a link re-establishment message (see subclause 6.5.6); or

2) shall be triggered upon the expiry of Trcw2 and the subsequent transmission, as soon as possible, of one re-establishment message (see subclause 6.5.6); or

3) shall be triggered if, prior to the expiry of Trcw2, the reliable detection of loss of synchronisation has occurred and the subsequent transmission, as soon as possible, of one same channel link re-establishment message (see subclause 6.5.6); or

4) shall be triggered after a minimum of three seconds loss of handshake and the subsequent transmission, as soon as possible, of one link re-establishment message (see subclause 6.5.6).

Link re-establishment shall be permitted only after a period of at least Tmin_re-establish from a previous link establishment or re-establishment.

5.4.6.1 Action at the CFP

If the CFP is initiating the re-establishment, by transmitting a Same_Channel_Re-establish message, the CFP shall transmit one re-establish message to the CPP in an unacknowledged packet. Upon completion of the transmission of the packet, the CFP shall start a timer, Trees, and force the transmission of IDLE_D bits in the D channel, thus ceasing transmission of any further code words on the D channel. Upon either the receipt of a re-establish message from CPP or expiry of Trees, the CFP shall begin transmitting LINK_GRANT code words in MUX2 (with SYNCF in the SYN channel) on the same channel, using the CPP's PID, looking for ID_OK responses from the CPP.

If the CFP is initiating the re-establishment, by transmitting an UnSpecified_Channel_Re-establish message, the CFP shall transmit one re-establish message to the CPP in an unacknowledged packet. Upon completion of the transmission of the packet, the CFP or CT2 system shall begin transmitting LINK_GRANT codewords in MUX2 (with SYNCF in the SYN channel) using the CPPs PID, looking for ID_OK responses from the CPP. The CFP may choose any channel subject to the channel change delay rules (subclause 4.10.2) and the free channel assessment rules (subclause 4.4.4). If the channel used is the same one as used prior to the re-establishment, the CFP shall ensure that the CPP has stopped transmitting or receiving in MUX1 before commencing transmission in MUX2.

If the CFP is initiating the re-establishment, by transmitting a Specified_Channel_Re-establish message for a different channel, the CFP shall transmit one Specified_Channel_Re-establish message to the CPP in an unacknowledged packet. Upon completion of the transmission of the packet, the CFP or CT2 system shall begin transmitting LINK_GRANT code words in MUX2 (with SYNCF in the SYN channel) on the specified channel, using the CPP's PID, looking for ID_OK responses from the CPP.

Where the re-establishment is required to hand-over a call to a new RFP on a different RF channel, the new RFP may begin transmissions in MUX2 up to three seconds prior to the transmission of the re-establishment message by the old RFP.

If no ID_OK responses are detected from the CPP after Tsrlgmax on the initial channel, the CFP shall select another free channel in accordance with the requirements of subclause 4.4.4, and begin transmitting LINK_GRANT code words on the selected channel for Tsrlg. This process shall be attempted a total of four times, the original attempt on the initial channel for Tsrlgmax, plus three further attempts after selecting a free channel, each for a period Tsrlg. If the CPP is not detected during this process, the CFP or CT2 system shall revert to receiving in MUX3, looking for CHMP in the SYN channel, the CPP's PID and the current and previously used LID, until Thlost expires.

If re-establishment is caused by the reception of a re-establish on the same channel message from the CPP, the CFP shall immediately begin transmitting LINK_GRANT code words (with SYNCF in the SYN channel) using the CPP's PID, on the same channel (or another channel subject to the conditions of subclause 4.10.2) for a period of Tsrlgmax. If no ID_OK responses are detected from the CPP during this period, the CFP shall select another free channel in accordance with the requirements of subclause 4.4.4, and begin transmitting LINK_GRANT code words on the selected channel for Tsrlg. This process shall be attempted a total of four times, the original attempt for Tsrlgmax, plus three further attempts, each for Tsrlg. If the CPP is not detected during this process, the CFP or CT2 system shall revert to receiving in MUX3, looking for CHMP in the SYN channel, the CPP's PID and the current and previously used LID, until Thlost expires.

5.4.6.2 Action at the CPP

If the CPP receives a Same_Channel_Re-establish message, or a Specified_Channel_Re-establish message indicating the current channel, from the CFP, it shall transmit one further packet containing an unacknowledged Same_Channel_Re-establish message, and immediately begin receiving only in MUX2 on the same channel, looking for LINK_GRANT code words, with SYNCF in the SYN channel, containing the CPP's PID. The CPP shall continue this for a period of Tsrlgmax.

If the CPP receives an unacknowledged Specified_Channel_Re-establish message (indicating a different channel) from the CFP, it shall immediately begin receiving only in MUX2 on the specified channel, looking for LINK_GRANT code words, with SYNCF in the SYN channel, containing the CPP's PID. The CPP shall continue this for a period of Tsrlgmax.

If after the expiry Tsrlgmax, the CPP has not detected the CFP, the CPP shall revert to scanning all channels looking for the MUX2 LINK_GRANT transmissions from the CFP or CT2 system, containing the CPP's PID, with SYNCF in the SYN channel. If after three periods of Tsrlgmax the CFP or CT2 system is not detected, the CPP shall select a channel according to the criteria in subclause 4.4.4, and begin MUX3 transmission on that channel, in the manner of a standard link re-establishment (see subclause 5.4.5), i.e. with CHMP in the SYN channel, its PID and the last received LID value. This shall continue until the expiry of Thlost.

If the CPP determines that re-establishment is required other than due to the reception of a re-establish message from the CFP, the CPP shall transmit a single Same_Channel_Re-establish message, and then shall commence scanning all channels, starting with the current channel, looking for MUX2 LINK_GRANT transmissions. If after four periods of Tsrlgmax the CFP is not detected, the CPP shall select a channel according to the criteria in subclause 4.4.4, and begin MUX3 transmission on that channel, in the manner of a standard link re-establishment (see subclause 5.4.5), i.e. with CHMP in the SYN channel, its PID and the last received LID value. This shall continue until the expiry of Thlost.

If the CPP receives an UnSpecified_Channel_Re-establish message, the CPP shall immediately transmit an UnSpecified_Channel_Re-establish message to the CFP and commence scanning all channels, looking for MUX2 LINK_GRANT transmissions. If after four periods of Tsrlgmax the CFP is not detected, the CPP shall select a channel according to the criteria of subclause 4.4.4, and begin MUX3 transmission on that channel, in the manner of standard link re-establishment (see subclause 5.4.5) i.e. with CHMP in the SYN channel, its PID and the last received LID value. This shall continue until successful re-establishment occurs or the expiry of Thlost.

5.5 ID handshaking

5.5.1 General

The supplier shall declare that the ID handshaking strategy of the CTA complies with each subclause of subclause 5.5.1.

5.5.1.1 Handshake code series

This shall be a series of at least 2,5 million discrete codes.

5.5.1.2 Code allocation

Manufacturers shall allocate CPP codes either randomly from the range available and without duplication until the range is exhausted or sequentially starting at a random point in the range. It shall not be possible for the user to program the handshake code at the CPP.

5.5.1.3 Code matching

The CFP and CPP shall use matching codes for handshake purposes.

NOTE: A CFP may be programmable to match the code(s) allocated to CPP(s). It is recommended that any user programming be a secure procedure.

5.5.1.4 Code recognition

The CFP and CPP shall establish mutual recognition by means of the handshake code before permitting communication.

5.5.1.5 Communication state

The handshake code shall be transmitted both ways between the CFP and CPP at least once per second during communication.

5.5.1.6 Lack of in-communication handshake: RF activity

If RF link conditions are such that greater than 10 s has elapsed without any successful handshake then the CTA shall cease RF activity.

5.5.1.7 Lack of in-communication handshake: off-line state

Following cessation of RF activity in a part of the CFP that was in the on-line state then that part of the CFP shall return to the off-line state within 1 s.

5.5.2 ID handshake operation

The CFP and the CPP shall both transmit ID handshake code words subsequent to link set up (see subclause 6.6.6 and 6.6.7) at a rate of Thtx (measured from the start of the last transmitted handshake). The ID handshake codeword to be transmitted is defined in subclause 5.5.3. The handshake interval (Thtx) shall be at a maximum rate of once every 400 ms, and a minimum rate of once every second and should be set such that handshakes are exchanged as fast as possible, typically close to 400 ms. The CFP and CPP transmissions are asynchronous.

NOTE: That the code words ID_OK, ID_LOST, LINK_REQUEST and LINK_GRANT (see subclause 6.4) all constitute valid ID handshakes.

5.5.3 Handshake protocol

If the CPP(CFP) has received a valid handshake from the CFP(CPP) within the last 1 second period, the next handshake transmitted by the CPP(CFP) shall be an ID_OK code word, otherwise it shall be an ID_LOST code word.

On reception of an ID_OK code word from the CFP(CPP), the CPP(CFP) shall restart a 10 second timer (Thlost).

The CFP(CPP) shall maintain a 1 second timer (Thrx) that is restarted on each reception of a valid handshake from the CPP(CFP). If the 1 second (Thrx) timer matures without reception of a valid handshake from the CPP(CFP), the CFP(CPP) shall transmit an ID_LOST code word (see subclauses 5.5.2 and 6.4) instead of an ID_OK code word, and shall not restart its 10 s timer (Thlost).

If the CFP(CPP) subsequently detects a valid handshake from the CPP(CFP), the CFP(CPP) shall restart its 1 s timer (Thrx) and revert to sending an ID_OK code word (instead of ID_LOST).

If the handshake is lost for at least 3 seconds, the CFP or CPP may attempt link re-establishment on this or any other channel following the requirements of subclause 4.4.

5.5.4 Reception of valid handshakes

Reception of any valid handshake instead of an ID_OK handshake shall prevent the restarting of the Thlost timer at the receiver (i.e. CFP or CPP). The receiver shall not update its Thlost timer on further handshake transmissions, and the transmitter shall not update its Thlost timer unless an ID_OK handshake is received. If the timer Thlost expires, the link shall be terminated and the call lost.

Table 6: Handshake timers

CFP	CPP	Timer	Timed Period
0,4 s to 1,0 s	0,4 s to 1,0 s	Thtx	Handshake interval
1,0 s	1,0 s	Thrx	Handshake loss period
10,0 s	10,0 s	Thlost	Handshake lost timer

There will always be a timing skew between the timer periods in the CFP and the CPP due to the transmission time of a message and software processing time at each end. This will normally be less than 500 ms.

5.5.5 ID handshake mechanism

The loss of handshake may be due to two reasons:

1) ID message to CPP is lost;

2) ID message to CFP is lost.

The scenarios for both these cases are shown in the following diagram (figure 8).

```
          1. Message to CFP lost

            CPP            CFP
                |   ID_OK  |
         /      |--------->|Tf:=10 s
         |      |          |
   h/s   |      | ID_OK    |
period <Tp:=10 s|<---------|
         |      |          |
         |      | ID_OK    |
         \      |--->|     |(Tf=9 s)
                |          |ID_OK lost
                | ID_LOST  |\_________/
       (Tp=9 s) |<---------| <-.
                | ID_OK    |   .
                |--->|     |(Tf=8 s)
                |          |   .
                | ID_LOST  |   .
       (Tp=8 s) |<---------| <-.
                | ID_OK    |   .
                |--->|     |(Tf=7 s)
                |          |
                |          |
       (Tp=7 s) |.    .   .|
                |.    .   .|  .
                |.    .   .|  .
        TRANSMIT|.    .   .|  .
        MUX3    |>--->    .|  RECEIVE
         .      |>--->    >|  MUX3
         .      |>--->    >|  .
```

```
          2. Message to CPP lost

            CPP            CFP
                |  ID_OK   |
         /      |--------->|Tf:=10 s
         |      |          |
   h/s   |      | ID_OK    |
period <Tp:=10 s|<---------|
         |      |          |
         |      |    ID_OK |
         \      |--------->|Tf:=10 s
                |          |
                | ID_OK    |
       (Tp=9 s) |     |<---|
     ID_OK lost|           |
     \_________/| ID_LOST  |
           .->  |--------->|(Tf=9 s)
           .    |          |
           .    |    ID_OK |
       (Tp=8 s) |     |<---|
           .    |          |
           .    | ID_LOST  |
           .->  |--------->|(Tf=8 s)
           .    |          |
                |    ID_OK |
       (Tp=7 s) |.    |<---|
                |.    .   .|(Tf=7 s)
                |>--->    .|
      TRANSMIT  |>--->    >| RECEIVE
      MUX3      |>--->    >| MUX3
```

NOTE 1: Tf is the 10 s timer (Thlost) in the CFP.

NOTE 2: Tp is the 10 s timer (Thlost) in the CPP.

NOTE 3: ID handshake interval (Thtx) = 0,4 s in the absence of signalling messages (range is 0,4 s to 1,0 s).

NOTE 4: ID_OK lost timer (Thrx) = 1,0 s.

NOTE 5: Link re-establishment allowed when Tf <= 7 s.

Figure 8: Handshake loss scenarios

6 Signalling layer two

The services provided by signalling layer two are:

- acknowledged and unacknowledged information transfer over the link (air interface);
- error detection;
- error correction by re-transmission and the correct ordering of messages (acknowledged operation only);
- identification of link endpoints (ID code handling);
- link maintenance.

6.1 Code word usage

A code word shall be sent at least once every Trate (100 ms in MUX1.2, and every 50 ms in MUX1.4 and MUX2).

Implementations of this I-ETS shall ensure that no more than 1 in 10^7 correctly transmitted code words is misinterpreted by the receiver when operating at a BER of better than 1 in 50.

6.2 General message format

Messages are passed between layer two and layer three by virtue of the DL_DATA and DL_UNIT_DATA primitives (see subclause 6.7). A layer three message may contain one or more layer three information elements (see subclauses 7.1 and 7.2). The breakdown of layer three messages into packets, and packets into code words is illustrated below (figure 9).

```
         +-----++- - -++- - -+                   +- - -+
         | ACW |. DCW .. DCW .                   . DCW .
         |     |.  1  ..  2  .   .  .  .  .  . .  5   .
         +-----++- - -++- - -+                   +- - -+
         \___________________ _____.  .  .  .  .________/
                               \/
               +------------------------------+    Maximum of six
LAYER TWO      |    PACKET containing 1-6     |    code words for
PACKET:        |        code words            |    each packet.
               +------------------------------+

                ________________________________. . . . _____________
               /                                                      \
               +------------+      +------------+         +------------+
LAYER THREE    |  PACKET 1  |      |  PACKET 2  |         |  PACKET N  |
MESSAGE:       |            |      |            |         |            |
               +------------+ . .  +------------+ . . . . +------------+

               ^                   ^                      ^
               |                   |                      |
               ACW                 ACW                    ACW
               L3_end=1            L3_end=1               L3_end=0
                                                        (last packet)
```

Figure 9: General message format

6.3 General packet format

A packet is composed of one or more code words each of eight octets. In order to meet the handshake requirements of subclause 5.5, layer three messages are formatted into one or more packets each of up to six code words in length. Layer three messages greater than one packet in length use the L3_end bit (see subclause 6.5.2). The first code word in a packet is an "address" code word and any subsequent code words are "data" code words (if required for longer packets). The address code word is always preceded by a 16-bit synchronisation word, SYNCD. Each code word contains 16 check bits for error control. IDLE_D is sent only when there is no D channel packet to send. The sequence IDLE_D, SYNCD, address code word is shown below.

Bit:	8	7	6	5	4	3	2	1	octet
IDLE_D	0	1	0	1	0	1	0	1	n-2
	0	1	0	1	0	1	0	1	n-1
	0	1	0	1	0	1	0	1	n
SYNCD	0	0	1	0	0	0	1	1	1
	1	1	1	0	1	0	1	1	2
ADDRESS CODE WORD								1	1
									2
									3
									etc.

6.3.1 Order of transmission and field mapping convention

The octets are transmitted in ascending numerical order starting with octet one. Within an octet, bit 1 is the first to be transmitted followed by the remaining bits in ascending order.

A data value is contained within a field which may not correspond with an octet in size. When a field is contained within a single octet, the bit within the field having the lowest bit number (i.e. the first of the bits in the field to be transmitted) represents the least significant bit of the data value. When the field spans more than one octet, the least significant part of the data value is contained within the lowest numbered octet (i.e. the octet which is transmitted first). As an example, a 12-bit field is shown below.

Bit:	8	7	6	5	4	3	2	1	octet
	2^7							2^0	n
					2^{11}			2^8	n+1

The exception to this convention is the check field. In this case bit 1 of the first octet is the high order bit and bit 8 of the second octet is the low order bit (i.e. the bits arrive in descending order of significance).

6.3.2 IDLE_D

IDLE_D (one-zero reversals) is transmitted in the D channel when there is no signalling packet or supervisory fill-in packet (see subclause 6.5.7) to be sent. Note that IDLE_D does not necessarily map onto preamble in MUX2 or MUX3 (figures 4 and 5). The final bit of an IDLE_D sequence (the bit before the signalling channel synchronisation word SYNCD) shall always be a binary zero.

6.3.3 Synchronisation word (SYNCD)

Every packet begins with a 16-bit synchronisation word to enable the receiver to establish code word framing. The synchronisation word is recognised when all 16 bits have been received correctly.

6.3.4 Code Words - (address and data code words)

Packets are transmitted in 64-bit code words (8 octets), and each packet may occupy a number of code words. The first code word of a packet is an address code word and any subsequent code words are data code words. Bit 1, octet 1 of the code words are encoded 1 and 0 for address code words and data code words respectively. Two packet formats exist as indicated by the format type bit, FT (octet 1, bit 2). The format type; when set to 0 indicates a fixed length link set up and handshake ACW type used for link end point addressing and service requests; when set to 1 indicates the variable length packet format which is used to transfer link supervisory and layer three messages. (FT is only significant in ACWs and should be set to 1 in DCWs).

An example code word is shown in annex G. The general code word format is shown below:

Bit:	8	7	6	5	4	3	2	1	octet
							FT=0/1 FT=1	1=ACW 0=DCW	1
									2
									3
									4
									5
									6
	CHECK (octet 1)								7
	CHECK (octet 2)								8

6.3.5 Code word transmission sequence

If, in MUX2, it is intended to transmit two ACWs from the same logical transmitter source, the second ACW immediately following the first ACW (neither of which is a fill-in ACW), then, unless it is known that the two ACWs are different, the second ACW shall be preceded by either the fill-in ACW or by a minimum of 48 bits of IDLE_D.

If, in MUX1, it is intended to transmit two ACWs from the same logical transmitter source, the second ACW immediately following the first ACW (neither of which is a fill-in ACW), then, unless it is known that the two ACWs are different, the second ACW shall be preceded by the fill-in ACW.

6.3.6 Check field encoding (octets 7 and 8)

The 16 check bits (octets 7 and 8) are calculated in three steps:

1) 15 check bits are appended to the 48 information bits (octets 1 to 6) by encoding them in a (63,48) cyclic code. For encoding the 48 information bits may be considered to be the coefficients of a polynomial having terms from x^{62} down to x^{15}. This polynomial is divided by the generating polynomial:

$$x^{15} + x^{14} + x^{13} + x^{11} + x^4 + x^2 + 1.$$

   The 15 check bits (octet 7 and octet 8 bits 1 to 7), correspond to the coefficients of the terms from x14 to x0 in the remainder polynomial found at the completion of the division.

2) Bit 7 of octet 8 is inverted.

3) Bit 8 of octet 8 is added such that the whole 64-bit code word has even parity.

Bit: 8	7	6	5	4	3	2	1	octet
							CRC msb	7
CHECK PARITY	CRC lsb\							8

6.4 Fixed length packet format (FT = 0)

The following fixed length format code word is defined for use in MUX2 and MUX3 for link initiation, and in MUX1 and MUX2 for handshaking.

Bit: 8	7	6	5	4	3	2	1	octet
HIC			0/1 SR	0/1 LS1	0/1 LS0	0 FT	1 ACW	1
HIC								2
HIC								3
MIC								4
LID								5
LID								6
CHECK (octet 1)								7
CHECK (octet 2)								8

6.4.1 Signalling Rate (SR) (octet 1 (part))

SR request/response bit: Used by the call initiator to request a signalling rate (two or four bits per burst), and by the call receptor to set the signalling rate (prior to communication in MUX1.2 or MUX1.4) at the maximum rate compatible with both their capabilities. SR = 1 corresponds to MUX1.4 and SR = 0 to MUX1.2 (i.e. the default is MUX1.2 if either end requests MUX1.2).

6.4.2 Link Status (LS) (octet 1 (part))

LS is a two-bit field that is used during call set up and handshaking. It defines the type of fixed format code word as in table 7:

Table 7: Coding of link status bits in handshakes

LINK STATUS LS1	LS0	MEANING
0	0	LINK_REQUEST
0	1	LINK GRANT
1	0	ID_OK
1	1	ID_LOST

LINK_REQUEST is transmitted as a request to "seize" the link. It is sent from CPP to CFP either in MUX3 as the first packet during CPP call set up and link re-establishment, or returned as a poll response in MUX2 from CPP to CFP during CFP call set up, when the CPP is attempting to answer the call.

LINK_GRANT is transmitted by the CFP subsequent to receiving a LINK_REQUEST from the CPP. It contains the link reference in the LID field, and this link reference is subsequently used in the LID field transmitted by the CPP. Reception of LINK_GRANT causes the handshake timers Thrx, and Thlost to be started (and restarted on further receptions of LINK_GRANT). In the CFP LINK_GRANT is transmitted continuously until either ID_OK is received or Tftx expires.

ID_OK is used as the handshake packet that is transmitted (at the handshake rate defined in subclause 5.5) when a valid handshake has been received within the last 1 second period. It is also used in link establishment from a CFP as the poll packet and as the poll response packet from a CPP.

ID_LOST is used as the handshake packet that is transmitted (at the handshake rate defined in subclause 5.5) when no valid handshake has been received within the last 1 second period.

LINK_REQUEST and LINK_GRANT code words shall only be transmitted during link set up and link re-establishment.

6.4.3 Handset Identification Codes (HIC) (octets 1 (part), 2, 3)

The HIC is a 19-bit field. Manufacturers are free to allocate the codes according to the procedures in subclause 5.5.1.2.

6.4.4 Manufacturer Identification Code MIC (octet 4)

The manufacturer identification code is an 8-bit field. HIC plus MIC together form a 27-bit field PID (portable identity code) which acts as a link end point address. Allocation of the code is controlled by and registered with the Standard Control Authority body. On complete allocation of the 19-bit HIC field, the manufacturer shall obtain and use from the Standard Control Authority a further unique MIC to avoid duplication of PIDs.

Specific code allocations are detailed in a separate document (obtainable from the SCA).

6.4.5 LID (octets 5 and 6)

The link identification code is used for the following purposes:

1) end point identification for CPP call set up. In this instance the LID identifies a specific CFP or a requested service;

2) link reference for associating CPP and CFP call during handshake exchanges and link re-establishment so that communication is maintained with the initial end point only. For this reason it is recommended that the link reference value be different from the BID;

3) Base Identifier (BID). This is a ringing address to which one or more CPPs, when appropriately programmed, will respond (during multiple ringing).

Table 8: Usage of the LID field

Link set up direction	Message direction	MUX mode	LID content
CPP to CFP	CPP -> CFP	MUX3	End point ID (System LID or LAI/LCI combination)
	CFP -> CPP	MUX2	Link reference ID
	both ways	MUX2 MUX1	Link reference ID
CFP to CPP	CFP -> CPP	MUX2	Base ID (BID)
	CPP -> CFP	MUX2	Base ID (BID)
	both ways	MUX2 MUX1	Link reference ID
Link re-establish (standard)	CPP -> CFP	MUX3	Link reference ID (see subclause 6.4.5.10)
	both ways	MUX2 MUX1	Link reference ID
Link re-establish (synchronous)	CFP -> CPP	MUX2	Link reference ID (see subclause 6.4.5.11)
	both ways	MUX2 MUX1	Link reference ID

6.4.5.1 Allocation of LID values

LID values are allocated as follows:

Table 9: Values used in the LID field

LID Value, hex	CONTENT	NOTE
0000 to 03EF	Specific values for public access services defined in a separate document (available from the SCA)	note 1
03F0 to 03FE	Reserved for future emergency access, allocated by the SCA	-
03FF	Emergency access (CAI).	note 2
0400	Poll decline request.	note 3
0401 to FFFE	Link reference, BID.	note 4
FFFF	ID registration.	note 5

NOTE 1: Specific values for public access services. LID values for public access are assigned in pairs, designated 2N and 2N+1. 2N values are used to specifically identify a target network, from which a CPP expects a response. 2N+1 values are used for roaming access, where the 2N part of the 2N+1 identifies the network with which the CPP is registered. This allows a receiving network to respond or not respond to a roaming request by determining whether or not the 2N part of the 2N+1 value is acceptable to the receiving network.

"Targeted" roaming is possible where a 2N LID value is used to target a specific public access network, even though the network is not the "home" network. In this situation, the home operator or network can be obtained by examining the OPSIC field in the AUTH_RES (subclause 7.2.9) or AUTH2_RES (subclause 7.2.18) layer three messages.

NOTE 2: Emergency access (CAI). This LID value shall be known to public access CFPs. CPPs attempting to set up a call using this LID value shall not be obstructed by authentication or registration requirements and shall be connected to the default emergency service (see subclause 7.3.3).

NOTE 3: Poll decline request. This LID value may be used by a CPP which is being polled in order to "drop out" of the polling, i.e. not answer the call (see subclause 6.6.5).

NOTE 4: Link reference, BID. The BID (base ID) is a LID value which identifies a CFP. The link reference is a value which occupies the same range as BID and is used to identify an established link.

NOTE 5: ID registration. This LID is allocated for use by the CPP to enable it to set up a link for on-air registration to a CFP.

A CPP may be registered with more than one system, eg. one (or more) residential bases, one (or more) private systems and one (or more) public access operators. For each registration a CPP must store a specific LID or BID, and for systems using authentication, must also store several other information fields. Each set of registration data constitutes a "registration slot" and the set of registration data in use at any one time for call set up or answer is the currently active registration slot.

The amount of storage available in a registration slot may limit the features that the slot can access. The smallest slots, storing only a LID/BID value, can only access systems which do not use authentication. Additional storage is needed for access to systems requiring authentication or if the CPP is to be programmed using Over The Air Registration (OTAR). The capabilities of a registration slot can be determined from the contents of the TERM_CAP information element (see subclause 7.2.10).

Slot types broadly fall into the following categories:

Slot type	Slot capabilities
A	No authentication ability;
B	Support for CPP authentication;
C	Support for CPP authentication and entry of registration data using Over The Air Registration (OTAR).

The minimum storage requirements for slots of type B and type C are defined in, annex B, subclause B.4.3.

On responding to an incoming call a CPP shall select an appropriate registration slot by comparing the received LID with the LID stored in each registration slot. If no LID match is found a virtual registration slot (using the received LID) may be used; but without valid registration data, authentication procedures may not be successful. If the SLOT_IDENTITY field of TERM_CAP is supported and is non-zero, it indicates the currently active registration slot number. The layer three access (via FA information elements) should be consistent with the incoming LID and/or FI information elements as described in table 13.

For most outgoing calls, the CPP user selects (actively or by default) a registration slot which determines the LID used to access the CFP or CT2 system and the registration data, if any, to be used in authentication. Virtual slots can be used for some outgoing calls. For example, when an emergency call is made, the CPP may assign the emergency access LID to the virtual slot prior to call set up (see subclause 6.4.5.1 NOTE 2). In most circumstances, other than for emergency access, the lack of registration data in a virtual slot would result in a failed call.

6.4.5.2 Link set up from the CPP: LID use by the CPP in LINK_REQUEST

The LID value used in the LINK_REQUEST code word transmitted by the CPP on CPP-originated link set up (see subclause 6.6.1) shall be either:

1) that BID or LID value assigned to the currently active registration slot (either actual or virtual, see subclause 6.4.5.1); or

2) a LID value derived from the LOCAL_CELL_IDENTITY and the LID fields of a CIS code word as follows:

    - Octet 6 of the LINK_REQUEST (msbyte LID) shall contain the value received in Octet 2 (LCI) of a CIS code word; and
    - Octet 5 of the LINK_REQUEST (lsbyte LID) shall contain the value received in Octet 5 (lsbyte of LID) of a CIS codeword.

6.4.5.3 Link set up from the CPP: LID use by the CFP in LINK_GRANT

The LID value in the LINK_GRANT code word transmitted by the CFP for CPP-originated link set up (see subclause 6.6.1) shall be assigned at random, or in a non-repeating fashion, from the range of BID values; or shall be a value from this range uniquely assigned to the CFP within a given radio coverage area.

6.4.5.4 Polling of CPPs (including link set up from the CFP): LID use by the CFP in ID_OK

The LID value in an ID_OK poll originating at a CFP (see subclause 6.6.4), including CFP-originated link set up (see subclause 6.6.3), shall be within the range of LID or BID values appropriate to the service.

Where polling transmissions are combined with CIS transmissions (see subclause 6.8.2.2), the LR_POLL_LID transferred using the LR_PARAMS information element shall be used.

6.4.5.5 CPP poll response : LID use by the CPP in ID_OK

The LID value in the ID_OK response of a CPP to polling by a CFP (see subclause 6.6.5) shall be the value received from the CFP by the CPP in the LID field of the last ID_OK poll containing the CPP's PID, or the poll decline LID.

6.4.5.6 Link set up from the CFP: LID use by the CPP in LINK_REQUEST

The LID value in the LINK_REQUEST code word transmitted by the CPP on CFP-originated link set up (see subclauses 6.6.3, 6.6.4 and 6.6.5) shall be the value received from the CFP by the CPP in the LID field of the last ID_OK poll containing the CPP's PID.

6.4.5.7 Link set up from the CFP: LID use by the CFP in LINK_GRANT

The requirements of subclause 6.4.5.3 shall also apply for CFP-originated link set up (see subclauses 6.6.3, 6.6.4 and 6.6.5).

6.4.5.8 Established or re-established link: LID use by the CPP in ID_OK and ID_LOST

For the duration of a link, up to any link re-establishment, the LID transmitted by the CPP in the ID_OK and ID_LOST handshakes shall be the LID value from the LINK_GRANT code word first received by the CPP at the most recent link set up or link re-establishment.

The link shall be deemed to be established, or re-established, at the CPP when it receives the first LINK_GRANT code word after the start of link set up or link re-establishment.

Link set up or re-establishment shall be deemed to have started at the CPP when it transmits a LINK_REQUEST code word; or transmits a request for the CFP to re-establish the link; or receives a request from the CFP to re-establish the link.

6.4.5.9 Established or re-established link: LID use by the CFP in ID_OK and ID_LOST

For the duration of a link, up to any link re-establishment, the LID transmitted by the CFP in the ID_OK and ID_LOST handshakes shall be the LID value originally transmitted by the CFP in the LINK_GRANT code word first sent by the CFP at the most recent link set up or link re-establishment.

The link shall be deemed to be established, or re-established, at the CFP when it receives the first ID_OK code word after the start of link set up or link re-establishment.

Link set up or re-establishment shall be deemed to have started at the CFP when it transmits a LINK_GRANT code word; or transmits a request for the CPP to re-establish the link; or receives a request from the CPP to re-establish the link.

6.4.5.10 Link re-establishment: LID use by the CPP in LINK_REQUEST

The LID value in the LINK_REQUEST code word transmitted by the CPP during link re-establishment (see subclause 6.6.2) shall be the LID value from the LINK_GRANT code word first received by the CPP at the most recent link set up or link re-establishment.

6.4.5.11 Link re-establishment: LID use by the CFP in LINK_GRANT

The LID value in the LINK_GRANT code word transmitted by the CFP in a link re-establishment shall be:

1) that received from the CPP in the LINK_REQUEST code word; or

2) in synchronous re-establishment, the LID value from the LINK_GRANT code word first transmitted by the CFP at the previous link setup or link re-establishment; or

3) it may be changed but shall then comply with the requirements of subclause 6.4.5.3.

A CFP shall only change LID on link re-establishment if it can determine that the CPP is capable of accepting a new LID. If the LRC bit in TERM_CAP (see subclause 7.2.10) is supported and has been set, then the CPP may be assumed to be capable of accepting a changed LID on link re-establishment.

If the LID value is changed by the CFP during link re-establishment, then the value shall not be changed again until the link has been re-established and a subsequent link re-establishment commences.

NOTE: On expiry of its Tfdetect timer in link re-establishment (see subclause 6.6.1) or the reversion to MUX3 from synchronous re-establishment, the CFP will have to recognise two possible outcomes if it has changed LID. The CPP will re-establish using the new LID value if it has seen the new LINK_GRANT from the CFP, but otherwise will use the old LID value.

6.4.5.12 Validity of handshakes

At link set up or link re-establishment from the CPP in a multi-CFP system, it is possible for a CPP to transmit a LINK_REQUEST and receive multiple LINK_GRANTs (each with a different LID value). According to the above paragraphs, the CPP shall only respond to ID handshakes which contain the LID value which was contained in the first LINK_GRANT which it received and to which it responded at either link set up or re-establishment. This will permit the correct response to multiple LINK_GRANTs originating from multiple CFP stations during a period where the CPP is lost.

6.4.6 CFP Identity and Status Code Word (CIS)

This fixed format ACW conveys information on the CFP Identity and Status to all CPPs monitoring these transmissions. A CPP may monitor CIS transmissions for various reasons including:

- determination of which CFP to address during call set-up attempts;
- presentation of an "in range" indicator;
- determination if it has moved from one Location Area to another (see subclause 6.8.2);
- determination if that CFP offers a Location registration service.

The CIS code word shall be transmitted in MUX2 with SYNCF in the SYN field.

The CIS code word shall have the following format:

Bit: 8	7	6	5	4	3	2	1	octet
TCA	SRA	ICI	ALR	PWR	IRI	0 FT	1 ACW	1
LOCAL_CELL_IDENTITY (LCI) / CHANNEL_NUM								2
LOCAL_AREA_IDENTIFIER (LAI)								3
1	1	1	1	1	1	1		4
CIS_IDENTIFIER							M	
LID							lsb	5
msb								6
CHECK (Octet 1)								7
CHECK (Octet 2)								8

TCA Traffic Channels Available.

1 = Traffic channels available.
0 = All traffic channels busy.

This bit shall be set to 1 if the CFP has, at the moment in time when this code-word is transmitted, equipment resources with which to complete call attempts.

SRA Signalling Receiver Available.
1 = Signalling receiver available.
0 = No signalling receiver available.

This bit shall be set to 1 if the CFP has equipment resources with which to detect CPP originated signalling.

ICI Incoming Call indication
0 = No incoming call from this CT2 system.
1 = Incoming CFP to CPP Call on traffic channel.

This bit shall be set to 1 if the CFP is attempting to establish an incoming call to a CPP on another channel. When this bit is set to 1, the CFP indicates the channel number, on which the incoming call request is being transmitted, in the LCI field (Octet 2).

ALR Automatic Location Registrations
0 = The CPP shall not transmit FA 3,29, and shall not transmit FA 3,30 or FA 3,31 except in response to deliberate user action.
1 = CPP may automatically transmit FA 3,29.

PWR Power
This bit shall be set to:
0 if the CFP transmitted the CIS code word at the normal power.
1 if the CFP transmitted the CIS code word at low power.

IRI In Range Indication
0 the CPP shall not give an in range indication to the user in response to this CIS codeword.
1 The CPP may give an in range indication to the user in response to this CIS codeword.

M If set to 1 this bit indicates that the CFP is alternately transmitting CIS codewords of up to eight different services in cyclic order. The values of the LAI and LCI fields in each CIS codeword shall be the same. The CIS codeword may be interleaved with polling. Otherwise set to zero.

Where less than eight different CIS codewords are being transmitted, the CPP should revert to scanning other channels when it determines that it has seen a complete sequence of CIS codewords. Where a CPP scans to ensure that the CIS transmissions are still present, it need only check the LAI/LCI field of any CIS codeword, and is not required to wait on channel until it sees the appropriate LID in a CIS codeword.

LID This field shall contain the operators system LID normally used for CPP call setup. In the case of a public access operator, the non-roaming (2N) LID shall be used if the CFP does not accept roaming calls, and the 2N+1 LID shall be used if the CFP accepts roaming calls from at least one other public access operator.

LOCAL_CELL_IDENTITY (/ CHANNEL_NUM) If the ICI bit is set to 0, this field shall contain the LCI of the CFP (see subclause 6.8.2). The value of LCI shall be in the range 04 - FE hex. Where CFPs within an LAI are identified by different values of LCI, the LCI value shall not match the value of the higher order octet (octet 3) of the value in the LID field. If CFPs are not individually identified by different values of LCI, the LCI value used may match the higher order octet of the LID.

If the ICI bit is set to 1, this field shall contain the channel number (in the range 0 -40) on which the CFP is transmitting an incoming call request. If this channel number is zero this shall signify an unspecified channel and the CPP shall scan all channels for the incoming call.

LOCATION_AREA_IDENTIFIER This field shall contain the LAI of the CFP (see subclause 6.8.2). The value of LAI shall be in the range 00 - FF hex.

CIS_IDENTIFIER This field shall be set to 7F hex.

6.5 Variable length packet format (FT = 1)

A layer three message is formatted into a number of packets depending on the length of the message. In "single frame acknowledge" (CCITT Recommendations Q.921 [3] and Q.931 [4]) mode, only one packet can be sent before the corresponding acknowledgement has been received. Received packets in one direction are acknowledged by using the N(r) bit in transmitted packets in the other direction. For transmission of acknowledged messages, DL_ESTABLISH_IND shall be set. DL_ESTABLISH_IND is set after receipt of SABM or SABM_ACK (see subclause 6.5.6). SABM may be sent at any time after link set up, and is independent of multiplex mode.

Address code words:

Bit: 8	7	6	5	4	3	2	1	octet
0 PI	0/1 L3_end	0/1 endwrd	code word no. or rem.			1 FT	1 ACW	1
control								2
content								3
								4
								5
								6
CHECK (octet 1)								7
CHECK (octet 2)								8

Data code words (in packets only where appropriate to message length):

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0/1 endwrd	code word no. or rem.			1 FT	0 DCW	1
content								2
								3
								4
								5
								6
CHECK (octet 1)								7
CHECK (octet 2)								8

6.5.1 Protocol Identifier (octet 1)

PI is the protocol identifier. This shall be set to 0 for basic operation, and set to 1 for enhanced operation. The protocol identifier shall be 0 for this application, (i.e. basic) meaning that the protocol used in communication is that defined in this I-ETS in conjunction with the control octet defined below. When PI is set to 1 then octet 2 is reserved for future applications.

6.5.2 L3_end (octet 1)

The L3_end bit is set to 1 to indicate that further layer three information follows in subsequent packets (ACW and any subsequent DCWs), and set to 0 for the last packet. If a message is transmitted in more than one packet then it is mandatory that acknowledged (numbered) packets be used. Supervisory messages are limited to one packet.

6.5.3 Endwrd and code word no/rem encoding (octet 1)

Bit 6, octet 1 (endwrd) is set to 0 in each code word except for the last code word of the packet (when endwrd is 1).

When endwrd is 0 then bits 3 to 5 of octet 1 (code word number) indicate (in binary) the number of data code words remaining in the packet; thus for a packet of three code words total, the first (address) code word has a code word no. of two, and so on.

When a code word has an endwrd value of 1, then bits 3 to 5 of octet 1 (rem) indicate the number of content octets remaining in that code word; thus if 1 octet only of the last code word contains significant supervisory or layer three information then rem is 1 (and any following octets in the code word are ignored).

6.5.4 Control (octet 2)

The control octet identifies the packet type and sequence number (where applicable). The use of this field is described below:

The control octet is used for link establishment and packet transmission for both unacknowledged and acknowledged packets with error correction by re-transmission.

Acknowledged (numbered) operation ensures that the layer two protocol delivers packets, numbered modulo 2 with the N(s) bit, in the correct order and without loss.

Acknowledgment (i.e. numbered operation) is via the N(r) bit in received packets from the other end of the link. The N(r) bit indicates the sequence number of the next expected numbered packet. If a re-transmission is required, the receiver may set the REJ bit, and sets the N(r) bit equal to the N(s) of the requested packet. Re-transmission using REJ may be used if, for instance, a DCW in a message is found to be corrupt (CRC failure) or if an unexpected DCW is received (i.e. not preceded by an ACW). Note that both layer three and supervisory packets share the same (layer two) numbering sequence.

Unacknowledged (unnumbered) operation delivers packets directly between peer layers without invoking the layer two re-transmission protocol. For example, unacknowledged operation must be used when alerting (multiple) CPPs.

Receipt of one or more unacknowledged (un-numbered) packets between the acknowledged (numbered) packets of a multi-packet layer three message shall not disrupt the reception of the acknowledged (numbered) message. The reception of an unacknowledged (un-numbered) packet cannot be guaranteed.

Two packet types are identified; a link supervisory type and an information type. The bit allocation shall be:

Bit: 8	7	6	5	4	3	2	1	octet
0	0 QUALIFIER	0	I/S	N(s)	P/F	N(r)	REJ	2

Qualifier: Set to 0 (reserved for future use).

I/S: 1 = information type (layer three),

0 = supervisory type (layer two or one).

This bit when set to 1 indicates that this packet contains layer three information and when set to 0 indicates that the packet contains link supervisory data.

N(s): Send sequence number. N(s) is don't care when P/F = 0.

P/F: Poll/final bit (CCITT Recommendation Q.921 [3]). When set to 0 this indicates unacknowledged operation, i.e. no response required. When set to 1 this indicates acknowledged operation (N(s) is significant).

N(r): Receive sequence number. Used for acknowledgment of received packets.

REJ: Reject bit. When set to 1 it indicates that a received packet was rejected. N(r) is equal to the N(s) value of the rejected packet.

Table 10: Coding of Control Octet values

P/F	I/S	PACKET CONTENT
0	1	Unacknowledged layer three packet
1	1	Acknowledged layer three packet
0	0	Unacknowledged supervisory packet
1	0	Acknowledged supervisory packet

N(s) and N(r) are used for packet acknowledgment. N(s) refers to the sequence number of the packet being sent, and N(r) indicates the sequence number of the next expected numbered packet.

6.5.5 Content

The octets marked content in the ACW and DCWs of packets are destined to carry layer three information as described in clause 7 but are also capable of carrying link supervisory data. Unused octets in ACWs and DCWs shall be filled with F0H. The link supervisory messages are described below.

6.5.6 Link supervisory messages

The link supervisory messages that follow are defined. All others are reserved for future allocation by the Standard Control Authority. Link supervisory messages have the following format:

Bit: 8 7 6	5 4 3 2 1	octet
Message type	Message content	X

If a CFP receives a basic SABM from a CPP, then it shall only send link supervisory message packets containing one of the following link supervisory messages in the first octet of the packet. It shall not send multiple link supervisory messages in the same packet.

Transmit power level control
Link re-establish on a given channel
SABM_ACK

NOTE: The CFP may transmit either basic or extended SABM_ACK, but only a CPP supporting the extended supervisory messages will interpret all four octets.

If a CPP receives a basic SABM_ACK, then it shall only send link supervisory message packets containing one of the following link supervisory messages in the first octet of the packet. It shall not send multiple link supervisory messages in the same packet.

Transmit power level control
Link re-establish on a given channel
SABM

NOTE: The CPP may transmit either basic or extended SABM, but only a CFP supporting the extended supervisory messages will interpret all four octets.

If a CFP receives an extended SABM, it may send link supervisory message packets containing one or more of the following link supervisory messages. The messages may be in any order within the packet, subject to any other restrictions stated in the individual descriptions of the supervisory messages.

Transmit power level control
Link re-establish
Basic or extended SABM_ACK
The format (but not necessarily the meanings) of Layer 2 code set shift messages
Null message

If a CPP receives an extended SABM_ACK, it may send link supervisory message packets containing one or more of the following link supervisory messages. The messages may be in any order within the packet, subject to any other restrictions stated in the individual descriptions of the supervisory messages.

Transmit power level control
Link re-establish
Basic or extended SABM
The format (but not necessarily the meanings) of Layer 2 code set shift messages
Null message

The following link supervisory messages are defined:

6.5.6.1 Transmit power level control

Bit:	8	7	6	5	4	3	2	1	octet
	0	0	0	0	0	0	0	tgain	X

This acknowledged message sets the transmit power level of the recipient's link end. It may be ignored by the CFP.

Table 11: Coding of Transmit Power Control

tgain	TRANSMIT POWER LEVEL
0	Full power
1	Low Power

6.5.6.2 Reserved for future use

Bit:	8	7	6	5	4	3	2	1	octet
	0	0	1	RFU	RFU	RFU	RFU	RFU	X

This message is reserved for future use by the CPP.

RFU: reserved for future use, and shall be set to 0. The allocation of these bits is controlled by and registered with the Standard Control Authority.

NOTE: If this message is sent by the CFP (see subclause 6.5.6.3) the message content bits may have different meanings.

6.5.6.3 Reserved for future use

Bit:	8	7	6	5	4	3	2	1	octet
	0	0	1	RFU	RFU	RFU	RFU	RFU	X

This message is reserved for future use by the CFP.

RFU: reserved for future use, and shall be set to 0. The allocation of these bits is controlled by and registered with the Standard Control Authority.

NOTE: If this message is sent by the CPP (see subclause 6.5.6.2) the message content bits may have different meanings.

6.5.6.4 Link re-establishment

Bit:	8	7	6	5	4	3	2	1	octet
	0	1	channel number						X

This message shall cause an immediate attempt at link re-establishment as specified by the message number as follows:

Channel number 0: Same_Channel_Re-establishment

This message is sent unacknowledged from either end and shall cause link re-establishment subject to subclause 5.4.4 or 5.4.6 on the same (i.e. current) channel .

NOTE 1: In some circumstances (see subclause 5.4.6) this message may result in re-establishment on a different channel.

Channel number 1-40: Specified_Channel_Re-establishment

These messages are sent unacknowledged from the CFP only and are subject to the provisions of subclauses 4.4.3, 4.4.4 and 4.10.2 and shall cause link re-establishment subject to subclause 5.4.5 or 5.4.6 on the channel corresponding to the message number where message number 1 corresponds to channel number 1 and is the lowest channel frequency and message number 40 corresponds to channel number 40 and is the highest channel frequency (see subclause 4.2).

Channel number 59: MUX3_Secondary_Service_Re-establishment.

This message is sent unacknowledged from the CFP and may be ignored by a CPP not indicating support for SSR in SABM. If interpreted it shall cause the CPP to do a secondary service channel assessment and choose a channel on which to attempt re-establishment in MUX3.

In each case if no secondary service channel is available, and the unit is still in a primary service, the CPP may select a channel based on a primary service channel assessment. If the CPP is already in a secondary service and no secondary service is available it shall not attempt to re-establish and the call shall end.

If the link is successfully re-established, the CPP shall transmit a secondary service channel availability message (see subclause 6.5.6.7.1) to indicate if the channel was chosen using the secondary or primary service criteria, and what power level should be used, in order to comply with subclause 4.4.4.2.

During and after the re-establishment the CFP shall retain the previous power setting until it receives a secondary service channel availability message.

Channel number 60: MUX3_Same_Channel_Re-establishment

This message is sent unacknowledged from the CFP only and may be ignored by any CPP not indicating support for synchronous re-establishment (see subclause 6.5.6.5). If interpreted it shall cause the CPP to attempt link re-establishment on the same (i.e. current) channel using MUX3 according to subclause 5.4.4.1.

Channel number 61: MUX3_UnSpecified_Channel_Re-establishment

This message is sent unacknowledged from the CFP and may be ignored by any CPP not indicating support for FCR (see subclause 6.5.6.5). If interpreted it shall cause the CPP to select one or more channels on which to attempt re-establishment using MUX3 according to subclause 5.4.5.1, 4) without reference to loss of handshake and subject to subclause 4.4.4.

This message may be sent unacknowledged from a CPP which has received an Extended SABM_ACK with the FCR bit set (see subclause 6.5.6.6) and shall cause the CFP to immediately scan all channels for MUX3 re-establishment. The CPP shall select one or more channels on which to attempt re-establishment without reference to loss of handshake and subject to the provisions of subclause 4.4.4 using MUX3 according to subclause 5.4.5.1, 4).

Channel number 62: Secondary_Service_Re-establishment.

This message is sent unacknowledged from either end and may be ignored by a CPP or CFP not indicating support for SSR in extended SABM/SABM_ACK.

If synchronous re-establishment is in use, this message shall cause the CFP to select a channel or channels using the secondary service channel assessment criteria and then attempt a synchronous re-establishment. The CPP shall scan all channels for a period of 4 times Tsrlgmax looking for the call, and, if this fails, it shall then do a secondary service channel assessment and attempt to re-establish in MUX3.

If standard (MUX3) re-establishment is in use the CPP shall do a secondary service channel assessment, then attempt to re-establish in MUX3.

In each case, if no secondary service channel is available, and the unit is still in a primary service, the unit which carries out the assessment may select a channel based on a primary service channel assessment. If the unit is already in a secondary service and no secondary service channel is available it shall not attempt to re-establish and the call shall end.

If the link is successfully re-established, the assessing end shall transmit a secondary service channel availability message (see subclause 6.5.6.7.1) to indicate if the channel was chosen using the secondary or primary service criteria, and what power level should be used in order to comply with subclause 4.4.4.2.

During and after the re-establishment the non-assessing end shall retain the previous power setting until it receives a secondary service channel availability message.

Channel number 63: UnSpecified_Channel_Re-establishment

This message is sent unacknowledged from the CFP and may be ignored by any CPP not indicating support for synchronous re-establishment (see subclause 6.5.6.5). If interpreted it shall cause the CPP to attempt re-establishment on an unspecified channel in accord with subclause 5.4.6.2. It shall only be sent when synchronous re-establishment in accordance with subclause 5.4.6 is in use.

When a CPP receives and interprets this message it shall send the same message unacknowledged as an acknowledgement in accordance with subclause 5.4.6.2.

All undefined message numbers are invalid and have no effect.

NOTE 2: This effectively uses two link supervisory message types.

6.5.6.5 Protocol initialisation (SABM), basic and extended

Bit: 8	7	6	5	4	3	2	1	octet
1	1	0	0	0	0	0	0	X

The basic SABM message (above) is an unacknowledged message that is sent from the CPP to cause protocol initialisation at the receiving end of the link, during link establishment only. The CFP shall not send basic SABM.

Bits 8,7,6 are set to 1,1,0 respectively. The remaining bits shall be set to 0, and the basic SABM message shall be placed in the first content octet of the ACW.

Bit: 8	7	6	5	4	3	2	1	octet
1	1	0	0	0	0	0	0	1
1	1	0	SSR	FCR	LRC	SRE	1	2
1	1	0	RFU	X	RFU	RFU	RFU	3
1	1	0	RFU	RFU	RFU	RFU	RFU	4

The extended SABM message (above) is an unacknowledged message of four octets in length, that may be sent instead of basic SABM from the CPP to cause protocol initialisation at the receiving end of the link, during link establishment only, and also carry CPP layer 2 attributes to the CFP. The extended SABM shall be sent in a single codeword packet. The CFP shall not send extended SABM.

In each octet, bits 8,7,6 are set to 1,1,0 respectively. In the first octet, the remaining bits shall be set to 0. In the three following octets, the remaining bits carry layer 2 attributes, dependent on the bit position within the octet, and the octet position within the message, thus allowing for up to 15 attributes to be declared by the CPP.

SRE shall be set to 1 if the CPP is capable of using the synchronous link re-establishment method, otherwise shall be set to 0.

LRC shall be set to 1 if a CPP shall accept a change of LID on link re-establishment. If the LRC bit is set in TERM_CAP (see subclause 7.2.10), then it shall be set in the extended SABM if used. If LRC is set to zero, a CPP may, but is not mandated to, accept a change of LID on re-establishment.

FCR: this bit shall be set to 1 if a CPP has the ability to act on a MUX3_UnSpecified_Channel_Re-establishment message (see subclause 6.5.6.4)

SSR shall be set to 1 if the CPP has the ability to act on the Secondary_Service_Re-establishment and MUX3_Secondary_Service_Re-establishment messages. Otherwise set to zero.

RFU: reserved for future use, and shall be set to 0. The allocation of these bits is controlled by and registered with the Standard Control Authority.

X: Do not decode on receipt. Transmit as 0.

NOTE: Where a new CFP accepts a re-established link, it is the responsibility of the network to correctly set the state variables in the new CFP so that the acknowledged messaging is correctly resumed. In this situation, the new CFP will have to be informed of the LID (link reference) value to expect or use for the re-establishment to occur, and the new CFP should in addition be informed of the state variable values, any appropriate layer 2 attributes of the CPP and any unfinished layer three transactions.

SABM messages (either basic or extended) are transmitted continuously from the CPP until a SABM_ACK message (either basic or extended) is received. V(r) shall be initialised to zero before SABM is sent. Upon receiving a SABM message at either CFP or CPP, the local state variables V(s) and V(r) shall be initialised to zero, DL_ESTABLISH_IND shall be set and an acknowledgment returned in the form of a SABM_ACK message. It is mandatory for a CPP to transmit either basic or extended SABM messages. The N(r) bit in the SABM message shall be set to 0, to prevent possible mis-interpretation of the received message. Protocol initialisation is shown below (figure 10):

```
CPP                                         CFP
===                                         ===
V(r) := 0        SABM
            ------------------>
                                        V(s) := 0
                                        V(r) := 0
                SABM_ACK                DL_ESTABLISH_INDICATION := true
            <------------------
V(s) := 0
DL_ESTABLISH_INDICATION := true
```

Figure 10: CFP to CPP link set up

V(s) is the send state variable; this denotes the sequence number of the next packet to be transmitted i.e. N(s) of transmitted packets := V(s).

V(r) is the receive state variable; the sequence number of the next packet expected. N(r) of transmitted packets := V(r). V(r) is checked against the N(s) field of incoming packets to make sure they are in sequence. An out of sequence packet shall be ignored.

6.5.6.6 Protocol acknowledgment (SABM_ACK), basic and extended

The SABM_ACK message is an unacknowledged message that is used to acknowledge the link initialisation (SABM) message. It shall be transmitted back to the other end of the link (either in basic or extended form) after a SABM message, either basic or extended, has been received, to cause protocol initialisation at the receiving end of the link. On reception of a SABM_ACK message, (either basic or extended) at the CPP, transmissions of SABM are ceased, the local state variable V(s) is initialised and DL_ESTABLISH_IND is set (see Figure 10 above).

Bit: 8	7	6	5	4	3	2	1	octet
1	0	1	0	0	0	0	0	1

The basic SABM_ACK message (above) shall have bits 8,7,6 set to 1,0,1 respectively. The remaining bits shall be set to 0.

Bit: 8	7	6	5	4	3	2	1	octet
1	0	1	0	0	0	0	0	1
1	0	1	SSR	NPSS	FCR	SRE	1	2
1	0	1	RFU	X	RFU	RFU	RFU	3
1	0	1	RFU	RFU	RFU	RFU	RFU	4

The extended SABM_ACK message (above) is an unacknowledged message four octets in length, that is sent from the CFP during link establishment only, and also conveys CFP layer 2 attributes to the CPP. The extended SABM_ACK shall be sent in a single codeword packet.

In each octet, bits 8,7,6 are set to 1,0,1 respectively. In the first octet, the remaining bits shall be set to 0. In the three following octets, the remaining bits carry layer 2 attributes, dependent on the bit position within the octet, and the octet position within the message, thus allowing for up to 15 attributes to be declared by the CFP.

SRE shall be set to 1 if the CFP is capable of using the synchronous link re-establishment method, otherwise shall be set to 0.

FCR may be set to 1, to indicate to a CPP that the CFP is capable of accepting fast channel change on re-establishment (see subclause 4.10.2). This bit shall be set to 0 if the CFP does not have physically separated RFPs, or if the SRE bit is set to 1.

NPSS If set to 1, this bit instructs a CPP to restrict secondary service channel assessments to channels which may be used at the normal power level according so subclause 4.4.4.2. Otherwise set to zero.

SSR shall be set to 1 if the CFP has the ability to act on the Secondary_Service_Re-establishment message. Otherwise set to zero.

RFU: reserved for future use, and shall be set to 0. The allocation of these bits is controlled by and registered with the Standard Control Authority.

X: Do not decode on receipt. Transmit as zero.

6.5.6.7 Layer 2 code set shift

This message provides a method of expanding the number of available layer 2 messages, and defines a generalised format for new, yet to be defined, layer 2 messages. If a CPP or CFP indicates that extended supervisory messaging is supported (by sending extended SABM or SABM_ACK), then each shall support the code shift message and generalised message format. Those layer two messages that are not implemented or recognised in compliant equipment (i.e. equipment supporting extended SABM/SABM_ACK), shall be ignored and shall not cause mis-operation of the equipment.

The code set shift shall apply to the single following code set shifted message only, and the code set shift is reset after processing of the message. (Processing in this context means actively ignoring or interpreting the message).

A code set shifted single octet message shall have the following format:

Bit: 8	7	6	5	4	3	2	1	octet
1	0	0	C	C	C	C	C	X
TYPE			0	CONTENT				X+1

CCCCC in the first octet contains a number (0 to 31) indicating the code set number that shall apply to the following message type. The allocation of these bits is controlled by and registered with the Standard Control Authority.

TYPE is the 3 bit message type in the indicated code set number. The allocation of these bits is controlled by and registered with the Standard Control Authority.

CONTENT is the 4 bit content associated with the message.

A code set shifted multi-octet message shall have the following format:

Bit: 8	7	6	5	4	3	2	1	octet
1	0	0	C	C	C	C	C	X
TYPE			1	LENGTH (N)				X+1
CONTENT OCTET 1								X+2
CONTENT OCTET 2								X+3
CONTENT OCTET N								X+N+1

CCCCC in the first octet contains a number (0 to 31) indicating the code set number that shall apply to the following message type. The allocation of these bits is controlled by and registered with the Standard Control Authority.

TYPE is the 3 bit message type in the appropriate code set number. The allocation of these bits is controlled by and registered with the Standard Control Authority.

LENGTH is the 4 bit number of following CONTENT octets, up to 15.

6.5.6.7.1 Secondary service channel availability

Bit: 8	7	6	5	4	3	2	1	octet
1	0	0	0	0	0	0	1	X
0	0	1	0	RFU	RFU	SSP	CAC	X+1

This acknowledged message shall be sent after a secondary service establishment or re-establishment has occurred to inform the non-assessing end of the link whether a channel suitable for a secondary service was found, and at what power level it can be used, or whether the link has been re-established according to the criteria for a primary service.

If the message indicates that no channel is free according to the secondary service rules (i.e. CAC=0) neither end shall initiate a secondary service. If a secondary service channel is available (i.e. CAC=1) the non assessing end shall switch to the power specified by SSP, or if unable to do so shall terminate the link. If the link has been re-established according to the criteria for a primary service the non-assessing end may revert to high power.

CAC denotes the Channel Assessment Criteria which was used:

1 if the channel was free according to the secondary assessment rules
0 in all other cases.

SSP denotes Secondary Service Power level to be used:

0 if normal power may be used
1 if low power must be used

6.5.6.8 NULL message

Bit: 8	7	6	5	4	3	2	1	octet
1	1	1	1	0	0	0	0	X

This is a single octet message, with the message type bits set to 1, 1, 1, and the message content set to 1, 0, 0, 0, 0. On receipt of this message, no action shall be taken.

6.5.7 Fill-in

This is an unacknowledged supervisory message of zero length, contained in a variable-format ACW, that is used as fill-in when there are no signalling messages to send. It maintains traffic on the D channel for bit error ratio monitoring. This message is sent in preference to the IDLE_D pattern. The full fill-in code word is therefore as follows:

Bit: 8	7	6	5	4	3	2	1	octet
0 PI	0 L3_end	1 endwrd	0	0 rem.	0	1 FT	1 ACW	1
0	0 QUALIFIER	0	0 I/S	X N(s)	0 P/F	1/0 N(r)	1/0 REJ	2
1	1	1	1	0	0	0	0	3
1	1	1	1	0	0	0	0	4
1	1	1	1	0	0	0	0	5
1	1	1	1	0	0	0	0	6
CHECK (octet 1)								7
CHECK (octet 2)								8

6.6 Link establishment and re-establishment

Link set up uses sequences of single address code words. The minimum transmission time for a single ACW + SYNCD (which precedes every ACW) is three bursts, i.e. 6 ms but subject to the conditions of subclause 6.3.5 may be greater. This is the basis of the timings in the following text.

NOTE: The LID field for group call identification is as explained in subclause 6.4.5, 3).

6.6.1 Link set up from the CPP

The CPP shall transmit LINK_REQUEST code words (LS = 00). Each code word contains the PID and end point ID code (in the LID field) necessary to access the required service. This fixed format ACW shall be transmitted in MUX3. The SR bit shall be set (=SRr) to request the maximum signalling bit rate of which the CPP is capable.

This fixed format ACW is repeated continuously for Tpmax (5 s) maximum with the CPP monitoring for a CFP response in MUX2.

The CFP detects the MUX3 CHMP from the calling CPP during its calling channel scan, and subsequently receives the ACW described above. If the received PID and LID are valid the CFP responds to the ACW from the CPP. The CFP examines the SR bit received from the CPP, and if it is capable of signalling in multiplex 1 at the requested rate, it sets SR (=SRc) equal to SRr, otherwise it sets SRc=0. The CFP then transmits LINK_GRANT code words (LS = 01), for the period Tftx, containing a link reference in the LID field for the CPP to use in future communications. If the received PID and LID are not valid, the CFP shall not respond and may return to calling channel scanning.

The CPP detects the CFP MUX2 transmission, and receives the LINK_GRANT code word. The CPP then starts its handshake timers Thtx, Thrx, and Thlost, and transmits an ID_OK handshake code word, echoing back the link reference (in the LID field) received from the CFP. On receipt of the ID_OK handshake code word, the CFP starts its handshake timers Thtx, Thrx, and Thlost, and stops transmission of LINK_GRANT code words. The CPP shall transmit an ID_OK code word on each reception of a LINK_GRANT code word, subject to the conditions of subclause 5.5.3. The requirement to transmit an ID_OK code word on each reception of a LINK_GRANT code word shall take precedence over the requirements of subclause 5.5.2.

The CFP waits a minimum of Tfdetect (100 ms) for a CPP ID_OK handshake code word (before reverting to channel scanning). It checks the received LID against its own link reference value, and if they are different the CFP returns to calling channel detection mode. If the received LID matches, then the link is set up, and protocol initialisation may be attempted. Protocol initialisation is performed by the CPP transmitting SABM packets. When acknowledgment (SABM_ACK) is received, the link state variables V(s) and V(r) are initialised, and DL_ESTABLISH_IND is set.

6.6.2 Link re-establishment

Link re-establishment may be performed by one of two mechanisms (see subclauses 5.4.4, 5.4.5 and 5.4.6). Link re-establishment may be due to the following reasons:

1) a Link Re-establish has been transmitted (see subclause 6.5.6.4);

2) a LINK Re-establish has been received (see subclause 6.5.6.4);

3) ID handshake loss has occurred;

4) expiry of the received code word timer, Trcw or Trcw2, if supported;

5) reliable detection of loss of synchronisation, if supported.

In standard re-establishment (subclauses 5.4.4 and 5.4.5), the CPP transmits LINK_REQUEST code words in MUX3, placing CHMP in the SYN channel, and the last received LID from the CFP in the LID field. This value of LID distinguishes the link re-establishment from a link establishment.

In synchronous re-establishment (subclause 5.4.6), the CFP transmits LINK_GRANT code words in MUX2 with SYNCF in the SYN channel. The SYNCF bit pattern distinguishes the link re-establishment from a link establishment. Trcw2 shall be supported if synchronous re-establishment is used.

The CPP shall transmit an ID_OK codeword on each reception of a LINK_GRANT codeword, subject to the conditions of subclause 5.5.3.

6.6.3 Link set up from the CFP

Ringing can be activated to either a single CPP or multiple CPPs within a registered group. The mechanism is identical in either case in that a single CPP is treated as a "multiple" group limited to one. Multiple ringing is a point to multi-point (or single point for a group of one) link set up attempt that reverts to a point to point link only when the CFP detects a response from a CPP when the CPP is requesting the link.

There are five requirements for multiple ringing:

1) packets from CFP to CPP during ringing shall be restricted to single ACW packets;

2) poll packets from the CFP containing the BID or LID shall be repeated every other packet (ACW), with a single ACW (UI) or the equivalent time of IDLE_D between them to enable the CPP to detect the poll. Successive poll packets shall not occur more frequently than once every 12 ms, and should occur more frequently than once every 16 ms;

3) the poll response from the CPP shall be a single ACW;

4) the poll response ACW shall be transmitted from the CPP in a transmit burst following the end of the receive burst containing the poll packet. The start of the poll response (the burst with 16 bits of IDLE_D and SYNCD) shall occur between 2 ms and 8 ms after the end of the poll (to allow time to set up the poll response ACW for the transmit burst). The end of the response occurs 5 ms after the start, i.e. within 13 ms of the end of the poll;

```
      ______    ______    ______    ______     ______    ______
     /CPP RX\__/CPP TX\../CPP RX\__/CPP TX\.../CPP TX\../CPP RX\..
     \______/  \______/  \______/  \______/   \______/| \______/
            |\__...___  ___...__/  |                 |
End of poll^        \/             ^Start of poll    ^End of poll
              2 ms...8 ms           response          response
             \_____________________ ____________________/
                                   \/
                           13 ms maximum.
```

Figure 11: Poll response timing

5) the polling from the CFP is performed on a cyclic basis, with only one poll per CPP per cycle, and with the relative order of poll position maintained.

For incoming public access to handsets, the public access LID values (0000H to 03EFH) may be used by the base station. If it is intended to subsequently authenticate the handset, the LID value used by the base shall be the LID value that is used by the handset to access that public access service.

6.6.4 CFP polling

The CFP transmits ID_OK code words to each CPP that is required to be called within a group. This poll serves a dual purpose:

1) to provide a "group calling" address using a BID or LID to enable all CPPs registered with that CFP to recognise this BID and so wait on the channel for reception of an individual CPP poll. This poll waiting timeout is Tpid (384 ms);

2) to address, or poll each CPP in the group calling list individually with a PID so that each CPP can respond to its poll in the appropriate response slot.

The CFP transmits a fixed format poll ACW and an optional variable format packet (e.g. alternately SIG (ring on/off) and FI) in MUX2 on a continuous repeated basis within a Tpid (384 ms) period (e.g. POLL1, SIG, POLL2, FI, POLL3, SIG, ..., POLLn, FI). A CPP may act on a NO_POLL message before it has recognised its own PID from a poll, but shall not act on any other unacknowledged layer three (e.g. SIG and FI) packets until it has recognised its own PID from a poll.

If a CFP transmits UIs between polls (instead of FILL_IN), and the UIs include SIG, FI and NO_POLL, then the recommended sequencing of the UI messages between polls is SIG, FI, SIG, NO_POLL, SIG, FI, SIG, NO_POLL. This is to allow rapid ring cadence following by polled CPPs.

The CFP transmits poll,(SIG, FI or NO_POLL) packets continuously (using CHMF in the SYN channel) so that all registered CPPs in the ringing list are polled, and monitors for CPP responses. The timeout for call set up is given in subclause 5.4.1. The CPP transmission of responses is constrained by a transmit window that is the period between poll packets from the CFP; a particular CPP's response window starts 2 ms after it has been polled, to avoid CPP poll response collisions.

The ID_OK poll contains the BID or LID in the LID field (for group call identification at the CPP) and a PID (for one of the group registered CPPs). The SR bit is set to indicate the MUX1 signalling rate capability (SR=SRr).

When the CPP detects a MUX2 CHMF from the CFP during its calling channel scan, It should wait Tbid (19 ms) to receive an ID_OK poll (ACW). If a SIG or FI information element is received before a poll, it shall not be considered valid. If a poll is received, the PID in the poll shall be compared with the stored PID. If they match, the CPP shall start a 1 second poll timer (Tpoll), and shall transmit an ID_OK poll response back to the CFP within the response "time-slot", and may act on subsequently received layer three UI packets (e.g. SIG or FI). If the PID does not match, the received BID or LID in the LID field shall be checked with the stored BID or LID, and if they match, this shall enable the CPP to continue to monitor the channel for up to Tpid (384 ms) to detect its own PID (if it does not detect its own PID it shall continue to channel scan). If the CPP subsequently receives a poll containing its PID, this enables the CPP to decode all subsequent UI packets (e.g. SIG, to start ringing). A CPP which has not received further polls within 1 second (Tpoll) shall revert to channel scanning.

6.6.5 CPP poll response

The CPP has three possible responses to a poll from the CFP:

1) the normal CPP poll response shall be an ID_OK code word, transmitted using SYNCP in the SYN channel and containing the PID and LID field. The LID field contains the value of the LID field received from the CFP (i.e. the CPP reflects the LID field back to the CFP);

2) a LINK_REQUEST code word (LS=00) which is sent after the CPP user takes the call, or a CPP determines it can accept the link as it is the only CPP being polled (see subclause 7.2.19);

3) a poll decline request. This is an ID_OK code word with the LID field containing a value of 0400H.

The CFP monitors for MUX2 (with SYNCP in the receive SYN channel) to detect CPP responses to its polling. If the CPP did not answer the call, but transmitted an ID_OK code word, the CFP logs the response (for call establishment not due to incoming ringing, the CFP halts its Tfmax2 (15 s) call set up timer here, see subclause 5.4.1. For call establishment due to incoming ringing, Tfmax is halted when the correct layer three feature activation (FA) information element (subclause 7.2.4) is received by the CFP). If all CPPs on the current group ringing list have responded to their polls, the CFP replaces CHMF by SYNCF in the transmit SYN channel to prevent unnecessary wake-up of other CPPs in range.

If a CPP user attempts to decline the link, the CPP sends a "poll decline" request every time it is polled; the CPP should remain on the channel until Tpoll expires, to ensure it is no longer being polled by the CFP.

Whenever the CFP detects an ID_OK poll response, the CFP starts a 1 second timer (Tfpres); if this timer expires, the CFP is required to scan for a free channel, and restart the polling process as if starting a new link set up (for incoming ringing), or terminate the link set up attempt (when not due to incoming ringing).

When the CFP accepts a LINK_REQUEST packet, the Tfpres timer shall be halted, and the timers Tftx and Tfdetect started.

If the CPP attempts to answer the call by transmitting a LINK_REQUEST code word, the SR bit in the LINK_REQUEST code word indicates the MUX1 rate selected (commanded) by the CPP (SR=SRc). The CFP subsequently transmits LINK_GRANT code words for a period of Tftx, and starts the Tfdetect timer, the period during which it expects to receive an ID_OK code word from the CPP. If Tfdetect matures, the CFP reverts to starting a new link set up to the CPPs (for incoming ringing), or terminates the link set up (when not due to incoming ringing). The CFP is then armed to signal at the commanded MUX1 rate. MUX1 is entered by means of a layer three message.

The CPP shall respond to LINK_GRANT code words by transmitting ID_OK code words, and shall start or restart its handshake timers Thrx, Thtx and Thlost.

The CPP only sends LINK_REQUEST code words on receipt of ID_OK polling code words from a CFP, containing the CPP's PID.

6.6.6 CPP link set up and standard re-establishment diagram

```
                    CPP                          CFP
 T3R2:              ===                          ===             R3:
                     | (CHMP,MUX3)PID,LID,LS=00   | MUX3 detected, PID
                    A| ==== LINK_REQUEST ======> |A' & LID validated.
                     |                            |
                     | (SYNCF,MUX2)PID,LID,LS=01 |             T2R2:
 MUX2 detected.     B| <=== LINK_GRANT ========= |
 T2R2: Set SR.       |                            |
                     | (SYNCP,MUX2)PID,LID,LS=10 |
                    C| ===== ID_OK ============> |B'
                     .                            .
```

The protocol shall be initialised from the CPP (during link establishment only):

```
                     .                            .
                     |       SABM  (SUP)          |
DL_ESTABLISH_REQ:    | ========================> | DL_ESTABLISH_IND
                     |       SABM_ACK (SUP)       | Set V(s):=V(r):=0
DL_ESTABLISH_IND,    | <======================== |
Set V(s):=V(r):=0    |                            |
                     .                            .
```

A : Start Tpcyc (min=750 ms, see subclause 5.4.2), for link establishment or re-establishment on another channel.

A': Start Tfdetect, Tftx.

B : Halt Tpcyc and Tpmax, Start Thlost, Thrx.

B': Start Thrx, Thtx and Thlost. Halt Tfdetect, Tftx. The link is set up at this point.

C : Start Thtx.

NOTE 1: After points B, B' the transmitter must start transmission of ID_OK handshakes such that an ID_OK is sent within 400 ms to 1 s of the last transmitted handshake.

NOTE 2: Up to point A', the LID field contains a link endpoint ID code, and from point A', the CFP replaces the link endpoint ID with a link reference ID (see subclause 6.4).

NOTE 3: During call re-establishment LID contains the last used link reference value.

NOTE 4: At point A during link re-establishment on the same channel, the CPP and CFP continue to transmit and receive respectively until the (minimum) 3 s loss of handshake timer matures, where-upon re-establishment on a different channel may occur as described above, i.e. Tpcyc is not active during link re-establishment on the same channel.

Figure 12: CPP link set up

6.6.7 CFP link set up diagram

```
                    CFP                           CPP
T2R2:               ===                           ===                R2:
                     |                             |   CPP1,2 out of range
                     |*(CHMF,MUX2)PID1,LID,LS=10   |  +---------------------+
      Poll CPP1:   A| ========= ID_OK ==========> |  |If ALL CPPs respond |
                     |                             |  |to POLL message send|
                     |*(CHMF,MUX2),UI              |  |SYNC not CHM. *     |
      Ring ALL:      | -------------------------->|  +---------------------+
                     |                             |
                     |*(CHMF,MUX2)PID2,LID,LS=10   |   NOTE: Assumes CFP has
      Poll CPP2:     | ========= ID_OK ==========> |   ID codes for 2 CPPs
                     |                             |   programmed.
                     |*(CHMF,MUX2),UI ++           |
      Ring ALL  ->   | -------------------------->|   ++ UI e.g.: SIG/FI
                     . . . . . . . . . . . . . . . .   CPP1 in range
                     .                             .
                     |*(CHMF,MUX2)PID1,LID,LS=10   |                  T2R2:
                     | ========= ID_OK ==========> |A'  CPP1 detects poll
                     |                             |    from CFP.-------+
                     |(SYNCP,MUX2)PID1,LID,LS=10   |                    |
   Poll response   B| <======== ID_OK =========== | <- CPP1 in range <-+
   detected.         . . . . . . . . . . . . . . . .
                     .                             .
                     |*(CHMF,MUX2)PID1,LID,LS=10   |    CPP1 LINE key pressed
      Poll CPP1:     | ========= ID_OK ==========> |A'          |
                     |                             |            |
                     |(SYNCP,MUX2)PID1,LID,LS=00   |            |
   Call seized     C| <==== LINK_REQUEST ======== | <----------+
   by CPP1.          |                             |
                     |(SYNCF,MUX2)PID1,LID,LS=01   |
                     | ===== LINK_GRANT =========> |D'
                     |                             |
                     |(SYNCP,MUX2)PID1,LID.LS=10   |
                    D| <===== ID_OK ============= |
                     .                             .
```

The protocol shall be initialised from the CPP (during link establishment only):

```
                     .       SABM  (SUP)           .
DL_ESTABLISH_IND,    | <========================== | <--- DL_ESTABLISH_REQ:
Set V(s):=V(r):=0.   |       SABM_ACK (SUP)        |
                     | ==========================> | ---> DL_ESTABLISH_IND-->
                     |                             |         Set V(s):=V(r):=0
                     |                             |
```

A : Start Tfcyc (min=1,4 s, see subclause 5.4.1).

A': Start (and re-start) Tpoll (see subclause 6.6.4).

B : Halt Tfcyc, Start (and re-start) Tfpres. For Tfmax actions, see subclause 6.6.5.

C : Start Tftx and Tfdetect. Halt Tfpres.

D': Start Thrx, Thtx. Start (and re-start) Thlost, Halt Tpoll.

D : Start Thrx, Thtx and Thlost. Halt Tftx and Tfdetect. The link is set up at this point.

NOTE 1: After point D the transmitter must start transmission of ID_OK handshakes such that an ID_OK is sent within 400 ms to 1 s of the last transmitted handshake.

NOTE 2: Up to point C, the LID field contains the BID, and from point C, the CFP replaces BID with the link reference ID (see subclause 6.4).

Figure 13: CFP link set up

6.6.8 Synchronous re-establishment diagram

```
                     CFP                          CPP
T2R2:                ===                          ===
                      |                            |
                      | (SYNCF,MUX2)PID,LID,LS=01  |            R2
                      | ===== LINK_GRANT =========> |
                      |                            |
                      | (SYNCF,MUX2),FILL_IN       |
                      | ------------------------->  |
                      |                            |
                      | (SYNCF,MUX2)PID,LID,LS=01  |
                      | ===== LINK_GRANT =========> | A' CPP detects
                      |                            |    LINK_GRANT
                      | (SYNCF,MUX2),FILL_IN       |
                      | ------------------------->  |
                      |                            |
                      | (SYNCP,MUX2)PID,LID,LS=10  |            T2R2
CFP detects          B| <======== ID_OK =========== |
ID_OK response        |                            |
                      |                            |
```

A': Start Thrx, Thtx and restart Thlost. Halt Tsrlg. The CPP deems link is re-established at this point.

B : Start Thrx, Thtx and Thlost. Halt Tsrlg. The CFP deems link is re-established at this point.

NOTE: After point A' at the CPP and point B at the CFP, the transmitter must start transmission of ID_OK handshakes such that ID_OK handshakes are transmitted within 400 ms to 1 s of the last transmitted handshake.

Figure 14: Synchronous re-establishment

6.7 Layer two link protocol set up and control

The layer two set up and control is performed using the control octet of the address code word. The protocol is based on CCITT Recommendation Q.921 LAPD single frame operation [3]. The frames referred to as SI0/1 shall be used for information transfer and link control. The acknowledged mode of information transfer shall require acknowledgment. The content of the four primitives DL_DATA_REQUEST, DL_UNIT_DATA_REQUEST, DL_DATA_INDICATION and DL_UNIT_DATA_INDICATION shall be a layer three message. This may contain one or more layer three information elements (see clause 7).

NOTE: This list is intended for guidance with individual manufacturers free to add to at their discretion, to achieve refinements to functions (including clear down), as required.

DL_ESTABLISH_REQUEST	Layer three request for protocol initialisation.
DL_ESTABLISH_INDICATION	Layer two acknowledgement of protocol initialisation.
DL_DATA_REQUEST	For sending acknowledged data from layer three to layer two.
DL_DATA_INDICATION	For sending acknowledged data from layer two to layer three.
DL_UNIT_DATA_REQUEST	For sending unacknowledged data from layer three to layer two.
DL_UNIT_DATA_INDICATION	For sending unacknowledged data from layer two to layer three.
DL_RELEASE_INDICATION	For sending release indication to layer three from layer two.
DL_RELEASE_REQUEST	For sending release request to layer two from layer three.

6.7.1 Layer two link protocol timings

There shall only ever be one outstanding packet waiting for acknowledgement in the acknowledged transfer mode (i.e. k=1 in CCITT Recommendations Q.921 [3] and Q.931 [4]). A timeout (Trtx) shall be maintained for re-transmission and this shall be not greater than:

1) 600 ms in MUX1.2; or

2) 320 ms in MUX1.4; or

3) 66 ms in MUX2.

The timer is started on completion of transmission of the packet. Receipt of a packet with REJ set shall cause this timer to mature immediately, and be re-started after re-transmission of the packet.

6.7.2 Layer two link operation

The layer two link operating protocol shall follow the following rules. The specific implementation of these rules is, however, not specified, and will depend on individual system design decisions. The rules follow the normal semantics of C coding.

The state variables in a system processing at layer two are V(r), V(s) and REJ'. The equivalent bits in a packet are N(r), N(s) and REJ, respectively. Processing of N(r)/V(r) and N(s)/V(s) shall be mandatory. Processing of REJ/REJ' may be omitted by:

- treating REJ as having the value 0 regardless of the value received in a packet; or
- setting REJ' to 0 at all times; or
- applying both (1) and (2).

The state variables are used as follows:

- V(r) is the receive state variable which signifies the next expected N(s);
- V(s) is the send state variable which signifies the next N(s) to be transmitted;
- REJ' is transmitted as REJ and may be used for requesting immediate re-transmission of a corrupted packet.

6.7.2.1 Link initialisation (see subclause 6.5.6.5)

Set up the link by setting V(r) = 0 and transmitting SABM continuously with I/S = 0, N(s) = 0, N(r) = 0, P/F= 0;

```
IF (the first SABM_ACK received) {
        stop transmitting SABM;
        set V(s) = 0;
        set DL_ESTABLISH_INDICATION;
        start transmitting in normal mode;
}
ELSE IF (SABM received) {
        set V(s) = 0;
        set V(r) = 0;
        set REJ' = 0;
        set DL_ESTABLISH_INDICATION;
        transmit SABM_ACK;
}
```

```
ELSE IF (second or subsequent SABM_ACK received) {
        no action;
}
```

6.7.2.2 Packet transmission

```
IF (an un-numbered packet is to be sent (DL_UNIT_DATA_REQUEST)) {
        send packet with P/F = 0, N(s) = X (don't care), N(r) = V(r), REJ = REJ';
        set REJ' = 0;
}
ELSE IF (a numbered packet is to be sent (DL_DATA_REQUEST)) {
        send packet with P/F = 1, N(s) = V(s), N(r) = V(r), REJ = REJ';
        set REJ' = 0;
        start re-transmission timer (Trtx);
}
IF (the re-transmission timer (Trtx) matures) {
        send packet with P/F = 1, N(s) = V(s), N(r) = V(r), REJ = REJ';
        set REJ' = 0;
        re-start re-transmission timer (Trtx);
}
```

6.7.2.3 Packet reception

```
IF (PI == 1) {
        ignore packet - unrecognised protocol;
}
ELSE /* i.e. PI == 0 */ {                              /* THE PROTOCOL IS RECOGNISED. */

/* (i)   Deal with packet reception control. */

        IF (P/F == 0) {                                /* un-numbered packet. */
                IF (I/S == 1) {                        /* packet for layer three. */
                        set DL_UNIT_DATA_INDICATION;
                        pass the contents of the un-numbered packet to layer three for processing;
                }
                ELSE {                                 /* packet for layer two (supervisory). */
                        terminate packet processing at layer two;
                }
        }
        ELSE /* i.e. P/F == 1 */ {                     /* numbered packet. */
                IF (DL_ESTABLISH_INDICATION is set) {
                        IF (N(s) == V(r)) {            /* packet is in-sequence. */
                                increment V(r);
                                set REJ' = 0;
                                IF (I/S == 1} {        /* packet for layer three. */
                                        IF (L3_end == 0) {
                                                set DL_DATA_INDICATION;
                                                pass the contents of all numbered packets to layer three for
processing;
                                        }
                                        ELSE {
                                                await further packet(s) to complete the numbered multi-packet
message;
                                        }
                                }
                                ELSE {                 /* packet for layer two (supervisory). */
                                        terminate packet processing at layer two;
```

```
                    }
                }
                ELSE /* i.e. N(s) != V(r) */ {
                    ignore packet - it is out-of-sequence;
                }
            }
            ELSE /* i.e. DL_ESTABLISH_INDICATION is not set. */ {
                ignore packet - packet numbering is not initialised;
            }
        }

/* (ii)  Deal with packet transmission control. */

        IF (REJ == 0) {
            IF (V(s) != N(r)) {                    /* in-sequence N(r): ack. of our last packet.
*/
                increment V(s);
                stop re-transmission timer (Trtx);
            }
            ELSE {                                 /* out-of-sequence N(r): ack. of our last packet.
*/
                no action;
            }
        }
        ELSE { /* i.e. REJ == 1 */
            IF ((DL_ESTABLISH_INDICATION is set) AND (V(s) == N(r)) {
                /* this is a re-transmission request. */
                complete transmission of the current packet and then re-transmit
                the packet immediately (subclause 6.7.2.2);
            }
            ELSE {
                no action;
            }
        }
/* (iii) Deal with bad packet received (see subclause 6.5.4). */
        IF (the last received packet received is bad AND it is required to request early re-transmission of
        the packet) {
            set REJ' = 1;
        }
}
```

6.8 Location tracking of CPPs

Location tracking of CPPs allows a CT2 system or network to monitor the location of a CPP with respect to its constituent CFPs in order to provide an incoming calling service over an extended area covered by multiple CFPs.

Two location tracking mechanisms are described in subclauses 6.8.1 and 6.8.2. The tracking mechanism used depends on the capabilities of the CFP and the abilities indicated by the CPP in TERM_CAP.

Receipt of FA3,31 from a CPP for which the system supports location tracking shall cause the initiation (or continuation) of location tracking.

NOTE: CPPs may be location registered to more than one CT2 system or network simultaneously.

6.8.1 Polling only location tracking

This location tracking mechanism uses the CFP polling mechanisms described in subclauses 6.6.3 and 6.6.4. The system may periodically poll a CPP to determine if it is still within range of a CFP. If a CPP fails to respond to polls, the CT2 system or network may extend the search to the coverage area of other CFPs.

If location tracking polls are not intended to alert the CPP user, the CFP should not interleave SIG or FI information elements between ID_OK polls.

In order to conserve the battery life of large populations of CPPs, the CFP may use the POLLING_LID information element to transfer an LT_POLLING_LID value to specific groups of CPPs (see subclause 7.2.26). If the LT_POLLING_LID matches the LID in any registration slot in the CPP, then any poll received containing this LID shall be treated as if it were a poll from the registered system. A CPP which is polled using LT_POLLING_LID transferred in a POLLING_LID information element is not required to remain on channel for a further period of Tpoll if LT_POLLING_LID does not match the LID in any registration slot in the CPP.

6.8.2 CIS assisted location tracking

This location tracking mechanism relies on a CPP to monitor for CIS transmissions from individual CFPs and to inform the CT2 system or network if it detects that it has moved to the coverage area of a different CFP or group of CFPs.

This form of location tracking supports a two tier structure for the identification of CFPs:

- the CFPs in a CT2 system or network are assigned to groups consisting of one or more CFPs. Each CFP within the group is assigned the same value of Location Area Identifier (LAI). Each group of CFPs (of a single system) with adjoining or overlapping coverage areas should be allocated a different value of LAI.

- each CFP within a group may be individually identified by the value of Local Cell Identifier (LCI)

A CPP shall inform the CT2 system or network of a change of location (using FA 3,29, see subclause 7.2.4) only when it detects a change in the LAI.

A modified polling mechanism may be used in conjunction with CIS assisted polling to allow a CT2 system or network to determine if a CPP is still within range of a given CFP.

A CFP instructs a CPP to monitor for CIS transmissions by transmitting an LR_PARAMS information element (see subclause 6.8.2.4).

CIS transmissions constitute a secondary service and the free channel assessment rules for secondary services (see subclause 4.4.4.2) shall be used.

A CFP shall alternate periods of transmission with periods where such transmissions are absent. The period of transmission shall be in the range Tfcyc to 2.Tfcyc. The minimum period of absence shall be 200 ms. During the period of absence the CFP may be used to detect CPP originated signalling.

Before resuming transmissions, the CFP shall again select a free channel for secondary services in accordance with the requirements of subclause 4.4.4.2. The CFP shall select the most recently used channel if this continues to meet the requirements of subclause 4.4.4.2.

Where it is intended for the CPP to give "in range" indication to the user as a result of CIS transmissions, the off period should not exceed 2 s.

6.8.2.1 CIS only transmissions

During the periods of transmission the CFP shall transmit CIS codewords. The rate at which the CFP transmits CIS code words shall be greater than or equal to once per T_max_cis_per (12 ms) and shall be subject to the requirements of subclause 6.3.5. The CFP may transmit unacknowledged information elements or FILL_IN between CIS code words.

6.8.2.2 Combined CIS/polling transmissions

A CFP may interleave the CIS codewords in a CIS transmission with ID_OK polling codewords. The polling mechanism is the same as that specified in subclauses 6.6.3 and 6.6.4 with the following exceptions.

a) The CFP shall use SYNCF in the SYN field.

b) The CFP shall use the value of LR_POLL_LID previously transmitted to the CPP in an LR_PARAMS information element.

c) The CFP shall transmit a CIS code word between successive ID_OK code words. The CFP shall not interleave ID_OK polls with SIG, NO_POLL, FILL_IN or FIs. The CFP shall roll call a group of "n" CPPs by using the following sequence of code word transmissions:

ID_OK (LR_POLL_LID, PID 1),
CIS,
ID_OK (LR_POLL_LID, PID 2)
...
...
CIS,
ID_OK (LR_POLL_LID, PID n)

Action at the CPP:

The CPP shall behave as specified in subclauses 6.6.5 and 7.2.25 with the following exceptions:

a) The CPP shall not transmit a LINK_REQUEST code word.

b) The CPP shall not transmit a poll decline request.

c) A CPP which is polled using the LR_POLL_LID transferred in an LR_PARAMS message is not required to remain on channel for a further period of Tpoll.

d) The CPP shall respond to the polls at the transmit power level indicated in the CIS codeword.

6.8.2.3 Requesting the service

The only method of requesting a CIS assisted location registration service shall be the use of FA 3,31 (see subclause 7.2.4). The transmission of FA 3,31 may be manually initiated, or under the conditions specified below, may, subject to user pre-programming, be automatically be sent by the CPP.

A CPP which detects CIS transmissions with the ALR bit set to 1 and containing a LID which:

a) matches exactly the LID stored in one of the CPP registration slots; or

b) is a public access LID which matches the 15 msb of a LID stored in one of the CPP registration slots, may set up a link to the CFP and transmit an FA 3,31.

NOTE: A roaming access CFP will only provide service to a roaming CPP if it has a roaming agreement with the CPPs home operator. The standard does not permit automatic (pre-programmed) initial location registration to a CFP which is not transmitting CIS codewords corresponding to the LID stored in one of the registration slots of the CPP.

When a CPP sets up a link in order to transmit an initial location registration (FA 3,31) as a result of pre-programming, it shall specifically target the CFP transmitting the CIS codewords by using a combination of the system LID and the LCI in the LID field of the LINK_REQUEST codeword (see subclause 6.4.5.2).

If pre-programming of automatic transmission of FA 3,31 is supported, it shall be possible to individually enable or disable the automatic transmission of FA 3,31 for each registration slot by user pre-programming.

The automatic transmission of FA 3,31 shall be disabled if the CPP has received using the same registration slot, an LR_PARAMS message with PERIOD_OF_SERVICE = 62. Automatic transmission may resume following a manual location registration using the same registration slot or CPP reset.

6.8.2.4 CIS monitoring by the CPP

A CPP monitoring CIS transmissions as a result of a command from a CFP (LR_PARAMS, PERIOD_OF_SERVICE not equal to 0 or 62) shall not transmit a relocation registration (FA 3,29) unless a CIS transmission from a different source is detected. This shall be denoted by:

a) the received CIS code word contains the same value in the LID field as the previously monitored CIS transmission; and

b) the received CIS code word contains a value in the LAI field different from the previously monitored CIS transmission.

The transmission of a relocation registration FA 3,29 may be further qualified by comparison of the relative RF field strength of the CIS transmissions.

The transmission of a relocation registration FA 3,29 shall not occur more frequently than once per T_rr_min (15 s) regardless of the nature of any further CIS transmissions received by the CPP.

When a CPP sets up a link in order to transmit a relocation registration (FA 3,29), it shall specifically target the CFP transmitting the CIS codewords by using a combination of the system LID and the LCI in the LID field of the LINK_REQUEST codeword (see subclause 6.4.5.2).

A CPP shall not transmit FA 3,29 if the CIS transmissions (of the CFP which it is targeting) have the ALR bit set to 0.

6.8.2.5 In range indication to the user

A CPP which detects CIS transmissions with the IRI bit set to 1 and containing a LID which:

a) matches exactly the LID stored in one of the CPP registration slots; or

b) is a public access LID which matches the 15 msb of a LID stored in one of the CPP registration slots; or

c) belongs to a service for which the CPP does not have an (identity) registration, but to which it has registered for incoming calls following a roaming access link set-up; or

d) is odd and in the range of public access values,

may indicate to the user that it is in range of a CFP.

NOTE: d) above allows a CPP to indicate that it is in range of a roaming access CFP. It does not guarantee that service is available.

7 Signalling layer three

Layer three carries the signalling messages destined for the PSTN and vice versa, plus call control messages within the CT2 internal network. The stimulus mode signalling procedures described below are appropriate for both circuit switched voice calls and circuit switched data calls. The signalling channel is not intended to carry packet data.

The layer three protocol on the D channel provides a set of messages that are used to establish compatible data transfer characteristics on a 32 kbit/s B channel.

Stimulus mode signalling is the most appropriate mode for the CT2 application and is described in CCITT Recommendation Q.931 [4] as follows: "signalling messages sent by stimulus mode terminals to the network are usually generated as a direct result of actions by the terminal user (e.g. handset lifted) and in general do little more than describe the event which has taken place at the man-machine interface. Similarly, signalling messages sent by the network to terminals operating in stimulus mode contain explicit instructions regarding the operations to be performed by the terminal (e.g. connect B channel, start alerting, etc.)".

The signalling system specified below is a simplified version of that described in CCITT Recommendation Q.931 [4]. The simplification involves the removal of fields not required in the CT2 application; viz. the protocol discriminator, call reference value and message types. The CT2 system uses a subset of the information fields of CCITT Recommendation Q.931 [4] (which have been re-coded), plus new information fields not found in CCITT Recommendation Q.931 [4]. The information element principles of CCITT Recommendation Q.931 [4] have been preserved and exist in both single octet and variable length form. A layer three message is defined as a group of information elements delivered error free by layer two to the far end. Unless explicitly stated, messages may be sent either acknowledged or unacknowledged at layer two. The information element grouping in a message is determined by actions at the user interface at the CPP and the call state at the CFP (see annexes A and F). The maximum layer three message length is 29 octets in equipment conforming to this standard. Single octet and variable length information elements are defined below.

It is not mandatory to provide all of the detailed signals defined in this document but any equipment implementing implied functions that are covered here shall use the appropriate signals as defined. Those layer three messages that are not implemented or not recognised shall be ignored and shall not cause mis-operation.

All fields in information elements which are denoted as RFU shall be transmitted with a value of zero and shall be ignored on receipt, unless explicitly stated otherwise.

7.1 Single octet information elements

The single octet information element is encoded as shown in the diagram below:

Bit: 8	7 6 5	4 3 2 1	octet
1	information element identifier	contents of information element	X

One single octet information element is encoded to allow a shift into alternative signal code sets:

Bit: 8	7	6	5	4	3	2	1	octet
1	0	0	1	U	new code set identifier			X

When U (bit 4) is set to 0 this indicates locking shift and the specified code set is activated for all information elements in the rest of the message. When set to 1 this indicates non-locking action and that only the next information element is taken from the specified code set. The default code set is that specified in this I-ETS. Other code sets should follow the same rules for single octet and variable length information formats as contained in this I-ETS.

Code set identifier:

Bit:	3 2 1	Significance
	0 0 0	Default code set.
	0 0 1 . . . 1 1 1	Code sets 1 to 7 are reserved for future use: allocation of these codes is controlled by and registered with the Standard Control Authority body. These code sets are reserved for future non-mandatory applications.

NOTE: The information element 7 is reserved for use as detailed in subclause 6.5.5. Other information elements are reserved for future allocation. Allocation is controlled by and registered with the SCA.

7.2 Variable length information elements

The variable length information element is encoded as shown in the diagram below:

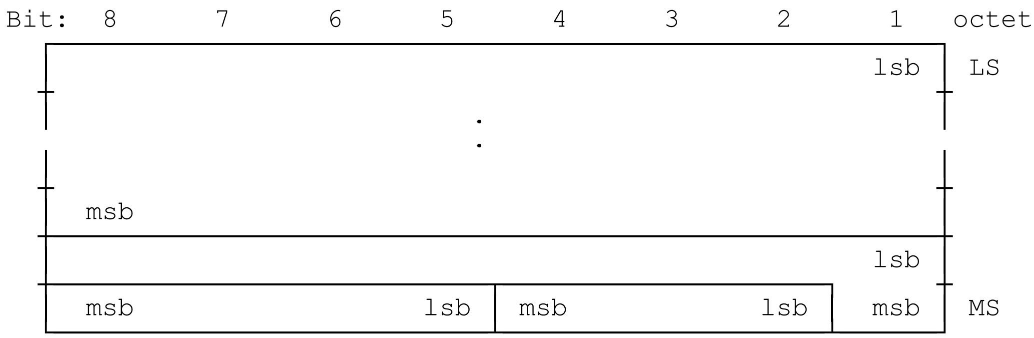
Bit: 8	7	6	5	4	3	2	1	octet
0	information element identifier							1
length of information element (octets)								2
contents of information element								3
etc.								4
								etc.

NOTE: Any additional information fields added within the content part of variable length information elements are controlled and registered with the Standard Control Authority. All information elements, whose length is explicitly defined in this standard, may have qualifying information appended to them, subject to the approval by the Standard Control Authority, but it is mandatory to act on the defined information element content.

Bit: 8	7	6	5	4	3	2	1	octet
0	information element identifier							1
length of information element (m + n)								2
contents of information element (m octets)								3
. .								etc.
(qualifying information) (n octets)								m+n+2

Layer three data fields are subject to the following interpretation:

The least significant bit in any field is the lower bit number and the least significant octet in any multi octet field is the lower octet number unless explicitly stated otherwise.



A list of the information element fields carried in layer three messages required to be transmitted over the D signalling channel is given below:

Table 12: Variable-length Information Elements

Mnemonic	Bit: 87654321	Dir'n CPP CFP	Function
KP	00000000	------>	Keypad
DISP	00000010	<------	Display
SIG	00000011	<------	Signal
FA	00000001	------>	Feature activation
FI	00000100	<------	Feature indication
CC	00000101	<------	Channel control
INIT	00000110	<------	Initialise
AUTH_REQ	00000111	<------	Authentication request
AUTH_RES	00001000	------>	Authentication response
TERM_CAP	00001001	------>	Terminal (CPP) capabilities
BAS_CAP	00001010	<------	Base (CFP) capabilities
CHAR	00001011	<----->	IA5 character
OARAC	00001100	<------	On air (de-)registration acknowledge
PAR_REQ	00001101	<----->	Parameter request
PAR_RES	00001110	<----->	Parameter response
PAR_SET	00001111	<----->	Parameter set
AUTH2_REQ	00010000	<------	Alternative AUTH_REQ
AUTH2_RES	00010001	------>	Alternative AUTH_RES
NO_POLL	00010010	<------	Number of handsets being polled
TRD_ALLOC	00010011	<------	Terminal registration data set
KEY_ALLOC	00010100	<------	Terminal KEY/EPID data set
NET_AUTH_REQ	00010101	------>	Network authentication request
NET_AUTH_RES	00010110	<------	Network authentication response
POLLING_LID	00010111	<------	Polling LID
CHANGE_SLOT	00011000	<------	Change registration slot
LR_PARAMS	00011001	<------	Location registration parameters
DAT_CAP	00011010	<----->	Data bearer capability
DAT_RES	00011011	<----->	Data bearer response

Experimental information elements are detailed in a separate document (obtainable from the SCA).

7.2.1 Keypad information element (KP)

The purpose of the keypad information element is primarily to convey IA5 characters entered at the CPP keypad for dialling purposes and is coded as shown below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0 keypad information element identifier	0	0	0	0	0	0	1
length of keypad information element								2
keypad information (IA5 characters)								3
								etc.

Packets containing this information element shall be acknowledged at layer 2. Informative annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipment built to earlier editions of this standard, CFPs shall respond correctly if this information element is received in an un-acknowledged packet.

The keypad information (octet 3 etc.) is capable of carrying the following IA5 characters. The coding allows for digit by digit sending (repeated keypad information elements with length field value 1) or en bloc sending (e.g. repertory numbers with one KP element and length as appropriate). IA5 characters occupy seven bits; the eighth bit shall be set to 0. The eighth bit when set to 1 denotes manufacturer specific information. Keypad information may also be used by manufacturers for on-air registration of CPPs.

KP elements carry dialling character information with characters presented in the order in which they were keyed by an operator. For example, the telephone number, 01 234 5678 is transported with the 0 in the least significant (lower numbered) octet of the KP element and 8 in the most. The terms most significant and least significant octets (as defined in subclause 7.2), therefore, do not apply to KP elements.

Allocation of keypad information codes:

Codes 0 to 31 (decimal)

These codes are used for CAI specific control purposes as follows:

Bit: 8 7 6 5 4 3 2 1	Value	Meaning
0 0 0 0 0 0 0 0	NUL	Ignore.
0 0 0 0 0 0 1 0	STX	Return home.
0 0 0 0 0 0 1 1	ETX	Return end.
0 0 0 0 0 1 0 1	ENQ	Pause. The type and duration of the pause is determined by the CFP in accordance with national regulations.
0 0 0 0 1 0 0 0	BS	Move back one column.
0 0 0 0 1 0 0 1	HT	Move forward one column.
0 0 0 0 1 0 1 0	LF	Move down one row.
0 0 0 0 1 0 1 1	VT	Move up one row.
0 0 0 0 1 1 0 0	FF	Clear display (and return home).
0 0 0 0 1 1 0 1	CR	Return to beginning of the current row.
0 0 0 0 1 1 1 0	SO	Flash off.
0 0 0 0 1 1 1 1	SI	Flash on (all following displayed characters until flash off).
0 0 0 1 0 0 0 1	DC1	Resume transmission (XON).
0 0 0 1 0 0 1 0	DC2	Go to decadic.
0 0 0 1 0 0 1 1	DC3	Stop transmission (XOFF).
0 0 0 1 0 1 0 0	DC4	Go to MF.
0 0 0 1 0 1 0 1	NAK	Fast flash on (all following characters until flash off).
0 0 0 1 0 1 1 0	SYN	Toggle scroll lock.
0 0 0 1 0 1 1 1	ETB	Long send mode on
0 0 0 1 1 0 0 0	CAN	Long send mode off
0 0 0 1 1 0 0 1	EM	Clear to end of display (maintain cursor position).
0 0 0 1 1 0 1 0	SUB	Clear to end of line (maintain cursor position).
0 0 0 1 1 0 1 1	ESC	Escape as in IA5. The usage of ESC to be as in ISO 2022 [20].

All other codes in the range 0 to 31 inclusive are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

ETB, CAN (Long send mode on/off)

These messages shall be ignored by the CFP if it is using loop disconnect dialling or if the CFP does not support long MF dialling.

A dialling sequence is a series of one or more dialled digits. A dialled digit is physically represented across the air interface by a KP code (0..9, *,#,a,b,c,d). Dialled digits are transported in an arbitrary number of KP information elements. For the purpose of long mode sending, the timing of arrival of the codes at the CFP is relevant.

The CPP may precede any dialled digit with the code ETB. The CPP shall send a CAN code as the next KP code following any dialled digit immediately preceded by an ETB.

On receipt of an ETB code followed by a dialled digit, the CFP shall commence sending the MF tones representing the dialled digit which may be subject to a minimum period determined by the CFP. The tones shall then continue until either a CAN code is received (as the next code) or a CFP dependent maximum period has expired. The next code shall then be considered. Any CAN received when the CFP is not sending long MF tones shall be ignored. The ETB code shall only apply to the next code and only if that code is a dialled digit. When sending long MF tones, the inter-digit pause shall be no less than that required by national regulations and is the responsibility of the CFP.

NOTE: Under adverse RF conditions, the duration of the MF tone may extend up to the timeout period.

Codes 32 to 127 (decimal)

These codes are used in the standard IA5 sense. Values '0' through '9' are mandatory for decadic dialling with '*' and '#' additionally mandatory for MF dialling. The characters 'a' through 'd' are optional additional dialling information in MF mode.

The action by the CFP in response to a keypad "dial message" ("dial message" means one of the characters 0..9,a,b,c,d,* or #) in any mode where user dialling is enabled shall be to send the appropriate tone (MF) or pulses (LD) to the line. The duration of MF tones is determined by the CFP and may be subject to national regulations.

Bit: 8 7 6 5 4 3 2 1	Value
0 0 1 1 0 0 0 0	'0'
0 0 1 1 0 0 0 1	'1'
0 0 1 1 0 0 1 0	'2'
0 0 1 1 0 0 1 1	'3'
0 0 1 1 0 1 0 0	'4'
0 0 1 1 0 1 0 1	'5'
0 0 1 1 0 1 1 0	'6'
0 0 1 1 0 1 1 1	'7'
0 0 1 1 1 0 0 0	'8'
0 0 1 1 1 0 0 1	'9'
0 0 1 0 1 0 1 0	'*'
0 0 1 0 0 0 1 1	'#'
0 1 1 0 0 0 0 1	'a'
0 1 1 0 0 0 1 0	'b'
0 1 1 0 0 0 1 1	'c'
0 1 1 0 0 1 0 0	'd'

NOTE: '*','#','a','b','c' and 'd' may be ignored by a CFP working in decadic mode.

Codes 128 to 255 (decimal)

These codes are reserved for manufacturer specific applications. The codes are F0 to F127. F0 to F11 are recommended for general use.

Bit: 8 7 6 5 4 3 2 1	Value
1 0 0 0 0 0 0 0	F0
. .	
. .	
1 0 0 0 1 0 0 1	F9
1 0 0 0 1 0 1 0	F10
1 0 0 0 1 0 1 1	F11
. .	
. .	
1 1 1 1 1 1 1 1	F127

7.2.2 Display information element (DISP)

The purpose of the display information element is to convey IA5 characters to the CPP display and is coded as shown below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	0	1	0	1
	display information element identifier							
length of display information element								2
display information (IA5 characters)								3
								etc.

The display information (octet 3 etc.) is capable of carrying any IA5 character. CPPs not equipped with a display can ignore normal display parameters.

Information shall be displayed in the order in which it is received e.g. a message containing display information "1234" followed by a message "5678" shall appear on a suitably large display as "12345678".

Allocation of display information codes:

Codes 0 to 31 (decimal)

These codes are used for CAI specific control purposes as follows:

Bit: 8 7 6 5 4 3 2 1	Value	Meaning
0 0 0 0 0 0 0 0	NUL	Ignore.
0 0 0 0 0 0 1 0	STX	Return home.
0 0 0 0 0 0 1 1	ETX	Return end.
0 0 0 0 0 1 0 1	ENQ	Pause. The type and duration of the pause is determined by the CFP in accordance with national regulations.
0 0 0 0 1 0 0 0	BS	Move back one column.
0 0 0 0 1 0 0 1	HT	Move forward one column.
0 0 0 0 1 0 1 0	LF	Move down one row.
0 0 0 0 1 0 1 1	VT	Move up one row.
0 0 0 0 1 1 0 0	FF	Clear display (and return home).
0 0 0 0 1 1 0 1	CR	Return to beginning of current row.
0 0 0 0 1 1 1 0	SO	Flash off.

0 0 0 0 1 1 1 1	SI	Flash on (all following displayed characters until flash off).
0 0 0 1 0 0 0 1	DC1	Resume transmission (XON).
0 0 0 1 0 0 1 0	DC2	Go to decadic.
0 0 0 1 0 0 1 1	DC3	Stop transmission (XOFF).
0 0 0 1 0 1 0 0	DC4	Go to MF.
0 0 0 1 0 1 0 1	NAK	Fast flash on (all following characters until flash off).
0 0 0 1 0 1 1 0	SYN	Toggle scroll lock.
0 0 0 1 0 1 1 1	ETB	Long send mode on
0 0 0 1 1 0 0 0	CAN	Long send mode off
0 0 0 1 1 0 0 1	EM	Clear to end of display (maintain cursor position).
0 0 0 1 1 0 1 0	SUB	Clear to end of line (maintain cursor position).
0 0 0 1 1 0 1 1	ESC	Escape as in IA5. The usage of ESC to be as in ISO 2022 [20].

The control code "FF clear display" (hexadecimal 0C) is required as a minimum for all displays.

All other codes in the range 0 to 31 inclusive are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

Codes 32 to 127 (decimal)

These codes are used in the standard IA5 sense. Values '0' through '9','*' and '#' are the minimum recommended for decadic and MF dialling. The characters 'a' through 'd' are optional additional dialling information in MF mode.

Bit: 8 7 6 5 4 3 2 1	Value
0 0 1 1 0 0 0 0	'0'
0 0 1 1 0 0 0 1	'1'
0 0 1 1 0 0 1 0	'2'
0 0 1 1 0 0 1 1	'3'
0 0 1 1 0 1 0 0	'4'
0 0 1 1 0 1 0 1	'5'
0 0 1 1 0 1 1 0	'6'
0 0 1 1 0 1 1 1	'7'
0 0 1 1 1 0 0 0	'8'
0 0 1 1 1 0 0 1	'9'
0 0 1 0 1 0 1 0	'*'
0 0 1 0 0 0 1 1	'#'
0 1 1 0 0 0 0 1	'a'
0 1 1 0 0 0 1 0	'b'
0 1 1 0 0 0 1 1	'c'
0 1 1 0 0 1 0 0	'd'

Codes 128 to 255 (decimal)

These codes are reserved for manufacturer specific applications.

7.2.3 Signal information element (SIG)

The purpose of the signal information element is to convey indications to prompt the CPP to generate alerting (tone caller), warning and error audible signals as coded below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	0	1	1	1
	signal information element identifier							
0	0	0	0	0	0	0	1	
length of signal information element								2
signal class				value				3

The signal content field (octet 3) is encoded as follows:

Signal class 0 (stop audible signals):

Bit:	Value 4 3 2 1	Significance
	x x x x	Stop all audible signals.

Signal class 1 (alerting signals):

Signal class 1 may cause one of several (according to value) ringing signals to be emitted at the CPP. The alerting class assumes a monostable action of 350 ms to 450 ms. The monostable action is re-triggered on receipt of further identical signals.

Bit:	Value 4 3 2 1	Significance
	0 0 0 0	General alerting signal.
	0 0 0 1	Line alerting signal.
	0 0 1 0	Intercom alerting signal.
	0 0 1 1	Enumerated alerting signal 3.
	. .	
	. .	
	. .	
	1 1 1 1	Enumerated alerting signal 15.

Signal class 2 (warning signals):

Signal class 2 may cause one of several (according to value) warning signals to be emitted at the CPP. The warning class signal event causes an audible warning signal, the duration of which is determined by the CPP.

Bit:	Value 4 3 2 1	Significance
	0 0 0 0	General warning signal.
	0 0 0 1	Enumerated warning signal 1.
	. .	
	. .	
	. .	
	1 1 1 1	Enumerated warning signal 15.

Signal class 3 (error signals):

Signal class 3 may cause one of several (according to value) error signals to be emitted at the CPP. The error class signal event causes an audible error signal, the duration of which is determined by the CPP.

Bit: Value 4 3 2 1	Significance
0 0 0 0	General error signal.
0 0 0 1	Enumerated error signal 1.
. .	
. .	
. .	
1 1 1 1	Enumerated error signal 15.

NOTE: All other classes are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.2.4 Feature activation information element (FA)

The purpose of the feature activation information element is to convey information on actions at the man-machine interface at the CPP and is coded as shown below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	0	0	1	1
	FA information element identifier							
0	0	0	0	0	0	0	1	
length of FA information element								2
feature class			value					3

Packets containing this information element shall be acknowledged at layer 2. Informative annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipments built to earlier editions of this standard, CFPs shall respond correctly if this information element is received in an un-acknowledged packet.

The feature activator content field (octet 3) is encoded as follows:

Feature class 0 (line selection):

Feature class 0 allows the potential selection of one of 31 directly addressed "outside" lines on private CFPs. The value of 0 is used for general line select.

Bit: Value 5 4 3 2 1	Significance
0 0 0 0 0	General line select.
0 0 0 0 1	Line select 1.
. .	
. .	
. .	
1 1 1 1 1	Line select 31.

Feature class 1 (system selection):

Feature class 1 allows the potential selection of one of 31 directly addressed "systems" within a private CFP environment. The value of 0 is used for general system select.

Bit: Value 5 4 3 2 1	Significance
0 0 0 0 0	General system select.
0 0 0 0 1	System select 1.
. .	
. .	
. .	
1 1 1 1 1	System select 31.

Feature class 2 (local intercom selection):

Feature class 2 allows the potential selection of one of 31 directly addressed CPPs within the intercom network of a CTA. The value of 0 is used for general intercom select and following KP digits may indicate the ("dialled") intercom address.

Bit: Value 5 4 3 2 1	Significance
0 0 0 0 0	general local intercom select.
0 0 0 0 1	named local intercom select 1.
. .	
. .	
. .	
1 1 1 1 1	named local intercom select 31.

Feature class 3 (public access selection):

Feature class 3 allows the potential selection of one of 28 public services. The value of 0 is used for general service select.

Bit: Value 5 4 3 2 1	Significance	
0 0 0 0 0	General service select.	
0 0 0 0 1	service 1.	
. .		
. .		
. .		
1 1 1 0 0	service 28.	
1 1 1 0 1	CPP relocation registration request.	(Not restricted to public access systems)
1 1 1 1 0	CPP terminate location registration request.	(Not restricted to public access systems)
1 1 1 1 1	CPP initial location registration request.	(Not restricted to public access systems)

CPP initial location registration and terminate registration are to be used to register or de-register a CPP with a CFP; once registered, a CPP could receive incoming calls from the network or system via the CFP, and de-registering prevents the network or system from directing further calls for the CPP to the specific CFP. These FAs do not request any change to the slot registration data and may be used in any CT2 CAI network or system that provides for location registration.

A CPP which can transmit an initial location registration request FA 3,31 shall also be capable of transmitting a terminate location registration request FA 3,30. Annex E contains recommendations for interim arrangements for CPPs supporting these FAs.

NOTE: Some equipments built to earlier editions of this standard may support FA3,31 but not support FA3,30.

If a CFP accepts a link and receives either Relocation registration (FA 3,29), Terminate Location Registration (FA 3,30) or Initial Location Registration (FA 3,31), the CFP, on completion of the layer 3 message exchange, and in the absence of further FAs to indicate a follow on call, shall ensure that the RF link is terminated by sending an INIT information element.

Initial Location Registration

The Initial location registration (FA 3,31) shall be sent in response to deliberate user action or user pre-programming (see subclause 6.8.2.3). If the CFP supports FA 3,31, it shall respond as follows:

- the CFP shall indicate its acceptance of this request by sending FI 3,31,1.

- if the location registration service is unobtainable, the CFP shall indicate this by sending FI 3,31,5.

These FIs shall be sent in acknowledged mode at layer 2.

NOTE 2: The transmission of FA 3,31 may cause the CPP user to incur service charges.

Terminate Location Registration

The CPP shall send the Terminate location registration FA 3,30 to de-register from the incoming call service. If the CFP supports FA 3,30, it shall respond as follows:

- the CFP shall indicate its acceptance of FA 3,30 with FI 3,30,0

- if the terminate location registration service is unobtainable, the CFP shall indicate this by sending FI 3,30,5.

These FIs shall be sent in acknowledged mode at layer 2. Following the transmission of FA 3,30 the CPP may cease monitoring those CIS transmissions which it is monitoring as a result of the reception of an LR_PARAMS information element.

NOTE 3: The reception of FA 3,30 should prevent the CPP user incurring further service charges.

Relocation registration

A CPP which indicates support for LRP in TERM_CAP (see subclause 7.2.10), shall, following the reception of a LR_PARAMS information element (see subclause 7.2.25), transmit relocation registrations (FA 3,29) under the condition specified in subclause 6.8.2.4 without further user intervention.

FA 3,29 shall not be transmitted as a direct result of user action, nor until the receipt of an LR_PARAMS message for the current registration slot.

If the CFP supports FA 3,29, it shall respond as follows:

- the CFP shall acknowledge receipt of relocation registration FA 3,29 with FI 3,29,1.

- if the relocation registration service is unobtainable, the CFP shall indicate this by sending FI 3,29,5.

These FIs shall be sent in acknowledged mode at layer 2. If the Relocation registration service is unobtainable, the CFP shall indicate this as specified in subclause 6.4.6.

Feature class usage

The following diagram (figure 15) illustrates the usage of the above four feature classes within the CT2 environment:

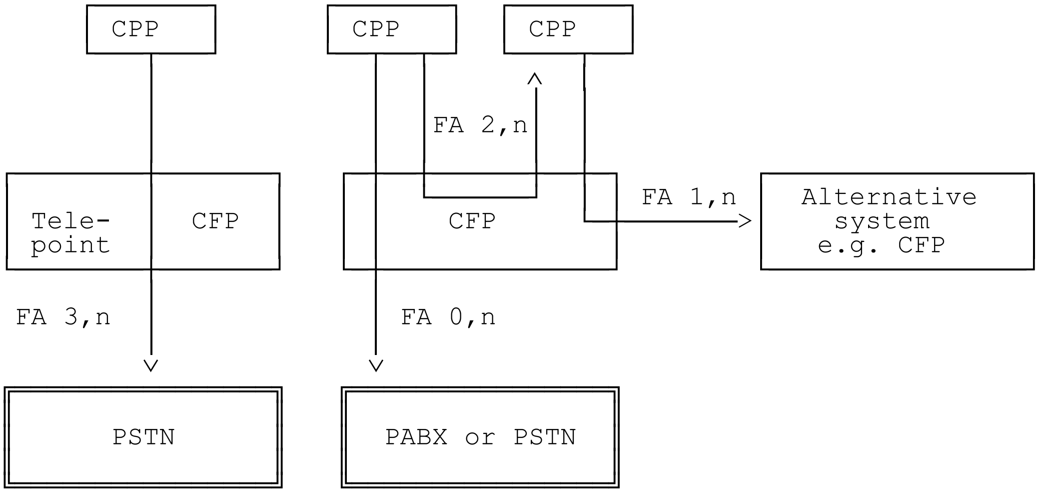


Figure 15: Feature class usage diagram

Feature class 4 (emergency access selection):

Feature class 4 allows the potential selection of one of 32 emergency services.

Bit:	Value 5 4 3 2 1	Significance
	0 0 0 0 0	default emergency service.
	0 0 0 0 1	emergency service 1.
	.	.
	.	.
	.	.
	1 1 1 1 1	emergency service 31.

NOTE: Emergency access may be via dedicated lines or via uncommitted PSTN lines. In the latter case it will be necessary for the CFP to dial the appropriate emergency service number.

Feature class 5 (data service selection):

Feature class 5 allows the establishment of data calls. The value shall indicate the type of data call termination being requested.

Bit	Value 5 4 3 2 1	Significance
	0 0 0 0 0	general data call
	0 0 0 0 1	DCE termination data call
	0 0 0 1 0	DTE termination data call

NOTE 4: All other values are reserved for future allocation. Allocation is controlled by and registered with the SCA.

Feature class 6 (reserved for future use.)

Allocation of this class is controlled by and registered with the SCA. This class is reserved for future applications.

Feature class 7 (auxiliary function selection):

Auxiliary functions for the purposes of call control are activated via feature class 7. "link communication" is defined here as "a maintained link at layer two", and a "session" is defined as meaning "the requesting, granting and use of a service."

Bit:	Value 5 4 3 2 1	Significance
	0 0 0 0 0	Clear.
	0 0 0 0 1	Full release.
	0 0 0 1 0	Register recall.
	0 0 0 1 1	Partial release.
	0 0 1 0 0	Hold.
	0 0 1 0 1	Alternative network function (e.g. Mercury in the UK).
	0 0 1 1 0	Supervisory mode.
	0 0 1 1 1	On air identity registration (for systems not using authentication see subclause 7.2.13).
	0 1 0 0 0	On air identity de-registration (for systems not using authentication see subclause 7.2.13).
	0 1 0 0 1	Call transfer.
	0 1 0 1 0	Continue dialling
	1 1 1 1 1	Null feature.

0) Clear causes termination of all sessions and link communications. This message shall be acknowledged at layer two.

1) Full release is a request to terminate the current session, and if no other sessions, then CFP originated clear down shall ensue. This message shall be acknowledged at layer two.

2) Register recall is totally equivalent to a wired telephone register recall switch.

3) Partial release is a request to terminate the current session. This message shall be acknowledged at layer two. After 20 s ±1 s, if no other session is requested by the CPP and granted by the CFP, then the CFP sends an acknowledged INIT, which terminates the link.

4) Hold causes the current session to be suspended. The RF link shall be retained in anticipation of starting or resuming another session.

5) Alternative network function which shall request a predefined call routing procedure to be actioned by the CFP.

6) Supervisory mode.

7) On air registration causes connection of the CPP to the CFP registration service.

NOTE 5: This is the local CFP identity registration service and is not a location registration service.

8) On air de-registration causes connection of the CPP to the CFP de-registration service.

NOTE 6: This is the local CFP identity de-registration service and is not a location de-registration service.

9) Call transfer. This feature activation invokes the CFP call transfer facility (if provided).

NOTE 7: Call transfer may be provided by the CFP without the use of this FA but by the use of other allocated information elements.

10) Continue dialling. Requests the CFP to continue dialling to line. Dialling may have been suspended at the CFP, subject to national requirements, by processing KP PAUSE (KP 5, ENQ) (see subclause 7.2.1).

31) Null feature. A feature activation that requests a null session (i.e. the link is maintained).

NOTE: All other values are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.2.4.1 Use of FAs for answering incoming calls

The CFP should accept the following FA values to answer an incoming call using the given LID value and FI information elements:

Table 13: Use of FA information elements in response to incoming calls

LID (hex) (transmitted)	FI class;value (transmitted)	FA class;value (response)	Comments
0000 - 03EF	FI x,y	FA x,y, FA x,0 or FA 3,0	Normal incoming public access call
	none	FA 3,0	
03F0 - 03FF	FI x,y	FA x,y, FA x,0 FA 0,0, FA 3,0 or FA 4,0	Incoming emergency call
	none	FA 3,0 or FA 0,0 or FA 4,0	
0400 - FFFF	FI x,y	FA x,y, FA x,0 or FA 0,0	Residential / private system incoming call
	none	FA 0,0	

7.2.5 Feature indication information element (FI)

The purpose of the feature indication information element is to convey information which may activate a "feature indicator" (e.g. an appropriate display character(s) or icon) at the CPP to show the call state and is coded as shown below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0 FI information element identifier	0	0	0	1	0	0	1
0	0 length of FI information element	0	0	0	0	1	0	2
feature class			value					3
state parameter								4

The feature class and value (octet 3) are encoded in the same way as the feature activation information element octet 3.

The significance of the state parameter depends on the associated feature class, as follows:

Feature class 0 (line selection):

Feature class 0 FIs identify the state of "outside" lines on private CFPs, with the significance of the state parameters as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	Line not seized/line call ceased.
	0 0 0 0 0 0 0 1	Line seized.
	0 0 0 0 0 0 1 0	Incoming line call.
	0 0 0 0 0 0 1 1	Line on hold.
	0 0 0 0 0 1 0 0	Line busy.
	0 0 0 0 0 1 0 1	Line unobtainable.

Feature class 1 (system selection):

Feature class 1 FIs identify the state of interconnections to "systems" within a private CFP environment, with the significance of the state parameters as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	System not selected/system call ceased.
	0 0 0 0 0 0 0 1	System selected.
	0 0 0 0 0 0 1 0	Incoming call from a system.
	0 0 0 0 0 0 1 1	Call to system on hold.
	0 0 0 0 0 1 0 0	Interconnection to system busy.
	0 0 0 0 0 1 0 1	System unobtainable.

Feature class 2 (local intercom selection):

Feature class 2 FIs identify the state of connection to one of the directly addressed CPPs within the intercom network of a CTA (where "connect" may , but not necessarily, be the RF link to the CPP). The significance of the state parameter is as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	Connection not made/ceased.
	0 0 0 0 0 0 0 1	Connection made.
	0 0 0 0 0 0 1 0	Incoming intercom call.
	0 0 0 0 0 0 1 1	Intercom connection on hold.
	0 0 0 0 0 1 0 0	CPP busy (engaged).
	0 0 0 0 0 1 0 1	CPP unobtainable (e.g. out of range or no RF link available).

Feature class 3 (public access selection)

Feature class 3 FIs identify the state of "outside" lines on public access base stations, with the significance of the state parameters as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	Line not seized/line call ceased.
	0 0 0 0 0 0 0 1	Line seized.
	0 0 0 0 0 0 1 0	Incoming line call.
	0 0 0 0 0 0 1 1	Line on hold.
	0 0 0 0 0 1 0 0	Line busy (line already in use).
	0 0 0 0 0 1 0 1	Line unobtainable.

The significance of the FI state parameter when associated with the CPP initial location registration, relocation registration and terminate location registration request (FA) is as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	Service ceased.
	0 0 0 0 0 0 0 1	Service accepted.
	0 0 0 0 0 0 1 0	Not applicable.
	0 0 0 0 0 0 1 1	Not applicable.
	0 0 0 0 0 1 0 0	Not applicable.
	0 0 0 0 0 1 0 1	Service unobtainable.

Feature class 4 (emergency access selection)

Feature class 4 FIs identify the state of lines reserved for emergency access or temporarily in use as emergency access lines. The significance of the state parameters is as follows:

Bit:	State parameter 8 7 6 5 4 3 2 1	Significance
	0 0 0 0 0 0 0 0	Line not seized/line call ceased.
	0 0 0 0 0 0 0 1	Line seized.
	0 0 0 0 0 0 1 0	Incoming call on dedicated emergency line.
	0 0 0 0 0 0 1 1	Line on hold.
	0 0 0 0 0 1 0 0	Line busy.
	0 0 0 0 0 1 0 1	Line unobtainable.

Feature class 5 (data service selection)

Feature Class 5 FIs identify the call state for data calls. The FI class 5 information element may also be used to initiate a data call establishment by the DCFP. The value indicates the type of data call termination being requested.

Bit	Value 5 4 3 2 1	Significance
	0 0 0 0 0	general data call
	0 0 0 0 1	DCE termination data call
	0 0 0 1 0	DTE termination data call

The state parameter indicates the state of the call establishment in the following way:

State parameter 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	line not seized/line call ceased
0 0 0 0 0 0 0 1	line seized
0 0 0 0 0 0 1 0	incoming data call
0 0 0 0 0 0 1 1	line on hold
0 0 0 0 0 1 0 0	line busy (line already in use)
0 0 0 0 0 1 0 1	line unobtainable

Feature class 7 (auxiliary function selection)

Feature indications may not meaningfully be attached to all auxiliary functions. It is recommended that FIs for the following functions are not used (but if used the state parameter should be set to idle (00000000)): clear, full release, register recall, partial release, hold, call transfer, continue dialling and null feature.

1) Alternative network function

Bit: State parameter 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	Line not seized/line call ceased.
0 0 0 0 0 0 0 1	Line seized.
0 0 0 0 0 0 1 0	Incoming line call.
0 0 0 0 0 0 1 1	Line on hold.
0 0 0 0 0 1 0 0	Line busy.
0 0 0 0 0 1 0 1	Line unobtainable.

2) Supervisory mode

Bit: State parameter 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	Supervisory service request not set up or ceased.
0 0 0 0 0 0 0 1	Supervisory service request accepted.
0 0 0 0 0 0 1 0	Not used.
0 0 0 0 0 0 1 1	Not used.
0 0 0 0 0 1 0 0	Supervisory service busy.
0 0 0 0 0 1 0 1	Supervisory service unobtainable.

3) On air identity registration

Bit: State parameter 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	Registration service request not set up or ceased.
0 0 0 0 0 0 0 1	Registration service request accepted.
0 0 0 0 0 0 1 0	Not used.
0 0 0 0 0 0 1 1	Not used.
0 0 0 0 0 1 0 0	Registration service busy.
0 0 0 0 0 1 0 1	Registration service unobtainable.

4) On air identity de-registration

Bit: State parameter 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	De-registration service request not set up or ceased.
0 0 0 0 0 0 0 1	De-registration service request accepted.
0 0 0 0 0 0 1 0	Not used.
0 0 0 0 0 0 1 1	Not used.
0 0 0 0 0 1 0 0	De-registration service busy.
0 0 0 0 0 1 0 1	De-registration service unobtainable.

NOTE: All other parameters are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.2.6 Channel control information element (CC)

The purpose of the channel control information element is to convey information from the CFP to cause the CPP to control the B channel connection and multiplex as coded below:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	1	0	1	
	CC information element identifier							1
0	0	0	0	0	0	0	1	
length of CC information element								2
B channel control parameter								3

The B channel control parameter (octet 3) is encoded as follows:

Bit: Parameter value 8 7 6 5 4 3 2 1	Significance
0 0 0 0 0 0 0 0	Use MUX1 with disconnected B channel.
0 0 0 0 0 0 1 0	Use MUX1 and connect B channel (no local sidetone).
0 0 0 0 0 0 1 1	Use MUX1 and connect B channel (with local sidetone).
0 0 0 0 0 1 0 0	Use MUX2 and disconnect B channel.
0 0 0 0 1 0 0 0	Use MUX 1 with B-channel loopback (CPP receiver muted)
0 0 0 0 1 0 0 1	Use MUX 1 with B-channel loopback (CPP receiver unmuted)

NOTE: All other parameters are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

In B channel loopback mode, the transmitted data in the B channel of a burst from a CPP shall be identical to that received in the immediately preceding received burst from the CFP.

It shall the responsibility of the CFP to ensure that the link returns to the correct multiplex mode under circumstances such as link re-establishment during multiplex mode changes.

7.2.7 Initialisation information element (INIT)

The initialise information element is used by the CFP to instruct the CPP to return to standby state whereby the B channel is disconnected, and all displays, indicators and tone generators are returned to an idle condition. This message shall be acknowledged at layer two.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	1	1	0	
	INIT information element identifier							1
0	0	0	0	0	0	0	1	
length of INIT information element								2
0	0	0	0	0	0	0	0	
INIT parameter								3

NOTE: All other parameters are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

This message may be sent at any time by the CFP to terminate a link. It is not necessary for the CPP to first send a CLEAR or equivalent feature activation from class 7.

The following diagrams explain the use of the CLEAR, FULL RELEASE and INIT messages used to perform the clear down procedure:

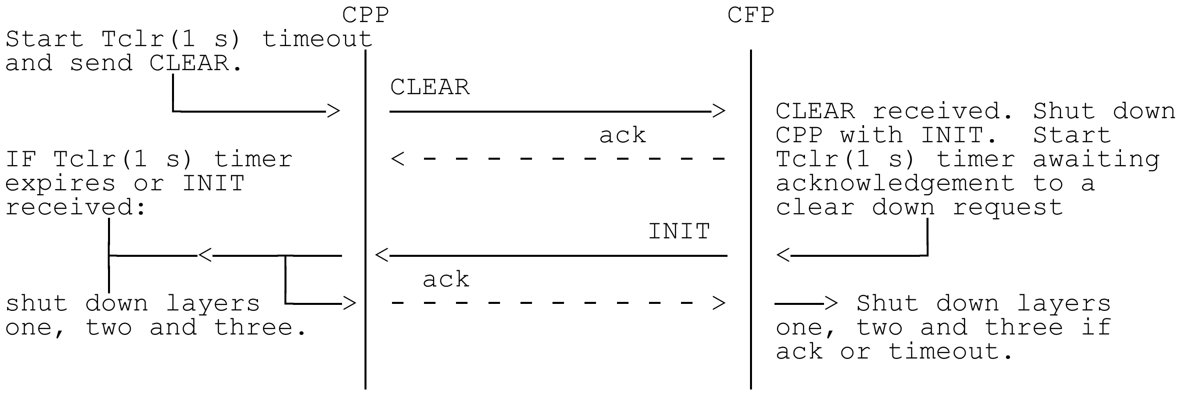


Figure 16: Clear Down procedure with CLEAR

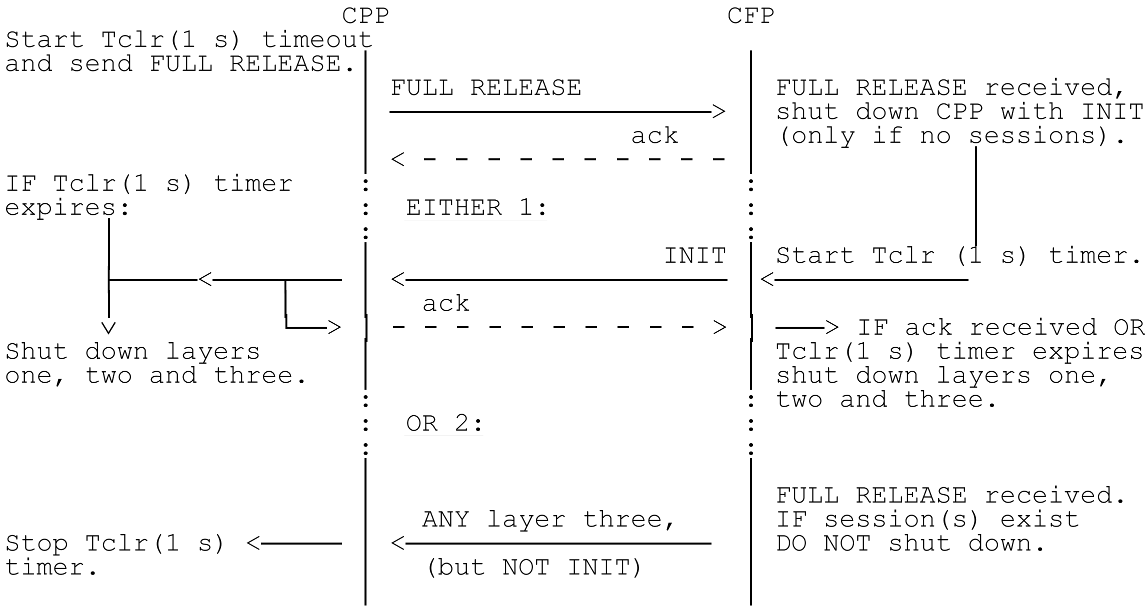


Figure 17: Clear Down procedure with FULL RELEASE

7.2.8 Authentication request information element (AUTH_REQ)

The authentication request information element is issued by a CFP to initiate the call authentication process. The authentication request information element has three parameters, RAND, INCZ and NAR, and causes the CPP to respond with the authentication response information element (AUTH_RES).

Packets containing this information element shall be acknowledged at layer 2. Informative annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipments built to earlier editions of this standard, CPPs shall respond correctly if this information element is received in an un-acknowledged packet.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	1	1	1	
	AUTH_REQ information element identifier							1
0	0	0	0	0	1	1	0	
length of AUTH_REQ information element								2
AUTH_NO								3
RAND								4
								5
								6
								7
RFU	RFU	RFU	RFU	RFU	NAR	RFU	INCZ	8

AUTH_NO is used to indicate to the CPP which of the authentication algorithms offered by the CPP is to be used, even if the CPP is only capable of performing one authentication process.

RAND is a 32-bit random number generated by the CFP to be used by the CPP in the call authentication process.

INCZ, when set to 1, causes the CPP to increment (modulo 16) the contents of a 4-bit ZAP field within the appropriate registration slot. When INCZ is set to 0 the field is left unchanged. The ZAP field is transferred to a CFP in the AUTH_RES information element and may be used by the system operator as a part of the overall CPP authentication process.

NAR. If the handset supports the NET_AUTH_REQ and NET_AUTH_RES information elements and the NAR field is set to 1, then the CPP shall respond using AUTH_RES and then initiate a network authentication request NET_AUTH_REQ (see subclause 7.2.21).

7.2.9 Authentication response information element (AUTH_RES)

The authentication response information element is sent by the CPP in response to an authentication request information element and conveys registration and authentication parameters to the CFP.

Packets containing this information element shall be acknowledged at layer 2. Informative annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipments built to earlier editions of this standard, CFPs shall respond correctly if this information element is received in an un-acknowledged packet.

Bit: 8	7	6	5	4	3	2	1	octet
0	0 AUTH_RES information element identifier	0	0	1	0	0	0	1
length of AUTH_RES information element								2
CKEY								3
								4
								5
								6
OPSIC							lsb	7
ZAP				TCOS			msb	8
TRD								9
								10
								11
								12
								13
								14
								15
								16
								17
								18

NOTE : TRD is shown at its maximum length of ten octets. The length of TRD may vary from 0 to 10 octets.

CKEY is the 32-bit result of the call authentication process, calculated by the CPP and returned to the CFP for checking.

OPSIC is the operators identification code. Specific code allocations for this field are detailed in a separate document (obtainable from the SCA).

TCOS (terminal class of service) field is used to transport terminal class of service details from the CPP. The use and interpretation of the data in this field is proprietary to the operator.

TRD (terminal registration data) field (variable length 0-10 octets) is used to transport the CPP details of the account being used. An unused BCD location in the TRD field shall contain binary 1111. The least significant account digit is placed in the right hand half of the octet immediately following the octet containing ZAP, with the next most significant digit in the left hand half, and so on. Where an unused location is filled with binary 1111, it shall always be in the left hand half of the most significant octet. Specific code allocations for this field are defined by and are the responsibility of the operators.

ZAP is the contents of the 4-bit ZAP field stored in the appropriate registration slot of a CPP as described in subclause 7.2.8.

7.2.10 Terminal capabilities information element (TERM_CAP)

The terminal capabilities information element is issued by the CPP following link establishment and before connection of the B channel. TERM_CAP shall also be sent in response to any action which changes the contents of the TERM_CAP message eg. a CHANGE_SLOT information element (see subclause 7.2.20) or OTAR (see annex B.4.2). An exception to this is an OTAR procedure which is terminated by an INIT information element. The first 9 octets of the information element shall be implemented. If any feature is implemented which requires data in octets 10, 11 or 12 then all 12 octets shall be implemented.

TERM_CAP is a statement of the capabilities of the CPP. The CFP shall operate within those capabilities or shall terminate the link.

If the terminal capabilities of the CPP vary for different registration slots, the capabilities indicated in TERM_CAP shall be those supported by the current active registration slot. If octet 10 is supported, then the current registration slot number shall be indicated in that octet.

Packets containing this information element shall be acknowledged at layer 2. Informative annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipments built to earlier editions of this standard, CFPs shall respond correctly if this information element is received in an un-acknowledged packet.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	0	0	1	1
	TERM_CAP information element identifier							
length of TERM_CAP information element								2
HSSC	DCAP			MB	CIC			3
MANIC								4
MODEL								5
AUTH_PREF								6
							lsb	7
AUTH_KEY								8
msb								9
SLOT_IDENTITY (optional)								10
ENHANCED FEATURES 1 (8 bits) (optional)								11
LRP	RFU	RFU	SLT	LAN	PL	NA	OTAR	
ENHANCED FEATURES 2 (8 bits) (optional)								12
RFU	RFU	RFU	RFU	RFU	DCPP	BLB	LRC	

CIC is a 3-bit field signifying the codec type used by the CPP. The CAI ADPCM voice codec (see subclause 8.1.4) has a CIC value of 000. Equipment without a codec (eg. DCFP and DCPP - see annex R) shall use a CIC value of binary 111. Other values shall only be allocated by the SCA.

MB = 0 signifies a CPP with a message buffer size limited to 29 octets at layer three (6 code words max.) and MB = 1 for CPP with full 128 octet capability.

DCAP identifies the CPPs display capabilities as below:

Bit: 3 2 1	Significance
0 0 0	No display.
0 0 1	Numeric only display.
0 1 0	7 segment display.
0 1 1	Full alphanumeric display.

HSSC indicates high speed signalling capability. HSSC set to 1 denotes the ability to revert to MUX2 signalling from MUX1 without the need for link re-establishment:

Bit:	1	Significance
	0	No high speed signalling capability.
	1	High speed signalling capability available.

MANIC identifies the CPP manufacturer, the value of zero to indicate anonymous. The assignment of MANIC field values is controlled by and registered with the Standard Control Authority body. Specific code allocations are detailed in a separate document (obtainable from the SCA).

MODEL is used to identify the CPP model number associated with the manufacturer ID in the MANIC field. Values assigned to this field are at manufacturer's discretion except where MANIC value is 0, when MODEL shall also be 0.

AUTH_PREF is used by the CPP to indicate to a CFP which one of the authentication algorithms offered by the CPP is the CPP's preferred algorithm for the current active registration slot. If only one algorithm is offered, this shall normally be indicated as the preferred algorithm in this field. If the SLOT IDENTITY field and ENHANCED FEATURES (1 and 2) fields are supported, then the AUTH_PREF field shall be set to zero when a CPP slot is pre-registered for Over The Air Registration (OTAR). The AUTH_PREF field will be changed to indicate the preferred algorithm during the over the air registration sequence. The only other circumstance when this field may be zero, is if the AUTH_KEY field is zero (i.e. no support for authentication).

AUTH_KEY is a bit field used to indicate to a CFP which authentication algorithms and which decryption algorithms the CPP is capable of performing. If no authentication or decryption algorithms are offered, all bits in this field shall be set to 0. A bit if set to 1 indicates that the CPP is capable of performing the associated algorithm, and if the bit is set to 0, then the CPP is not capable of performing the associated algorithm. The assignment of bits in this field is controlled by and registered with the Standard Control Authority. The least significant bits are used for authentication algorithms, the most significant bits are used for decryption algorithms. Specific bit allocations are detailed in a separate document (obtainable from the SCA).

The relationship between the AUTH_NO (in AUTH_REQ and AUTH2_REQ), AUTH_PREF and AUTH_KEY fields is as follows (illustrated by way of example, all numbers in hexadecimal):

If the following allocations for authentication mechanisms X, Y and Z and no decryption mechanisms are assumed (for example only):

AUTH_KEY	Significance
000000	No authentication ability.
000001	Bit 1 indicates ability X.
000002	Bit 2 indicates ability Y.
000004	Bit 3 indicates ability Z.

then the following example combinations may be interpreted:

AUTH_KEY	Significance
000003	indicates abilities X and Y.
000005	indicates abilities X and Z.
000006	indicates abilities Y and Z.
000007	indicates abilities X, Y and Z.

If a CPP has ability X only, then the AUTH_KEY bit field is coded as 000001; in this case, the AUTH_PREF field in TERM_CAP is coded 01 (bit 1), and AUTH_NO in AUTH_REQ is coded as 01. For a CPP indicating the ability to perform the X and Z algorithms, AUTH_KEY is 000005, and AUTH_PREF will be either of 03 (bit 3, prefers to use Z), or 01 (prefers to use X). AUTH_NO will be either 03 (instructing the CPP to use Z), or 01, (instructing the CPP to use X).

If the CPP is capable of performing an algorithm which is requested using AUTH2_REQ and AUTH2_RES, the value placed in the AUTH_NO field of AUTH2_REQ shall indicate which algorithm to use; if for example algorithm Z is requested by AUTH2_REQ, then the AUTH_NO value shall be 03 in the example above.

SLOT_IDENTITY shall contain the number (1 to 255) of the currently active registration slot. SLOT_IDENTITY=0 is a special case indicating that the handset is using a virtual slot, or cannot match the received LID (on incoming calls) to the LID stored in any of its slots or air interface slot identification is not supported.

RFU Reserved for future enhancements to the standard. Set to 0. Allocation is controlled by and registered with the Standard Control Authority.

PL shall be set to 1 if the CPP has the ability to accept and to use an LT_POLLING_LID transferred to it in a POLLING_LID information element. Otherwise set to zero.

SLT shall be set to 1 if the CPP supports the CHANGE_SLOT information element.

LAN shall be set to 1 if the CPP supports the preferred language parameter, i.e. PAR_REQ and PAR_RES with parameter type = 2.

LRP shall be set to 1 if the CPP supports the LR_PARAMS information element (see subclause 7.2.25). Otherwise set to zero.

NA shall be set to 1 if the CPP has the ability to authenticate the network (NET_AUTH_REQ and NET_AUTH_RES information elements).

OTAR shall be set to 1 if the CPP supports Over The Air Registration (OTAR). If OTAR is set, then NA shall also be set since the implementation of OTAR requires that network authentication is also supported.

LRC shall be set to 1 if a CPP shall accept a change of LID during call re-establishment. If LRC is set to zero, a CPP may, but is not mandated to, accept a change of LID on re-establishment.

BLB shall be set to 1 if the CPP is capable of performing B channel loopback using the CC values of 8 and 9 (see subclause 7.2.6).

DCPP This bit shall be set if the CPP has the capability to transmit data on the B channel (see annex R). Otherwise set to zero. Data capabilities are further defined in the DAT_CAP and DAT_RES information elements.

7.2.11 Base capabilities information element (BAS_CAP)

The base capabilities information element is issued by the CFP following link establishment and before connection of the B channel. BAS_CAP is a statement of the capabilities of the CFP. The CPP shall operate within those capabilities or shall terminate the link. TERM_CAP and BAS_CAP operate independently and do not form a capabilities negotiating mechanism.

The first 5 octets of the information element shall be implemented. Octet 6 is optional.

Packets containing this information element shall be acknowledged at layer 2. Annex E contains recommendations concerning interim arrangements for the transmission of this information element. To maintain compatibility with equipments built to earlier editions of this standard, CPPs shall respond correctly if this information element is received in an un-acknowledged packet.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	0	1	0	
	BAS_CAP information element identifier							1
0	0	0	0	0	0	1	1	
length of BAS_CAP information element								2
HSSC	DCAP			MB	ICOM			3
MANIC								4
BASET								5
ENHANCED CFP FEATURES 1								
RFU	RFU	RFU	RFU	RFU	RFU	RFU	DCFP	6

ICOM identifies the intercom capability of the CFP:

Bit:	3 2 1	Significance
	0 0 0	No intercom.
	0 0 1	Tone only page (both directions).
	0 1 0	CFP and CPP speech intercom.
	0 1 1	CPP and CPP speech intercom.
	1 0 0	CFP and CPP, plus CPP and CPP speech intercom.

MB = 0 signifies a CFP with a message buffer size limited to 29 octets at layer three (6 code words max.) and MB = 1 for CFP with full 128 octet capability.

DCAP identifies the CFPs display capabilities as below:

Bit:	3 2 1	Significance
	0 0 0	No display.
	0 0 1	Numeric only display.
	0 1 0	7 segment display.
	0 1 1	Full alphanumeric display.

HSSC indicates high speed signalling capability. HSSC set to 1 denotes the ability to revert to MUX2 signalling from MUX1 without the need for link re-establishment:

Bit:	1	Significance
	0	No high speed signalling capability.
	1	High speed signalling capability available.

MANIC identifies the CFP manufacturer, the value of zero to indicate anonymous. The assignment of MANIC field values is controlled by and registered with the Standard Control Authority body. Specific code allocations are detailed in a separate document (obtainable from the SCA).

BASET indicates the CFP type, as follows:

Bit:	8 7 6 5 4 3 2 1	Significance
	0 0 0 0 x 0 0 0	Domestic CFP.
	0 0 0 0 x 0 0 1	Public access CFP.
	0 0 0 0 x 0 1 0	Plan/key system CFP.
	0 0 0 0 x 0 1 1	PBX.

The x (bit 4) indicates ISDN type:

Bit:	4	Significance
	0	non-ISDN.
	1	ISDN.

DCFP : This bit shall be set if the CFP has the capability to transmit data on the B channel (see annex R). Otherwise set to zero. Data capabilities are further defined in the DAT_CAP and DAT_RES information elements

RFU : Reserved for future use. Set to zero. Allocation is controlled by and registered with the Standard Control Authority."

7.2.12 Character information element (CHAR)

The purpose of the character information element is to convey IA5 characters between the CFP and CPP in both directions. The interpretation of the characters is manufacturer specific.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	0	1	1	1
	character information element identifier							
	length of character information element							2
	IA5 character(s)							3
								etc.

The IA5 characters carried by CHAR are ordered such that a character sequence within CHAR may equivalently be transmitted as a number of successive CHAR messages carrying the same constituent parts, i.e. CHAR('A','B','C') would be equivalent to CHAR('A'), CHAR('B'), CHAR('C').

7.2.13 On-air (de-)registration acknowledge information element (OARAC)

OARAC is transmitted by the CFP on successful completion of the on-air registration/de-registration process (initiated by FA 7,7/8) and conveys the BID field (see subclause 6.4.5). The BID field is set to FFFFH for successful de-registration (or null registration).

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	1	0	0	1
	registration information element identifier							
0	0	0	0	0	0	1	0	
length of registration information element								2
registration base identifier (BID)								3
								4

7.2.14 Parameter set information element (PAR_SET)

PAR_SET is a bi-directional information element used by either the CFP of CPP to change the identified parameter type to the given parameter value at the far end of the link. The parameter type and value are defined in the content field of this information element. Only one parameter can be sent per PAR_SET information element.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	1	1	1	1
	PAR_SET information element identifier							
length of PAR_SET information element								2
parameter type								3
parameter value								4
								etc.

Specific values for parameter type and parameter value are given in subclause 7.4 PAR_SET is a bidirectional information element, but when used with some parameter types it may have meaning in one direction only. Some parameter types may not be changed over the air interface and are therefore not valid for use with the PAR_SET information element. However, they are still valid when used in conjunction with parameter request (PAR_REQ) and parameter response to (PAR_RES) information elements. Usage of each parameter type is given in table 14.

7.2.15 Parameter request information element (PAR_REQ)

PAR_REQ is a bi-directional information element used by either the CFP of CPP to request additional parameters from the other end of the link. The requested parameter type is defined in the content field of this information element. Only one parameter can be requested per PAR_REQ information element.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	1	0	1	1
	PAR_REQ information element identifier							
0	0	0	0	0	0	0	1	
length of PAR_REQ information element								2
requested parameter type								3

Requested parameter types are defined in subclause 7.4.

7.2.16 Parameter response information element (PAR_RES)

PAR_RES is bi-directional information element which forms a response to PAR_REQ and whose content field contains the requested parameter. The content field size is parameter dependent.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	1	1	0	1
	PAR_RES information element identifier							
length of PAR_RES information element								2
response parameter type								3
								etc.

The response parameter type is identical to the associated parameter type in PAR_REQ. If the requested parameter is not recognised, a PAR_RES information element of length one shall be returned.

7.2.17 Alternative authentication request information element (AUTH2_REQ)

This alternative authentication request information element is issued by a CFP to initiate the alternative call authentication process.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	0	0	0	1
	AUTH2_REQ information element identifier							
length of AUTH2_REQ information element								2
AUTH_NO								3
								etc.

AUTH_NO is used to indicate to the CPP which of the authentication algorithms offered by the CPP is to be used, even if the CPP is only capable of performing one authentication process.

7.2.18 Alternative authentication response information element (AUTH2_RES)

This alternative authentication response information element is sent by the CPP in response to an alternative authentication request information element and conveys alternative registration and authentication parameters to the CFP.

The usage of bits 2-8 of octet 4 and any subsequent octets of this information element are dependent on the authentication algorithm in use.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	0	0	1	1
	AUTH2_RES information element identifier							
length of AUTH2_RES information element								2
OPSIC							lsb	3
							msb	4
								etc.

OPSIC is the operator's identification code. Specific code allocations for this field are detailed in a separate document (obtainable from the SCA).

7.2.19 Number of CPPs polled information element (NO_POLL)

This information element may be used during link establishment from a CFP to CPPs to indicate the number of CPPs the CFP is currently polling. During link establishment, this information element can be transmitted unacknowledged by the CFP between fixed format poll code words (subclause 6.6.4). If the CPP is being polled, and if the RES (respond) bit in the information element parameter is set, the CPP is able to establish a link to the CFP before any user action to initiate the link request. (The CPP sends a LINK_REQUEST before the user has accepted the call, and the NULL FA (7,31) after TERM_CAP and BAS_CAP exchange, in order to maintain the correct syntax at layer three. The appropriate FA (e.g. LINE or ICOM) is only sent once the user has pressed the appropriate key on the CPP.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	0	1	0	1
	NO_POLL information element identifier							
0	0	0	0	0	0	0	1	
length of NO_POLL information element								2
RES	number of CPPs being polled							3

RES = 0 prevents the CPP from establishing a link, except by user action, even if the CPP is the only CPP being polled.

RES = 1 allows a CPP to establish a link without user action. The RES bit shall only be set by the CFP when the number of CPPs being polled is one.

7.2.20 Change slot information element (CHANGE_SLOT)

If this information element is supported it shall be indicated to the CFP by the SLT bit and the SLOT_IDENTITY field in the TERM_CAP information element.

On receipt of this information element, the CPP shall change to another slot with the same LID. The CPP may restrict the slot change to a slot of the same type (see subclause 6.4.5.1). If no other slot with the same LID exists, the active slot shall remain unchanged. If several slots with the same LID exist, the CPP shall cycle sequentially through each matching slot in response to further CHANGE_SLOT information elements. LID matching shall only be on LIDs stored in a registration slot and not on a LID stored for any other purpose. After each CHANGE_SLOT information element, the CPP shall respond by sending a TERM_CAP information element.

The contents of the information element (octet 3) shall be 00H.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	1	0	0	0	
	CHANGE_SLOT information element identifier							1
0	0	0	0	0	0	0	1	
length of CHANGE_SLOT information element								2
0	0	0	0	0	0	0	0	
contents of information element								3

NOTE: It is possible for a CPP to have two or more slot registrations with the same LID. Since both slots use the same LID, a CPP could respond to an incoming call by selecting either slot. If handset authentication is to succeed, the CFP must ensure that the correct slot is used. The CPP indicates the slot number to the CFP in the TERM_CAP message.

7.2.21 Network authentication request (NET_AUTH_REQ)

If a CPP enters a mode in which it supports NET_AUTH_REQ and NET_AUTH_RES information elements, then it shall indicate this to the CFP by sending a new TERM_CAP information element with the NA bit set.

Packets containing this information element shall be acknowledged at layer 2.

The network authentication request is issued by the CPP following a (CPP) authentication request with the NAR field set to 1. A CPP may also initiate network authentication without being instructed to do so by the CFP. However, the CPP cannot expect a meaningful response to a NET_AUTH_REQ if it is sent before the CFP has authenticated the CPP. The CFP is not mandated to respond to NET_AUTH_REQ if the CPP has not previously been authenticated. A network authentication sequence shall use the same authentication algorithm used by the CFP to authenticate the CPP.

NOTE: Although the same authentication algorithm is used for both CPP authentication and network authentication, the mechanisms are slightly different, see figureS B.1 and B.2.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	1	0	1	
	NET_AUTH_REQ information element identifier							1
0	0	0	0	0	1	0	0	
length of NET_AUTH_REQ information element								2
RAND								3
								4
								5
								6

RAND is a 32-bit random or non-repeating number generated by the CPP to be used by the CFP in the network authentication process.

7.2.22 Network authentication response (NET_AUTH_RES)

The NET_AUTH_RES information element is sent by the CFP in response to a NET_AUTH_REQ information element and conveys authentication parameters to the CPP. The CFP is not mandated to respond to NET_AUTH_REQ if the CPP has not previously been authenticated. Any NET_AUTH_RES information element from the CFP under these conditions may not be valid.

Packets containing this information element shall be acknowledged at layer 2.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	1	1	0	
	NET_AUTH_RES information element identifier							1
0	0	0	0	0	1	0	0	
length of NET_AUTH_RES information element								2
CKEY								3
								4
								5
								6

CKEY is the 32-bit result of the network authentication process, calculated by the CFP and returned to the CPP for checking.

7.2.23 Terminal registration data allocate information element (TRD_ALLOC)

This information element is issued by the CFP during the Over The Air Registration (OTAR) process. It is used either alone or in conjunction with KEY_ALLOC to transfer authentication and registration parameters to the CPP. LID, AUTH_PREF, OPSIC, TCOS, TRD and ZAP are sent using the TRD_ALLOC information element. The TRD_ALLOC and KEY_ALLOC messages may be sent in any order. No changes to permanently stored registration data shall be made until successful conclusion of the OTAR sequence. This shall be indicated by reception at the CPP of either an AUTH_REQ information element or the INIT information element.

If the AUTH_REQ information element is used to terminate the OTAR process, the contents of the AUTH_PREF field in the TRD_ALLOC information element shall be identical to the contents of the AUTH_NO field in the AUTH_REQ information element.

Packets containing this information element shall be acknowledged at layer 2.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	0	1	1	
	TRD_ALLOC information element identifier							1
0	0	0	0	1	1	1	1	
length of TRD_ALLOC information element								2
LID								3
								4
AUTH_PREF								5
OPSIC								6
ZAP				TCOS				7
TRD (0 - 10 octets)								8
								17

NOTE : TRD (and hence the information element) is shown at its maximum length. The length of TRD may vary from 0 to 10 octets.

LID indicates the new value of LID to be stored in the CPP for use in all future network access attempts using the current slot.

AUTH_PREF is the new value of AUTH_PREF to be stored in the CPP and used in TERM_CAP in all future network access attempts using the current slot.

OPSIC, ZAP, TCOS, TRD are values to be stored in the CPP and used in AUTH_RES and AUTH2_RES in all future network access attempts using the current slot.

7.2.24 Key allocate information element (KEY_ALLOC)

This information element is issued by the CFP during the Over The Air Registration (OTAR) process. It is used either alone or in conjunction with TRD_ALLOC to transfer authentication and registration parameters to the CPP. An updated value of KEY or EPID is sent using the KEY_ALLOC information element. The new values may be sent in clear or encrypted form. The TRD_ALLOC and KEY ALLOC messages may be sent in any order. No changes to permanently stored registration data shall be made until successful conclusion of the OTAR sequence. This shall be indicated by reception at the CPP of either an AUTH_REQ information element or the INIT information element.

If the AUTH_REQ information element is used to terminate the OTAR process, the contents of the AUTH_NO field in the AUTH_REQ information element shall be identical to the contents of the AUTH_PREF field in the TRD_ALLOC information element (if transmitted by the CFP). If no TRD_ALLOC information element has been received by the CPP as part of a first time registration, then the CPP's behaviour may be indeterminate in this case.

Packets containing this information element shall be acknowledged at layer 2.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	0	1	0	0	
	KEY_ALLOC information element identifier							1
0	0	0	1	0	0	1	0	
length of KEY_ALLOC information element								2
USE (8 bits)								3
RFU	RFU	RFU	RFU	RFU	RFU	TYP	ENC	
OTAR_NO								4
EKEY1 (4 octets)								5-8
EKEY2 (4 octets)								9-12
EKEY3 (8 octets)								13-20

TYP indicates whether the information element contains new EPID data (TYP=1) or new KEY data (TYP=0)

ENC indicates whether the data is encrypted (ENC=1) or clear (ENC=0).

OTAR_NO indicates the decryption algorithm to be used to decrypt the data if ENC=1. The assignment of values is controlled by and registered with the Standard Control Authority. Specific bit allocations are detailed in a separate document (obtainable from the SCA).

Each different authentication or decryption algorithm is assigned a value in the range 1 to 24. For example, suppose a particular decryption algorithm is assigned a value x by the Standard Control Authority. If the CFP wishes to instruct the CPP to use decryption algorithm x, then it shall set the value of OTAR_NO in KEY_ALLOC to x. Support by the CPP for a particular decryption algorithm shall be indicated to the CFP by setting the appropriate bit, i.e. bit x (the least significant bit is bit 1), of the (24 bit) AUTH_KEY field in the TERM_CAP information element. Where more than one algorithm is supported, this shall be indicated by setting each relevant bit of the AUTH_KEY field. The relationship between OTAR_NO and AUTH_KEY is identical to the relationship between AUTH_NO and AUTH_KEY (see subclause 7.2.10).

EKEY1, EKEY2 are arguments to be used in the decryption algorithm. If the data is sent in clear form, these fields shall be set to zero.

EKEY3 contains the new value of EPID or KEY in encrypted or clear form to be stored in the CPP and used in future OTAR registration sequences (EPID) or in future CPP or network authentication sequences (KEY).

7.2.25 Location registration parameters information element (LR_PARAMS)

The LR_PARAMS information element shall only be sent to a CPP which the CFP has determined to support the information element from the LRP field in TERM_CAP (see subclause 7.2.10).

A CPP supporting this information element shall also be capable of monitoring CIS transmissions and transmitting relocation registration requests as detailed in subclause 6.8.2.

For the purposes of this subclause the term CFP may be taken to mean either a single CFP or a group of CFPs which are interconnected to enable location tracking of CPPs over a larger area.

The LR_PARAMS information element may be used by a CFP to inform a CPP of the circumstances under which it should send relocation registration requests. Specifically this information element:

a) instructs a CPP to monitor for CIS transmissions from the specified service (identified by LID and LAI) for a specified period; and

b) grants a CPP permission to transmit relocation registration requests subject to the provisions of subclause 6.8.2.4; and

c) supplies the value of LID which the CFP may subsequently use in ID_OK location tracking transmissions (see subclause 6.8.2.2); and

d) supplies an initial value of Location Area Identifier and system LID.

This information element may be sent by any CFP which provides an incoming calling service.

The LR_PARAMS information element may be sent in response to the reception of an initial location registration request FA 3,31.

The LR_PARAMS message may be sent at other times, but the CFP shall not send the LR_PARAMS information element to a CPP unless it has received at least one initial location registration request FA 3,31 from that CPP.

The CFP shall send an LR_PARAMS message in response to a relocation registration message from a CPP.

Bit: 8	7	6	5	4	3	2	1	octet
0	0 0 1 1 0 0 1 LR_PARAMS information element identifier							1
0 0 0 0 0 1 1 0 length of LR_PARAMS information element								2
PERIOD_UNIT		PERIOD_OF_SERVICE						3
LOCATION_AREA_IDENTIFIER								4
LID lsb								5
msb								6
LR_POLL_LID lsb								7
msb								8

PERIOD_OF_SERVICE: the PERIOD_OF_SERVICE (together with the PERIOD_UNIT) indicates how long the location registration shall remain in force.

The CPP shall, subject to the provisions of subclause 6.8.2.4, send relocation registrations (FA 3,29) within the PERIOD_OF_SERVICE, provided no user action has terminated the service.

The CPP may operate a timer in order to be able to determine the PERIOD_OF_SERVICE remaining and to determine when the PERIOD _OF_SERVICE has expired. Where such a timer is supported, the CPP shall not transmit relocation registration requests after the expiry of the timer.

0 If a value of 0 is received the location registration request or relocation registration request has been denied or terminated. The CPP shall not automatically send further relocation registration messages (FA 3,29).

1-60 If any value between 1 and 60, inclusive, is received, the PERIOD_OF_SERVICE shall be that number of PERIOD_UNITs.

61 If a value of 61 is received the CPP shall not alter the value of the PERIOD_OF_SERVICE and shall ignore the contents of PERIOD_UNIT. This value shall only be sent to a CPP which is already location registered to the CFP and shall not be sent if the PERIOD_OF_SERVICE conveyed in a previous LR_PARAMS message has expired.

62 If a value of 62 is received the location registration request or relocation registration request has been denied. The CPP shall not automatically send further location registration or relocation registration messages. This shall apply to the current registration slot until the CPP is reset or a manual location registration is made using that registration slot.

63 If a value of 63 is used then the PERIOD_OF_SERVICE shall be indefinite.

PERIOD_UNIT: The units of time in which the PERIOD_OF_SERVICE is expressed.

0	Minutes
1	Hours
2	Days
3	Reserved for Future Use.

LOCATION_AREA_IDENTIFIER: This is Location Area Identifier of the area in which the CPP has location registered. This is the initial value of LAI which the CPP shall compare with the LAI in received CIS codewords in order to determine when to transmit relocation registration requests FA 3,29 (see subclause 6.8.2.4).

LID: This identifies the system LID of the CFP transmitting the CIS codewords which are to be monitored

NOTE: A CPP which makes a link to an operator other than his home operator, using a 2N+1 (roaming access) LID could (manually) location register and then track the CIS transmissions of that operator if the LID is known.

LR_POLL_LID: The CFP may use the Location Registration Poll LID value for the purposes of polling CPPs in conjunction with CIS transmissions (see subclause 6.8.2.2) within the PERIOD_OF_SERVICE. This field shall not contain the end point identification used for CPP call set-up. The field may contain any other value in the range 0401 - FFFE Hex. This LR_POLL_LID shall not be used for call establishment by the CFP or the CPP.

7.2.26 Polling Lid information element (POLLING_LID)

If a CPP enters a mode in which this information element is supported it shall be indicated to the CFP by the PL bit in TERM_CAP (see subclause 7.2.10).

Packets containing this information element shall be acknowledged at layer 2.

A CFP may use the POLLING LID information element to convey an auxiliary LID value (LT_POLLING_LID - Location Tracking Polling LID) to a CPP. The CFP may use the LT_POLLING_LID in conjunction with the CFP polling procedure of subclauses 6.6.3 and 6.6.4 in order to determine whether or not particular CPPs are within range. Where a CFP assigns an LT_POLLING_LID to a CPP using this information element, it shall be different to the LID used for normal call setup to the CPP. The field may contain any other value in the range 0401 - FFFE Hex. The LT_POLLING_LID should not be used for call establishment, by the CFP or the CPP.

It is recommended that CPPs provide storage for LT_POLLING_LID for each registration slot. If storage for LT_POLLING_LID is provided, this shall be in non-volatile memory.

Bit: 8	7	6	5	4	3	2	1	octet
0	0 POLLING_LID information element identifier	0	1	0	1	1	1	1
0	0	0	0	0	0	1	0	2
length of POLLING_LID information element								
LT_POLLING_LID							lsb	3
msb								4

7.2.27 Data bearer capability information element (DAT_CAP)

The data bearer capability information element shall be issued by the originator of the call (DCFP or DCPP) following link establishment and before connection of the B channel. The DAT_CAP information is a statement of the capabilities of the DCFP or DCPP and the services requested.

The DAT_CAP information element may be sent during a voice call to confirm end to end data compatibility prior to initiating a switch to data mode (see annex R, subclause R.5.3).

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	1	0	1	0	1
	DAT_CAP information element identifier							
0	0	0	0	0	0	1	1	2
length of DAT_CAP information element								
FLO			CHAR		SVC			3
RFU	RFU	RFU	RFU	E	RATE_PREF			4
RATE								5

RFU reserved for future use. Set to 0.

SVC is a three-bit field specifying the end-user service. Defined values are:

000	Reserved
001	Asynchronous Data
010	Synchronous (transparent) data
011	Reserved
100	Reserved
101	Reserved
110	Reserved
111	Reserved

FLO identifies, for the asynchronous data service, the flow control mechanism to be utilized across the air interface:

000	no flow control (over run characters are lost)
001	XON and XOFF characters inserted and interpreted
010	interface signal leads (CCITT Recommendation V.24 [26])

For data services other than the asynchronous data service, FLO shall be set to 000.

CHAR identifies, for the asynchronous data service, the length of the characters being transported. The following combinations are supported:

CHAR	Description	
01	5 bits no parity	
10	6 bits no parity,	5 bits with parity
11	7 bits no parity,	6 bits with parity
00	8 bits no parity,	7 bits with parity

In all cases a single stop bit shall be provided, and no parity shall be provided with 8 bit characters.

For data services other than the asynchronous data service, CHAR shall be set to 00.

E identifies calls for which there is associated CCITT Recommendation V.24 [26] line control signalling information (even if the control leads are not used for flow control):

0	No CCITT Recommendation V.24 [26] line control signalling information
1	CCITT Recommendation V.24 [26] line control signalling information present

RATE is an eight bit bit-mapped field used to indicate to a DCPP (DCFP) what data rates the DCFP (DCPP) is capable of performing.

RATE_PREF is a three-bit field used by the DCFP (DCPP) to indicate to a DCPP (DCFP) which one of the data rates offered by the DCFP (DCPP) is the DCFP's (DCPP's) preferred rate. If only one data rate is offered, this shall be indicated as the preferred data rate in this field.

Data Rate	RATE	RATE_PREF
300 bits/s	00000001	000
1200 bits/s	00000010	001
2400 bits/s	00000100	010
4800 bits/s	00001000	011
9600 bits/s	00010000	100
14400 bits/s	00100000	101
19200 bits/s	01000000	110
32000 bits/s	10000000	111

NOTE: All field values other than those specified above are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.2.28 Data bearer response information element (DAT_RES)

This information element shall be sent by the DCPP (DCFP) in response to a data bearer capability information element issued by the DCFP (DCPP).

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	1	1	0	1	1	1
	DAT_RES information element identifier							
0	0	0	0	0	0	1	0	2
length of DAT_RES information element								
FLO			CHAR		SVC			3
RFU	RFU	RFU	RFU	E	RATE_PREF			4

RFU reserved for future use. Set to 0.

FLO, CHAR, SVC, E shall have the same meaning as in DAT_CAP (see subclause 7.2.27).

RATE_PREF shall be used to indicate to the DCFP (DCPP) which of the data rates offered by the DCFP (DCPP) shall be used.

The relationship between the various messages, parameters and fields (e.g., RATE_PREF and RATE) shall be similar to the relationships used to select an authentication algorithm and is illustrated, by way of example, in subclause 7.2.10.

If after the exchange of capability parameters, there is no mutually acceptable mode, a DAT_RES message with all parameters set to zero shall be used to indicate no match of capabilities and shall cause abandonment of the call establishment procedure.

DAT_RES and DAT_CAP shall only be considered mutually acceptable when the following conditions are met:

1) the fields E, FLO, CHAR and SVC match exactly;

2) the RATE_PREF field in DAT_RES matches a declared data rate in the RATE field of DAT_CAP; and

3) if the FLO fields identify a link using CCITT Recommendation V.24 [26] interface signalling leads, the E fields declare that CCITT Recommendation V.24 [26] control lead signalling information is present.

NOTE: All field values other than those specified above are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.3 Layer three mandatory syntax

7.3.1 Access to layer three

At a CPP, access to layer three shall require that layer two has been initialised; that, subsequently, TERM_CAP and BAS_CAP information elements have been exchanged; and that the current BAS_CAP is acceptable.

At a CFP, access to a session at layer three shall require that layer two has been initialised; that, subsequently, TERM_CAP and BAS_CAP information elements have been exchanged, that the current TERM_CAP is acceptable and that an acceptable FA has been received from the CPP.

7.3.2 Exit from layer three

At a CPP, exit from layer three shall occur in response to the termination of layer two; to the receipt of INIT from the CFP; or to an attempt to access layer three with an unacceptable BAS_CAP.

At a CFP, exit from all sessions at layer three shall occur in response to the termination of layer two; to the receipt of CLEAR from the CPP; to an attempt to access a session at layer three with an unacceptable TERM_CAP; or to an attempt to access a session at layer three with an unacceptable FA when no previous session exists.

7.3.3 Emergency access

If emergency access is provided in a CFP then the CFP shall accept access to layer two via an emergency LID followed by access to layer three via an emergency FA.

The CFP may refuse to accept an emergency access FA at layer three initialisation if access to layer two was not via an emergency LID.

If the CFP provides emergency access from the "call in progress" state (see annex A) then it shall accept the sequence PARTIAL RELEASE followed by an emergency FA.

NOTE: Permitting non-emergency follow-on calls after emergency access to layer three may cause a breach of security.

7.3.4 On-air registration

If on-air registration is provided in a CFP then the CFP shall, as a minimum, accept access to layer two via the ID registration LID followed by access to layer three via the on-air registration FA and shall provide confirmation of successful completion of the registration via the on-air registration acknowledge information element.

7.4 Parameter values for PAR_SET, PAR_REQ, PAR_RES

The parameter types and parameter values to be used with PAR_SET, PAR_REQ and PAR_RES are detailed below. PAR_REQ, PAR_RES and PAR_SET are bidirectional information elements, but when used with some parameter types they may have meaning in one direction only. Some parameter types may not be changed over the air interface and are therefore not valid with PAR_SET information element. However, they are still valid when used in conjunction with parameter request (PAR_REQ) and parameter response (PAR_RES) information elements. Some parameter types may be changed by the user via the keypad interface. The exact keypad sequence for these parameter changes is implementation dependent. Usage of each parameter type shall be as defined in table 14.

Table 14: Parameter types and their usage

Parameter Type	Parameter Name	Bit: 87654321	PAR_SET accepted by:	Directly Changeable via keypad
0	Class of Service	00000000	CPP	NO
1	Extension no.	00000001	CPP	NO
2	Lang. preference	00000010	Neither	YES
3	Display	00000011	Neither	NO
4	Parameter list	00000100	Neither	NO
5	Preferred channels	00000101	CPP	NO

NOTE: All other types (6 to 255) are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

7.4.1 Parameter type = 0; class of service

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	e	d	c	b	a	
parameter value								4

Value	Significance
a = 1	intercom permitted.
b = 1	local calls permitted.
c = 1	national calls permitted.
d = 1	international calls permitted.
e = 1	one (predefined) hotline number is accessed automatically by the CFP.

7.4.2 Parameter type = 1; extension number (BCD)

Bit: 8	7	6	5	4	3	2	1	octet
MSBCD digit				LSBCD digit				
parameter value								4

7.4.3 Parameter type = 2; language preference

This parameter type enables a CFP to determine a users preferred language. This may be used if the CFP provides voice guidance messages.

Bit: 8 7 6 5 4 3 2 1	octet
Most preferred language - first character	4
Most preferred language - second character	5
2nd preferred language - first character	6
2nd preferred language - second character	7
nth preferred language - first character	2n+2
nth preferred language - second character	2n+3

The most preferred language shall be specified in the first pair of octets in the parameter value field, the mth most preferred language shall be specified in the mth pair of octets in the parameter value field. A maximum of 13 preferred languages may be specified. The encoding of the language shall be by two IA5 characters corresponding to the preferred language as defined in annex M. The first character of the language code shall be transmitted in the lower numbered octet followed by the second character in the next octet. If the CFP is unable to support any of the preferred languages, it shall revert to a "default" language. If the desired language code is 0000H (i.e. IA5 NUL characters), this shall be interpreted as the default language. The default language should be a language generally used in the region where the CFP is located. If a CPP supports language preference, but no preferred language has been stored, the CPP shall return a default value of 0000H (anonymous/null). The case of the stored characters shall be that specified in annex M.

7.4.4 Parameter type = 3; enhanced display

This parameter provides information on enhanced display capabilities. The enhanced display shall come under the control of the CFP whilst the link is active.

The data fields of the PAR_RES information element shall be coded as follows:

Bit: 8 7 6 5 4 3 2 1	octet
Number of stored display characters (least sig byte)	4
Number of stored display characters (most sig byte)	5
Number of lines in the (physical) display	6
Number of characters per line	7
Display behaviour field	8

Valid values for the number of stored display characters shall be in the range 0 to 65535. A value of 0 shall be indicated if the CPP has no display capability.

Valid values for the number of lines in the display shall be in the range 0 to 255. Values in the range 1 to 255 shall indicate the number of lines in the display. A value of 0 shall indicate no display capability in line with the declaration of TERM_CAP (7.2.10) or BAS_CAP (7.2.11).

Valid values for the number of characters per line shall be in the range 0 to 255. Values in the range 1 to 255 shall indicate the number of characters per line. A value of 0 shall indicate no display capability in line with the declaration of TERM_CAP (7.2.10) or BAS_CAP (7.2.11)."

Valid values for the display behaviour field shall be in the range 0 to 255. A value of zero shall be declared if the display is not declared to be compliant with one of the behaviour types. Definition of display behaviours is controlled by and registered with the Standard Control Authority.

NOTE: Behaviour types 3 to 255 are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority.

7.4.4.1 Display Behaviour types

Display behaviour type =1 and 2

If a CPP supports PAR_REQ with type=3, and indicates display behaviour type=1 or 2, then its display shall conform to the following behaviour.

The only difference between display behaviours types 1 and 2 is the type of scrolling (by character, line or page).

7.4.4.2 Minimum character set

CPPs indicating this display behaviour type shall, as a minimum, support the following cursor control codes:

- STX Return home;
- ETX Return end;
- FF Clear display;
- CR Return to beginning of current row;
- LF Move down one row;
- VT Move up one row;
- SUB Clear to end of line (maintain cursor position);
- EM Clear to end of display (maintain cursor position);

7.4.4.3 Display mapping

When the amount of stored display data exceeds the size of the physical display, the display shall be able to show sections (windows) of the stored data. If the window starts at character x in the stored display, the xth character shall appear at the home position of the display and the (np -1) subsequent characters shall be mapped, line by line, sequentially to the rest of the display (where n is the number of lines in the display and p is the number of characters per line). The allowed window positions determine whether the display scrolls by character, by line or by page.

7.4.4.4 Scrolling behaviour and window origins

If the display has only one row and supports display behaviour type = 1 then it shall scroll by character.

If the display has more than one row and supports display behaviour type = 1 then it shall scroll by line.

If the display has only one row and supports display behaviour type = 2 then it shall scroll by page.

NOTE: There is no distinction between line and page scrolling in a single line display.

If the display has more than one row and supports display behaviour type = 2 then it shall scroll by page.

The scrolling behaviour is summarised in the following table:

Table 15: Display scrolling behaviour

	Display behaviour type = 1	Display behaviour type = 2
Single line display	scroll by character	scroll by page (see NOTE above)
Multi line display	scroll by line	scroll by page

A CPP display which scrolls may set its window origin as shown in the following table. The first stored character is character 1.

Table 16: Allowed window origins

Scroll type	Character	Line	Page
Window origin	1	1	1
	2	p+1	np+1
	3	2p+1	2np+1
	.	.	.
	.	.	.
	etc	etc	etc

where n is the number of lines in the display and p is the number of characters per line.

7.4.4.5 Display behaviour

The effect of changing the display is to over-write existing characters. It is not possible to insert characters.

The action of the DISP information element FF shall be to clear the entire stored display and reset the display window and cursor to the first stored character.

The action of the DISP information element STX shall be to reset the display window and cursor to the first stored character.

The action of the DISP information element ETX shall be to move the cursor to the end of the current display window. Any further displayable characters shall cause the display to scroll.

When a line is filled, further characters will be displayed at the beginning of a new line. A CR/LF sequence should not be sent unless a line is terminated before the end of the display line.

The cursor (indicating where the next displayable character will appear) should normally be within the visible window. However, when the display is filled, the displayed characters shall remain until a further display character is received, i.e. the cursor may not be within the visible window. When another display character is received, the CPP shall move the window origin by one character, line or page as appropriate. (The character insert position within the stored display does not change.) The newly received characters are then displayed.

If the cursor is moved backwards or upwards through the display, the display shall scroll up (by character, line or page) when the cursor moves off the top of the screen. In upwards scrolling the cursor shall remain visible within the display window.

Manufacturers may incorporate automatic techniques to change display windows or may provide key sequences to allow the user to move the display windows In either case this shall not affect the position in the stored display at which further characters are stored and the CPP shall remember the window origin prior to the action. Immediately following the receipt of a further DISP character, the CPP shall reset its display to the window position prior to the action and the DISP character shall be actioned as normal.

When the CFP sends messages to the display (other than echoing back KPs), it should ensure that the capacity of the stored display is not exceeded. If the end of the stored display is reached, further characters shall be displayed but the subsequent behaviour of the display may be unpredictable.

7.4.5 Parameter type = 4; Parameter List

This parameter type enables a CFP or a CPP to determine the others support of the full 256 parameter types definable within this standard in a simple efficient method reported across the air interface. This parameter type is optional, but if implemented shall conform to the complete requirements of this specification.

The Parameter List parameter type transports a statement of support for the parameters in blocks of 16. Each block of parameters may be specifically requested or transmitted en mass.

The PAR_REQ information element for the Parameter List parameter type is as follows :

Bit: 8	7	6	5	4	3	2	1	octet
RFU	RFU	RFU	Block number					4

On receipt of a PAR_REQ with a block number in the range 0 - 15, the receiving unit shall transmit a PAR_RES for that requested block (see below).

On receipt of a PAR_REQ with a block number of 16, the receiving unit shall transmit a PAR_RES information element for block 0 (parameters 0 - 15), and shall also transmit a PAR_RES information element for block 15 (parameters 240 - 255). It shall also transmit PAR_RES information elements for every other block that has a supported parameter to be declared. Blocks specifying no support of any of the parameters may be omitted. Blocks shall be transmitted in strict ascending numerical order (i.e. block 0 first and block 15 last).

Block numbers 17 - 31 are reserved for future allocation and if received shall be ignored. Allocation is controlled and registered with the Standard Control Authority body.

The RFU bits are reserved for future allocation and shall be transmitted as zeros. They shall be ignored on receipt. Allocation is controlled and registered with the Standard Control Authority body.

The PAR_SET message, if received shall be ignored.

The PAR_RES information element for the Parameter List parameter type is as follows :

Bit: 8	7	6	5	4	3	2	1	octet
RFU	RFU	RFU	Block number					4
Parameter value (0)								5
Parameter value (1)								6

The block number is defined above for PAR_REQ. Each PAR_RES (Parameter List) information element for block n states the support or otherwise for parameters numbered in the range from 16n to 16n + 15.

Block numbers 16 - 31 are reserved for future allocation and if received shall be ignored. Allocation is controlled and registered with the Standard Control Authority body.

Bit i of parameter value (0 <= i <= 15) shall be set to a 1 if parameter (16n + i) is supported and 0 otherwise (n is the block number : 0 <= n <= 15). Bit 0 represents the least significant bit of octet 5 and bit 15 the most significant bit of octet 6. Bits are numbered sequentially from right to left.

NOTE: The Parameter List parameter map is not directly changeable via the keypad. However, a product feature that affects the support or otherwise of a parameter may be enabled or disabled from the keypad. It is not possible to determine whether the value of a parameter has been changed nor the value to which a parameter has been changed by the Parameter List mechanism. This information is available in the normal way using a PAR_REQ / PAR_RES exchange for the required parameter type.

If a unit causes a parameter to change its supported state (i.e. become supported if previously it was declared unsupported or vice-versa), then that unit shall send a PAR_RES (Parameter List) information element to the part with which it is in communication including at least those blocks that are changed.

7.4.6 Parameter type = 5; Preferred channels

Bit: 8	7	6	5	4	3	2	1	octet
8	7	6	5	4	3	2	1	4
16	15	14	13	12	11	10	9	5
24	23	22	21	20	19	18	17	6
32	31	30	29	28	27	26	25	7
40	39	38	37	36	35	34	33	8

Each bit position in octets 4 to 8 represents one of the 40 RF channels. A preferred channel is indicated by setting the corresponding bit to 1.

The CFP may transmit, to the CPP, the list of preferred channels which may be used preferentially for call set up by the CFP or CPP whilst in accordance with subclauses 4.2.1, 4.4 and 4.9.

8 Speech coding and telephony

This clause specifies the requirements for cordless telephone apparatus capable of transmission of analogue information over the CT2 common air interface B channel.

In order to ensure satisfactory interworking of different CPPs and CFPs it is necessary to specify the performance of the analogue information transmitted via the B channel over the digital link. This requires not only use of a common speech algorithm, but standardisation of frequency responses, notional reference speech levels (or loudness) at the air interface, and various other parameters.

A single transmission plan is proposed where characteristics are lumped into ideal elements.

This clause proposes a method using reference transceivers for frequency sensitivity measurements suitable for a common air interface meeting the requirements of the CT2 specifications.

The sum of the speech sub-paths in the CPP and the CFP (i.e. the combined speech paths from audio interfaces to the telephone line interface) is specified by the appropriate national standard. This document defines the send and receive speech sub-paths between the audio interfaces and the air interface for the CPP only. Send and receive sub-paths, in the CFP, between the air interface and the telephone line interface may be derived by subtraction of the (specified) CPP send and receive sub-paths from the speech paths specified in the appropriate national standard.

8.1 Definitions

8.1.1 Cordless Portable Part (CPP)

A portable part of the cordless telephone apparatus which, by integral radio and aerial means and in conjunction with an associated cordless fixed part, permits some or all of the functions of normal telephone apparatus including manual initiation and termination of calls by a deliberate act.

8.1.2 Fixed geometry CPP

A CPP in which the electro-acoustic transducers and their associated acoustic components are held in fixed relative positions and/or orientations during all on-line conditions of the CPP.

8.1.3 Variable geometry CPP

A CPP that allows the position and/or orientation of its electro-acoustic transducers and their associated components to be changed during all on-line conditions of the CPP.

8.1.4 CAI ADPCM voice codec (CIC = 0)

The ADPCM voice codec algorithm shall be in accordance with CCITT Recommendation G.721 [6]. The codec in a CPP and in a CFP which provides an analogue speech connection may be of reduced specification in that the functions in CCITT Recommendation G.721 [6] associated with the compressed PCM interfaces (PCM format conversion and synchronous tandem coding adjustment) may be omitted. In a CFP which provides a digital speech connection the full algorithm in CCITT Recommendation G.721 [6] shall be used. Annex E contains recommendations concerning interim arrangements for portable part codecs.

8.2 Speech transmission algorithm

8.2.1 Speech coding algorithm

The speech coding algorithm corresponding to CIC = 0 (see subclause 7.2.10) shall comply with the definitions in subclause 8.1.4.

Compliance shall be by supplier's declaration.

8.2.2 Codec for public access CFP

A public access CFP shall contain a codec that conforms to CCITT Recommendation G.721 [6].

Compliance shall be by supplier's declaration.

8.3 Bit transmission sequence

The sixteen complete ADPCM words comprising each burst shall be transmitted in chronological order, and with the most significant bit transmitted first within each word.

Compliance shall be by supplier's declaration.

8.4 Frequency responses

To allow total compliance with national standard for any combination of CPP and CFP, the sum of the CPP to CAI and CAI to CFP telephone line frequency responses shall meet the appropriate published national requirements.

8.4.1 Sending frequency response

The CPP sending frequency response (from MRP to CAI) shall be below the upper limit and above the lower limit defined in table 17 and shown in figure 18.

Table 17: Co-ordinates of sending response limit curves

Limit curve	Frequency Hz	Sending response dB(arbitrary level)
Upper limit	100 200 3400 4000	-18 - 5 + 2 0
Lower limit	300 300 1000 3000 3400 3400	-inf -12 - 5 - 6 - 8 -inf

The limit curves shall be determined by straight lines joining successive co-ordinates given in the table, when frequency response is plotted on a linear scale against frequency on a logarithmic scale.

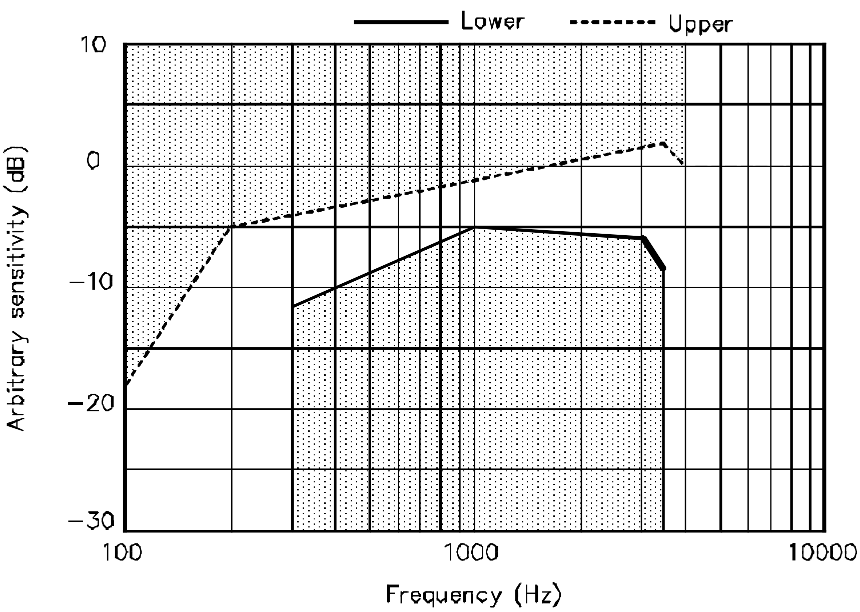


Figure 18: Sending frequency response mask

Compliance shall be checked by the test described in subclause 11.4.

8.4.2 Receiving frequency response

The CPP receiving frequency response (from CAI to ERP) shall be below the upper limit and above the lower limit defined in table 18 and shown in figure 19.

Table 18: Co-ordinates of receiving response limit curves

Limit curve	Frequency Hz	Receiving response dB(arbitrary level)
Upper limit	100 160 300 1000 3000 4000	-18 - 5 0 0 + 2 + 2
Lower limit	300 300 500 3000 3400 3400	-inf - 8 - 4 - 4 - 8 -inf

The limit curves shall be determined by straight lines joining successive co-ordinates given in the table, when frequency response is plotted on a linear scale against frequency on a logarithmic scale.

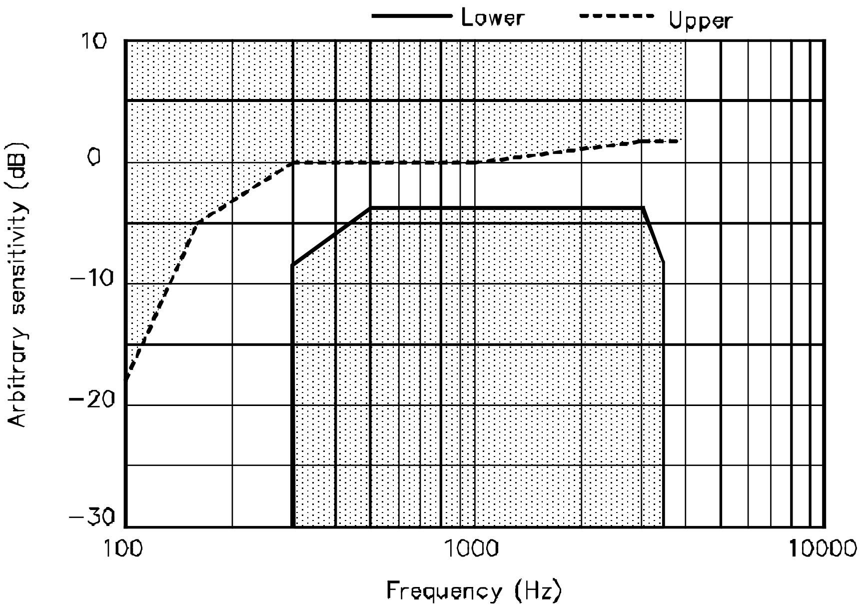


Figure 19: Receiving frequency response mask

Compliance shall be checked by the test described in subclause 11.5.

8.5 Digital signal level

The "level" of the digital signal at the uniform PCM interface is defined in dBm0. A 1,020 kHz sine wave whose peak signal corresponds with the maximum PCM code is assigned a level of +3,14 dBm0 (CCITT Recommendation G.711 [15]). The "impedance" associated with signals at a digital interface shall be 600 ohms. Hence 0 dBm0 corresponds to 775 mV rms or -2,2 dBV.

8.6 Sending and receiving loudness ratings

Two loudness ratings are defined: the CPP loudness ratings (SLRH, RLRH) between the acoustic reference points and the uniform PCM interface.

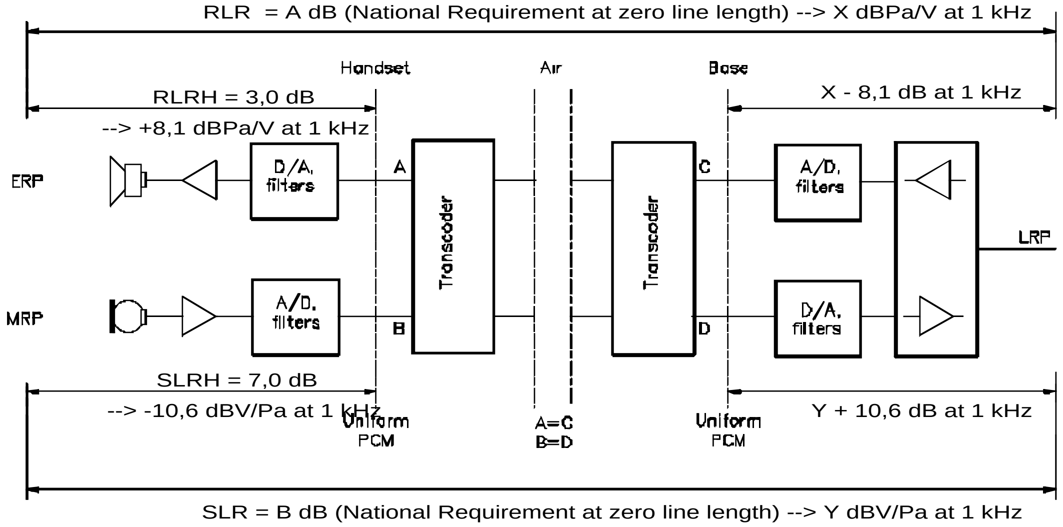
The loudness ratings shall be within the following limits:

1) the CPP send loudness rating (SLRH) shall be 7,0 dB ± 3,0 dB; and

2) if the CPP is not fitted with a user-controlled receiving volume control, the CPP receive loudness rating (RLRH) shall be 3,0 dB ± 3,0 dB;

3) if the CPP is fitted with a user-controlled receiving volume control, the maximum CPP receive loudness rating (RLRH) shall not exceed -7,0 dB ± 3,0 dB. For at least one position of the receiving volume control, the RLRH shall meet the specification for a CPP not fitted with a user-controlled receiving volume control. Compliance with specifications shall be checked with the volume control set at maximum unless otherwise stated.

The SLRH and RLRH shall be checked as described in subclauses 11.6 and 11.7 of this specification.



NOTE 1: Line interface gains are for zero line length.

NOTE 2: Any companding/CODEC functions are contained within the "A/D, filters" blocks.

NOTE 3: National frequency response adjustments may be made in the "A/D, filters" blocks in the CFP.

Figure 20: CAI high-level transmission plan

For guidance, an equivalent high level transmission plan, derived from the specified RLRH and SLRH and a national specification, showing nominal 1 kHz levels, is shown in figure 20. The nominal send and receive sensitivities from acoustic reference points to CAI are:

1) send sensitivity at nominally 1 kHz (MRP to CAI) of -10,6 dBV/Pa; and

2) receive sensitivity at nominally 1 kHz (CAI to ERP) of +8,1 dBPa/V.

8.6.1 CPP ambient noise rejection

The single figure DELSM for a CPP should be ≥ 3 dB. This means that the CPP should be at least 3 dB more sensitive to speech than to ambient acoustic noise. The CPP should meet this requirement for all settings of the receiver volume control.

Compliance should be checked by the test described in subclause 11.25.

8.7 Sidetone loudness ratings

8.7.1 Sidetone for analogue telephony

When the speech path between the CPP and the analogue telephone line connection at the associated CFP is established, negligible local sidetone shall be provided within the handset. Sidetone shall be provided by the CFP.

8.7.2 Sidetone for digital telephony

For operation of the CPP with a "digital" CFP, sidetone shall be provided locally within the CPP. This shall be under control of the layer three signalling message as defined in subclause 7.2.6.

8.7.2.1 Talker sidetone

The value of the SideTone Masking Rating (STMR) shall be within the range 13 dB ± 5 dB.

Where a user-controlled receiving volume control is provided, the STMR shall meet the above requirement at the volume control setting where the RLRH is at the nominal value.

Compliance shall be checked by the test described in subclause 11.8.

NOTE: It is recommended that the sidetone level is independent of the receiving volume control.

8.7.2.2 Listener sidetone

The value of the listener sidetone ratio shall not be less than 15 dB.

Where a user-controlled receiving volume control is provided, the LSTR shall meet the above requirement at the volume control setting where the RLRH is at the nominal value.

Compliance shall be checked by the test described in subclause 11.22.

8.8 Clipping

The apparatus shall be designed such that clipping occurs by "saturation" of the digital speech encoding function.

8.9 Distortion

NOTE: CT2 apparatus containing ADPCM processing will by its nature cause some distortion of signals transmitted over the speech channel. It cannot therefore be expected that such apparatus meet the same requirements for distortion as apparatus which does not utilise ADPCM processing.

ETS 300 085 [7] expects only 1 QDU of distortion (CCITT Recommendation G.711 [15]), rather than 3,5 QDU (CCITT Recommendations G.113 [17] and G.721 [6]) which CT2 apparatus will in reality produce. Similarly apparatus which includes ADPCM processing may not be able to meet the linearity requirements for apparatus designed to meet CCITT Recommendation G.711 [15] only. To ensure there is no gross distortion contributed by the analogue circuitry, the following tests are included.

8.9.1 Sending distortion

For a pure tone of nominal frequency 1 kHz and level -4,7 dBPa applied at the MRP, the ratio of signal to total distortion (harmonic and quantising) shall be not less than 35 dB.

Compliance shall be checked by the test of subclause 11.9.

8.9.2 Receiving distortion

For a pure tone of nominal frequency 1 kHz applied at the reference CFP so as to produce a level of -10 dBm0 at the uniform PCM interface, the ratio of signal to total distortion (harmonic and quantising) measured at the ERP shall be not less than 35 dB.

Compliance shall be checked by the test of subclause 11.10.

8.9.3 Sidetone distortion

The third harmonic distortion generated by the terminal equipment shall not be greater than 10%.

Compliance shall be checked by the test of subclause 11.23.

8.10 Noise

8.10.1 Sending

The noise produced by the apparatus in the sending direction shall not exceed -68 dBm0p (psophometric weighting).

Compliance shall be checked by the test of subclause 11.11.

8.10.2 Sending (narrow-band noise)

The narrow-band noise produced by the apparatus in the sending direction and contained within any 10 Hz bandwidth between the frequency limits 300 Hz to 3400 Hz, shall not exceed -73 dBm0.

Compliance shall be checked by the test of subclause 11.12.

8.10.3 Receiving

The noise produced by the apparatus under test and measured at the ERP shall not exceed -60 dBPa A-weighted. If the apparatus is fitted with a user-controlled receiving volume control, the requirement shall be met for the volume control setting for which the RLRH is equal to the nominal value.

Compliance shall be checked by the test of subclause 11.13.

8.11 Delay

Due to the burst nature of the CT2 transmission, the total "loop" delay is a combination of conventional analogue delays of transducers, filters etc. and the digital delay caused by the burst structure. In order to ensure different types of CPP can interwork with different types of CFP, it is necessary to define the delay of the CPP and the delay in the CFP.

8.11.1 CPP delay

The CPP audio group delay shall not exceed 2,75 ms.

The measured delay between commencement of an acoustic input at the CPP and its arrival at the receiving reference point of the CPP when operating with a reference CFP, shall be averaged over the frequency range 500 Hz to 2500 Hz. This delay shall not exceed the sum of 2,75 ms plus the delay caused by the reference CFP in looping back the ADPCM (digital) signal.

Compliance shall be checked by the method given in subclause 11.14.

8.11.2 CFP delay

When measured with the worst-case CPP permitted under 8.11.1 the CFP shall meet the following requirement. The sum of the delay from MRP to the line interface and the delay from the line interface to the ERP shall not exceed 5,0 ms when averaged over the frequency range 500 Hz to 2500 Hz.

Compliance shall be checked by manufacturer's declaration.

8.11.3 Network echo from a CFP with a 2-wire analogue interface

Informative annex L contains information relating to network echo from a CFP with a 2-wire analogue interface.

8.12 Terminal coupling loss

8.12.1 Weighted terminal coupling loss (TCLw)

Weighted terminal coupling loss shall be measured with the CPP suspended in free air (free field). The CPP shall be positioned at least 0,5 m away from the nearest part of the test chamber. TCLw measured from the digital input to digital output shall be at least 34 dB. Informative annex E contains recommendations concerning interim arrangements for weighted terminal coupling loss.

Compliance shall be checked by the test of subclause 11.15.

8.12.2 Stability loss (fixed geometry CPPs)

With the CPP lying on and the transducers facing a hard surface, the attenuation from the digital input to the digital output shall be at least 6 dB at all frequencies in the range 200 Hz to 4000 Hz. If the apparatus is fitted with a user-controlled receiving volume control, the requirement shall be met for the volume control setting for which the RLRH is equal to the nominal value.

Compliance shall be checked by the test of subclause 11.16.

8.12.3 Stability loss (variable geometry CPPs)

If the apparatus is fitted with a user-controlled receiving volume control, the requirement shall be met for the volume control setting for which the RLRH is equal to the nominal value. The apparatus shall be capable of meeting at least one of the following conditions 1) or 2).

1) If it is possible to position the earpiece directly in front of the mouthpiece with a distance of 150 mm between the front planes of each, the attenuation from the digital input to the digital output shall be at least 6 dB at all frequencies in the range 200 Hz to 4000 Hz: (a) in this relative position; and (b) in the just off-hook position.

2) If the relative movement and orientation of the acoustic and electro-acoustic elements are limited by means of a hinge or similar mechanism, the attenuation from the digital input to the digital output shall be at least 6 dB at all frequencies in the range 200 Hz to 4000 Hz with the transducers in any relative position and orientation that can be achieved whilst the CPP is in the active condition (i.e. the B channel is established between the CPP and an associated reference CFP).

Compliance shall be checked by the test of subclause 11.17.

8.12.4 CFP with a 4-wire interface

Informative annex K contains information relating to artificial echo loss for CFPs with a 4-wire connection.

8.13 Out of band signals

8.13.1 Discrimination against out-of-band input signals (sending)

With any sine-wave signal in the range 4,6 kHz to 8,0 kHz applied at the MRP at a level of -4,7 dBPa, the level of any image frequency produced at the digital interface shall be below the following limit. For sine-wave signals of 4,6 kHz and 8,0 kHz the reference limit levels shall be -30 dB and -40 dB respectively below a reference level obtained at 1 kHz and the same acoustic input level.

The image frequency limit shall be defined by a straight line joining the two reference limit levels when drawn on a logarithmic (frequency) - linear (dB sensitivity) scale.

Compliance shall be checked by the test of subclause 11.18.

8.13.2 Spurious out-of-band signals (receiving)

For a sine wave in the frequency range 300 Hz to 3400 Hz applied at the reference CFP so as to cause a level of 0 dBm0 at the digital interface, the level of spurious out-of-band image signals measured selectively at the ERP shall be lower than the in-band acoustic level obtained by a digital input signal of -35 dBm0 at 1 kHz.

Compliance shall be checked by the test of subclause 11.19.

8.14 Sampling frequency level (receiving)

The level of any 8 kHz acoustic signal at the ERP shall be less than -70 dBPa. If the apparatus is fitted with a user-controlled receiving volume control, the requirement shall be met for the volume control setting for which the RLRH is equal to the nominal value.

Compliance shall be checked by the test of subclause 11.20.

8.15 Acoustic shock

8.15.1 Maximum intended sound pressure level

With a digitally encoded signal representing the maximum possible signal at the digital interface, the sound pressure level at the ERP shall not exceed +24 dBPa (rms unweighted).

Compliance shall be checked by the test of subclause 11.21.

8.15.2 Maximum possible sound pressure level

The sound output from the receiver shall be limited by the power output capability of the receiver drive amplifier to give a peak sound pressure at the ERP not greater than 36 dBPa under any continuous or transient conditions.

Compliance shall be by supplier's declaration.

8.16 Audible incoming call indication

8.16.1 Provided on CPP: sound pressure level

If audible incoming call indication is provided anywhere on the CPP, the sound pressure level at the ERP shall not exceed 24 dBPa.

NOTE: The initial sound pressure in subclause 8.16.1 should not exceed 0 dBPa and should rise in increments no greater than 6 dB, at a rate not greater than 6 dB/s, to a maximum within not less than 6 s.

8.16.2 Generated other than through the earpiece: maximum sound pressure level

If audible incoming call indication on the CPP is generated other than through the earpiece, the sound pressure at the commencement of such indication shall not exceed 50 dB A-weighted at 1 m free field in any direction, and shall also comply with subclause 8.16.1.

NOTE: The initial level in 8.16.2 should rise in increments no greater than 6 dB, at a rate not greater than 6 dB/s, to a maximum within not less than 6 s.

9 Radio frequency parametric and system tests

9.1 Test conditions, power sources and ambient temperatures

9.1.1 Normal and extreme test conditions

Type tests shall be made under normal test conditions, and also, where stated, under extreme test conditions.

9.1.2 Test power source

During the tests, the power source of the equipment shall be replaced by a test power source, capable of producing normal and extreme test voltages as specified in subclauses 9.1.3.2 and 9.1.4.2. The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of tests, the voltage of the power source shall be measured at the input terminals of the equipment.

If the equipment is provided with a permanently connected power cable, the test voltage shall be measured at the point of connection of the power cable to the equipment.

In equipment with incorporated batteries, the test power source shall be applied as close to the battery terminals as practicable.

During tests, the power source voltages shall be maintained within a tolerance of ± 3% relative to the voltage at the beginning of each test.

9.1.3 Normal test conditions

9.1.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

temperature	+15°C to +35°C,
relative humidity	20% to 75%.

It should be noted that when it is impracticable to carry out the tests under these conditions, a statement giving the actual temperature and relative humidity during the tests, shall be added to the test report.

9.1.3.2 Normal test power source

9.1.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of this standard, the nominal voltage shall be the voltage or voltages for which the equipment was designed as declared by the manufacturer. The frequency of the test power source corresponding to the AC mains shall be between 49 Hz and 51 Hz.

9.1.3.2.2 Regulated lead acid battery power sources

When the radio equipment is intended for operation from the usual type of regulated lead acid battery source, the normal test source voltage shall be 1,1 times the nominal voltage of the battery (6 volts, 12 volts etc.).

9.1.3.2.3 Nickel cadmium battery

When the equipment is intended for operation from the usual type of nickel cadmium battery, the normal test voltage shall be the nominal voltage of the battery (1,2 volt per cell).

9.1.3.2.4 Other power sources

For operation from other power sources or types of battery, either primary or secondary, the normal test source voltage shall be that declared by the equipment manufacturer.

9.1.4 Extreme test conditions

9.1.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in subclause 9.1.5 at an upper value of +40°C and at a lower value of 0°C.

9.1.4.2 Extreme test source voltages

9.1.4.2.1 Mains voltage

The extreme test source voltages for equipment to be connected to an AC mains source shall be the nominal mains voltage ±10%. The frequency of the test power source shall be between 49 Hz and 51 Hz.

9.1.4.2.2 Regulated lead acid battery power sources

When the equipment is intended for operation from the usual type of regulated lead acid battery source, the extreme test voltages shall be 1,3 and 0,9 times the nominal voltage of the battery.

9.1.4.2.3 Nickel cadmium battery

When the equipment is intended for operation from the usual type of nickel cadmium battery, the extreme test voltages shall be 1,25 and 0,85 times nominal voltage of the battery.

9.1.4.2.4 Other power sources

The lower extreme test voltage for equipment with power sources using primary batteries shall be as follows:

a) for Leclanché type of battery - 0,85 times the nominal voltage;

b) for other types of primary battery - the end point voltage declared by the equipment manufacturer.

For equipment using other power sources, or capable of being operated from a variety of power sources, or designed for operation within extreme voltage limits not in accordance with those quoted above the extreme test voltages shall be those agreed between the equipment manufacturer and the testing authority and shall be recorded with the test results.

9.1.5 Procedure for tests at extreme temperatures

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilising period. If the thermal balance is not checked by measurements, a temperature stabilising period of at least one hour, or such period as may be decided by the testing laboratory, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled, so that excessive condensation does not occur.

Before tests at the upper temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the active condition for a period of half an hour after which the equipment shall meet the specified requirements.

9.2 Electrical test conditions

9.2.1 Arrangements for signals to be applied to the fixed and portable receivers

The cordless telephone equipment utilises radio frequency link control protocols involving the transmission of a handshake code between the fixed and portable parts to maintain the radio frequency communication link. Subclause 5.5.1.6 contains a requirement for the radio frequency link to cease operation if a time greater than 10 seconds has elapsed without a successful handshake taking place.

In order to carry out the radio frequency tests contained in this standard it is necessary to arrange for transmission of the relevant handshake code to be maintained for the duration of the tests. This handshake shall be obtained by coupling the fixed or portable part under test to its associated portable or fixed part such that reliable handshaking is established. If the equipment is fitted with a dynamic radio frequency output power control, the equipment should operate at its maximum power.

In the case of equipment with an integral antenna, the required level of coupling shall be achieved by, placing the associated fixed part (with if necessary an antenna connected) or portable part, at a distance such as to produce the signal required for link establishment. In the case of equipment with antenna terminals, or when an equipment with an integral antenna is being tested in the test fixture, a radio frequency coupling network shall apply the correct signal level.

Care should be taken to ensure that the coupling method employed causes the minimum effect on the test results.

9.2.2 Artificial antenna

Tests on the transmitter shall be carried out with a substantially non-reactive non-radiating 50 ohm load connected to the terminals, or in the case of equipments with integral antenna, to the test fixture terminal.

9.2.3 Test fixture for integral antenna

In the case of equipment intended for use with an integral antenna, the manufacturer shall supply a test fixture suitable to allow relative measurements to be made on the submitted sample.

This test fixture shall provide a 50 ohm radio frequency terminal at the working frequencies of the equipment.

The test fixture shall provide means of making an external connection to at least the radio frequency input and output and of replacing the power source by an external power supply.

The performance characteristics of this test fixture under normal and extreme conditions will be subject to the approval of the testing laboratory.

The characteristics of interest to the testing laboratory will be that:

a) the coupling loss shall not be excessive, that is not greater than 20 dB; and

b) the variation of the coupling loss with frequency shall not cause errors exceeding 2 dB in measurements using the test fixture; and

c) the coupling device shall not include any non-linear elements.

The testing laboratory may provide its own test fixture.

9.2.4 Test site and general arrangements for measurements involving the use of radiated fields

9.2.4.1 Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground.

At one point on the site, a ground plane of at least 5 m diameter shall be provided. In the middle of this ground plane, a non-conducting support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1,5 metres above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of lambda/2 or 3 m whichever is the greater. The distance actually used shall be recorded with the results of the tests carried out on the site.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site and ground reflections do not degrade the measurement results.

9.2.4.2 Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements; where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics.

This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarisation and for the height of its centre above ground to be varied over the range 1 to 4 m. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20% of the measuring distance.

For receiver and transmitter radiation measurements, the test antenna is connected to a measuring receiver capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. For receiver radiated sensitivity measurements the test antenna is connected to a reference CTA.

9.2.4.3 Substitution antenna

When measuring in the frequency range up to 1 GHz, the substitution antenna shall be a lambda/2 dipole, resonant at the frequency under consideration, or a shortened dipole calibrated to the lambda/2 dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 GHz and 4 GHz either a lambda/2 dipole or a horn radiator may be used. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an external antenna is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall be at least 0,3 metre.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall be operated at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

9.2.4.4 Optional additional indoor site

When the frequency of the signals being measured is greater than 80 MHz, use may be made of an indoor site. If this alternative site is used, this shall be recorded in the test report.

The measurement site may be a laboratory room with a minimum area of 6 metres by 7 metres and at least 2,7 metres in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The site arrangement is shown in principle in figure 21.

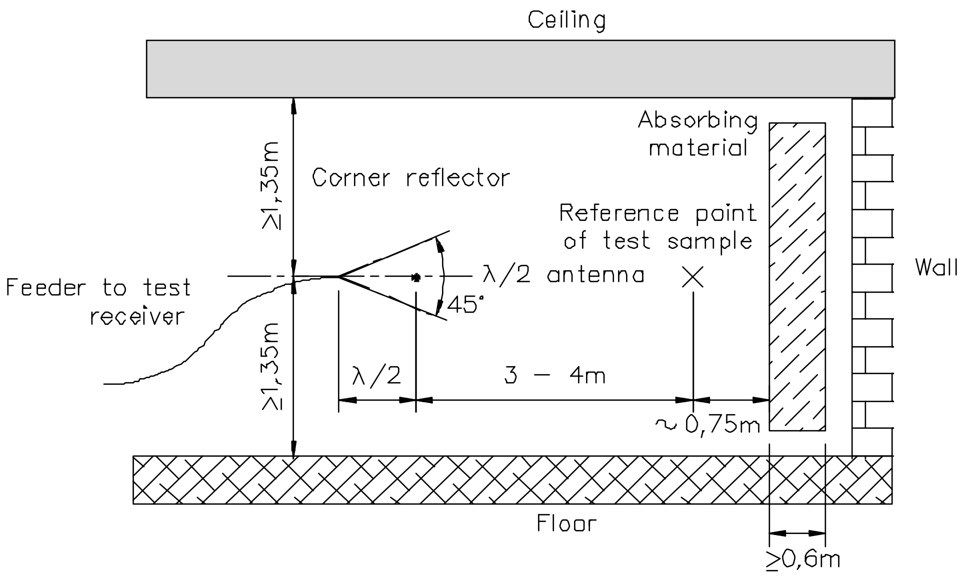


Figure 21: Indoor site arrangement

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling in the case of horizontally polarised measurements.

Similarly, the corner reflector reduces the effects of reflections from the side walls vertically polarised measurements.

For the lower part of the frequency range (below approximately 175 MHz) no corner reflector or absorbent barrier is needed.

For practical reasons, the lambda/2 antenna in figure 21 may be replaced by an antenna of constant length, provided that this length is between lambda/4 and lambda at the frequency of measurement and the sensitivity of the measuring system is sufficient. In the same way the distance of lambda/2 to the apex may be varied.

The test antenna, test receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method.

To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of ±0,1 m in the direction of the test antenna as well as in the two directions perpendicular to this first direction. If these changes of distance cause a signal change of greater than 2 dB, the test sample should be resited until a change of less than 2 dB is obtained.

9.2.5 Combined transmitter/receiver test facility

The manufacturer shall supply facilities to enable control of those functions of the equipment which are associated with the parameters measured in clause 9.

Adequate operating instructions relevant to the equipment submitted for test shall be provided.

Control shall be provided of switching between the normal active mode (at maximum rated transmitter power) and the idle mode.

Connections shall be provided to enable external access to the equipment power supply.

The manufacturer shall ensure that the control and connection facilities provided do not have a significant effect on the measured results.

9.2.6 Guidance on the use of radiation test sites

Guidance on the use of radiation test sites may be found in ETS 300 086 [25] (annex A, clause A.2).

9.2.7 Further optional alternative indoor test site using an anechoic chamber

For radiation measurements where the frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor site being a well-shielded anechoic chamber simulating the free space environment. Guidance on such sites may be found in ETS 300 086 [25] (annex A, clause A.3).

9.2.8 Test frequencies

In band wanted and interfering test signals and channel power measurements shall be on nominal channel centre frequencies unless otherwise stated.

9.3 Transmitter

The tests in this subclause require the testing laboratory to provide a reference part (CPP and CFP), or the manufacturer to supply a complete CTA.

9.3.1 Transmitter carrier power

9.3.1.1 Definition

The transmitter carrier power is the mean power delivered to the artificial antenna during a single cycle of the radio frequency carrier or, in the case of equipment with an integral antenna or antennas, the effective radiated power in the direction of maximum field strength under specified conditions of measurement (subclause 9.2.4) if possible in the absence of modulation.

9.3.1.2 Method of measurement for equipment with an antenna connection

The handshake code between the fixed and portable parts is established as described in subclause 9.2.1.

The transmitter shall be connected to an artificial antenna (subclause 9.2.2), and the power delivered to this artificial antenna shall be measured.

The mean power measured shall be multiplied by 2 to obtain the carrier power.

The measurements shall be made under normal test conditions (subclause 9.1.3) and extreme test conditions (subclauses 9.1.4.1 and 9.1.4.2 applied simultaneously).

9.3.1.3 Method of measurement for equipment with an integral antenna.

9.3.1.3.1 Method of measurement under normal test conditions

On a test site, fulfilling the requirements of subclause 9.2.4 the sample shall be placed on the support in the following position:

1) for equipment with an internal antenna it shall stand so that the axis of the equipment, which in its normal use is closest to the vertical, shall be vertical;

2) for equipment with a rigid external antenna, the antenna shall be vertical;

3) for equipment with a non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The test receiver shall be tuned to the frequency of the signal being measured.

The test antenna shall be orientated for vertical polarisation and shall be raised or lowered through the specified height range until a maximum signal level is detected on the test receiver. The transmitter shall then be rotated through 360° until the maximum signal is received.

It should be noted that the maximum may be a lower value than the value obtainable at heights outside the specified limits.

The transmitter shall be replaced by the substitution antenna, as defined in subclause 9.2.4.3 and the test antenna raised or lowered as necessary to ensure that the maximum signal is still received. The input signal to the substitution antenna shall be adjusted in level until an equal or a known related level to that detected from the transmitter is obtained in the test receiver.

The carrier power is equal to the power supplied to the substitution antenna, increased by the known relationship if necessary.

The measurement shall be repeated for any alternative antenna supplied by the manufacturer.

A check should be made at other planes of polarisation to ensure that the value obtained above is the maximum. If larger values are obtained, this fact should be recorded in the test report.

9.3.1.3.2 Method of measurement under extreme test conditions

The equipment shall be placed in the test fixture (subclause 9.2.3). The handshake code between the fixed portable parts is established as described in subclause 9.2.1. The power delivered to the artificial antenna shall be measured. The measurements shall be made under normal test conditions (subclause 9.1.3) and extreme test conditions (subclauses 9.1.4.1 and 9.1.4.2 applied simultaneously).

The mean power measured shall be multiplied by 2 to obtain the carrier power.

9.3.1.4 Limits

The limits shall be those specified in subclause 4.5.1.

9.3.2 Adjacent channel power (narrow-band)

9.3.2.1 Definition

The adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within a specified pass-band centred on the nominal frequency of either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

9.3.2.2 Method of measurement

The adjacent channel power shall be measured with a spectrum analyser which conforms to subclause 9.3.2.3.

Equipment with an antenna terminal shall have the terminal connected to a spectrum analyser by a coupling device which provides the appropriate input level to the spectrum analyser. Equipment with an integral antenna shall be placed in the test fixture (subclause 9.2.3) and the radio frequency output of the test fixture shall be applied to the spectrum analyser at the appropriate input level. The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The transmitter shall be operated at the measured carrier power (subclause 9.3.1) under normal test conditions (subclause 9.1.3) such as to produce a modulated output representative of normal active use (subclause 9.6).

The spectrum analyser shall be adjusted so that the spectrum of the transmitter output, including that part which falls in the adjacent channels, is displayed.

For the purpose of this test the integration bandwidth used in this measurement shall be 80 kHz with a tolerance of ±5%.

The centre frequency of the bandwidth within which measurements are to be made shall have a 100 kHz separation from the nominal carrier frequency of the transmitter.

The adjacent channel power is the sum of the power levels of each of the discrete components and of the noise falling in the appropriate bandwidth.

This sum may be automatically calculated by the spectrum analyser, or an automatic power level integrating device may be used to obtain it (see subclause 9.3.2.4).

In the latter case, the relative power level of the modulated transmitter is initially measured by integration over the appropriate bandwidth, centred on the nominal frequency. The measurement is repeated with this bandwidth centred on the nominal frequency of the adjacent channel and the input level to the integrating device is increased until the same power level at the output of the device is obtained.

The difference between the input levels, in dB, gives the ratio of the adjacent channel power to the carrier power.

The adjacent channel power, expressed as an effective radiated power, is calculated by applying this ratio to the carrier power as determined in subclause 9.3.1.

The measurement shall be repeated for the other adjacent channel.

The measurement shall be repeated under extreme conditions (subclauses 9.1.4.1 and 9.1.4.2 applied simultaneously).

9.3.2.3 Characteristics of the spectrum analyser

Characteristics of the spectrum analyser shall meet at least the following requirements:

It shall be possible to measure the amplitude of a signal or noise at a level 3 dB or more above the noise level of the spectrum analyser, as displayed on the screen, to an accuracy of ± 2 dB in the presence of a signal separated in frequency by 10 kHz at a level 90 dB above that of the signal to be measured.

The reading accuracy of the frequency marker shall be within ± 2 kHz.

The accuracy of relative amplitude measurements shall be within ± 1 dB.

It shall be possible to adjust the spectrum analyser to allow the separation on its screen of two components with a frequency difference of 1 kHz.

The video bandwidth should be relatively low e.g. 1 kHz.

9.3.2.4 Integrating and power summing device

This device will be required for use only if the sum of the components and the noise has not been calculated automatically. When the device is connected to the video output of the spectrum analyser, described in subclause 9.3.2.3, it shall be possible to sum the effective power of all discrete components and the noise power falling in the selected bandwidth and to measure this as a ratio relative to the carrier power.

The position and the width of the integration range selected can be indicated on the spectrum analyser by brightening the trace.

When measuring power levels of the order of 50 nW, the output of the device should exceed the integral noise level by at least 10 dB. The dynamic range shall permit measurement of the values required under subclause 9.3.2.5 with a reserve of at least 10 dB.

9.3.2.5 Limits

The limits shall be those specified in subclause 4.5.5.

9.3.3 Out of band power arising from transmitter transients

9.3.3.1 Definition

The out-of-band power arises from transients in the transmitter and is the peak power of the modulation products which result from the rapid on and off switching of the transmitter and which fall within a specified frequency band on either side of the nominal frequency.

9.3.3.2 Method of measurement

If the transmitter is equipped with an antenna terminal it shall be connected to a spectrum analyser by a coupling device which provides the appropriate input level to the spectrum analyser. If the transmitter is equipped with an integral antenna it shall be placed in the test fixture (subclause 9.2.3) and the radio frequency output of the test fixture applied to the spectrum analyser at the appropriate input level.

The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The transmitter shall be operated at the measured carrier power (subclause 9.3.1) under normal test conditions (subclause 9.1.3) such as to produce a modulated output representative of normal active use (subclause 9.6).

The two multiplex modes MUX1.2 and MUX1.4 (if applicable) shall be tested.

9.3.3.3 Characteristics of the spectrum analyser

Characteristics of the spectrum analyser shall meet at least the following requirements:

- the spectrum analyser shall be suitable for making measurements on signals resulting from switching transients;
- the spectrum analyser shall be provided with a 4 pole synchronously tuned intermediate frequency filter;
- the spectrum analyser shall be operated in the peak hold mode;
- the resolution bandwidth shall be set to 10 kHz and the video bandwidth to 3 MHz;
- the levels displayed on the spectrum analyser at frequencies 100 kHz and 0,5 MHz above and below the nominal signal frequency shall be recorded.

9.3.3.4 Limits

The limits shall be those specified in subclause 4.5.6.

9.3.4 Intermodulation attenuation

This requirement applies to transmitters/receivers to be contained (nested) in a single enclosure or a single unit containing two or more transmitters/receivers which are not separable.

9.3.4.1 Definition

For the purpose of this standard the intermodulation attenuation is a measure of the capability of a transmitter to inhibit the generation of signals in its non-linear elements caused by the presence of the carrier and an interfering signal.

9.3.4.2 Method of measurement

Two transmitters/receivers of the type which will be contained (nested) in a single enclosure shall be operated in the enclosure immediately adjacent to each other. Where the transmitter/receivers are equipped with antenna terminals, these shall be connected to the antenna combining system and the antenna which will be employed with the commercial product.

On a test site, fulfilling the requirements of subclause 9.2.4 the sample shall be placed on the support in the following position:

1) for equipment with an internal antenna, it shall stand so that the axis of the equipment which is in its normal use is closest to vertical shall be vertical;
2) for equipment with a rigid external antenna, the antenna shall be vertical;
3) for equipment with a non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

The handshake codes for the two systems are established as described in subclause 9.2.1.

The transmitters shall be operated at the power levels measured under subclause 9.3.1.

Radiation of any third order intermodulation products shall be detected by the test antenna and a spectrum analyser with a resolution bandwidth of 10 kHz and a video bandwidth of 30 kHz.

At the frequencies at which products are detected, the equipment under test shall be rotated to obtain the maximum response, and the effective radiated power of that product determined by a substitution measurement.

The measurement shall be repeated with the test antenna in the orthogonal polarisation plane.

9.3.4.3 Limits

The limits shall be those specified in subclause 4.5.7.

9.3.5 Prevention of mis-operation due to adverse power supply conditions

9.3.5.1 Definition

For the purpose of this standard mis-operation shall be defined as the generation of emissions outside the specified limits due to a reduction of power supply voltages.

9.3.5.2 Method of measurement

a) The transmitter/receiver under test shall be placed in the test fixture or connected to a suitable artificial load. The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The emission shall be monitored on a spectrum analyser.

b) The radiated spectrum shall be monitored whilst the supply voltage (AC or DC) shall be slowly reduced from the normal value to zero at the rate recommended by the equipment manufacturer.

c) The levels of adjacent channel power and spurious emissions shall be measured and recorded.

9.3.5.3 Limits

The limits shall be those specified in subclause 4.7.1.

NOTE 1: If a back up power supply, i.e. a rechargeable battery, is provided in the fixed part, the test shall be repeated with the battery replaced by a variable DC power supply.

NOTE 2: Any non-repetitive transient condition (of duration less than 50 ms) shall be ignored.

9.4 Spurious emissions

The tests in this subclause require the testing laboratory to provide a reference part (CPP and CFP), or the manufacturer to supply a complete CTA.

9.4.1 Spurious emissions of the combined transmitter/receiver

9.4.1.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal modulation.

The level of spurious emissions shall be measured as:

1) their power level in a transmission line or antenna and

2) their effective radiated power when radiated by the cabinet and structure of the equipment. This is also known as "cabinet radiation".

For equipment which can only be used with an integral antenna, only the measurement mentioned under (2) applies.

9.4.1.2 Method of measuring the power level, subclause 9.4.1.1, (1)

Spurious emissions shall be measured as the peak power level within the measurement bandwidth delivered into a 50 ohm load. This may be done by connecting the transmitter/receiver output through an attenuator to a spectrum analyser or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (subclause 9.2.2). The bandwidth of the measurement shall be as specified in table 19.

The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The measurements shall be made over the frequency range 100 kHz to 12,75 GHz, except for the channel on which the transmitter/receiver is operating and its adjacent channels.

The measurement shall be repeated with the transmitter/receiver in the idle mode.

Annex E contains recommendations concerning interim arrangements for measuring the power level.

Table 19: Bandwidths for measurement of spurious emissions

Frequency range	Active mode		Idle mode	
	Resolution bandwidth	Video bandwidth	Resolution bandwidth	Video bandwidth
up to 864,1 MHz	10 kHz	300 kHz	10 kHz	300 kHz
864,1 MHz to 868,1 MHz	10 kHz	300 kHz	1 kHz	300 kHz
868,1 MHz to 1000 MHz	10 kHz	300 kHz	10 kHz	300 kHz
above 1000 MHz	100 kHz	3 MHz	100 kHz	3 MHz

9.4.1.3 Method of measuring the effective radiated power, (subclause 9.4.1.1, 2)

On a test site, fulfilling the requirements of subclause 9.2.4, the sample shall be placed at the specified height on a non-conducting support. The handshake code between the fixed and portable parts is established as described in subclause 9.2.1.

The transmitter/receiver shall be operated with the carrier power delivered to an artificial antenna (subclause 9.2.2), except in the case of testing equipment with an integral antenna.

Radiation of any spurious components shall be detected by the test antenna and a spectrum analyser over the frequency range 25 MHz to 12,75 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels. The bandwidth of the measurement shall be as specified in table 19.

At each frequency at which a component is detected, the sample shall be rotated to obtain the maximum response and the effective radiated peak power of that component determined by a substitution measurement.

The measurement shall be repeated with the test antenna in the orthogonal polarisation plane.

The measurements shall be repeated with the transmitter in the idle mode.

Annex E contains recommendations concerning interim arrangements for measuring the effective radiated power.

9.4.1.4 Limits

The limits shall be those specified in subclause 4.7.2.

9.5 Radio frequency system operation

The tests in this subclause require the testing laboratory to provide a reference part (CPP and CFP).

9.5.1 Definitions

Ability to receive: the reference part shall transmit 10 acknowledged (numbered) packets each of 4 code words to the test receiver. The number of acknowledged (numbered) packets that are indicated as having been correctly received (as detected by acknowledgements received at the reference part) shall be counted.

If four or more are correct, then the receiver has the ability to receive. If three or fewer are correct, then the receiver does not have this ability.

9.5.2 Channel frequencies

9.5.2.1 Ability to transmit on each of the 40 channels

This test is covered by subclause 9.5.2.2.

9.5.2.2 Ability to receive on each of the 40 channels

The reference part shall set up link on the top and bottom channels and at least one in between.

9.5.2.3 Ability to receive when the carrier frequency is up to ±10 kHz from nominal

The reference part transmitter carrier frequency shall be adjusted over this range at a defined level of sensitivity (20 dB above the minimum sensitivity requirement).

9.5.2.4 Ability to receive when carrier frequency is varying at a rate of up to 1 kHz/ms

The reference part transmitter carrier frequency shall be adjusted at this rate at a defined level of sensitivity (20 dB above the minimum sensitivity requirement).

9.5.3 Dynamic RF channel allocation strategy

9.5.3.1 No channel is occupied

The channel selection is random when no channel is occupied. For both CPP and CFP by manufacturer's declaration supported by details of the implementation of "random".

9.5.3.2 One channel only below the threshold

That with one channel only below the threshold, that it is selected. For both CPP and CFP an interferer shall occupy all channels except, in turn, channels 1 and 40 which shall be subject to a field strength below the threshold value.

9.5.3.3 All channels occupied

That with all channels occupied, the channel with the lowest signal strength is selected. For both CPP and CFP this shall be as in subclause 9.5.3.2 but with the power level raised so that, in turn, channels 1 and 40 have the lowest signal strength, but above the threshold.

9.5.4 Adaptive CPP transmitter power control

For CPP transmitters only, when commanded, to switch to a low power setting in the range 16 dB ±4 dB down on the effective radiated power. As in subclause 9.3.1, but at the specified reduced power.

9.5.5 RF modulation

9.5.5.1 Peak frequency deviation: transmission

The peak frequency deviation under all possible data patterns shall be in the range 14,4 kHz to 25,2 kHz.

For a CPP, a pure tone acoustic test signal at a frequency between 1004 Hz and 1025 Hz is applied with a sound pressure level of -4,7 dBPa at the mouth reference point.

For a CFP, a pure tone electrical test signal at a frequency between 1004 Hz and 1025 Hz is applied at the CFP so as to produce a level of -10 dBm0 at the uniform PCM interface.

Confirm that for CPP and CFP the peak deviation of the transmitter is greater than 14,4 kHz and is less than 25,2 kHz.

9.5.5.2 Peak frequency deviation: reception

Ability to receive when peak deviation is anywhere in the range 14,4 kHz to 25,2 kHz. The reference part transmitter to be configured to generate peak deviation at 14,4 kHz and 25,2 kHz with the link maintained.

9.5.6 RF envelope

9.5.6.1 Transmitter output: ramp-down

Transmitter to maintain output power within 6 dB of the amplitude obtained during the transmission (figure 1) of normal data, for not less than 0,5 bit periods after the end of the last bit of normal data. By inspection of the envelope using MUX1.2, MUX1.4 (if applicable), MUX2, and MUX3 (if applicable).

9.5.6.2 Transmitter output: ramp-up

Transmitter to attain output power within 3 dB of the amplitude obtained during the transmission (figure 1) of normal data by the start of the first bit of normal data. By inspection of the envelope using MUX1.2, MUX1.4 (if applicable), MUX2, and MUX3 (if applicable).

9.5.6.3 CPP transmit amplitude during off period

The provisions of this subclause apply to CPPs only. Annex E contains recommendations concerning interim arrangements for the CPP ramp up and ramp down times.

The amplitude of the RF envelope at the times specified in subclause 4.5.4.1 shall be <-60 dB relative to the peak amplitude of the transmission. By measurement of the RF envelope. To be tested in MUX1.4 if MUX1.4 is supported. To be tested in MUX1.2 if MUX1.4 is not supported.

9.5.6.4 CFP transmit amplitude during off period

The provisions of this subclause apply only to CFPs with external synchronisation ports as defined in annex N.

The amplitude of the RF envelope at the times specified in subclause N.2.2 shall be <-60 dB relative to the peak amplitude of the transmission. By measurement of the RF envelope. To be tested in MUX1.4 if MUX1.4 is supported. To be tested in MUX1.2 if MUX1.4 is not supported.

The CFP shall synchronise its transmissions as specified in subclause N.2.2. This test is to be made under two circumstances:

1) using an internally generated synchronisation signal (no external input);
2) using an external synchronisation signal applied to the external synchronisation input port.

The external synchronisation signal shall conform to subclause N.2.1 with a differential amplitude equal to the minimum specified in N.2.1. In both of the above cases, the output synchronisation signal shall be required to conform to the requirements of subclause N.2.

9.5.7 Radio receiver sensitivity

9.5.7.1 Raw bit error rate

The raw bit error rate shall not exceed 1 in 1000 at a field strength which is specified in subclause 4.6.2. The following procedure is to be adopted to distinguish between those receivers with a BER performance worse than $3{,}2 \times 10^{-3}$ and those with a performance better than 1×10^{-3}:

1) the signal strength at the receiver's antenna shall be set to the field strength specified in subclause 4.6.2;

2) the reference part transmits, with the maximum peak frequency deviation which is specified in subclause 4.5.2, ten acknowledged packets of 4 code words to the test receiver. The number of acknowledged packets that are indicated as having been correctly received (as detected by acknowledgements received at the reference part) are counted:

   a) if 9 or 10 are correct, then accept the receiver;

   b) if 3 or fewer are correct, then reject the receiver;

   c) if 4 to 8 packets are correct, go to the next stage;

3) 20 acknowledged packets of 4 code words are sent to the test part:

   a) if 15 or more of this 20 are correct, then accept the receiver;

   b) if 10 or fewer packets are correct, then reject the receiver;

   c) if 11 to 14 packets are correct, go to the next stage;

4) another 20 acknowledged packets of 4 code words are sent to the test part:

   a) if 14 or more of this second 20 are correct, then accept the receiver;

   b) if 11 or fewer packets are correct, then reject the receiver;

   c) if 12 or 13 packets are correct, go to the next stage;

5) another 20 acknowledged packets of 4 code words are sent to the test part:

   a) if 13 or more are correct, then accept the receiver;

   b) if 12 or fewer packets are correct, then reject the receiver.

The above procedure results in: the probability of rejecting a CPP that gives 1×10^{-3} BER is 1,23%; and the probability of accepting a CPP that gives 3×10^{-3} BER is 1,21%

If the peak frequency deviation of the reference test equipment is not equal to the maximum specified in subclause 4.5.2 a correction factor X shall be applied to the measurements.

$$S(f_{\max}) = S(f_{actual}) - X$$

Where:

$S(f_{max})$ is the sensitivity for the maximum frequency deviation (dBm or dBµV/m)

$S(f_{actual})$ is the measured frequency deviation using a deviation factual (dBm or dBµV/m)

X is the correction factor = 20 $\log(f_{max}/f_{actual})$

9.5.8 Radio receiver blocking performance

9.5.8.1 Ability to receive in the presence of unmodulated interfering signals

Manufacturers shall supply their characteristics for all the ranges. The test will be to ensure that the link is maintained with no change of channel in the presence of a continuously transmitting interferer. Channels may then be selected as follows:

1) select a channel for co-channel interference tests;

2) select a channel for adjacent channel interference tests (one interferer only);

3) select up to 10 other channels at random for co-channel and adjacent channel tests.

9.5.8.2 Ability to receive in the presence of asynchronous modulated interfering signals

As in subclause 9.5.8.1, but using asynchronous modulated interferers.

9.5.9 Blocking due to spurious responses

9.5.9.1 Blocking requirements

As defined in subclause 4.6.4. Additionally, manufacturers shall supply their results and frequency generation plan for the RF parts and also state the frequencies of any other supplies or sources used.

Tests on up to 10 spot frequencies may be carried out.

9.5.9.2 Intermodulation response rejection

As defined in subclause 4.6.5. Additionally, manufacturers shall supply their results and frequency generation plan for the RF parts and also state the frequencies of any other supplies or sources used.

Tests on up to 10 spot frequencies may be carried out.

9.6 Transmitter modulation

The equipment presented for type approval shall be set up such that, when the radio frequency link between the fixed and portable parts is established, the modulation of the transmitter is representative of normal active use.

9.7 Power supply units

The fixed and portable parts shall be operated with their appropriate power supply units which shall be submitted with the equipment at the time of type approval. Means for connecting an external power supply to portable equipment shall be provided.

9.8 Declarations by the manufacturer

When submitting an equipment for type testing, the manufacturer shall supply the following information:

1) transmitters:

    a) the oscillator frequencies, intermediate frequencies and carrier generation formula or, the technique of frequency generation;

1) receivers:

    a) the oscillator frequencies, intermediate frequencies and local oscillator generation formula;

1) power supply:

    a) the nominal supply voltage;

    b) the type of battery where applicable;

    c) the battery end-point voltage where applicable.

9.9 Identification

The equipment shall be provided with a clear indication of the type number and description under which it is submitted for type testing.

10 Signalling system tests

The tests in this clause require the testing laboratory to provide a reference part (CPP and CFP).

10.1 Multiplex alignment and timing

10.1.1 Alignment of D and B channels in MUX1

Covered by link establishment.

10.1.2 Alignment of D and SYN channels in MUX2

Covered by link establishment.

10.1.3 Transmit/listen timing of MUX3

Covered by link establishment.

10.1.4 Alignment of P, D and SYN channels in MUX3

Covered by link establishment. The CFP manufacturer shall declare his implementation to ensure that all sub-multiplexes are detectable.

10.2 Calling channel detection at the CPP

When stimulated by valid MUX2 transmissions of ID_OK, from a reference CFP, the CPP shall respond with MUX2 transmission of ID_OK, with SYNCP in the SYN channel, and the contents of the LID field reflected back.

This is covered by link establishment, additionally noting that the LID field shall be checked.

10.3 Calling channel detection at the CFP

When stimulated by valid MUX3 transmissions of LINK_REQUEST, from a reference CPP, the CFP shall respond with MUX2 transmissions of LINK_GRANT, with SYNCF in the SYN channel, and reflecting back the CPP PID together with a valid link reference value in the LID field.

This is covered by link establishment. Manufacturers shall declare their method of deriving link reference (to ensure that link references are always in the correct range).

Timers: Tftx, Tfdetect.

10.4 Link set up from CFP to CPP

10.4.1 For a CFP

10.4.1.1 To acquire a free RF channel and generate MUX2 Transmissions

To acquire a free RF channel and generate MUX2 transmissions of ID_OK. This is covered by link establishment.

Timers: Tfmax, Tfdetect.

10.4.1.2 Generation of LINK_GRANT

If a valid MUX2 response from a reference CPP is received, the CFP shall generate LINK_GRANT. This is covered by link establishment.

Timer: Tcfp.

10.4.1.3 If no valid MUX2 response is received

If no valid MUX2 response from a CPP is received, if the CFP selects a new RF channel then it shall repeat the operations in subclause 10.4.1.1 to the expiry of Tfmax with transmissions of ID_OK. This test shall confirm selection of a different channel under the above circumstances.

Timers: Tfcyc, Tfmax.

10.4.2 For a CPP

When stimulated by valid MUX2 transmissions of ID_OK, from a reference CFP, the CPP shall respond as the test in subclause 10.2. This is covered by subclause 10.2.

10.5 Link set up from CPP to CFP

10.5.1 For a CPP

10.5.1.1 To acquire a free RF channel and generate MUX3 transmissions of LINK_REQUEST

This is covered by link establishment.

Timers: Tpcyc, Tpmax.

10.5.1.2 Valid MUX2 response

If a valid MUX2 response of LINK_GRANT, from a reference CFP is received, the CPP shall synchronise to SYNCF and generate MUX2 transmissions of ID_OK, echoing back the LID value as received.

Also, if an invalid MUX2 response is received from the reference CFP, it shall be confirmed that the CPP ceases MUX3 transmissions but later resumes them on a different channel.

10.5.1.3 No valid MUX2 response

If no valid MUX2 response from a CFP is received, the CPP shall select a new RF channel and generate MUX3 transmissions of LINK_REQUEST. Repeat the test in subclause 10.5.1.1 but to expiry of Tpmax or up to 5 channels attempted.

10.5.2 For a CFP

When stimulated by valid MUX3 transmissions of LINK_REQUEST, from a reference CPP, the CFP shall respond as in the test in subclause 10.3.

10.6 Set up collision resolution

Channel scanning algorithm selection of start channel number shall demonstrate a random distribution. This shall be checked by manufacturer's declaration and implementation description (this applies to the CFP only).

10.7 Link re-establishment on the existing channel

10.7.1 For a CPP

10.7.1.1 Valid link re-establishment message

When stimulated by a valid link re-establishment message from a reference CFP, the CPP shall respond with MUX3 transmission of LINK_REQUEST, using the last received link reference value in the LID field.

Also, with two link re-establishments within 300 ms (for MUX1.4, MUX2) or 600 ms (for MUX1.2), it shall be confirmed that the second is either not actioned, or is not actioned until after the expiry of this time.

10.7.1.2 Valid MUX2 response

If a valid MUX2 response of LINK_GRANT, from the reference CFP is transmitted, the CPP shall respond as in the test in subclause 10.5.1.2.

10.7.1.3 No valid MUX2 response

If no valid MUX2 response from a CFP is received, the CPP shall not transmit beyond the expiry of Thlost. This shall be tested by measurement of Thlost.

If a CPP claims to offer the feature of generating link re-establishment messages, then this feature shall be demonstrated by manufacturer's declaration.

10.7.2 For a CFP

10.7.2.1 Valid link re-establishment message

When stimulated by a valid link re-establishment message from a reference CPP, the CFP shall respond by ceasing transmissions (implying that the CFP is listening for MUX3). Testing will be by generating link re-establishment messages with valid and invalid link references.

10.7.2.2 Valid MUX3 LINK REQUEST

If a valid MUX3 LINK_REQUEST from the reference CPP is received, the CFP shall respond as in the test in subclause 10.3.

When stimulated by valid MUX3 transmissions of LINK_REQUEST from a reference CPP, the CFP shall respond with MUX2 transmissions if the LID was correct.

10.7.2.3 No valid MUX3 LINK REQUEST

If no valid MUX3 LINK_REQUEST from a CPP is received, the CFP shall timeout on the expiry of Thlost. If a CFP claims to offer the feature of generating link re-establishment messages, then this feature is to be demonstrated by manufacturer's declaration.

10.8 Link re-establishment on a different channel

10.8.1 For a CPP

If the CPP attempts re-establishment, it shall be at least 3 s after loss of handshake. It should generate MUX3 transmissions of LINK_REQUEST, using the last received link reference value in the LID field. Re-establishment attempts shall cease within Thlost (10 s).

The reference CFP shall cease transmission of handshake. After not less than 3 s the CPP shall generate MUX3 transmissions.

10.8.2 For a CFP

No earlier than after 3 s loss of handshake, the CFP shall respond as in the tests in subclauses 10.7.2.1, 10.7.2.2 and 10.7.2.3. This shall be tested as in the above subclauses, but stimulated by loss of handshake for no less than 3 s.

10.9 Generation and reception of valid handshakes

10.9.1 Handshake intervals

By call logging over a period of 50 s, this test shall confirm the minimum and maximum handshake intervals for MUX1.2, MUX1.4, and MUX2 if a high-speed signalling capability is claimed.

10.9.2 For a CPP

10.9.2.1 Response to loss of valid handshakes

When interworking with a reference CFP which ceases transmission of valid handshakes check expiry of Thrx and transmission of ID_LOST.

10.9.2.2 Re-acquisition of valid handshakes

In the event of a valid handshake's being transmitted from the reference CFP within these times, Thlost to be reset and normal communications shall be resumed. Confirm ID_LOST is replaced by ID_OK on receipt of a valid handshake.

10.9.3 For a CFP

10.9.3.1 Response to loss of valid handshakes

When interworking with a reference CPP which ceases transmission of valid handshakes check expiry of Thrx and transmission of ID_LOST.

10.9.3.2 Re-acquisition of valid handshakes

In the event of a valid handshake's being transmitted from the reference CPP within these times, Thlost to be reset and normal communications resumed. Confirm ID_LOST is replaced by ID_OK on receipt of a valid handshake.

10.10 Layer two parameters

Following are the layer two parameters:

1) code words to be transmitted at least once every Trate. By the use of a logging device and inspection;

2) less than 1 in 10^7 code words to be misinterpreted at a BER of 1 in 50. By manufacturer's declaration of the implementation of the CRC algorithm;

3) confirm general message format. Covered by link establishment;

4) confirm general packet format. Covered by link establishment;

5) confirm non-repetition of two identical ACWs. By manufacturer's declaration;

6) confirm CRC calculation. Covered in 2).;

7) confirm code word formats (ACWs, DCWs). Covered by link establishment;

8) confirm correct allocation of HIC/MIC. Manufacturer to declare his value of MIC and this to be confirmed by inspection of logged transmissions. The allocation of HIC is to be declared by the manufacturer;

9) confirm operation of MUX1.2, and of MUX1.4 if claimed. Covered elsewhere;

10) confirm handshake operation. Covered elsewhere;

11) confirm correct allocation of LID field. Emergency access is to be tested, and also any other claimed accesses;

12) confirm PI=0. PI=0 checking to be built in to the reference parts;

13) confirm ability to receive layer 3 messages spread over more than one packet. Test reception by message composition in the reference part. Where the manufacturer declares an ability to transmit layer three messages over more than one packet, this feature is to be tested by manufacturer's declaration;

14) confirm operation of endwrd and code word number/remainder encoding for reception, and where declared for transmission. Generate incorrect Endwrd/code word number remainder messages and confirm operation;

15) confirm numbered/unnumbered message operation. Generate messages by reference part to both CPP and CFP to confirm acceptance of numbered and unnumbered messages;

16) confirm unused octets filled with F0(hex). By inspection of logged data;

17) confirm transmit power control operation. See subclause 9.5.4;

18) confirm Fill-in generated when required, and of the correct format. By inspection of logged data confirm IDLE_D or FILL_IN is transmitted;

19) if the manufacturer declares an ability to support transmit or receive layer three buffer sizes of 128 bytes, this feature is to be tested by manufacturer's declaration.

10.11 Layer one and layer two timers

1) Tbid: Manufacturer's declaration;

2) Tcfp (CFP processing time (18 ms, recommended 4 ms)): Timings to be declared by the manufacturer for the worst case, i.e. the processing time for the largest possible number of stored PIDs and LIDs;

3) Tcpp (CPP processing time (6,2 ms)): Timings to be declared by the manufacturer for the worst case, i.e. the processing time for the largest possible number of stored LIDs;

4) Tfcyc: Simple measurement of the CFP minimum MUX2 transmission time;

5) Tfdetect: Manufacturer's declaration;

6) Tfmax: Simple measurement of the CFP link establishment timeout when due to incoming ringing;

7) Tftx: Simple measurement of transmit time after transmission of LINK_GRANT;

8) Thlost: Establish link, turn off transmitter at other end and note time to cease RF;

9) Thrx: See Handshaking, below;

10) Thtx: By inspection of the logged data stream. Also see handshaking, below;

11) Tpcyc: Simple measurement of the CPP MUX3 minimum transmission time;

12) Tpid: Manufacturer's declaration;

13) Tpmax: Simple measurement of the CPP call set up time with no response from the CFP;

14) Tpoll: Manufacturer's declaration;

15) Trate: By inspection of the logged data stream for each MUX;

16) Trtx: By inspection of the logged data stream for each MUX to ensure that should Trtx expire re-transmission occurs;

17) Link Re-establishments (300/600 ms): Already covered;

18) Tfmax2: Simple measurement of the CFP link establishment timeout when not due to incoming ringing.

10.12 Acknowledged message protocol validation

Correct operation to and from both CPP and CFP to be checked by controlled insertion of errors into the reference CPP and CFP transmitted and received messages as follows:

10.12.1 CPP response to received packets

1) reference CFP transmits a packet with a single-bit error inserted in the Content (octets 3 to 6 inclusive) of the ACW. The CPP shall respond with re-transmission request or no action;

2) reference CFP re-transmits a correct packet to simulate a lost/corrupted acknowledgement. The CPP shall respond with correct acknowledgement;

3) reference CFP transmits correct packet. The CPP shall respond with correct acknowledgement.

10.12.2 CPP transmit actions

1) reference CFP inserts a single-bit error in the received signal from the CPP and responds with a re-transmission request. The CPP shall respond with a re-transmission;

2) reference CFP responds to a transmission from the CPP with the correct acknowledgement. The CPP shall respond by transmitting the next packet;

3) reference CFP makes no response to a transmission from the CPP. The CPP shall respond by re-transmitting the packet at least once on expiry of the Trtx timeout. This does not preclude the possibility of the CPPs re-transmitting a packet before the expiry of Trtx.

10.12.3 CFP response to received packets

1) reference CPP transmits a packet with a single-bit error inserted in the Content (octets 3 to 6 inclusive) of the ACW. The CFP to respond with re-transmission request or no action;

2) reference CPP re-transmits a correct packet to simulate a lost/corrupted acknowledgement. The CFP to respond with correct acknowledgement;

3) reference CPP transmits correct packet. The CFP to respond with correct acknowledgement.

10.12.4 CFP transmit actions

1) reference CPP inserts a single-bit error in the received signal from the CFP and responds with a re-transmission request. The CFP to respond with a re-transmission;

2) reference CPP responds to a transmission from the CPP with the correct acknowledgement. The CFP to respond by transmitting the next packet;

3) reference CPP makes no response to a transmission from the CPP. The CFP to respond by re-transmitting the packet at least once on expiry of the Trtx timeout. This does not preclude the possibility of the CFPs re-transmitting a packet before the expiry of Trtx.

10.13 Handshake operation

Additional to the basic requirement of exchange of handshake as defined for subclause 5.5, the following special conditions to be checked for both CFP and CPP when working with a reference CPP and a reference CFP, respectively:

1) response to not receiving the correct handshake from the reference part.

   The test part shall respond by transmitting ID_LOST on the expiry of Thrx;

2) response to receiving the correct handshake from the reference part.

   The test part shall respond by transmitting ID_OK;

3) response to receiving from the reference part a valid handshake which is not that allocated to the test part.

   The test part shall respond by transmitting ID_LOST on expiry of Thrx;

4) Thrx to be tested: (a) With handshakes from the reference part at a period of less than 1 s, confirm that no ID_LOSTs are transmitted by the test part; and (b) With handshakes from the reference part at a period over 1,040 s, ID_LOSTs are transmitted (intermixed with ID_OKs).

10.14 Layer three parameters

10.14.1 The receiving end

By manufacturer's declaration, confirm that the receiving end:

1) responds correctly to all mandatory messages appropriate to the territory in which approval is sought;

2) responds correctly to all non-mandatory CAI messages for which operation of the feature is claimed; and

3) ignores all other messages, without spurious operation or mis-operation of any valid feature.

10.14.2 The transmitting end

By manufacturer's declaration, confirm that the transmitting end:

1) generates correctly all the mandatory messages appropriate to the territory in which approval is sought;

2) generates correctly all non-mandatory CAI messages for which operation of the feature is claimed; and

3) generates no other messages.

10.15 Layer three timers

Tclr: manufacturer's declaration.

Partial release timer: manufacturer's declaration.

10.16 Declarations by the manufacturer

Where parameters, capabilities, etc., are subject to manufacturer's declaration and not to a specific test, it shall be the manufacturer's responsibility to:

1) supply the measured value of the parameter, characteristic, etc.;

2) be prepared to submit full details as to how the item was tested, test results, and in general full documentary evidence that the testing was valid;

3) be prepared, if necessary, to reproduce the tests on demand.

10.16.1 Information

The manufacturer shall supply the following information:

1) details of the blocking performance of the receiver for all of the specified frequency ranges in subclauses 4.6.3, 4.6.4 and 4.6.5;

2) details of the means by which RF channel selection is random from RF channels which are all free;

3) details of the MUX1 B channel scrambling and de-scrambling algorithms;

4) details of the algorithm for selection of link reference values;

5) the value of MIC used in the unit;

6) details of emergency access methods and registration access methods.

10.16.2 Declarations

The manufacturer shall make the following declarations:

1) that the transmitter RF carrier frequency complies with subclause 4.2;

2) that the signalling strategy complies with subclause 4.3;

3) that the dynamic channel allocation strategy complies with subclause 4.4;

4) that the modulation of the transmitted RF carrier complies with subclause 4.5.2;

5) that the unit complies with subclause 4.6.1;

6) that the unit complies with subclause 4.8;

7) that the unit complies with subclause 4.9;

8) that subclause 4.10 is applicable. Informative annex E contains recommendations concerning interim arrangements for channel switching capability;

9) that the absolute data rate, and the drift and jitter of the data rate lie within the limits of subclause 5.1.1;

10) that the unit has the ability to receive under all conditions of the absolute data rate, and the drift and jitter limits of subclause 5.1.1;

11) that the unit complies with subclause 5.1.3;

12) that if the unit is a CPP, the sub-multiplexes of MUX3 are all identical;

13) that if the unit is a public access CFP, the RF channel scanning starts at a random RF channel number;

14) that if the unit is a CPP whether it is or is not capable of generating link re-establishment messages;

15) that code word usage complies with subclause 6.1;

16) that the code word transmission sequence complies with subclause 6.3.5;

17) that the unit is or is not capable of transmitting layer three messages over more than one packet;

18) that the unit does or does not support transmit and receive buffer sizes of 128 bytes;

19) that the timer Tbid lies within the required range;

20) that the timer Tcfp lies within the required range under the worst case, i.e. the processing time for the largest possible number of stored PIDs and LIDs;

21) that the timer Tcpp lies within the required range under the worst case, i.e. the processing time for the largest possible number of stored LIDs;

22) that the timer Tfdetect lies within the required range;

23) that the timer Tpid lies within the required range;

24) that the timer Tpoll lies within the required range;

25) that the timer Tclr lies within the required range;

26) that the partial release timer lies within the required range;

27) that the ZAP field is reset to FH on manual registration or OTAR pre-registration.

10.17 Additional test requirements

10.17.1 Specifics for authentication to UKF1

Authentication is to be tested by offering a series of random challenges to the CPP and noting the response. Sufficient details of the authentication process for testing purposes are contained in a document to be made available through the United Kingdom Department of Trade and Industry (DTI).

In addition, the following shall apply:

1) manufacturers shall declare their list of features and supply details as to how registration data is to be included in CPPs;

2) specific links are to be established for:

   a) general accesses in the following sequence:

      - with an unregistered CPP, that the test CFP does not permit the call to proceed;

      - with a registered CPP, that the link is established.

      The reference CFP should then generate 16 AUTH_REQs with INCZ set to 1, in each case by inspection noting that the ZAP field in AUTH_RES is incremented and that eventually it cycles round to its initial value.

   b) emergency accesses for both registered and unregistered CPPs to public access CFPs, to ensure that in both instances the call proceeds;

3) CPP manufacturers to declare that no mechanisms have been provided to modify the ZAP field other than manual registration (or re-registration) or OTAR pre-registration of the CPP slot and that permitted by annex B, subclause B.3.3.

4) manufacturers to declare their CFP and CPP capabilities, and these are to be checked against the logged data stream;

5) Manufacturers to declare the compliance of their CFPs and CPPs with the mandatory layer three syntax requirements of annex A.

10.17.2 Reserved for future use

10.18 Characteristics of the reference test set

To perform the tests described, the approvals test system requires the following capabilities:

1) a full implementation of the CAI radio and layers one to three specifications for both CFP and CPP;

2) a capability of monitoring and logging the data bit streams;

3) an ability to select a defined channel for operation;

4) an ability to vary its transmission characteristics to permit:

   - a variation of the transmit carrier frequency by up to ±10 kHz;
   - a variation of the transmit carrier frequency at a rate of 1 kHz/ms;
   - full variation of the frequency stability, drift and jitter;
   - a variation of the modulation index to generate minimum and maximum peak frequency deviations.

5) an ability to indicate link continuity status. Specifically when a link re-establishment takes place;

6) an ability to observe minimum and maximum frequency deviations as a receiver;

7) an ability to conduct transmitter output power measurements;

8) an ability to conduct field strength measurements;

9) an ability to observe envelope shaping;

10) easy substitution of alternative codec types;

11) an ability to count transmitted and received code words and re-transmissions;

12) an ability to insert bit-errors into the data stream;

13) an ability to adjust the handshake transmission rate to less than once every 1,04 s;

14) An ability to confirm that PI=0;

15) The ability to control signal strength;

16) The ability to measure jitter and drift;

17) An ability to cater for reception and transmission of 128-octet layer three messages.

11 Speech and telephony tests

11.1 Measurement philosophy

The performance of the CPP when operating into the common air interface is measured by means of a reference CFP.

The reference CFP shall provide the equivalent of true air interface measurements and therefore shall not contain circuitry which will modify the true air interface speech frequency performance. To meet these requirements measurements shall be referred to a uniform PCM interface. The CCITT Recommendation G.721 [6] algorithm requires such a uniform interface although it may be embedded within an IC in any particular implementation and thus not physically available.

The transcoding algorithms are specified such that encoding and decoding are symmetrical, i.e. with an encoder and decoder connected in tandem, the "levels" of the digital signals at the uniform PCM input to the encoder and output from the decoder are identical. Once the speech channel signals are in the digital domain they are essentially loss-less and hence the level at the common air interface can be related to any digital interface.

Ideally, to measure the send signals from the CPP at the air interface a PCM level meter would be connected to the reference decoder uniform PCM output, and to generate receive signals for the CPP at the air interface a PCM signal generator would be connected to the reference encoder uniform PCM input.

A more practical means of measuring the speech channel performance may be achieved by converting the uniform PCM to standard m or A law PCM and then using a standard PCM test set and applying the appropriate correction factor as defined in CCITT Recommendations G.711 [15] and G.721 [6], (although this could have a deleterious effect on some parameters such as distortion).

A reference CFP is shown in figure 22 and incorporates the specified transcoder algorithm.

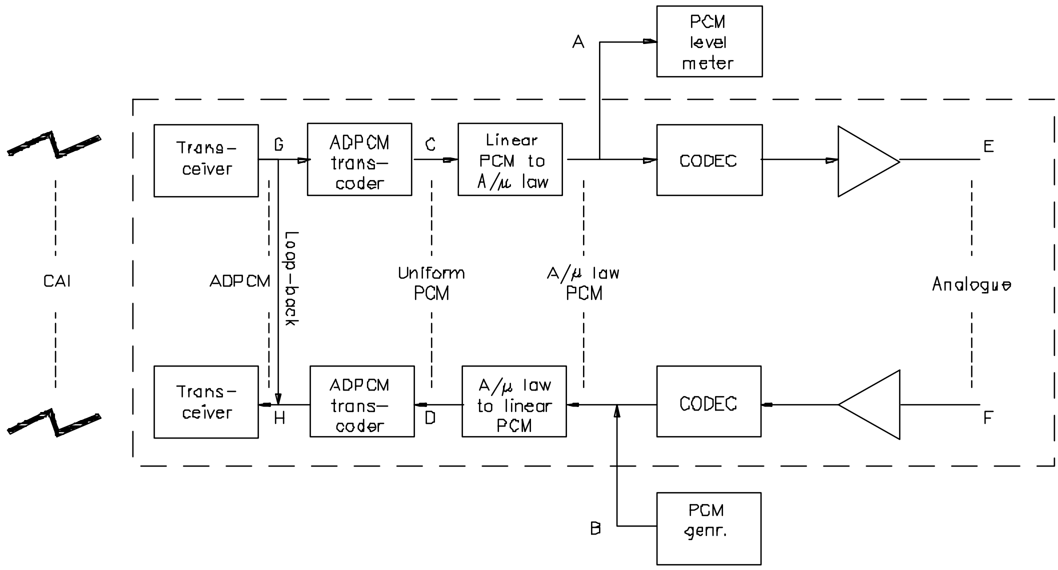


Figure 22: Reference CFP

The uniform PCM interfaces (Points C and D in figure 22) are those designated SL and SR in CCITT Recommendation G.721 [6].

11.2 Digital signal level

The digital signal levels in a transmission plan are defined in subclause 8.5.

11.3 General conditions of test

Unless otherwise stated in this standard, the tests are made under the normal operating conditions specified as follows:

- ambient temperature of +20°C ± 5°C;
- relative humidity of 45% to 75%; and
- air pressure of 86 kPa to 106 kPa.

The CPP under test shall be tested in conjunction with the reference CFP separated by some unobstructed distance, between 2 m and 10 m, in a substantially RF interference and reflection free environment, and such that the normal handshaking between CFP and CPP is maintained.

Unless otherwise stated in a particular test, where the mouthpiece of the CPP under test is fixed relative to the earpiece, the CPP is placed in the LRGP as described in CCITT Recommendation P.76, annex A [16]. Where the mouthpiece of the CPP under test is not fixed relative to the earpiece, the front plane of the mouthpiece is mounted 15 mm in front of the lip ring and coaxial with the artificial mouth.

Unless otherwise stated in a particular test, the volume control on a CPP with a user-controlled receiving volume control shall be set to maximum.

The PCM level meter used with the reference CFP and shown in figure 22 uses a codec to convert the companded digital bit-stream to the equivalent analogue values, so that existing test equipment and procedures may be used. This codec should be a high quality codec whose characteristics are close to ideal. The codec should have characteristics such as attenuation/frequency distortion, idle channel noise, quantising distortion etc. which exceed the requirements specified in CCITT Recommendation G.714 [11] so as not to mask the corresponding parameters of the apparatus under test. The linear A/D and D/A convertors used by the codec should have at least 14-bit resolution, and the filter response should lie within the upper and lower limits given in table 20.

Table 20: Frequency response of the reference codec

Limit curve	Frequency Hz	Loss dB
Upper limit	0	0,0
	80	0,0
	80	-0,25
	3600	-0,25
	3600	0,0
	4000	0,0
Lower limit	100	+40,0
	100	+0,25
	3000	+0,25
	3000	+0,9
	3400	+0,9
	3400	+40,0

The limit curves shall be determined by straight lines joining successive co-ordinates given in the table, when loss is plotted on a linear scale against frequency on a logarithmic scale.

11.4 Sending sensitivity frequency response (subclause 8.4.1)

A pure tone signal of -4,7 dBPa is applied at the MRP as described in CCITT Recommendation P.64 [13], using an artificial mouth conforming to CCITT Recommendation P.51 [12].

A digital measuring instrument, or high quality digital decoder followed by an analogue level measuring set, is connected to point A of the reference CFP as shown in figure 22.

Measurements are made at one twelfth-octave intervals as given by the R40 series of preferred numbers in ISO 3 [18] for frequencies from 100 Hz to 4 kHz inclusive. At each frequency the level for an input sound pressure of -4,7 dBPa is measured.

11.5 Receiving sensitivity frequency response (subclause 8.4.2)

A digital signal generator is connected to point B of the reference CFP as shown in figure 22, and the level adjusted to produce a level of -16 dBm0 at the uniform PCM interface.

Measurements are made at one twelfth-octave intervals as given by the R40 series of preferred numbers in ISO 3 [18] for frequencies from 100 Hz to 4 kHz inclusive. At each frequency, the sound pressure level in the artificial ear is measured.

11.6 CPP sending loudness rating (subclause 8.6)

The sending sensitivity is measured at each of the 14 frequencies given in table 2 of CCITT Recommendation P.79 [14], bands 4-17.

The sensitivity is expressed in terms of dBV/Pa and the loudness rating is calculated according to the formula 4.19b of CCITT Recommendation P.79 [14] over bands 4-17, and using the sending weighting factors from table 2, adjusted according to table 3 of the recommendation.

11.7 CPP receiving loudness rating (subclause 8.6)

The receiving sensitivity is measured at each of the 14 frequencies given in table 2 of CCITT Recommendation P.79 [14], bands 4-17.

The sensitivity is expressed in terms of dBPa/V and the loudness rating is calculated according to the formula 4.19c of CCITT Recommendation P.79 [14] over bands 4-17, and using the receiving weighting factors from table 2 of CCITT Recommendation P.79 [14], adjusted according to table 3. The artificial ear sensitivity shall be corrected using the real ear correction of table 4 of the Recommendation.

11.8 CPP sidetone masking rating (subclause 8.7.2.1)

A pure tone signal of -4,7 dBPa is applied at the MRP as described in CCITT Recommendation P.64 [13], using an artificial mouth conforming to CCITT Recommendation P.51 [12].

The reference CFP is arranged to send the appropriate control signal (via the D channel) to the CPP to enable the local sidetone path.

Measurements are made at one twelfth-octave intervals as given by the R40 series of preferred numbers in ISO 3 [18] for frequencies from 100 Hz to 4 kHz inclusive. At each frequency the level at the artificial ear for an input sound pressure of -4,7 dBPa is measured.

The sidetone path loss (Lmest) is expressed in dB and the STMR is calculated from the formula 8-4 of CCITT Recommendation P.79 [14], using the weighting factors of column 3 in table 6 (unsealed), and values of real ear correction in accordance with table 4.

11.9 Sending distortion (subclause 8.9.1)

A pure tone signal of -4,7 dBPa and a frequency in the range 1004 Hz to 1025 Hz is applied at the MRP as described in CCITT Recommendation P.64 [13], using an artificial mouth conforming to CCITT Recommendation P.51 [12].

A digital measuring instrument, or high quality digital decoder followed by an analogue level measuring set, is connected to point A of the reference CFP as shown in figure 22.

The ratio of the signal to total distortion power of the digital signal output is measured with the psophometric noise weighting (see CCITT Recommendations G.714 [11] and O.132 [24]).

11.10 Receiving distortion (subclause 8.9.2)

A digital signal generator is connected to point B of the reference CFP as shown in figure 22, and the level adjusted to produce a digitally simulated sine-wave of frequency in the range 1004 Hz to 1025 Hz at a level of -10 dBm0 at the uniform PCM interface.

The ratio of signal to total distortion power of the digital signal output in the artificial ear is measured with the psophometric noise weighting (see CCITT Recommendations G.714 [11] and O.132 [24]).

11.11 Sending noise (subclause 8.10.1)

The CPP shall be mounted at the LRGP and the earpiece sealed to the knife-edge of the artificial ear in an acoustically quiet environment (ambient noise less than 30 dB A-weighted).

A digital measuring instrument, or high quality digital decoder followed by an analogue level measuring set, is connected to point A of the reference CFP as shown in figure 22.

The noise level at the uniform PCM interface is measured using psophometric weighting to CCITT Recommendation G.223 [10], table 4.

11.12 Sending noise (narrow band) (subclause 8.10.2)

The CPP shall be mounted at the LRGP and the earpiece sealed to the knife-edge of the artificial ear in an acoustically quiet environment (ambient noise less than 30 dB A-weighted).

A high quality digital decoder followed by a selective measuring set or spectrum analyser with an effective bandwidth of 10 Hz is connected to point A of the reference CFP as shown in figure 22.

The rms voltage of the 10 Hz band limited signal is measured within the frequency range 305 Hz to 3395 Hz.

11.13 Receiving noise (subclause 8.10.3)

A digital signal generator is connected to point B of the reference CFP, and is set to provide a signal corresponding to decoder value number 1 at the uniform PCM interface (point D of figure 22).

With an ambient noise level not exceeding 30 dB A-weighted, the noise level in the artificial ear is measured.

11.14 CPP delay (subclause 8.11.1)

1) The CPP is mounted in the LRGP and the earpiece is sealed to the knife-edge of the artificial ear. A frequency response analyser is connected to the artificial ear and voice as shown in figure 23 configuration A.

2) The reference CFP is arranged to provide loop-back of the ADPCM signal as shown between points G and H of figure 22.

3) The reference CFP is arranged to send the appropriate control signal (via the D channel) to the CPP to disable the local sidetone path.

4) For each of the nominal frequencies (f0) given in table 21 in turn, the delay is derived from the measurements at the corresponding values of f1 and f2.

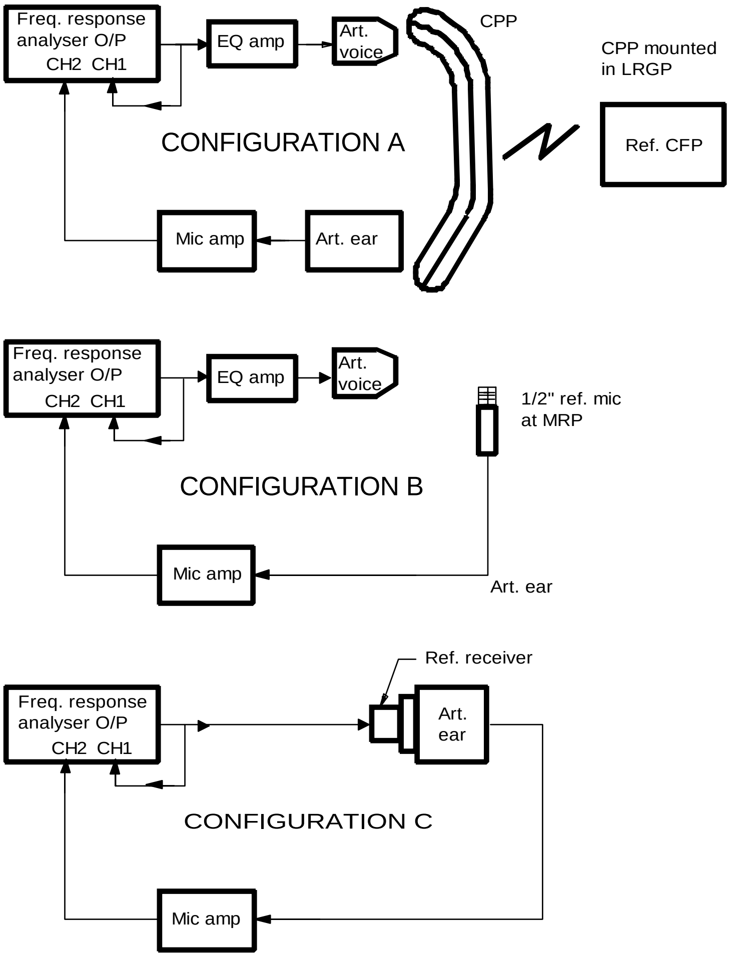


Figure 23: CPP delay test configuration

Table 21: Frequencies for delay measurement

f0 (Hz)	f1 (Hz)	f2 (Hz)
500	475	525
630	605	655
800	775	825
1000	975	1025
1250	1225	1275
1600	1575	1625
2000	1975	2025
2500	2475	2525

5) For each value of f0, the delay is evaluated as follows:

a) output the frequency f1 from the frequency response analyser;

b) measure the phase shift in degrees between CH1 and CH2 (P1);

c) output the frequency f2 from the frequency response analyser;

d) measure the phase shift in degrees between CH1 and CH2 (P2);

e) compute the delay in milliseconds using the formula:

$$D = \{1000 \times (P2 - P1)\}/\{360 \times (f2 - f1)\}$$

f) Average the 8 delay values to find the delay value D1.

6) Arrange a reference microphone at the MRP of the artificial voice as shown in configuration B of figure 23.

7) Repeat the tests in subclause 11.14.4 to find the average delay D2.

8) Arrange a close coupled reference receiver at the ERP of the artificial ear as shown in configuration C of figure 23.

9) Repeat the tests in subclause 11.14.4 to find the average delay D3.

10) The CPP delay is calculated using the expression:

D = D1 - (D2 + D3) - DRLB

where DRLB is the reference CFP ADPCM loopback delay.

The reference CFP ADPCM loopback delay is nominally 1,007 ms if the CFP re-transmits the entire 64 bit received packet as the following transmit B channel packet (B channel loopback). If the entire B channel is not looped back intact, the reference CFP ADPCM loopback delay is the sum of two delays: (a) the delay from the received CAI bit n of the B channel to the corresponding sample in the 32 kbit/s ADPCM stream and (b) the delay to the transmitted CAI bit n of the B channel from the corresponding sample in the 32 kbit/s ADPCM stream.

The reference CFP loopback delay may be calculated as 1,007 ms plus 0,125 ms per ADPCM sample which is not looped back in the immediately following transmit B channel but is delayed until the second following transmit B channel packet.

This figure assumes that:

1) there is zero propagation delay; and

2) the transmit response time of the CPP under test (as defined in subclause 6.4) is exactly 3,5 or 5,5 bit periods.

In practice, CPP transmit response times may vary by ±1/4 bit period. The reference CFP ADPCM loopback delay will vary as a result.

11.15 Weighted terminal coupling loss (subclause 8.12.1)

1) A digital signal generator is connected to point B of the reference CFP, and a PCM level meter is connected to point A as shown in figure 22.

2) The digital signal generator is set to provide a signal level of 0 dBm0 at the uniform PCM point (point D of figure 22).

3) The reference CFP is arranged to send the appropriate control signal (via the D channel) to the CPP to disable the local sidetone path.

4) The level at the uniform PCM interface (point C of figure 22) is evaluated using the level meter for one twelfth-octave intervals as given by the R40 series of preferred numbers in ISO 3 [18] for frequencies 300 Hz to 3400 Hz.

5) The echo loss is calculated according to CCITT Recommendation G.122 [8] annex B, clause B.4 (trapezoidal rule).

11.16 Stability loss - fixed geometry (subclause 8.12.2)

With the digital signal generator set to provide a signal level of 0 dBm0 at the uniform PCM point (point D of figure 22), the attenuation from digital input to digital output (point C of figure 22) is measured at one-twelfth octave intervals for frequencies in the range 200 Hz to 4000 Hz under the following conditions:

1) The CPP shall be placed on one inside surface of three perpendicular plane smooth hard surfaces forming a corner. Each corner shall extend 0,5 m from the apex of the corner. One surface shall be marked with a diagonal line extending from the corner and a reference position marked on the line 250 mm from the corner.

2) The CPP shall be positioned centrally along the diagonal line with the earcap nearer to the apex of the corner such that:

    a) the mouthpiece and earcap shall face towards the surface; and

    b) the extremity of the CPP shall coincide with the normal to the reference point.

11.17 Stability loss - variable geometry (subclause 8.12.3)

With the digital signal generator set to provide a signal level of 0 dBm0 at the uniform PCM point (point D of figure 22), the attenuation from digital input to digital output is measured at one-twelfth octave intervals for frequencies in the range 200 Hz to 4000 Hz.

11.18 Out of band (sending) (subclause 8.13.1)

1) A digital level meter is connected to point A of the reference CFP as shown in figure 22.

2) A pure sine wave of level -4,7 dBPa is applied at the MRP.

3) For frequencies of 4,65 kHz, 5,0 kHz, 6,0 kHz, 6,5 kHz, 7,0 kHz, 7,5 kHz, the level of any image frequency is measured.

11.19 Out of band (receiving) (subclause 8.13.2)

A digital signal generator is connected to point B of the reference CFP, and is set to provide a signal level of 0 dBm0 at the uniform PCM interface (point D of figure 22).

For input signals at the frequencies 500 Hz, 1000 Hz, 2000 Hz, and 3150 Hz, the level of any out-of-band signals at frequencies up to 8 kHz is measured at the ERP.

11.20 Sampling frequency level (receiving) (subclause 8.14)

A digital signal generator is connected to point B of the reference CFP, and is set to provide a signal corresponding to decoder value number 1 at the uniform PCM interface (point D of figure 22).

With an ambient noise level not exceeding 30 dB A-weighted, the level of any 8 kHz signal in the artificial ear is measured.

11.21 Acoustic shock (subclause 8.15)

A digital signal generator is connected to point B of the reference CFP as shown in figure 22, and the level adjusted to produce a level of +3,14 dBm0 (Tmax) at the uniform PCM interface.

Measurements are made at one-third octave intervals as given by the R10 series of preferred numbers in ISO 3 [18] for frequencies from 200 Hz to 4 kHz inclusive. At each frequency, the sound pressure level in the artificial ear is measured.

11.22 Listener sidetone (subclause 8.7.2.2)

The sound field is calibrated in the absence of any local obstacles. The averaged field shall be uniform to within +4 dB/-2 dB within a radius of 0,15 m of the MRP, when measured in one-third octave bands from 100 Hz to 8 kHz (bands 1 to 20).

A calibrated half-inch microphone is mounted at MRP. The sound field is measured in one-third octave bands. The spectrum shall be "Hoth" CCITT Volume V, Supplement 13 [19] to within ±1 dB and the level shall be adjusted to 50 dB A-weighted (-44 dBPa A-weighted). The tolerance on this level is ±1 dB.

NOTE: Where adaptive techniques or voice switching circuits are not used, it is recommended to increase the sound level to 60 dB A-weighted (-34 dBPa A-weighted) to help measurement accuracy.

The artificial mouth and ear are placed in the correct position relative to MRP, and the CPP is mounted at LRGP and the earpiece is sealed to the knife-edge of the artificial ear.

Measurements are made in one-third octave bands for the 14 bands centred at 200 Hz to 4000 Hz (bands 4-17). For each band the sound pressure in the artificial ear is measured by connecting a suitable measuring set to the artificial ear.

The listener sidetone path loss is expressed in dB and the LSTR is calculated from the formula 8-4 of CCITT Recommendation P.79 [14], using the weighting factors in column (3) in table 6/CCITT Recommendation P.79 [14], and the values of L_E; in accordance with table 4/CCITT Recommendation P.79 [14].

11.23 Sidetone distortion (subclause 8.9.3)

The CPP is mounted at LRGP and the earpiece is sealed to the knife-edge of the artificial ear. An instrument capable of measuring the third harmonic distortion of signals with fundamental frequencies in the range of 315 Hz to 1000 Hz is connected to the artificial ear.

A pure-tone signal of -4,7 dBPa is applied at the MRP at frequencies of 315 Hz, 500 Hz and 1000 Hz. For each frequency, the third harmonic distortion is measured in the artificial ear.

11.24 Subjective speech quality

11.24.1 Overall requirements

The CTA shall give acceptable speech performance.

This requirement shall be deemed to be fulfilled when either the conditions of subclause 11.24.2 or those of subclauses 11.24.3 and 11.24.4 are met, the criteria of subclause 11.24.5 being applied in each case to the results obtained by following the appropriate option (A or B respectively) in the test described in annex J.

In either case, the test as described in annex J may be carried out with a wire connection instead of the normal radio connection from the encoder outputs to the corresponding decoder inputs (notwithstanding the fact that in such a case the apparatus tested cannot strictly be called cordless), provided that the radio connection which replaces the wire connection, when tested in accordance with the general conditions specified in subclause 11.3, does not introduce any effective degradation of the digital signal. Compliance with this condition shall be by a supplier's declaration.

11.24.2 CTA tested as an entirety

When the CTA is to be treated as an entirety it shall meet the following requirements:

1) The standard of performance specified in subclause 11.24.5 shall be attained for the entire CTA.

2) The frequency response characteristics shall be such that the spectrum of the speech originating from the microphone of the CPP, when it reaches the input to the sending path encoder, is the same as the expected average spectrum of the speech coming from the network when it reaches the input to the receiving path encoder; given that it may be assumed for this purpose that speech arriving directly from the network has in general had imposed upon it a frequency-response characteristic between the limits shown in figure 18.

3) The gains or losses before the two encoders shall be such that, if a 1000 Hz sine wave at -5 dBPa at the MRP produces an electrical level x dBV at the sending encoder input, and a 1000 Hz sine wave at -20 dBV applied at the NTTA produces an electrical level y dBV at the receiving encoder input, then x and y shall not differ by more than 3 dB.

4) The same process of analogue-to-digital conversion, encoding, decoding and digital-to-analogue conversion shall be used in both directions.

5) Any adaptive process shall operate identically in both directions.

Compliance with the requirements of 1) shall be checked by the test described in annex J, option A. Compliance with the requirements of 2), 3), 4) and 5) shall be by manufacturer's declaration.

11.24.3 Codec to be treated in isolation

Where the codec is to be treated in isolation, the standard of performance specified in subclause 11.24.5 shall be attained for the codec pair.

Compliance shall be checked by the test described in annex J option B.

For the purposes of this subclause, the supplier shall designate an active speech level, measured in dBV, in accordance with the method described in annex J, subclause J 1.4, to be known as the nominal optimum level. This level shall then be used as the central value of the three input levels applied to the codec in the test described in annex J.

NOTE 1: The term "codec" for the purposes of this subclause is taken to mean the complete apparatus as tested in accordance with option B of annex J, in the same operating conditions as those in which it was tested. For clarity, this means that the coder-decoder pair together with any associated signal conditioning circuits (to effect gain, loss, impedance changing, anti-alias filtering, frequency-response adjustments, and similar modifications), and any non-linear processors (such as voice switching devices or companders), are all in the same state as they were during the said test.

NOTE 2: The codec input and output have to be actual electrically accessible points for the test described in annex J, but may be purely notional points in the complete CTA. That is, the above requirements do not preclude the combining together of circuit elements that were partly within and partly outside the codec in the sense defined above, provided that the overall sensitivity-frequency responses of the analogue paths (up to the analogue-to-digital interfaces and from the digital-to-analogue interfaces) are not altered.

11.24.4 CTA incorporating codec complying with 11.24.3

Where a CTA incorporates a codec in accordance with subclause 11.24.3, and is not to be treated as an entirety, it shall meet the following requirements:

1) No non-linear processing shall be incorporated in the CTA except:

   a) non-linear signal processes normally accepted in simple telephones;

   b) non-linear processes forming part of the apparatus complying with the other requirements of this subclause.

2) Any CTA in which the codec is eventually incorporated shall be designed to have the nominal sensitivity-frequency responses of its component parts within the following limits:

   a) sending side of the CPP (from MRP up to the input of the codec);

   between the lower limit and the upper limit of figure 18, but with an additional loss or gain, the same at all frequencies, sufficient to ensure that a 1000 Hz sinusoidal input at a level of -5 dBPa at the MRP results in an electrical input to the codec within the range: nominal optimum level ±1 dB;

   b) receiving side of the CFP (from the NTTA to the input of the codec);

   a gain or loss, the same at all frequencies, sufficient to ensure that a 1000 Hz sinusoidal signal at a level of - 20 dBV applied at the NTTA results in an input to the codec in the range: nominal optimum level ± 1 dB.

3) The codec used for the CTA sending direction and the codec used for the CTA receiving direction shall both be identical in function and performance with the one approved as a result of undergoing the test described in annex J option B.

4) When a codec is replaced by a purely analogue connection having the same sensitivity-frequency response, the resulting system shall meet the appropriate national requirements. Compliance shall be by supplier's declaration.

11.24.5 Standard of performance

The following criteria shall be used when assessing the values of Q_r that are tabulated as a result of the tests described in annex J.

1) For the combinations of input and output levels marked with an x in table 22, there shall be not less than 6 codes in category A, not more than 1 code in category C and none in category D.

2) For the remaining combinations of input and output levels, there shall be not more than a total of 7 codes in categories C and D combined, of which not more than 3 codes are in category D.

Table 22: Classification of input-output level combinations

Condition	Male Speech				Female Speech			
	Listening Level, dBv				Listening Level, dBv			
	-12	-22	-32	-42	-12	-22	-32	-42
1 High input level		x	x			x	x	
2 Medium input level		x	x			x	x	
3 Low input level		x	x			x	x	
4 Medium input level + noise								

11.25 CPP ambient noise rejection (subclause 8.6.1)

The sensitivity of the CPP to both room noise and noise from an artificial mouth is measured as described in Appendix A of CCITT Handbook on Telephonometry [22]. The noise spectrum used for the room noise sensitivity measurements shall be the Hoth noise spectrum. The level of the room noise shall be 70 dBA. When a suitable "street" noise spectrum is freely available, this shall be adopted for new equipment. The measurement shall be made at each of the 14 frequencies given in table 2 of CCITT Recommendation P.79 [14], bands 4-17.

The single figure DELSM (SFDELSM) is calculated from the above measurements as follows:

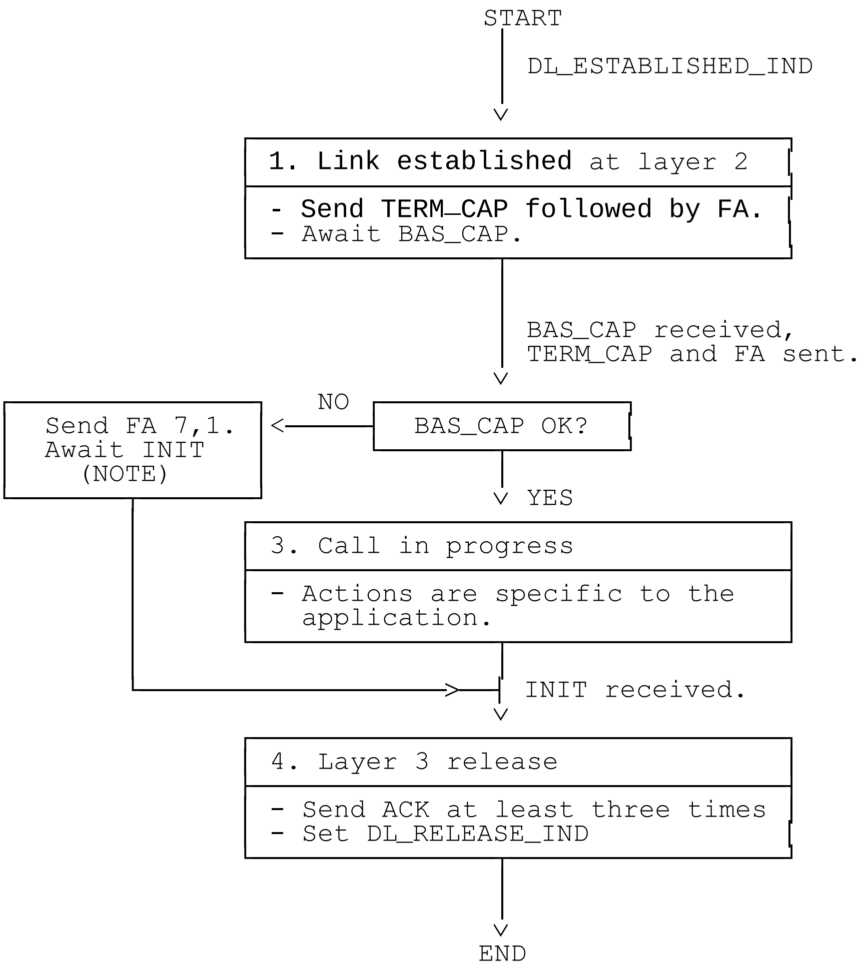
$$SFDELSM = -\frac{4}{5}\sum_{n=4}^{17} DEL_n * 10^{(-0.0175 * Wsn)}$$

Where :

	n	are the 14 standard test frequencies
	DEL_n	is the value of DELSM measured at frequency n
	W_{sn}	is send loudness rating weighting at frequency n (listed in table 2 of CCITT recommendation P.79 [14])

Annex A (normative): Layer three mandatory syntax diagrams

A.1 CPP mandatory layer three initialisation syntax



NOTE: A one second timeout applies if acknowledgement is not received.

Figure A.1: CPP mandatory layer three initialisation syntax

A.2 CFP mandatory layer three initialisation syntax

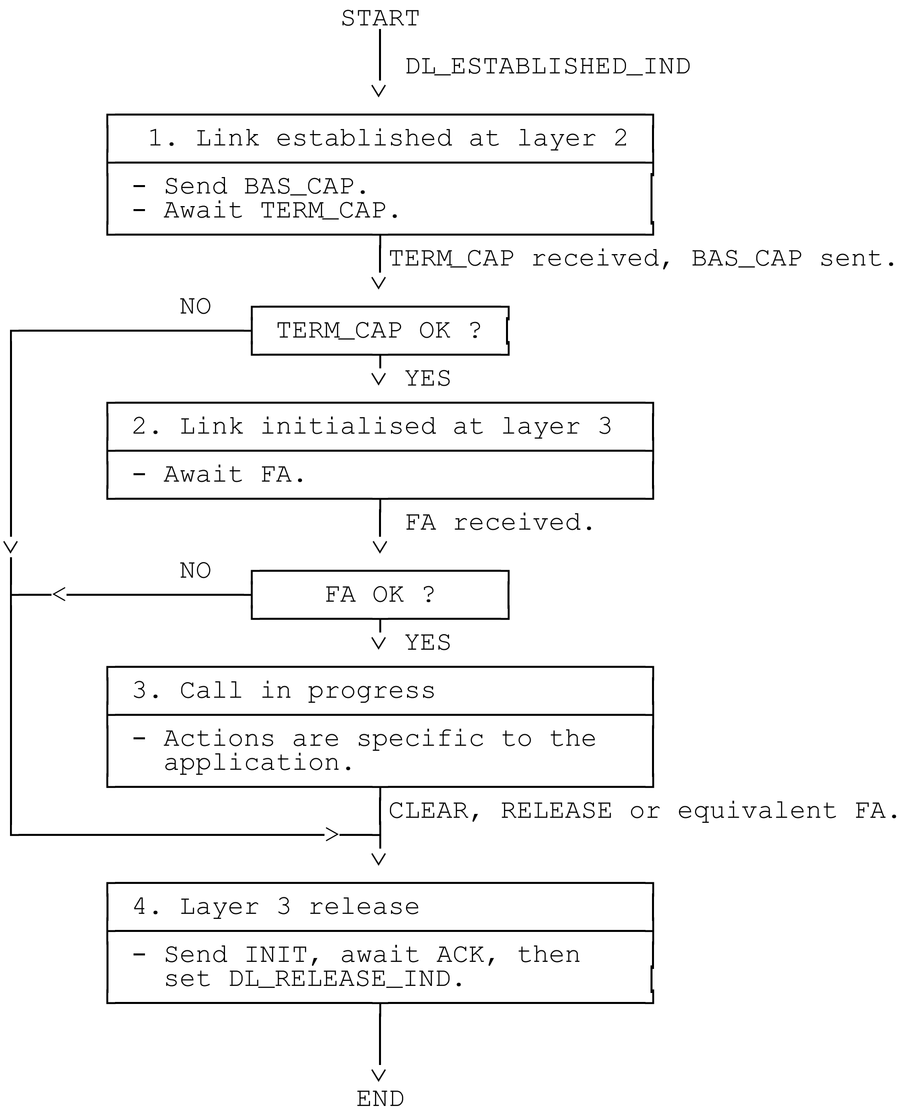
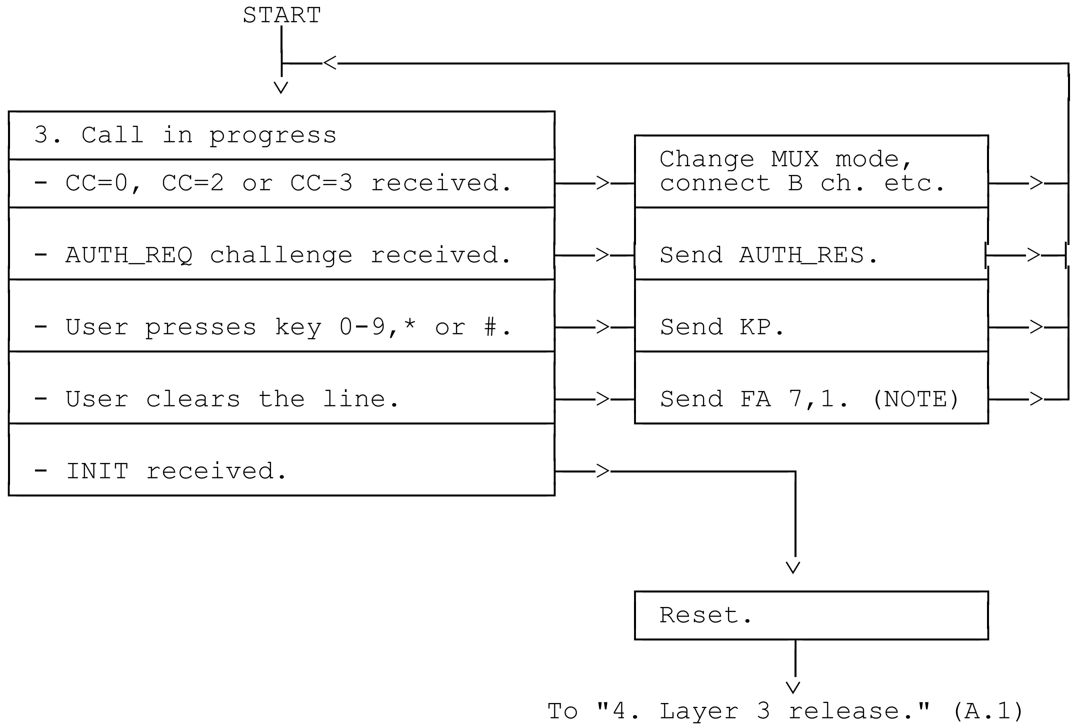


Figure A.2: CFP mandatory layer three initialisation syntax

A.3 Public access CPP mandatory layer three syntax



NOTE: A one second timeout applies if acknowledgement is not received.

Figure A.3: Public access CPP mandatory layer three syntax

A.4 Public access CFP mandatory layer three syntax

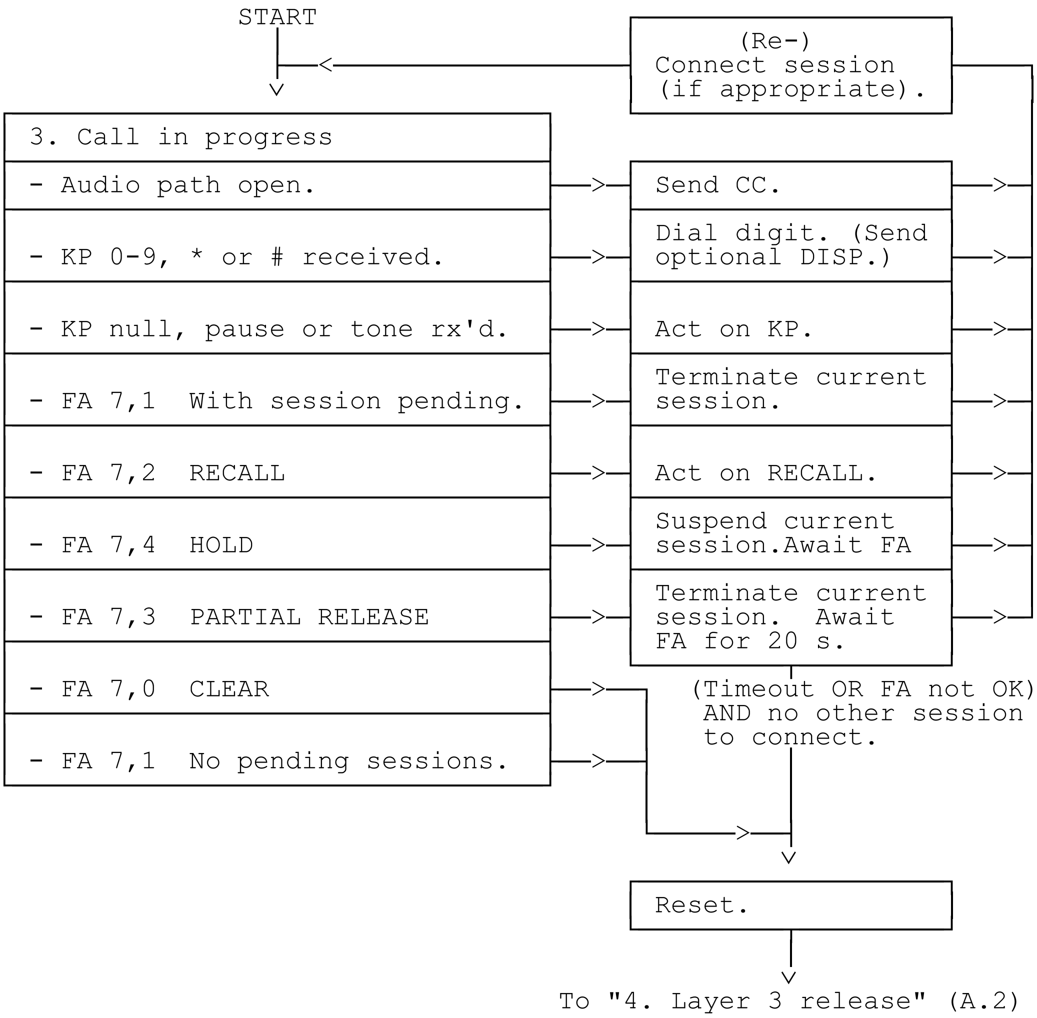


Figure A.4: Public access CFP mandatory layer three syntax

Annex B (normative): Authentication procedures

This annex describes the CT2 CAI procedures for network authentication and CPP authentication. A CPP shall support CPP authentication if it is to be used with a public access system. CPP authentication may also be required if a CPP is to be used with other CT2 systems.

B.1 Minimum configuration for CPPs using authentication

Table B.1: Minimum CPP configuration for systems using authentication

Information Element	Direction CPP CFP	CPP transmits	CPP receives & processes
KP	-------->	0-9,*,#	
DISP	<--------		- (1)
SIG	<--------		-
FA	-------->	Class 3 (public access) value 00000 value 11110, 11111 (2) Class 4 (emergency) value 00000 Class 7 (auxiliary) 00001 (full release)	
FI	<--------		-
CC	<--------		00000000 (release B) 00000010 (con B, no ls) 00000011 (con B, ls)
INIT	<--------		All
BAS_CAP	<--------		All
CHAR	--------> <--------	-	 -
OARAC	<--------		-
PAR_SET	--------> <--------	-	 -
PAR_REQ	--------> <--------	-	 - (4)
PAR_RES	--------> <--------	- (4)	 -
NO_POLL	<--------		-
AUTH_REQ	<--------		All
AUTH_RES	-------->	All	
AUTH2_REQ	<--------		-
AUTH2_RES	-------->	-	
TERM_CAP	-------->	Octets 1-9	
TRD_ALLOC	<--------		- (3)
KEY_ALLOC	<--------		- (3)
NET_AUTH_REQ	-------->	- (3)	
NET_AUTH_RES	<--------		- (3)
POLLING_LID	<--------		-
CHANGE_SLOT	<--------		-
LR_PARAMS	<--------		-
DAT_CAP	<------->	-	-
DAT_RES	<------->	-	-

(continued)

Table B.1 (concluded): Minimum CPP configuration for systems using authentication

NOTE 1:	"-" means non-mandatory
NOTE 2:	Some CPP equipments built to earlier editions of this standard do not support FA3,30 and FA3,31 (see annex E).
NOTE 3:	These information elements are mandatory if OTAR is supported.
NOTE 4:	There are no mandatory parameters (see subclause 7.4) that a CPP must support. However if a PAR_REQ is received a PAR_RES information element should be returned to the CFP (see subclause 7.2.16).

B.2 Minimum configuration for public access CFPs using authentication

Table B.2: Minimum CFP configuration for public access systems using authentication

Information Element	Direction CPP CFP	CFP transmits	CFP receives & processes (3)
KP	-------->	- (1)	0-9,*,#,NUL,pause,go to MF
DISP	<--------	-	
SIG	<--------	-	
FA	-------->		Class 3 (public access) values 00000-11111 Class 4 (emergency) values 00000-11111 Class 7 (auxiliary) 00000 (clear) 00001 (full release) 00010 (recall) 00011 (partial release) 00100 (hold)
FI	<--------	-	
CC	<--------	00000010 (con B, - ls) or 00000011 (con B, + ls) (2)	
INIT	<--------	All	
BAS_CAP	<--------	All	
CHAR	--------> <--------	 -	-
OARAC	<--------	-	-
PAR_SET	--------> <--------	 -	-
PAR_REQ	--------> <--------	 -	- (6)
PAR_RES	--------> <--------	 - (6)	-
NO_POLL	<--------		-
AUTH_REQ	<--------	All	
AUTH_RES	-------->		All
AUTH2_REQ	<--------	- (4)	
AUTH2_RES	-------->		- (4)
TERM_CAP	-------->		Octets 1-9
TRD_ALLOC	<--------	-	
KEY_ALLOC	<--------	-	
NET_AUTH_REQ	-------->		-
NET_AUTH_RES	<--------	-	
POLLING_LID	<--------	-	
CHANGE_SLOT	<--------	-	
LR_PARAMS	<--------	-	
DAT_CAP	<------->	-	-
DAT_RES	<------->	-	-

(continued)

Table B.2 (concluded): Minimum configuration for public access CFPs using authentication

NOTE 1:	"-" means non-mandatory
NOTE 2:	Although not mandatory, it is recommended that the CFP sends CC value 00000000 (use MUX1, no B) and checks that the CPP is operating in MUX1 before sending either CC value 00000010 (use MUX1, con B, no LS), or CC value 00000011 (use MUX1, con B, with LS). This avoids an audible switch from MUX2 to MUX1. Similarly, it is recommended that the CPP check that it is not receiving MUX2 before it unmutes its audio receive path.
NOTE 3:	Some Information elements may be processed, if required, outside a CFP.
NOTE 4:	Informative annex E contains recommendations concerning the possible future use of AUTH2_REQ and AUTH2_RES.
NOTE 5:	Where coverage areas are likely to overlap, CFPs should respond to call requests from CPPs in such a way as to allow the CFP that is most likely to offer the best quality link to be the most likely to establish a link with the CPP.
NOTE 6:	There are no mandatory parameters (see subclause 7.4) that a CFP must support. However if a PAR_REQ is received a PAR_RES information element should be returned to the CPP (see subclause 7.2.16).

B.3 Authentication

B.3.1 Introduction

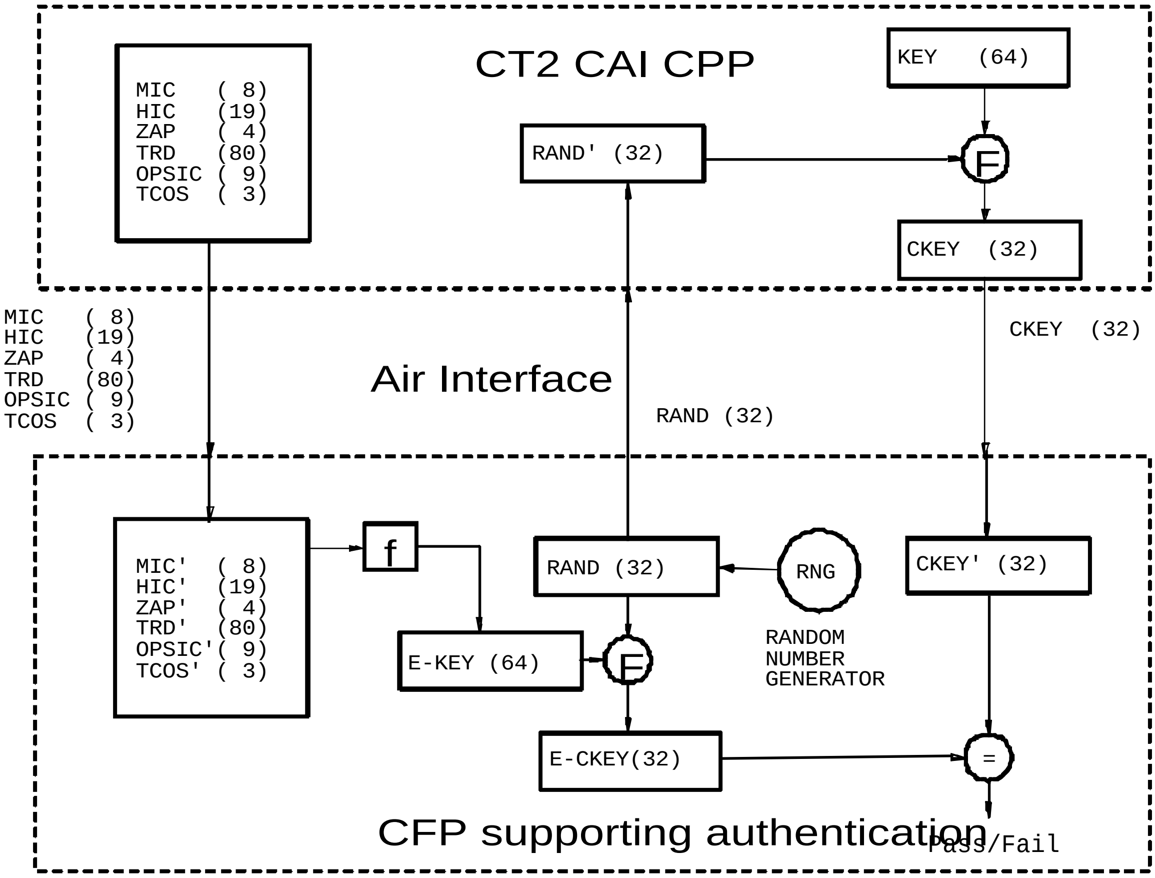
This subclause specifies the mechanisms of basic authentication to be used in CT2 CAI CPPs, offering UKF1 authentication facilities. This mechanism is also designed for use worldwide as a system of authentication for roaming customers.

This subclause does not seek to justify the need for security, or to establish a required level of security.

Authentication as described below is one part of the overall user validation processes which will be undertaken by system operators; the remainder are outside the scope of this specification and have no implications for roaming product (i.e. CPP) design.

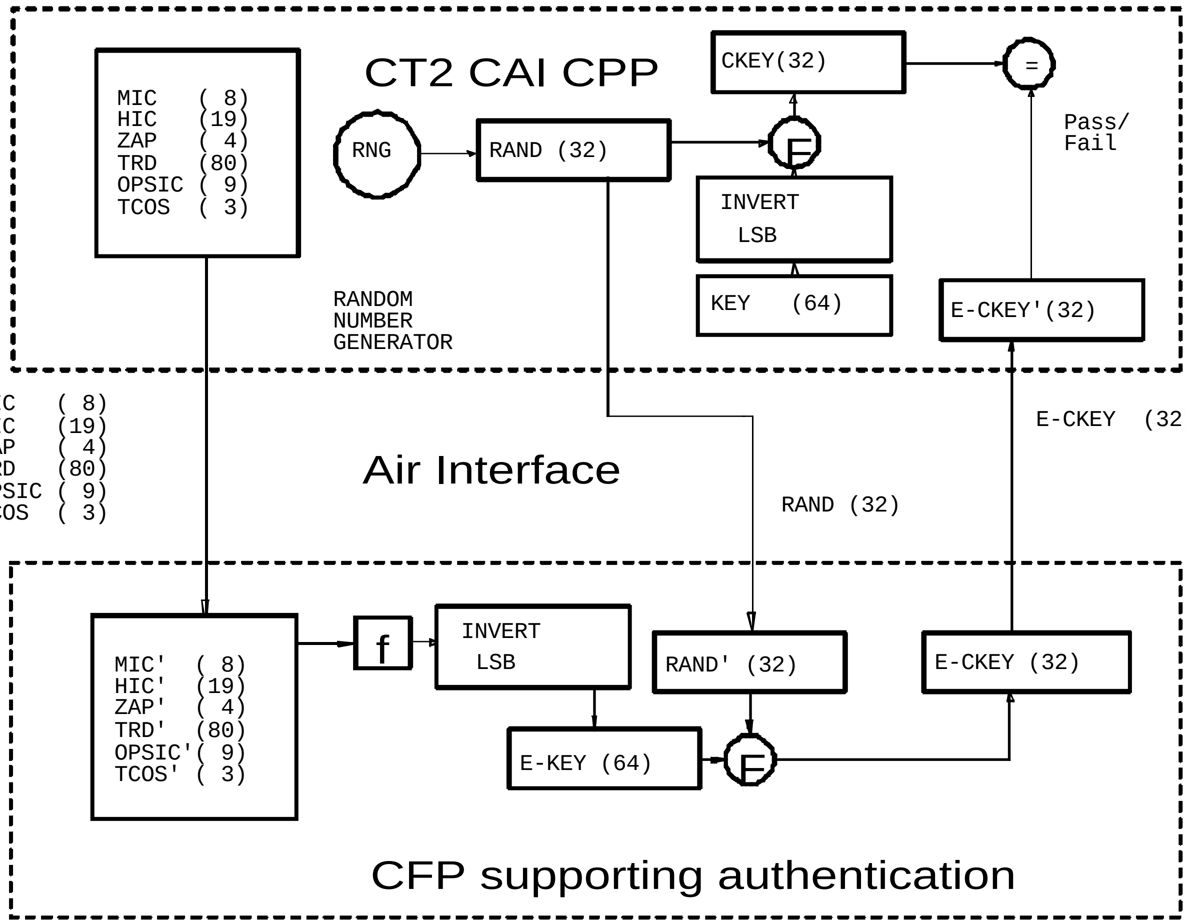
The same basic algorithm is used for both CPP authentication and network authentication. Only CPP authentication is described in detail. The KEY used in Network Authentication is different from, but related to, the KEY used in CPP authentication. The Network Authentication KEY is derived from the KEY stored in the CPP by inverting the least significant bit of the KEY stored in the CPP. Figures B.1 and B.2 illustrate the differences between CPP and network authentication.

B.3.2 Basis of operation



NOTE: The relationship shown f is the proprietary to individual system operators.

Figure B.1: CPP Authentication scheme UKF1



NOTE 1: The relationships shown **f** is proprietary to individual system operators.

NOTE 2: TRD is shown at it's maximum length

Figure B.2: Network authentication using UKF1

The basic mechanism of CPP authentication is described below and is also shown in figure B.1.

B.3.2.1 Identification information

A registration slot in a CPP contains identification information which is transmitted to the public access CFP during the set up and authentication phases of a public access call. The same information is also used in private systems using authentication. This information is sufficient to identify uniquely both the CPP making the call and also the account to which the call should be charged.

The information comprises the following fields:

- MIC 8 bits Manufacturer identity code;
- HIC 19 bits Handset identity code;
- OPSIC 9 bits Home service identity;
- TCOS 3 bits Terminal class of service;
- ZAP 4 bits ZAP field;
- TRD 80 bits Terminal registration data.

The HIC and MIC fields (see subclauses 6.4.3 and 6.4.4) are sufficient to identify uniquely the calling CPP (but not necessarily the account). They are transmitted to the CFP in signalling layer two fixed-format address code words (ACWs) during link initiation and subsequently during handshaking.

OPSIC identifies the users "home" service; i.e. the service with which the user has registered. This main use for this is during roaming when it identifies to the operator accepting the call the service through which the call should be charged. OPSIC codes will be allocated by the SCA.

TCOS gives a terminal class of service indication; i.e. the level of service that should be made available to the user. The values used will be agreed (for roaming service) and published by the SCA. Individual operators may wish to supplement this field (for example using TRD) for their "home" subscribers.

The TRD field provides additional information as necessary to ensure that the account is uniquely identified. For roaming use the format of the data will be standardised (and published by the SCA), but for "home" use the format of the data will be proprietary to individual operators.

The ZAP field, which is intended to allow a system operator to temporarily or permanently bar a CPP registration from that specific service, is defined in subclause B.3.3.

OPSIC, TCOS, TRD and ZAP are transmitted from the CPP to the CFP in layer three information element AUTH_RES (see subclause 7.2.9).

It shall not be possible for the user to display, or otherwise obtain from the CPP the values in the fields TCOS, ZAP and TRD. The value of the LID and OPSIC field may be made available to the user.

B.3.2.2 KEY number

The CPP also stores internally a KEY number which is transmitted to the CFP during the set up and authentication phases of a call. Authentication is achieved by comparing the KEY received from the CPP with the correct KEY for that CPP.

To avoid problems of fraud (arising from the monitoring of the air-interface and the cloning of valid CPPs) the KEY will be ciphered (encrypted) before transmission over the air-interface. It shall not be possible for the user to display, or otherwise obtain from the CPP, the value of the KEY field.

The process by which the content of the KEY field is interrogated by the CFP and the CPP authenticated is:

1) the CFP transmits to the CPP a 32-bit random challenge (RAND) in the layer three information element AUTH_REQ where it is received as RAND';

2) the CPP encrypts the 64-bit KEY using an encryption function "F", and using RAND' as the key, to produce the 32-bit ciphered-KEY (CKEY);

3) the CPP then transmits CKEY to the CFP in the layer three information element AUTH_RES where it is received as CKEY';

4) the CFP determines the expected-KEY (E-KEY) for the CPP using the identification information (see subclause 7) and using the same function "F", with RAND as the key, calculates the expected value of CKEY (E-CKEY);

5) the CFP compares the received CKEY (CKEY') with the expected value (E-CKEY). If the values match the CPP is judged to be valid.

B.3.2.3 Function "F"

The function "F" used in the cipher process described above is common to all systems using the UKF1 authentication algorithm, and shall be incorporated into all CPPs which support authentication.

B.3.2.4 Assignment of KEY numbers

The sections above have assumed that the CFP, given the identity of the CPP and account, will "know" the value of the KEY expected from the CPP (E-KEY). The means by which this is achieved is proprietary to individual system operators.

B.3.3 ZAP facility

Each CPP slot of type B or C (see subclause 6.4.5.1) shall have a 4-bit ZAP field associated with the registration data which is intended to allow the system operator to temporarily or permanently bar that CPP registration from access to the service.

The contents of the ZAP field are sent to the CFP during the authentication phase of a call in the layer three information element AUTH_RES. Following successful manual entry of registration data (see subclause B.4.1) into a CPP registration slot or successful OTAR pre-registration (see subclause B.4.2), the corresponding ZAP field shall be set to FH. This shall be the only mechanism by which the CPP may alter the value of ZAP in any registration slot without explicit instruction from a CFP.

The use of the ZAP field in achieving user validation is proprietary to individual system operators, and in some cases the field may not be used. The ZAP facility shall, however, be provided by all CAI-compatible CPPs.

B.4 Entry of registration and authentication data

The data used in the authentication process described above must be programmed (e.g. by the user) into the CPP. The exceptions to this are HIC and MIC which are programmed into the CPP at manufacture, and ZAP, which shall be set to FH following successful manual programming of registration data (see subclause B.4.1.) or successful OTAR pre-registration (see subclause B.4.2.).

In addition the CPP must be programmed with a link identification code (LID); this is the value used in the LID field when the CPP establishes a call to the "home" service (see subclause 6.4.5). It therefore allows the CPP to target one specific service. The LID value for a given service will be allocated to the operator by the SCA.

There are two methods of entering registration data: manual registration and over the air registration (OTAR). All CPPs shall support manual entry of data. OTAR registration is an optional feature. If a CPP enters a mode in which it supports OTAR, then this shall be indicated by sending a new TERM_CAP information element with the OTAR bit set.

B.4.1 Manual registration

The data to be programmed is supplied, at registration, by the system operator. The data is:

- LID 16 bits link identification code;
- KEY 64 bits KEY number assigned to the CPP;
- OPSIC 9 bits home service identification code;
- TCOS 3 bits terminal class of service;
- TRD 80 bits terminal registration data.

The LID, KEY, OPSIC and TCOS fields are mandatory and fixed-length but the TRD field may be used or omitted at the discretion of the system operator. The TRD field is optional and is variable-length up to a maximum of 20 BCD digits. The number of digits used is determined by the individual operator.

It is essential for system operators that the method by which registration data is programmed into a CPP is basically identical for all CPP types.

The required entry mechanism is described below. This requires that every CPP has keys 0-9,'*' and '#'.

B.4.1.1 Basic data entry

For coding simplicity fields which are specified in straight binary will be input as series of octal digits (0-7). Fields which are specified in BCD digits will be input as series of decimal digits (0-9). Thus for the information to be input as part of the registration:

- LID 16 bits denoted ss....ss input in octal;
- KEY 64 bits denoted pp....pp input in octal;
- OPSIC 9 bits denoted oo....oo input in octal;
- TCOS 3 bits denoted ccc input in octal;
- TRD 80 bits denoted tt....tt input in decimal.

Data will be input in blocks of eight characters where each character represents data bits as:

	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8
Block 0:	sss	sss	sss	sss	sss	spp	ppp	ppp
Block 1:	ppp	ppp	ppp	ppp	ppp	ppp	ppp	ppp
Block 2:	ppp	ppp	ppp	ppp	ppp	ppp	ppp	ppp
Block 3:	ppp	ppp	ppo	ooo	ooo	ooc	cc?	???
Block 4:	tttt	tttt	tttt	tttt	tttt	tttt	tttt	tttt
Block 5:	tttt	tttt	tttt	tttt	tttt	tttt	tttt	tttt
Block 6:	tttt	tttt	tttt	tttt				

NOTE 1: Characters are entered left to right (on the above table), blocks are entered in ascending numerical order.

NOTE 2: Bits are entered as defined in subclause 6.3.1; thus the least significant bit of each field is input first (and is shown on the top-left hand side of the field in the above table) and the most significant bit of the field is input last (and is shown on the bottom-right hand side of the field in the table).

NOTE 3: Bits shown "?" are used for padding only and are not allocated; the bits entered can take any value and are ignored.

NOTE 4: The value of the digit entered to represent the 3- or 4-bit group is calculated where the left-hand bit of the group as shown in the table (i.e. the bit entered first) is the least significant bit and has a binary weighting of 1.

NOTE 5: The TRD field is variable length and is shown in the above table at its maximum length of 20 BCD characters; where TRD is either omitted or used at less than its maximum length then fewer blocks may need to be input.

NOTE 6: Where the final block consists of less than 8 digits then the final data digit shall be followed by a '*' character to terminate entry and then the block should be padded as necessary with random digits (0-9) to fill the block; where the final block is of exactly 8 digits (i.e. where TRD is of length 0, 8 or 16 digits) then no '*' character will be used.

B.4.1.2 Check digits

Each block of eight characters (0-9 or '*') will be followed by a ninth character (0-9 or '*') as a check character. This character is calculated as the modulo-11 sum of the block number (0-6) plus the value of each character entered multiplied by its position in the block.

NOTE 1: The first character entered in a block is at position 1, the final character is a position 8.

NOTE 2: When the modulo-11 sum has value 10 (decimal) then the '*' character is used as the check character.

NOTE 3: In calculation of the check character the '*' terminating character has value 10 (decimal) and the random padding digits are included.

B.4.1.3 Termination of data entry

After the final data block a terminating block is required. This takes the form of 4 characters; a 2-digit modulo-100 sum (00-99) of all the previously entered data digits followed by a single modulo-11 check character of these two digits (calculated as in subclause B.4.1.2) and a '#' terminating character.

Note that the '*' terminating character (if present), the random padding digits and the check character in each block are ignored for the purposes of the calculation of the modulo-100 sum.

B.4.1.4 Example

By way of example consider the case when the data to be input takes the values shown below. In this example TRD is used with a length of 4 digits.

LID	(msb)	0000	0000	1000	1000			(lsb)
KEY	(msb)	0000	0001	0010	0011	0100	0101	
		0110	0111	1000	1001	1010	1011	
		1100	1101	1110	1111			(lsb)
OPSIC	(msb)	1	0000	1111				(lsb)
TCOS	(msb)	000						(lsb)
TRD	(msb)	1001	0111	0101	0011			(lsb)

This data would be coded as:

	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8
Block 0:	000	100	010	000	000	011	110	111
Block 1:	101	100	111	101	010	110	010	001
Block 2:	111	001	101	010	001	011	000	100
Block 3:	100	000	001	111	000	010	00?	???
Block 4:	1100	1010	1110	1001				

The 4 bits marked "?" in the above table will be filled with random data. If, for example, they are filled with binary "1s" the data becomes:

	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7	Ch8
Block 0:	000	100	010	000	000	011	110	111
Block 1:	101	100	111	101	010	110	010	001
Block 2:	111	001	101	010	001	011	000	100
Block 3:	100	000	001	111	000	010	001	111
Block 4:	1100	1010	1110	1001				

This data would then be input with the following strings of digits:

Block 0:	012006370
Block 1:	517523242
Block 2:	745246015
Block 3:	104702478
Block 4:	3579*3451
Block 5:	268#

NOTE: Block 4 contains the terminating character '*' and three random padding digits ("345" in this instance).

A CFP intending to authenticate the CPP will issue an AUTH_REQ message. Assuming the value of RAND given below,

RAND (msb) 0010 0110 0001 1000 1010 1111 0000 1001 (lsb)

the AUTH_REQ message will be:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	0	1	1	1	
	AUTH_REQ information element identifier							1
0	0	0	0	0	1	1	0	
	length of AUTH_REQ information element							2
0	0	0	0	0	0	0	1	
	AUTH_NO							3
0	0	0	0	1	0	0	1 (lsb)	4
1	0	1	0	1	1	1	1	5
	RAND							
0	0	0	1	1	0	0	0	6
0 (msb)	0	1	0	0	1	1	0	7
0	0	0	0	0	NAR	0	INCZ	8

Running the "F" algorithm with the above RAND and KEY yields the value of CKEY given below.

CKEY (msb) 1110 1101 1110 0100 0011 0010 1001 0011 (lsb)

Given the above registration and encryption data, and assuming that ZAP has the value given below,

ZAP (msb) 0011 (lsb)

the AUTH_RES response from the CPP shall be as follows:

Bit: 8	7	6	5	4	3	2	1	octet
0	0	0	0	1	0	0	0	
	AUTH_RES information element identifier							1
0	0	0	0	1	0	0	0	
length of AUTH_RES information element								2
1	0	0	1	0	0	1	1 (lsb)	3
0	0	1	1	0	0	1	0	4
CKEY								
1	1	1	0	0	1	0	0	5
1 (msb)	1	1	0	1	1	0	1	6
0	0	0	0	1	1	1	1 (lsb)	7
OPSIC								
0	0	1	1	0	0	0	1 (msb)	8
ZAP				TCOS				
0	1	0	1	0	0	1	1 (lsb)	9
TRD								
1 (msb)	0	0	1	0	1	1	1	10

B.4.1.5 Man-machine interface (MMI) for manual registration

The procedure for manual entry of registration data should be common to all CPP types. The required procedure is:

1) the user selects the correct mode for entry of registration information and, where more than one registration "slot" is provided, the correct "slot" identity. This procedure may vary between different CPP types. CPP emits short (confidence) "beep" and clears display if present;

2) the user enters the 9 characters (0-9,'*') comprising the first/next block of data. Characters echoed to display if present. Normal use may be made of <Backspace> or other editing keys;

3) after the final character of the block has been input the CPP checks for a digit error in the block by performing the modulo-11 calculation. If no error is discovered the CPP emits a short (confidence) beep, clears the display if present and continues from 2) with the next data block;

4) if an error is encountered in the modulo-11 check, the CPP emits a warning/error beep and requires the user to re-enter the digits of the block from step 2);

5) when the terminating '#' is detected the CPP checks that it is correctly positioned and that the modulo-11 check for that block is correct. If an error is detected the CPP emits a warning/error beep and requires that the digits of that block be re-entered;

6) if the modulo-11 character is correct then the CPP performs the overall modulo-100 check. If an error is discovered the CPP will abort the registration procedure;

7) if no error is found the CPP emits a short (confidence) beep and completes the registration procedure by writing the registration data to semi-permanent storage;

8) if any other key is pressed (or event occurs) which would normally terminate such a procedure, or if the CPP is switched off, the registration procedure should be aborted and all data entered should be discarded;

9) any other key depression should be ignored (may emit a warning/error beep).

NOTE: If a registration procedure is terminated early or aborted because of an entry error then the data entered should be discarded. At the very least, steps should be taken to ensure that the "incorrect" data can never be used in a call set up request, and, ideally, the previous "valid" data in the "slot" should remain intact.

B.4.2 Over the air registration

A CPP supporting OTAR shall support all the functions listed below:

NET_AUTH_REQ, NET_AUTH_RES
KEY_ALLOC information element
TRD_ALLOC information element
Support for octets 10,11,12 in TERM_CAP
The decryption algorithm, FTD1

There are two stages involved in OTAR:

1) before OTAR can occur for the first time in a given slot, the slot must be pre-registered by the manual entry of an LID and optionally an EPID. EPID is an initial value in the decryption process;

2) after pre-registration, the CPP slot is capable of establishing a link to a CFP and registration data is then loaded over the air interface. After initial registration, a CPP can be re-registered using the air interface without the need for a pre-registration process

B.4.2.1 Pre-registration of LID only

This is the minimum key sequence which may be entered to pre-register a CPP. The user enters the LID to be used for OTAR access. The value of EPID used in the on-air OTAR process is either the existing value of EPID or a Global PID (GPID) stored in the CPP at manufacture. This is a manufacturers option, it is not selectable in the pre-registration process. The value of GPID will vary between CPPs. CPP manufacturers shall make the value of GPID stored in each CPP available to system operators and may mark the value on each CPP.

After successful entry of LID in the pre-registration, the AUTH_PREF field associated with the registration slot shall be set to all zeros i.e. 00H and the "NEW_LID" flag shall be set. Each bit of the KEY, TRD, ZAP, OPSIC and TCOS fields shall be set to 1. All other fields associated with the slot (with the exception of EPID when the CPP contains a GPID) shall remain unchanged.

The key sequence used to enter LID data shall be as follows:

!!LLLLC#

where:

!! represents a manufacturer dependent enabling sequence;
LLLL represents the 4 digit octal representation of the LID;
C represents the check digit;
is the terminating character.

The four LID (LLLL) digits represent the 12 least significant bits of the 16 bit LID. The most significant four bits shall automatically be set to 0. The first digit entered represents the most significant three bits of the 12 bits entered.

The sequence is terminated by the entry of the character "#", and the LID shall be accepted unless the check digit fails, or if the registration slot is restricted to public access services only and the LID is outside the range of public access values (i.e. 0-03EFH see subclause 6.4.5), or if the registration slot is restricted to private systems use only and the LID value entered is outside the Link reference range (i.e. 0401-FFFEH see subclause 6.4.5). In the event of a failed pre-registration, the existing stored values in the registration slot shall not be updated and failure shall be indicated to the user by some audible and/or visible means.

The check digit (C) is calculated as the modulo 11 sum of each digit entered multiplied by its position in the input stream. If the result of the check is 10 (decimal) then the character "*" shall be used to represent this. The first digit of the LID is position 1.

By way of example consider the pre-registration of a CPP with LID=0076H.

0076 Hex	=	0166 Octal
1*0+2*1+3*6+4*6	=	44
44 modulo 11	=	0
Keypad sequence is:		!!01660#

B.4.2.2 Pre-registration of LID and EPID

This process allows the entry of the LID and variable length EPID into the CPP. The length of EPID entered is determined by the operator and is a compromise between ease of user data entry and security.

After successful entry of LID and EPID in the pre-registration, the AUTH_PREF field associated with the registration slot shall be set to all zeros i.e. 00H and the "NEW_LID" flag shall be set. Each bit of the KEY, TRD, ZAP, OPSIC and TCOS fields shall be set to 1. All other fields associated with the slot (with the exception of EPID when the CPP contains a GPID) shall remain unchanged.

The key sequence used to enter LID and EPID data shall be as follows:

!!LLLLEE...EEC#

where:

!!	represents a manufacturer dependent enabling sequence. This shall be the same sequence used for LID only entry;
LLLL	represents the 4 digit octal representation of the LID exactly as described for LID only entry;
EE...EE	represents a variable length EPID (1-21 octal digits);
C	represents the check digit and contains a component derived from the PID of the CPP;
#	is the terminating character.

The four LID (LLLL) digits represent the 12 least significant bits of the 16 bit LID. The most significant four bits shall automatically be set to 0. The first digit entered represents the most significant three bits of the 12 bits entered.

The maximum length EPID field (21 octal digits) allows the entry of a 63 bit number. If more than 21 EPID digits are entered then the EPID is out of range and shall be rejected. If less than 21 EPID digits are entered, these shall represent the least significant portion of the EPID and the most significant portion (including bit 64 which is never entered) shall be set to 1.

When any part of the EPID is entered, the check digit (C) shall include a component derived from the CPP serial number. The first part of the check sum is calculated as the modulo 11 sum of each digit (LID and EPID) entered multiplied by its position in the input stream. The first digit of the LID is position 1. To this is added the modulo 11 addition of each of the 12 decimal digits in the mandatory part of the human-readable CPP serial number. The result (modulo 11) is the check digit. If the result of the check is 10 (decimal) then the character "*" shall be used to represent this.

The sequence is terminated by the entry of the digit "#", and the LID and EPID shall be accepted unless the check digit fails or if the registration slot is restricted to public access services only and the LID is outside the range of public access values (i.e. 0-03EFH see subclause 6.4.5), or if the registration slot is restricted to private systems use only and the LID value entered is outside the Link reference range (i.e. 0401-FFFEH see subclause 6.4.5). In the event of a failed pre-registration, the existing stored values in the registration slot shall not be updated and failure shall be indicated to the user by some audible and/or visible means.

By way of example consider the pre-registration of a CPP with LID=0072H, EPID=012345678H (as 36 bits) and serial no. 008001123456 Decimal.

LID/EPID component

0072 Hex = 0162 Octal
012345678 Hex = 2215053170 Octal

36 bits is 12 octal digits therefore EPID is entered 002215053170

```
digit              1111111
position    1234567890123456

entered digit   0162002215053170
```

checksum = 335
335 modulo 11 = 5

Serial number component

serial number = 008001123456

checksum = 30
30 modulo 11 = 8

total checksum = 13
13 modulo 11 = 2

Keypad sequence is : !!01620022150531702#

When padded out with ones, this produces an expanded EPID (64-bit) of:

FFFFFFF012345678

It is recommended that when presenting the pre-registration data to the user, the digits are laid out in groups as indicated below:

!! 0162 0022 1505 3170 2#

B.4.2.3 Man-machine interface (MMI) for OTAR pre-registration

The procedure for entry of OTAR pre-registration data should be common to all CPP types. The required procedure is:

1) the user selects the correct mode for entry of registration information and, where more than one registration "slot" is provided, the correct "slot" identity. This procedure may vary between different CPP types. CPP shall emit short (confidence) "beep" and shall clear the display if present;

2) the user enters the characters (0-9,'*','#') comprising the data. Characters shall be echoed to display if present. Normal use may be made of <Backspace> or other editing keys;

3) after the final character has been input('#'), the CPP shall check for a digit error in the block by performing the appropriate modulo-11 calculation. If no error is found the CPP shall emit a short (confidence) beep and complete the registration procedure by writing the registration data to semi-permanent storage;

4) if any other key is pressed (or an event occurs) which would normally terminate such a procedure, or if the CPP is switched off, the pre-registration procedure shall be aborted and all data entered shall be discarded.

If a pre-registration procedure is terminated early or aborted because of an entry error then the data entered shall be discarded.

Steps shall be taken to ensure that the "incorrect" data can never be used in a call set up request, and, the previous "valid" data in the "slot" shall remain intact.

B.4.2.4 On-air registration process

Once the CPP is pre-registered it is capable of establishing a link with the CFP of the target network. The CPP shall establish communication in the normal way using the pre loaded LID value. Once the link is established and after exchange of TERM_CAP and BAS_CAP, the CPP shall send a PUBLIC Feature Activation, FA = 3;0 if the public feature is activated by the user.

Once the network determines that the CPP requires full registration, (eg. by noting that the LID value is different to the normal access LID value and/or that the AUTH_PREF field is zero while AUTH_KEY is non zero), the registration data needs to be loaded into the CPP over the air interface. If the CFP attempts to authenticate the CPP at this stage, the CPP shall perform the authentication and respond, but the CFP shall not expect the response to be correct.

The network determines the authentication abilities of the CPP from the AUTH_KEY field in TERM_CAP. If the network is not able to offer registration data to suit any of the available authentication algorithms, then OTAR shall fail. In addition, the network determines the decryption abilities of the CPP, also from the AUTH_KEY field in TERM_CAP. If the network is unable to support any of the available decryption algorithms, then OTAR shall fail.

Registration and authentication parameters are transferred using the TRD_ALLOC and/or KEY_ALLOC information elements. These may be sent in any order. The updated information shall not be stored permanently until the OTAR sequence is correctly terminated. The correct termination sequence shall be the receipt at the CPP of either an AUTH_REQ information element or INIT information element. If the AUTH_REQ information element is used then the newly received data shall be used to generate the AUTH_RES information element.

It is not possible to carry out any successful authentication process prior to initial over the air registration. However, it is desirable at subsequent OTAR processes for the CFP and CPP to authenticate each other. If network authentication is required in these situations, it shall be initiated by the CFP using the NAR field in AUTH_REQ.

Bit 64 of EPID and the "NEW_LID" flag are used by the CPP to determine if network authentication is required before registration data is changed. If bit 64 of EPID is 1 (as it must be after manual pre-registration) then mutual authentication is not required before OTAR. If bit 64 of EPID is 0 and "NEW_LID" flag is 1 an OTAR operation may be made without successful network authentication. The "NEW_LID" flag shall be reset to zero following a successful OTAR sequence. If bit 64 of EPID is 0 and "NEW_LID" flag is 0 then mutual authentication shall occur prior to further OTAR operations i.e. any TRD_ALLOC and KEY_ALLOC messages received before successful network authentication shall be ignored.

B.4.2.5 FTD1 Decryption Algorithm

This subclause describes the operation of the FTD1 (France Telecom Decryption 1) algorithm. If this algorithm is available it shall be indicated by setting bit 24 of the AUTH_KEY field of TERM_CAP to 1 and by setting OTAR_NO in the KEY_ALLOC information element to 18H (24 decimal). This (or an alternative, as yet undefined) algorithm must be used to decrypt the data if the ENC bit of KEY_ALLOC is set. The decryption process results in a new value of KEY or EPID depending on the value of TYP (see subclause 7.2.24).

The new value of EPID or KEY is derived from EKEY1, EKEY2, EKEY3 and the current value of EPID by the following formula:

$$KEY'(EPID')=(F(EKEY1,EPID)+F(EKEY2,EPID)*2^{32})XOR\ EKEY3)$$

The encryption function F is identical to that used in the UKF1 authentication algorithm. The use of the FTD1 algorithm is shown in figure B.3.

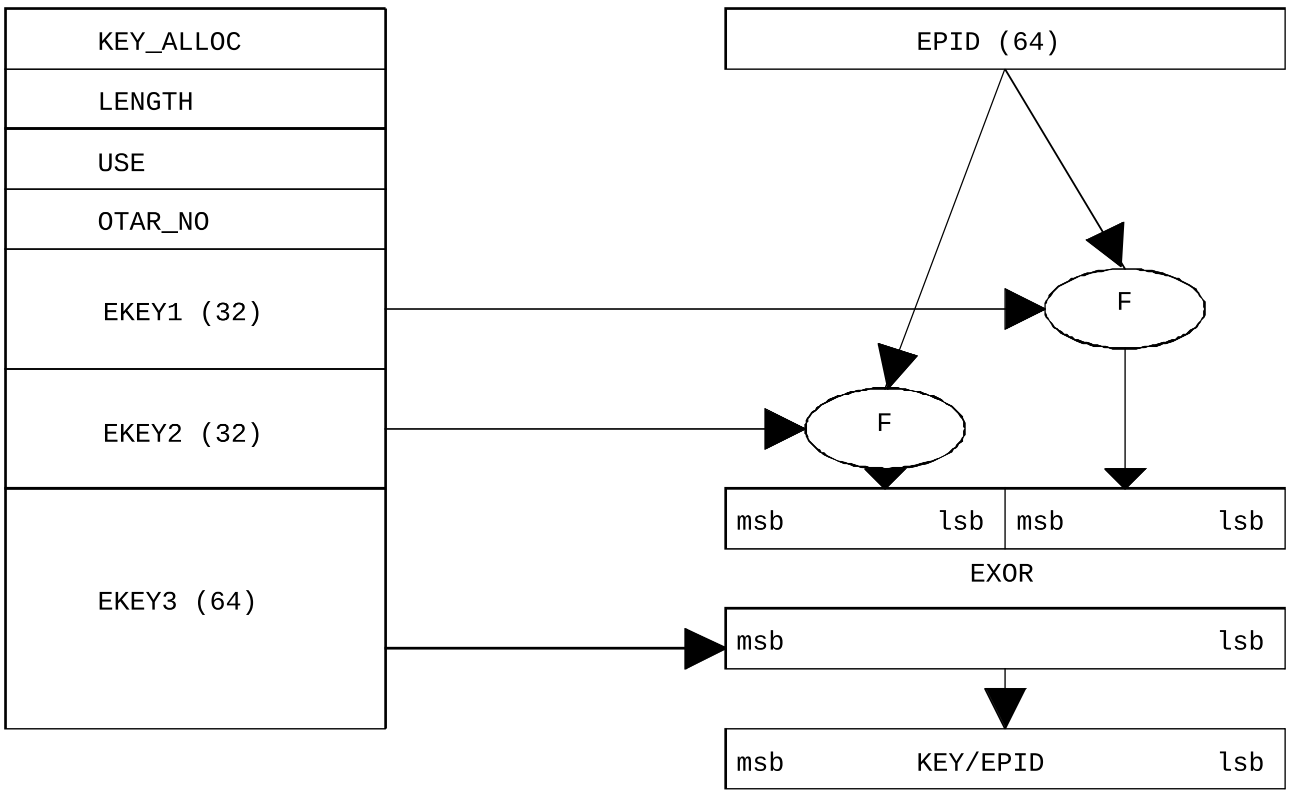


Figure B.3 Key decryption algorithm FTD1

If the data is sent in encrypted form, EKEY1 and EKEY2 shall contain "random" or non-repeating numbers to be used as indicated in the formula.

B.4.3 CPP registration capacity

As a minimum, a CAI compatible CT2 CPP shall have two independent registration slots, each meeting, or exceeding the requirements of B.4.3.1

B.4.3.1 Manual registration slot

The registration information described above is specific to one registration. Each manual registration slot requires storage as follows:

LID	16 bits
KEY	64 bits
OPSIC	9 bits
TCOS	3 bits
TRD	80 bits
ZAP	4 bits
	---
	176 bits

This means that a manual registration "slot" will require 22 bytes of non-volatile storage.

B.4.3.2 OTAR registration slot

If OTAR is supported in a registration slot, a greater amount of storage is required. Each OTAR registration slot requires storage as follows:

LID	16 bits
KEY	64 bits
OPSIC	9 bits
TCOS	3 bits
TRD	80 bits
ZAP	4 bits
EPID	64 bits
NEW_LID	1 bit
AUTH_PREF	8 bits
	---
	249 bits

This means that an OTAR compatible registration slot will require 32 bytes of non-volatile storage. In addition, if a GPID value is stored an extra 8 bytes of non-volatile storage per CPP is needed.

Annex C (normative): Serial number and GPID format

The standard serial number format for CT2 CAI handsets shall be as follows:

MMM mmm HHHHHH xx...xx

or, when the recommended checksum character is provided:

C MMM mmm HHHHHH xx...xx

where:

C — is the check character. The check character is calculated as the sum of each digit in the mandatory part of the string multiplied by its position in the string modulo 11. The first digit of the PID (after the C) is position 1. This sum is then transformed into an alphabetical character by adding the result (0 to 10) to the IA5 code for the letter P (decimal 80). The resultant character will lie between P and Z.

Example calculation of check digit:

Mandatory part is 008002027760
0+0+24+0+0+12+0+16+63+70+66+0 = 251
251 modulo 11 =9
IA5 89 is "Y"

The resulting serial number is: Y008002027760

MMM — is the decimal representation of the MIC, in the range 000 to 255 (2^8 - 1);

mmm — is the decimal representation of the MODEL number in the handset (and is the decimal equivalent of the MODEL field in TERM_CAP), and lies in the range 000 to 255 (2^8 - 1);

HHHHHH — is the decimal representation of the HIC, and lies in the range 000000 to 524287 (2^{19} - 1); and

xx...xx — is free-format, manufacturer-specific data, and thus may be alphanumeric.

The serial number in this format shall be accessible to the user of a CPP (e.g. on a display and accessed by a specified key sequence, or on a printed label in the battery compartment).

If a CPP has a GPID, it may (at manufacturers option) be accessible to the user of a CPP (e.g. on a display and accessed by a specified key sequence, or on a printed label in the battery compartment).

The standard GPID number format for CT2 CAI handsets shall be as follows:

GGGGGGGGGGGGGGGG

where GGGGGGGGGGGGGGGG is the hexadecimal representation of the GPID with most significant digit on the left and least significant digit on the right.

Annex D (normative): Accuracy of measurement

D.1 Radio frequency parametric and system tests

The overall accuracy of measurement shall be as follows:

Table D.1: Accuracy of RF parameter measurements

Item	Accuracy
DC voltage	±3 %
AC mains voltage	±3 %
AC mains frequency	±0,5 %
Radio frequency	±50 Hz
Radio frequency voltage	±2 dB
Radio frequency field strength	±3 dB
Radio frequency carrier power	±10 %
Adjacent channel power	±3 dB
Impedance of artificial loads, combining units, cables, plugs, attenuators etc.	±5 %
Source impedance of generators and input impedance of measuring receivers	±10 %
Attenuation of attenuators	±0,5 dB
Temperature	±1 °C
Humidity	±5 %

D.2 Signalling system tests

The overall accuracy of measurement shall be as follows:

Table D.2: Accuracy of signalling system measurements

Item	Accuracy
Time	± 5 %

D.3 Speech and telephony tests

The overall accuracy of measurement shall be as follows:

Table D.3: Accuracy of speech and telephony measurements

Item	Accuracy
Electrical signal power (for signals ≥ -50 dBm)	± 0,2 dB
Electrical signal power (for signals < -50 dBm)	± 0,4 dB
Sound Pressure	± 0,6 dB
Time	± 5 %
Frequency	± 2 % (see note)

NOTE: When measuring sampled systems, it is advisable to avoid measuring at sub-multiples of the sampling frequency. There is a tolerance of ± 2% on the frequencies, which may be used to avoid this problem, except for 4 kHz where only the -2% tolerance may be used.

Annex E (informative): Interim arrangements

E.1 Minimum RF power

Notwithstanding the provisions of subclause 4.5.1.2, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st December 1992, national authorities accept the use of CFPs and CPPs meeting a reduced specification for minimum RF output power (as defined in subclause 9.3.1), provided that the following is met:

- at nominal design operating voltage the normal carrier output power or effective radiated power under normal test conditions shall not be less than 1 mW.

E.2 Radio receiver sensitivity

Notwithstanding the provisions of subclause 4.6.2, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st December 1992, national authorities accept the use of CFPs and CPPs meeting a reduced specification for radio receiver sensitivity (as defined in subclause 9.5.7), provided that the following is met:

- the radio receiver sensitivity shall be at least 45 dBmV/m. It is recommended that this be achieved by ensuring that the radio receiver sensitivity is typically 40 dBmV/m or better. The receiver sensitivity (see subclause 9.5.7) shall be defined at a bit error ratio of 1 in 1000 or better in both the B (speech data) and D (signalling data) channels (see subclause 5.2).

E.3 Portable part ADPCM voice codec

Notwithstanding the provisions of subclause 8.1.4, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st March 1993, national authorities accept the use of a reduced specification codec in the portable part, provided that it meets the following requirement:

- any design variations to enable compliance with alternative relevant national standards shall be confined to the CFP in order to allow for maximum roaming. When working to a full G.721 codec in the fixed part (as defined in subclause 8.1.4), the codec in the portable part may be of reduced specification, but shall interwork with a full CCITT Recommendation G.721 [6] codec to meet the objective and subjective tests contained in subclause 11.24.

E.4 Weighted terminal coupling loss

Notwithstanding the provisions of subclause 8.12.1, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st March 1993, national authorities accept portable parts with a reduced TCLw (weighted terminal coupling loss), provided that it meets the following requirement:

- with the earpiece sealed to an artificial ear, the weighted terminal coupling loss (TCLw) measured from the digital input to the digital output shall be at least 25 dB. Compliance shall be checked by the test of subclause 11.15.

E.5 Alternative authentication algorithms

Implementors of public access CFPs should be aware that discussions are taking place between public access service operators that may lead to a change of status from non-mandatory to mandatory for AUTH2_REQ and AUTH2_RES information elements in the minimum public access CFP configuration.

E.6 Alternative re-establishment algorithms

Notwithstanding the provisions of subclauses 5.4.4 and 5.4.5, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st March 1994, national authorities accept the use of alternative link re-establishment algorithms provided they comply with the following alternative wording for subclauses 5.4.4 and 5.4.5.:

E.6.1 Interim wording for subclause 5.4.4

5.4.4 Link re-establishment on the existing channel

"Link re-establishment on the same RF channel may occur upon request from either end in an existing link. The method used is to cause the CPP to transmit in MUX3 with CHMP in the SYN channel in a similar fashion to normal call set up from the CPP. Link re-establishment is permitted only after a period of at least 300 ms for MUX1.4 and MUX2, and at least 600 ms for MUX1.2, from a previous link establishment or re-establishment.

After transmission or reception of a link re-establishment message, the CPP immediately switches to MUX3 and, using the last received link reference in the LID field, continues to transmit fixed format link request code words (see subclause 6.4) in MUX3 until either the link is re-established, or the 10 second handshake timeout (Thlost) matures (see subclause 5.5.1.6)".

E.6.2 Interim wording for subclause 5.4.5

5.4.5 Link re-establishment on a different channel

"After three seconds loss of handshake, link re-establishment may be attempted by the CPP on a different channel (see subclause 4.10). The action at the CPP may be to acquire a free channel (in accordance with the requirements of subclause 4.4) and transmit in MUX3 with CHMP in the SYN channel, but using the last received link reference in the LID field, in a similar fashion to link re-establishment on the existing channel from the CPP (see subclause 5.4.4). The action at the CFP shall then be to channel-scan continuously looking for CPP transmissions. Link re-establishment attempts shall cease when the 10 second handshake timeout (Thlost) matures (see subclause 5.5.1.6)".

E.7 CPP ramp-up and ramp-down specifications

Notwithstanding the provisions of subclause 4.5.4.1, the ETSI Technical Committee Radio Equipment and Systems recommends that, for an interim period ending 31st December 1993, national authorities accept the use of CPPs which conform to the following alternative wording for subclause 4.5.4.1:

E.7.1 Interim wording for subclause 4.5.4.1

4.5.4.1 Amplitude

"The amplitude of the RF envelope at the start of the first valid bit to be transmitted shall be within 3 dB of the final amplitude of the burst, as shown in figure 1".

E.8 In Communication channel switching

Notwithstanding the provisions of subclause 4.10.1, the ETSI Technical Committee Radio Equipment and Systems recommends that, for an interim period ending 31st December 1993, national authorities accept the use of CTAs which do not support in communication channel switching. The supplier shall declare whether the CTA is capable of in communication channel switching.

E.9 Acknowledgement of KP, FA, AUTH_REQ, AUTH_RES, TERM_CAP and BAS_CAP information elements

Notwithstanding the provisions of subclauses 7.2.1, 7.2.4, 7.2.8, 7.2.9, 7.2.10 and 7.2.11, the ETSI Technical Committee Radio Equipment and Systems recommends that for an interim period ending 31st December 1994, national authorities accept the use of CTAs which do not send KP, FA, AUTH_REQ, AUTH_RES, TERM_CAP and BAS_CAP information elements in acknowledged packets.

E.10 Interference rejection

Notwithstanding the provisions of subclauses 4.6.3.1 and 4.6.3.2, the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st December 1994, national authorities accept equipment complying with the following values for table 1 (subclause 4.6.3.1), table 2 (subclause 4.6.3.2).

E.10.1 Interim values for table E.1

Table E.1: Unmodulated Interfering Signals

Frequency Range(s)	Extreme conditions	Nominal conditions
25 MHz to 800 MHz	120 dBµV/m	123 dBµV/m
800 MHz to 850 MHz 890 MHz to 4 GHz	110 dBµV/m	113 dBµV/m
850 MHz to 860 MHz 872 MHz to 890 MHz	100 dBµV/m	103 dBµV/m
860 MHz to f_c-300 kHz f_c+300 kHz to 872 MHz	35 dBc	38 dBc
f_c-300 kHz to f_c-200 kHz f_c+200 kHz to f_c+300 kHz	30 dBc	33 dBc
f_c-200 kHz to f_c-100 kHz f_c+100 kHz to f_c+200 kHz	20 dBc	20 dBc
f_c-100 kHz to f_c+100 kHz	-20 dBc	-20 dBc

E.10.2 Interim values for table E.2

Table E.2: Modulated Interfering Signals

Frequency Range(s)	Extreme conditions	Nominal conditions
860 MHz to W - 4 W + 4 to 872 MHz	80 dBµV/m	83 dBµV/m

E.11 Spurious emissions of the combined transmitter/receiver

Notwithstanding the provisions of subclauses 4.7.2, 9.4.1.2 and 9.4.1.3 the ETSI Radio Equipment and Systems (RES) Technical Committee recommends that, for an interim period ending 31st December 1994, national authorities accept equipment complying with the following wording for subclause 4.7.2, 9.4.1.2 and 9.4.1.3.

E.11.1 Interim wording for subclause 4.7.2

4.7.2 Spurious emissions of the combined transmitter/receiver

"The power of any spurious emission in the specified range of frequencies when the equipment is in the active mode, shall not exceed the value of 20 nW in the frequency bands:

- 41,0 MHz to 68,0 MHz;
- 87,5 MHz to 118,0 MHz;
- 162,0 MHz to 230,0 MHz;
- 470,0 MHz to 862,0 MHz;
- 10,7 GHz to 12,75 GHz.

and shall not exceed a value of 250 nW on other frequencies below 1000 MHz.

On frequencies above 1000 MHz the power of any spurious emission shall not exceed a value of 1 µW.

The power of any spurious emission in the specified range of frequencies, when the equipment is in the idle mode shall not exceed 0,2 nW in the range 864 MHz to 868 MHz (when measured in a 1 kHz bandwidth), 2 nW in the range 100 kHz to 1000 MHz, 4 nW in the range 10,7 GHz to 12,75 GHz, and shall not exceed 20 nW at other frequencies in the range 1000 MHz to 12,75 GHz".

E.11.2 Interim wording for subclause 9.4.1.2

9.4.1.2 Method of measuring the power level subclause, 9.4.1.1, 1)

"Spurious emissions shall be measured as the power level of any discrete signal delivered into a 50 ohm load. This may be done by connecting the transmitter/receiver output through an attenuator to a spectrum analyser with a resolution bandwidth of 100 kHz and a video bandwidth of 300 kHz or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (subclause 9.2.2).

The handshake code between the fixed and portable parts is established as described in subclause 9.2.1. The measurements shall be made over the frequency range 100 kHz to 12,75 GHz, except for the channel on which the transmitter/receiver is operating and its adjacent channels.

The measurement shall be repeated with the transmitter/receiver in the idle mode".

E.11.3 Interim wording for subclause 9.4.1.3

9.4.1.3 Method of measuring the effective radiated power, subclause 9.4.1.1, 2)

"On a test site, fulfilling the requirements of subclause 9.2.4, the sample shall be placed at the specified height on a non-conducting support. The handshake code between the fixed and portable parts is established as described in subclause 9.2.1.

The transmitter/receiver shall be operated with the carrier power delivered to an artificial antenna (subclause 9.2.2), except in the case of testing equipment with an integral antenna.

Radiation of any spurious components shall be detected by the test antenna and a spectrum analyser with a resolution bandwidth of 100 kHz and a video bandwidth of 3 MHz over the frequency range 25 MHz to 12,75 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a component is detected, the sample shall be rotated to obtain the maximum response and the effective radiated power of that component determined by a substitution measurement.

The measurement shall be repeated with the test antenna in the orthogonal polarisation plane.

The measurements shall be repeated with the transmitter in the idle mode".

E.12 Intermodulation rejection

Notwithstanding the provisions of subclauses 4.6.1.1, 4.6.1.2 and 4.6.5 the ETSI Radio Equipment and Systems Technical Committee recommends that, for an interim period ending on 31st March 1994, national authorities accept equipment which:

1) is covered by the terms of subclause 4.6.1.1, complies with subclauses 4.6.3 and 4.6.4, but complies with the interim wording for subclause 4.6.5 given below;

2) is covered by the terms of subclause 4.6.1.2, complies with subclauses 4.6.3 and 4.6.4, but does not meet the requirements of subclause 4.6.5.

E.12.1 Interim wording for subclause 4.6.5

4.6.5 Intermodulation response rejection

"The communications state, once established between a CFP and one of its associated CPPs, shall be maintained without interruption when the CFP is receiving a signal from this CPP at a signal strength of 45 dB relative to 1 µV/m and when two interfering signals are introduced, each of which generates a signal strength of 85 dB relative to 1 µV/m at the antenna of the CFP (each modulated as described below) in each of the following cases (where f_c is the frequency of operation):

1) at frequencies of f_c+ 400 kHz and f_c+ 800 kHz;

2) at frequencies of f_c - 400 kHz and f_c - 800 kHz;

3) at frequencies of f_c+ 400 kHz and f_c - 400 kHz.

The interfering signals shall each bear continuous data modulation similar to that produced by the CPP. The data modulating the interfering signals shall not, either separately or when combined in any way, simulate the handshake code required to maintain the communications state between the CPP and CFP".

E.13 Initial location registration and terminate location registration FAs

Notwithstanding the provisions of subclause 7.2.4 the ETSI Radio Equipment and Systems (RES) Technical Committee recommends that for an interim period ending 31st December 1994, national authorities accept CPP equipment which supports FA 3,31 but which does not support FA 3,30.

Notwithstanding the provisions of table B.1 the ETSI Radio Equipment and Systems (RES) Technical Committee recommends that for an interim period ending 31st December 1995, national authorities accept CPP equipment which does not support FA 3,30 and FA 3,31.

Annex F (informative) : Message sequence diagrams

The following diagrams represent typical layer three message sequences used in CT2 applications. Where multiple messages are shown, the convention is adopted that the message closest to the head of the arrow is the first to be sent and the first to arrive.

Examples of the following situations are shown:

- call set up from CPP to public access CFP;
- call set up from CPP to private CFP;
- group call from private CFP to CPPs;
- call set up from public access CFP to CPP;
- call clear down;
- on-air registration from CPP to private CFP.

Note that although not shown in these diagrams, messages may, on occasion, overlap. That is, one may be in the course of being sent from one end of a CTA whilst another, shown subsequently in the diagram, is in the course of being received at that end. This is usually true of TERM_CAP, FA and BAS_CAP at the transition from LINK ESTABLISHED to CALL IN PROGRESS. Some messages cannot overlap, such as AUTH_REQ and AUTH_RES, where the complete reception of the first is essential before sending of the second can be started.

F.1 Call set up to a public access CFP

INITIAL STATE: CPP idle.

ACTION: The user initiates a call to a public access system. The user, after the authentication procedure (UKF1), dials 7654, using overlap sending.

```
            CPP              |             MESSAGE                |          CFP
=============================================================================================
   Call request              | ==================MUX3=========>   |
   (public access)           | <====bidirectional MUX2=========>  |
 > DL_ESTABLISH_REQ--->      |    layer one, two initialise       |
   DL_ESTABLISH_IND<---      |  (subclause 5 and subclause 6)     | ---> DL_ESTABLISH_IND
=============================================================================================
     LINK ESTABLISHED        |                                    |   LINK ESTABLISHED
                             | FA=3;n  TERM_CAP=CIC,MB            |
   ------------------->      | -------------------------------->  | n recognised ?
                             | BAS_CAP                            | Codec etc compatible?
                             | <--------------------------------  | <---------------------
     CALL IN PROGRESS        | DISP=FF,<MESSAGE>(NOTE) FI=3;n,1   |   CALL IN PROGRESS
 Display cleared             | <--------------------------------  |
 Show "public access         | AUTH_REQ(RAND,INCZ=0)              | Authentication req.
       active"               | <--------------------------------  | (no "zap")
 CPP sends authent-          | AUTH_RES(CKEY,TRD,ZAP)             |
 ication data.               | -------------------------------->  | Authentication OK?
                             |                                    |
                             | CC=0 (transmitted in MUX2)         | T2R1 (Tx in MUX2,
                             | <--------------------------------  |       Rx in MUX1)
 T1R1 (Tx in MUX1,           | ack (transmitted in MUX1)          |
       Rx in MUX1)           | - - - - - - - - - - - - - - - - >  |
                             | CC=2 (transmitted in MUX1)         | T1R1 (Tx in MUX1,
                             | <--------------------------------  |       Rx in MUX1)
 Connect B channel           | ack                                |
                             | - - - - - - - - - - - - - - - - >  | Connect B channel to
                             |                                    | line (dial tone)
                             | <====bidirectional MUX1=========>  |
 User keys first             | KP='7'                             |
 address digit.              | -------------------------------->  | (in band dial tone
                             | DISP=FF,'7'                        | off)
 Display echo char.          | <--------------------------------  |
 User keys remaining         | KP='6'                             |
 digits.                     | -------------------------------->  |
                             | DISP='6'                           |
                             | <--------------------------------  |
                             | KP='5'                             |
                             | -------------------------------->  |
                             | DISP='5'                           |
                             | <--------------------------------  |
                             | KP='4'                             |
                             | -------------------------------->  |
                             | DISP='4'                           | (in band exchange
                             | <--------------------------------  | ring back tone - far
                             |                                    | end answers - call
                             | <====call in progress==========>   | in progress)
=============================================================================================
```

NOTE: <MESSAGE> may be any indication of the availability of the public access service.

F.2 Call set up to a private CFP

INITIAL STATE: CPP idle.

ACTION: The user initiates a call to a private system using feature activator 0,0. The user dials 7654 from the number store (the digits are sent en bloc).

CPP	MESSAGE	CFP
Call request > DL_ESTABLISH_REQ---> DL_ESTABLISH_IND<---	=================MUX3======> <===bidirectional MUX2======> layer one, two initialise (subclause 5 and subclause 6)	---> DL_ESTABLISH_IND
LINK ESTABLISHED └──────────────────>	FA=0,0 TERM_CAP ---------------------------->	LINK ESTABLISHED
CALL IN PROGRESS	BAS_CAP <----------------------------	<──────────────────┘ CALL IN PROGRESS
Display cleared.	FI=0,0;1 DISP=FF <----------------------------	
	CC=0 (transmitted in MUX2) <----------------------------	T2R1 (Tx in MUX2, Rx in MUX1)
T1R1 (Tx in MUX1, Rx in MUX1)	ack (transmitted in MUX1) - - - - - - - - - - - - - - - >	
	CC=2 (transmitted in MUX1) <----------------------------	T1R1 (Tx in MUX1, Rx in MUX1)
Connect B channel	ack - - - - - - - - - - - - - - - >	Connect B channel to line (dial tone)
	<===bidirectional MUX1======>	
User retrieves number from store.	KP='7654' ---------------------------->	(in band dial tone off)
Display echo chars.	DISP='7654' <----------------------------	(in band exchange ring back tone - far end answers - call in progress)
	<===call in progress========>	

F.3 Private CFP incoming (group) call

INITIAL STATE: CPP idle.

ACTION: An outside call arrives at the CFP. Multiple ringing is initiated to two CPPs registered as a single ringing group. Both CPP are in range and respond to layer two messages. User at CPP 1 answers.

CFP	MESSAGE	CPP
Incoming line call detected. --->	<===poll, responses MUX2====>	
Repeat ring signal until answer, following cadence.	SIG = 1,0 or FI=0,n;2 (UI) --------------------------->	Incoming ringing on
	SIG = 0,X or FI=0,n;2 (UI) --------------------------->	Incoming ringing off
		User at CPP 1 selects line. <---
DL_ESTABLISH_IND<---	layers one, two and protocol initialised (subclauses 5 & 6).	---> DL_ESTABLISH_IND
LINK ESTABLISHED	TERM_CAP, FA = 0,m <---------------------------	LINK ESTABLISHED <---
--->	SIG = 0,X, FI = 0,n;1 --------------------------->	Stop ringing
--->	BAS_CAP --------------------------->	
CALL IN PROGRESS T2R1 (Tx in MUX2, Rx in MUX1)	CC=0 (transmitted in MUX2) --------------------------->	CALL IN PROGRESS
	ack (transmitted in MUX1) < - - - - - - - - - - - - - - -	T1R1 (Tx in MUX1, Rx in MUX1)
T1R1 (Tx in MUX1, Rx in MUX1)	CC=2 (transmitted in MUX1) --------------------------->	
Connect B channel to line	ack < - - - - - - - - - - - - - - -	Connect B channel
	<===bidirectional MUX1======>	
	<=== call in progress ======>	

F.4 Public access CFP incoming call

INITIAL STATE: CPP idle.

ACTION: An outside call arrives at the public access CFP. Ringing is initiated to a registered CPP. The CPP is in range and responds to layer two messages. The user at the CPP answers.

CFP	MESSAGE	CPP
Incoming line call detected.	<=====poll, responses MUX2======>	
Repeat ring signal until answer, following cadence.	SIG = 1,0 or FI=3,n;2 (UI) -------------------------------->	Incoming ringing on
	SIG = 0,X or FI=3,n;2 (UI) -------------------------------->	Incoming ringing off
		User at CPP 1 selects line.
DL_EST_IND <--------	layers one, two and protocol initialised (subclauses 5 & 6).	---------> DL_EST_IND
LINK ESTABLISHED	TERM_CAP, FA = 3;m <--------------------------------	LINK ESTABLISHED
	SIG = 0,X, FI = 3,n;1 -------------------------------->	Stop ringing
	BAS_CAP -------------------------------->	
CALL IN PROGRESS	FI=3;n,1 DISP=FF,<MESSAGE> (NOTE) -------------------------------->	CALL IN PROGRESS Display cleared. Show "public access active".
Authentication request (no "zap").	AUTH_REQ(RAND,INCZ=0) -------------------------------->	CPP sends authentication data.
Authentication OK?	AUTH_RES(CKEY,TRD,ZAP) <--------------------------------	
T2R1 (Tx in MUX2, Rx in MUX1)	CC=0 (transmitted in MUX2) -------------------------------->	
	ack (transmitted in MUX1) < - - - - - - - - - - - - - - - - - -	T1R1 (Tx in MUX1, Rx in MUX1)
T1R1 (Tx in MUX1, Rx in MUX1)	CC=2 (transmitted in MUX1) -------------------------------->	
	ack < - - - - - - - - - - - - - - - - - -	Connect B channel
Connect B channel to line	<=====bidirectional MUX1=======>	
	<===== call in progress =======>	

NOTE: <MESSAGE> may be any indication of the availability of the public access service.

F.5 Call clear down

INITIAL STATE: Call in progress.

ACTION: User clears the call.

CPP	MESSAGE	CFP
CALL IN PROGRESS	<===call in progress========>	CALL IN PROGRESS
Call release req.	FA=7,1 -----------------------------> ack < - - - - - - - - - - - - - - -	No outstanding sessions. Exchange line released.
B chan off,disp idle, transducers off.	INIT <----------------------------- ack - - - - - - - - - - - - - - - >	Terminate call
	<=== end of call ===========>	
	Layers one and two released (not shown)	

F.6 On air identity registration from CPP to private CFP

INITIAL STATE: CPP idle.

ACTION: The user enables on-air registration at the CFP and then activates the registration sequence from the CPP. A four-digit pin is requested, which the user enters ('3*09'). It is echoed as '----' for security.

CPP	MESSAGE	CFP
		The user presses the registration enable button.
The user invokes the registration feature.	= LID=11...11 === MUX3 =====>	
	<== bidirectional MUX2 =====>	
> DL_ESTABLISH_REQ--->	layer one, two initialise	
DL_ESTABLISH_IND<---	(subclause 5 and subclause 6)	---> DL_ESTABLISH_IND
LINK ESTABLISHED		LINK ESTABLISHED
	FA=7,7 TERM_CAP	
——————————————>	------------------------------>	
	BAS_CAP	
	<------------------------------	<——————————————
CALL IN PROGRESS		CALL IN PROGRESS
	FI=7,7;1 DISP=FF	
Display cleared. On-air registration icon illuminated.	<------------------------------	
	DISP = 'EntEr Pin '	
	<------------------------------	
User enters pin.	KP = '3'	
	------------------------------>	
	DISP = FF,'-'	
	<------------------------------	
	KP = '*'	
	------------------------------>	
	DISP = '-'	
	<------------------------------	
	KP = '0'	
	------------------------------>	
	DISP = '-'	
	<------------------------------	
	KP = '9'	
	------------------------------>	
	DISP = '-'	
	<------------------------------	
	OARAC(BID)	
	<------------------------------	
	DISP = FF DISP = 'donE'	
	<------------------------------	
Display idle, icons cleared	INIT	
	<------------------------------	
	ack	
	- - - - - - - - - - - - - - - >	
	<=== end of registration ===>	

Annex G (informative): Code word example

An example code word with CRC is shown below. This is a fill-in code word with N(s), N(r) and REJ all set to 0.

Bit: 8	7	6	5	4	3	2	1	octet
0	0	1	0	0	0	1	1	1
0	0	0	0	0	0	0	0	2
1	1	1	1	0	0	0	0	3
1	1	1	1	0	0	0	0	4
1	1	1	1	0	0	0	0	5
1	1	1	1	0	0	0	0	6
0	1	0	1	0	0	0	0	7
1	1	1	0	1	1	1	1	8

The CRC is calculated as follows:

1) division of x^{15} times the data in octets 1 to 6 above by the generating polynomial of 6.3.6, 1), gives a 15-bit remainder of:

   $x^{10} + x^{8} + x^{6} + x^{5} + x^{4} + x^{3} + x^{1}$;

   that is 000010101111010. The division may be carried out by normal long division techniques but using exclusive-or as the digit-by-digit subtraction method;

2) the last bit (the coefficient of x^{0}) is then inverted (6.3.6 (2));

3) the parity bit is then added to provide even parity for the 64-bit code word (6.3.6 (3)). The check word thus becomes 0000101011110111 as shown above (note the ordering of the bits).

Annex H (informative): Intellectual property rights

The following six companies have signed an intellectual property rights agreement concerning the manufacture of equipment which complies with the standard for the CT2 (CAI) telephone service, of which this specification forms a part.

The companies have patent and other intellectual property rights which may relate to the specification and have agreed to make available certain specified licensing rights to users and manufacturers in specific territories. In certain cases these rights will be available free of charge.

For information, the CAI secretariat should be contacted at the following address:

CAI Secretariat
FAO Mr R.J. Hart
Lingdales
Glendyke Road
LIVERPOOL L18 6JR
UK
Telephone Number +44 (0)51 724 5591
Fax Number +44 (0)51 724 6938

For further information, the patent department of the following companies should be contacted at the address provided:

British Telecommunications PLC
Intellectual Property Unit
13th Floor
151 Gower Street
LONDON WC1E 6BA
UK
Telephone Number +44 (0)71-728-7436
Fax Number +44 (0)71-728-7849

Trio-Kenwood UK Ltd
Kenwood House
Dwight Road
WATFORD
Hertfordshire WD1 8EB
UK
Telephone Number +44 (0)923-816444
Fax Number +44 (0)923-212477

GPT Ltd
Director of Legal and Commercial Affairs
PO Box 53
New Century Park
COVENTRY
CV3 1HJ
UK
Telephone Number +44 (0)203-563051
Fax number +44 (0)203 562269

NT Europe Ltd
Patent and Licensing
West Road
HARLOW
Essex CM20 2SH
UK
Telephone Number   +44 (0)279-445991
Fax Number   +44 (0)279-641336

Orbitel Mobile Communications Ltd
The Keytech Centre
Ashwood Way
BASINGSTOKE
Hampshire RG23 8BG
UK
Telephone Number   +44 (0)256-843468
Fax Number   +44 (0)256-843207

AT&T Wireless Communication Products Ltd
Capital House
48-52 Andover Road
WINCHESTER
Hampshire SO23 7BH
UK
Telephone Number   +44 (0)962-855925
Fax Number   +44 (0)962-855903

Annex J (normative): Subjective speech quality tests

NOTE: The references cited in this annex are listed in clause J.6.

Throughout this annex, two options are contemplated, as referred to in subclause 11.24, namely:

Option A: whereby the CTA is tested as an entirety; and

Option B: whereby the codec (as defined in subclause 11.24.3) is tested in isolation, with a view to approval for incorporation in a variety of CTAs subject to the conditions of subclause 11.24.2.

Where the requirements of the two options diverge, they are stated and headed separately. Otherwise the same requirements apply for both options, and the phrase "apparatus under test" is used to denote either the complete CTA or the codec as the case may be.

The test comprises the following stages:

1) preparing a master recording of group of sentences;

   a) replaying the sentences in a defined manner through the apparatus under test and re-recording the output; and

   b) re-recording the sentences through a certain controlled-distortion system;

2) replaying the output from 2) to 20 subjects, and collecting from each subject a response to each group of sentences;

3) processing the results so obtained to derive ratings, to which the criteria of subclause 11.24.3 are then applied.

Stages 1) and 1) b) can be carried out once for all, and the resulting recordings used in all subsequent tests. Alternatively, as explained below, the re-recording part of stage 1)a) or 1) b) or both may be omitted if the appropriate apparatus is available for real-time use during the listening sessions themselves.

J.1 Preparation of master recordings

J.1.1 Speech material

The speech material shall consist of 440 simple, meaningful, short sentences, all different, and chosen at random as being easy to understand (e.g. from current non-technical literature or newspapers). Very short and very long sentences shall be avoided, the aim being that each sentence when spoken should have a duration of about 2 s.

These sentences shall be made up into lists in random order, in such a way that there is no obvious connection of meaning between one sentence and the next. There shall be 22 such lists, each having 20 sentences in 5 groups of 4. Suitable sentences can be found in appendix 3 of CCITT Study Group XVIII Document no. 51R (see clause J.6), and can be rearranged to constitute the required number of lists and groups.

Four talkers are required. They shall be native speakers of English without obvious speech defects; two male and two female.

Let the lists of sentences be denoted by the letters A to T, Y and Z. Let the talkers be designated 1, 2, 3 and 4. Then talkers shall record the following lists respectively (table J.1).

Table J.1: Lists to be recorded by talkers

Talker	Lists
1 (male)	A B C D E Y
2 (male)	F G H I J
3 (female)	K L M N O Z
4 (female)	P Q R S T

J.1.2 Apparatus and environment

The talkers shall be seated (one at a time) in a room with reverberation time less than 500 ms, and room noise level below 30 dB A-weighted with no dominant peaks in the spectrum.

Speech shall be recorded from a linear microphone and low-noise amplifier with a flat frequency response as specified in IEC Publication 581-5. The microphone shall be positioned between 140 mm and 200 mm from the talker's lips. A wind-screen shall be used if breath puffs from the talker are noticed.

The same speech shall also be recorded simultaneously from the sending output of a telephone equivalent in sending performance to the Intermediate Reference System [J.2], with the handset held in the normal manner.

The recording system [1)] shall be a high-quality two-channel cassette system with a frequency response that is flat within ±1 dB from 50 Hz to 8000 Hz and a dynamic range (peak signal to average noise ratio) of at least 60 dB. Two separate recording systems shall be used simultaneously: one for recording the wideband speech in one channel, and the other for recording the telephone speech in the corresponding channel. The other channel of each recording system shall be used for recording control signals as explained below.

J.1.3 Recording procedure

The talkers shall enunciate each list according to the following pattern.

"Talker no.1"

"Beginning of list A"

"Beginning of group 1"

sentence 1 from list A

sentence 2 from list A

sentence 3 from list A

sentence 4 from list A

"End of group 1"

"Beginning of group 2"

---

1) The PCM-F1 Digital Audio Processor, manufactured by Sony, used with the 14-bit option, in conjunction with the Sony SL-F1UB or SL-F1E videocassette recorder, has been found suitable.

sentence 5 from list A

sentence 6 from list A

sentence 7 from list A

sentence 8 from list A

"End of group 2"

and so on to the end of the list

"End of list 1"

and similarly for other talkers and lists.

Talkers should pronounce the sentences fluently but not dramatically.

Each announcement shall be followed by a pause lasting up to 5 s, and the sentences within each group shall be timed to begin at regular intervals of 4 s.

This can be achieved by giving a sequence of lamp signals (3 s on, 1 s off) to indicate to the talker when to read the next sentence from a script. However, the following method is far superior, and is strongly recommended, in order to satisfy the timing requirements, to provide synchronization and control signals suitable for automating the subsequent processing and replay of the recordings, and to avoid noise from sources such as the rustling of paper.

The announcement or sentences are presented to the talker one by one on visual display. The display of each sentence is immediately preceded by a control tone (e.g. 1 kHz at a conveniently high level) lasting 0,5 s, recorded in the second channel. A computer program co-ordinates these events according to the following time sequence (table J.2).

Table J.2: Required sequence of events

Duration (s)	On display	In second channel
3	"Talker" announcement	
2	blank	
3	"List" announcement	
2	Blank	
3	"Beginning of group" announcement	
0,5	blank	
0,5	blank	control tone
3	sentence	
0,5	blank	
0,5	blank	control tone
3	sentence	
0,5	blank	
0,5	blank	control tone
3	sentence	
0,5	blank	
0,5	blank	control tone
3	sentence	
0,5	blank	
0,5	blank	control tone
3	"End of group" announcement	
2	blank	
3	"Beginning of group" announcement	
0,5	blank	
0,5	blank	control tone

and so on to the end of the list.

J.1.4 Calibration signals and speech levels

The active speech level shall be observed during recording. Care shall be taken during the recording process that the active speech level in both recording systems is between 20 dB and 30 dB below the overload point of recording system for each sentence measured separately. Any group of sentences for which this does not hold shall be re-recorded.

The recordings when completed shall be played back, and the active speech level of each sentence shall be measured. The lists (announcements, sentences and control tones) shall then be re-recorded on to a second system with the necessary gain adjustments, so as to bring each group of sentences to the standardised active speech level specified below, and still preserve the proper time relationships between the sentences and the tone signals in the other channel. At the beginning of each resulting recording, 20 s of 1 kHz tone shall be inserted at the re-recording stage (for calibration purposes) at the level specified below.

For the narrowband speech, the standardised level shall be derived by measuring and adjusting the narrowband recorded signal directly, and shall be -20 dB (±0,5 dB) relative to the peak overload level of the recording system. The 1 kHz calibration tone shall have its r.m.s. level equal to the mean active level of the re-recorded speech. The resulting standardised recordings shall be called "telephone-band input recordings".

For the wideband speech, the individual target speech levels shall be such that equality is maintained at the output of an electric-acoustic-electric replay chain consisting of:

1) a bandpass filter, passing only the one-third octave bands from that centred at 200 Hz to that centred at 4 kHz inclusive; and

2) an artificial mouth; and

3) an IRS sending end, with the handset mounted as follows:

   Where the mouthpiece of the apparatus is fixed relative to the earpiece, the handset is placed in the LRGP as described in annex A of CCITT Recommendation P.76 [16]. Where the mouthpiece of the apparatus is not fixed relative to the earpiece, the front plane of the mouthpiece is mounted 15 mm from the front of the lip ring and coaxial with the artificial mouth. The earcap is sealed to the knife-edge of the artificial ear.

The speech shall be measured at the output of the IRS sending end, but re-recorded from the output of the bandpass filter, with the gain adjustment before the bandpass filter calculated to give a level of -17 dBV (± 0,5 dB) at the measurement point. In order to avoid overloading the artificial mouth, care shall be taken during this process to keep speech level at the mouth reference point low enough, even before adjustment, to give an active level not exceeding -5 dBPa for any sentence. The 1 kHz calibration tone shall have its r.m.s. level at the re-recording point such that when measured through the electric-acoustic-electric replay chain it is at -12 dBV. The resulting standardised recordings shall be called "4 kHz input recordings".

J.2 Processing of recordings

J.2.1 General

The input recordings shall be played through various conditions to generate ten sets of output cassettes as follows. The input gain of the re-recording system shall be so adjusted for each condition that the level of the calibration tone on the output cassettes is the same for all conditions.

In all cases the second channel of each input recording, containing the control tones, shall be directly copied on to the second channel of the corresponding output cassette simultaneously with the processing described below, so as to maintain the time relationships on the output cassettes.

The re-recording part of this processing may be dispensed with in subclause J.2.2 if the apparatus under test is available for use in real time during the listening sessions, and in subclause J.2.3 if the Modulated Noise Reference Unit is available for use in real time during the listening sessions, provided that the resulting signal delivered to the telephone receiving end meets the condition specified in subclause J.3.1.

J.2.2 Processing through the apparatus under test

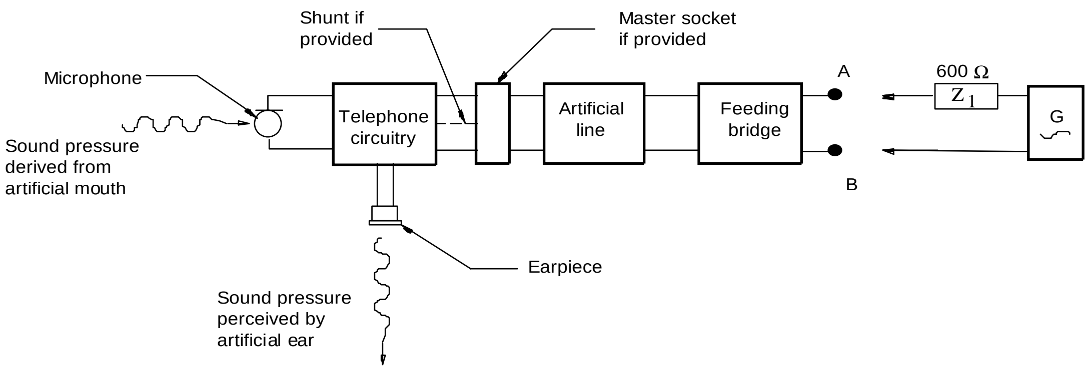
Option A. The CTA shall have the 4 kHz input recordings for lists A to T inclusive re-recorded through its sending path in the following conditions:

1) CTA sending with high vocal level (0 dBPa);

2) CTA sending with median vocal level (-8 dBPa);

3) CTA sending with low vocal level (-16 dBPa);

4) CTA sending with median vocal level and added noise.



NOTE 1: The artificial line and the feeding bridge shall meet the appropriate national requirements.

NOTE 2: The artificial mouth and the artificial ear are described in CCITT Recommendations P.51 [12] and P.57 [23].

Figure J.1: The local telephone system (LTS)

This re-recording shall be carried out with the arrangement of apparatus as specified in CCITT Recommendation P.64 (§ 6 and annex B § 1, upper envelope method [13]) with a line length of 1 km. The cassette replaying apparatus shall be connected through a level-control attenuator to the artificial mouth, in place of the signal generator. Hardware equalization interposed after the level-control attenuator shall ensure that the frequency response from cassette-replaying apparatus to the mouth reference point is flat within ±2 dB (a measurement of pink noise input and output in one-third octave bands suffices to check this requirement). The acoustic level shall be adjusted until the calibration tone is at the sound pressure level specified for condition 1 above. All the lists shall be played through, and re-recordings (to include all the announcements and the calibration tones) shall be made on a identical recording system connected to points A and B of figure J.1, with the same precautions regarding the relationship between signal levels and peak overload level as were observed in making the original recordings. The same process shall be repeated for conditions 2, 3, and 4. The different acoustic levels required for these conditions shall be achieved by varying the level-control attenuator. In condition 4 the noise (which may be added either on replay of the input recordings or at recording time on to a special version of the input recording) shall be white noise, band-limited (300 Hz to 3400 Hz), at an average level (psophometrically weighted) 35 dB below the active speech level.

Option B. The telephone-band input recordings for lists A to T inclusive shall be re-recorded through the codec in the following conditions:

1) codec with high input level (8 dB above nominal optimum level);

2) codec with median input level (nominal optimum level);

3) codec with low input level (8 dB below nominal optimum level);

4) codec with median input level and added noise.

The cassette-replaying apparatus shall be connected to the codec input through a level-control attenuator. The input level shall be adjusted until the calibration tone is at the r.m.s. voltage level specified for condition 1 above. All the lists shall be played through, and re-recordings (to include all the announcements and the calibration tones) shall be made on an identical recording system connected to points A and B of figure J.1, with the same precautions regarding the relationship between signal levels and peak overload level as were observed in making the original recordings. The same process shall be repeated for conditions 2, 3, and 4. The different input levels required for these conditions shall be achieved by varying the level-control attenuator. In condition 4 the noise (which may be added either on replay of the input recordings or at recording time on to a special version of the input recording) shall be white noise, band-limited (300 Hz to 3400 Hz), at an average level (psophometrically weighted) 35 dB below the active speech level.

J.2.3 Processing through controlled distortion

The telephone-band input recordings of lists A to T inclusive shall be played at constant level into the Modulated Noise Reference Unit CCITT Recommendation P.81, see clause J.6), and re-recorded at the output (correctly terminated) in the following five conditions:

5) normal telephone speech via MNRU at Q = 10;

6) normal telephone speech via MNRU at Q = 15;

7) normal telephone speech via MNRU at Q = 20;

8) normal telephone speech via MNRU at Q = 25;

9) normal telephone speech via MNRU at Q = 30.

The telephone-band input recordings will also be used in the following condition, which does not require any processing (i.e. the output cassettes are simple copies of the input recordings):

10) normal telephone speech without MNRU (or Q = infinity).

Lists Y and Z will be used for practice for the listeners, in a special condition 0, generated from the telephone-band input recording of these lists with noise added (as in condition 4) at 20 dB below the active speech level to the second and fourth groups only. The output cassettes for this condition, like those for conditions 5 to 10, can be prepared once for all.

J.3 Conduct of listening test

J.3.1 Apparatus, calibration and environment

The output recordings shall be replayed via a level-control attenuator into a telephone with receiving performance equivalent to that of the Intermediate Reference System (CCITT Recommendation P.48, see clause J6). There shall be five predetermined settings of the attenuator such as to deliver the following calibration tone levels (and hence nominal active speech levels) in dBV to the listening end for all conditions: -12, -22, -32, -42, -52. The listening room shall meet the same conditions as the recording room.

Band-limited white noise, (300 Hz to 3400 Hz), with an average level equivalent to -70 dBmp measured at the 0 dB RLR input, shall be injected into the receiving end of the Intermediate Reference System at all times when the subject is listening, whether any speech is being transmitted to the subject or not.

J.3.2 Selection of subjects.

Subjects shall be native speakers of English without any obvious defects in hearing. The following shall be excluded: persons who admit to specialist knowledge of the transmission, processing, broadcasting or recording of speech; and persons familiar with the sentence lists, such as those who compiled or recorded them. Subjects should ideally never have heard the lists of sentences before, but in any case no subject shall participate in a listening test using the same lists of sentences more than once in 12 months.

J.3.3 Procedure

Subjects shall undergo the listening test in two sessions, with an interval of not less than 10 minutes. Recordings shall be played back to subjects according to the following experimental design (based on two 10 x 10 graeco-latin squares interleaved, tables J.3 and J.4).

Table J.3: First Session

Column: Row	P	1	2	3	4	5	6	7	8	9	10
1	0 Y	6 A	1 K	2 I	7 R	1 J	6 S	7 C	5 T	9 G	10 L
2	0 Z	9 I	8 Q	1 G	2 L	2 A	1 R	10 J	7 S	4 C	6 T
3	0 Y	4 F	9 P	10 C	8 K	9 E	3 M	5 A	2 R	2 B	1 S
4	0 Z	10 H	2 T	3 A	10 P	4 B	9 K	8 I	8 M	6 D	5 O
5	0 Y	8 J	4 S	5 B	3 T	6 C	10 Q	9 H	9 L	1 E	8 N
6	0 Z	1 C	6 R	6 F	5 S	5 H	4 T	2 E	10 K	3 J	9 M
7	0 Y	3 E	3 L	9 D	4 M	8 F	5 N	4 G	6 O	7 H	7 P
8	0 Z	5 G	5 M	7 J	6 N	10 D	7 O	6 B	1 P	8 A	2 Q
9	0 Y	7 B	10 O	4 H	9 Q	3 I	8 L	1 D	4 N	10 F	3 R
10	0 Z	2 D	7 N	8 E	1 O	7 G	2 P	3 F	3 Q	5 I	4 K

Table J.4: Second Session

Column: Row	P	11	12	13	14	15	16	17	18	19	20
1	0 Z	8 B	9 N	5 F	8 P	3 H	2 M	4 D	3 O	10 E	4 Q
2	0 Y	5 D	10 M	8 H	9 O	7 F	3 N	6 E	4 P	3 B	5 K
3	0 Z	1 H	7 T	3 D	10 N	6 J	4 O	7 I	5 Q	8 G	6 L
4	0 Y	7 E	4 R	9 J	3 S	2 G	6 Q	1 F	7 L	5 C	1 N
5	0 Z	2 F	6 P	10 I	5 R	4 A	7 K	3 G	1 M	7 D	2 O
6	0 Y	10 G	8 O	7 A	7 Q	8 D	1 L	9 B	2 N	4 I	3 P
7	0 Z	6 I	1 Q	2 C	2 K	10 B	8 R	5 J	9 S	1 A	10 T
8	0 Y	3 C	3 K	4 E	4 L	1 I	9 T	2 H	10 R	9 F	8 S
9	0 Z	9 A	2 S	6 G	1 T	5 E	5 P	8 C	6 K	2 J	7 M
10	0 Y	4 J	5 L	1 B	6 M	9 C	10 S	10 A	8 T	6 H	9 R

where:

- rows represent listeners;
- columns represent order of presentation;
- numbers represent conditions as described in clause J.2; and
- letters represent lists of sentences (each with its own talker).

Each row shall be used for two listeners, who may listen and respond simultaneously if this is convenient, provided their responses are recorded distinctly and are not known to each other. Within each row, the specified condition-list combinations shall be played in the given order, each session commencing with the cell in the appropriate column headed "P". Within each list (single cell of the square), each group of four sentences shall be presented at a different one of the five predetermined attenuations (listening levels), the order of these attenuations being freshly randomised each time.

It is strongly recommended that each list in each condition should be recorded on a separate output cassette, so that the condition-list combinations can be administered to each subject in the required order with a minimum of winding time. If this is done, each session can be expected to last between 20 minutes and 30 minutes.

The announcements, "Beginning of list 1" and so on, are recorded for the benefit of the processing laboratory and the experimenter conducting the listening test, but shall not be played back in such a way that they could be heard by the subjects.

For each group of sentences, each listener shall give a response on the following scale.

Opinions based on the effort required to understand the meanings of sentences:

A) complete relaxation possible; no effort required;

B) attention necessary: no appreciable effort required;

C) moderate effort required;

D) considerable effort required;

E) no meaning understood with any feasible effort.

Subjects' responses may be collected by any convenient method, e.g. pencil and paper, press-buttons controlling lamps recorded by the operator, or automatic data-logging equipment. But whatever method is used, subjects shall not be able to observe other subjects' responses, nor shall they be able to see the record of their own previous responses. Apart from the inevitable memory and practise effects, each response must be independent of every other. No information shall be available to the subjects which could identify the circuit conditions or the listening levels, or indicate which of them are the same. The only information available to the subjects must be that which they derive by their own powers of perception in listening to the speech.

Together with each response, information shall be recorded identifying the row and column of the design (hence identifying the condition, list and talker), and the listening level used in each case; the two listeners using the same row of the design shall be distinguished.

On arrival, subjects shall receive the following instructions in writing.

NOTE: For convenience the instructions are here formulated with reference to one particular method of signalling to the subject and recording the responses, but if a different method is used then the wording in italics is to be adapted accordingly.

LISTENING EXPERIMENT

In this experiment you will be listening to short groups of sentences via the telephone handset, and giving your opinion of the speech you hear.

On the table in front of you is *a box with five illuminated press buttons*. When *all the lamps go on*, you will hear four sentences. Listen to these, and when *the lamps go out, press the appropriate button* to indicate your opinion on the following scale.

Effort required to understand the meanings of sentences.

A Complete relaxation possible; no effort required.
B Attention necessary; no appreciable effort required.
C Moderate effort required.
D Considerable effort required.
E No meaning understood with any feasible effort.

The button you have pressed will light up for a short time. Then *the lamp will go out and* there will be a brief pause before *all the lamps go on again* for the next four sentences.

There will be a longer pause after every 20 sentences (i.e. after every 5 opinions). There will be a total of 210 sentences (calling for 55 opinions) in this session, and the same number in your second session.

Thank you for your help in this experiment.

After having read these instructions, and having had the opportunity to ask for any needed clarification, the subject shall listen to the preliminary list and give a response to each group, in order to become familiar with the procedure. No suggestion should be made that the speech in the preliminary list exhausts the range of qualities that can be expected to be heard. After this the subject should be asked whether he or she is ready to go ahead with the rest of the experiment. Questions about procedure or about the meaning of the instruction shall be answered, but any technical questions must be met with the response "We cannot tell you anything about that until the experiment is finished".

At the beginning of the second session the subject shall hear the other preliminary list, in order to become accustomed again to the procedure.

If substantial errors occur in the administration of the test (e.g. if responses are missed, or the wrong recordings are played back) then all the results from the subject concerned shall be discarded (even though as a matter of courtesy the subject may be allowed to finish the sessions and not informed of the error), and that row of the design shall be repeated with a fresh subject. It is essential that each row should be completed by the same subject throughout and that repeat attempts by the same listener with the same sentences should be avoided.

J.4 Treatment of results

Numerical scores shall be allocated to the responses as follows:

- A = 4; B = 3; C = 2; D = 1; E = 0;

and all further analysis shall be in terms of these numbers (known as listening-effort opinion scores). Data from the two P columns (condition 0, lists Y and Z) shall be omitted from all the calculations, i.e. the expression "all scores" is to be taken as meaning "all scores except those in the P columns". Let suffixes be allocated as follows (table J.5).

Table J.5: Allocation of suffixes

Suffix	Range	Denoting
i	1-20	Subjects (2 per row)
j	1-20	Columns
p	1-20	Condition-Voice combinations (where for condition t, 1 ú t ú 10, p = t for male speech and p = t + 10 for female speech)
r	1-20	Lists (A to T inclusive)
n	1-5	Listening levels

With these conventions, let y_{ipn} denote the score for the i th listener in the p th condition-voice combination at the n th listening level, and similarly for other suffixes. The mean over talkers and listeners, denoted by Y_{pn} shall be calculated separately for each combination p at each listening level n.

Analysis of variance shall be carried out to evaluate the following effects and test them for significance: rows (listeners), columns (sequence effects), numbers (conditions), letters (talkers and lists, including the male/female talker contrast), listening levels, and the interaction of listening levels with each of the other factors. The results of these significance tests shall be used to determine whether there are any abnormal features of the data such as might cast any reasonable doubt on their reliability, and shall be produced as evidence in defence against any challenge to the proper conduct of the experiment.

The procedure for carrying out the analysis of variance is as follows.

NOTE 1: In the following formulae, some variables are denoted by symbols consisting of more than one alphanumeric character. Such character strings are not products. The multiplication sign "×" will be inserted explicitly where required, except in matrix products.

NOTE 2: In the above analysis-of-variance computations, it is advisable to carry at least 7 decimal places, and to express Sums of Squares and Mean Squares to 4 decimal places; for the F ratios, 2 decimal places are usually sufficient.

Compute the following subtotals and totals:

$S_{in} = \sum_{j=1}^{20} y_{ijn}$

$C_{jn} = \sum_{i=1}^{20} y_{ijn}$

$K_{pn} = \sum_{i=1}^{20} y_{ipn}$

$U_{rn} = \sum_{j=1}^{20} y_{irn}$

$L_n = \sum_{j=1}^{20} S_{in}$

$S_i = \sum_{n=1}^{5} S_{in}$

$C_j = \sum_{n=1}^{5} C_{jn}$

$K_p = \sum_{n=1}^{5} K_{pn}$

$U_r = \sum_{n=1}^{20} U_{rn}$

$m_n = \sum_{r=1}^{10} U_{rn}$

$f_n = \sum_{r=11}^{20} u_{rn}$

$M = \sum_{n=1}^{5} m_n$

$F = \sum_{n=1}^{5} f_n$

$G = \Sigma_i \Sigma_j \Sigma_n \; y_{ijn}$ = sum of all scores, and let Gq = G^2/2000.

Compute the "sq" terms, known as "Sums of Squares" to be inserted in the following Analysis of Variance table.

Factor	D.F.	Sum of Squares
Listening levels	4	$sq1 = (\Sigma_{n=1}^{5} \; L_n^2)/400 - Gq$
Male/female talkers	1	$sq2 = (M^2 + F^2)/1000 - Gq$
Interaction (M/F × levels)	4	$sq3 = (\Sigma_{n=1}^{5} \; m_n^2 + \Sigma_{n=1}^{5} \; f_n^2)/200 - Gq - sq1 - sq2$
Subjects	19	$sq4 = (\Sigma_{i=1}^{20} \; S_i^2)/100 - Gq$
Interaction (Subjects × levels)	76	$sq5 = (\Sigma_{n=1}^{5} \; \Sigma_{i=1}^{20} \; s_{in}^2)/20 - Gq - sq1 - sq4$

Columns	18	$sq6 = (\sum_{j=1}^{20} C_j^2)/100 - Gq - sq2$
Interaction (Columns × levels)	72	$sq7 = (\sum_{n=1}^{5} \sum_{j=1}^{20} c_{jn}^2)/20 - Gq - sq1 - sq6 - sq2 - sq3$
Conditions	18	$sq8 = (\sum_{p=1}^{20} K_p^2)/100 - Gq - sq2$
Interaction (Subjects × levels)	72	$sq9 = (\sum_{n=1}^{5} \sum_{p=1}^{20} k_{pn}^2)/20 - Gq - sq1 - sq8 - sq2 - sq3$
Lists	18	$sq10 = (\sum_{r=1}^{20} U_r^2)/100 - Gq - sq2$
Interaction (Lists x levels)	72	$sq11 = (\sum_{n=1}^{5} \sum_{r=1}^{20} u_{rn}^2)/20 - Gq - sq1 - sq10 - sq2 - sq3$
Residual	1625	$sq12 = sq13 - sq1 - sq2 - sq3 - sq4 - sq5 - sq6 - sq7 - sq8 - sq9 - sq10 - sq11$
Total	1999	$sq13 = \sum_{n=1}^{5} \sum_{i=1}^{20} \sum_{j=1}^{20} (y_{ijn})^2 - Gq$

"D.F." stands for "degrees of freedom".

From each sum of squares divided by the degrees of freedom in the same row, compute a "mean square" to be entered on that same row in a further column of the above table.

From each mean square (except the last two) compute the corresponding "F ratio", by dividing by the appropriate denominator. This is the Residual Mean Square in all cases except two, namely:

a) the Male/Female Talkers mean square (sq2/1), for which the denominator is the Lists mean square (sq10/18); and

b) the M/F × Levels Interaction mean square (sq3/4), for which the denominator is the Lists × Levels Interaction mean square (sq11/72).

Test the significance of each factor by comparing its F ratio with the values in a standard table, such as table 18 in “Biometrika tables for Statiticians”, see clause J.6. Each effect can then be judged "not significant", "significant" or "highly significant".

"Significant" in this context is a technical term meaning that the magnitude of the observed effect is such that there is a probability smaller than 0,05 of obtaining an equal or greater observed value "by chance", i.e. by sampling fluctuation only from a population with the amount of inherent variation estimated by the Residual Mean Square: in common-sense terms, one would rather believe in such a case that there is a real effect operating than that the sample is merely an unusual one from a population without such a real effect operating. "Highly significant" is similarly defined but with a probability smaller than 0,01.

In this sense it may be expected that Levels, Subjects, Conditions and usually the interaction between Levels and Conditions will be significant or highly significant; that the Male/Female factor and its interaction with levels may or may not be significant, depending on the nature of the codec; and that the Lists factor sometimes, and the Columns factor and other interactions more often, will be not significant. The Residual Mean Square will almost always lie in the range 0,2 to 0,4. Any major deviation from this pattern will call for explanation, and will generally raise suspicion of errors: in the functioning of the apparatus, in the administration of the experiment, in the collection of the scores, or in the arithmetic. Such errors can often be located by examining the mean scores as a function of the value of an unexpectedly behaving variable. For example, an insignificant Levels factor would almost certainly imply that the listening-level control attenuator was not functioning, while a highly significant Columns factor would indicate some abnormality in the time sequence (cassettes out of order; strong fatigue or practise effects, systematic differences between first and second session, etc.).

A RMSexceeding 0,5 is expected to occur with only a very low probability, estimated at less than once in every hundred tests, provided these are carried out strictly according to the foregoing instructions and without abnormally large fluctuations in the functioning of the apparatus or in the general conditions. Therefore, a RMSlarger than 0,5, unless it can be satisfactorily accounted for, shall be regarded as sufficient reason to discard the results and repeat the test.

The value of the RMSq enters into the confidence limits to be used for judging whether the function fits are satisfactory (see below).

By standard weighted least-squares regression, an equation shall be derived to express the mean score for conditions 5 to 9 inclusive as a function of the listening level and the signal-to-correlated-noise ratio Q. The equation shall be of the form:

$$\ln (Y/(4-Y)) = a + (b\times L) + (c\times L^2) + (d\times L\times M) + (e\times M) + (f\times M^2)$$

where:

$M = 10^{-0,03Q}$;

Y = predicted mean score;

L = listening level in dBV;

and a, b, c, d, e and f are the coefficients to be determined by the regression and the weight to be applied to each value is (Y/(4-Y))/16.

This shall be done separately for the results arising from male speech and the results arising from female speech, a separate equation being derived for each.

The regression coefficients are evaluated as follows.

From the score totals $\mathbf{k}_{pn}$ (where p ranges from 5 to 9 for male speech and from 15 to 19 for female speech), evaluate the mean scores $\mathbf{Y}_{pn}$ and hence the corresponding transformed values.

$$\mathbf{T}_{pn} = \ln (\mathbf{Y}_{pn}/(4-\mathbf{Y}_{pn}))$$

and the weighting coefficients

$$\mathbf{W}_{pn} = \ln (\mathbf{Y}_{pn}\times(4-\mathbf{Y}_{pn}))/16;$$

there are 25 pairs of values ($\mathbf{T}_{pn}$ and $\mathbf{W}_{pn}$) for male speech and 25 for female speech, each having an associated value of Q (related to p) and of L (listening level, related to n).

For each of these values of $\mathbf{T}_{pn}$ in turn:

- form the column vector:

  $\mathbf{G} = [W\times T, W\times T\times L, W\times T\times L^2, W\times T\times L\times M, W\times T\times M, W\times T\times M^2]'$;

- accumulate successive values of **G** into a column vector **J**;

- form the column vector $\mathbf{E} = [1, L, L^2, L\times M, M, M^2]'$;

- accumulate successive values of the product Wx**EE'** into a matrix $\mathbf{F_m}$ (i.e. each term of **EE'** accumulated into $\mathbf{F_m}$ is multiplied by W).

At the end of this accumulation, calculate the inverse of matrix $\mathbf{F_m}$:

$$\mathbf{H_m} = \mathbf{F_m}^{-1}$$

Premultiply $\mathbf{J_m}$ by $\mathbf{H_m}$ to give a column vector $\mathbf{A_m}$:

$$\mathbf{A_m} = \mathbf{H_m J_m}.$$

The vector $\mathbf{A_m}$ then contains the coefficients a, b, c, d, e, f in that order; in other words,

$$\mathbf{A_m} = [a, b, c, d, e, f]'.$$

By standard least-squares regression, 8 further separate equations shall be derived to express the mean score for each of conditions 1, 2, 3 and 4 as a function of the listening level, separately for the results arising from male speech and the results arising from female speech. These equations shall be of the form.

$$\ln (Y/(4-Y)) = a + b\times L + c\times L^2$$

where:

Y = predicted mean score;

L = listening level in dBV;

and a, b, and c are the coefficients to be determined by the regression.

These equations shall be regarded as satisfactory for the purpose of this standard if, among all the results from conditions 1, 2, 3, and 4, not more than 2 of the observed scores for male speech and not more than 2 of the observed scores for female speech differ from the corresponding predicted scores by more than the appropriate confidence interval, obtained by multiplying $1{,}96\sqrt{(RMSq/20)}$ by the following factor depending on L (table J.6).

Table J.6: Factors for determining the confidence interval

L, dBV	-12	-22	-32	-42	-52
Factor	1,3732	1,1711	1,2189	1,1711	1,3732

The regression coefficients shall be evaluated as follows:

Within each condition (p ranging from 1 to 4 for male speech and from 11 to 14 for female speech), from the score totals k_{pn}, evaluate the mean scores Y_{pn} and hence the corresponding transformed values

$T_{pn} = \ln (Y_{pn}/(4-Y_{pn}))$. In each condition-voice combination p, there are 5 of these, each having an associated value of L (listening level, related to n).

For each of these values of T_{pn} in turn:

- form the column vector **G** = $[T, T \times L, T \times L^2]'$;
- accumulate successive values of **G** into column vector $\mathbf{J_p}$;
- form the column vector **E** = $[1, L, L^2]'$;
- accumulate successive values of the product **EE'** into a matrix $\mathbf{F_c}$.

At the end of this accumulation, calculate the inverse of matrix $\mathbf{F_c}$:

$$\mathbf{H_c} = \mathbf{F_c}^{-1}$$

Premultiply $\mathbf{J_p}$ by $\mathbf{H_c}$ to give a column vector $\mathbf{A_p}$:

$$\mathbf{A_p} = \mathbf{H_c}\mathbf{J_p}$$

The vector $\mathbf{A_p}$ then contains the coefficients a, b, c in that order; in other words:

$\mathbf{A_p}$ = [a, b, c]' for condition-voice combination p.

NOTE 3: If the values of L, and the numbers of scores per condition, are all exactly as specified above, then the matrix $\mathbf{F_c}$ will always contain the same values, regardless of p, namely:

$$\mathbf{F_c} = \begin{bmatrix} 5,0000000 & -160,0000000 & 6120,0000000 \\ -160,0000000 & 6120,0000000 & -259840,0000000 \\ 6120,0000000 & -259840,0000000 & 11726880,0000000 \end{bmatrix}$$

The matrix $\mathbf{H_c}$ will also contain the same values, regardless of p, namely:

$$\mathbf{H_c} = \begin{bmatrix} 6,07382857100000 & 0,40868571430000 & 0,00588571428600 \\ 0,40868571430000 & 0,03025714286000 & 0,00045714285710 \\ 0,00588571428600 & 0,00045714285710 & 0,00000714285714 \end{bmatrix}$$

to 14 decimal places.

Normally, therefore, these matrices need not be recalculated. However, any deviation in detail (such as using a different value for one of the listening levels) will necessitate calculating these two matrices afresh.

For each of conditions 1 to 4 in turn, separately for male and female speech at each listening level, the following method shall be used to find the corresponding value of Q_r (Q rating for the condition, listening level and type of voice in question); that is, a value of Q yielding the same value of Y when substituted into the equation for the MNRU conditions with the same listening level and type of voice.

- evaluate Y for listening level L from the equation for condition-voice combination p;

- substitute the same value of L in the MNRU equation with the set of coefficients determined for male or female speech, as the case may be;

- substitute Q=0 in this equation, evaluate Y and call this value Y_m;

- increase Q in small steps, re-evaluating Y_m each time, until $Y_m \geq Y$ (the step size may be adaptive but should never exceed 1 dB and the boundary finally determined should be accurate within 0,1 dB);

- the value of Q at which Y_m first exceeds Y is designated Q_r (the Q-rating for the condition, listening level and type of voice in question);

- if Y_m remains smaller than Y when Q reaches the value of 40, then Q_r need only be recorded as ">40".

This value of Q_r shall be compared with boundary values, established individually for each approved testing laboratory (as described in clause J.5), and classed, accordingly, in one of four categories denoted by A, B, C and D as follows (table J.7):

Table J.7: Categorisation of Qr

Category	Male speech	Female speech
A	$Qr \geq Q_{M1}$	$Qr \geq Q_{F1}$
B	$Q_{M2} \leq Qr < Q_{M1}$	$Q_{F2} \leq Qr < Q_{F1}$
C	$Q_{M3} \leq Qr < Q_{M2}$	$Q_{F3} \leq Qr < Q_{F2}$
D	$Qr < Q_{M3}$	$Qr < Q_{F3}$

NOTE 4: This description of the method of arriving at the categories is conceptually the simplest. However, an equivalent but computationally simpler method is to substitute into the regression equation the boundary values of Qr, evaluate the corresponding boundary values of Y_m and compare these with the observed values; for example whenever Y exceeds the value of Y_m obtained with $Q=Q_{M1}$, the category is A for that listening level.

The category letters are tabulated in the form shown in table 5, the rows of which correspond to conditions 1 to 4 and the columns to the first 4 listening levels, separately for male and female speech. The distribution of categories in this table shall determine whether the apparatus under test meets the requirements of subclause 11.24.5.

NOTE 5: The surface-fitting and curve-fitting computations, described above, require very high-precision calculating facilities when carried out by the foregoing method that, nevertheless, has its own distinct advantages. Traditional methods of calculation make use of "coding", i.e. adjusting the origin and scale of each variable so as to express all quantities in terms of a small range of numbers surrounding their means, then restoring all quantities to their original units at the end. Use of this technique was considered for the test method described above. However, in this test, the only variable suitable for such treatment is L, as the other variables involve non-linear functions, and it is doubtful whether much would be gained by its use. An alternative method, utilizing the above technique may be acceptable if evidence were available that demonstrated its equivalence but in cases of dispute or arbitration, only the specified method should be used to demonstrate compliance.

J.5 Determination of laboratory-specific Q-rating boundaries for the purposes of subclause 11.24.5

In order to determine the classifications specified in subclause 11.24.5, the boundary values applied to the Q-ratings, as described in J.4, shall be established independently for each test laboratory before that laboratory is authorised to carry out definitive tests as described in annex J. The method of establishing these boundary conditions shall be as follows.

The laboratory in question shall carry out not less than eight "calibration tests", consisting of the complete testing process as specified in annex J up to and including the evaluation of Q ratings, using, for Conditions 1 to 4, a codec that to the satisfaction of the test-laboratory accreditation authority is shown to conform rigorously to CCITT Recommendation G.721 [6]. The same apparatus and the same speech material shall be used each time. The procedure for the selection of subjects shall be the same as will ultimately be used in the definitive tests. However, it is important that the same individual subjects shall not be included more than once, on any account, in this series of tests. Any test for which the Residual Mean Square as defined in J.4 exceeds the value of 0,5 shall not be allowed to count as a calibration test.

Six provisional boundary values (Q_{m1}, Q_{m2} and Q_{m3} applicable to male speech; Q_{f1}, Q_{f2} and Q_{f3} applicable to female speech) shall be located in such a way as to meet all the following conditions simultaneously:

1) all 6 values shall be positive integers;

2) $Q_{m1} \leq 26$;

3) $Q_{m1} - Q_{m2} = Q_{m2} - Q_{m3} = 4$;

4) $Q_{f1} \leq 26$;

5) $Q_{f1} - Q_{f2} = Q_{f2} - Q_{f3} = 4$;

6) when the boundaries Q_{m1}, Q_{m2}, Q_{m3} are applied to male speech and the boundaries Q_{f1}, Q_{f2}, Q_{f3} to female speech, to categorise the Qr values as explained in J.4, the G.721 codec shall fulfil the criterion of 11.24.5 in at least seven tests out of eight, or a proportionately higher number if more calibration tests are carried out.

Choose the set that results in the highest average of Q_{m1} and Q_{f1} from the alternative sets of values fulfilling the preceding conditions; if more than one set of values meets this condition, then the set that makes Q_{m1} most nearly equal to Q_{f1} shall be chosen. If more than one possibility still remains, then further calibration tests shall be carried out until the combined evidence from all the calibration tests leads to an unambiguous solution.

Each of these provisional values shall then be reduced by 2 dB to give the definitive values (Q_{M1}, Q_{M2}, Q_{M3}, Q_{F1}, Q_{F2} and Q_{F3}) to be used by the test laboratory concerned;

i.e. $Q_{M1} = Q_{m1} - 2$ $Q_{F1} = Q_{f1} - 2$

$Q_{M2} = Q_{m2} - 2$ $Q_{F2} = Q_{f2} - 2$

$Q_{M3} = Q_{m3} - 2$ $Q_{F3} = Q_{f3} - 2$.

J.6 References

[J.1] CCITT Study Group XVIII. Document no. 51R of Rapporteur's Group on Wideband Coding within 64 kbit/s. "Plan for opinion-score tests on 64 kbit/s 7 kHz systems" (1984).

[J.2] CCITT Recommendation P.48 (1989): "Specification for an Intermediate Reference System".

[J.3] CCITT Recommendation P.56 (1989): "The Objective Measurement of Active Speech Level".

[J.4] CCITT Recommendation P.81 (1989): "Modulated Noise Reference Unit (MNRU)". (Geneva, 1989), Blue Book Volume V, pp 198 to 203.

[J.5] E.S. Pearson and H.O. Hartley: "Biometrika tables for Statisticians" (Volume 1, 3rd edition). (Cambridge University Press 1966).

[J.6] IEC Publication 581-5: “High fidelity auto equipment and systems; Minimum performance requirements Part 5: Microphones”.

Annex K (informative): Artificial echo loss for a CFP with a 4-wire interface

An artificial echo loss may be required which simulates the echo from a very good analogue 2-wire telephone. When a public network operator uses an echo canceller in the network (e.g. for a satellite link), the artificial echo loss path provides an in-range echo to ensure that the echo canceller, and its NLP, is active. The NLP cancels the 34 dB handset echo.

It is recommended that it is implemented in the CFP between the line input and the line output, as shown in figure K.1. The loss of the echo path should be 24 dB ± 2 dB.

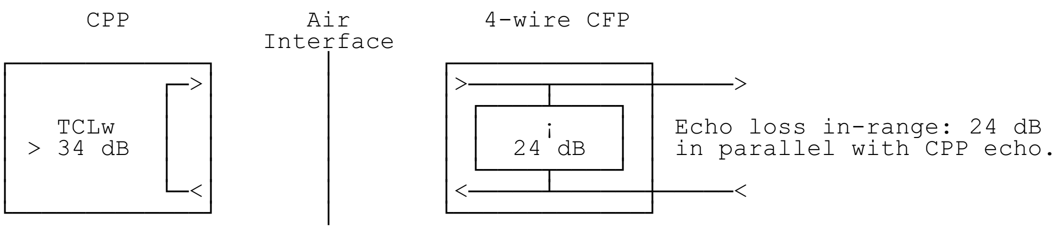


Figure K.1: Artificial echo path in a 4-wire CFP

For connections when it is known that there are no echo cancellers in the public network the artificial echo loss may be disabled.

Annex L (informative): Network echo from a CFP with a 2-wire analogue interface

The April 1992 edition of this standard stated that, "It may be required to control the network echo perceived by the CPP user by inserting into the receive speech path of the CFP an extra echo loss of X dB."

The value of X shall be 0dB.

Annex M (normative): Code for the representation of names of languages

The following code allocations have been based on the languages identified in ISO 639 [21].

Language Code	Language Name	Language Code	Language Name	Language Code	Language Name
		iw	Hebrew	ro	Romanian
[1]	Anonymous /Null	hi	Hindi	ru	Russian
ab	Abkhazian	hu	Hungarian	sm	Samoan
om	(Afan) Oromo	is	Icelandic	sg	Sangho
aa	Afar	in	Indonesian	sa	Sanskrit
af	Afrikaans	ia	Interlingua	gd	Scots Gaelic
sq	Albanian	ie	Interlingue	sr	Serbian
am	Amharic	ik	Inupiak	sh	Serbo-Croatian
ar	Arabic	ga	Irish	st	Sesotho
hy	Armenian	it	Italian	tn	Setswana
as	Assamese	ja	Japanese	sn	Shona
ay	Aymare	jw	Javanese	sd	Sindhi
az	Azerbaijani	kn	Kannada	si	Singhalese
ba	Bashkir	ks	Kashmiri	ss	Siswati
eu	Basque	kk	Kazakh	sk	Slovak
bn	Bengali;Bangla	rw	Kinyarwanda	sl	Slovenian
dz	Bhutani	ky	Kirghiz	so	Somali
bh	Bihari	rn	Kirundi	es	Spanish
bi	Bislama	ko	Korean	su	Sundanese
br	Breton	ku	Kurdish	sw	Swahili
bg	Bulgarian	lo	Laothian	sv	Swedish
my	Burmese	la	Latin	tl	Tagalog
be	Byelorussian	lv	Latvian,	tg	Tajik
km	Cambodian	Lettish		ta	Tamil
ca	Catalan	ln	Lingala	tt	Tatar
zh	Chinese	lt	Lithuanian	te	Telugu
co	Corsican	mk	Macedonian	th	Thai
hr	Croatian	mg	Malagasy	bo	Tibetan
cs	Czech	ma	Malay	ti	Tigrinya
da	Danish	ml	Malayalam	to	Tonga
nl	Dutch	mt	Maltese	ts	Tsonga
en	English	mi	Maori	tr	Turkish
eo	Esperanto	mr	Marathi	tk	Turkmen
et	Estonian	mo	Moldavian	tw	Twi
fo	Faroese	mn	Mongolian	uk	Ukrainian
fj	Fiji	na	Nauru	ur	Urdu
fi	Finnish	ne	Nepali	uz	Uzbek
fr	French	no	Norwegian	vi	Vietnamese
fy	Frisian	oc	Occitan	vo	Volap_k
gl	Galician	or	Oriya	cy	Welsh
ka	Georgian	ps	Pashto, Pushto	wo	Wolof
de	German	fa	Persian	xh	Xhosa
el	Greek	pl	Polish	ji	Yiddish
kl	Greenlandic	pt	Portuguese	yo	Yoruba
gn	Guarani	pa	Punjabi	zu	Zulu
gu	Gujarati	qu	Quechua		
ha	Hausa	rm	Rhaeto-Romance		

[1] 00H in both octets of the language field

The following language codes have been identified as language requirements for CAI systems but are not defined in ISO 639 [21]. Appropriate two letter codes have therefore been allocated.

Language Code	Language Name
cn	Cantonese

All other codes are reserved for future allocation. Allocation is controlled by and registered with the Standard Control Authority body.

Annex N (normative): External synchronisation ports

External synchronisation ports may be provided to synchronise the transmitter burst envelopes of CFPs or CT2 systems. External synchronisation ports are specified to allow co-location and operation of equipment from different operators or manufacturers. It is not mandatory for a CFP or CT2 system to provide external synchronisation ports, nor does this specification preclude the use of other means of synchronisation within one operators or one manufacturers CT2 system. Where external synchronisation ports are provided they shall comply with the specifications in this annex.

The synchronisation specification is based on the EIA 422-A-78 standard [27]. In the case of a conflict between the EIA 422-A-78 specification and this annex, this annex shall take precedence.

N.1 External synchronisation ports

The external synchronisation ports shall comprise an input synchronisation port and an output synchronisation port.

N.1.1 External synchronisation output port

The external synchronisation output port shall conform to EIA 422-A-78 subclause 4.1 [27].

The external synchronisation output port shall be marked "OUT". One terminal shall be marked "Tx" (corresponding to A in EIA 422-A-78) and the other terminal may be marked "Rx" (corresponding to B in EIA 422-A-78).

N.1.2 External synchronisation input port

The external synchronisation input port shall conform to EIA 422-A-78 subclause 4.2 [27] and shall present a termination impedance of 100 Ω ± 10%.

The external synchronisation input port shall be marked "IN". One terminal shall be marked "Tx" (corresponding to A' in EIA 422-A-78) and the other terminal may be marked "Rx" (corresponding to B' in EIA 422-A-78).

NOTE: The Tx terminal is positive with respect to the Rx terminal during the transmit bursts at the CFP and the Rx terminal is positive with respect to the Tx terminal during the CFP receive slots.

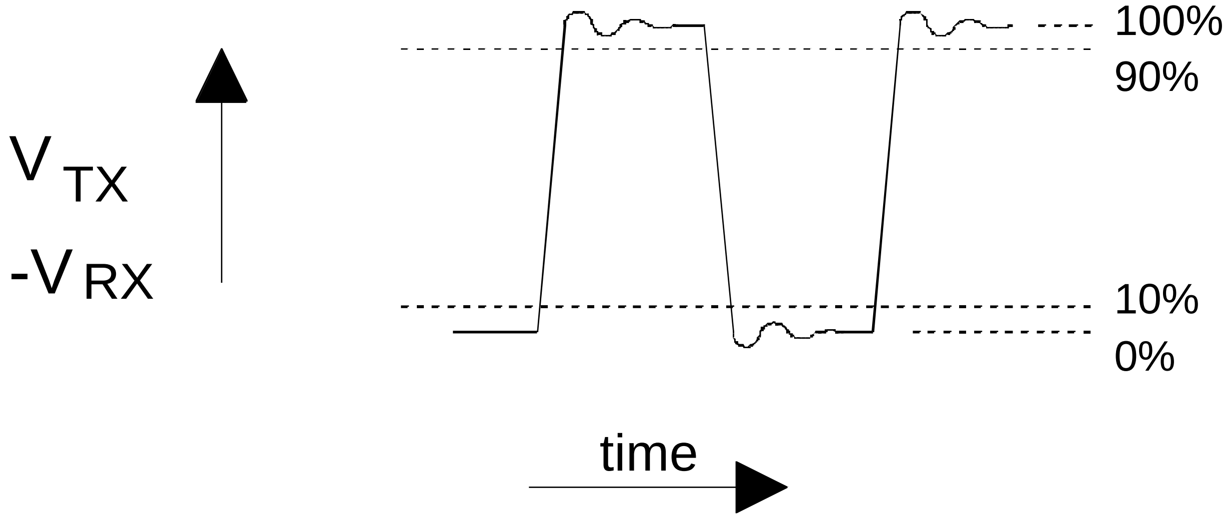


Figure N.1: Interconnection of synchronised CFPs

N.2 Synchronisation

The CFP or CT2 system shall monitor the external synchronisation input port for a valid input synchronisation signal. The CFP or CT2 system may consider any input signal not meeting the requirements of N.2.1 as invalid.

The detection or loss of an input synchronisation signal should result in the minimum of disruption to established calls and to the output synchronisation signal.

NOTE: The valid signal threshold level is not necessarily equal to the sensitivity level of the receiver circuit.

If a valid synchronisation signal is detected, the CFP shall regenerate that signal at its output synchronisation port. The propagation delay in the regenerated signal, between the input and output synchronisation ports shall not exceed ± 200 ns. The propagation delay shall be measured at the zero crossing points of the differential input and output signals. The regeneration circuit should incorporate input hysteresis (the difference between positive going and negative going input threshold voltages) of nominally 50 mV.

When no valid input synchronisation signal is detected, the CFP shall generate its own synchronisation signal at the output synchronisation port meeting the requirements of subclause N.2.1.

The transition times of the synchronisation signal at the output synchronisation port, either generated or regenerated within the CFP, from the 10% to 90% points and from the 90% to 10% points shall not exceed 60 ns when measured into a 100 Ω ± 10% load (see figure N.2).

The amplitude of the synchronisation signal, either generated or regenerated within the CFP, or an externally generated synchronisation signal, shall conform to the specifications of EIA 422-A-78 subclause 4.1 [27].

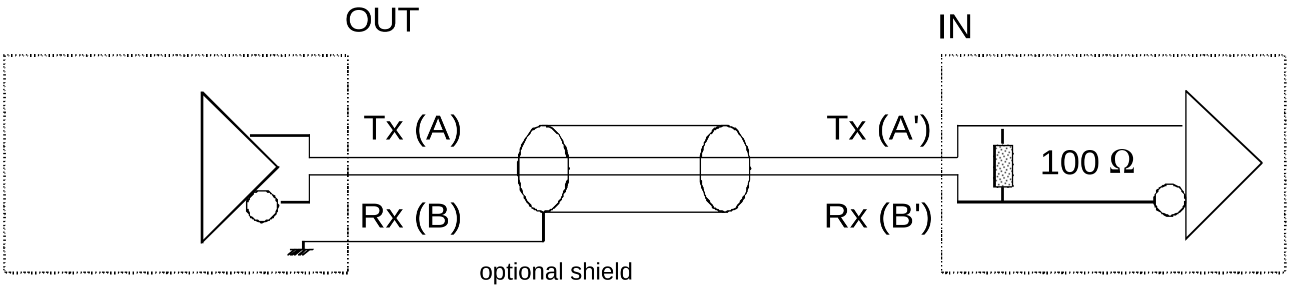


Figure N.2: Transition timing of synchronisation signal

N.2.1 External synchronisation input signal

An externally applied synchronisation signal shall be a 500 Hz square wave with a long term frequency drift of less than ± 50 ppm, a duty cycle of 50% ± 500 ns (measured at the zero crossing points). The random phase jitter on the signal shall not exceed 1,5 µs rms. The differential amplitude shall be greater than 400 mV pk-pk. The signal transition time at the input synchronisation port (measured between the 10% and 90% points) shall not exceed 200 ns.

N.2.2 Envelope synchronisation

CFPs or CT2 systems shall synchronise their transmissions such that the frequency crossing point (see figure 1) between the first "B" bit and the preceding "D" bit of a MUX1.2 or MUX1.4 frame shall occur 7 ± 0,25 bit periods (measured at the CFP antenna) after the signal at the output Tx terminal becomes positive with respect to the output Rx terminal.

The RF power envelope shall not begin more than 4,75 bit periods before the frequency crossing point (see figure 1) between the first "B" bit and the preceding "D" bit of a MUX1.2 or MUX1.4 frame. The ramp up period so defined will support a round trip propagation delay (CFP to CPP and CPP to CFP) in MUX1.4 of 0,5 bit periods.

The RF power envelope shall be complete no more than 4 bit periods after the frequency crossing point (see figure 1) between the final "B" bit and the following "D" bit of a MUX1.2 or MUX1.4 frame.

All bit transition timings are referred to the antenna of the CFP. For measurement purposes the RF envelope shall be deemed to be off at -60 dBc.

N.3 Interconnection

Where interconnecting cable is used to provide synchronisation between CFPs or CT2 systems, it shall provide two independent signal paths, neither of which is grounded. The type and length of interconnecting cable used for synchronisation shall ensure that during the transition period, the signal waveform (measured at the input synchronisation port) shall change monotonically between the 10% and 90% points and shall not cross the 10% and 90% thresholds again until the next state transition point. The interconnection cable shall ensure that the input signal meets the requirements of annex N subclause 2.1. If shielded cable is used for the interconnection of synchronised CFPs then only the end of the cable connected to the output synchronisation port CFP may be grounded.

N.4 Safety

The external synchronisation ports shall be SELV (Safety Extra Low Voltage) ports and shall conform to the requirements of subclause 4.1 of EN 41003 [28].

N.5 Delay

The total propagation delay, due to signal regeneration and cable propagation, between the output synchronisation signal of the CFP at the start of any chain of synchronised bases and the output synchronisation signal of all other CFP synchronised to that CFP should not exceed 6,9 µs (see annex P).

Annex P (informative): Propagation delay of base synchronisation signals

The purpose of this annex is to show the derivation of the maximum base synchronisation signal propagation delay, and to illustrate the trade off between the number of CFPs which may be connected in a cluster and the total length of interconnecting cable.

Let the maximum propagation delay of the synchronisation signal from the first CFP in a cluster to the final CFP be D_{max}. The time D_{max} is derived as follows:

$$D_{max} = (G - J - S - T) \times B$$

where	G = CFP-CPP guard time	= 3,5 bits	see subclause 5.2.2
	J = CPP timing jitter	= 0,25 bits	see subclause 5.2.2
	S = synchronisation accuracy	= 0,5 bits	see subclause N.2.2
	T = ramp down time	= 2,25 bits	see subclause N.2.2
	B = length of bit	= 13,9 µs	see subclause 5.1.1

Therefore maximum allowable delay is given by:

$$D_{max} = 6{,}9\ \mu s$$

The maximum number of regenerations, R_{max}, with no cable delay is:

$$R_{max} = D_{max} / T_{reg}$$

where:

T_{reg} = regeneration delay in a CFP = 200 ns see clause N.2

Therefore, the maximum number of regenerations is given by:

$$R_{max} = 35$$

The maximum cable length, L_{max}, with no regenerations, is given by:

$$L_{max} = c \times VF \times D_{max}$$

where:

c= speed of light= $3 \times 10^8\ ms^{-1}$
VF= cable velocity factor

For a cable velocity factor in the range 0,6 to 0,7, the maximum theoretical cable length (in a cluster comprising two CFPs only) is between 1242 m and 1449 m. This calculation indicates the maximum total length of cable (for a system comprising of two CFPs or CT2 systems). The maximum practical length for an individual section of cable between two CFPs will also be restricted by transmission line effects (see clause N.3).

Neither the maximum cable length nor the maximum number of regenerations derived above will be achievable in any practical system. There will always be a trade-off between the number of synchronised CFPs or CT2 systems (i.e. regenerations) and the length of cable needed to interconnect them.

Annex R (normative): Protocols for data services

R.1 Introduction

This annex describes the data bearer services supported by the radio interface. Data CPPs (DCPPs) and Data CFPs (DCFPs) provide circuit-switched data services. The scope of this annex is restricted to the radio interface and does not include the data terminal or network interfaces. This annex includes the protocols to establish data connections and select the operating mode.

The radio interface supports two different circuit-mode data bearer services over the 32 kbit/s B channel:

1) full-duplex asynchronous data services;
2) full-duplex synchronous (transparent) data services.

A DCPP or DCFP may provide any combination of data services, and may provide voice service as well.

R.1.1 Full-duplex asynchronous data services

The asynchronous data bearer services allow a DCPP to communicate with landline computer facilities at asynchronous data rates of 300, 1200, 2400, 4800, 9600, 14400 or 19200 bits per second. Asynchronous data transport employs an automatic repeat request (ARQ) protocol for the re-transmission of erroneous blocks, together with a forward error control (FEC) scheme. A flow control mechanism (see subclause R.2.5.2) may be used to control the data rate at the user terminal or the host computer when severe degradation of the radio path occurs.

R.1.2 Full-duplex synchronous (transparent) data services

The transparent data bearer services provide the user with unrestricted access to the 32 kbit/s B channel, or to lower-rate channels. Data rates are synchronous and user selectable. The supported rates are 300, 1200, 2400, 4800, 9600, 14400, 19200 and 32000 bit/s. The service provides FEC for all rates except 32 kbit/s. However, there is no ARQ protocol and therefore no guarantee of data integrity. The flow control mechanisms (see subclause R.2.5.2) are not used in this service.

R.2 Circuit-mode data transport components

The end-user services are provided by the combination of various data transport components within the DCFP or DCPP. These components are:

- radio Link (see subclause R.2.1);
- Framing and Forward Error Control, FFEC (see subclause R.2.2);
- Link Access Protocol for Radio, LAPR (see subclause R.2.3);
- Synchronous Rate Adaptor (see subclause R.2.4);
- Asynchronous Terminal Packet Assembler/Disassembler, Async PAD (see subclause R.2.5); and
- Landline Physical Interface, LPI (see subclause R.2.6).

The relationship among these components is shown in figure R.1.

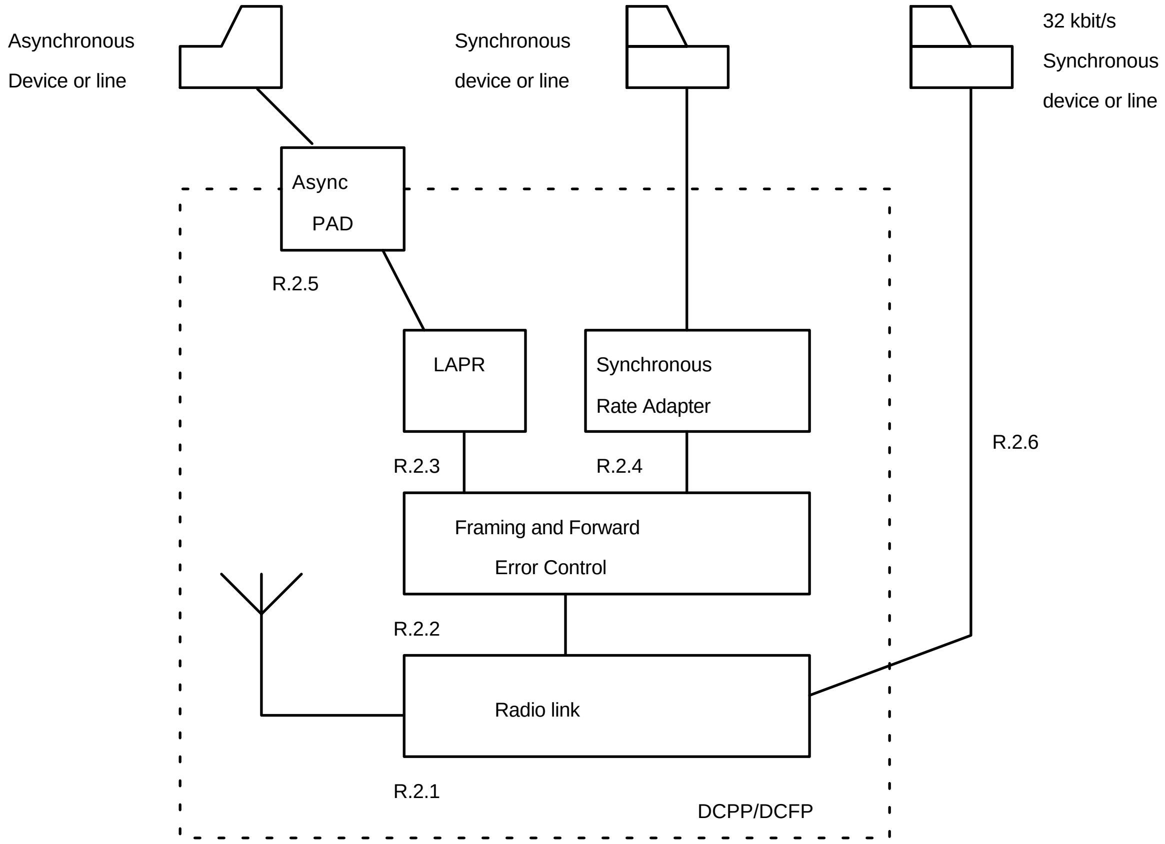


Figure R.1: Circuit-Mode Data Transport Components

NOTE: These components are for specification purposes only. An implementation of this specification may use such hardware and software components as appropriate to provide the correct external interfaces for the end-user data services.

R.2.1 Radio link

The radio link provides a full-duplex unrestricted 32 kbit/s binary channel. All user data are carried in the B channel portion of the radio link bursts. Users wishing to transmit data at 32 kbit/s without error control may use this channel directly.

R.2.2 Framing and forward error control (FFEC)

The FFEC shall group the data into Forward Error Control (FEC) frames and shall provide Reed-Solomon error-control coding of user data to correct a number of errors occurring over the radio interface. In the transmit direction, FFEC shall add the parity symbols and shall pass the codeword to the radio link. In the receive direction, FFEC shall check and remove the parity symbols.

An FEC frame shall consist of a 8-bit synchronization pattern (01111110, the leftmost bit shall be transmitted first) followed by a 504-bit Reed-Solomon codeword. The Reed-Solomon codeword shall comprise 63 eight-bit symbols, k of which shall carry control information and user data, and 63-k of which shall be parity symbols. The resulting 512-bit frame shall fully occupy the B channel portion of eight contiguous transmit bursts, as shown in figure R.2. The bits in an FFEC codeword shall be transmitted from left to right (parity symbols last).

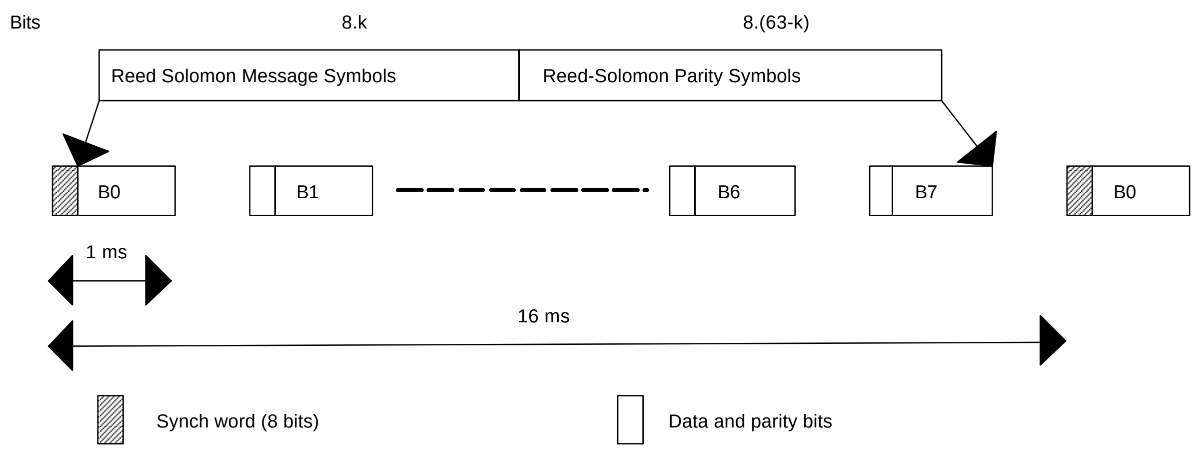


Figure R.2: FEC Frame Structure

R.2.2.1 FEC framing

The FEC frames shall be synchronous, with the DCPP synchronized to the DCFP. During a data connection using the FFEC, the DCFP shall transmit an FEC frame every 16 ms. The DCPP shall find the frame boundary by searching for the synchronization pattern at the start of a burst. Once found, the DCPP shall verify alignment by checking the parity symbols. A DCPP shall be in alignment when it has received three consecutive frames containing a synchronization symbol in the first symbol of the frame, and any two of which have good parity. A DCPP shall re-synchronize when three of eight consecutive received frames do not contain the synchronization symbol in the first symbol of the frame.

When the DCPP has achieved frame alignment, it shall transmit an FEC frame every 16 ms. The DCPP shall start a frame on the ninth burst following the start of a DCFP frame, as shown in figure R.3. This will give an Automatic Repeat Request (ARQ) protocol 10 ms (in the DCPP) and 8 ms (in the DCFP) to check the Reed-Solomon parity before the first opportunity to send an acknowledgement or rejection. The use of ARQ is restricted to asynchronous services.

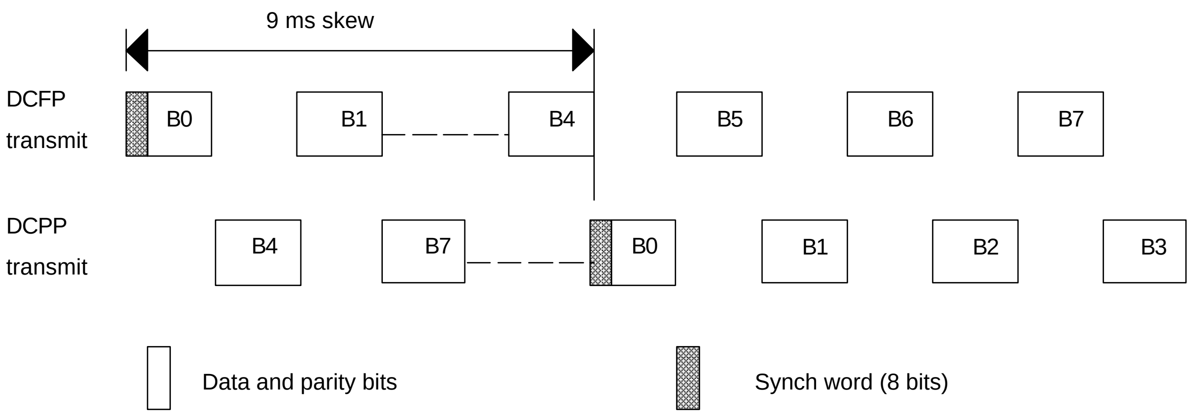


Figure R.3: DCFP-DCPP Framing Skew

R.2.2.2 Forward error control (FEC)

Systematic shortened Reed-Solomon block codes (63,k;3) with 8-bit symbols shall be used for FEC.

A Reed-Solomon code is described as a (N,K;d) code, where N is the number of m-bit symbols in a codeword, K is the number of message symbols and d is the number of symbols reserved for error detection. In this case, m=8 and $N=2^m-1=255$ symbols per codeword. The code is shortened to a (n,k;d) code where n=N-i and k=K-i by setting the i most significant codewords (i.e., mi bits) to zero. The Reed-Solomon decoder can correct up to the (the integer part of) (n-k-d)/2 symbols. In this case n=63 and i=192 symbols (i.e. 1536 bits).

The Reed-Solomon codes use polynomials in the Galois Field GF(256), which is an extension field of GF(2) constructed with the primitive polynomial:

$$g(x)=1+x^2+x^3+x^4+x^8$$

Since a codeword containing all zeroes is a valid codeword, the parity symbols of a codeword shall be inverted (one's-complement negation).

The Framing and FEC (FFEC) shall check the parity symbol by computing a syndrome over the codeword. If the syndrome is zero, the codeword contains no detectable errors. If the parity symbols indicate that the codeword is in error (i.e. it has a non-zero syndrome), FFEC may either apply the error correction algorithm to the codeword or leave it unaltered. To reduce the number of decoder errors, if the syndrome indicates that more than (n-k-3)/2 (rounded down) symbols are in error, the codeword shall be declared uncorrectable and no change shall be made to the codeword.

After checking and possibly correcting the codeword, FFEC shall pass the message portion of the codeword to the upper layers (e.g. LAPR, subclause R.2.3, or the synchronous rate adaptor, subclause R.2.4) with one of three possible indications:

1) the codeword contains no detectable errors;

2) the codeword contained one or more errors but error correction has been applied;

3) the codeword contained one or more errors but error correction has not been applied.

The use of the error indication is dependent on the upper layers.

R.2.3 Link access protocol for radio (LAPR)

LAPR is an Automatic-Repeat-Request (ARQ) data link protocol providing strong error control in addition to the forward error correction provided by FFEC.

LAPR is based on X.25 LAPB [29]. The modifications to LAPB are only with respect to section 2.2 of [29] (frame format). LAPR frames shall be carried in the FFEC message symbols, one LAPR frame per FFEC codeword. The LAPR frame consists of several fields. Starting at the beginning of the FFEC codeword, these shall be:

- RFU: Reserved for future use. 4 bits, initially set to 0;
- length: 6 bits, indicating the number of valid octets following the User Defined Field in the LAPR frame;
- user Defined: 6 bits. This is available to higher level protocols to carry status and control information out of band;
- address: 8 bits. Usage is as per LAPB;
- control: 8 bits. Usage and format are as per LAPB, basic (modulo-8) mode.;
- information: An integral number of octets, up to a maximum specified below.

Figure R.4 shows the frame structure. The bits in an FFEC codeword shall be transmitted from left to right (RFU field first, parity symbols last).

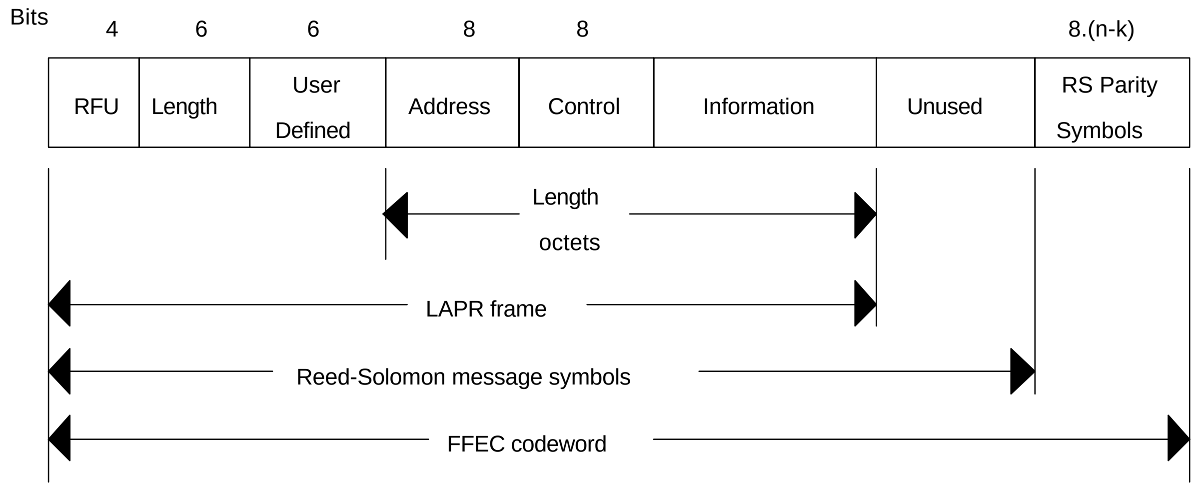


Figure R.4: LAPR Frame Format

LAPR frames shall contain an integral number of octets after the User Defined, Length and RFU fields. They shall contain no flags, bit stuffing, or frame check sequence. A frame shall not be aborted once it has started transmission. The Length field shall define the logical end of a LAPR frame, and the FFEC shall indicate erroneous frames.

The maximum number of bits S_{max} in a LAPR frame is 8k, where k is the number of message symbols in the Reed-Solomon codeword. Sixteen of these S_{max} bits are for the RFU, Length, and User Defined fields, and the remaining usable bits must make a multiple of eight. The maximum value for the Length field, L_{max}, is therefore k-2. The maximum number of usable octets in the Information Field is L_{max}-2 and the maximum data rate (in bits/s) is 8R(L_{max}-2) where R is the frame rate (62,5 frames/s).

The codeword format for LAPR is:

Table R.1: Reed-Solomon Formats for LAPR

Reed-Solomon Code (n,k;d)	S_{max}	L_{max}	Maximum Information Field Length	Maximum data rate (bit/s)
63,44;3	352	42	40	20000

Allowed values of the Length field are:

- 0: the frame carries no control, address or Information field data. This shall be used as channel fill.
- $2 \leq$ Length $\leq L_{max}$: This is a Supervisory, Unnumbered or Information frame.

The User Defined field shall always contain valid data, such as line control information.

R.2.4 Synchronous Rate Adaptor

The radio link may be used to carry synchronous channels between a DCPP and a DCFP. The DCPP (and the DCFP) may connect to DTE (Data Terminal Equipment) or DCE (Data Communications Equipment) using an interface such as CCITT V.24 [26].

A DCPP supporting synchronous data services shall provide one or more of the following standard rates (in bit/s): 300, 1 200, 2 400, 4 800, 9 600, 14 400, and 19 200. The adaptor shall convert these rates to the radio link's 32 kbit/s rate by choosing a Reed-Solomon code whose message rate is slightly higher than the synchronous line's rate. The available message rates do not match the desired synchronous rates exactly. Thus, the adaptor shall periodically reduce the message rate at the transmitter. The length bit in the synchronous adaption frame allows this. A one in this bit shall indicate that all subsequent bits in the frame carry user data, while a zero shall indicate that the last message symbol is unused. See figure R.5.

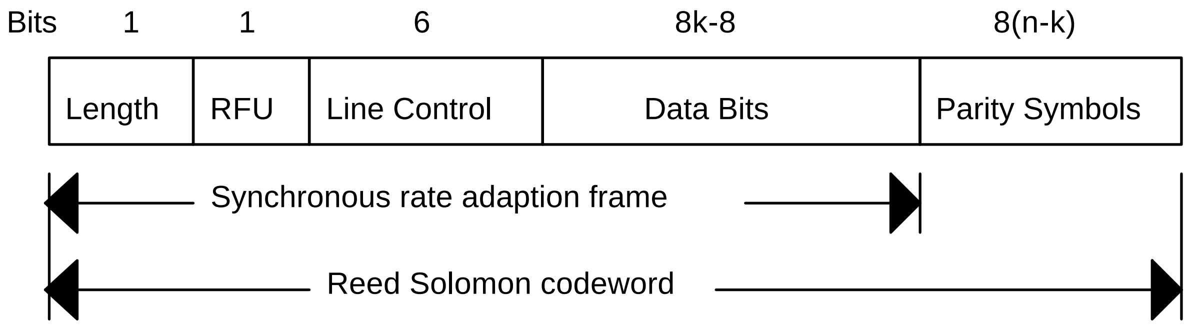


Figure R.5: Synchronous Rate Adaption Frame

The RFU bit is reserved for future use. It shall be set to 0.

Following the Length and RFU bits are six line control bits for carrying status and control information out of band between the DCE and DTE. The Line Control signals are shown in table R.2.

Table R.2: Line Control Signals

Signal	CCITT Rec. V.24 [26] Lead	Direction
Data Rate Select	111	SRA->DCE (note 3) DTE->SRA
Clear to Send	106	SRA->DTE (note 3) DCE->SRA
Request to Send	105	SRA->DCE (note 3) DTE->SRA
Carrier Detect	109	SRA->DTE (note 3) DCE->SRA
Secondary Tx Data	118	SRA->DCE (note 3) DTE->SRA
Secondary Rx data	119	SRA->DTE (note 3) DCE->SRA
Data Terminal Ready (DTR)	108/2	SRA->DCE (note 3) DTE->SRA
Data Set Ready (DSR)	107	SRA->DTE (note 3) DCE->SRA

NOTE 1: The Data Rate Select signal is used to signal the data rate between a DTE and a DCE and does not affect the rate at which the radio channel operates.

NOTE 2: Carrier Detect is also referred to as Received Line Signal Detect (RLSD).

NOTE 3: The abbreviation SRA is used here to refer to the Synchronous Rate Adapter.

The use of these bits is shown in table R.3.

Table R.3: Synchronous Line Control Message Format

Bit	5	4	3	2	1	0
DTE to DCE	Reserved, equal to 0	Reserved, equal to 0	DTR	Secondary Tx Data	Data Rate Select	Request to Send
DCE to DTE	Reserved, equal to 0	Reserved, equal to 0	DSR	Secondary Rx data	Clear to Send	Carrier Detect

Following the line control bits are the user data bits. The structure is shown in figure R.5.

The Reed-Solomon codes for the different rates are as follows:

Table R.4: Reed-Solomon Formats for Synchronous Data

Synchronous line rate	Reed Solomon Code	User data per codeword (bits)		User data (bit/s)	
(bit/s)	(n,k;d)	Max (length=1)	Min (length=0)	Max (length=1)	Min (length=0)
300	63,2;3	8	0	500	0
1200	63,4;3	24	16	1500	1000
2400	63,6;3	40	32	2500	2000
4800	63,11;3	80	72	5000	4500
9600	63,21;3	160	152	10000	9500
14400	63,30;3	232	224	14500	14000
19200	63,40;3	312	304	19500	19000

R.2.5 Asynchronous Packet Assembler/Disassembler (PAD)

In the DCFP, the PAD lies between the LPI and LAPR; at the DCPP, it lies between LAPR and the asynchronous device such as a terminal or host computer. The PAD receives asynchronous characters from the land-line or DTE. Asynchronous characters typically consist of a start bit that indicates the start of a character, one or more stop bits that indicate the end of the character, and a certain number of bits in between that define the specific character. The character may also contain a parity bit.

The PAD shall strip the start and stop bits from an asynchronous character. If the number of data bits per character, plus parity (if any) is less than or equal to eight, the data bits shall be placed in the least significant bits of the octet. The parity bit (if any) shall go in the least significant bit position not occupied by a data bit, and the remaining bits shall contain 0. An example is shown in figure R.6 for the case of one start, eight data bits, one stop, no parity. For transmission, the PAD shall collect the asynchronous characters into a packet. Characters shall not be placed in a packet until they are completely received. Every 16 ms, the PAD shall sample the line control signals and shall create a Line Control Message.

If the PAD detects a "break" condition from the DTE/DCE while collecting characters, the Break bit of the Line Control Message shall be set. A "break" condition typically consists of a "space" condition persisting longer than one character time. The PAD shall then send the packet and the Line Control Message on to LAPR for transmission over the synchronous radio link. The packet shall be transmitted in the Information field, and the Line Control Message in the User Defined field of the LAPR frame. Upon reception of a signalling symbol with the break bit set, the receiver shall assert a break condition to the associated DTE/DCE interface until the break bit is again received as zero.

The Line Control Message bits are defined in table R.5. A one in the Line Control Message shall indicate assertion of the assigned signal or condition; a zero shall indicate the negation.

Table R.5: Asynchronous Line Control Message Format

Bit	5	4	3	2	1	0
DTE to DCE	Reserved, equal to 0	Break	Data Terminal Ready	Secondary Tx Data	Data Rate Select	Request to Send
DCE to DTE	Reserved, equal to 0	Break	Data Set Ready	Secondary Rx data	Clear to Send	Carrier Detect

NOTE 1: The Data Rate Select signal is used to signal the data rate between a DTE and a DCE and does not affect the rate at which the radio channel operates.

NOTE 2: Carrier Detect is also referred to as Received Line Signal Detect (RLSD).

A DTE shall transmit the line control message and the DCE shall interpret a received line control message according to the line labelled "DTE to DCE". A DCE shall transmit the line control message and the DTE shall interpret a received line control message according to the line labelled "DCE to DTE".

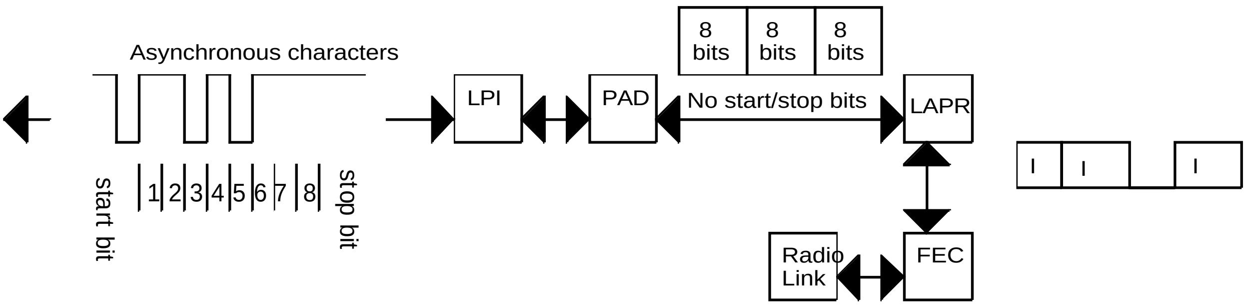


Figure R.6: Packet Assembler/Disassembler

For reception, the PAD shall take received information frames from LAPR and shall disassemble them into characters. The start and stop bits shall be added, and the characters shall be then passed to the LPI. The PAD shall contain buffers to avoid overflows due to transmission delays and DTE response times. The PAD also shall provide flow control to prevent buffer overflow when radio transmission degrades for a long period of time.

A single FFEC format is used to support all line rates as given in table R.1.

R.2.5.1 PAD parameters

The PAD shall support the following formats for asynchronous characters:

- 5 bits, no parity;
- 5 bits, with parity;
- 6 bits, no parity;
- 6 bits, with parity;
- 7 bits, no parity;
- 7 bits, with parity;
- 8 bits, no parity.

The PAD shall not check or generate parity on characters exchanged with a DTE or DCE. All formats shall use one stop bit.

R.2.5.2 Flow control

Flow control may be initiated by the user, or by the PAD because of LAPR congestion. PADs shall support three flow control methods:

- XON/XOFF;
- Line Control;
- Null.

XON/OFF is an in-band method, which reserves two character codes for flow control. It shall not interpret or alter the line control signals. Line Control shall not interpret or alter the character stream but reserves two hardware interface signals. The Null method shall provide no flow control whatsoever and may discard data in case of congestion. It shall not interpret or alter either the character stream or the line control signals.

The flow control method shall be determined at the start of a call and shall be used for the duration of the call.

R.2.5.2.1 XON/XOFF

A PAD may send XOFF (IA5 DC3) to stop the flow of characters from the DTE/DCE. The PAD shall accept up to 8 characters from the DTE/DCE after sending the XOFF. The PAD may discard subsequent characters received, until it sends XON. The PAD may re-enable the flow of characters from the DTE/DCE by sending XON (IA5 DC1).

A DTE (or DCE) may stop the flow of characters from the PAD by sending XOFF. The PAD shall transmit a maximum of 3 characters (excluding XOFF and XON) to the DTE (DCE) after receiving an XOFF. The PAD shall also relay the XOFF to the remote DCE (DTE). The PAD may resume sending characters to a local DTE (DCE) when the DTE (DCE) sends XON. The XON shall be relayed to the remote DCE (DTE). A PAD may send XON or XOFF to a DTE (DCE) at any time, XOFF from the DTE (DCE) notwithstanding. When using this method, Bit 3 (DTR/DSR) of the line control message is not used and shall be set to zero.

R.2.5.2.2 Line control

A PAD may stop the flow of characters from the DTE (or DCE) by negating Data Set Ready (DSR) or Data Terminal Ready (DTR) control signal respectively. The PAD shall accept up to 8 characters from the DTE (DCE) after negating the control signal. The PAD may discard subsequent characters received from the DTE (DCE), until it reasserts DSR (DTR). The PAD may re-enable the flow of characters from the DTE/DCE by asserting DSR or DTR to the DTE (DCE) respectively.

A DTE (or DCE) may stop the flow of characters from the PAD by negating DTR (DSR respectively). The PAD shall transmit a maximum of 3 characters to the DTE (DCE) after the control signal is negated. The PAD may resume sending characters to a local DTE (DCE) when the DTE (DCE) reasserts DTR (DSR).

R.2.5.2.3 Null

In the Null method, the PAD shall not provide flow control. The user may send any data and use the line control signals in any fashion without affecting the PAD. The PAD, DTE, or DCE may discard data without warning.

R.2.6 Landline physical interface (LPI)

A DCPP may be attached to data terminals such as facsimile machines or X.25 terminals. A DCFP may be attached to network facilities via the LPI. The LPI may implement one of the existing standards such as voiceband modems or rate adaptation protocols.

R.3 End-user data services

R.3.1 Asynchronous data services

Figure R.7 shows the general system configuration of the asynchronous data service. At the DCPP, a subscriber may connect a personal computer (PC) or other data terminal equipment (DTE) directly to the DCPP through a suitable interface, e.g. CCITT V.24 [26]. The DCPP runs the asynchronous data protocol over the radio link. The DCFP also runs the asynchronous data protocol. After appropriate conversion, the data is transmitted through the network to data communications equipment (DCE) which is connected to a host computer, a workstation, or any other device that appropriately interfaces to it.

In effect three protocols exist. One for the radio interface, one for the DCPP-to-DTE interface, and one for the DCFP-to-landline interface. This document specifies only the radio interface.

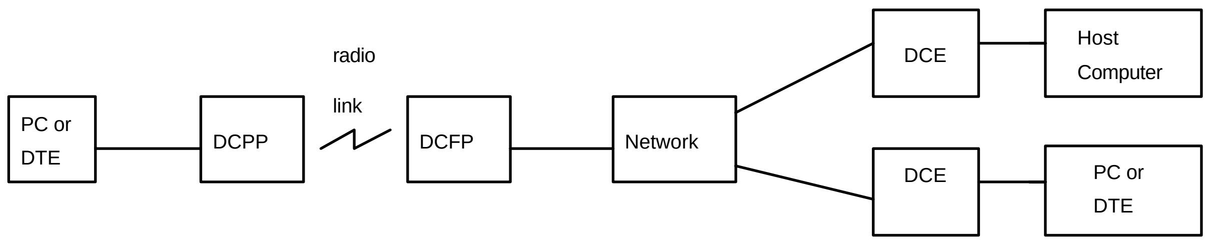


Figure R.7: General Configuration for Asynchronous Data Service

Figure R.8 shows the main components of the system that enable the asynchronous data service. These are:

- LPI;
- PAD;
- LAPR;
- FFEC;
- Radio Link.

The PAD provides for the asynchronous-to-synchronous interface between the asynchronous DTE to the synchronous radio data link. FFEC implements forward error correction (FEC) and LAPR is an automatic repeat request (ARQ) protocol.

The PAD, LAPR, and FEC reside in both the DCPP and DCFP, whereas the LPI resides only at the DCFP. An asynchronous terminal handler associated with the PAD provides a suitable interface, e.g. CCITT Recommendation V.24, [26] to the DTE. The system also transports line control information, e.g. CCITT Recommendation V.24 [26] "Data Terminal Ready" over the radio link.

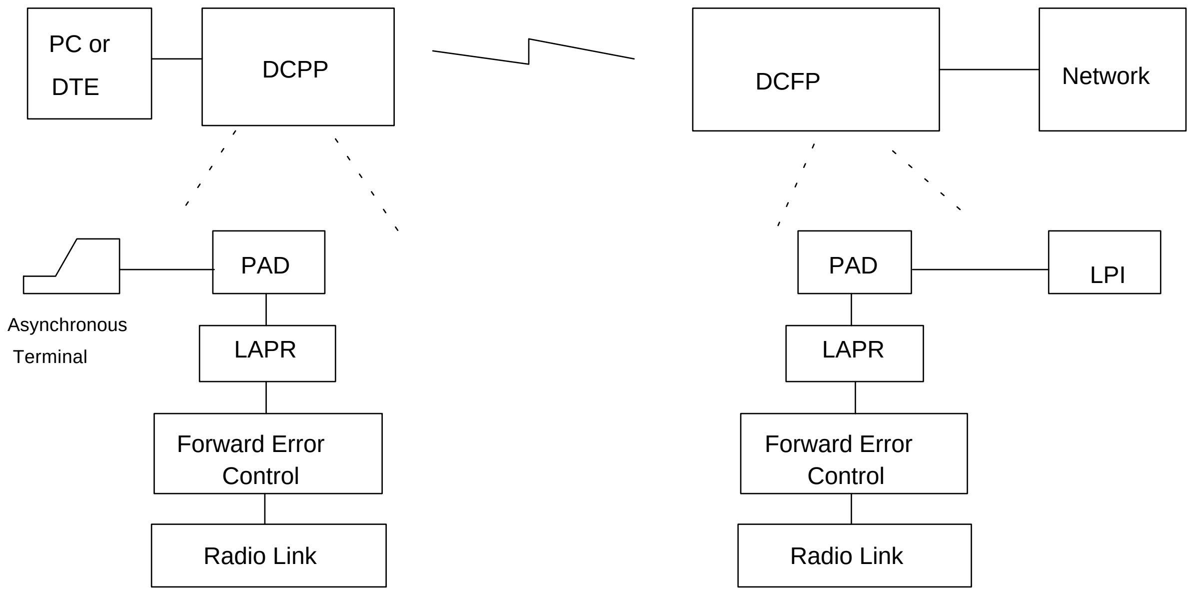


Figure R.8: Asynchronous Data Service Architecture

R.3.2 Synchronous transparent data services

The transparent data bearer services provide the user with unrestricted access to the 32 kbit/s B channel, or to lower-rate channels. Data rates are synchronous and user selectable. The supported rates are 300, 1 200, 2 400, 4 800, 9 600, 14 400, 19 200 and 32 000 bit/s. The service provides FEC for all rates except 32 kbit/s. There is no ARQ protocol and, therefore, no guarantee of data integrity.

For 32 kbit/s operation, the entire B-channel is used for user data. The user connects directly to the Radio Link. For sub-32 kbit/s rates, the user connects to the Synchronous Rate Adaptor, as shown in figure R.9.

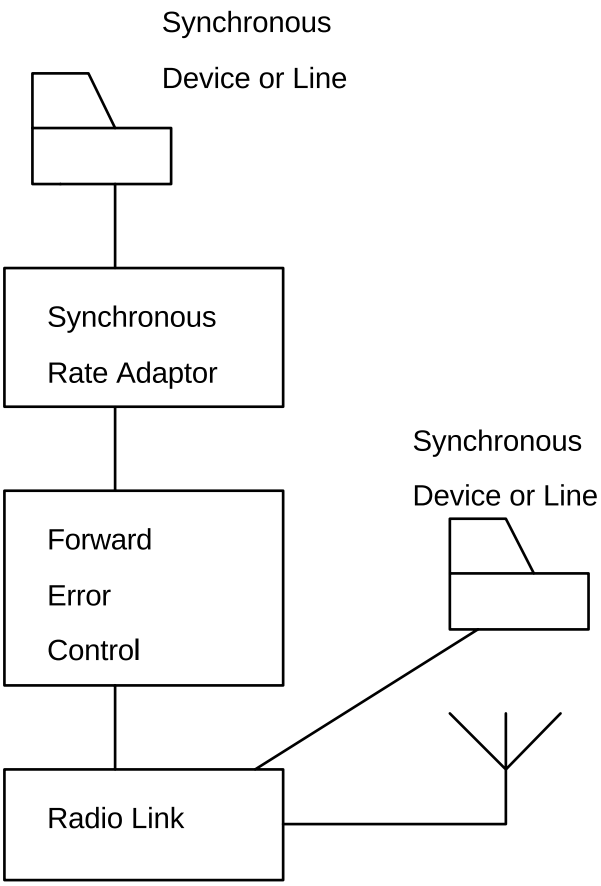


Figure R.9: Synchronous Data Service Architecture

R.4 Octet format and bit ordering

Bits in an octet shall be numbered from 1 to 8. Bit 1 shall be the least significant bit and bit 8 the most significant bit. All serial radio links shall transmit the bits of an octet in ascending numerical order. Similarly, the first received bit of an octet shall be numbered 1, and subsequent bits shall be numbered in ascending numerical order.

R.5 Data Call Establishment

Data calls may originate from either the DCPP or the DCFP. A similar establishment procedure shall be used in both cases (see below). However, the final resolution of the mode of operation shall rest with the terminating end of the call. That is at the DCFP for a DCPP originated call, and at the DCPP for a DCFP originated call.

R.5.1 Layers one and two

Data calls shall be a secondary service according to the requirements of subclause 4.4.4. A free RF channel shall be interpreted according to subclause 4.4.4.2.

R.5.2 Establishment of calls in data mode

Calls to be set up in data mode shall perform an RF channel assessment according to the requirements of subclause 4.4.4.2. If a free RF channel is not found, the link shall not be set up.

R.5.3 Switch from voice to data mode

Calls to be switched from voice to data mode shall perform an RF channel assessment or re-assessment according to the requirements of subclause 4.4.4. As part of the switch from voice mode to data mode, it may be required for the link to be re-established on a new RF channel. If a free RF channel is not found, the link shall either be terminated or shall remain in voice mode.

If one end of the link wishes to switch from voice to data and this requires a re-establishment of the link, that end shall send a Secondary_Service_Re-establishment (or alternatively a MUX3_Secondary_Service_Re-establishment message if it is a CFP) to the other end. When the link is re-established, the end which performed the assessment during the re-establishment shall send a Secondary service channel availability message. If the message indicates that a secondary service channel was not available, the unit attempting to initiate the data call may either terminate the link or remain in voice mode.

Any re-establishment necessary to ensure secondary service channel selection shall be carried out before FA 5,x or FI 5,x is sent to start the data service.

R.5.4 Operation within data mode

The point of establishment of data mode shall be defined as the point at which the CPP sends FA 5,x, or the CFP sends FI 5,x;1.

Within time Tdata0 of the original link establishment in (or the switch to) data mode, the RF channel in use shall be re-assessed according to the requirements of subclause 4.4.4. As part of the operation of the link in data mode, it may be required for the link to be re-established on a new RF channel. If a free RF channel is not found, the link shall be terminated.

Subsequently, if a link remains in data mode, the RF channel in use shall be re-assessed according to the requirements of subclause 4.4.4 at intervals of no more than Tdata1. As part of the operation of the link in data mode, it may be required for the link to be re-established on a new RF channel. If a free RF channel is not found, the link shall be terminated.

If Tdata0 or Tdata1 expires and the CFP cannot re-assess the channel without re-establishing the link it shall send a Secondary_Service_Re-establishment or MUX3_Secondary_Service_Re-establishment message to the CPP. If the assessing end finds that no secondary service channel is available it shall not attempt to re-establish the call, but shall stop the call, leaving the non-assessing end to timeout on Thlost. If the assessing end finds that there is a channel available it shall attempt to re-establish, using the appropriate power level. If the link is successfully re-established the assessing end shall send a Secondary service availability message, indicating the power to be used. The non-assessing end shall then set its power as indicated.

The Feature Indication FI 5,x,0 may be sent up to Tdata2 prior to a forced data link termination resulting from the expiry of Tdata0 or Tdata1. Tdata2 shall be 20 s.

Operation of the link within the timing requirements defined by Tdata0 and Tdata1 shall be the responsibility of the CFP only. The values of Tdata0 and Tdata1 may be specified by a relevant National Telecommunications Regulatory Authority. In the absence of any such alternative specification, the values shall be 5 minutes for Tdata0 and 5 minutes for Tdata1.

R.5.5 Switching from data mode to voice mode

A call in data mode shall only be switched to voice mode by intervention of the user. Subclause 4.5.3.3 shall apply.

R.5.6 Re-establishment in data mode

A call in data mode that must be re-established for reasons other than those associated with the requirements of R.5.4 shall also perform a channel assessment according to subclause 4.4.4. As part of the re-establishment of the link in data mode, it may be required for the link to be re-established on a new RF channel. If a free RF channel is not found, the link shall be terminated.

The end of the link which determines that re-establishment is required shall send a Secondary_Service_Re-establishment (or alternatively a MUX3_Secondary_Service_Re-establishment message if it is a CFP) to the other end. If the assessing end finds that no secondary service channel is available it shall not attempt to re-establish the call, but shall stop the call, leaving the non-assessing end to timeout on Thlost. If the assessing end finds that there is a channel available it shall attempt to re-establish using the appropriate power level. If the link is successfully re-established the assessing end shall send a Secondary service channel availability message, indicating the power to be used. The non-assessing end shall then set its power to that indicated.

R.5.7 Layer three for DCPP originated calls

The sequence for the establishment of a data call, or the switch from voice mode to data mode, with the DCPP as the originator is indicated in figure R.10. In establishing a data call, TERM_CAP and BAS_CAP are mandatory; in switching a call from voice mode to data mode, TERM_CAP and BAS_CAP are optional.

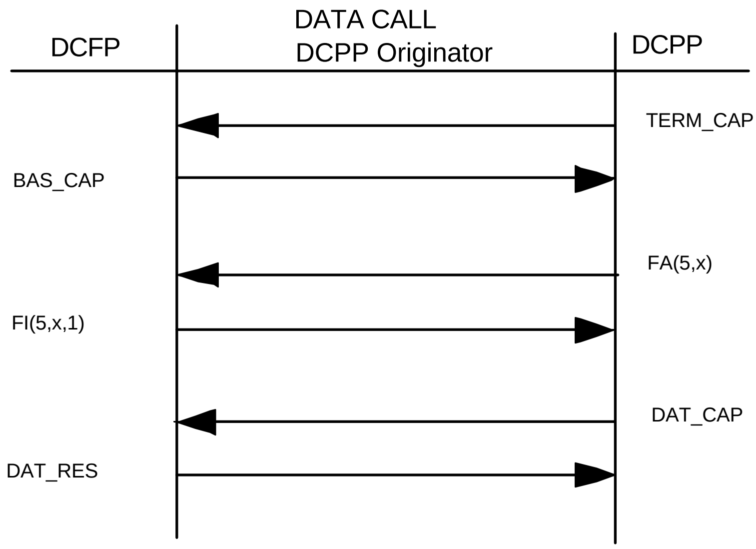


Figure R.10: Data Call Set-Up from DCPP

The originator of the call, in this case the DCPP, shall indicate its request for data service by means of the FA (5,x) information element. The DCFP shall respond with a FI (5,x,1) information element indicating it is ready to accept the call. The DCPP shall then send the DAT_CAP information element to indicate its preferred mode of operation and its capabilities. After selecting a compatible mode, the DCFP shall respond with a DAT_RES element indicating the data mode to be used. Data communication service shall then proceed with the establishment of the B channel in the MUX1 mode.

R.5.8 Layer three for DCFP originated calls

The sequence for the establishment of a data call, or the switch from voice mode to data mode, with the DCFP as the originator is indicated in figure R.11. In establishing a data call, TERM_CAP and BAS_CAP are mandatory; in switching a call from voice mode to data mode, TERM_CAP and BAS_CAP are optional.

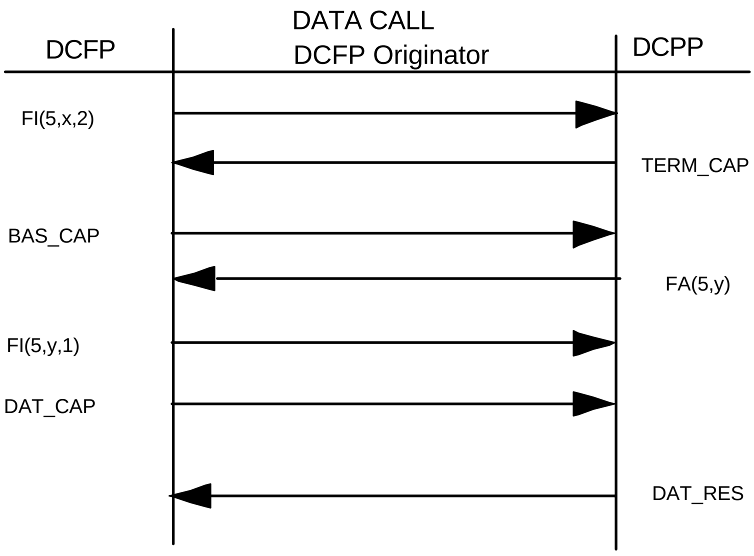
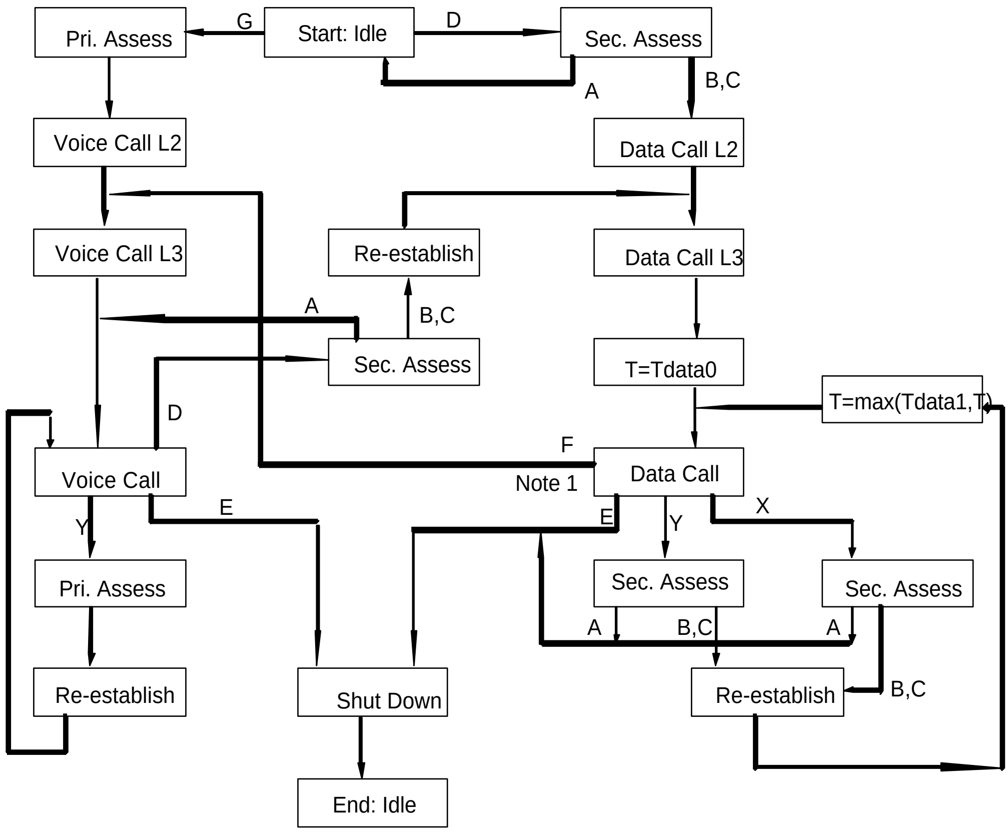


Figure R.11: Data Call Set-Up from DCFP

The originator of the call, in this case the DCFP, shall indicate its request for data service by means of the FI (5,x,2) information element. The DCPP shall respond with its normal TERM_CAP information plus a FA (5,y) element indicating it is ready to accept the data call. The DCFP shall confirm this with an additional FI (5,y,1) information element. The DCFP shall then send the DAT_CAP information element to indicate its preferred mode of operation and its capabilities. After selecting a compatible mode, the DCPP shall respond with a DAT_RES element indicating the data mode to be used. Data communication service shall then proceed with the establishment of the B channel in the MUX1 mode.



Primary Assessment:
RF channel always selected for use.

Secondary Assessment:
channel selected only if RF spectrum is not heavily loaded.

RF Assessment outcomes
A: No RF channel OK
B: Same RF channel OK
C: Other RF channel OK

Notes:
1: Subclause 4.5.3.3 applies.

Events:
D: CTA set up required in data mode
E: CTA shut down required
F: CPP user activates voice mode RF (manual,never automatic)
G: CTA set up required in voice mode
X: T expires
Y: RF channel re-establishment needed

Figure R.12: DATA and VOICE modes in a CTA (informative)

History

Document history	
April 1992	First Edition
November 1994	Second Edition
February 1996	Converted into Adobe Acrobat Portable Document Format (PDF)