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Foreword

This Interim European Telecommunication Standard (I-ETS) has been developed by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now published following the public enquiry and the voting phase of the ETSI standards approval procedure (PE21 1991-07-15 to 1991-12-06, V27 1992-09-21 to 1992-11-13).

This I-ETS is developed from CEPT Recommendation T/R 24-04 and is complementary to CEPT Recommendations T/R 20-10 and T/R 75-02. It concerns the minimum technical characteristics necessary for Digital Short Range Radio (DSSR), designed to operate in the 900 MHz band.

This I-ETS will in future be likely to be superseded or complemented by a corresponding ETS.

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1 Scope

This Interim European Telecommunication Standard (I-ETS) for Digital Short Range Radio (DSRR) applies to equipment designed to operate within the private land mobile radio service.

DSRR is a radiocommunication system in the land mobile service based on a dynamic frequency selection method providing digital short range communications for voice and/or data in the frequency bands 933 - 935 MHz and 888 - 890 MHz with a maximum power output of 4 Watts (W) and is comprised of the following stations:

Portable DSRR station: a station in the land mobile service intended to be used while carried by a person.

Mobile DSRR station: a station in the land mobile service mounted in a vehicle and intended to be used in motion or during halts at unspecified points.

DSRR base station: a station in the land mobile service installed at a fixed location.

DSRR repeater: a station in the land mobile service installed at a fixed location which is intended to establish radiocommunications between portable and/or mobile stations.

Mobile and portable stations may be capable of transmitting in the frequency bands 933 - 935 MHz and/or 888 - 890 MHz.

Base stations and repeater stations transmit only in the 933 - 935 MHz frequency band, (see table).

Mode A: simplex in frequency band 933 - 935 MHz;

Mode B: two frequency semi-duplex in the frequency band 933 - 935 MHz, paired with 888 - 890 MHz.

Transmit frequencies DSRR (MHz)			
Equipment	Mode A	Mode B	both A and B
Portable	933 - 935	888 - 890	both bands
Mobile	933 - 935	888 - 890	both bands
Base station	933 - 935	933 - 935	933 - 935
Repeater	not possible	933 - 935	not possible

This I-ETS covers the minimum characteristics considered necessary for the DSRR system using digital transmission techniques and an automated multi-channel access technique in order to make the best use of the available frequencies. It does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represent the optimum performance achievable.

This I-ETS contains the system specification and technical characteristics to be used for DSRR equipment intended to provide short range radio voice and/or data radiocommunication.

This I-ETS specifies three principle system elements as follows:

Unit: an equipment operating in the simplex mode with single and two frequency working;

Master unit: an equipment operating in the two frequency semi-duplex mode without repeater facilities;

Repeater: an equipment operating in the two frequency semi-duplex mode with repeater facilities.

Communication on an individual or a group call basis is provided for in the I-ETS.

Using the three principle system elements, the following types of equipments can be constructed:

- a vehicle installed mobile equipment or a hand portable equipment operating in the single frequency mode;

- a vehicle installed mobile equipment or a hand portable equipment operating in the two frequency mode;

- a base station operating in the single frequency mode;

- a base station operating in the two frequency mode;

- a repeater station operating in the two frequency mode.

2 Normative references

This I-ETS incorporates by dated or undated references, 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] GSM Recommendation 06.10 version 3.2.0: "GSM Full-Rate Speech Transcoding".

[2] CCIR Report 903: "Digital transmission in the land mobile service".

[3] CCITT Recommendation O.153 (1988): "Characteristics of distortion and error-rate measuring apparatus for data transmission".

[4] ETR 028 (1992): "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

3 Definitions and abbreviations

The timing parameters in the signalling protocol description (Clause 5) are defined individually in Annex B. These timing parameters are denoted throughout the text as T_(TIMERNAME).

3.1 Definitions

For the purpose of this I-ETS, the following definitions apply:

ACKnowledgement (ACK): a successfully decoded Selective Signalling Code (SSC) with the following code values is used by the calling unit as an acknowledgement:

- SSC number = "0";

- first call code = individual address of receiving unit, or in the case where the receiving equipment is a repeater, the individual address of the calling unit involved in the call set-up;

- second call code = individual address of the called unit.

Associated channel: the corresponding channel in the other frequency band (High Band (HB) or Low Band (LB)) with the same channel number as that of the current channel.

Called unit (group): the unit (group of units) with which the calling unit requires voice or data communication.

Calling unit: corresponds to the unit responsible for initiation of the call set-up procedures following call activation from the user.

Channel observation: observation of the Radio Frequency (RF) level on a channel to determine whether the channel is occupied or not.

Channel monitoring: observation of the RF level on a channel to determine whether the channel is occupied or not, as well as decoding and interpretation of any signalling (4 kbit/s) or decoding of voice/data (16 kbit/s) on the channel if it is found to be occupied.

Communication: period of time for which the required units and repeater or master unit are exchanging valid voice/data in communication mode before termination occurs (either at user's request or by time-out).

Free control channel: in the case of a unit, master unit or repeater monitoring an HB channel to determine if it is free, the control channel shall be deemed free if any of cases 1) to 3) are found to be true when monitoring:

1) the control channel is not deemed to be occupied over an observation period of T_MON_CC;

2) any SSC with an SSC number of "0" is successfully identified as completed on the control channel;

3) a period of T_MON_CC has passed since any SSC with an SSC number of "1" was successfully identified as completed on the control channel;

In the case of a unit in two frequency operation monitoring the HB control channel to determine if the associated LB channel is free, the control channel shall be deemed free if any of cases 4) to 7) are found to be true when the unit is monitoring:

4) the control channel is not deemed to be occupied over an observation period of T_MON_CC;

5) any SSC with an SSC number of "0" is successfully identified as completed on the control channel;

6) any single frequency SSC is successfully identified as completed on the control channel;

7) a period of T_MON_CC has passed since any two-frequency SSC with an SSC number of "1" was identified as completed on the channel.

NOTE: Case 6) does not affect the single frequency call set-up procedures as the monitoring unit is preparing to transmit on the LB control channel, which will not interfere.

Free traffic channel: a traffic channel shall be deemed free if it is not deemed to be an occupied channel over the appropriate observation period.

High Band (HB) channel: a channel with frequency allocation in the frequency band 933 - 935 MHz.

Low Band (LB) channel: a channel with frequency allocation in the frequency band 888 - 890 MHz.

Null signal: is the transmission made on the HB traffic channel by a master unit to indicate to other DSRR equipments that the channel is in use. The null signal may be a carrier wave only or a modulated signal transmitting a pseudo-random sequence. It shall not be preamble.

Occupied channel: a control or traffic channel shall be deemed occupied if the median value, over the observation period, of the input voltage is equal to or exceeds a value of 6 dB below the limit for the maximum usable sensitivity.

Opposite control channel: the opposite control channel to channel 26 is channel 52 and vice versa.

Preamble: the transmission of bit reversals, "101010...". In this I-ETS, preamble is transmitted using the signalling modulation scheme.

Primary control channel: the primary control channel for a unit, master unit or repeater with an even call code shall be channel 26. The primary control channel for one with an odd call code shall be channel 52.

Secondary control channel: the secondary control channel for a unit, master unit or repeater with an even call code shall be channel 52. The secondary control channel for one with an odd call code shall be channel 26.

Selective Signalling Code (SSC): is designed to set up an appropriate two-way communication channel, so that communication by voice and/or data may follow. The structure of the SSC is described in subclause 6.1.

Signalling: any SSCs transmitted on either control or traffic channels. All signalling transmissions shall be made using the signalling modulation scheme (Gaussian Minimum Shift Keying, GMSK - Bandwidth Time, BT = 0,50 at 4 kbit/s).

Spurious signal (control channel): a spurious signal is any signal above the limit for the receiver maximum usable sensitivity which is not recognised as signalling.

Unwanted SSC: a SSC which has been successfully decoded but which is not a wanted SSC.

Valid voice/data communication: information which is received using the voice/data modulation scheme and which fits into the voice or data coding scheme described in subclause 6.4 (voice) or 6.5 (data).

Voice/data communication: all voice/data transmissions shall be made using the voice/data modulation scheme (GMSK - BT = 0,3 at 16 kbit/s).

Wanted SSC: a SSC which has been successfully decoded and which contains the appropriate code values for the recipient's current state and mode of operation, as defined in Annex D.

3.2 Abbreviations

For the purpose of this I-ETS, the following abbreviations apply:

ACK	Acknowledgement
BT	Bandwidth Time product
CC	Control Channel
CRC	Cyclic Redundancy Check
DSRR	Digital Short Range Radio
HB	High Band
LB	Low Band
PLL	Phase Lock Loop
SSC	Selective Signalling Code
TC	Traffic Channel

4 System characteristics

4.1 General

A Digital Short Range Radio (DSRR) is a low power radio transmitter-receiver (transceiver) of the private land mobile service intended to provide short range radio communications using voice or data and capable of single frequency simplex operation in the frequency band 933 - 935 MHz and/or of two frequency semi-duplex operation in the frequency band 933 - 935 MHz paired with 888 - 890 MHz.

This I-ETS specifies three principal system elements: units, master units, and repeaters.

The DSRR system consists of 2 control channels and 76 traffic channels with a channel separation of 25 kHz in either frequency band. For two frequency operation, each channel in the lower frequency band is associated with a channel in the high frequency band with a 45 MHz duplex frequency spacing.

Direct carrier modulation is used to send the Selective Signalling Code (SSC) and voice or data messages. The DSRR system provides different transmission rates and modulation schemes for signalling messages and for voice/data communication.

The DSRR system uses an automated multi-channel access technique which operates without the assistance of a central controller in single frequency simplex operation. In two frequency operation repeaters and master units take care of traffic channel allocation for the units that wish to communicate. With single frequency operation the call initiating equipment is responsible for the traffic channel allocation.

4.2 Equipment characteristics

All DSRR equipment shall have a unique identity code as described in subclause 6.1.

For the purpose of traffic channel reoccupation and collision detection, all DSRR equipment shall be able to detect signalling (4 kbit/s) which precedes voice/data communication (16 kbit/s). This detection shall be achieved within the duration of the SSC preamble.

As a minimum requirement, a DSRR system element shall be capable of participation in individual calls in either single or two frequency operation. For a repeater and a master unit the minimum capability shall be participation in two frequency individual calls.

Participation in group or individual calls in single or two frequency operation, if implemented, shall be achieved by following the procedures specified in the appropriate subclauses of this I-ETS.

4.2.1 Units

Units shall be capable of single frequency operation and/or two frequency operation. This is left to the manufacturer's discretion.

In single frequency operation, a unit shall be able to transmit and receive on all channels in the frequency band from 933 - 935 MHz. The unit shall communicate using simplex operation, i.e. the unit shall either transmit or receive on a channel in the 933 - 935 MHz band (an HB channel).

In two frequency operation, a unit shall always transmit on an LB channel in the frequency band from 888 - 890 MHz and receive on the associated HB channel in the frequency band from 933 - 935 MHz. The unit shall be capable of operation on any of the channels of one frequency band and its associated channel in the other frequency band. The unit shall communicate using semi-duplex operation, i.e. at any one time the unit shall either transmit in the 888 - 890 MHz frequency band or receive in the 933 - 935 MHz band.

4.2.2 Repeaters

In a DSRR system, a repeater is a system element which serves as intermediate link between two or more units to set up and maintain one communication.

A repeater shall always work in two frequency operation. It shall be capable of full duplex operation, where it shall be able to receive on any LB channel in the frequency band 888 - 890 MHz and simultaneously transmit on the associated HB channel. For signal retransmission a repeater shall always retransmit a complete SSC, including 64 ms of preamble.

A repeater shall also be able to sense the RF level on all channels in the frequency band 933 - 935 MHz (free traffic channel detection), while it is receiving in the frequency band 888 - 890 MHz.

In order to limit unauthorised use of repeaters, each repeater shall have a data base, into which all individual call codes of the units that are allowed to use the repeater are entered. Annex C gives further details on the access control for a repeater.

4.2.3 Master units

In a DSRR system, a master unit is a system element which provides its user with the possibility of communicating in two frequency operation without the assistance of a separate repeater.

A master unit shall be able to work in two frequency operation with a reversed frequency assignment compared to mobile and portable units, i.e. it shall be able to transmit on any channel in the 933 - 935 MHz band, and it shall be able to receive on the associated channel in the 888 -890 MHz band. A master unit shall maintain a traffic channel during a communication by continuously transmitting a signal on the HB channel when it is not transmitting its own user's information.

A master unit shall be able to sense the RF level on all channels in the frequency band 933 -935 MHz (free traffic channel detection).

4.3 Communication possibilities

Within the DSRR protocol communication shall be possible from:

1) a unit to a unit or group of units (single frequency);

2) a unit via a repeater to a unit or group of units (two frequency);

3) a unit to a master unit (two frequency);

4) a master unit to a unit or group of units (two frequency).

4.4 System configuration and system restrictions

A DSRR system consists of the user's own equipment including units, repeaters and master units.

The call codes of the users units are registered in the repeater's data base to allow the use of the repeater for individual and group calls between the user's units.

If there is more than one repeater, a single unit's call code may only be registered at one repeater in areas of overlapping coverage.

A non-registered unit may access a repeater as a visitor for communication with a registered unit. The repeater access response to a calling visitor unit shall be delayed to avoid interference with the visitor's own repeater.

In a repeater and a master unit it shall be possible to programme a subset of traffic channels, for which DSRR communication is prohibited at that repeater or master unit.

5 Signalling protocol

A DSRR system element shall obey the signalling protocol specified in this Clause. The signalling protocol consists of three distinct modes: standby, call set-up and communication. A system element may operate in any one of these modes at one time. Standby mode may be entered from any other mode. Call set-up mode shall only be entered from standby mode as specified in subclause 5.1. Communication mode shall only be entered from call set-up mode as specified in subclause 5.2 (single frequency operation) or subclause 5.3 (two frequency operation). At power up all system elements shall enter standby mode. This Clause contains references to a number of indications which may be activated at different stages, while Annex K contains details of how these indications may be passed to the user.

5.1 Standby mode

5.1.1 Unit standby mode

A unit in standby mode shall continuously monitor the current control channel for SSCs. The unit shall normally remain on its primary HB control channel (in the frequency band 933 - 935 MHz) for this process. The equipment ready indication may be given when the unit enters standby mode.

If, at any time, spurious signals are detected on the primary control channel for a period exceeding T_PRIM_SPUR, the unit shall switch to monitor its secondary control channel. After monitoring the secondary control channel for a period of T_SEC_RETURN, it shall switch back automatically to monitor its primary control channel.

5.1.1.1 Reception of a wanted SSC

If a unit which is capable of single frequency operation receives a wanted SSC with the two frequency bit set to "0", the unit shall immediately enter the call set-up mode as a called unit without changing the control channel. The unit shall follow the single frequency control channel call set-up procedures specified in subclause 5.2.2.2 (individual call) or subclause 5.2.4.2 (group call).

If a unit which is capable of two frequency operation receives a wanted SSC with the two frequency bit set to "1", the unit shall follow the two frequency control channel call set-up procedures specified in subclause 5.3.1.2 (individual call) or subclause 5.3.4.2 (group call).

5.1.1.2 Call activation

To initiate a call, the user selects the call code of the called unit (or group of units) and the operation procedures which apply (single or two frequency operation, individual or group) and activates the call function. The unit shall immediately enter the call set-up mode as the calling unit.

If single frequency operation is selected, the unit shall follow the single frequency call set-up procedures beginning at subclause 5.2.1. If two frequency operation is selected, the unit shall follow the two frequency call set-up procedures as described in subclauses 5.3.1.1 (individual call) or subclause 5.3.4.1 (group call).

5.1.2 Repeater standby mode (two frequency operation only)

A repeater in standby mode shall continuously monitor the current LB control channel for SSCs. On entering standby mode at power up, the repeater shall begin monitoring either LB control channel.

If at any time the repeater detects spurious signals on its current LB control channel for a period exceeding T_PRIM_SPUR, it shall switch to the opposite LB control channel and monitor it.

The repeater in standby mode shall also scan the HB traffic channels, using the procedures of Annex A to identify one which is currently free. On locating a free traffic channel, the repeater shall store this channel number in its memory for future use in a call set-up.

If this channel is deemed to be occupied in standby mode, the repeater shall repeat the scanning procedure to locate another free channel.

If the channel scanning process fails to identify a free traffic channel the repeater shall repeat the scanning procedure to locate a free channel.

5.1.2.1 Reception of a wanted SSC

For a repeater in standby mode, a wanted SSC shall correspond to a two frequency individual call set-up SSC in which either the first or the second call code (or both) correspond to an individual unit which is a member of its database, or a two frequency group call set-up SSC in which the calling unit is a member of its data base.

On receipt of a wanted SSC in which the second call code (individual) corresponds to a member of its data base (an owner), the repeater shall switch to the call set-up mode to handle the call set-up for the calling unit as an owner. The repeater shall follow the procedures specified in subclause 5.3.1.3 (individual call) or subclause 5.3.4.3 (group call).

On receipt of a wanted individual call set-up SSC in which only the first call code corresponds to a member of its own data base, the repeater shall enter the call set-up mode to handle the call set-up for the calling unit as a visitor. The repeater shall follow the call set-up procedures specified in subclause 5.3.1.3.

5.1.3 Master unit standby mode

The master unit shall follow the same procedure as specified for a unit in standby mode in subclause 5.1.1, except that the master unit shall monitor the LB control channels for SSCs.

The master unit in standby mode shall also scan the HB traffic channels, using the procedures of Annex A to identify one which is currently free. On locating a free traffic channel, the master unit shall store this channel number in its memory for future use in a call set-up.

If this channel is deemed to be occupied in standby mode, the master unit shall repeat the scanning procedure to locate another free channel.

If the channel scanning process fails to identify a free traffic channel the master unit shall repeat the scanning procedure to locate a free channel.

5.1.3.1 Reception of a wanted SSC

On receipt of a wanted SSC, the master unit shall immediately enter the call set-up mode as a called master unit. The master unit shall follow the control channel call set-up procedures specified in subclause 5.3.3.2. All SSCs with the two frequency bit set to "0" shall be ignored and likewise all SSCs with the group bit set to "1" shall be ignored.

5.1.3.2 Call activation

To initiate a call, the user selects the call code of the called unit (or group of units) and the operation procedures which apply (individual or group call) and activates the call function at the calling master unit. The master unit shall immediately enter the call set-up mode as the calling unit, and follow the procedures specified in subclause 5.3.3.1 (individual call) or subclause 5.3.6.1 (group call).

5.2 Single frequency call set-up mode

The call set-up mode shall always be entered from standby mode. For the calling unit, this mode shall be entered following a call activation by the user. For a called unit it shall be entered following reception of a wanted SSC on one of the control channels. Any unit may exit the call set-up mode at any time and revert to standby mode following an action by the user.

There are a number of call failure conditions described in this subclause which will also cause the units to revert to standby mode from call set-up mode. Under these conditions, it is optional for either unit to indicate to the user that a call has failed. This indication is recommended at the calling unit.

The behaviour of a unit in the call set-up mode will depend on whether it is a calling or a called unit. For an individual call, the called unit shall only transmit in response to a wanted SSC. For a group call, a member of the called group shall not transmit while in call set-up mode.

The call set-up indication may be activated when a unit enters call set-up mode.

All transmissions made in call set-up mode are signalling and shall be made using the signalling modulation scheme.

5.2.1 Traffic channel scanning cycle

After switching to call set-up mode, the calling unit shall initiate the traffic channel scanning cycle in order to locate a free traffic channel. The traffic channel scanning cycle applies to both individual and group calls and shall follow the procedures described in Annex A.

Once a free traffic channel has been located, the unit shall store the corresponding channel number in its memory and follow the control channel procedures of subclause 5.2.2.1 (individual call) or subclause 5.2.4.1 (group call).

If the calling unit is unable to locate a free channel by following the procedures of Annex A, then it shall return to standby mode. The system busy indication may be activated.

5.2.2 Control channel procedures - individual call

The control channel call set-up procedures for an individual call correspond to the calling unit establishing contact with the called unit and notifying it of the chosen traffic channel. This signal will be acknowledged by the called unit. If there is a problem with establishing contact, the calling unit implements automatic re-try procedures on both control channels.

5.2.2.1 Procedures for the calling unit

The calling unit shall not transmit on a control channel unless it has first monitored the channel and deemed it to be free.

5.2.2.1.1 First call set-up attempt

After successfully locating a free traffic channel, the calling unit shall switch to the primary control channel of the called unit and shall monitor the channel to determine whether it is free. See subclause 3.1 for the criteria used to determine whether the control channel is free.

When the calling unit has deemed the control channel free it shall transmit the full SSC described in subclause 6.1. The SSC transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free. This SSC shall have the following code values in its code words:

- the SSC number shall be set to "1";

- the traffic channel code shall be set to indicate the number of the free traffic channel as identified in the traffic channel scanning cycle;

- the first call code shall correspond to that of the called unit;

- the command code shall be set to indicate the relevant operation procedures; group call bit = "0", two frequency bit = "0", control channel select bit = "0";

- the reserved bits shall be set to their default value;

- the manufacturer's code of the calling unit shall be set as appropriate;

- the second call code shall correspond to the calling unit's own individual call code.

After the transmission of the full SSC word, the calling unit shall switch to receive on the control channel within time T_SWITCH of the end of its own transmission, and shall wait for an acknowledgement from the called unit.

If no acknowledgement is received within T_RX_ACK of the end of the calling unit's own SSC, or if any other SSC is received in this time, the calling unit shall implement the control channel re-try procedures of subclause 5.2.2.1.2.

On receipt of an acknowledgement within T_RX_ACK of the end of its own SSC transmission, or to one of its re-try SSCs, the calling unit shall switch to the previously located free traffic channel and follow the traffic channel call set-up procedures of subclause 5.2.3.1. The channel switch shall be made so that the unit is able to begin observing the channel within time T_SWITCH of the end of the received acknowledgement.

If the monitoring process fails to identify the primary control channel as free within a total monitoring period of T_MON_SPUR, the calling unit shall implement the re-try procedures specified in subclause 5.2.2.1.2.

5.2.2.1.2 Re-try procedures

The re-try procedures described in this subclause shall be followed in the case where no acknowledgement is received within T_RX_ACK of the end of the first call set-up attempt SSC on the control channel, or where the unit is unable to access the control channel for its first attempt due to spurious signalling.

The unit shall monitor the appropriate control channel to determine if it is free for each re-try attempt. If the monitoring process fails to identify the channel as free over a monitoring period of T_MON_SPUR, the unit shall consider the attempt to have failed and initiate the next (if there is one).

After transmission of each re-try call set-up SSC, the calling unit shall switch to receive on the same control channel and wait for an acknowledgement under the same conditions as for the first attempt.

If no acknowledgement is received within T_RX_ACK of the end of a re-try call set-up attempt, or if any other SSC is received in this time, the calling unit shall consider the attempt to have failed and initiate the next (if there is one).

For the first re-try attempt, the calling unit shall generate a random number, n, in the range 0 to 5 inclusive. The calling unit shall then follow the same channel monitoring procedure as for the first call set-up attempt, but shall delay the beginning of the monitoring period for a time T_BACK_OFF equal to this random number, n, multiplied by T_SLOT.

Once the control channel has been deemed free following the repeated monitoring process, the calling unit shall retransmit its SSC in an identical form to that of the first call set-up attempt. This transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free.

The third attempt shall be made by following the same procedure as the second, except that in this case the calling unit shall generate its random number, n, in the range 0 to 10 inclusive.

If all three attempts on the called unit's primary control channel are unsuccessful, the calling unit shall switch to the secondary control channel of the called unit and repeat the call set-up procedure (including re-try procedures if necessary).

If the call set-up and re-try procedures are completed on both control channels without success, the calling unit shall return to the standby mode. The number unobtainable indication may be activated.

5.2.2.2 Procedures for the called unit

After switching to the call set-up mode, the called unit shall respond to the received SSC by transmitting an acknowledgement. This transmission shall be made so that the first bit is transmitted at time T_SWITCH from the end of the received SSC. The acknowledgement shall have the format shown in subclause 6.2.

On completion of the acknowledgement transmission, the called unit shall switch to the traffic channel indicated in the received SSC and shall follow the traffic channel call set-up procedures of subclause 5.2.3.2.

The channel switch shall be made so that the unit is able to begin monitoring the channel within time T_SWITCH of the end of the transmitted acknowledgement.

5.2.3 Traffic channel procedures - individual call

If either unit in call set-up mode decodes an unwanted SSC on the traffic channel, then the unit shall not transmit on that channel and shall return to standby mode. The system busy indication may be activated at the calling unit.

In the event of a call failure after the control channel call set-up procedures have been completed, there are no automatic re-try procedures.

5.2.3.1 Procedures for the calling unit

After switching to the previously located free traffic channel, the calling unit shall observe the channel for a period of T_OBS_CHK to check that it has not become occupied during the control channel call set-up signalling. If the chosen traffic channel is deemed occupied after this observation period, the calling unit shall not transmit on the traffic channel and shall return to the standby mode. The system busy indication may be activated.

If the traffic channel is not deemed occupied in this time, the calling unit shall transmit the call set-up SSC on the traffic channel. This transmission shall be identical in format to the call set-up SSC which was transmitted on the control channel, and the transmission shall begin within time T_SWITCH of the end of the observation period.

After transmission of the call set-up SSC on the traffic channel, the calling unit shall switch to receive on the traffic channel within time T_SWITCH and shall wait for an acknowledgement from the called unit.

On receipt of the acknowledgement, the calling unit shall switch to the communication mode described in subclause 5.4.1.

If no acknowledgement has been received within time T_RX_ACK of the end of the transmitted SSC, the calling unit shall return to the standby mode. The system busy indication may be activated.

5.2.3.2 Procedures for the called unit

After switching to the traffic channel indicated in the call set-up SSC, the called unit shall begin to monitor the channel and wait for further call set-up signalling from the calling unit.

If no wanted SSC is received on the traffic channel within time T_NO_RX from the end of the control channel acknowledgement, the called unit shall return to the standby mode.

On receipt of a wanted SSC from the calling unit on the traffic channel, the called unit shall respond to the received SSC by transmitting an acknowledgement. This transmission shall be made so that the first bit is transmitted at time T_SWITCH from the end of the received SSC. The acknowledgement shall have the format shown in subclause 6.2.

On completion of this transmission, the called unit shall enter the communication mode described in subclause 5.4.1.

5.2.4 Control channel procedures - group call

For a group call set-up, the SSC contains a group call command code which, when set to "1", shall inhibit transmission of an acknowledgement by any member of the group of called units. The calling unit shall transmit two SSCs on each control channel. There are no re-try attempts for a group call set-up.

5.2.4.1 Procedures for the calling unit

The calling unit shall not transmit on a control channel unless it has first monitored the channel and deemed it to be free.

After successfully locating a free traffic channel by following the traffic channel scanning cycle of Annex A, the calling unit shall switch to the primary control channel corresponding to the called group's call code and shall monitor the channel to determine whether it is free for the transmission of two group call set-up SSCs.

Each SSC shall have the format shown in subclause 6.1 and shall contain the following code values in its code words:

- the SSC number shall be set to "1" in the first SSC and to "0" in the second;
- the traffic channel code shall be set to indicate the number of the free traffic channel previously identified in the traffic channel scanning cycle;
- the first call code shall correspond to that of the called group;
- the command code shall be set to indicate the relevant operation procedures; group call bit = "1", two-frequency bit = "0", control channel select bit = "0";
- the reserved bits shall be set to their default value;
- the manufacturer's code of the calling unit shall be set as appropriate;
- the second call code shall correspond to the calling unit's own individual call code.

For a group call, two SSCs shall be transmitted on the primary control channel corresponding to the called group's call code. The SSCs shall be transmitted with a pause of T_SWITCH between the last bit of the first SSC and the first bit of the second. During this pause the unit shall transmit preamble. The calling unit shall then switch to the secondary control channel and repeat the monitoring process there. The two SSCs shall be transmitted on the secondary control channel with the pause as above. If the monitoring process fails to identify the primary control channel as free within a monitoring period of T_MON_EXT, the calling unit shall abandon the primary control channel signalling and switch to the secondary control channel to continue there.

If the monitoring process is unsuccessful on both control channels when accessing, the calling unit shall return to standby mode. The number unobtainable indication may be activated.

After monitoring and attempting the group call set-up signalling on both control channels, and succeeding on at least one, the calling unit shall switch to the previously located traffic channel and shall follow the traffic channel procedures specified in subclause 5.2.5.1. The channel switch shall be made so that the unit is able to observe the RF level on the traffic channel within time T_SWITCH of the end of the last SSC transmission.

5.2.4.2 Procedures for a member of the called group

On switching to the call set-up mode, the called unit shall switch to the traffic channel number indicated in the received SSC. The called unit shall then follow the traffic channel procedures specified in subclause 5.2.5.2. The channel switch shall be made so that the unit is able to observe the channel within time T_SWITCH of the end of the received SSC.

5.2.5 Traffic channel procedures - group call

If any unit in call set-up mode decodes an unwanted SSC on the traffic channel, then the unit shall not transmit on that channel and shall return to standby mode. The system busy indication may be activated at the calling unit.

5.2.5.1 Procedures for the calling unit

After switching to the previously located free traffic channel, the calling unit shall wait for a period of T_SWITCH and shall then observe the RF level on the channel over a period of T_OBS_CHK to check that it has not become occupied during the call set-up signalling procedures on the control channel. If the chosen traffic channel is deemed occupied over this observation period, the calling unit shall not transmit on the traffic channel and shall return to the standby mode. The system busy indication may be activated.

If the traffic channel is not deemed occupied in this time, then the calling unit shall enter the communication mode specified in subclause 5.4.1.

5.2.5.2 Procedures for a member of the called group

After switching to the traffic channel indicated in the call set-up SSC, the called unit shall observe the channel for a period T_OBS_CHK. If the channel is deemed occupied over this observation period, the unit shall return to standby mode.

If the channel is not deemed occupied in this time, the member of the called group shall enter the communication mode described in subclause 5.4.1.

5.3 Two frequency call set-up mode

The call set-up mode shall always be entered from standby mode. The call set-up procedures for the calling and called unit(s) and for a repeater are given in this subclause.

In two frequency operation, the calling or called unit may correspond to a master unit. Call set-up procedures for a master unit are given in subclause 5.3.3 (individual call) and subclause 5.3.6 (group call).

For the calling unit, the call set-up mode shall be entered following a call activation by the user. For a called unit or for a repeater, it shall be entered following reception of a wanted SSC on one of the control channels. Any unit may exit the call set-up mode at any time and revert to standby mode following an action by the user.

There are a number of call failure conditions described in this subclause which will also cause the units (or master unit) to revert to standby mode from call set-up mode. Under these conditions it is optional for either unit to indicate to the user that a call has failed. This indication is recommended at the calling unit.

The behaviour of a unit in the call set-up mode will depend on whether it is a calling or a called unit. For an individual call, a called unit shall only transmit in response to a wanted SSC on the control or traffic channel. For a group call, a mobile/portable unit which is a member of the called group shall not transmit while in call set-up mode.

All transmissions made in call set-up mode are signalling and shall be made using the signalling modulation scheme.

5.3.1 Control channel procedures - individual call

The control channel call set-up procedures for a unit to unit individual call (via a repeater) correspond to the calling unit establishing contact with the repeater. The repeater then transmits the call set-up SSC on the HB primary control channel of the called unit. This transmission also serves as confirmation to the calling unit that the repeater is handling the call. The repeater's signal will be acknowledged by the called unit. The repeater is then responsible for the allocation of a free traffic channel on which the call set-up will continue.

If the calling unit does not get confirmation from the repeater that the call is being handled, it implements automatic re-try procedures on alternate control channels.

If the repeater experiences a problem establishing contact with the called unit, it implements a reduced number of automatic re-try procedures on both control channels. A repeater will handle a call set-up for which either individual call code is contained in its data base. Repeated call set-up SSCs for visiting units are delayed in order to prevent them from clashing with a repeated SSC from the unit's own repeater in the event of overlap.

The call set-up indication may be activated when a unit enters the call set-up mode.

5.3.1.1 Procedures for the calling unit

This subclause applies to a mobile/portable unit. The equivalent procedures for a calling master unit are specified in subclause 5.3.3.1.

The calling unit shall not transmit on a control channel unless it has first monitored the channel and deemed it to be free.

5.3.1.1.1 First call set-up attempt

After switching to call set-up mode the calling unit shall monitor the HB primary control channel of the called unit to determine whether the associated LB channel is free. See subclause 3.1 for the criteria used to determine whether the associated LB control channel is free.

If the monitoring process fails to identify the channel as free within time T_MON_SPUR, the unit shall implement the re-try procedures specified in subclause 5.3.1.1.2.

Once the calling unit has deemed the control channel to be free, it shall switch to the associated LB control channel and shall transmit its call set-up SSC. The channel switch shall be made so that the first bit of the SSC is transmitted on the channel at time T_SWITCH after the point at which the channel was deemed to be free.

The transmitted SSC shall have the structure shown in subclause 6.1 and shall have the following code values in its code words:

- the SSC number shall be set to "1";
- the traffic channel code shall be set to zero;
- the first call code shall correspond to that of the called unit;
- the command code shall be set to indicate the relevant operation procedures; group call bit = "0", two-frequency bit = "1", control channel select bit = "0";
- the reserved bits shall be set to their default value;
- the manufacturer's code shall be set to that of the calling unit;
- the second call code shall be set to the calling unit's own individual call code.

After the transmission of the full SSC, the calling unit shall switch to receive on the HB primary control channel of the called unit. This switch shall be made within time T_SWITCH of the end of its SSC transmission. The calling unit shall then monitor the HB primary control channel waiting for the repeater's call set-up SSC, which confirms that the call set-up is in progress.

If no such confirmation is received within time T_INT_ACK of the end of the transmitted SSC, the unit shall implement the call set-up re-try procedures of subclause 5.3.1.1.2.

If the unit successfully decodes the repeater's SSC within time T_INT_ACK of the end of its own transmission, then it shall check the value of the control channel select bit in this SSC. If this bit is set to "0", the calling unit shall remain on the HB primary control channel of the called unit and monitor it. If this bit is set to "1", then it shall switch to the HB secondary control channel of the called unit and monitor it. In this case the channel switch shall be made so that the unit is able to begin monitoring the HB secondary control channel within time T_SWITCH of the end of the received repeater's SSC.

During this phase of the call set-up, the calling unit shall only accept as a wanted SSC, the following:

- a two frequency individual SSC containing its own individual address as the second call code, identifying the called unit's individual address as the first call code, and containing a valid traffic channel number.

Any other signalling received within time T_TRAF_A of the end of the repeater's SSC shall be ignored by the unit in this phase of the call set-up mode. If a wanted SSC is not received within time T_TRAF_A of the end of the repeater's SSC, the calling unit shall return to standby mode. The number unobtainable indication may be activated.

On receipt of the wanted SSC, the unit shall switch to the traffic channel indicated and follow the traffic channel call set-up procedures specified in subclause 5.3.2.1. This channel switch shall be made so that the unit is able to begin monitoring the channel within time T_SWITCH of the end of the received SSC.

5.3.1.1.2 Re-try procedures

The re-try procedures described in this subclause shall be implemented by a calling unit experiencing problems in a two-frequency call set-up. They shall be implemented in the case where the control channel cannot be identified as free for the first call set-up attempt over a period exceeding T_MON_SPUR, or in the case where no confirmation that the repeater is handling the call set-up is received within time T_INT_ACK of the end of the first call set-up attempt SSC.

There shall be a maximum of 5 re-try attempts (6 attempts in total) taking place on alternating control channels.

If the calling unit receives confirmation that the repeater is handling the call within time T_INT_ACK of one of the re-try attempts then it shall continue with the call set-up procedures as described for the first call set-up attempt in subclause 5.3.1.1.1.

If no confirmation that the repeater is handling the call is received within time T_INT_ACK of the end of a re-try attempt then the unit shall consider the re-try attempt to have failed and initiate the next (if there is one).

If the unit is unable to identify a control channel as free for a re-try attempt over a period exceeding T_MON_SPUR, the unit shall consider the re-try attempt to have failed and initiate the next (if there is one).

For the first re-try attempt (second attempt), the calling unit shall switch to and monitor the HB secondary control channel of the called unit to determine whether the associated LB channel is free. When it has deemed this channel to be free, it shall transmit the call set-up SSC on the LB secondary control channel of the called unit. This transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was deemed to be free.

After transmitting this SSC, the unit shall switch to the HB primary control channel of the called unit and follow the same procedure as for the first call set-up attempt. This channel switch shall be made so that the unit is able to begin monitoring the channel within time T_SWITCH of the end of the transmitted SSC.

For the second re-try attempt the calling unit shall generate a random number, n, in the range 0 to 5 inclusive. The unit shall return to the HB primary control channel and repeat the call set-up procedure there. For this attempt, the calling unit shall follow the same procedure as for the first call set-up attempt on the primary control channel of the called unit, except that the initial monitoring period shall be delayed by a period T_BACK_OFF which shall be equal to this random number, n, multiplied by T_SLOT.

For the third re-try the calling unit shall generate a new random number, n, also in the range 0 to 5 inclusive. The unit shall follow the same procedure as for the first re-try attempt on the secondary control channel of the called unit, except that the initial monitoring period shall be delayed by a period T_BACK_OFF which shall be equal to this random number, n, multiplied by T_SLOT.

The fourth and fifth re-try attempts (fifth and sixth attempts) shall follow the same procedures as for the second and third re-tries respectively, except that the random number, n, shall be generated in the range 0 to 10 inclusive for each of these attempts.

If no confirmation that the repeater is handling the call is received within time T_INT_ACK of the end of the sixth SSC transmission, the calling unit shall immediately return to standby mode. The number unobtainable indication may be activated.

5.3.1.2 Procedures for the called unit

This subclause applies to a mobile/portable unit. The equivalent procedures for a called master unit are specified in subclause 5.3.3.2.

After switching to the call set-up mode, the called unit shall switch to the appropriate control channel to transmit its acknowledgement. The acknowledgement shall have the structure specified in subclause 6.2.

If the control channel select bit in the received SSC was set to "0", the called unit shall transmit its acknowledgement on its own primary control channel. If this bit was set to "1", the acknowledgement shall be transmitted on the unit's own secondary control channel.

If the received SSC occurred on the same channel as that on which the acknowledgement is to be transmitted, the unit shall switch to the LB control channel and transmit its acknowledgement there. This acknowledgement shall be transmitted so that the first bit is transmitted at time T_SWITCH from the end of the received SSC.

However, if the received SSC occurred on the opposite control channel to that on which the acknowledgement is to be transmitted, the unit shall switch to the opposite HB control channel and monitor it to determine if the associated LB channel is free. This channel switch shall be made so that the unit is able to monitor the opposite channel within time T_SWITCH of the end of the received SSC. Once the control channel is identified as free, the unit shall transmit its acknowledgement. This transmission shall be made at time T_SWITCH after the point at which the channel is determined to be free.

If the unit is unable to identify the control channel as free within a total monitoring period of T_MON_SPUR, then it shall not transmit the acknowledgement and shall return to standby mode.

On completion of the acknowledgement transmission, the called unit shall switch to receive on the associated HB control channel, and shall monitor the channel for traffic channel allocation. A called unit in this phase of call set-up shall only accept as a wanted SSC the following: a two frequency individual SSC with its individual address as the first call code, identifying the correct calling unit as the second call code and containing a valid traffic channel number.

Any other signalling received within time T_TRAF_B of the end of the transmitted acknowledgement shall be ignored by the unit in this phase of the call set-up mode. If a wanted SSC is not received within time T_TRAF_B of the end of the transmitted acknowledgement, the called unit shall return to the standby mode.

On receipt of the wanted SSC, the called unit shall switch to the traffic channel indicated and follow the traffic channel call set-up procedures specified in subclause 5.3.2.2. This channel switch shall be made so that the unit is able to begin monitoring the HB traffic channel within time T_SWITCH of the end of the received SSC.

5.3.1.3 Procedures for the repeater

An individual call through a repeater shall be from a mobile/portable unit to another mobile/portable unit. While the repeater is in call set-up mode for a particular pair of units, it shall only accept as a wanted SSC an acknowledgement from the called unit. All other signalling received during the call set-up procedures shall be ignored.

5.3.1.3.1 First repeater call set-up attempt

After switching to the call set-up mode to handle a call set-up for a calling unit which is a visitor, the repeater shall follow the same procedure as for an owner, except that it shall delay the beginning of the procedure by T_DEL_VIS.

After switching to the call set-up mode to handle a call set-up for a calling unit which is a member of its data base (an owner), the repeater shall switch to the HB primary control channel of the called unit and monitor it to determine if it is free.

If the repeater is unable to identify the channel as free within a monitoring period of T_MON_SPUR then it shall abandon the signalling attempt and revert to standby mode.

Once the channel has been identified as free the repeater shall transmit its call set-up SSC on the channel. This SSC shall be transmitted so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free. This SSC shall have the format shown in subclause 6.1 and shall have the same code values in its code words as the SSC which was received from the calling unit, with the possible exception of the control channel select bit.

If the repeater will continue the call set-up procedures on the secondary control channel of the called unit (for example if there is spurious signalling present on the called unit's LB primary control channel) then it shall set the control channel select bit to "1" in the SSC transmission. Otherwise this bit shall be set to "0".

If the control channel select bit in the transmitted SSC is set to "0", then the repeater shall switch to and monitor the called unit's LB primary control channel on completion of the transmission. If the control channel select bit is set to "1", it shall switch to and monitor the called unit's HB secondary control channel. In either case this switch shall be made so that the repeater is able to begin monitoring the channel within time T_SWITCH of the end of its own transmission.

If no acknowledgement is received from the called unit within time T_RX_ACK of the end of the transmitted SSC on the called unit's primary control channel, (or within time T_MON_SPUR + T_RX_ACK of the end of the transmitted SSC, on the secondary control channel), the repeater shall implement the re-try procedures of subclause 5.3.1.3.2.

On receipt of the required acknowledgement within the appropriate time, the repeater shall follow the traffic channel allocation procedures specified in subclause 5.3.1.3.3.

5.3.1.3.2 Repeater re-try procedures

The re-try procedures described in this subclause shall be implemented by a repeater which receives no acknowledgement from the called unit within the appropriate time from the end of its first call set-up attempt. The repeater may make up to 3 re-try attempts (4 attempts in total).

If the repeater is unable to identify the control channel as free over a monitoring period exceeding T_MON_SPUR for any of the re-try attempts, then it shall consider the attempt to have failed and implement the next re-try (if there is any).

If no acknowledgement is received within the appropriate time of the end of a re-try attempt, the repeater shall consider the attempt to have failed and implement the next (if there is any).

On receipt of the required acknowledgement within the appropriate time of the end of a re-try attempt, the repeater shall follow the traffic channel allocation procedures specified in subclause 5.3.1.3.3.

The first re-try attempt shall take place on the HB primary control channel of the called unit. The repeater shall generate a random number, n, in the range 0 to 5 inclusive. The repeater shall follow the same process as for the first call set-up attempt, except that the initial monitoring process shall be delayed by a period T_BACK_OFF equal to this number, n, multiplied by T_SLOT.

The second and third re-tries (if made) shall take place on the secondary control channel of the called unit.

For the first attempt on the called unit's secondary control channel, the repeater shall switch to the HB channel and monitor it to determine whether it is free. Once the control channel has been deemed free the repeater shall transmit its re-try attempt SSC. This SSC shall have the same format as that of the first repeater call set-up attempt. The transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free.

If the control channel select bit in the transmitted SSC was set to "0", then the repeater shall switch to and monitor the called unit's LB primary control channel on completion of the transmission. If the control channel select bit was set to "1", it shall switch to and monitor the called unit's HB secondary control channel. In either case this switch shall be made so that the repeater is able to begin monitoring the channel within time T_SWITCH of the end of its own transmission.

If no acknowledgement is received from the called unit within time T_MON_SPUR + T_RX_ACK of the end of the transmitted SSC on the called unit's primary control channel, (or within time T_RX_ACK of the end of the transmitted SSC, on the secondary control channel) the repeater shall implement the next re-try.

The third (final) re-try shall follow the same procedure as the second (with the same SSC format), except that the repeater shall generate a random number, n, in the range 0 to 5 and shall delay the beginning of the channel monitoring procedure by a time T_BACK_OFF equal to this number, n, multiplied by T_SLOT.

If no acknowledgement is received within the appropriate time from the end of the final re-try SSC transmission, the repeater shall return immediately to the standby mode.

5.3.1.3.3 Traffic channel allocation procedures

If the repeater is currently holding in its memory a traffic channel number which was identified as free while in standby mode, then it shall switch to the HB traffic channel and observe it for a time T_OBS_CHK to check that it has not become occupied during the preceding control channel call set-up signalling procedures.

If the repeater does not currently hold in its memory a suitable traffic channel number, or if the stored channel is found to be occupied after the observation period, it shall implement the traffic channel scanning procedures described in Annex A in order to locate a free traffic channel.

If the channel scanning procedure is unsuccessful in locating a free traffic channel then the repeater shall return to standby mode.

Once a free traffic channel has been located, or if the channel held in the repeater's memory is found to be free during the observation period, then the repeater shall switch to the HB control channel on which the called and calling units are waiting.

The repeater shall monitor this channel to determine whether it is free.

If the repeater is unable to identify the channel as free within time T_MON_EXT then it shall return to the standby mode.

Once the control channel has been deemed free, the repeater shall transmit two SSCs on the control channel. This transmission shall be made so that the first bit of the first SSC is transmitted at time T_SWITCH after the point at which the channel was identified as free. The SSCs shall be transmitted with a pause of T_SWITCH between the last bit of the first SSC and the first bit of the second SSC. During this pause the unit shall transmit preamble. The SSCs shall have the structure shown in subclause 6.1 and shall have the following code values in their code words:

- the SSC number shall be set to "1" in the first SSC and set to "0" in the second;

- the traffic channel code shall be set to the number of the located free traffic channel;

- all other code values shall be set to the same values as in the first call set-up SSC transmitted.

After completing the two transmissions of this SSC, the repeater shall switch to the previously located free traffic channel and follow the traffic channel call set-up procedures specified in subclause 5.3.2.3. This channel switch shall be made so that the repeater is able to begin observing the traffic channel within time T_SWITCH of the end of its last SSC transmission.

5.3.2 Traffic channel procedures - individual call

If either the called or calling unit in call set-up mode decodes an unwanted SSC on the traffic channel, then it shall not transmit on that channel and shall return to standby mode. The system busy indication may be activated at the calling unit.

In the event of a call failure after the control channel call set-up procedures have been completed, there are no automatic re-try procedures on the traffic channel or on the control channel.

5.3.2.1 Procedures for the calling unit

After switching to the traffic channel indicated in the repeater's call set-up SSC, the calling unit shall monitor the HB channel for the repeater's identification SSC in order to detect when the repeater has entered its communication mode on the channel.

If the unit has not received the repeater's identification SSC within time T_REP_ID_IN from the end of the received control channel SSC, then it shall not transmit on the channel and shall return to the standby mode. The system busy indication may be activated.

If the calling unit successfully decodes the repeater's identification SSC on the channel then it shall switch to the LB traffic channel to transmit the call set-up SSC. This SSC shall have the format shown in subclause 6.1 and shall contain the same code values as the repeater's channel allocation SSC received on the control channel. The SSC transmission shall be made so that the first bit is transmitted within time T_SWITCH of the end of the repeater's identification SSC.

After transmission of the call set-up SSC, the calling unit shall switch to and monitor the HB traffic channel for an acknowledgement from the called unit. This switch shall be done so that the unit is capable of monitoring the HB channel within time T_SWITCH of the end of its transmitted SSC.

On receipt of the acknowledgement, the calling unit shall switch to communication mode specified in subclause 5.4.1.

If no acknowledgement has been received within time T_RX_ACK + 2 (T_SSC_DELAY) of the end of the transmitted SSC, the calling unit shall return to the standby mode. The system busy indication may be activated.

5.3.2.2 Procedures for the called unit

After switching to the traffic channel indicated in the repeater's call set-up SSC, the called unit shall monitor the HB channel for the repeater's identification SSC, in order to detect when the repeater has entered communication mode on the channel.

If the unit has not received the repeater's identification SSC within time T_REP_ID_IN from the end of the received control channel SSC, then it shall not transmit on the channel and shall return to standby mode.

On receipt of the repeater's identification SSC, the called unit shall continue to monitor the channel and wait for call set-up signalling from the calling unit.

If no wanted SSC is received on the traffic channel within time T_SLOT + T_SSC_DELAY from the end of the repeater's identification SSC, the called unit shall return to the standby mode.

On receipt of a wanted SSC on the traffic channel, the called unit shall respond to the received SSC by transmitting an acknowledgement. This transmission shall be made so that the first bit is transmitted at time T_SWITCH after the end of the received SSC. The acknowledgement shall have the format shown in subclause 6.2.

On completion of this transmission, the called unit shall enter the communication mode specified in subclause 5.4.1.

5.3.2.3 Procedures for the repeater

The procedures specified in this subclause apply to both individual and group calls.

After switching to the previously located free traffic channel, the repeater shall observe the HB channel for a period of T_OBS_CHK to check that it is still free. If the chosen traffic channel is deemed occupied after this observation period, the repeater shall not transmit on the traffic channel and shall return to standby mode.

If the traffic channel is not deemed occupied in this time, the repeater shall transmit its own identification SSC on the traffic channel. This SSC shall have the format shown in subclause 6.3 and the transmission shall begin within time T_SWITCH of the end of the observation period.

On completion of this transmission the repeater shall immediately enter the communication mode specified in subclause 5.4.2.

5.3.3 Master unit procedures - individual call

The call set-up procedures for a master unit (called or calling) are designed so that the mobile/portable units involved follow the same procedures for all two frequency individual call set-ups.

5.3.3.1 Procedures for a calling master unit

5.3.3.1.1 Control channel procedures - individual call

A calling master unit shall not transmit on a control channel unless it has first monitored the channel and deemed it to be free.

5.3.3.1.1.1 First call set-up attempt

After switching to call set-up mode, the calling master unit shall monitor the HB primary control channel of the called unit to determine whether it is free.

If the monitoring process fails to identify the channel as free within time T_MON_SPUR, the master unit shall abandon this attempt and initiate the re-try procedures of subclause 5.3.3.1.1.2.

Once the calling master unit has deemed the HB primary control channel of the called unit to be free, it shall transmit its call set-up SSC on that channel. This transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free.

If the master unit wishes to continue with the call set-up procedure on the secondary control channel of the called unit (for example if there is spurious signalling present on the called unit's LB primary control channel), then it shall set the control channel select bit to "1" in the SSC transmission. Otherwise this bit shall be set to "0".

The transmitted SSC shall have the structure shown in subclause 6.1 and shall have the following code values in its code words:

- the SSC number shall be set to "1";

- the traffic channel code shall be set to zero;

- the first call code shall correspond to that of the called unit;

- the command code shall be set to indicate the relevant operation procedures; group call bit = "0", two-frequency bit = "1", control channel select bit shall be set as appropriate;

- the reserved bits shall be set to their default value;

- the manufacturer's code shall be set to that of the calling master unit;

- the second call code shall be set to the calling master unit's own individual call code.

After the transmission of the full SSC, the calling master unit shall switch to the appropriate LB primary control channel to wait for the called unit's acknowledgement. If the control channel select bit was set to "0", it shall switch to the called unit's LB primary control channel. If the control channel select bit was set to "1", it shall switch to the called unit's LB secondary control channel. In either case this switch shall be made so that the master unit is able to begin monitoring the channel within time T_SWITCH of the end of its own SSC transmission.

If no acknowledgement is received within time T_RX_ACK of the end of the master unit's own transmission on the primary control channel, (or within T_MON_SPUR + T_RX_ACK on the secondary control channel), the master unit shall implement the re-try procedures of subclause 5.3.3.1.1.2.

On receipt of an acknowledgement within the appropriate time of its own SSC transmission, the master unit shall follow the traffic channel allocation procedures of subclause 5.3.3.1.1.3. This channel switch shall be made so that the master unit is able to begin observing the traffic channel within time T_SWITCH of the end of its SSC transmission.

5.3.3.1.1.2 Re-try procedures

The master unit shall follow the same re-try procedures as specified for a repeater in subclause 5.3.1.3.2.

On receipt of the required acknowledgement within the appropriate time of the end of a re-try attempt, the master unit shall follow the traffic channel allocation procedures specified in subclause 5.3.3.1.1.3.

5.3.3.1.1.3 Traffic channel allocation procedures

The master unit shall follow the same traffic channel allocation procedures as specified for a repeater in subclause 5.3.1.3.3.

On completion of transmission of the two SSCs the master unit shall switch to the previously located free traffic channel and follow the traffic channel call set-up procedures specified in subclause 5.3.3.1.2.

5.3.3.1.2 Traffic channel procedures - individual call

After switching to the previously located free traffic channel, the master unit shall observe the channel for a period T_OBS_CHK to check that it is still free. If the chosen traffic channel is deemed to be occupied after this observation period, the master unit shall not transmit on the traffic channel and shall return to the standby mode. The system busy indication may be activated.

If the traffic channel is not deemed occupied in this time, the master unit shall transmit its identification SSC on the HB traffic channel. This SSC shall have the format shown in subclause 6.3 and the transmission shall begin within time T_SWITCH of the end of the observation period.

Directly after this transmission, the master unit shall transmit its traffic channel allocation SSC once on the HB traffic channel. This SSC shall have exactly the same format as the last transmission on the control channel.

After transmission of the call set-up SSC on the HB traffic channel, the calling master unit shall switch to and monitor the LB traffic channel for an acknowledgement from the called unit. This switch shall be made so that the master unit is able to monitor the channel within time T_SWITCH of the end of its transmitted SSC. The master unit shall also begin to transmit its null signal on the HB traffic channel.

If no acknowledgement has been received within time T_RX_ACK of the end of the transmitted call set-up SSC, the calling master unit shall return to the standby mode. The system busy indication may be activated.

On receipt of an acknowledgement within time T_RX_ACK of the end of its transmitted SSC, the calling master unit shall switch to the communication mode specified in subclause 5.4.3.

5.3.3.2 Procedures for a called master unit

5.3.3.2.1 Control channel procedures - individual call

5.3.3.2.1.1 Confirmation to calling unit

After switching to the call set-up mode, the called master unit shall switch to its own HB primary control channel and shall monitor the channel to determine if it is free.

If the master unit is unable to identify the control channel as free within a total monitoring period of T_MON_SPUR, then it shall abandon the call set-up and return to the standby mode.

Once the control channel is deemed to be free the master unit shall transmit its call set-up SSC. This SSC shall have the same format and code values as the one received from the calling unit, with the possible exception of the control channel select bit. The SSC transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free.

If the master unit wishes to continue with the call set-up procedure on its secondary control channel (for example if there is spurious signalling present on the its LB primary control channel) then it shall set the control channel select bit to "1" in the SSC transmission. Otherwise this bit shall be set to "0".

On completion of this transmission, the master unit shall proceed with the traffic channel allocation procedures of subclause 5.3.3.2.2.

5.3.3.2.1.2 Traffic channel allocation procedures

The master unit shall follow the same traffic channel allocation procedures as specified for a repeater in subclause 5.3.1.3.3.

On completion of transmission of the two SSCs, the master unit shall switch to the previously located free traffic channel and follow the traffic channel call set-up procedures specified in subclause 5.3.3.2.2. This channel switch shall be made so that the master unit is able to begin observing the traffic channel within time T_SWITCH of the end of the SSC transmissions.

5.3.3.2.2 Traffic channel procedures - individual call

After switching to the previously located free traffic channel, the master unit shall observe the channel for a period T_OBS_CHK to check that it is still free. If the chosen traffic channel is deemed to be occupied after this observation period, the master unit shall not transmit on the traffic channel and shall return to the standby mode.

If the traffic channel is not deemed occupied in this time, the master unit shall transmit its identification SSC on the traffic channel. This SSC shall have the format shown in subclause 6.3 and the transmission shall begin within time T_SWITCH of the end of the observation period.

After this transmission, the master unit shall switch to receive on the LB traffic channel and monitor the channel while waiting for call set-up signalling from the calling unit. This switch shall be made within time

T_SWITCH of the end of its transmission. As well as monitoring the LB channel, the master unit shall begin to transmit its null signal on the HB traffic channel.

If no wanted SSC is received on the traffic channel within time T_SLOT from the end of the master unit's identification SSC, the master unit shall return to the standby mode.

On receipt of a wanted SSC from the calling unit on the traffic channel, the master unit shall respond by transmitting an acknowledgement. This transmission shall be made so that the first bit is transmitted at time T_SWITCH from the end of the received SSC, and shall over-ride the null signal transmission. The acknowledgement shall have the format shown in subclause 6.2.

On completion of this transmission, the called master unit shall enter the communication mode specified in subclause 5.4.3.

5.3.4 Control channel procedures - group call

A repeater will handle a group call set-up for which the calling unit's call code is contained in its data base. The control channel call set-up procedures for a group call from a unit (via a repeater) correspond to the calling unit establishing contact with the repeater. The repeater then transmits a call set-up SSC on the HB primary control channel corresponding to the called group's call code.

This transmission serves as confirmation that the repeater is handling the call. The repeater's signal will not be acknowledged by the called group.

The repeater is then responsible for the allocation of a free traffic channel on which the call set-up will continue.

If the calling unit does not get confirmation from the repeater that the call is being handled, it implements automatic re-try procedures on alternate control channels. There are no repeater re-try procedures for a group call.

The call set-up indication may be activated when a unit enters the call set-up mode.

5.3.4.1 Procedures for the calling unit

This subclause applies to mobile/portable units only. The corresponding procedures for a calling master unit are specified in subclause 5.3.6.1.

The calling unit in a two frequency group call set-up shall follow the same control channel procedures as those specified for the calling unit in an individual two frequency call set-up (including re-try procedures) in subclause 5.3.1.1, with the following substitutions.

It will use the primary and secondary control channels corresponding to the called group's call code instead of those of the "called unit" in all cases.

The calling unit's transmitted SSC shall have the following code values in its code words:

- the SSC number shall be set to "1";
- the traffic channel code shall be set to zero;
- the first call code shall correspond to that of the called group;
- the command code shall be set to indicate the relevant operation procedures; group call bit = "1", two-frequency bit = "1", control channel select bit = "0";
- the reserved bits shall be set to their default value;
- the manufacturer's code shall be set to that of the calling unit;

- the second call code shall be set to the calling unit's own individual call code.

During the phase of the call set-up where the unit is awaiting channel allocation from the repeater, the calling unit shall only accept as a wanted SSC a two frequency group SSC containing its own individual address as the second call code, identifying the called group address as the first call code, and containing a valid traffic channel number.

On receipt of the repeater's channel allocation SSC, the unit shall switch to the traffic channel indicated and follow the traffic channel call set-up procedures specified in subclause 5.3.5.1. This channel switch shall be made so that the unit is able to begin monitoring the channel within time T_SWITCH of the end of the received SSC.

5.3.4.2 Procedures for a member of the called group

This subclause applies to mobile/portable units only.

On switching to the call set-up mode the called unit shall switch to the traffic channel number indicated in the received SSC. The unit shall then follow the traffic channel procedures specified in subclause 5.3.5.2. The channel switch shall be made so that the unit is able to begin monitoring the channel within time T_SWITCH of the end of the received SSC.

5.3.4.3 Procedures for the repeater

All signalling received at the repeater while it is in call set-up mode for a group call shall be ignored.

After switching to call set-up mode for a group call, the repeater shall switch to the HB primary control channel corresponding to the called group's call code and monitor it to determine if it is free.

If the monitoring process is unable to identify the channel as free within a monitoring period of T_MON_SPUR, then it shall abandon the signalling attempt and return to the standby mode.

Once the channel has been identified as free the repeater shall transmit its call set-up SSC on the channel. This SSC shall be transmitted so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free. This SSC shall have the format shown in subclause 6.1, and shall have the same code values in its code words as the SSC which was received from the calling unit.

After completing this transmission, the repeater shall follow the traffic channel allocation procedures of subclause 5.3.4.3.1.

5.3.4.3.1 Traffic channel allocation procedures

If the repeater is currently holding in its memory a traffic channel number which was identified as free while in standby mode, then it shall switch to the HB traffic channel and observe it for a time T_OBS_CHK to check that it has not become occupied during the preceding control channel call set-up signalling procedures.

If the repeater does not currently hold in its memory a suitable traffic channel number, or if the stored channel is found to be occupied after the observation period, it shall implement the traffic channel scanning procedures described in Annex A in order to locate a free traffic channel.

If the channel scanning procedure is unsuccessful in locating a free traffic channel then the repeater shall return to standby mode.

Once a free traffic channel has been located, or if the channel held in the repeater's memory is found to be free during the observation period, then the repeater shall switch to the HB primary control channel corresponding to the called group's call code.

The repeater shall monitor this channel to determine whether it is free.

If the repeater is unable to identify the channel as free within time T_MON_EXT then it shall switch to the opposite HB channel and continue there.

Once the control channel has been deemed free, the repeater shall transmit two SSCs on the control channel. This transmission shall be made so that the first bit of the first SSC is transmitted at time T_SWITCH after the point at which the channel was identified as free. The SSCs shall be transmitted with a pause of T_SWITCH between the last bit of the first SSC and the first bit of the second SSC. During this pause the unit shall transmit preamble. The SSCs shall have the structure shown in subclause 6.1, and shall have the following code values in their code words:

- the SSC number shall be set to "1" in the first SSC and set to "0" in the second;

- the traffic channel code shall be set to the number of the located free traffic channel;

- all other code values shall be set to the same values as in the first call set-up SSC transmitted.

After completing the transmission of these two SSCs, the repeater shall switch to the opposite HB control channel and repeat the monitoring process there to determine whether the channel is free.

Once the control channel has been deemed free, the repeater shall transmit the two SSCs, in exactly the same format as for the previous control channel, and with the same timing constraints, on this control channel.

After completing the monitoring process on both control channels, and transmitting on at least one, the repeater shall switch to the previously located free traffic channel and follow the traffic channel call set-up procedures specified in subclause 5.3.5.3. This channel switch shall be made so that the repeater is able to begin observing the traffic channel within time T_SWITCH of the end of the last transmitted SSC.

If the monitoring process is unsuccessful on both control channels when trying to access, the repeater shall return to the standby mode.

5.3.5 Traffic channel procedures - group call

If any of the units decodes an unwanted SSC on the traffic channel while in call set-up mode, then it shall not transmit on that channel and shall return to standby mode. The system busy indication may be activated at the calling unit.

5.3.5.1 Procedures for the calling unit

After switching to the traffic channel indicated in the repeater's call set-up SSC, the calling unit shall monitor the HB channel for the repeater's identification SSC in order to detect when the repeater has entered its communication mode on the channel.

If the unit has not received the repeater's identification SSC within time T_REP_ID_GR of the end of the received control channel SSC, then it shall not transmit on the channel and shall return to the standby mode. The system busy indication may be activated.

On receipt of the repeater's identification SSC on the channel, the calling unit shall enter the communication mode specified in subclause 5.4.1.

5.3.5.2 Procedures for a member of the called group

After switching to the traffic channel indicated in the repeater's call set-up SSC, the unit shall monitor the channel in order to detect when the repeater has entered its communication mode on the channel.

If the unit has not received the repeater's identification SSC within time T_REP_ID_GR of the end of the received control channel SSC, then it shall not transmit on the channel and shall return to standby mode.

On receipt of the repeater's identification SSC, the unit shall enter the communication mode specified in subclause 5.4.1.

5.3.5.3 Procedures for the repeater

After switching to the previously located free traffic channel for a two-frequency group call, the repeater shall follow the same procedures as specified for a two-frequency individual call in subclause 5.3.2.3.

5.3.6 Master unit procedures - group call

The call set-up procedures for a master unit are designed so that the mobile/portable units involved follow the same procedures for all two frequency group call set-ups.

5.3.6.1 Procedures for a calling master unit

5.3.6.1.1 Control channel procedures

There are no acknowledgements and no master unit re-try procedures for a group call.

For a group call two SSCs shall be transmitted on the primary control channel corresponding to the called group's call code. The master unit shall then switch to the opposite control channel and repeat the monitoring procedure there. Two SSCs shall then be transmitted on the secondary control channel. The SSCs shall be transmitted with a pause of T_SWITCH between the last bit of the first SSC and the first bit of the second SSC. During this pause the unit shall transmit preamble.

5.3.6.1.1.1 Traffic channel allocation procedures

If the master unit is currently holding in its memory a traffic channel number which was identified as free while in standby mode, then it shall switch to the HB traffic channel and observe it for a time T_OBS_CHK to check that it has not become occupied during the preceding control channel call set-up signalling procedures.

If the master unit does not currently hold in its memory a suitable traffic channel number, or if the channel is deemed occupied in this observation period, then it shall implement the traffic channel scanning procedures described in Annex A in order to locate a free traffic channel.

If the channel scanning procedure is unsuccessful in locating a free traffic channel, then the master unit shall return to standby mode. The system busy indication may be activated.

Once a free traffic channel has been located, or if the channel held in the master unit's memory is found to be free during the observation period, the master unit shall switch to the HB primary control channel corresponding to the called group's call code, and monitor this channel to determine whether it is free.

If the monitoring process fails to identify the primary control channel as free within a total monitoring period of T_MON_EXT, the calling master unit shall abandon the primary control channel signalling, and switch to the secondary control channel to continue there.

Once the control channel has been deemed free, the master unit shall transmit two SSCs on the control channel. The SSCs shall be transmitted with a pause of T_SWITCH between the last bit of the first SSC and the first bit of the second SSC. During this pause, the master unit shall transmit preamble. The transmission shall be made so that the first bit is transmitted at time T_SWITCH after the point at which the channel was identified as free. The SSCs shall have the structure shown in subclause 6.1 and shall have the following code values in their code words:

- the SSC number shall be set to "1" in the first SSC, and to "0" in the second;
- the traffic channel code shall be set to the number of the previously located free traffic channel;
- the first call code shall correspond to that of the called group;
- the command code shall be set to indicate the relevant operation procedures; group call bit = "1", two-frequency bit = "1", control channel select bit = "0";

- the reserved bits shall be set to their default value;

- the manufacturer's code shall be set to that of the calling master;

- the second call code shall be set to the calling master unit's own individual call code.

After completing the transmission of these two SSCs on the HB primary control channel corresponding to the group call code, the master unit shall switch to the opposite HB control channel and repeat the monitoring process there to determine whether the channel is free.

If the monitoring process is unsuccessful on both control channels, the calling master unit shall return to standby mode. The number unobtainable indication may be activated.

After monitoring both control channels, and successfully transmitting the group call set-up SSCs on at least one, the calling master unit shall switch to the previously located traffic channel and shall follow the traffic channel procedures specified in subclause 5.3.6.1.2. The channel switch shall be made so that the master unit is able to observe the RF level on the traffic channel within time T_SWITCH of the end of the last SSC transmission.

5.3.6.1.2 Traffic channel procedures

After switching to the previously located free traffic channel, the master unit shall observe the channel for a period of T_OBS_CHK to check that it is still free. If the chosen traffic channel is deemed occupied after this observation period, the master unit shall not transmit on the traffic channel and shall return to the standby mode. The system busy indication may be activated.

If the traffic channel is not deemed occupied in this time, the master unit shall transmit its own identification SSC on the HB traffic channel. This SSC shall have the format shown in subclause 6.3 and transmission shall begin within time T_SWITCH of the end of the observation period.

On completion of this transmission the master unit shall immediately enter the communication mode specified in subclause 5.4.3.

5.4 Communication mode

In communication mode voice or data communication between two or more units, or between a master unit and a unit (or group of units), takes place on the traffic channel. Unit to unit communication may take place in single frequency operation or via a repeater in two frequency operation.

All voice/data transmissions in communication mode shall be preceded by a full SSC. These SSCs are used to enhance privacy on the system and for monitoring purposes.

All SSCs transmitted in communication mode correspond to signalling and shall be made using the signalling modulation scheme. Voice/data transmission shall be made using the voice/data modulation scheme.

The call ready indication may be activated when a unit or master unit enters communication mode.

5.4.1 Units' communication mode

All units in communication mode have equal status in that there is no longer any concept of calling or called unit.

For single frequency operation a unit enters the communication mode from the call set-up mode as described in subclause 5.2.3 for individual calls and in subclause 5.2.5 for group calls.

For two frequency operation a unit enters the communication mode from the call set-up mode as described in subclause 5.3.2 for individual calls and in subclause 5.3.5 for group calls.

The units may remain in communication mode for a period up to the maximum communication duration (T_COMM), as long as they are exchanging valid voice/data communication subject to the procedures specified in this subclause.

A unit in communication mode shall not transmit unless it has received a transmission activation from its user. Also, the unit shall ignore a transmission activation for as long as it is receiving valid voice/data.

5.4.1.1 Voice/data sensing time-out

When a unit has just entered communication mode, and no voice/data transfer has taken place, the unit may wait for a period of T_COM_WAIT for voice/data transfer to begin. If after this time no valid voice/data transfer has taken place, then the unit shall leave the communication mode and return to standby mode.

Apart from the circumstances described above, the unit shall leave the communication mode and return to standby mode if no valid voice/data transfer has taken place over a monitoring period of T_COM_HOLD.

On return to standby mode, the call termination indication may be activated.

> NOTE: T_COM_HOLD limits the time allowed for a change in the communication direction. A longer period is allowed for the establishment of the first voice/data transfer, in order to allow for the user being unaware that the call has begun.

5.4.1.2 Channel (re)occupation detection and contention control

When a unit is not transmitting it shall monitor the HB traffic channel for voice/data. When not receiving valid voice/data, the unit shall operate a signalling detection facility for the identification of any 4 kbit/s signalling on the channel.

If the unit detects some signalling on the traffic channel, it shall immediately try to demodulate it. If an unwanted SSC is received within a period of T_MON_TC from the point at which the signalling detection occurred, the unit shall revert to standby mode. Otherwise it shall return to monitoring the traffic channel for voice/data. If it returns to standby mode, the call termination indication may be activated.

5.4.1.3 Communication time-out

To limit congestion on the system, the period of time that a unit remains in communication mode shall not exceed T_COMM. If the communication period reaches this value, the unit shall return to standby mode, switching off its transmitter if necessary.

The call termination indication may be activated at this point. Also, if voice communication is used, a communication termination indication may be activated 10 seconds before the call is terminated.

5.4.1.4 Call termination (optional)

This subclause is only valid for individual two frequency calls and is a manufacturers option.

Units may be equipped with a call terminate function (on-hook device). When this function is activated, the unit shall transmit 1,0 s of preamble (alternating one and zeros using the signalling modulation scheme). On completion of this transmission the unit shall revert immediately to standby mode.

The call terminate function shall be disabled for group calls so that no call termination sequence is transmitted to a group.

On detection of the call termination sequence, the unit shall revert to standby mode. The call termination indication may be activated.

5.4.2 Repeater's communication mode (two frequency operation only)

The repeater enters the communication mode from call set-up mode as described in subclause 5.3.2.3 for both individual and group calls.

In communication mode, the repeater shall by default retransmit on the HB traffic channel voice/data using the voice/data modulation scheme. However, if the repeater detects signalling on the LB traffic channel, the procedures of subclause 5.4.2.2 apply.

The repeater retransmission delay for voice/data shall not be greater than T_V/D_DELAY.

The repeater remains in communication mode for as long as necessary, subject to the procedures specified in this subclause.

5.4.2.1 Voice/data sensing time-out

The repeater shall follow the same procedures as specified for a unit in subclause 5.4.1.1.

5.4.2.2 Channel (re)occupation detection and contention control

The repeater shall operate a signalling detection facility for the identification of any 4 kbit/s signalling preceding voice/data transmissions on the LB traffic channel.

If the repeater detects signalling on the LB traffic channel, it shall immediately try to demodulate it.

If an SSC is successfully decoded within a period of T_MON_TC from the point at which the signalling detection occurred, the repeater shall retransmit the complete SSC (including 64 ms of preamble) on the HB traffic channel using the signalling modulation scheme. The repeater delay for retransmission of a successfully decoded SSC shall be no greater than T_SSC_DELAY.

If an unwanted SSC is decoded, the repeater shall cease transmission after the SSC has been repeated and shall revert to standby mode.

Otherwise it shall return to retransmitting voice/data received on the LB traffic channel to the HB traffic channel and to operating the signalling detection facility for signalling preceding the voice/data received on the LB channel.

5.4.2.3 Call termination (optional)

This subclause is a manufacturer's option. On detection of the call termination sequence, the repeater may retransmit this sequence on the HB traffic channel and revert to standby mode.

5.4.3 Master unit's communication mode (two frequency operation only)

The master unit enters the communication mode from call set-up mode as described in subclause 5.3.3.1.2 or subclause 5.3.6.1.2 (when calling) and subclause 5.3.3.2.2 (when called).

When a master unit is not transmitting its own user's information, it shall by default transmit on the HB traffic channel a null signal. This null signal may be a carrier wave signal or a pseudo-random sequence modulated carrier. It shall not be preamble. However, if the master unit detects signalling on the LB traffic channel, the procedures of subclause 5.4.3.2 apply.

A transmission activation from the master unit's user shall over-ride this null signal.

The master unit remains in communication mode for as long as necessary for the communication, subject to the procedures specified in this subclause.

5.4.3.1 Voice/data sensing time-out

The master unit shall follow the same procedures as specified for a unit in subclause 5.4.1.1.

5.4.3.2 Channel (re)occupation detection and contention control

While it is transmitting the null signal on the HB traffic channel, the master unit shall operate a simultaneous signalling detection facility to identify any 4 kbit/s signalling on the LB traffic channel.

If the master unit detects some signalling on the LB traffic channel, it shall immediately try to demodulate it.

If an SSC is successfully decoded within a period of T_MON_TC from the point at which the signalling detection occurred, the master unit shall retransmit the complete SSC (including 64 ms of preamble) on the HB traffic channel using the signalling modulation scheme. The retransmission delay for a successfully decoded SSC at the master unit shall be no greater than T_SSC_DELAY.

If an unwanted SSC is decoded, the master unit shall cease transmission after the SSC has been repeated and shall revert to standby mode. The call termination indication may be activated.

Otherwise it shall return to transmitting the null signal on the HB traffic channel while operating the signalling detection facility.

5.4.3.3 Communication timeout

The master unit shall follow the same procedures as specified for a unit in subclause 5.4.1.3.

5.4.3.4 Call termination (optional)

The master unit may follow the same procedures as specified for a unit in subclause 5.4.1.4.

6 Frame layout

This Clause specifies the frame layout for both signalling and voice/data.

Subclauses 6.1 to 6.3 specify the structure of the SSC used for call set-up signalling, acknowledgements and monitoring purposes.

Every unit, repeater or master unit in a DSRR system shall have a unique identity code, for the purposes of unique identification of the equipment. This identity code shall consist of a manufacturer's code and a call code.

6.1 The Selective Signalling Code (SSC)

A SSC consists of a single bit synchronisation sequence followed by a frame synchronisation with associated data code word which are repeated three times.

Bit Sync. (Preamble)	256 bits	
Frame Sync.	16 bits }	x3
Code word	}	
SSC number	1 bit }	
Traffic Channel Code	7 bits }	
First Call Code (unit to which the SSC is sent)	24 bits }	
Command Code	4 bits }	
Reserved	2 bits }	
Code word counter	2 bits }	
Manufacturer's code	8 bits }	
Second Call Code (the transmitting unit)	24 bits }	
Cyclic Redundancy Check	16 bits }	
	568 bits	

The SSC can then be represented thus:

Preamble	F.Sync	Codeword	F.Sync	Codeword	F.Sync	Codeword

All numbers are encoded in binary. The most significant bit is transmitted first.

6.1.1 Preamble (256 bits)

The SSC transmission begins with a 256 bit preamble of bit reversals "101010.....10" so that the receiver data demodulator can acquire bit synchronisation.

6.1.2 Frame synchronisation word (16 bits)

The frame begins with a 16 bit synchronisation word, to enable the receiver decoder to establish code word framing, as illustrated below:

Bit Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bit Value	1	1	0	0	0	1	0	0	1	1	0	1	0	1	1	1
	(Bit number 1 is transmitted first)															

6.1.3 Code word layout (88 bits)

SSC number	Traffic Channel Code	First Call Code	Command word	Reserved	Code-word count	Manufacturer	Second call code	CRC
1	7	24	4	2	2	8	24	16

The SSC number is transmitted first. All numbers are encoded in binary. The most significant bit is transmitted first.

6.1.3.1 SSC number

This bit identifies the number (modulo 2) of the SSC in a sequence. It shall be set to "0" to indicate that the SSC is the second SSC of a sequence. This is used for acknowledgement and for control channel monitoring purposes.

6.1.3.2 Traffic channel code

For all SSCs in single frequency operation, and for SSCs in two frequency after (and including) traffic channel allocation, this code shall correspond to the decimal number of the selected free traffic channel translated into a binary number of 7 bits. For two frequency call set-up SSCs transmitted before traffic channel allocation has taken place, this code shall be set to "0000000".

6.1.3.3 First call code

The first call code shall be set to the call code of the unit to which the SSC is sent. This shall be the binary equivalent of a decimal number in the range 0000000 to 9999999.

6.1.3.4 Command word layout

The command word consists of 4 bits, used to indicate the particular operation procedures which apply.

Reserved = 0	Control channel select	Two freq. working	Group call

The reserved bit is transmitted first.

The reserved bit shall be set to its default value of "0".

The control channel select bit shall be set to "0" in all cases of SSC transmission with the following 2 exceptions:

1) a repeater or master unit in two frequency call set-up mode transmitting an SSC which requires the addressed unit to switch to the secondary control channel of the called unit in order to transmit its acknowledgement and receive further call set-up signalling;

2) the unit transmitting its acknowledgement to 1) above.

The two frequency working bit shall be set to "0" for SSCs transmitted in single frequency operation. It shall be set to "1" for SSCs transmitted in two frequency operation.

The group call bit shall be set to "0" for SSCs transmitted in an individual call set-up or communication. It shall be set to "1" for SSCs transmitted in a group call set-up or communication.

6.1.3.5 Reserved bits

The reserved bits shall be set to their default value of "00".

6.1.3.6 Code word counter

The code word counter shall be set in each code word to indicate the number of times that the frame synchronisation and code word will be repeated after the current code word in the SSC (this information is used by the recipient to identify the end of the SSC transmission).

In the first code word of the SSC, the code word counter bits shall be set to "10".

In the second code word the code word counter bits shall be set to "01"

In the third code word the code word counter bits shall be set to "00".

6.1.3.7 Manufacturer's code

The 8 bit manufacturer's code shall be set to the manufacturer's code of the unit which generates the SSC. This shall be the binary equivalent of a decimal number in the range 000 to 255.

6.1.3.8 Second call code

The second call code shall be set to the binary representation of the call code of the unit which generates the SSC. This shall be the binary equivalent of a decimal number in the range 0000000 to 9999999.

6.1.3.9 Cyclic Redundancy Check, CRC

The cyclic redundancy check of 16 bits for encoding and error checking has to be calculated 3 times, one time for each repeated code word. The procedure is split into two steps.

First, sixteen check bits are appended to the 72 information bits by encoding them in an (88,72) cyclic code. For encoding the information, bits 1 to 72 may be considered to be the coefficients of polynomial having terms from X^{71} down to X^{16}. This polynomial is divided modulo 2 by the generating polynomial $X^{16} + X^{14} + X^{12} + X^{11} + X^{9} + X^{8} + X^{7} + X^{4} + X + 1$. The sixteen check bits, code word bits 73 - 88, correspond to the coefficients of the terms from X^{15} to X^{0} in the remainder polynomial on completion of the division. The (88,72) cyclic code has a minimum distance of 6 and so guarantees detection of up to 5 bit errors in one code word.

Second, the final check bit of the (88,72) cyclic code (code word bit 88) is inverted to protect against misframing in the decoder.

At the receiver each code word may be checked for errors by re-calculating the check bits for the received information bits. Any difference between the received check bits and the recalculated check bits indicates that the received code word contains errors.

It is left to the manufacturer to choose whether identification of errors causes the SSC to be rejected, or whether to take advantage of the SSC's potential error correction capability.

Even if an SSC is successfully decoded, it shall be rejected, if any of the following are found to be true:

- the traffic channel number is not in the range 1 to 78 (excluding 26 and 52) or equal to zero as used in two frequency operation;
- the reserved bits do not have their default value.

Since the end of an SSC is used for protocol timing, the SSC decoder shall also determine the end of an accepted SSC. Implementation of this facility is simplified by the code word counter included in the SSC.

6.2 Acknowledgement, ACK

An acknowledgement shall only be generated in response to a received SSC. Acknowledgements shall only be transmitted while operating in call set-up mode. An acknowledgement corresponds to an SSC with the following values for the codes in its code words:

- the SSC number shall be set to "0";
- the traffic channel code shall be set to the same value as that in the received SSC to which the acknowledgement is responding;
- the first call code shall be set to that of the unit to which the acknowledgement is sent. (This will correspond to the second call code in the received SSC to which the acknowledgement is responding);
- the 4 bits of the command word shall have the same values as in the received SSC;
- the reserved bits shall be set to their default value as in the received SSC;
- the codeword counter bits shall be set as in the received SSC;
- the manufacturers code shall be set to correspond to that of the unit which is generating the acknowledgement;
- the second call code shall be set to correspond to that of the unit which is generating the acknowledgement. (This will correspond to the first call code in the received SSC).

6.3 Repeater/master unit identification SSC

There is a particular type of SSC used for repeater/master unit identification. This identification SSC is used for monitoring purposes in identifying the transmitting repeater/master unit; it is also used by the units involved in the call to determine that the repeater/master unit is handling the communication.

The repeater/master unit identification SSC is an SSC with a fixed code word. The layout of the code word shall be as shown in subclause 6.1.3, and the specific code values shall be as specified in subclause 6.3.1.

A repeater's call code shall be allocated by the manufacturer and it is advised that it is allocated the binary equivalent of a decimal number in the range 10 000 000 to 2^{24} - 1. A master unit may use its normal call code in its identification SSC, or may be allocated a special code, also in the range 10 000 000 to 2^{24} - 1.

6.3.1 Code values

The codes in the repeater/master unit identification SSC shall have the following values in their words:

- the SSC number shall always be set to "1";

- the traffic channel number shall be set to the binary equivalent of the actual traffic channel (where the identification code is transmitted);

- the first call code shall be set to the repeater/master unit's own call code;

- the 4 bits of the command code shall be set as appropriate for the call which the repeater/master unit is setting up when it transmits its identification SSC;

- the reserved bits shall be set to their default value;

- the code word counter bits shall be set as specified for an SSC in subclause 6.1.3.6;

- the manufacturer's code shall be set to the repeater/master unit's manufacturers code;

- the second call code shall be set to the repeater/master unit's own call code;

- the CRC shall be calculated as specified for an SSC in subclause 6.1.3.9.

6.4 Source coding for voice transmissions

The speech transcoding algorithm for use with voice transmission and reception shall be in accordance with the standard adopted for full rate speech transcoding within the GSM Recommendation 06.10 [1], except that the transcoder delay requirement in subclause 2.2 of GSM Recommendation 06.10 is relaxed. For DSRR, the transcoder delay shall be less than 100 ms.

Only the encoding process is prescribed in this subclause. Decoding is left open for the manufacturer to choose, some guidance can be found in Annex K.

The GSM speech code encodes each 20 ms speech frame into 76 speech parameters. These 76 parameters are quantised using 260 bits which are ordered in terms of decreasing importance by the speech codec, contained in GSM Recommendation 06.10 [1].

The 34 most important speech bits are defined as class 1 bits (protected bits), while the remaining 226 speech bits are defined as class 2 bits (unprotected).

The ordered speech bits are labelled { d(0), d(1),..., d(259) }, where d(0) is the most important bit and d(259) is the least important bit.

6.4.1 Parity and tailing bits

a) Parity Bits.

The 34 class 1 speech bits together with a generator polynomial $g(X) = (1 + X^2 + X^5)$ are used to generate a (39,34) systematic cyclic redundancy code which consists of the 34 speech bits plus 5 parity bits { p(0), p(1),... , p(4) }.

The parity bits in this system { p(0), p(1),... , p(4) } are defined by the following method:

1) multiply the message polynomial m(X) by X^5:

where $m(X) = d(0) + d(1)X + ... + d(33)X^{33}$

and {d(0), d(1),... , d(33)} are the 34 most important speech as defined in subclause 6.4.

2) divide $m(X)X^5$ by the generator polynomial g(X) to obtain the remainder b(X)

where $g(X) = 1 + X^2 + X^5$

and $b(X) = b(0) + b(1)X + b(2)X^2 + b(3)X^3 + b(4)X^4$

The parity bits are then given by the following p(k) = b(k)   k = 0,1,... ,4.

3) the cyclic code word bits are defined by the coefficients of the polynomial $b(X) + m(X)X^5$, i.e. { p(0), p(1),... , p(4), d(0), d(1),... , d(33) };

b) tailing bits and re-ordering.

The 34 class 1 speech bits are re-ordered and combined with the 5 parity bits and 4 tail bits giving 43 bits { u(0), u(1), ...u(42) } defined by:

u(k) = d(2k)   k = 0,1,2,... ,16

u(17+k) = p(k)   k = 0,1,2,3,4   (parity bits)

u(38-k) = d(2k+1)   k = 0,1,2,... ,16

u(k) = 0   k = 39,40,41,42   (tail bits)

6.4.2 Convolutional coding

The 34 class 1 speech bits, 5 parity bits and 4 tail bits are all encoded with a 1/2 rate convolutional code, defined by the polynomials:

$$G0 = 1 + D^3 + D^4$$

$$G1 = 1 + D + D^3 + D^4$$

The class 2 speech bits are uncoded.

The coded bits { c(0), c(1),... , c(311) } are therefore defined by:

class 1:

c(2k) = u(k) + u(k-3) + u(k-4)

c(2k + 1) = u(k) + u(k-1) + u(k-3) + u(k-4)

for k = 0,1,2,... ,42 and u(m) = 0 for m < 0

class 2:

c(86+k) = d(34+k) for k = 0,1,... ,225

6.4.3 Synchronisation bits

8 synchronisation bits {s(0), s(1),..., s(7)} are appended to the 312 coded bits to give 320 bits { i(0), i(1),... , i(319) }, defined by:

i(k)= c(k)   for k = 0,1,... ,311

i(312+k)= s(k)   for k = 0,1,... ,7

The synchronisation bits are defined by:

{s(0), s(1),... , s(7)} = {1,1,1,0,1,0,0,1}

6.4.4 Interleaving

The transmitted data is generated by interleaving within a frame to yield {t(0), t(1),..., t(319)} where:

$$t(k) = i(n + m) \qquad \text{for } k = 0,1,\ldots,319$$

where $n = 16(k \bmod 20)$;

and $m = \text{integer}(k/20)$.

The order of bit transmission is t(0), t(1),... t(319).

6.5 Source coding for data transmissions

The coding system used for user data transmission and reception is left to the manufacturer's discretion.

7 Radio characteristics

7.1 Carrier frequencies and channel numbers

The following carrier frequencies with their associated numbers shall be used:

Single frequency simplex operation:

933,0375 MHz transmitting and receiving Channel 01

933,0625 MHz transmitting and receiving Channel 02

933,0875 MHz transmitting and receiving Channel 03

and then at 25 kHz intervals up to:

933,6625 MHz transmitting and receiving Channel 26

and then at 25 kHz intervals up to:

934,3125 MHz transmitting and receiving Channel 52

and then at 25 kHz intervals up to:

934,9625 MHz transmitting and receiving Channel 78

Two frequency semi-duplex operation (master unit and repeater frequencies):

933,0375 MHz transmitting 888,0375 MHz receiving Channel 01

933,0625 MHz transmitting 888,0625 MHz receiving Channel 02

933,0875 MHz transmitting 888,0875 MHz receiving Channel 03

and then at 25 kHz intervals up to:

933,6625 MHz transmitting 888,6625 MHz receiving Channel 26

and then at 25 kHz intervals up to:

934,3125 MHz transmitting 889,3125 MHz receiving Channel 52 and then at 25 kHz intervals up to:

934,9625 MHz transmitting 889,9625 MHz receiving Channel 78

7.2 Control channels

Channels 26 and 52 are used as the control channels. The same control channels are used for single and two frequency channels.

7.3 Channel separation

The channel separation for DSRR equipment is 25 kHz.

7.4 Modulation

On the control channels the method of modulation is Gaussian Minimum Shift Keying (GMSK) at 4 kbit/s with a BT value of 0,50. On the traffic channels the method of modulation is GMSK at 4 kbit/s with a BT value of 0,50 for signalling, and GMSK at 16 kbit/s with a BT value of 0,30 for voice/data (see CCIR Report 903 [2]).

7.5 Synthesisers and PLL systems

The transmitter shall be inhibited when the synthesiser is out of lock.

7.6 Time limitation on channel occupancy

In the event that the emission on the control channel continues due to any fault in the radio equipment, the emission shall cease automatically within 1 minute.

7.7 Threshold level for RF sensing

To determine the availability of a channel the DSRR shall be equipped with a RF level detector which provides an RF sensing facility.

A channel shall be considered as free if the median value of the input voltage is not higher than 6 dB below maximum usable sensitivity.

8 Mechanical and electrical design

8.1 Controls

Those controls and components which, if maladjusted, might increase the risk of interference or improper functioning of the equipment shall not be accessible to the user.

8.2 Indication of the communication frequency and control signal information

The frequency actually used during a transmission or reception, including the channel number to express that frequency, and the content of the control signal received shall neither be indicated nor be accessible to the user.

Precautions shall be taken against extension of the usable frequency range by the user, e.g. the physical and electrical design of the channel switching system shall permit operation in not more than the above mentioned 78 channels.

8.3 Call code selection

The transceiver shall be equipped with a call code selector to make it possible to select any call code in the range from 0000000 to 9999999 to call any wanted unit with a call code within that range.

8.4 Programming of the unique identity code

The transceiver shall be provided with a read only memory facility which contains its call code and manufacturer's code. This facility shall meet all of the following functional and technical requirements:

a) the call code together with the manufacturer's code, giving the identity of each DSRR system element is unique to each element and shall be programmed in by the manufacturer. The manufacturer shall be allocated the manufacturer's code in the manner prescribed by ETSI. The manufacturer shall choose the call code for each system element on a random or pseudo-random basis, taking precautions to avoid repetition of call codes previously issued by the same manufacturer;

b) the user shall have no access to the means of entering these codes and shall not have any means of changing or erasing these codes;

c) means shall be provided to maintain the integrity of these codes when the power supply is removed;

d) the integrity of all the codes shall be maintained under normal and extreme test conditions.

8.5 Marking

The equipment shall be marked in a visible place. This marking shall be legible, temper proof and durable. The marking shall include:

- the name of the manufacturer or his trade mark;

- type number of designation and serial number;

- type approval number (when allocated by appropriate authorities).

9 RF technical characteristics and methods of measurement

The technical characteristics to be met by DSRR equipment and methods of measurement under specified test conditions are contained in Annex E. A summary is given below:

Frequency band:	933 to 935 MHz for single frequency operation 933 to 935 MHz and 888 to 890 MHz for two frequency operation
Channel separation:	25 kHz
Type of modulation:	GMSK with a BT value of 0,3 at 16 kbs/s (speech and data) GMSK with a BT value of 0,5 at 4 kbs/s (signalling)
Number of channels:	78 total
Channel allocation:	2 control channels 26 and 52 76 traffic channels 01 to 25, 27 to 51, and 53 to 78
Channel 01 frequency:	Single frequency operation: 933,0375 MHz unit transmitting and receiving Two frequency operation: 933,0375 MHz repeater/master unit transmitting 888,0375 MHz unit transmitting
Channel 78 frequency:	Single frequency operation: 934,9625 MHz unit transmitting and receiving

	Two frequency operation: 934,9625 MHz repeater/master unit transmitting 889,9625 MHz unit transmitting
Transmitter maximum carrier power:	4 W
Transmitter frequency error:	± 2,5 kHz maximum
Transmitter adjacent channel power:	- 70 dB outside the 2 MHz sub band relative to carrier for channels 1 and 78. - 50 dB inside the 2 MHz sub band relative to carrier for channels 1 to 78 inclusive. The adjacent channel power does not need to be below 0,2 microwatt.
Transmitter spurious emissions (transmitter operating): a) conducted:	0,25 microwatt from 9 kHz to 1 GHz 1 microwatt from 1 GHz to 12,75 GHz
b) radiated:	0,25 microwatt from 30 MHz to 1 GHz 1 microwatt from 1 GHz to 4 GHz
(transmitter standby: same as receiver)	
Transmitter intermodulation(for stations installed at a fixed location):	40 dB minimum 70 dB minimum in special cases
Transmitter attack time:	5 ms minimum 25 ms maximum
Transmitter release time:	5 ms minimum 25 ms maximum
Receiver maximum usable sensitivity:	better than + 6 dB relative to 1 microvolt emf for a Bit Error Rate (BER) of 10^{-2}
Receiver co-channel rejection:	- 18 dB minimum
Receiver adjacent channel selectivity:	50 dB minimum
Receiver spurious response rejection for simplex operation:	60 dB minimum
Receiver desensitisation under duplex operation:	3 dB maximum
Receiver spurious response rejection for duplex operation:	57 dB minimum
Receiver inter-modulation response:	55 dB minimum
Receiver blocking:	94 dB minimum
Receiver spurious emissions:	
a) conducted:	2 nanowatt from 9 kHz to 1 GHz 20 nanowatt from 1 GHz to 12,75 GHz
b) radiated:	2 nanowatt from 30 MHz to 1 GHz 20 nanowatt from 1 GHz to 4 GHz

Annex A (normative): Traffic channel scanning procedure

The traffic channel scanning procedure shall be implemented by the calling unit (single frequency call), or the repeater or master unit (two frequency call) in order to locate a free traffic channel. The traffic channel scanning cycle applies to both individual and group calls.

The traffic channel scanning cycle shall start from a randomly selected channel number, N, between 1 and 78, excluding control channels 26 and 52. At power up, the value of N shall be initialised as follows. Initially a relative traffic channel number, J, is selected:

$$J = (U)\text{mod}76$$

where: U is the value of the 7 least significant bits of the unit's or repeater's own call code.

This is converted to the traffic channel number N by the following algorithm:

$$N = J + K + 1$$

where: K = 0, for $0 \leq J \leq 24\leq$
K = 1, for $25 \leq J \leq 49$
K = 2, for $50 \leq J \leq 75$

In order to complete the channel scanning cycle as rapidly as possible, traffic channel N shall first be observed for a period not exceeding T_MON_OCC. If the channel is identified as occupied after this time, N shall be updated as:

$$J = (J+1)\text{mod}76$$

$$N = J + K + 1$$

where: K is as defined above.

The scanning unit (or master unit/repeater) shall then continue the scanning procedure, using the updated value for N.

If, a particular traffic channel has not been deemed occupied after time T_MON_OCC, the total observation time shall be extended to T_MON_FULL. If the traffic channel is identified as occupied after an observation period of T_MON_FULL, N shall be updated again, and scanning process shall be continued, using the updated value for N.

If, after an observation period of at least T_MON_FULL, a particular traffic channel has not been deemed occupied, this channel shall be identified as free. The current value of N shall be stored in the unit's (or master unit/repeater's) memory as the identified free channel.

At this stage, the new SSC including the number of the free traffic channel can be constructed. When the SSC has been constructed, the unit (or master unit/repeater) shall use the value L, to give the starting point for the next scanning cycle. The next value for N shall be initialised as:

$$N = (L+1)\text{mod}76$$

$$N = J + K + 1$$

where: L is the value of the 7 least significant bits of the CRC calculated for the third code word in this SSC and K is as defined above.

Use of the value L will ensure that the scanning cycle starts from a random channel number and the addition of 1 will ensure that the same traffic channel is not selected twice in the case of a manual re-try.

If all 76 traffic channels have been observed and found occupied, the channel scanning process shall be deemed to have failed to locate a free traffic channel.

Annex B (normative): Signalling protocol timers

B.1 Standby mode timers

T_PRIM_SPUR	Period of time of detecting spurious signals on the primary control channel in standby mode after which the unit, repeater or master unit will switch to the secondary control channel.	5 s
T_SEC_RETURN	Period of time after which a unit or master unit in standby mode which has switched to its secondary control channel due to spurious signals will receive on the secondary control channel before automatically reverting to the primary control channel.	5 s

B.2 Call set-up mode timers

T_BACK_OFF	The period of time for which a calling unit (or repeater) will delay its access attempt on the control channel when making a re-try call set-up attempt. The value is determined by the random number, n, multiplied by T_SLOT.	n x 200 ms
T_DEL_VIS	The period of time by which a repeater shall delay its initial response procedure for a call set-up SSC from a visitor.	200 ms
T_INT_ACK	The maximum time that a calling unit will wait for confirmation that a repeater is handling a two-frequency call set-up before initiating re-try procedures.	1 s
T_MON_CC	The minimum monitoring period necessary to identify a free control channel.	142 ms
T_MON_EXT	Maximum time for which a control channel shall be monitored to determine whether it is free for call set-up signalling when spurious signalling is detected (Note T_MON_SPUR is used in some cases).	1 s
T_MON_FULL	The minimum observation period for which a scanning unit (or master unit/repeater) shall observe an apparently unoccupied traffic channel before deeming it to be free during the traffic channel scanning procedure.	1 s
T_MON_OCC	The maximum observation period for which a scanning unit (or master unit/repeater) shall dwell on an occupied traffic channel during the traffic channel scanning procedure.	50 ms
T_MON_SPUR	Maximum time for which a control channel shall be monitored to determine whether it is free for call set-up signalling when spurious signalling is detected (Note T_MON_EXT is used in some cases).	600 ms
T_NO_RX	The maximum period that a called unit in an individual call shall wait for a wanted call set-up SSC directly after switching to a traffic channel (single frequency).	500 ms
T_OBS_CHK	The period of time for which a called or calling unit (or repeater) shall observe a traffic channel directly after switching to the channel.	200 ms
T_REP_ID_GR	Maximum period that a unit in two frequency group call set-up mode shall wait on a traffic channel for the repeaters identification SSC indicating that the repeater has entered its communication mode.	2,116 s
T_REP_ID_IN	Maximum period that a unit in two frequency individual call set-up mode shall wait on a traffic channel for the repeater's identification SSC indicating that the repeater has entered its communication mode.	658 ms
T_RX_ACK	The time within which transmission of an acknowledgement will take place on the same (or associated) channel as the SSC transmission to which the ACK is responding.	200 ms
T_SLOT	The duration of a single control channel virtual slot.	200 ms
T_SSC_DELAY	The maximum retransmission delay permitted for a repeater or master unit when retransmitting a complete successfully decoded SSC (including preamble).	200 ms
T_SWITCH	The maximum time permitted for a unit, repeater or master unit to switch from one function to another, (e.g. Tx to Rx) including any necessary channel change.	58 ms
T_TRAF_A	Maximum period that a calling unit in two frequency call set-up mode shall wait for the repeater to allocate a free traffic channel.	12 s
T_TRAF_B	Maximum period that a called unit in two frequency call set-up mode shall wait for the repeater to allocate a free traffic channel.	7 s

B.3 Communication mode timers

T_COM_HOLD	The maximum time permitted to remain in communication mode if no valid voice/data or transmission activation from the user is received (apart from the case where it has just entered communication mode, when T_COM_WAIT applies).	5 s
T_COMM	The maximum permitted duration for a single communication.	3 mn
T_COM_WAIT	The maximum time permitted to remain in communication mode, just after entering it, if no valid voice/data or transmission activation from the user is received.	10 s
T_MON_TC	The period of time for which a traffic channel shall be monitored to check for SSCs when 4 kbit/s signalling has been detected while receiving voice/data at 16 kbit/s.	200 ms
T_SSC_DELAY	The maximum retransmission delay permitted for a repeater or master unit when retransmitting a complete successfully decoded SSC (including preamble).	200 ms
T_V/D_DELAY	The maximum retransmission delay permitted for a repeater or master unit when retransmitting voice/data.	200 ms

Annex C (normative): Access control for repeaters

C.1 General

Each repeater shall be equipped with a data base in which the individual call codes of the units which are authorised to use the repeater are stored.

The data base shall be freely programmable for the user to fulfill their needs. However, the user should notice that a particular call code shall only be entered into the data base of one repeater in areas of overlapping coverage.

The minimum set of operations on the data base shall be the possibility of insertion and deletion of call codes in order to allow or prohibit use of the repeater by particular units.

C.2 Call validation

An individual call set-up shall be regarded as valid and shall be handled by the repeater if either the call code of the calling unit or the call code of the called unit is registered in its data base. This allows either the called or calling unit to communicate as a visitor at a particular repeater.

A group call set-up shall be regarded as valid and shall be handled by the repeater if the call code of the calling unit is registered in its data base.

Invalid access attempts shall be ignored by the repeater.

Annex D (normative): Definition of a wanted SSC for the 3 protocol modes

The following tables show the layout of a wanted SSC for the different protocol states. The manufacturer is free to decide to check only a subset of the code word information at the receiver (e.g. the control channel select bit is used only in two frequency operation mode, thus it is not required to be checked in single frequency operation mode).

D.1 Standby mode

SSC no.	TC#	first call code	CC sel	1f/ 2f	ind/ grp	second call code	received by
1 X 1 X	TC# TC# 0 TC#	own# own grp# own# own grp#	0 0 X 0	0 0 1 1	0 1 0 1	calling# calling# calling# calling#	unit to enter call set-up mode
1 1 1 1	0 0 0 0	reg'd# reg'd# vis'r# group#	0 0 0 0	1 1 1 1	0 0 0 1	reg'd# vis'r# reg'd# reg'd#	repeater to enter call set-up mode
1	0	own#	0	1	0	calling#	master unit to enter call set-up mode

Remarks:

X — may be either 0 or 1;

TC# — a number within the valid TC range (1 to 25, 27 to 51, 53 to 78);

own# — unit's call code number;

own grp# — programmed group call code number at the unit;

reg'd# — registered call code number in the repeater's (registered) data base;

vis'r# — not registered call code number in the repeater's (visitor) data base;

calling# — a number within the valid unit call code range (0 to 9999999);

group# — group call code for current call;

CC sel — 0 -> use primary control channel;

1 -> use secondary control channel;

1f/2f — 0 -> single frequency operation mode;

1 -> two frequency operation mode;

ind/grp — 0 -> individual call;

1 -> group call.

D.2 Call set-up mode

SSC no	TC#	first call code	CC sel	1f/ 2f	ind/ grp	second call code	received by (referred action)
							calling unit
0	TC#	own#	0	0	0	called#	-ACK on CC and TC
1	0	called#	X	1	0	own#	-confirmation SSC on CC
X	TC#	called#	0	1	0	own#	-TC assignment on CC
1	TC#	repeater#/ master unit#	0	1	0	repeater#/ master unit#	-identification SSC on TC
0	TC#	own#	0	1	0	called#	-ACK on TC
1	0	own grp#	0	1	1	own#	-confirmation SSC on CC
X	TC#	own grp#	0	1	1	own#	-TC assignment on CC
1	TC#	repeater#/ master unit#	0	1	1	repeater#/ master unit#	-identification SSC on TC
							called unit
1	TC#	own#	0	0	0	calling#	-SSC on CC and TC
X	TC#	own#	0	1	0	calling#	-TC assignment on CC
1	TC#	repeater#/ master unit#	0	1	0	repeater#/ master unit#	-identification SSC on TC
1	TC#	own#	0	1	0	calling#	-SSC on TC
1	TC#	repeater#	0	1	1	repeater#	-identification SSC on TC
							repeater
0	0	calling#	X	1	0	called#	-ACK on CC
							calling master unit
0	0	own#	X	1	0	called#	-ACK on CC
0	TC#	own#	0	1	0	called#	-ACK on TC
							called master unit
1	TC#	own#	0	1	0	calling#	-SSC on TC

Remarks:

X	may be either 0 or 1;
TC#	a number within the valid TC range (1 to 25, 27 to 51, 53 to 78);
own#	unit's call code number;
own grp#	programmed group call code number at the unit;
called#	called unit's call code number for current call;
calling#	calling unit's call code number for current call;
master unit#	called/calling master unit's call code number;
repeater#	a number within the valid repeater call code range (10000000 to 2^{24} - 1);
CC sel	0 -> use primary control channels;
	1 -> use secondary control channels
1f/2f	0 -> single frequency operation mode
	1 -> two frequency operation mode;
ind/grp	0 -> individual call;;
	1 -> group call.

D.3 Communication mode

SSC no.	TC#	first call code	CC sel	1f/ 2f	ind/ grp	second call code	received by
1	TC#	own#	0	0	0	partner's#	a unit
1	TC#	own grp#	0	0	1	tx unit's#	
1	TC#	own#	0	1	0	partner's#	
1	TC#	own grp#	0	1	1	tx unit's#	
1	TC#	called#/ calling#	0	1	0	calling#/ called#	repeater
1	TC#	group#	0	1	1	tx unit's#	
1	TC#	own#	0	1	0	partner's#	master unit

Remarks:

TC# a number within the valid TC range (1 to 25, 27 to 51, 53 to 78);

own# unit's call code number;

partner's# call code number of partner (individual call);

own grp# programmed group call code number at the unit;

tx unit's# a number within the valid unit call code range (0 to 9999999);

called#/calling#: either called# or calling# for current call;

group# group call code for current call;

CC sel 0 -> use primary control channels;

1 -> use secondary control channels;

1f/2f 0 -> single frequency operation mode;

1 -> two frequency operation mode;

ind/grp 0 -> individual call;

1 -> group call.

Annex E (normative): RF technical characteristics and methods of measurement

E.1 Technical characteristics

E.1.1 Transmitter parameter limits

E.1.1.1 Frequency error

For the definition and the measuring method see subclause E.4.1.

The frequency error shall not exceed ± 2,50 kHz under normal and extreme test conditions, or in any intermediate set of conditions. However for practical reasons the measurement will be performed only at nominal and extreme test conditions as stated in subclause E.4.1.

For hand portable equipments having integral power supplies, the frequency error given shall not be exceeded over a temperature range of 0°C to + 30°C. Under extreme temperature conditions (subclause E.2.4.1) the frequency error shall not exceed ± 3,00 kHz.

E.1.1.2 Carrier power

For the definition and the measuring method see subclause E.4.2.

The carrier output power shall not exceed the maximum value of 4 W under normal test conditions.

The carrier power under the specified conditions of measurement (subclause E.4.2.2) and at normal test conditions, shall be within ± 1,50 dB of the rated carrier power .

The carrier power under extreme test conditions shall be within + 2,0 dB and - 3,0 dB of the rated output power.

E.1.1.3 Adjacent channel power

For the definition and the measuring method see subclause E.4.3.

For channels number 01 and 78 the adjacent channel power below and respectively above the carrier frequency shall not exceed a value of 70,0 dB below the carrier power of the transmitter without any need to be below 0,20 microwatt.

For channel numbers 26 and 52 the adjacent channel power shall not exceed a value of 70 dB below the carrier power of the transmitter without any need to be below 0,20 microwatt.

For all other cases the adjacent channel power shall not exceed a value of 50,0 dB below the carrier power of the transmitter without any need to be below 0,20 microwatt.

E.1.1.4 Spurious emissions

For the definition and the measuring method see subclause E.4.4.

The power of any spurious emission shall not exceed the values given in tables E.1 and E.2:

Table E.1: Conducted emissions

Frequency range	9 kHz to 1 GHz	above 1 GHz to 12,75 GHz
Tx operating	0,25 microwatt	1,00 microwatt
Tx standby	2,00 nanowatt	20,00 nanowatt

Table E.2: Radiated emissions

Frequency range	30 MHz to 1 GHz	above 1 GHz to 4 GHz
Tx operating	0,25 microwatt	1,00 microwatt
Tx standby	2,00 nanowatt	20,00 nanowatt

E.1.1.5 Intermodulation attenuation

This requirement applies only to transmitters to be used in base stations and repeaters. For the definition and the measuring method see subclause E.4.5. If a unit is intended to be used as a base station, this subclause is also applicable.

Two classes of transmitter intermodulation attenuation are defined, the equipment shall fulfil one of the requirements:

- in general the intermodulation attenuation ratio shall be at least 40,0 dB for any intermodulation component;

- for base station and repeater equipment to be used in special service conditions (e.g. at sites where more than one transmitter will be in service) or when the regulatory authority makes it a condition of the licence, the intermodulation attenuation ratio shall be at least 70,0 dB for any intermodulation component. In the case where the performance is achieved by additional internal or external isolating devices (such as circulators) they shall be supplied at the time of type testing and shall be used for the measurements.

E.1.1.6 Transmitter attack time

For the definition and the measuring method see subclause E.4.6.

The transmitter attack time (t_{am}) shall be between 5 and 25 ms.

E.1.1.7 Transmitter release time

For the definition and the measuring method see subclause E.4.7.

The transmitter release time (t_{rm}) shall be between 5 and 25 ms.

E.1.2 Receiver parameter limits

E.1.2.1 Maximum usable sensitivity

For the definition and the measuring method see subclause E.5.1.

The maximum usable sensitivity shall not exceed an emf of + 6,0 dBµV under normal test conditions, and an emf of + 12,0 dBµV under extreme test conditions.

E.1.2.2 Co-channel rejection

For the definition and the measuring method see subclause E.5.3.

The value of the co-channel rejection ratio, expressed in dB, at the signal displacements given in the method of measurement, shall be between - 18,0 dB and 0 dB.

E.1.2.3 Adjacent channel selectivity

For the definition and the measuring method see subclause E.5.4.

The adjacent channel selectivity shall not be less than 50 dB under normal test conditions, and 45 dB under extreme test conditions.

E.1.2.4 Spurious response rejection

For the definition and the measuring method see subclause E.5.5.

At any frequency separated from the nominal frequency of the receiver by more than one channel separation, the spurious response rejection shall not be less than 60,0 dB.

E.1.2.5 Intermodulation response

For the definition and the measuring method see subclause E.5.6.

The intermodulation response ratio shall not be less than 55,0 dB.

E.1.2.6 Blocking or desensitisation

For the definition and the measuring method see subclause E.5.7.

The blocking ratio for any frequency within the specified ranges shall not be less than 94,0 dB, except at frequencies on which spurious responses are found (subclause E.5.5).

E.1.2.7 Spurious radiations

For the definition and the measuring method, see subclause E.5.8.

The power of any spurious radiation shall not exceed the values given in tables E.3 and E.4.

Table E.3: Conducted components

Frequency range	9 kHz to 1 GHz	above 1 GHz to 12,75 GHz
Limit	2,00 nanowatt	20,00 nanowatt

Table E.4: Radiated components

Frequency range	30 MHz to 1 GHz	above 1 GHz to 4 GHz
Limit	2,00 nanowatt	20,00 nanowatt

E.1.3 Duplex operation - receiver limits for repeaters and master units

E.1.3.1 Receiver desensitisation and maximum usable sensitivity (with simultaneous transmission and reception)

For the definition and the measuring method, see subclause E.6.1.

The desensitisation shall not exceed 3,0 dB and the limit of maximum usable sensitivity under normal test conditions, subclause E.1.2.1, shall be met.

E.1.3.2 Receiver spurious response rejection

For the definition and the measuring method see subclause E.6.2.

At any frequency separated from the nominal frequency of the receiver by more than two channels, the spurious response rejection ratio shall not be less than 57,0 dB.

E.2 Test conditions, power source and ambient temperature

E.2.1 Normal and extreme test conditions

Type-approval tests shall be made under normal test conditions, and also, where stated, under extreme test conditions.

The test conditions and procedures shall be as specified in subclauses E.2.2 to E.2.5.

E.2.2 Test power source

During type approval 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 E.2.3.2 and E.2.4.2. 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.

For battery operated equipment the battery shall be removed and the test power source shall be applied as close to the battery terminals as practicable.

During test the power source voltages shall be maintained within a tolerance ± 1 % relative to the voltage at the beginning of each test.

The value of this tolerance is critical for power measurements. Using a smaller tolerance will provide a better uncertainty value for these measurements.

E.2.3 Normal test conditions

E.2.3.1 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 %.

When it is impracticable to carry out the tests under these conditions a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

E.2.3.2 Normal test power source

E.2.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of these specifications, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment was designed.

The frequency of the test power source corresponding to the ac mains shall be between 49 and 51 Hz.

E.2.3.2.2 Regulated lead-acid battery power source used on vehicles

When the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source used on vehicles, the normal test voltage shall be 1,1 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

E.2.3.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer and approved by the test authority. Such values shall be stated in the test report.

E.2.4 Extreme test conditions

E.2.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in subclause E.2.5, at the upper and lower temperatures of - 15° C to + 55° C.

For the purpose of subclause E.1.1.1, 2nd paragraph, an additional extreme temperature range of 0° C to + 30° C shall be used.

E.2.4.2 Extreme test source voltages

E.2.4.2.1 Mains voltage

The extreme test voltage for equipment to be connected to an ac mains source shall be the nominal mains voltage ± 10 %.

E.2.4.2.2 Regulated lead-acid battery power source on vehicles

When the radio equipment is intended for operation from the usual type of regulated lead-acid battery power source used on vehicles the extreme test voltages shall be 1,3 and 0,9 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

E.2.4.2.3 Power source using other types of batteries

The lower extreme test voltages for equipment with a power source using batteries shall be as follows:

- for Leclanché or lithium type of battery: 0,85 times the nominal voltage of the battery;

- for mercury type or nickel-cadmium type of battery: 0,9 times the nominal voltage of the battery.

No upper extreme test voltages apply.

E.2.4.2.4 Other power sources

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages shall be those agreed between the equipment manufacturer and the testing authority and shall be recorded in the test report.

E.2.5 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.

In the case of equipment containing temperature stabilisation circuits designed to operate continuously, the temperature stabilisation circuits may be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements. For such equipment the manufacturer shall provide for the power source circuit feeding the temperature stabilisation circuit to be independent of the power source for the rest of the equipment.

If the thermal balance is not checked by measurements, a temperature stabilising period of at least one hour 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 extreme temperature the equipment shall be switched on to the standby condition and placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on for one minute in the transmit condition, followed by four minutes in the standby condition, after which the equipment shall meet the specified requirements. For hand held equipment the one minute period will be shortened to 30 s.

For tests at the lower extreme temperature the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute after which the equipment shall meet the specified requirements.

E.3 General conditions

E.3.1 Principles of test procedure

This specification applies to equipment fitted with a permanent or temporary connector which allows access to the transmitter output and the receiver input.

The characteristics of the voice circuits of the equipment, which involve digital speech with an analogue to digital converter for the transmitter and a digital to analogue converter for the receiver, do not lend themselves to instrument measurements of the RF characteristics.

Therefore, all measurements are made at the data input to the transmitter and the data output from the receiver, at the full bit rate independent of any forward error detection and/or correction.

Equipment that do not have an input/output socket for the data facility, either internally mounted or mounted on an external surface can be temporarily modified to provide a suitable facility. Alternatively, a method of test acceptable to the testing authority can be proposed by the manufacturer.

The manufacturer is responsible for supplying any ancillary equipment that is necessary to ensure that the signal generators used for the receiver tests have identical modulation characteristics with that used in the equipment transmitter.

All measurements are made with a bit rate of 16 kbit/s unless otherwise stated.

E.3.2 Arrangements for test signals applied to the receiver input

Sources of test signals for application to the receiver input shall be connected in such a way that the impedance presented to the receiver input is 50 Ω non-reactive (see subclause E.3.5).

This requirement shall be met irrespective of whether one or more signals using a combining network are applied to the receiver simultaneously.

The levels of the test signals shall be expressed in terms of emf at the receiver input terminals (RF socket).

The effects of any intermodulation products and noise produced in the test signal sources should be negligible.

E.3.3 Receiver mute or squelch facility

If the receiver is equipped with a mute or squelch circuit, this shall be made inoperative for the duration of the type approval tests.

E.3.4 Normal test signal and normal test modulation

The normal test signal used to modulate signal generators for receiver tests and the transmitter are chosen from the following as appropriate:

- signal M1, consisting of a pseudorandom bit sequence of at least 511 bits (according to CCITT Recommendation O.153 [3]) at 16 kbit/s with a BT value of 0,3;

- signal M1', this is the same type as M1, but the pseudorandom bit sequence is independent of M1 (perhaps identical with M1 but started at another point of time);

- signal M2, consisting of a radio frequency signal, modulated by an audio frequency signal of 1 000 Hz with a deviation of 12 % of the channel separation. This signal is used as an unwanted signal;

- signal M3 is the same as M1, but at 4 kbit/s with a BT value of 0,5.

Applying infinite series of 0-bit or 1-bit does normally not produce the typical bandwidth. Signal M1 is supposed to produce a good approximation of the typical bandwidth.

E.3.5 Impedance

In this I-ETS, the term "50 Ω" is used for a 50 Ω non-reactive impedance.

E.3.6 Artificial antenna

Tests shall be carried out using an artificial antenna which shall be a substantially non-reactive non-radiating load of 50 Ω connected to the antenna connector.

E.3.7 Tests of equipment with a duplex filter

If the equipment is provided with a built-in duplex filter or a separate associated filter, the requirements of this I-ETS shall be met when the measurements are carried out using the antenna connector of this filter.

E.3.8 Facilities for access

E.3.8.1 RF access

Equipment not fitted with an external antenna socket shall be provided with a permanent or temporary internal 50 Ω RF connector, which allows access to the transmitter output and the receiver input.

E.3.8.2 Raw data input/output

Equipment not fitted with an external raw data input/output shall be provided with a permanent or temporary internal access facility.

E.3.8.3 Raw bit stream access

The raw bit stream is the stream of bits at the modulator input or the demodulator output respectively. In order to make the measurements according to Clauses E.4, E.5 and E.6 an access to the raw bit stream should be provided for the equipment to be tested.

E.3.8.4 Coupling arrangements

For the measurements of the receiver on a test site arrangements to couple the unit to be tested to the bit error ratio measuring device shall be available (see subclause E.3.8.3).

E.3.9 Test site and general arrangements for measurements involving the use of radiated fields

For guidance, see Appendix E.A. Descriptions of the radiated measurement arrangements are included in this Annex.

E.3.10 Modes of operation of the transmitter

For the purpose of the measurements according to this I-ETS there should be a facility to operate the transmitter unmodulated. The method of obtaining an unmodulated carrier or special types of modulation patterns may also be decided by agreement between the manufacturer and the test laboratory. It shall be described in the test report. It may involve suitable temporary internal modifications of the equipment under test.

E.4 Methods of measurement for transmitter parameters

Unless otherwise specified, tests shall be carried out on one traffic channel. The transmitters of combined two frequency and single frequency units shall be tested in both frequency bands.

E.4.1 Frequency error

E.4.1.1 Definition

The frequency error of the transmitter is the difference between the measured carrier frequency and its nominal value.

E.4.1.2 Method of measurement

Measurements shall be carried out on channels 02, 39 and 77.

The equipment shall be connected to the artificial antenna (subclause E.3.6).

The carrier frequency shall be measured in the absence of modulation. The measurement shall be made under normal test conditions (subclause E.2.3) and extreme test conditions (subclauses E.2.4.1 and E.2.4.2 applied simultaneously).

E.4.2 Carrier power

E.4.2.1 Definition

For the purpose of this specification, the carrier power is the average power delivered to the artificial antenna during one radio frequency cycle.

The rated carrier power shall be declared by the manufacturer.

E.4.2.2 Method of measurement

The transmitter shall be connected to an artificial antenna (subclause E.3.6), and the power delivered to this artificial antenna shall be measured.

The measurement shall be made under normal test conditions (subclause E.2.3), and extreme test conditions (subclauses E.2.4.1 and E.2.4.2 applied simultaneously).

E.4.3 Adjacent channel power

E.4.3.1 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 passband 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.

E.4.3.2 Method of measurement

The adjacent channel power may be measured with a power measuring receiver which conforms to Appendix E.B (referred to in this subclause E.4.3.2 as the "receiver"). The adjacent channel power shall be measured on 3 traffic channels and on one control channel.

a) The transmitter shall be operated at the carrier power determined in subclause E.4.2 under normal test conditions (subclause E.2.3). The output of the transmitter shall be linked to the input of the "receiver" by a connecting device such that the impedance presented to the transmitter is 50 Ω and the level at the "receiver input" is appropriate;

b) with the transmitter unmodulated, the tuning of the "receiver" shall be adjusted so that a maximum response is obtained. This is the 0 dB response point. The "receiver" attenuator setting and the reading of the meter shall be recorded;

c) the frequency of the "receiver" shall be adjusted above the carrier frequency of the transmitter operating on a traffic channel, except channels 01 and 78, so that the "receiver" - 6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in the table E.5 below for 25 kHz channel separation;

Table E.5: Frequency displacement

Channel separation (kHz)	Specified necessary bandwidth (kHz)	Displacement from the - 6 dB point (kHz)
25,0 37,5	16 16	17,0 29,5

d) the transmitter shall be modulated by a normal test signal M1 according to subclause E.3.4;

e) the "receiver" variable attenuator shall be adjusted to obtain the same meter reading as in step b) or a known relation to it;

f) the ratio of the adjacent channel power to the carrier power is the difference between the attenuator settings in steps b) and d), corrected for any differences in the reading of the meter;

g) the measurement shall be repeated with the frequency of the "receiver" adjusted below the carrier so that the "receiver" - 6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in the table above;

h) the measurement shall be repeated, following the same procedure, on one of the control channels (26 or 52);

i) the measurement is repeated following the same procedure with the transmitter operating on channels 01 and 78 but using the displacement from the nominal carrier frequency as given in the table E.5 for 37,5 kHz channel separation.

   On channel 01 the adjacent channel power is only measured with the "receiver" tuned below the transmitter carrier frequency, and on channel 78 it is only measured with the "receiver" tuned above the transmitter carrier frequency.

E.4.4 Spurious emissions

E.4.4.1 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:

a) their power level in a specified load (conducted spurious emission); and

b) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation).

E.4.4.2 Method of measuring the power level

Spurious emissions shall be measured as the power level of any discrete signal delivered into a 50 Ω load. This may be done by connecting the transmitter output through an attenuator to a spectrum analyser[1] or selective voltmeter, or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (subclause E.3.6).

The transmitter shall be unmodulated, and the measurements made in the frequency range 9 kHz - 12,75 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

The measurement shall be repeated with the transmitter in the "stand-by" position.

NOTE: See also Appendix E.B, subclause E.B.2.

E.4.4.3 Method of measuring the effective radiated power

On a test site, fulfilling the requirements of subclause E.3.9 and Appendix E.A, subclause E.A.2, the sample shall be placed at the specified height on the support. The transmitter shall be operated at the carrier power as specified under subclause E.4.2, delivered to an artificial antenna (subclause E.3.6), or in case of hand portable equipment to the normal antenna.

The transmitter shall be unmodulated and the radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz - 4 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 maximum response and the effective radiated power of that component determined by a substitution measurement.

The measurements shall be repeated with the test antenna in the orthogonal polarisation plane.

The measurements shall be repeated with the transmitter in the "standby" position.

E.4.5 Intermodulation attenuation

This requirement applies only to transmitters to be used in base stations and repeaters.

E.4.5.1 Definition

For the purpose of this I-ETS, 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 entering the transmitter via its antenna.

E.4.5.2 Method of measurement

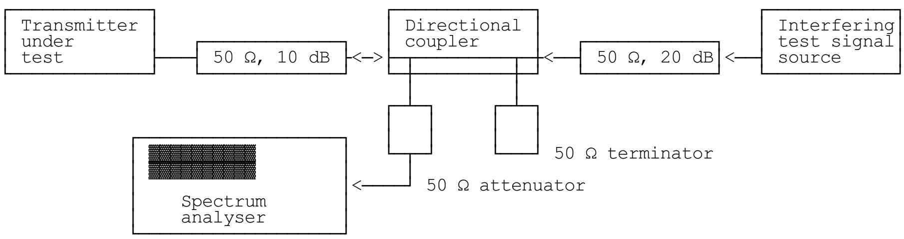


Figure E.1: Measurement arrangement

1 The resolution bandwidth of the measuring instrument shall be the smallest bandwidth available which is greater than the spectral width of the spurious component being measured.

The measurement arrangement shown in figure E.1, shall be used.

The transmitter shall be connected to a 50 Ω 10 dB power attenuator and via a directional coupler to a spectrum analyser. An additional attenuator may be required between the directional coupler and the spectrum analyser to avoid overloading.

In order to reduce the influence of mismatch errors it is important that the 10 dB power attenuator is coupled to the transmitter under test with the shortest possible connection.

The interfering test signal source may be either a transmitter providing the same power output as the transmitter under test and be of a similar type, or a signal generator and a linear power amplifier capable of delivering the same output power as the transmitter under test.

The directional coupler shall have an insertion loss of less than 1 dB, a sufficient bandwidth and a directivity of more than 20 dB.

The transmitter under test and the test signal source shall be physically separated in such a way that the measurement is not influenced by direct radiation.

The transmitter under test shall be unmodulated and the spectrum analyser adjusted to give a maximum indication with a frequency scan width of 500 kHz.

The interfering test signal source shall be unmodulated and the frequency shall be within 50 kHz to 100 kHz above the frequency of the transmitter under test.

The frequency shall be chosen in such a way that the intermodulation components to be measured do not coincide with other spurious components. The power output of the interfering test signal source shall be adjusted to the carrier power level of the transmitter under test by the use of a power meter.

The intermodulation component shall be measured by direct observation on the spectrum analyser and the ratio of the largest third order intermodulation component with respect to the carrier.

This measurement shall be repeated with the interfering test signal source at a frequency within 50 kHz to 100 kHz below the frequency of the transmitter under test.

E.4.6 Transmitter attack time

E.4.6.1 Definition

The transmitter attack time (t_a) is the time which elapses between:

- the initiation of the "transmitter on" function (T_{xon}); and
- the moment when the transmitter output power has reached a level 1 dB below or 1,5 dB above the steady state power (P_c) and maintains a level within + 1,5 dB/- 1 dB from P_c thereafter as seen on the measuring equipment or in the plot power as a function of time.

The measured value of t_a is t_{am}.

T_{xon}: is the time at which the final irrevocable logic decision to power on the transmitter is taken.

E.4.6.2 Method of measurement

The test arrangement for transmitter attack (and release) time is given in figure E.2 following:

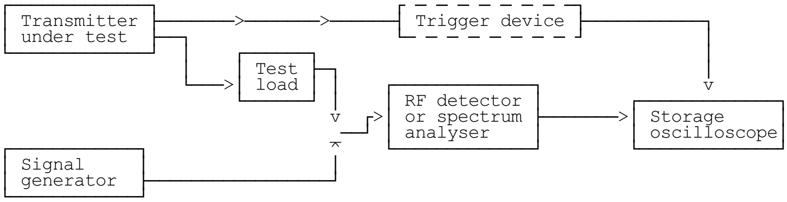


Figure E.2: Test arrangement for transmitter attack and release time

The transmitter is connected to a storage oscilloscope via a matched test load attenuator and the oscilloscope amplitude response is calibrated to display the steady state output power at a suitable level. By appropriate means, a triggering pulse to the oscilloscope is generated at the moment when the "transmitter on" function is initiated (T_{xon}).

The measurement can also be performed using a spectrum analyser set to measure and display power as a function of time ("zero span mode").

The bandwidth shall be set to 100 kHz.

E.4.7 Transmitter release time

E.4.7.1 Definition

The transmitter release time (t_r) is the time which elapses between the initiation of the "transmitter off" function (T_{xoff}) and the moment when the transmitter output power has reduced to a level 50 dB below the steady state power (P_c) and remains below this level.

The measured value of t_r is t_{rm}.

T_{xoff}: is the time at which the final irrevocable logic decision to power off the transmitter is taken.

E.4.7.2 Method of measurement

The transmitter is connected to a spectrum analyser via a power attenuator. By appropriate means, a triggering pulse is generated at the moment when the "transmitter off" function is initiated.

The spectrum analyser is set to measure and display power as a function of time ("zero span mode").

The test arrangement for transmitter release time is given in figure E.2 in subclause E.4.6.2.

E.5 Methods of measurement for receiver parameters

E.5.1 Maximum usable sensitivity

E.5.1.1 Definition

The maximum usable sensitivity of the receiver is the minimum level of signal (emf) at the receiver input, at the nominal frequency of the receiver, with normal test signal (subclause E.3.4), which without interference will produce after demodulation a data signal with a specified bit error ratio.

E.5.1.2 Method of measurement

a) An input signal with a frequency equal to the nominal frequency of the receiver, modulated by the normal test signal M1 (subclause E.3.4), shall be applied to the receiver input terminals;

b) the bit pattern of the modulating signal shall be compared to the bit pattern obtained from the receiver after demodulation;

c) the emf of the input signal of the receiver is adjusted until the BER is 10^{-2};

d) the maximum usable sensitivity is the emf of the input signal to the receiver;

e) the measurement shall be repeated under extreme test conditions (subclauses E.2.4.1 and E.2.4.2 applied simultaneously).

E.5.2 Level of the wanted signal for the degradation measurements

E.5.2.1 Definition

The level of the wanted signal for the degradation measurements of the receiver corresponds to the minimum level of signal (emf) at the receiver input, at the nominal frequency of the receiver, with normal test signal (subclause E.3.4), which will produce after demodulation a data signal with a specified bit error ratio or a specified successful message ratio, in the case of degradation due to interference conditions.

E.5.2.2 Defined level

The level of the wanted signal for the degradation measurements is an emf of + 9 dB microvolt. It is 3 dB above the limit of the maximum usable sensitivity.

E.5.3 Co-channel rejection

E.5.3.1 Definition

The co-channel rejection is a measure of the capability of the receiver to receive a wanted modulated signal without a given degradation due the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

E.5.3.2 Method of measurement

a) The two input signals shall be connected to the receiver via a combining network (see also subclause E.3.2); the wanted signal shall be modulated by the normal test signal M1 (subclause E.3.4), and the unwanted signal shall be the test signal M2. Both signals shall be at the nominal frequency of the receiver;

b) initially the unwanted signal shall be switched off and the amplitude of the wanted signal shall be adjusted to establish the level of the wanted signal (specified in subclause E.5.2) at the receiver input terminals;

c) the unwanted signal shall then be switched on, and the input level adjusted until a BER of about 10^{-1} is obtained;

d) the normal test signal M1 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a BER of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded;

e) the co-channel rejection ratio shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal, at the receiver input. This ratio shall be noted;

f) the measurement shall be repeated for displacements of ± 1,5 KHz and ± 3,0 KHz of the unwanted signal.

The lowest of the five values expressed in dB, noted in step e) shall be recorded as the co-channel rejection.

The value of the co-channel rejection ratio, expressed in dB, is generally negative (therefore, for example, - 12 dB is lower than - 8 dB).

E.5.4 Adjacent channel selectivity

E.5.4.1 Definition

The adjacent channel selectivity is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted signal which differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended.

E.5.4.2 Method of measurement

a) Two signals generators A and B shall be applied to the receiver via a combining network (see also subclause E.3.2).

   Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (subclause E.3.4).

   Signal generator B shall be modulated with the signal M2 and shall be adjusted to the frequency of the channel immediately above that of the wanted signal;

b) initially signal generator B shall be switched off. Signal generator A will be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal (specified in subclause E.5.2) at the receiver input terminals;

c) the unwanted signal (generator B) shall then be switched on, and the input level adjusted until a BER of 10^{-1} is obtained;

d) the normal test signal M1 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a BER of 10^{-2} or better obtained. The level of the unwanted signal shall then be recorded;

e) the adjacent channel selectivity shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal, at the receiver input;

f) the measurement shall be repeated with the unwanted signal at the frequency of the channel below that of the wanted signal;

g) the adjacent channel selectivity shall be expressed as the lower value of the ratios for the upper and lower adjacent channel of the levels of the unwanted signal to the level of the wanted input signal (generator A);

h) the measurement shall be repeated under extreme test conditions (subclauses E.2.4.1 and E.2.4.2 applied simultaneously), using the level of the wanted signal (specified in subclause E.5.2) increased by 6 dB.

E.5.5 Spurious response rejection

E.5.5.1 Definition

The spurious response rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal at any other frequency, at which a response is obtained.

E.5.5.2 Introduction to the method of measurement

To determine the frequencies at which spurious responses can occur the following calculations shall be made.

a) Calculation of the "limited frequency range".

The "limited frequency range" is equal to:

- the frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver ± the sum of the intermediate frequencies (if_1,...if_n) and half the switching range (sr) of the receiver. Hence:

- the "limited frequency range" = $f_{lo} \pm (if_1 + if_2 +..+ if_n + sr/2)$.

b) Calculation of frequencies outside the "limited frequency range".

A calculation of the frequencies at which spurious responses can occur outside the range determined in a) is made for the remainder of the frequency range of interest, as appropriate, see subclause E.5.5.2.2.

The frequencies outside the "limited frequency range" are equal to:

- the harmonics of the frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver or the harmonics of any frequency generated in the equipment (f_r) ± the numeric value of the 1st intermediate frequency (if_1) of the receiver. Hence:

- the frequencies of these spurious responses = $nf_{lo} \pm if_1$ and $pf_r \pm if_1$, where "n" is an integer greater than or equal to 2 and where "p" is an integer greater than or equal to 1.

The measure of the first image response of the receiver shall initially be made to verify the calculation of spurious response frequencies.

For the calculations a) and b) above, the manufacturer shall state the frequency of the receiver, the frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver, the intermediate frequencies (if_1, if_2, etc.) and the switching range (sr) of the receiver.

E.5.5.2.1 Method of search over the "limited frequency range"

a) Two signal generators A and B shall be connected to the receiver via a combining network (see also subclause E.3.2).

Signal generator A (wanted signal) shall be at the nominal frequency of the receiver and shall be modulated with the signal M1 (see subclause E.3.4).

Signal generator B (unwanted signal) shall be modulated with the signal M2;

b) initially signal generator B shall be switched off. Signal generator A shall be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal, specified in subclause E.5.2 (data), at the receiver input terminals (i.e. 9 dB above 1 µV emf) under normal test conditions.

The BER of the receiver after demodulation shall be noted;

c) the unwanted signal (generator B), shall then be switched on and its amplitude shall be adjusted to a level of 86 dBµV at the receiver input terminals. The frequency of the unwanted signal generator shall be varied incrementally over the "limited frequency range" to search for frequencies at which spurious response occur. The incremental steps of the frequency of the unwanted signal shall be 5 kHz;

d) the frequency of any spurious response detected (by an increase in the previously noted BER) during the search shall be recorded for use in the measurements in accordance with subclause E.5.5.2.

E.5.5.2.2 Method of measurement

a) Two signals generators A and B shall be connected to the receiver via a combining network (see also subclause E.3.2).

   Signal generator A (wanted signal) shall be at the nominal frequency of the receiver modulated by the normal test signal M1 (subclause E.3.4), at an emf of + 9 dBµV (subclause E.5.2);

b) signal generator B (unwanted signal) shall be modulated with the signal M2 at an emf of 86 dBµV;

c) at each frequency where a spurious response occurs the level of the unwanted signal shall be adjusted until a BER of 10^{-1} is obtained;

d) the normal test signal M1 shall be transmitted whilst observing the BER. The level of the unwanted signal shall be reduced in steps of 1 dB until a BER of 10^{-2} or better obtained. The level of the unwanted signal shall then be recorded;

e) the spurious response rejection shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal (generator A) at the receiver input.

The measurement shall be performed at all spurious response frequencies found during the search over the "limited frequency range" (subclause E.5.5.2.1) and those frequencies calculated for the remainder of the spurious response frequencies in the frequency range over the frequency range of 100 kHz to 4 GHz.

E.5.6 Intermodulation response

E.5.6.1 Definition

The intermodulation response is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

E.5.6.2 Method of measurement

a) Three signal generators A, B and C shall be applied to the receiver via a combining network (see also subclause E.3.2).

   Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (subclause E.3.4).

   Signal generator B shall be unmodulated and shall be adjusted to a frequency 50 kHz above (or below) the nominal frequency.

   Signal generator C shall be modulated with the signal M2 and shall be adjusted to a frequency 100 kHz above (or below) the nominal frequency;

b) initially, signal generators B and C will be switched off. Signal generator A will be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal (specified in subclause E.5.2) at the receiver input terminals. This level is noted;

c) signal generators B and C (providing the unwanted signals) will then be switched on. The output levels of the two signal generators shall be kept equal and adjusted to a value such that a BER of about 10^{-1} is obtained;

d) the normal test signal M1 shall be transmitted whilst observing the BER. The level of the unwanted signal shall be reduced in steps of 1 dB until a BER of 10^{-2} or better is obtained. The level of the input signals shall then be recorded;

e) the intermodulation response is expressed as the value in dB of the input levels of the two signal generators to the level of the wanted signal (generator A);

f) the measurements shall be repeated with the frequencies of the unwanted signals on the other side of the wanted input signal.

E.5.7 Blocking or desensitisation

E.5.7.1 Definition

Blocking is a measure of the capability of the receiver to receive a modulated wanted input signal in the presence of an unwanted input signal on frequencies other than those of the spurious responses or the adjacent channels, without these unwanted input signals causing a degradation of the performance of the receiver beyond a specified limit.

E.5.7.2 Method of measurement

a) Two input signals shall be applied to the receiver via a combining network (see also subclause E.3.2). The wanted signal shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M1 (subclause E.3.4). The amplitude (emf) of the wanted signal shall be adjusted to the level of the wanted signal (specified in subclause E.5.2) at the receiver input terminals;

b) the unwanted signal shall be unmodulated and the frequency shall be varied between + 1 MHz and + 10 MHz also between - 1 MHz and - 10 MHz relative to the nominal frequency of the receiver.

   However for practical reasons, measurements will be carried out at certain frequencies of the unwanted signal at approximately + 1 MHz, + 2 MHz, + 5 MHz and + 10 MHz. At any frequency in the specified range, other than those at which a spurious response could occur (see subclause E.5.5), the level of the unwanted signal shall be adjusted until a BER of less then 10^{-1} is obtained;

c) the normal test signal shall then be transmitted whilst observing the BER. The level of the unwanted signal shall be reduced in steps of 1 dB until a BER of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded;

d) the blocking level is expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal, at the receiver input.

E.5.8 Spurious radiations

E.5.8.1 Definition

Spurious radiations from the receiver are emissions at any frequency, radiated by the equipment and its antenna.

The level of spurious radiations shall be measured by:

a) their power level in a specified load (conducted spurious emission);

   and

b) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation).

E.5.8.2 Method of measuring the power level

Spurious radiations shall be measured as the power level of any discrete signal at the input terminals of the receiver. The receiver input terminals are connected to a spectrum analyser or selective voltmeter having an input impedance of 50 Ω and the receiver is switched on.

If the detecting device is not calibrated in terms of power input, the level of any detected components shall be determined by a substitution method using a signal generator.

The measurements shall extend over the frequency range of 9 kHz to 12,75 GHz.

E.5.8.3 Method of measuring the effective radiated power

On a test site, fulfilling the requirements of subclause E.3.9 and Appendix E.A, subclause E.A.2, the sample shall be placed at the specified height on the non-conducting support. The receiver shall be operated from a power source via a radio frequency filter to avoid radiation from the power leads.

The receiver shall be connected to an artificial antenna (subclause E.3.6), or in case of hand portable equipment with its normal antenna.

Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz to 4 GHz.

At each frequency at which a component is detected, the sample shall be rotated to obtain 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.

E.6 Duplex operation

If the equipment is designed for duplex operation, when submitted for type testing it shall be fitted with a duplex filter and the following additional measurements shall be carried out to ensure satisfactory duplex operation.

E.6.1 Receiver desensitisation with simultaneous transmission and reception

This measurement shall be performed on channels 01, 39 and 78.

E.6.1.1 Definition

The desensitisation is the degradation of the sensitivity of the receiver resulting from the transfer of power from the transmitter to the receiver due to coupling effects. It is expressed as the difference in dB of the maximum usable sensitivity levels, with simultaneous transmission and without.

E.6.1.2 Method of measurement when the equipment has a duplex filter

The antenna terminal of the equipment comprising the receiver, transmitter and duplex filter is connected through a coupling device to the artificial antenna specified in subclause E.3.6. A signal generator modulated by a normal test signal M1 (subclause E.3.4) is connected to the coupling device so that it does not affect the impedance matching. The transmitter is brought into operation at the carrier output power as defined in subclause E.4.2, modulated by a normal test signal M1'. The receiver sensitivity is then measured in accordance with subclause E.5.1.

The output level of the signal generator is recorded as C in dB relative to an emf of 1 µV.

The transmitter is switched off and the receiver sensitivity is again measured.

The output level of the signal generator is recorded as D in dB relative to an emf of 1 µV.

The desensitisation is the difference between the values of C and D.

E.6.1.3 Measuring method when the equipment has to operate with two antennas

The transmitter is connected to an attenuator to dissipate the nominal RF output power of the transmitter the rating of which is declared by the manufacturer. The attenuator output is connected to the receiver input by means of a coupling device and a filter, if the latter is part of the standard equipment. The total attenuation between transmitter and receiver is 30 dB. A signal generator modulated by normal test signal M1 (subclause E.3.4) is connected to the coupling device in such a way as not to affect the impedance matching. The transmitter is brought into operation with an output power as defined in subclause E.4.2, modulated by a normal test signal M1'. The receiver sensitivity is then measured in accordance with subclause E.5.1.

The output level of the signal generator is recorded as C in dB relative to an emf of 1 µV.

This transmitter is then switched off and the receiver sensitivity is measured again.

The output level of the signal generator is recorded as D in dB relative to an emf of 1 µV.

The desensitisation is the difference between the values of C and D.

E.6.2 Receiver spurious response rejection

The receiver spurious response rejection is measured as specified in subclause E.5.5 with the equipment arrangement described in subclause E.6.1.2, except that the transmitter shall be unmodulated. The transmitter shall be operated at the carrier output power as defined in subclause E.4.2.

NOTE: Care should be taken to avoid intermodulation effects caused by the signal from the transmitter under test in the output stage of the signal generator providing the unwanted signal.

E.7 Measurement uncertainty

Absolute measurement uncertainties: maximum values.

Valid up to 1 GHz for the RF parameters unless otherwise stated.

Radio Frequency	$\pm 1 \times 10^{-7}$
RF Power (up to 160 W)	± 0,75 dB
Adjacent channel power	± 5 dB
Conducted emission of transmitter valid up to 12,75 Ghz	± 4 dB
Conducted emission of receiver, valid up to 12,75 GHz	± 3 dB
Two-signal measurement, valid up to 4 GHz	± 4 dB
Three-signal measurement	± 3 dB
Radiated emission of transmitter, valid up to 4 GHz	± 6 dB
Radiated emission of receiver, valid up to 4 GHz	± 6 dB
Transmitter attack and release time	± 1 ms
Transmitter intermodulation	± 3 dB
Receiver desensitisation (duplex operation)	± 0,5 dB

For the test methods according to this I-ETS, the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in ETR 028 [4].

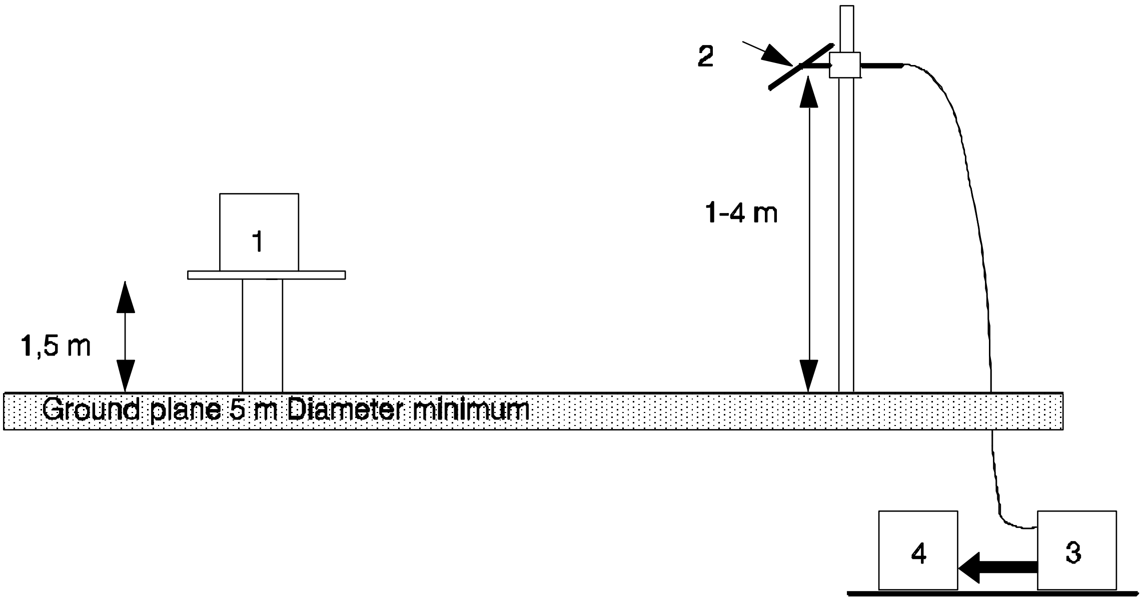
Appendix E.A: Radiated measurements[1]

E.A.1 Test site and general arrangements for measurements involving the use of radiated fields

E.A.1.1 Test site

The 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 m 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 measurements results.



Legend:
1. Equipment under test
2. Test antenna
3. High pass filter (necessary for strong fundamental Tx radiation)
4. Spectrum analyser or measuring receiver

Figure E.A.1

E.A.1.2 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.

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1 The specifications regarding channel separations of 12,5 and 20 kHz do not apply in this I-ETS.

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 signal generator.

E.A.1.3 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 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 m.

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 tuned to 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.

E.A.1.4 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 m by 7 m and at least 2,7 m 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 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 for 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 E.A.2 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, measuring 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 ± 0,10 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 re-sited until a change of less than 2 dB is obtained.

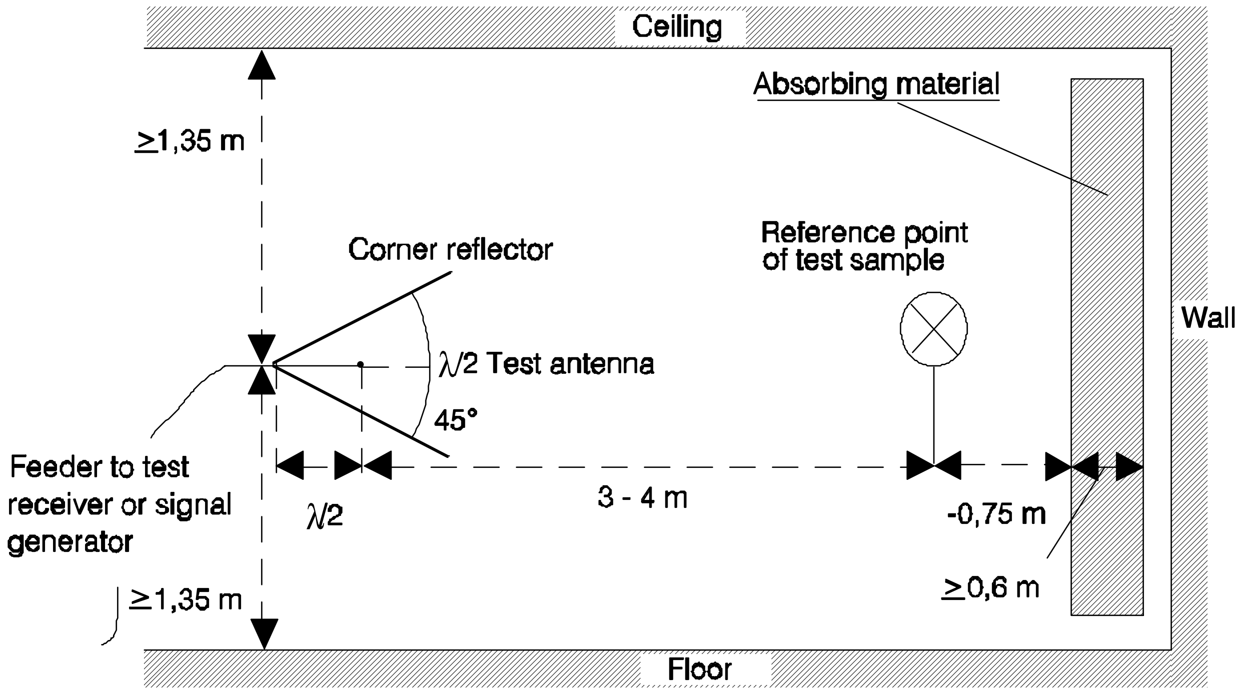


Figure E.A.2: Indoor site arrangement (shown for horizontal polarisation)

E.A.2 Guidance on the use of radiation test sites

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of Clause E.A.1 of this Appendix. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

E.A.2.1 Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than lambda/2 at the frequency of measurement, and the precautions described in this Appendix are observed. Measuring distances of 3, 5, 10 and 30 m are in common use in European test laboratories.

E.A.2.2 Test antenna

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 to 4 m is essential in order to find the point at which the radiation is a maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below about 100 MHz.

E.A.2.3 Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below about 80 MHz.

Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the site. Correction factors shall be taken into account when shortened dipole antennas are used.

E.A.2.4 Artificial antenna

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample.

In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

E.A.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables, etc.) which are not adequately decoupled may cause variations in the measuring results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support).

E.A.2.6 Acoustic measuring arrangement

When carrying out measurements of the maximum usable sensitivity (radiated) of the receiver, the audio output shall be monitored by acoustically coupling the audio signal from the receiver loudspeaker/transducer to the test microphone. On the radiation test site all conducting materials shall be placed below the ground surface and the acoustic signal is conveyed from the receiver to the test microphone in a non-conducting acoustic pipe.

The acoustic pipe shall have an appropriate length. The acoustic pipe shall have an inner diameter of 6 mm and a wall thickness of 1,5 mm. A plastic funnel of a diameter corresponding to the receiver loudspeaker/transducer shall be attached to the receiver surface centred in front of the receiver loudspeaker/transducer. The plastic funnel shall be very soft at the attachment point to the receiver in order to avoid mechanical resonance. The narrow end of the plastic funnel shall be connected to the one end of the acoustic pipe and the test microphone to the other.

E.A.3 Further optional alternative indoor site using an anechoic chamber

For radiation measurements when 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 free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, test receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method, Clause E.A.1. In the range between 30 MHz and 100 MHz some additional calibration may be necessary.

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high.

Walls and ceiling should be coated with RF absorbers of 1 m height.

The base should be covered with absorbing material 1 m thick, and a wooden floor, able to carry test equipment and operators.

A measuring distance of 3 to 5 m in the long middle axis of the chamber can be used for measurements up to 12,75 GHz. The construction of the anechoic chamber is described in the following Clauses.

E.A.3.1 Example of the construction of a shielded anechoic chamber

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers.

Figure E.A.3 shows the requirements for shielding loss and wall return loss of such a room.

As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection).

Attenuation < 20 dB such a room is preferably suitable for measurements above 100 MHz.

Figure E.A.4 shows the construction of a shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed absorbers approximately 1 m high. The base is covered with absorbers which are able to carry and which forms a sort of floor.

The available internal dimensions of the room are 3 m x 8 m x 3 m, so that a measuring distance of maximum 5 m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2 lambda.

The floor absorbers reject floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measuring tolerances have the smallest possible values due to the simple measuring configuration.

For special measurements it can be necessary to re-introduce floor reflections. Taking away the floor absorbers would mean a removal of approximately 24 m^3 absorber material. Therefore the floor absorbers are covered with metal plates of metallic nets instead.

E.A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the distant field the correlation $E = E_o (R_o/R)$ is valid for the dependence of the field strength E on the distance R, whereby E_o is the reference field strength in the reference distance R_o.

It is useful to use just this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation nor antenna mismatch or antenna dimensions are of importance.

Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method shows the disturbances due to reflections more readily and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in subclause E.A.3.1 at low frequencies up to 100 MHz there are no distant field conditions, and therefore reflections are stronger so that careful calibration is necessary.

In the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well.

In the frequency range of 1 to 12,75 GHz, because more reflections will occur, the dependence of the field strength on the distance will not correlate so closely.

E.A.3.3 Calibration of the shielded anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 12,75 GHz.

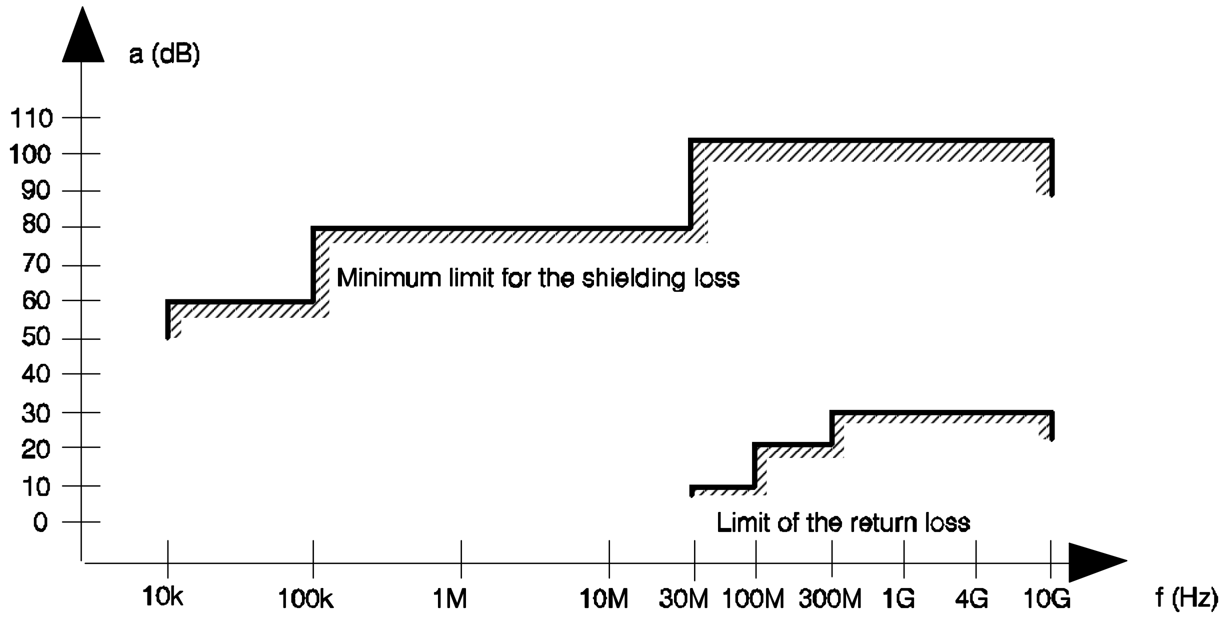


Figure E.A.3: Specifications for shielding and reflections

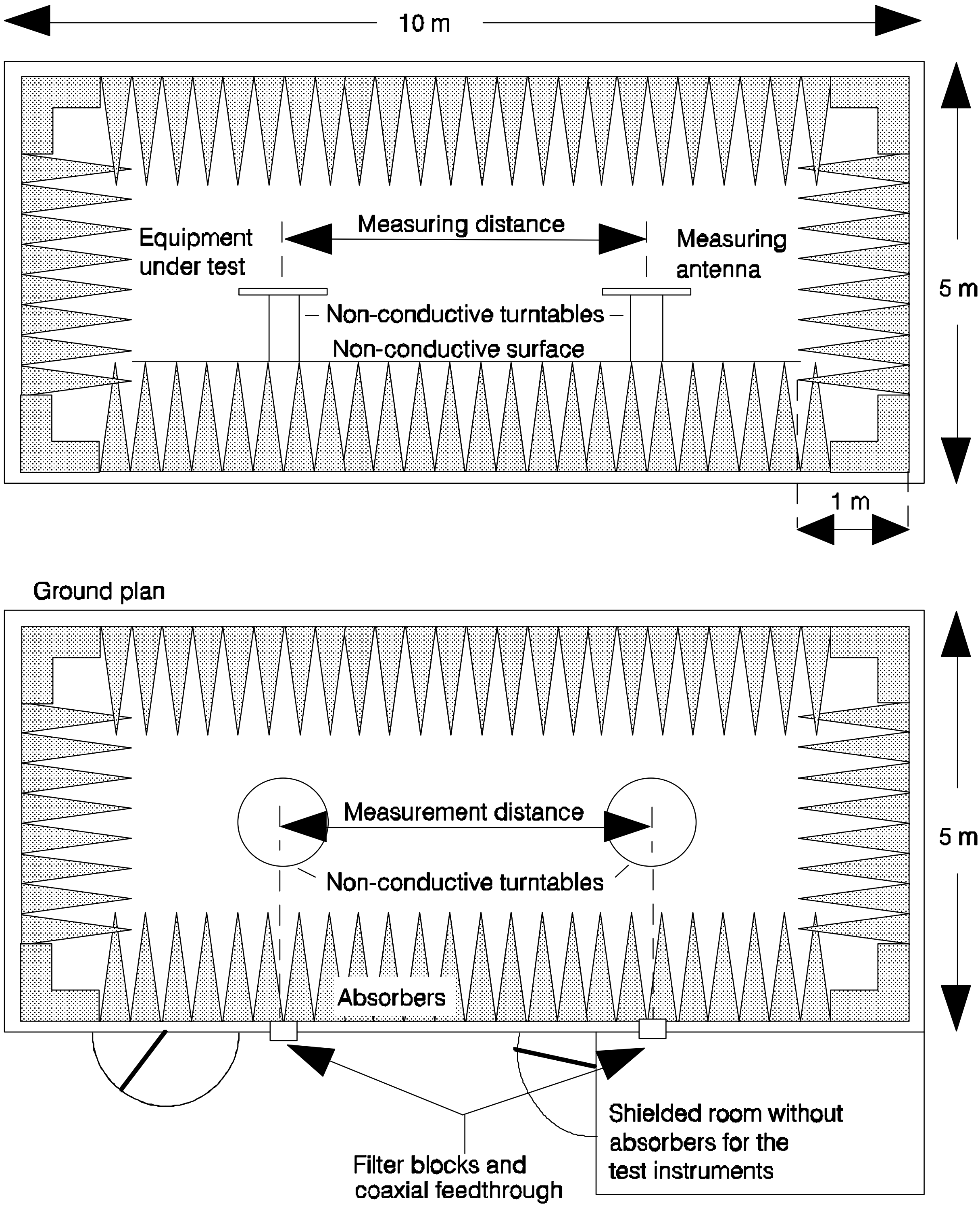


Figure E.A.4: Example of the construction of an anechoic shielded chamber.

Appendix E.B: Specification for some particular measurement arrangements[1]

E.B.1 Power measuring receiver specification

The power measuring receiver consists of a mixer, an IF filter, an oscillator, an amplifier, a variable attenuator and a rms value indicator.

Instead of the variable attenuator with the rms value indicator it is also possible to use a rms voltmeter calibrated in dB. The technical characteristics of the power measuring receiver are given below.

E.B.1.1 IF filter

The IF filter shall be within the limits of the selectivity characteristic of figure E.B.1.

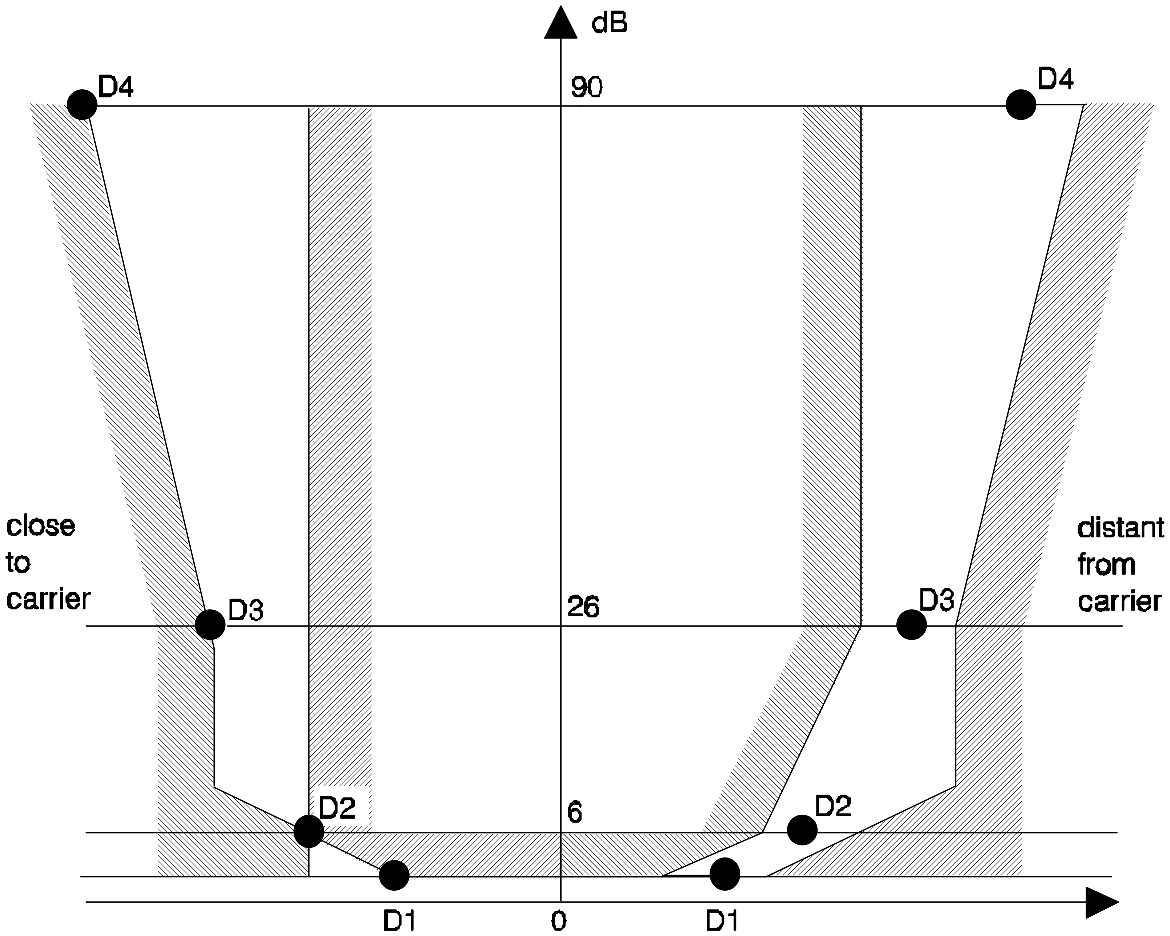


Figure E.B.1

Depending on the channel separation, the selectivity characteristic shall keep the frequency separations from the nominal centre frequency of the adjacent channel as stated in table E.B.1.

1 The specifications regarding channel separations of 12,5 and 20 kHz do not apply in this I-ETS.

Table E.B.1: Selectivity Characteristic

Channel separation (kHz)	Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
	D1	D2	D3	D4
12,5	3	4,25	5,50	9,50
20,0	4	7,00	8,25	12,25
25,0	5	8,00	9,25	13,25

Depending on the channel separation, the attenuation points shall not exceed the tolerances as stated in tables E.B.2 and E.B.3.

Table E.B.2: Attenuation points close to carrier

Channel separation (kHz)	Tolerances range (kHz)			
	D1	D2	D3	D4
12,5	+ 1,35	± 0,1	- 1,35	- 5,35
20,0	+ 3,10	± 0,1	- 1,35	- 5,35
25,0	+ 3,10	± 0,1	- 1,35	- 5,35

Table E.B.3: Attenuation points distant from the carrier

Channel separation (kHz)	Tolerances range (kHz)			
	D1	D2	D3	D4
12,5	± 2,0	± 2,0	± 2,0	+ 2,0 - 6,0
20,0	± 3,0	± 3,0	± 3,0	+ 3,0 - 7,0
25,0	± 3,5	± 3,5	± 3,5	+ 3,5 - 7,5

The minimum attenuation of the filter outside the 90 dB attenuation points must be equal to or greater than 90 dB.

E.B.1.2 Attenuation indicator

The attenuation indicator shall have a minimum range of 80 dB and a reading accuracy of 1 dB. With a view to future regulations an attenuation of 90 dB or more is recommended.

E.B.1.3 Rms value indicator

The instrument shall accurately indicate non-sinusoidal signals in a ratio of up to 10:1 between peak value and rms value.

E.B.1.4 Oscillator and amplifier

The oscillator and the amplifier shall be designed in such a way that the measurement of the adjacent channel power of a low-noise unmodulated transmitter, whose self-noise has a negligible influence on the measurement result, yields a measured value of ≤ - 90 dB for channel separation of 20 and 25 kHz and of ≤ - 80 dB for a channel separation of 12,5 kHz, referred to the carrier of the oscillator.

E.B.2 Spectrum analyser specification

The specification shall include the following requirements:

- it shall be possible, using a resolution bandwidth of 1 kHz, 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 the wanted signal;

- the accuracy of relative amplitude measurements shall be within ± 1 dB;

- for statistically distributed modulations, the spectrum analyser and the integrating device (when appropriate) must allow determination of the real spectral power density (energy per time and bandwidth), which has to be integrated over the bandwidth in question.

E.B.3 Integrating and power summing device

The integrating and power summing device is connected to the video output of the spectrum analyser, referred to in Clause E.B.2.

It shall be possible to summate the effective power of all discrete components, the spectral power density and the noise power in the selected bandwidth and to measure this as a ratio relative to the 14 carrier power.

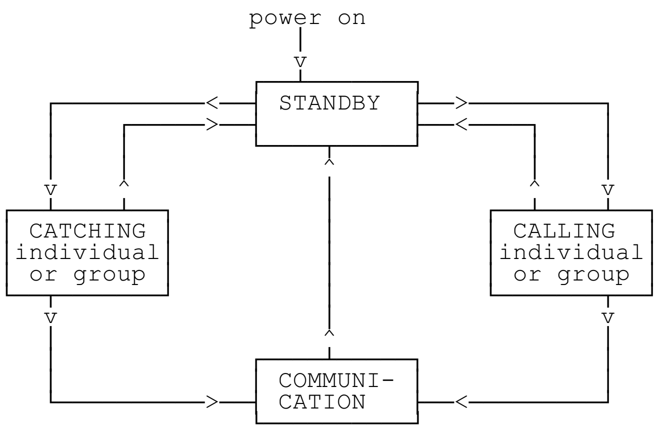
The position and the width of the integration range selected can be indicated on the spectrum analyser by brightening the trace.

Annex F (informative): State transition diagrams for single frequency operation

General remark: throughout this Annex the term "catching" is used for "being called".

F.1 Main operation for a unit (including two frequency operation)

F.1.1 State transition diagram



F.1.2 State transition table

State	Event	Action	Next State
STANDBY	>power on	>equipment ready indication	STANDBY
	>single frequency> call activation by user	call set-up indication	CALLING (single freq.)
	>two frequency call activation by user	>call set-up indication	CALLING (two freq.)
	>reception of a wanted single frequency SSC on CC		CATCHING (single freq.)
	>reception of a wanted two frequency SSC on CC		CATCHING (two freq.)
CALLING	>no free traffic channel located (single freq.)	>system busy indication	STANDBY
	>access not possible on both control channels	>number unobtainable indication	STANDBY
	>re-try procedures failed (individual, single freq.)	>number unobtainable indication	STANDBY
	>unit's re-try procedures failed (two freq.)	>system busy indication	STANDBY
	>no TC SSC received from repeater (two freq.)	>system busy indication	STANDBY
	>TC found occupied	>system busy indication	STANDBY
	>no acknowledgement SSC reception on TC	>system busy indication	STANDBY
	>reception of an unwanted SSC on TC (group, two freq.)	>system busy indication	STANDBY
	>reception of acknowledgement SSC on TC (individual, single & two freq.)	>call ready indication	COMMUNICATION
	>TC detected free (group, single freq.)	>call ready indication	COMMUNICATION
	>reception of identification SSC on TC (group, two freq.)	>call ready indication	COMMUNICATION
	>activation of a user function		STANDBY

(continued)

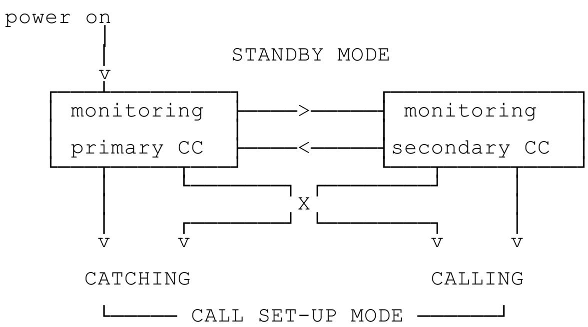
Table concluded

State	Event	Action	Next State
CATCHING	>TC found occupied		STANDBY
	>no wanted SSC reception on		STANDBY
	>reception of an unwanted SSC on TC (group, two freq.)		STANDBY
	>reception of wanted SSC on TC (individual, single & two freq.)	>call ready indication	COMMUNICATION
	>TC detected free (group, single freq.)	>call ready indication	COMMUNICATION
	>reception of identification SSC on TC (two freq.)	>call ready indication	COMMUNICATION
	>activation of a user function		STANDBY
COMMUNI-CATION	>voice sensing timeout occurred	>call termination indication	STANDBY
	>reception of an unwanted SSC	>call termination indication	STANDBY
	>communication timeout occurred	>call termination indication	STANDBY
	>activation of call termination function (two freq. individual		STANDBY
	>reception of call termination sequence (two freq. individual	>call termination indication	STANDBY
	>activation of a user function		STANDBY

*: optional

F.1.3 Standby mode for a unit (single & two frequency)

F.1.3.1 Standby mode state transition diagram

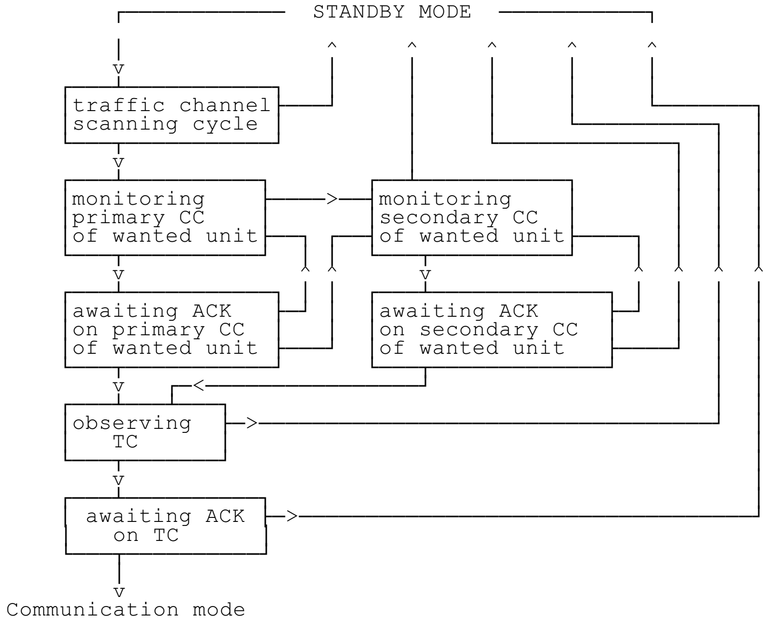


F.1.3.2 Standby mode state transition table

State	Event	Action	Next State
	->power on	>equipment ready indication	standby/ monitoring primary CC
standby/ monitoring primary CC	>single frequency individual call activation by user	>call set-up indication	calling 1f in/ traffic channel scanning cycle
	>two frequency individual call activation by user	>call set-up indication	calling 2f in/ monitoring primary CC of wanted unit
	>single frequency group call activation by user	>call set-up indication	calling 1f gr/ traffic channel scanning cycle
	>two frequency group call activation by user	>call set-up indication	calling 2f gr/ monitoring primary CC of wanted group
	>reception of a wanted single frequency individual SSC on CC	>transmit ACK >switch to TC	catching 1f in/ observing TC
	>reception of a wanted two frequency individual SSC on CC	>if control channel select bit not set, transmit ACK on primary CC and stay on primary CC	catching 2f in/ awaiting TC SSC on indicated CC
		>if control channel select bit set, switch to secondary CC	catching 2f in/ monitoring secondary CC
	>reception of a wanted single frequency group SSC on CC	>switch to TC	catching 1f gr/ observing TC
	>reception of a wanted two frequency group SSC on CC	>switch to TC	catching 2f gr/ awaiting identification SSC on TC
	>spurious signal detected	>switch to opposite CC	standby/ monitoring secondary CC
standby/ receiving on secondary CC	>single frequency individual call activation by user	>call set-up indication	calling 1f in/ traffic channel scanning cycle
	>two frequency individual call activation by user	>call set-up indication	calling 2f in/ monitoring primary CC of wanted unit
	>single frequency group call activation by user	>call set-up indication	calling 1f gr/ traffic channel scanning cycle
	>two frequency group call activation by user	>call set-up indication	calling 2f gr/ monitoring primary CC of wanted unit
	>reception of a wanted single frequency individual SSC on CC	>transmit ACK >switch to TC	catching 1f in/ observing TC
	>reception of a wanted two frequency individual SSC on CC	>if control channel select bit not set, switch to primary CC	catching 2f in/ monitoring primary CC
		>if control channel select bit set, transmit ACK and stay on secondary CC	catching 2f in/ awaiting TC SSC on indicated CC
	>reception of a wanted single frequency group SSC on CC	>switch to TC	catching 1f gr/ observing TC
	>reception of a wanted two frequency group SSC on CC	>switch to TC	catching 2f gr/ awaiting identification SSC on TC
	>secondary CC reception timeout occurred	>switch to opposite CC	standby/ monitoring primary CC

F.1.4 Call set-up mode (calling)

F.1.4.1 Individual call state transition diagram (calling)



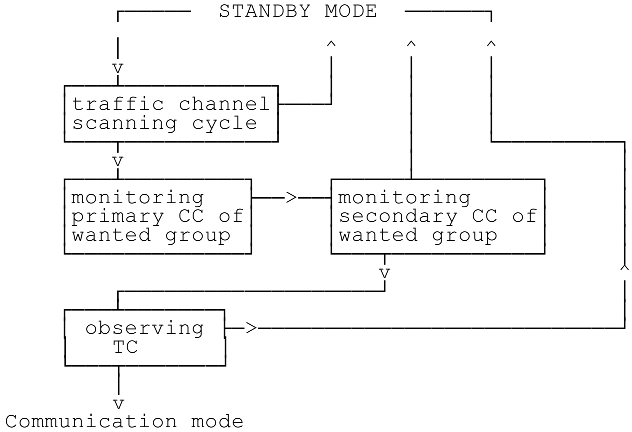
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

F.1.4.2 Individual call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>single frequency individual call activation by user	>call set-up indication	calling 1f in/ traffic channel scanning cycle
calling 1f in/ traffic channel scanning cycle	>free TC located	>set n = 0 (number of call attempts)	calling 1f in/ monitoring primary CC of wanted unit
	>no free TC located after one scanning cycle	>system busy indication	standby/ monitoring primary CC
calling 1f in/ monitoring primary CC of wanted unit	>free CC located	>transmit SSC on CC >n = n + 1	calling 1f in/ awaiting ACK on primary c.c of wanted unit
	>CC not identified free after T_MON_SPUR and n < 2	>n = n + 1	calling 1f in/ monitoring primary CC of wanted unit
	>CC not identified free after T_MON_SPUR and n = 2	>n = n + 1	calling 1f in/ monitoring secondary CC of wanted unit
calling 1f in/ monitoring secondary CC of wanted unit	>free CC located	>transmit SSC on CC >n = n + 1	calling 1f in/ awaiting ACK on secondary CC of wanted unit
	>CC not identified free after T_MON_SPUR and n < 5	>n = n + 1	calling 1f in/ monitoring secondary CC of wanted unit
	>CC not identified free after T_MON_SPUR and n = 5	>number unobtainable indication	standby/ monitoring primary CC
calling 1f in/ awaiting ACK on primary CC	>ACK successfully decoded	>switch to TC	calling 1f in/ observing TC
	>no ACK received within T_RX_ACK and n < 3		calling 1f in/ monitoring primary CC of wanted unit
	>no ACK received within T_RX_ACK and n = 3	>switch to secondary CC of wanted unit	calling 1f in/ monitoring secondary CC of wanted unit
calling 1f in/ awaiting ACK on secondary CC	>ACK successfully decoded	>switch to TC	calling 1f in/ observing TC
	>no ACK received within T_RX_ACK and n < 6		calling 1f in/ monitoring secondary CC of wanted unit
	>no ACK received within T_RX_ACK and n = 6	>number unobtainable indication	standby/ monitoring primary CC
calling 1f in/ observing TC	>TC detected free	>transmit SSC	calling 1f in/ awaiting ACK on TC
	>TC detected occupied	>system busy indication	standby/ monitoring primary CC
calling 1f in/ awaiting ACK on TC	>called unit's ACK successfully decoded	>call ready indication	communication Rx 16 kbit/s
	>no ACK received within T_RX_ACK	>system busy indication	standby/ monitoring primary c.c

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. For n = 2,3,5,6 randomisation applies before transmission.

F.1.4.3 Group call state transition diagram (calling)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

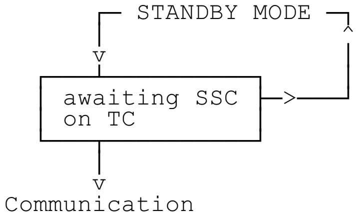
F.1.4.4 Group call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>single frequency group call activation by user	>call set-up indication	calling 1f gr/ traffic channel scanning cycle
calling 1f gr/ traffic channel scanning cycle	>free TC located >no free TC located after one scanning cycle	 >system busy indication	calling 1f gr/ monitoring primary CC of wanted group standby/ monitoring primary CC
calling 1f gr/ monitoring primary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT	>transmit two SSCs on CC	calling 1f gr/ monitoring secondary CC of wanted group "
calling 1f gr/ monitoring secondary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT and free primary CC located >CC not identified free after T_MON_EXT and primary CC was not identified free after T_MON_EXT	>transmit two SSCs on CC >switch to TC >switch to TC >number unobtainable indication	calling 1f gr/ observing TC calling 1f gr/ observing TC standby/ monitoring primary CC
calling 1f gr/ observing TC	>TC detected free >TC detected occupied	>call ready indication >system busy indication	communication Rx 16 kbit/s standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. For n = 2,3,5,6 randomisation applies before transmission.

F.1.5 Call set-up mode (catching)

F.1.5.1 Individual call state transition diagram (catching)



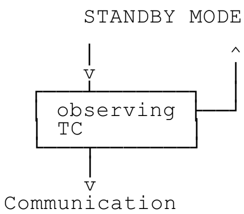
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

F.1.5.2 Individual call state transition table (catching)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>reception of a wanted single frequency individual SSC on CC	>transmit ACK >switch to TC	catching 1f in/ awaiting SSC on TC
catching 1f in/ awaiting SSC on TC	>SSC successfully decoded >no SSC received within T_NO_RX	>transmit ACK >call ready indication	communication Rx 16 kbit/s standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

F.1.5.3 Group call state transition diagram (catching)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

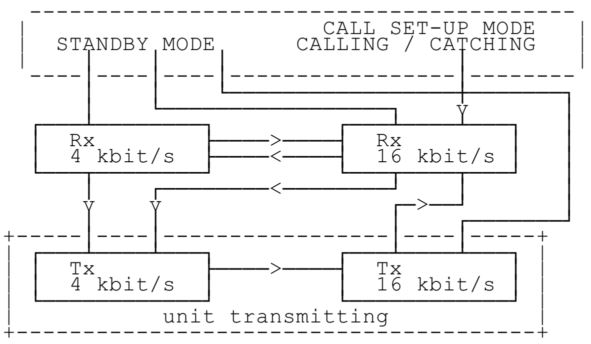
F.1.5.4 Group call state transition table (catching)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>reception of a wanted single frequency group SSC on CC	>switch to TC	catching 1f gr/ observing TC
catching 1f gr/ observing TC	>TC detected free >TC found occupied	>call ready indication	communication Rx 16 kbit/s standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

F.1.6 Communication mode (single & two frequency)

F.1.6.1 Communication mode state transition diagram



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

F.1.6.2 Communication mode state transition table

State	Event	Action	Next State
calling 1f in/ awaiting ACK on TC	>called unit's ACK successfully decoded	>call ready indication	communication Rx 16 kbit/s
calling 2f in/ awaiting ACK on TC	>called unit's ACK successfully decoded	>call ready indication	communication Rx 16 kbit/s
calling 1f gr/ observing TC	>TC detected free	>call ready indication	communication Rx 16 kbit/s
calling 2f gr/ awaiting identification SSC on TC	>identification SSC successfully decoded	>call ready indication	communication Rx 16 kbit/s
catching 1f in/ awaiting SSC on TC	>calling unit's SSC successfully decoded	>transmit ACK >call ready indication	communication Rx 16 kbit/s
catching 2f in/ awaiting SSC on TC	>calling unit's SSC successfully decoded	>transmit ACK >call ready indication	communication Rx 16 kbit/s
catching 1f gr/ observing TC	>TC detected free	>call ready indication	communication Rx 16 kbit/s
catching 2f gr/ awaiting identification SSC on TC	>identification SSC successfully decoded	>call ready indication	communication Rx 16 kbit/s
communication Rx 4 kbit/s	>detection of a wanted SSC		communication Rx 16 kbit/s
communication Rx 4 kbit/s	>T_MON_TC expired without successfully decoding an SSC		communication Rx 16 kbit/s
communication Rx 4 kbit/s	>activation of transmission function by user	>transmit SSC	communication Tx 4 kbit/s
communication Rx 4 kbit/s	>voice sensing timeout occurred	>call termination indication	standby/ monitoring primary CC
communication Rx 4 kbit/s	>detection of an unwanted SSC	>call termination indication	standby/ monitoring primary CC
communication Rx 4 kbit/s	>communication timeout occurred	>call termination indication	standby/ monitoring primary CC
*	>activation of call termin-ation function (two freq., individual)	>transmit call termin-ation, sequence	communication Tx 4 kbit/s
*	>detection of call termina-tion sequence (two freq., individual)	>call termination indication	standby/ monitoring primary CC
communication Rx 16 kbit/s	>activation of transmission function by user and no valid voice/data reception	>transmit SSC	communication Tx 4 kbit/s
communication Rx 16 kbit/s	>4 kbit/s modulation detected		communication Rx 4 kbit/s
communication Rx 16 kbit/s	>voice sensing timeout occurred	>call termination indication	standby/ monitoring primary CC
communication Rx 16 kbit/s	>communication timeout occurred	>call termination indication	standby/ receiving on primary CC
*	>activation of call termina-tion sequence (two freq., individual)	>transmit call termi-nation sequence	communication Tx 4 kbit/s
communication Tx 4 kbit/s	> SSC transmitted>	transmit voice/data	communication Tx 16 kbit/s
*	>call termination sequence transmitted (two freq., individual)		standby/ monitoring primary CC
communication Tx 16 kbit/s	>deactivation of transmitter function by user		communication Rx 16 kbit/s
communication Tx 16 kbit/s	>communication timeout occurred	>call termination indication	standby/ monitoring primary CC

*: optional

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

Annex G (informative): State transition diagrams for two frequency operation

General remark: throughout this Annex the term "catching" is used for "being called".

G.1 Main operation for a unit

G.1.1 State transition diagram

See Annex F, subclause F.1.1.

G.1.2 State transition table

See Annex F, subclause F.1.2.

G.1.3 Standby mode

See Annex F, subclause F.1.3.

G.1.3.1 Standby mode state transition diagram

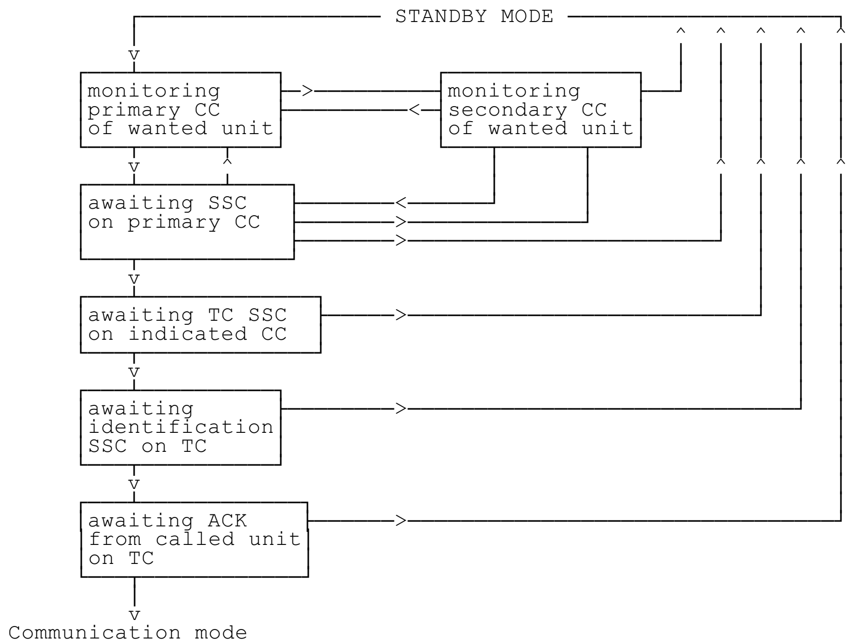
See Annex F, subclause F.1.3.1.

G.1.3.2 Standby mode state transition table

See Annex F, subclause F.1.3.2.

G.1.4 Call set-up mode (calling)

G.1.4.1 Individual call state transition diagram (calling)



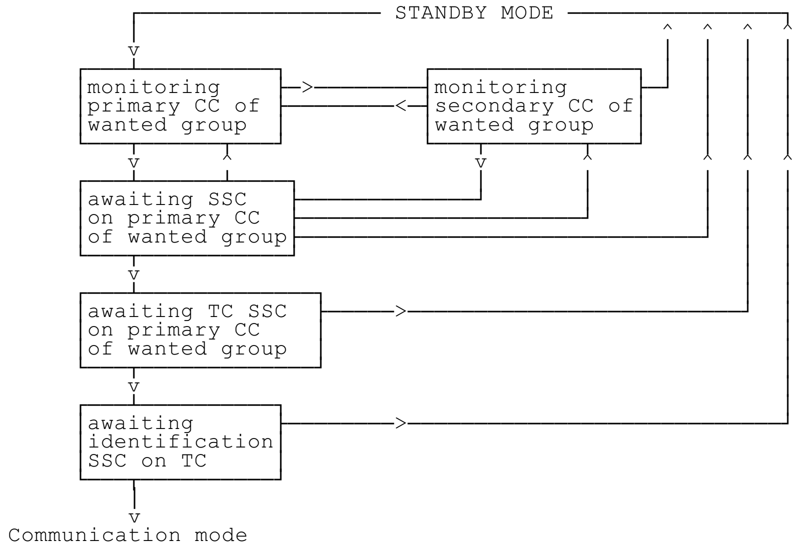
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

G.1.4.2 Individual call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>two frequency individual call activation by user	>call set-up indication >set n = 0 (number of call attempts)	calling 2f in/ monitoring primary CC of wanted unit
calling 2f in/ monitoring primary CC wanted unit	>free CC located >CC not identified free after T_MON_SPUR	>transmit SSC on LB CC >n = n + 1 >n = n + 1	calling 2f in/ awaiting SSC on primary of c.c calling 2f in/ monitoring secondary CC of wanted unit
calling 2f in/ monitoring secondary CC of wanted unit	>free CC located >CC not identified free after T_MON_SPUR and n < 5 >CC not identified free after T_MON_SPUR and n = 5	>transmit SSC on LB CC >switch to primary CC >n = n + 1 >n = n + 1 >number unobtainable indication	calling 2f in/ awaiting SSC on primary CC calling 2f in/ monitoring primary CC of wanted unit standby/ monitoring primary CC
calling 2f in/ awaiting SSC on primary CC	>SSC successfully decoded >no SSC received within T_INT_ACK, n even and n < 6 >no SSC received within T_INT_ACK, n odd and n < 6 >no SSC received within T_INT_ACK and n = 6	>if control channel select bit is set, switch to opposite CC >number unobtainable indication	calling 2f in/ awaiting TC SSC on indicated CC calling 2f in/ monitoring primary CC of wanted unit calling 2f in/ monitoring secondary CC of wanted unit standby/ monitoring primary CC
calling 2f in/ awaiting TC SSC on indicated CC	>TC SSC successfully decoded >no TC SSC received within T_TRAF_A	>switch to TC >system busy indication	calling 2f in/ awaiting identification SSC on TC standby/ monitoring primary CC
calling 2f in/ awaiting identification SSC on TC	>identification SSC successfully decoded >no identification SSC received within T_REP_ID_IN	>transmit own SSC >system busy indication	calling 2f in/ awaiting ACK on TC standby/ monitoring primary CC
calling 2f in/ awaiting ACK on TC	>called unit's ACK successfully decoded >no ACK received within T_RX_ACK + 2(T_SSC_DELAY)	>call ready indication >system busy indication	communication Rx 16 kbit/s standby/ monitoring primary c.c

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. For n = 2,3,5,6 randomisation applies before transmission.

G.1.4.3 Group call state transition diagram (calling)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

G.1.4.4 Group call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>two frequency group call activation by user	>call set-up indication >set n = 0 (number of call attempts)	calling 2f gr monitoring primary CC of wanted group
calling 2f in/ monitoring primary CC of wanted group	>free CC located	>transmit SSC on LB CC >n = n + 1	calling 2f in/ awaiting SSC on primary CC of wanted group
	>CC not identified free after T_MON_SPUR	>n = n + 1	calling 2f in/ monitoring secondary CC of wanted group
calling 2f in/ monitoring secondary CC of wanted group	>free CC located	>transmit SSC on LB CC >n = n + 1	calling 2f in/ awaiting SSC on primary CC of wanted group
	>CC not identified free after T_MON_SPUR and n < 5	>n = n + 1	calling 2f in/ monitoring primary CC of wanted group
	>CC not identified free after T_MON_SPUR and n = 5	>number unobtainable indication	standby/ monitoring primary CC

(continued)

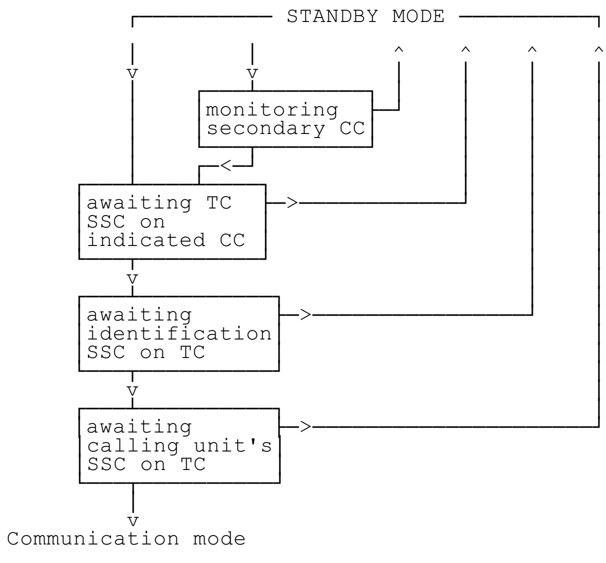
Table concluded

State	Event	Action	Next State
calling 2f in/ awaiting SSC on primary CC of wanted group	>SSC successfully decoded		calling 2f in/ awaiting TC SSC on primary CC
	>no SSC received within T_INT_ACK, n even and n < 6		calling 2f in/ monitoring primary CC of wanted unit
	>no SSC received within T_INT_ACK, n odd and n < 6		calling 2f in/ monitoring secondary CC of wanted group
	>no SSC received within T_INT_ACK and n = 6	>number unobtainable indication	standby/ monitoring primary CC
calling 2f in/ awaiting TC SSC on primary CC	>TC SSC successfully decoded	>switch to TC	calling 2f in/ awaiting identification SSC on TC
	>no TC SSC received within T_TRAF_A	>system busy indication	standby/ monitoring primary CC
calling 2f in/ awaiting identification SSC on TC	>identification SSC successfully decoded		communication Rx 16 kbit/s
	>no identification SSC received within T_REP_ID_GR	>system busy indication	standby/ monitoring primary CC
	>detection of an unwanted SSC	>system busy indication	standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. For n = 2,3,5,6 randomisation applies before transmission.

G.1.5 Call set-up mode (catching)

G.1.5.1 Individual call state transition diagram (catching)



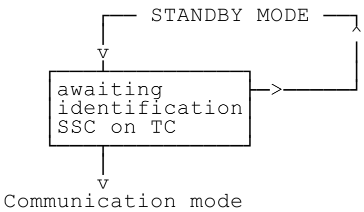
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

G.1.5.2 Individual call state transition table (catching)

State	Event	Action	Next State
standby/ monitoring primary CC	>reception of a wanted two frequency individual SSC on CC	>if control channel select bit not set, transmit ACK on primary CC and stay on primary CC	catching 2f in/ awaiting TC SSC on indicated CC
		>if control channel select bit set, switch to secondary CC	catching 2f in/ monitoring secondary CC
standby/ monitoring secondary CC	>reception of a wanted two frequency individual SSC on CC	>if control channel select bit not set, switch to primary CC	catching 2f in/ monitoring primary CC
		>if control channel select bit set, transmit ACK and stay on secondary CC	catching 2f in/ awaiting TC SSC on indicated CC
catching 2f in/ monitoring secondary CC	>free CC located	>transmit ACK on secondary CC	catching 2f in/ awaiting TC SSC on indicated CC
	>CC not identified free after T_MON_SPUR		standby/ monitoring primary CC
catching 2f in/ awaiting TC SSC on indicated CC	>TC SSC successfully decoded	>switch to TC	catching 2f in/ awaiting identification SSC on TC
	>no TC SSC received within T_TRAF_B		standby/ monitoring primary CC
catching 2f in/ awaiting identification SSC on TC	>identification SSC successfully decoded		catching 2f in/ awaiting calling unit's SSC on TC
	>no identification SSC received within T_REP_ID_IN		standby/ monitoring primary CC
catching 2f in/ awaiting calling unit's SSC on TC	>calling unit's SSC successfully decoded	>transmit ACK >call ready indication	communications
	>no SSC received within T_SLOT + T_SSC_DELAY		Rx 16 kbit/s standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

G.1.5.3 Group call state transition diagram (catching)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

G.1.5.4 Group call state transition table (catching)

State	Event	Action	Next State
standby/ monitoring primary CC monitoring secondary CC	>reception of a wanted two frequency group SSC on CC	>switch to TC	catching 2f in/ awaiting identification SSC on TC
catching 2f in/ awaiting identification SSC on TC	>identification SSC successfully decoded		communication
	>no identification SSC received within T_REP_ID_GR		Rx 16 kbit/s standby/ monitoring primary CC
	>detection of an unwanted SSC		standby/ monitoring primary CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

G.1.6 Communication mode

See Annex F, subclause F.1.6.

G.1.6.1 Communication mode state transition diagram

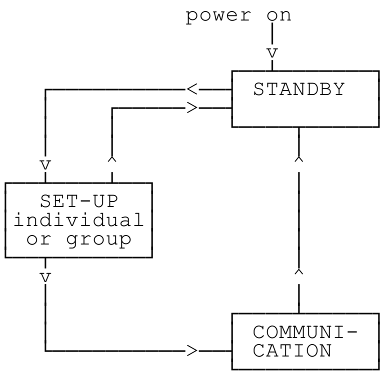
See Annex F, subclause F.1.6.1.

G.1.6.2 Communication mode state transition table

See Annex F, subclause F.1.6.2.

G.2 Main operation for a repeater

G.2.1 State transition diagram



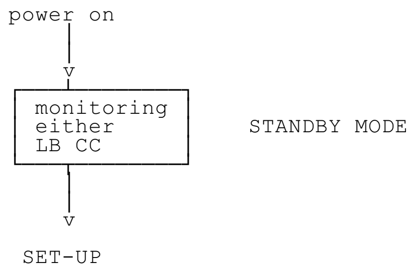
G.2.2 State transition table

State	Event	Action	Next State
STANDBY	>power on >reception of a wanted two frequency SSC on LB CC		STANDBY SET-UP
SET-UP	>no free traffic channel located >access not possible on both control channels >re-try procedures failed (individual) >TC found occupied >TC found free SSC on TC	>transmit identification	STANDBY STANDBY STANDBY STANDBY COMMUNICATION
COMMUNICATION	>voice sensing timeout occurred >reception of an unwanted SSC >reception of call termination sequence	>stop retransmission >retransmit SSC >retransmit sequence	STANDBY STANDBY STANDBY

*: optional

G.2.3 Standby mode

G 2.3.1 Standby mode state transition diagram



NOTE: Free traffic channel identification procedure not shown on diagram.

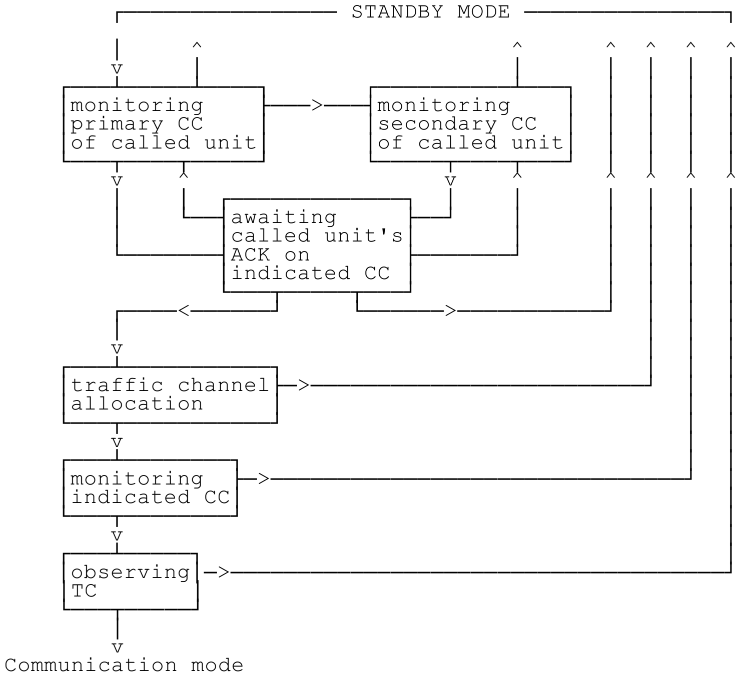
G.2.3.2 Standby mode state transition table

State	Event	Action	Next State
	>power on		standby/ monitoring either LB CC
standby/ monitoring either LB CC	>reception of a wanted two frequency individual SSC on CC >reception of a wanted two frequency group SSC on CC >spurious signal detected	 >switch to opposite CC	set-up 2f in/ monitoring primary CC of called unit set-up 2f gr/ monitoring primary CC of wanted group standby/ monitoring either LB CC

NOTE: Free traffic channel identification procedure not shown in table.

G.2.4 Set-up mode

G.2.4.1 Individual call state transition diagram



G.2.4.2 Individual call state transition table

State	Event	Action	Next State
standby/ monitoring either LB CC	>reception of a wanted two frequency individual SSC on CC	>set n = 0 (number of call attempts)	set-up in/ monitoring primary CC of wanted unit
set-up in/ monitoring primary CC of wanted unit	>free CC located >CC not identified free after T_MON_SPUR and n = 0 >CC not identified free after T_MON_SPUR and n = 1	>transmit SSC (with control channel select bit set to appropriate value) >n = n + 1 >n = n + 1	set-up in/ awaiting called unit's ACK on indicated CC standby/ monitoring either LB CC set-up in/ monitoring secondary CC of called unit
set-up in/ monitoring secondary CC of called unit	>free CC located >CC not identified free after T_MON_SPUR and n = 2 >CC not identified free after T_MON_SPUR and n = 3	>transmit SSC (with control channel select bit set to appropriate value) >n = n + 1 >n = n + 1	set-up in/ awaiting called unit's ACK on indicated CC set-up in/ monitoring secondary CC of called unit standby/ monitoring either LB CC

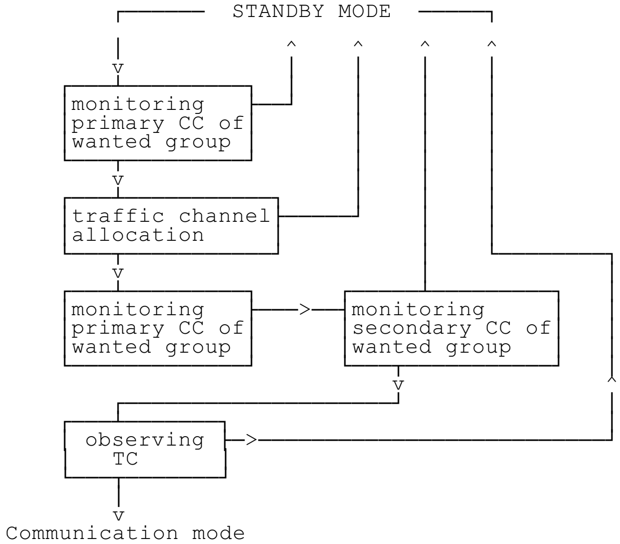
(continued)

Table concluded

State	Event	Action	Next State
set-up in/ awaiting called unit's ACK on indicated CC called unit within	>called unit's ACK successfully decoded		set-up in/ traffic channel allocation
	>no ACK received from T_RX_ACK (called unit does not have to switch channel) and n = 1		set-up in/ monitoring primary CC of called unit
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 1		"
	>no ACK received from called unit within T_RX_ACK (called unit does not have to switch channel) and n = 2 or n = 3		set-up in/ monitoring secondary CC of called unit
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 2 or n = 3		"
	>no ACK received from called unit within T_RX_ACK (called unit does not have to switch channel) and n = 4		standby/ monitoring either LB CC
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 4		"
set-up in/ traffic channel allocation	>free TC located		set-up in/ monitoring indicated CC
	>no free TC located		standby/ monitoring either LB CC
set-up in/ monitoring indicated CC	>free CC located	>transmit two TC SSCs	set-up in/ observing TC
	>CC not identified free after T_MON_EXT		standby/ monitoring either LB CC
set-up in/ observing TC	>TC detected free	>transmit identification SSC on TC	communication Rx & Tx 16 kbit/s
	>TC detected occupied		standby/ monitoring either LB CC

NOTE: For n = 2,4 randomisation applies before transmission.

G.2.4.3 Group call state transition diagram

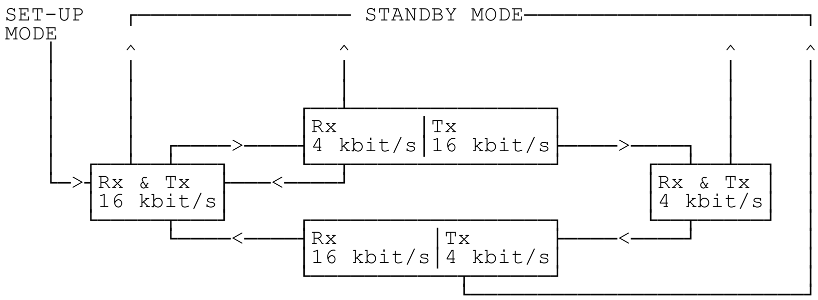


G.2.4.4 Group call state transition table

State	Event	Action	Next State
standby/ monitoring either LB CC	>reception of a wanted two frequency group SSC on CC and SSC valid		set-up gr/ monitoring primary CC of wanted group
set-up gr/ monitoring primary CC of wanted group	>free CC located >CC not identified free after T_MON_SPUR	>retransmit SSC	set-up gr/ traffic channel allocation standby/ monitoring either LB CC
set-up gr/ traffic channel allocation	>free TC located >no free TC located		set-up gr/ monitoring primary CC of wanted group standby/ monitoring either LB CC
set-up gr/ monitoring primary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT	>transmit two TC SSCs on CC	set-up gr/ monitoring secondary CC of wanted group
set-up gr/ monitoring secondary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT and free primary CC located >CC not identified free after T_MON_EXT and primary CC was not identified free after T_MON_EXT	>transmit two TC SSCs on CC >switch to TC >switch to TC	set-up gr/ observing TC set-up gr/ observing TC standby/ monitoring either LB CC
set-up gr/ observing TC	>TC detected free >TC detected occupied	>transmit identification SSC on TC	communication Rx & Tx 16 kbit/s standby/ monitoring either LB CC

G.2.5 Communication mode

G.2.5.1 Communication mode state transition diagram



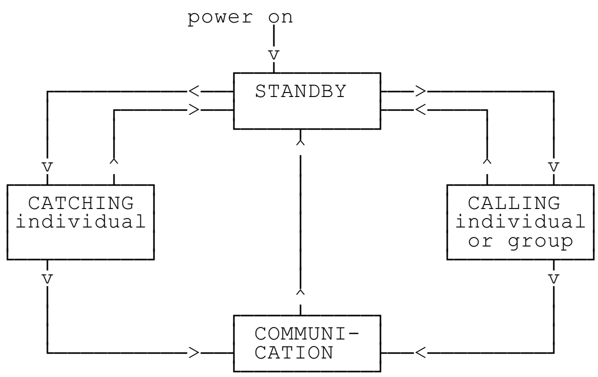
G.2.5.2 Communication mode state transition table

State	Event	Action	Next State
set-up in/ observing TC set-up gr/ observing TC	>TC detected free	>transmit identification SSC on TC	communication Rx & Tx 16 kbit/s
communication Rx & Tx 16 kbit/s	4 kbit/s modulation detected		communication Rx 4 kbit/s/ Tx 16 kbit/s
	>voice sensing timeout occurred		standby/ monitoring either LB CC
communication Rx 4 kbit/s/ Tx 16 kbit/s	>SSC successfully decoded (wanted or unwanted)	>retransmit SSC	communication Rx & Tx 4 kbit/s
	>no successfully decoded SSC within T_MON_TC		communication Rx & Tx 16 kbit/s
	>voice sensing timeout occurred		standby/ monitoring either LB CC
*	>call termination sequence detected (individual)	>retransmit call termination sequence	communication Rx & Tx 4 kbit/s
communication Rx & Tx 4 kbit/s	>SSC successfully identified as completed		communication Rx 16 kbit/s/ Tx 4 kbit/s
	>voice sensing timeout occurred		standby/ monitoring either LB CC
*	>call termination sequence identified as completed (individual)		communication Rx 16 kbit/s/ Tx 4 kbit/s
communication Rx 16 kbit/s/ Tx 4 kbit/s	>wanted SSC transmitted		communication Rx & Tx 16 kbit/s
	>unwanted SSC transmitted		standby/ monitoring either LB CC
*	>call termination sequence transmitted (individual)		standby/ monitoring either LB CC

*: optional

G.3 Main operation for a master unit

G.3.1 State transition diagram



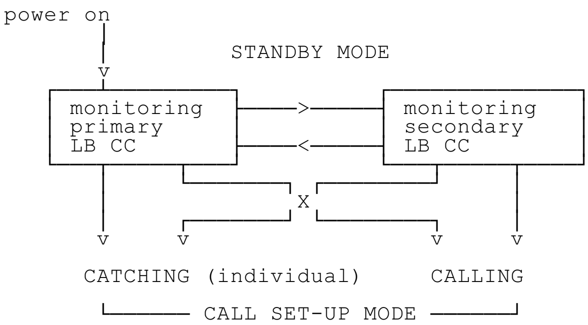
G.3.2 State transition table

State	Event	Action	Next State
STANDBY	>power on	>equipment ready indication	STANDBY
	>two frequency call activation by user	>call set-up indication	CALLING
	>reception of a wanted two frequency SSC on LB CC (individual only)	CATCHING	
CALLING	>no free traffic channel located	>system busy indication	STANDBY
	>access not possible on both control channels	>number unobtainable indication	STANDBY
	>re-try procedures failed (individual)	>number unobtainable indication	STANDBY
	>TC found occupied	>system busy indication	STANDBY
	>no acknowledgement SSC reception on TC (individual)	>system busy indication	STANDBY
	>reception of acknowledge-ment SSC on TC (individual)	>call ready indication	COMMUNICATION
	>identification SSC transmitted (group)	>call ready indication	COMMUNICATION
	>activation of a user function		STANDBY
CATCHING (individual)	>no free traffic channel located		STANDBY
	>access not possible on own primary CC		STANDBY
	>TC found occupied		STANDBY
	>no wanted SSC reception on TC		STANDBY
	>reception of wanted SSC on TC	>call ready indication	COMMUNICATION
	>activation of a user function		STANDBY
COMMUNICATION	>voice sensing timeout occurred	>call termination indication	STANDBY
	>reception of an unwanted SSC	>call termination indication	STANDBY
	>communication timeout occurred	>call termination indication	STANDBY
	>activation of call termination function (individual)		STANDBY
*	>reception of call termination sequence (individual)	>call termination indication	STANDBY
	>activation of a user function		STANDBY

*: optional

G.3.3 Standby mode

G.3.3.1 Standby mode state transition diagram



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram. Free traffic channel identification procedure not shown on diagram.

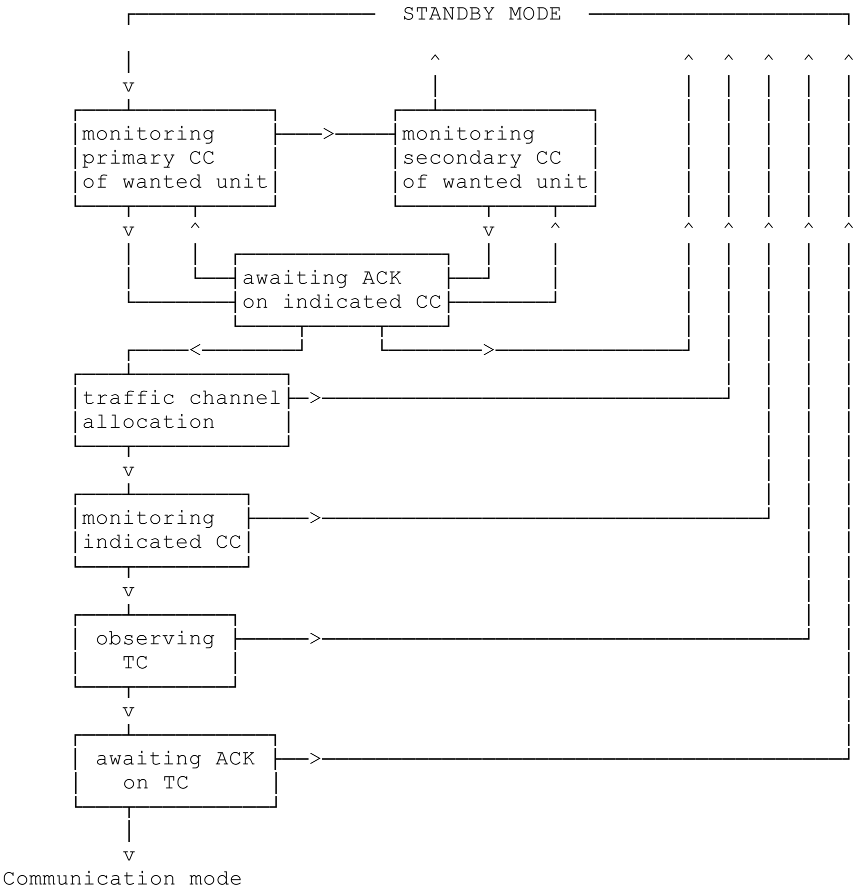
G.3.3.2 Standby mode state transition table

State	Event	Action	Next State
			monitoring primary LB CC
standby/ monitoring primary LB CC	>individual call activation by user >group call activation by user >reception of a wanted individual SSC on CC >spurious signal detected	>call set-up indication >call set-up indication >switch to opposite CC	calling in/ monitoring primary CC of wanted unit calling gr/ traffic channe allocation catching in/ traffic channel allocation standby/ monitoring secondary LB CC
standby/ monitoring secondary LB CC	>individual call activation by user >group call activation by user >reception of a wanted individual SSC on CC >spurious signal detected	>call set-up indication >call set-up indication >switch to opposite CC	calling in/ monitoring primary CC of wanted unit calling gr/ traffic channel allocation catching in/ traffic channel allocation standby/ monitoring primary LB CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. Free traffic channel identification procedure not shown on diagram.

G.3.4 Call set-up mode (calling)

G.3.4.1 Individual call state transition diagram (calling)



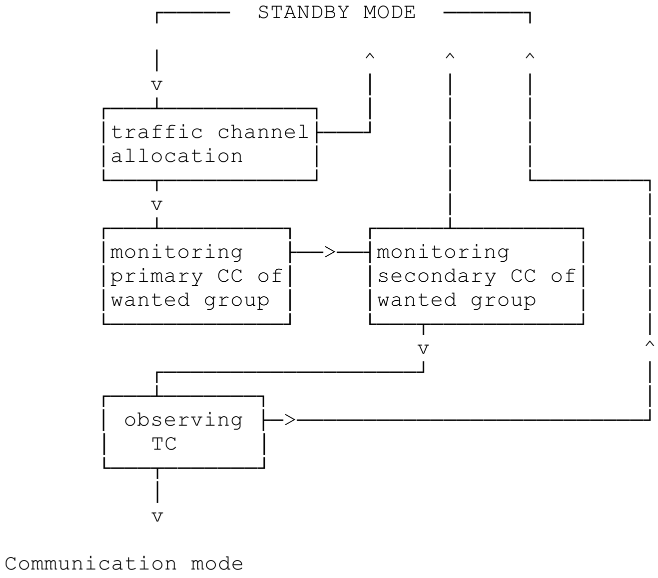
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

G.3.4.2 Individual call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary LB CC monitoring secondary LB CC	>individual call activation by user	>call set-up indication >set n = 0 (number of call attempts)	calling in/ monitoring primary CC of wanted unit
set-up in/ monitoring primary CC of called unit	>free CC located	>transmit SSC to called unit on CC with control channel select bit not set CC >n = n + 1	set-up in/ awaiting ACK on indicated
	>free CC located and spurious signal on unit's LB primary channel detected	>transmit SSC to called unit on CC with control channel select bit set n = n + 1	"
	>CC not identified free after T_MON_SPUR and n = 0	>n = n + 1	set-up in/ monitoring primary CC of called unit
	>CC not identified free after T_MON_SPUR and n = 1	>n = n + 1	set-up in/ monitoring secondary CC of called unit
set-up in/ monitoring secondary CC of called unit	>free CC located control channel select bit	>transmit SSC to called unit on CC with unit's ACK on not set >n = n + 1	set-up in/ awaiting called primary CC
	>free CC located and spurious signal on unit's LB primary channel detected	>transmit SSC to called unit on CC with control channel select bit set >n = n + 1	set-up in/ awaiting called unit's ACK on secondary CC
	>CC not identified free after T_MON_SPUR and n = 2	>n = n + 1 secondary CC	set-up in/ monitoring of wanted unit
	>CC not identified free after T_MON_SPUR and n = 3	>number unobtainable indication	standby/ monitoring primary LB CC
set-up in/ awaiting called unit's ACK on indicated CC	>called unit's ACK successfully decoded		set-up in/ traffic channel allocation
	>no ACK received from called unit within T_RX_ACK (called unit does not have to switch channel) and n = 1		set-up in/ monitoring primary CC of called unit
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 1		"
	>no ACK received from called unit within T_RX_ACK (called unit does not have to switch channel) and n = 2 or n = 3		set-up in/ monitoring secondary CC of called unit
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 2 or n = 3		"
	>no ACK received from called unit within T_RX_ACK (called unit does not have to switch channel) and n = 4		standby/ monitoring primary LB CC
	>no ACK received from called unit within T_MON_SPUR + T_RX_ACK (called unit has to switch channel) and n = 4	>number unobtainable indication	"
calling in/ traffic channel allocation	>free TC located		calling in/ monitoring indicated CC
	>no free TC located	>system busy indication	standby/ monitoring primary CC
calling in/ monitoring indicated CC	>free CC located	>transmit two TC SSCs	calling in/ observing TC
	>CC not identified free after T_MON_EXT	>system busy indication	standby/ monitoring primary CC
calling in/ observing TC	>TC detected free	>transmit identification SSC, followed by TC SSC	calling in/ awaiting ACK on TC
	>TC detected occupied	>system busy indication	standby/ monitoring primary CC
calling in/ awaiting ACK on TC	>called unit's ACK successfully decoded	>call ready indication	communication Rx & Tx 16 kbit/s
	>no ACK received within T_RX_ACK	>system busy indication	standby/ monitoring

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table. For n = 2,4 randomisation applies before transmission.

G.3.4.3 Group call state transition diagram (calling)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

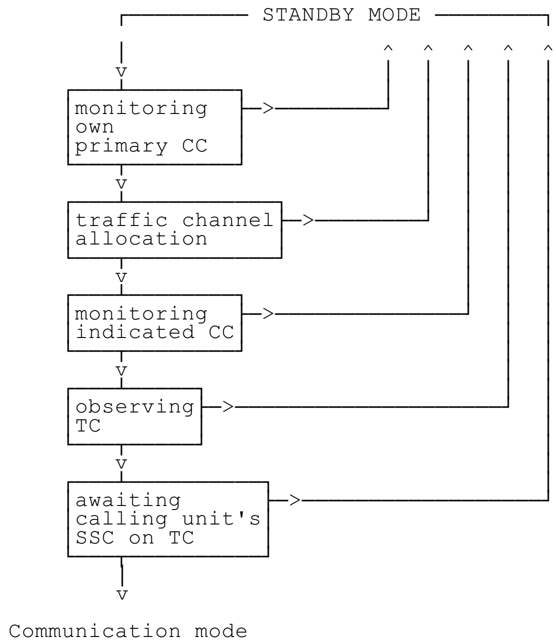
G.3.4.4 Group call state transition table (calling)

State	Event	Action	Next State
standby/ monitoring primary LB CC monitoring secondary LB CC	>two frequency group call activation by user	>call set-up indication	calling gr/ traffic channel allocation
calling gr/ traffic channel allocation	>free TC located >no free TC located	 >system busy indication	calling gr/ monitoring primary CC of wanted group standby/ monitoring primary LB CC
calling gr/ monitoring primary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT	>transmit two SSCs on CC	calling gr/ monitoring secondary CC of wanted group
calling gr/ monitoring secondary CC of wanted group	>free CC located >CC not identified free after T_MON_EXT and free primary CC located >CC not identified free after T_MON_EXT and primary CC was not identified free after T_MON_EXT	>transmit two SSCs on CC >switch to TC >switch to TC >number unobtainable indication	calling gr/ observing TC calling gr/ observing TC standby/ monitoring primary LB CC
calling gr/ observing TC	>TC detected free >TC detected occupied	>transmit identification SSC >call ready indication >system busy indication	communication Rx & Tx 16 kbit/s standby/ monitoring primary LB CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

G.3.5 Call set-up mode (catching)

G.3.5.1 Individual call state transition diagram (catching)



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram.

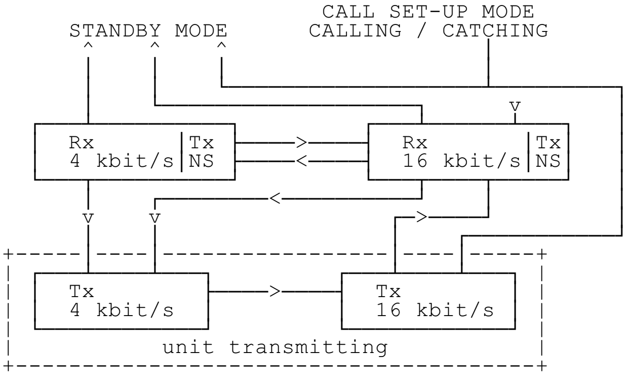
G.3.5.2 Individual call state transition table (catching)

State	Event	Action	Next State
standby/ monitoring primary LB CC monitoring secondary LB CC	>reception of a wanted two frequency individual SSC on CC		catching in/ monitoring own primary
catching in/ monitoring own primary	>free CC located >CC not identified free after T_MON_SPUR	>retransmit SSC (with control channel select bit set to appropriate value) >switch CC if control channel selection bit set	catching in/ traffic channel allocation standby/ monitoring primary LB CC
catching in/ traffic channel allocation	>free TC located >no free TC located		catching in/ monitoring indicated CC standby/ monitoring primary LB CC
catching in/ monitoring indicated CC	>free CC located >CC not identified free after T_MON_EXT	>transmit two TC SSCs	catching in/ observing TC standby/ monitoring primary LB CC
catching in/ observing TC	>TC detected free >TC detected occupied	>transmit identification SSC on TC	catching in/ awaiting calling unit's SSC on TC standby/ monitoring primary LB CC
catching in/ awaiting calling unit's SSC on TC	>SSC successfully decoded >no SSC received within T_SLOT	>transmit ACK	communication Rx & Tx 16 kbit/s standby/ monitoring primary LB CC

NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

G.3.6 Communication mode

G.3.6.1 Communication mode state transition diagram



NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown on the diagram. NS is the abbreviation for "Null Signal".

G.3.6.2 Communication mode state transition table

State	Event	Action	Next State
calling in/ awaiting ACK on TC	>called unit's ACK successfully decoded	>call ready indication	communication Rx 16 kbit/s/ Tx NS
calling gr/ observing TC	>TC detected free	>transmit identification SSC	
catching in/ awaiting calling unit's SSC on TC	>SSC successfully decoded	>call ready indication >transmit ACK	
communication Rx 16 kbit/s/ Tx NS	>4 kbit/s modulation detected		communication Rx 4 kbit/s/ Tx NS
	>voice sensing timeout occurred	>call termination indication	standby/ monitoring primary LB CC
	>communication timeout occurred	>call termination indication	standby/ monitoring primary LB CC
	>activation of transmission function by user and no valid voice/data reception	>transmit SSC	communication Tx 4 kbit/s
*	>activation of call termination function (individual)	>transmit call termination sequence	communication Tx 4 kbit/s
communication Rx 4 kbit/s/ Tx NS	>detection of a wanted SSC		communication Rx 16 kbit/s/ Tx NS
	>T_MON_TC expired without successfully decoding an SSC		communication Rx 16 kbit/s/ Tx NS
	>activation of transmission function by user	>transmit SSC	communication Tx 4 kbit/s
	>voice sensing timeout occurred	>call termination indication	standby/ monitoring primary CC
	>detection of an unwanted SSC	>call termination indication	standby/ monitoring primary CC
	>communication timeout occurred	>call termination indication	standby/ monitoring primary CC
*	>activation of call termination function (two freq,. individual)	>transmit call termination sequence	communication Tx 4 kbit/s
*	>detection of call termina tion sequence (two freq,. individual)	>call termination indication	standby/ monitoring primary CC
communication Tx 4 kbit/s	>SSC transmitted	>transmit voice/data	communication Tx 16 kbit/s
*	>call termination sequence transmitted (individual)		standby/ monitoring primary LB CC
communication Tx 16 kbit/s	>deactivation of transmitter function by user		communication Rx 16 kbit/s/ Tx NS
	>communication timeout occurred	>call termination indication	standby/ monitoring primary LB CC

*: optional

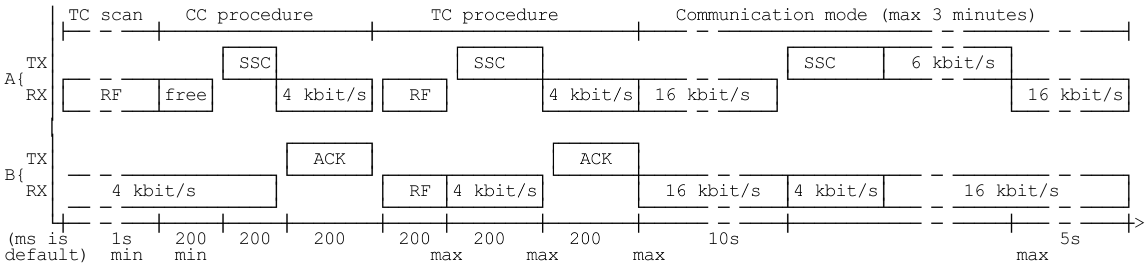
NOTE: Possible return to standby mode from every state by the event "activation of a user function" not shown in the table.

Annex H (informative): Timing diagrams

H.1 Single frequency timing diagrams

H.1.1 Single frequency individual call set-up

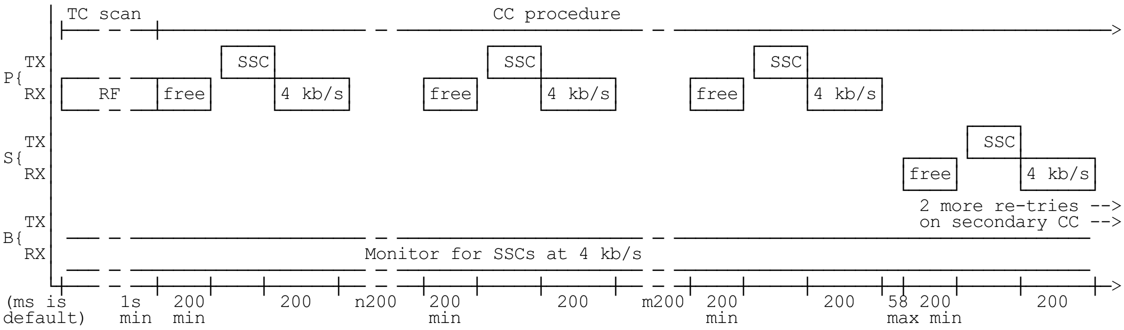
(no re-tries).



A	is the calling unit;
B	is the called unit;
RF	observing the RF level on the traffic channel;
free	monitoring the control channel to determine whether it is free or not;
4 kbit/s	receiving with the signalling modulation scheme (waiting for an SSC or an ACK);
SSC	transmitting an SSC (142 ms);
ACK	transmitting an ACK (142 ms);
16 kbit/s	transmitting or receiving with the voice/data modulation scheme.

H.1.2 Single frequency re-try procedures

(There is no response from the called unit).



P calling unit's attempts on called unit's primary CC;

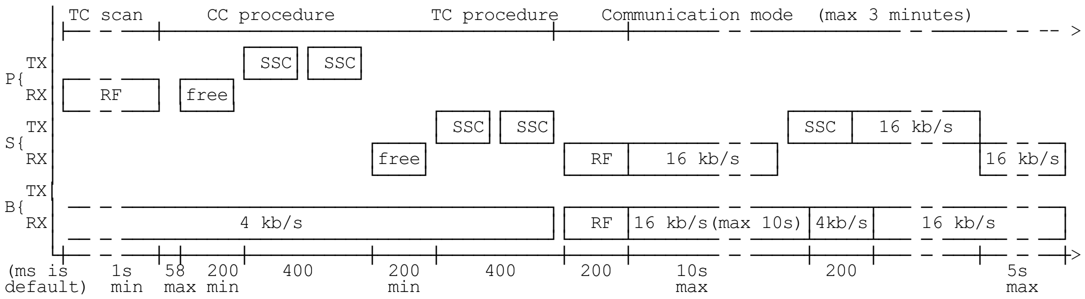
S calling unit's attempts on called unit's secondary CC;

B is the called unit.

After the 3 SSC transmissions have failed on the primary control channel, the called unit makes 3 new re-tries on the secondary control channel (including two new random numbers).

RF	observing the RF level on the traffic channel;
free	monitoring the control channel to determine whether it is free or not;
4 kbit/s	receiving with the signalling modulation scheme (waiting for an ACK);
SSC	transmitting an SSC (142 ms);
n	random number between 0 and 5 inclusive;
m	random number between 0 and 10 inclusive.

H.1.3 Single frequency group call set-up



P calling unit's attempt on group's primary CC;

S calling unit's attempt on group's secondary CC;

B is one of the members of the group (on called group's secondary CC);

RF observing the RF level on the traffic channel;

free monitoring the control channel to determine whether it is free or not;

4 kbit/s receiving with the signalling modulation scheme (waiting for an SSC or an ACK);

SSC transmitting an SSC (142 ms);

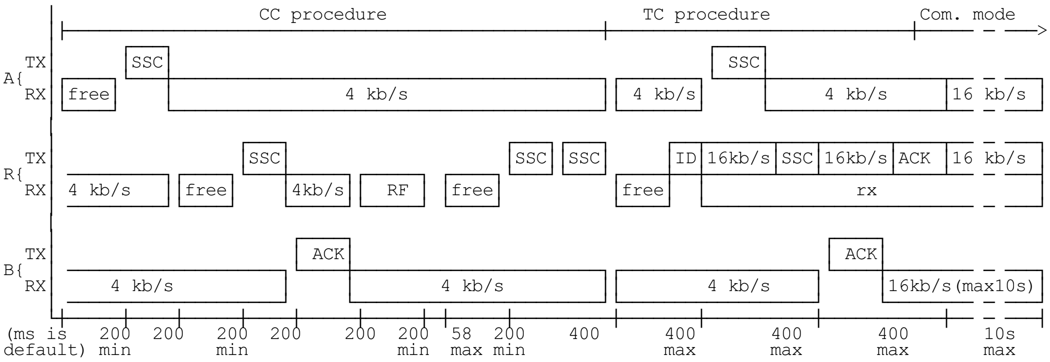
ACK transmitting an ACK (142 ms);

16 kbit/s transmitting or receiving with the voice/data modulation scheme.

H.2 Two frequency timing diagrams

H.2.1 Two frequency call set-up unit to unit

(no re-tries, not a visitor call, all equipment on B's primary control channel).



A is the calling unit (on B's primary CC);

R is the repeater (on B's primary CC);

B is the called unit (on B's primary CC);

free monitoring the control channel to determine whether it is free or not;

RF repeater observing the RF level on the traffic channel;

4 kbit/s receiving with the signalling modulation scheme (waiting for an SSC or an ACK);

SSC transmitting an SSC (142 ms);

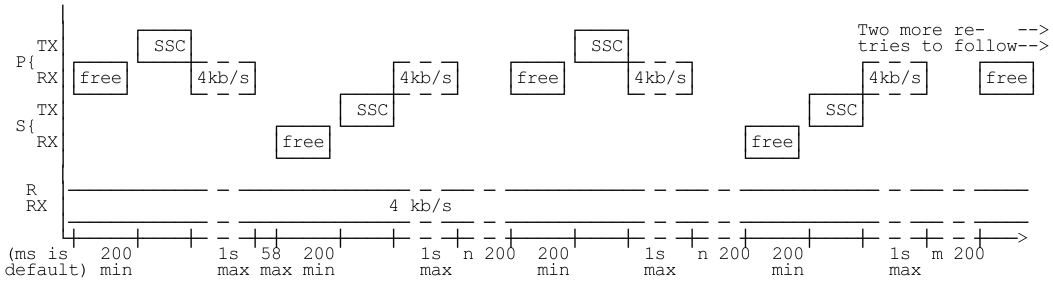
ACK transmitting an ACK (142 ms);

ID repeater transmitting its identification SSC (142 ms);

16 kbit/s transmitting or receiving with the voice/data modulation scheme.

H.2.2 Unit's re-try procedures

(No response from the repeater).



P calling unit's attempt on called unit's primary CC;

S calling unit's attempt on called unit's secondary CC;

R is the repeater.

Called unit takes no part in this.

There will be two more re-tries after the random number between 0 and 10 is generated, following the same scheme as the first four tries (altogether there will be 6 tries to access the repeater).

free monitoring the control channel to determine whether it is free or not;

4 kbit/s waiting for the repeated SSC on the HB CC;

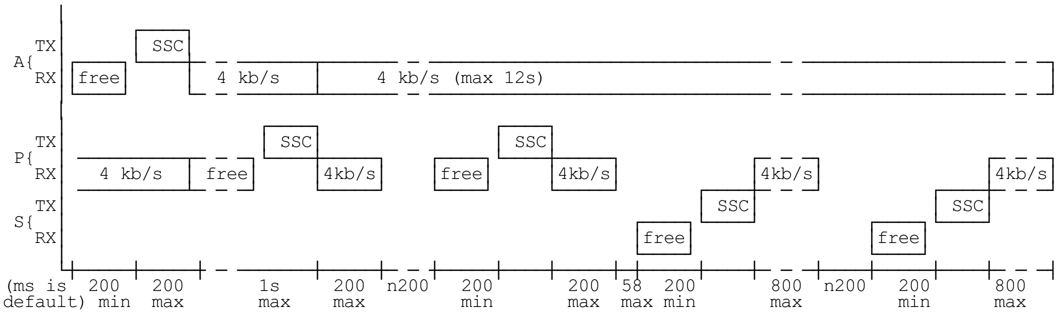
SSC transmitting an SSC on the LB control channel (142 ms);

n random number between 0 and 5 inclusive;

m random number between 0 and 10 inclusive.

H.2.3 Repeater re-try procedures

(No response from the called unit. Repeater is on called units primary CC. The CC select bit is set to "0").



P repeater's attempt on called unit's primary CC;

S repeater's attempt on called unit's secondary CC;

A is the calling unit on called unit's primary CC.

Called unit takes no part in this.

free monitoring the HB control channel to determine whether it is free or not;

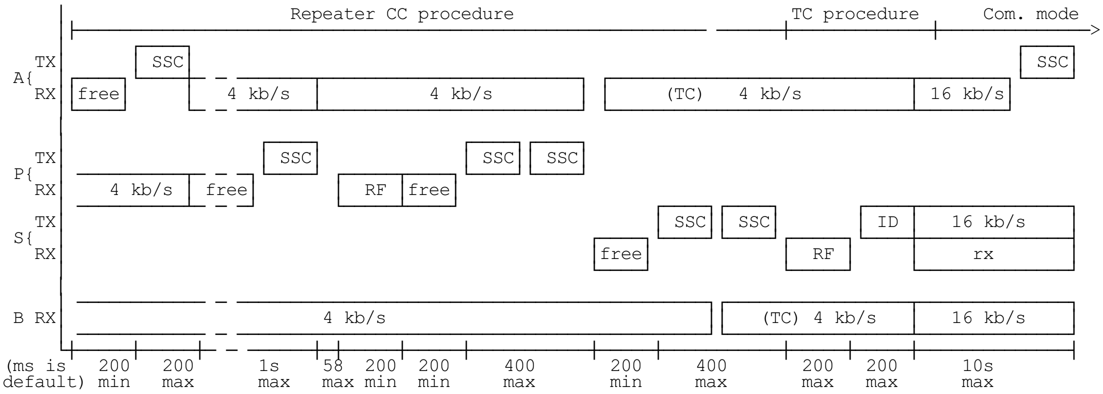
4 kbit/s receiving with the signalling modulation scheme (waiting for an SSC or an ACK);

SSC transmitting an SSC (142 ms);

n random number between 0 and 5 inclusive.

H.2.4 Two frequency group call set-up, unit to group of units

(Repeater is on called group's primary CC).



P — repeater's attempt on called group's primary CC;

S — repeater's attempt on called group's secondary CC;

A — is the calling unit on the group's primary CC;

B — is one of the called group on the group's secondary CC;

free — monitoring the control channel to determine whether it is free or not;

RF — repeater observing the RF level on the HB traffic channel;

4 kbit/s — receiving with the signalling modulation scheme (waiting for an SSC);

SSC — transmitting an SSC (142 ms).

Annex J (informative): User indicators

To give the user confidence of the equipment's operation and to indicate the loading of the system, the following indicators are recommended. The indicators may be logical, audible or visual, or any combination of the three.

The equipment ready indicator which denotes the unit is switched on and in the standby mode.

The set-up indicator which denotes that the unit is calling the wanted unit (or units) on the control channel or is scanning for a free channel.

The call ready indicator which denotes that the scanning sequence to select a free traffic channel has been successful and communication on that channel may begin.

The termination warning indicator which operates 10 seconds before the maximum transmission time-out will stop the unit from continuing with the call.

The system busy indicator which denotes that no free control or traffic channel could be found at the call set-up attempt.

The number unobtainable indicator which denotes that no response was received to a call attempt.

The call termination indicator which denotes that a successful call has been terminated.

Annex K (informative): Establishing groups of units

The user can elect to set up a number of units to form a group of unlimited size. Unlike the individual call codes, group call codes are entered by the user and can be changed at any time to any number in the range from 0 to 9999999.

In order to avoid the case where two groups are set up with the same group call code, the user should always select the group call code to be identical to one of the group members individual call codes.

Annex L (informative): Notes on decoding

L.1 Convolutional Code

A viterbi decoder can be used to decode the convolutional code. A sixteen state viterbi decoder is required. The use of soft decision information (if available) is optional, as is the constraint length.

L.2 CRC error detection

An error in the received cyclic codeword is detected if the syndrome, defined by $s = r \times H$, where r is the received codeword vector and H is the parity check matrix, is non-zero.

The vector r is defined by the coefficients of the received cyclic codeword polynomial which are equal to the coefficients of the transmitted cyclic code polynomial (see subclause 6.4) in an ideal channel with no errors.

For an (n,k) cyclic code in systematic form the syndrome may also be computed by the following method. The received cyclic codeword r is treated as a polynomial of degree n-l or less,

i.e. $$r(X) = r(0) + r(1)X + ...r(n-1)X^{(n-1)}$$

Dividing r(X) by the generator polynomial g(X) gives

$$r(X) = a(X) \times g(X) + s(X)$$

where the coefficients of s(X) form the syndrome s. If the syndrome is zero, the received codeword is one of 2^k transmitted codes and no error is detected.

L.3 Bad frame

When due to excessive errors, a frame cannot be decoded, the frame can be suppressed and an alternative frame substituted, for example a "silent" frame or a repeated good frame.

L.4 Synchronisation

The method of synchronisation should be chosen to provide:

- fast acquisition;
- low probability of false synchronisation;
- immunity to fading.

History

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