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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Digital Enhanced Cordless Telecommunications (DECT).

The present document is based on ETSI EN 300 175, parts 1 [1] to 8 [8] and ETSI EN 300 444 [9]. Further details of the DECT system may be found in ETSI TR 101 178 [i.1].

The present document has been developed in accordance with the rules of documenting a profile specification as described in ISO/IEC 9646-6 [i.2].

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The DECT Advanced Audio Profile (AAP) is an application profile for audio devices, such as loudspeakers, headphones or microphones, based on DECT radio communication technology. It is intended to enable the implementation of interoperable audio products but can also be used as a reference for best practices in audio systems which are not intended to be interoperable.

The advanced audio profile is based on the DECT base standard (ETSI EN 300 175, parts 1 [1] to 8 [8]) and also reuses some definitions and procedures defined in the Generic Access Profile (GAP) ETSI EN 300 444 [9].

1 Scope

The present document specifies a set of functionalities for the support of advanced audio services over the DECT air interface.

All DECT devices claiming to be compliant with this application profile will offer at least the services defined as mandatory. In addition to these, optional features can be implemented to offer additional DECT services.

The aim of the present document is to guarantee a sufficient level of interoperability and to provide an easy route for development of DECT advanced audio applications.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 175-1: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 1: Overview".

[2] ETSI EN 300 175-2: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 2: Physical layer (PHL)".

[3] ETSI EN 300 175-3: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 3: Medium Access Control (MAC) layer".

[4] ETSI EN 300 175-4: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 4: Data Link Control (DLC) layer".

[5] ETSI EN 300 175-5: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 5: Network (NWK) layer".

[6] ETSI EN 300 175-6: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 6: Identities and addressing".

[7] ETSI EN 300 175-7: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 7: Security features".

[8] ETSI EN 300 175-8: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 8: Speech and audio coding and transmission".

[9] ETSI EN 300 444: "Digital Enhanced Cordless Telecommunications (DECT); Generic Access Profile (GAP)".

[10] ETSI TS 103 634: "Digital Enhanced Cordless Telecommunications (DECT); Low Complexity Communication Codec plus (LC3plus)".

[11] ETSI EN 300 176-2: "Digital Enhanced Cordless Telecommunications (DECT); Test specification; Part 2: Audio and speech".

[12] ETSI EN 301 406: "Digital Enhanced Cordless Telecommunications (DECT); Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 101 178: "Digital Enhanced Cordless Telecommunications (DECT); A high Level Guide to the DECT Standardization".

[i.2] ISO/IEC 9646-6: "Information technology -- Open Systems Interconnection -- Conformance testing methodology and framework -- Part 6: Protocol profile test specification".

[i.3] ISO/IEC 9646-7: "Information technology -- Open Systems Interconnection -- Conformance testing methodology and framework -- Part 7: Implementation Conformance Statements".

[i.4] Recommendation ITU-R BS.1116-3: "Methods for the subjective assessment of small impairments in audio systems".

[i.5] Recommendation ITU-R BS.1387: "Method for objective measurements of perceived audio quality".

[i.6] ETSI TS 102 527-1: "Digital Enhanced Cordless Telecommunications (DECT); New Generation DECT; Part 1: Wideband speech".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

codec frame: portion of the media for a single channel, e.g. speech or audio or a combination thereof, that is input to the encoder or output of the decoder for one channel

NOTE: A codec frame includes a codec frame duration of audio (see codec frame duration definition below).

codec frame duration: time duration for a frame

NOTE: For WB, SWB, FB, FBHR or UBHR, the frame duration is 2,5 ms, 5 ms or 10 ms.

downlink: transmission in the direction FT to PT

end-to-end delay: time difference for the first sample of one encoder input frame between entering the linear PCM digital encoder interface and exiting the linear PCM digital decoder output interface (see annex E)

NOTE: This delay does not include any pre- or post-processing nor any external interfaces, for example via USB or similar.

fullband: speech or audio sampled at 48 kHz

high-resolution mode: high-resolution mode of the LC3plus codec, targeting higher bit rates, higher signal-to-noise ratios and coding the full audio spectrum up to the Nyquist frequency

NOTE: As defined by ETSI TS 103 634 [10].

Low Complexity Communication Codec plus (LC3plus): standard for narrowband to fullband low delay audio communication designed for very high quality communication application including all kind of audio signals, e.g. speech and music

NOTE: As defined by ETSI TS 103 634 [10].

Low Frequency Effects (LFE) channel: audio channel specifically intended for bass frequencies up to approximately 250 Hz

R-side: receiving side of a double simplex bearer

super-wideband: speech or audio sampled at 32 kHz

T-side: transmitting side of a double simplex bearer

ultraband: speech or audio sampled at 96 kHz

uplink: transmission in the direction PT to FT

wideband: speech or audio sampled at 16 kHz

3.2 Symbols

For the purposes of the present document, the following symbols apply:

B_S	Slow Broadcast channel
C	Conditional to support (process mandatory)
C_F	higher layer signalling Channel (fast)
C_S	higher layer signalling Channel (slow)
I	out-of-scope (provision optional, process optional) not subject for testing
I_N	higher layer Information channel (uNprotected)
I_{NB}	higher layer Information channel unprotected, normal delay operation
M	Mandatory to support (provision mandatory, process mandatory)
M_T	Mac control channel on A-tail field, or one message on such channel
N	identities channel
N_T	Identities information, one N channel message
N/A	Not Applicable (in the given context the specification makes it impossible to use this capability)
O	Optional to support (provision optional, process mandatory)
Q	system information channel
Q_H	Q field Header
Q_T	system information and multiframe marker (MAC logical channel)
P_T	paging channel message
ZAP	ability first to assign and then to re-program the account data held in the PT

Provision mandatory, process mandatory means that the indicated feature service or procedure will be implemented as described in the present document and may be subject to testing.

Provision optional, process mandatory means that the indicated feature, service or procedure may be implemented, and if implemented, the feature, service or procedure shall be implemented as described in the present document and may be subject to testing.

NOTE: The used notation is based on the notation proposed in ISO/IEC 9646-7 [i.3].

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AA	Advanced Audio
AAP	Advanced Audio Profile
AC	Authentication Code

AES	Advanced Encryption Standard
A-MAP	A-field Mapping
A-VOL	Adaptive-Volume
BPSK	Binary Phase Shift Keying
CC	Call Control
CN	Carrier Number
CODEC	COder-DECoder
CRC	Cyclic Redundancy Check
D8PSK	Differential 8-Phase Shift Keying
DBPSK	Differential Binary Phase Shift Keying
DCK	Derived Cipher Key
DECT	Digital Enhanced Cordless Telecommunications
DLC	Data Link Control
DLEI	Data Link Endpoint Identifier
DQPSK	Differential Quaternary Phase Shift Keying
DSAA	DECT Standard Authentication Algorithm
DSAA2	DECT Standard Authentication Algorithm #2
DSC	DECT Standard Cipher (algorithm)
DSC2	DECT Standard Cipher (algorithm) #2
E/U MUX	switch between E-type and U-type MUltipleXes
ECN	Exchanged Connection Number
EP	Error Protection
ESC	ESCape bit
FB	FullBand
FBHR	FullBand High-Resolution
FBLFE	FullBand Low Frequency Element
F-CC	FT side-Call Control
FEC	Forward Error Correction
F-IWU	FT side-Interworking Unit
FMID	Fixed part MAC IDentity
FP	Fixed Part
FT	Fixed radio Termination
FU1	DECT DLC U-Plane Frame format 1
GAP	Generic Access Profile
GFSK	Gaussian Frequency Shift Keying
HATS	Head And Torso Simulator
IE	Information Element
IPUI	International Portable User Identity
IWU	InterWorking Unit
LAPC	DLC Layer C-plane protocol entity
LAP-U	Link Access Protocol - User
LBN	Logical Bearer Number
LC3	Low Complexity Communication Codec
LCE	Link Control Entity
LCN	Logical Connection Number
LED	Light Emitting Diode
LFE	Low-Frequency Effects
LLME	Lower Layer Management Entity
LSB	Least Significant Bit
LU1	LAP-U service 1
MAC	Medium Access Control
MBC	Multi-Bearer Control
MCS	Modulation and Coding Scheme
ME	Management Entity
MM	Mobility Management
MUX	time MUltipleXer
NG-DECT	New Generation DECT
NR	Normal-Reverse
N-REJ	Noise Rejection
NWK	NetWorK
ODG	Objective Difference Grade
PARK	Portable Access Rights Key

PCM	Pulse Code Modulation
PEAQ	Perceived Audio Quality
PHL	PHysical Layer
PIN	Personal Identification Number
PLI	Park Length Indicator
PMID	Portable part MAC IDentity
PP	Portable Part
PSCN	Primary receiver Scan Carrier Number
PT	Portable radio Termination
PUN	Portable User Number
PUT	Portable User Type
RFP	Radio Fixed Part
RFPI	Radio Fixed Part Identity
RPN	Radio Fixed Part Number
RSSI	Received Signal Strength Indicator
S/R	Send/Reject
SAP	Service Access Point
SAPI	Service Access Point Identifier
SARI	Secondary Access Rights Identity
SDU	Service Data Unit
SN	Slot Number
SP	Start Position
SPR	Spare Bits
SWB	Super-Wideband
TBC	Traffic Bearer Controller
THD	Total Harmonic Distortion
THD+N	Total Harmonic Distortion plus Noise
T-MUX	Tail-Multiplex
TPUI	Temporary Portable User Identity
TRUP	TRansparent UnProtected service
UBHR	UltraBand High-Resolution
USB	Universal Serial Bus
VoIP	Voice over Internet Protocol
WB	WideBand

4 Description of services

4.1 Introduction

In DECT standards such as GAP [9] and NG-DECT [i.6] the primary audio application is telephony. With the availability of improved audio codecs such as LC3plus [10] and changes in the DECT base standard [2] to [8] to enable asymmetric data rates and lower latency, new application areas can be addressed. In this profile the following types of application are covered:

- Wireless speakers
- Wireless headphones
- Wireless high-resolution headphones
- Wireless gaming headsets
- Wireless smart speakers
- Professional wireless microphones

Each of the above devices has different requirements in terms of audio bandwidth and latency. A summary of the general characteristics for each application is given in Table 1.

Table 1: General Audio Application Characteristics

Application	Downlink (FT->PT)	Uplink (PT->FT)	End to End Delay
Wireless speakers/headphones	Fullband audio or better, stereo	(Control only)	Short or very short delay, to ensure lip sync in video related applications
Wireless high-resolution headphones	Ultraband audio, stereo	(Control only)	Short or very short delay, to ensure lip sync in video related applications
Wireless gaming headsets	Fullband audio or better, stereo	Wideband or Super-wideband voice audio, can be mono	Short or very short delay, to ensure sync with gameplay
Wireless smart speakers	Fullband audio, stereo	Wideband or Super-wideband voice audio, can be mono	Short delay
Professional wireless microphones	(Control only)	Fullband audio, mono only	Very short delay

Although these are not telephony applications, this profile is nevertheless based on aspects of GAP, ETSI EN 300 444 [9], which cover procedures such as authentication that are largely independent of the application. However, major differences to telephony exist due to the low latency, asymmetric nature of the services and these aspects are described in detail in the present document.

The following chapters give an overview of the high-level requirements for each of the use cases.

4.2 High level application requirements

4.2.1 Wireless speakers/headphones

In this application, the fixed part is connected to an audio source, e.g. a television or personal computer, and each portable part is connected to one or more speakers or to one or more headphones. There is audio transmission in downlink direction only, with the uplink direction being used only for control information. Table 2 gives an overview of the audio configuration for this type of application.

Table 2: Wireless speaker/headphone audio configuration

Parameter	Downlink	Uplink
Audio codec	LC3plus	LC3plus control channel only
Minimum bandwidth, gross bit rate per channel	Fullband, 64 kbit/s (note)	N/A
Minimum number of channels at FT	2	N/A
Minimum number of channels per PT	1	N/A
Minimum codec frame duration	5 ms	N/A
Maximum codec frame duration	10 ms	N/A
Maximum end-to-end delay	42,5 ms	N/A
Minimum sample resolution	16 bits	N/A
High-resolution mode	Optional	N/A
NOTE: • For Low Frequency Effects (LFE) channels, a configuration of 32 kbit/s and fullband is recommended. The LC3plus encoder shall be aware of the LFE content. • For headphone applications a higher minimum bitrate of 96 kbit/s is recommended.		

4.2.2 Wireless high-resolution headphones

In this application, the fixed part is connected to an audio source streaming high-resolution audio content, e.g. 96 kHz sampling rate and 24 bits per sample, and each portable part is connected to one or more headphones. There is audio transmission in downlink direction only, with the uplink direction being used only for control information. For such devices, a very low distortion level, e.g. by means of THD+N, is expected over the complete audio chain. Table 3 gives an overview of the audio configuration for this type of application.

Table 3: High-resolution speaker/headphone audio configuration

Parameter	Downlink	Uplink
Audio codec	LC3plus	LC3plus control channel only
Minimum bandwidth, gross bit rate per channel	Fullband,128 kbit/s Ultraband, 160 kbit/s	N/A
Minimum number of channels at FT	2	N/A
Minimum number of channels per PT	1	N/A
Minimum codec frame duration	10 ms	N/A
Maximum codec frame duration	10 ms	N/A
Maximum end-to-end delay	42,5 ms	N/A
Minimum sample resolution	24 bits	N/A
High-resolution mode	Enabled	N/A

4.2.3 Wireless gaming headsets

In this application the fixed part is connected to a gaming console, personal computer or similar, while the portable part is connected to a headset. In the downlink direction, the characteristics of the headsets are similar to those of wireless speakers in clause 4.2.1. In addition, there is an audio path in the uplink which is used for voice communication. Table 4 gives an overview of the audio configuration for this type of application.

Table 4: Wireless gaming headset audio configuration

Parameter	Downlink	Uplink
Audio codec	LC3plus	LC3plus
Minimum bandwidth, gross bit rate per channel	Fullband, 64 kbit/s	Wideband, 32 kbit/s
Minimum number of channels at FT	2	1
Minimum number of channels per PT	2	1
Minimum codec frame duration	2,5 ms	10 ms
Maximum codec frame duration	5 ms	10 ms
Maximum end-to-end delay	22,5 ms	42,5 ms
Minimum sample resolution	16 bits	16 bits
High-resolution mode	Optional	Optional
NOTE: • For a 5 ms codec frame interval, the minimum bandwidth is 64 kbit/s. • For a 2,5 ms codec frame interval, the minimum bandwidth is 128 kbit/s.		

4.2.4 Wireless smart speakers

In this application the fixed part is connected to an internet connected device, while the portable part is connected to the smart speaker. In the downlink direction, the characteristics of the smart speaker are similar to those of wireless speakers in clause 4.2.1. In addition, there is an audio path in the uplink which is used for voice control. Table 5 gives an overview of the audio configuration for this type of application.

Table 5: Wireless smart speaker audio configuration

Parameter	Downlink	Uplink
Audio codec	LC3plus	LC3plus
Minimum bandwidth, gross bit rate per channel	Fullband, 64 kbit/s	Wideband, 32 kbit/s
Minimum number of channels at FT	2	1
Minimum number of channels per PT	1	1
Minimum codec frame duration	5 ms	10 ms
Maximum codec frame duration	10 ms	10 ms
Maximum end-to-end delay	42,5 ms	42,5 ms
Minimum sample resolution	16 bits	16 bits
High-resolution mode	Optional	N/A

4.2.5 Professional wireless microphones

In this profile an LC3plus based wireless microphone is specified. However, other professional wireless microphones using proprietary codecs also exist. For these devices, no interoperability is expected and hence all requirements are optional and should only be considered as best practices.

In this application the fixed part is connected to audio processing equipment, e.g. a mixing desk, while the portable part is connected to the microphone. In the uplink direction there is high quality audio while in the downlink direction there is only control information. Table 6, Table 7 and Table 8 give an overview of the typical audio configuration parameters for this type of application.

Table 6: Example professional microphone audio configuration

Parameter	Downlink	Uplink
Audio codec	Control channel only	Proprietary
Minimum bandwidth, gross bit rate per channel	N/A	Fullband, 192 kbit/s
Minimum number of channels at FT	N/A	1
Minimum number of channels per PT	N/A	1
Minimum codec frame duration	N/A	1,25 ms
Maximum codec frame duration	N/A	1,67 ms
Maximum end-to-end delay	N/A	5 ms
Minimum sample resolution	N/A	24 bits
High-resolution mode	N/A	Yes

Table 7: Example karaoke microphone audio configuration

Parameter	Downlink	Uplink
Audio codec	Control channel only	Proprietary
Minimum bandwidth, gross bit rate per channel	N/A	Fullband, 128 kbit/s
Minimum number of channels at FT	N/A	1
Minimum number of channels per PT	N/A	1
Minimum codec frame duration	N/A	1,67 ms
Maximum codec frame duration	N/A	2,5 ms
Maximum end-to-end delay	N/A	7,5 ms
Minimum sample resolution	N/A	24 bits
High-resolution mode	N/A	Yes

Table 8: LC3plus based low latency microphone audio configuration

Parameter	Downlink	Uplink
Audio codec	LC3plus control channel only	LC3plus
Minimum bandwidth, gross bit rate per channel	N/A	Fullband, 128 kbit/s
Minimum number of channels at FT	N/A	1
Minimum number of channels per PT	N/A	1
Minimum codec frame duration	N/A	2,5 ms
Maximum codec frame duration	N/A	2,5 ms
Maximum end-to-end delay	N/A	12,5 ms
Minimum sample resolution	N/A	16 bits
High-resolution mode	N/A	No

5 Service and feature definitions

5.1 Audio coding definitions

For the purposes of the present document, the following definitions shall apply:

LC3plus codec:

LC3plus is standardized as ETSI TS 103 634 [10]. The LC3plus codec is designed for very high audio quality for all kinds of audio signals, i.e. speech and music.

For regular 16 bit music encodings at 48 kHz sampling rate, LC3plus provides an audio bandwidth of 20 kHz and good music quality starting from 64 kbit/s per channel, reaching an excellent level of quality at 96 kbit/s per channel and perceptually transparent audio quality for most users at 128 kbit/s per channel, see also annex C. Additionally, LC3plus supports 24 bit high-resolution audio content for the sampling rates 48 kHz and 96 kHz and provides an audio bandwidth up to Nyquist frequency and a THD+N level of down to -130 dB.

For speech encoding, LC3plus codec is integrated in the AAP as WB and SWB speech codec:

- WB is encoded/transmitted at 32 kbit/s;
- SWB and FB at 64 kbit/s.

Due to the constraints of the DECT slot format, only a subset of the possible gross bit rates is supported for DECT applications.

ETSI TS 103 634 [10] contains Forward Error Correction (FEC) capabilities (channel coder as described in clause A.1) which shall be used for LC3plus transmission over DECT. At a constant gross bit rate, this error protection (EP) comes with a reduction of the net bit rate available for source coding. The specification supports four EP classes, where "1" stands for lowest and "4" for highest protection capability. The LC3plus also includes a very performant packet loss concealment algorithm which shall be used.

The configurations of the LC3plus codec shown in Table 9 are supported by this profile.

Table 9: LC3plus codec configurations

Type	Bandwidth	Sampling rate	Codec frame duration	Gross bitrate	Gross bytes per codec frame	Number channels	High-resolution
Single channel - normal resolution							
AA.AC.1	0 kHz to 8 kHz	16 kHz	10 ms	32 kbit/s	40	1	disabled
AA.AC.2	0 kHz to 16 kHz	32 kHz	10 ms	64 kbit/s	80	1	disabled
AA.AC.3	0 kHz to 20 kHz	48 kHz	10 ms	64 kbit/s	80	1	disabled
AA.AC.4	0 kHz to 20 kHz	48 kHz	10 ms	96 kbit/s	120	1	disabled
AA.AC.5	0 kHz to 20 kHz	48 kHz	10 ms	128 kbit/s	160	1	disabled
AA.AC.6	0 kHz to 20 kHz	48 kHz	5 ms	128 kbit/s	80	1	disabled
AA.AC.7	0 kHz to 20 kHz	48 kHz	5 ms	160 kbit/s	100	1	disabled
AA.AC.8	0 kHz to 20 kHz	48 kHz	5 ms	192 kbit/s	120	1	disabled
AA.AC.9	0 kHz to 20 kHz	48 kHz	2,5 ms	128 kbit/s	40	1	disabled
AA.AC.10	0 kHz to 20 kHz	48 kHz	2,5 ms	256 kbit/s	80	1	disabled
Single channel - high-resolution							
AA.AC.11	0 kHz to 24 kHz	48 kHz	10 ms	128 kbit/s	160	1	enabled
AA.AC.12	0 kHz to 24 kHz	48 kHz	10 ms	160 kbit/s	200	1	enabled
AA.AC.13	0 kHz to 24 kHz	48 kHz	10 ms	192 kbit/s	240	1	enabled
AA.AC.14	0 kHz to 48 kHz	96 kHz	10 ms	160 kbit/s	200	1	enabled
AA.AC.15	0 kHz to 48 kHz	96 kHz	10 ms	192 kbit/s	240	1	enabled
AA.AC.16	0 kHz to 48 kHz	96 kHz	10 ms	256 kbit/s	320	1	enabled
AA.AC.17	0 kHz to 48 kHz	96 kHz	10 ms	320 kbit/s	400	1	enabled

Type	Bandwidth	Sampling rate	Codec frame duration	Gross bitrate	Gross bytes per codec frame	Number channels	High-resolution
Single channel - LFE							
AA.AC.18	0 kHz to 250 Hz	48 kHz	10 ms	32 kbit/s	40	1	disabled
AA.AC.19	0 kHz to 250 Hz	48 kHz	5 ms	64 kbit/s	40	1	disabled
Two channel							
AA.AC.20	0 kHz to 20 kHz	48 kHz	10 ms	128 kbit/s	160	2	disabled
AA.AC.21	0 kHz to 20 kHz	48 kHz	5 ms	256 kbit/s	160	2	disabled
AA.AC.22	0 kHz to 20 kHz	48 kHz	2,5 ms	320 kbit/s	100	2	disabled
AA.AC.23	0 kHz to 20 kHz	48 kHz	2,5 ms	512 kbit/s	160	2	disabled

5.2 Audio feature definitions

For the purposes of the present document, the following definitions shall apply:

Mono compatibility [AA.AF.1]: Capability to provide one-channel mono signal, usually on PCM level, in case more channels are available at the audio origin. This feature is required for instance, if an FT transmits stereo content to a PT supporting only mono.

Maximum end-to-end delay [AA.AF.2]: The maximum end-to-end delay shall not exceed $T_{end\text{-}to\text{-}end}$ which is defined as:

$$T_{end\text{-}to\text{-}end} = 2{,}5 \text{ ms} + 4 \cdot T_{frame}$$

where T_{frame} = LC3plus codec frame duration (see annex E).

PP audio type 2c (HATS tested "improved" wideband handset or headset) [AA.AF.3]: Improved wideband HATS-tested DECT PP with better characteristics as defined by ETSI EN 300 175-8 [8], clause 7.2.11. Compatible with LC3plus [10] in WB mode, operating at 32 kbit/s.

PP audio type 4b (HATS tested wideband "improved" loudspeaking and handsfree) [AA.AF.4]: HATS tested wideband "improved" loudspeaking and handsfree as defined by ETSI EN 300 175-8 [8], clause 7.2.13. Compatible with LC3plus [10] in WB mode, operating at 32 kbit/s.

PP audio type 5a (Super-wideband 14 kHz handset or headset) [AA.AF.5]: super-wideband 14 kHz handset or headset as defined by ETSI EN 300 175-8 [8], clause 7.2.14. Compatible with LC3plus [10] in SWB mode, operating at 64 kbit/s.

PP audio type 5b (Super-wideband 14 kHz loudspeaking handsfree) [AA.AF.6]: Super-wideband 14 kHz loudspeaking handsfree as defined by ETSI EN 300 175-8 [8], clause 7.2.15. Compatible with LC3plus [10] in SWB mode, operating at 64 kbit/s.

PP audio type 7a (fullband 20 kHz handset or headset) [AA.AF.7]: Handset or headset for 20 kHz service (fullband), as defined by ETSI EN 300 175-8 [8], clause 7.2.17. Compatible with LC3plus [10] in FB mode operating at 64 kbit/s, 96 kbit/s, 128 kbit/s, 160 kbit/s, 192 kbit/s or 256 kbit/s.

PP audio type 7b (fullband 20 kHz loudspeaking handsfree) [AA.AF.8]: Handsfree device for 20 kHz service (fullband), as defined by ETSI EN 300 175-8 [8], clause 7.2.18. Compatible with LC3plus [10] in FB mode operating at 64 kbit/s, 96 kbit/s, 128 kbit/s, 160 kbit/s, 192 kbit/s or 256 kbit/s.

PP audio type 7c (fullband 20 kHz, stereo audio device, 128 kbit/s) [AA.AF.9]: Fullband 20 kHz frequency range stereo streaming device as defined by ETSI EN 300 175-8 [8], clause 7.2.19. Compatible with LC3plus [10] operating in fullband stereo mode at 128 kbit/s for left and for right channel combined and 10 ms frame size. The device could be a handset, headset or stereo loudspeaker.

PP audio type 7f (fullband 20 kHz, stereo audio device, shorter frame lengths) [AA.AF.10]: Fullband 20 kHz frequency range stereo streaming device as defined by ETSI EN 300 175-8 [8], clause 7.2.19. Compatible with LC3plus [10] operating in fullband stereo mode at 256 kbit/s for 5ms frame size, 320 kbit/s for 2,5 ms frame size and at 512 kbit/s for 2,5 ms frame size. The device could be a handset, headset or stereo loudspeaker.

PP audio type 7g (fullband 24 kHz headset device) [AA.AF.11]: Fullband headset device providing 24 kHz frequency range at bitrates 128 kbit/s, 160 kbit/s and 192 kbit/s for 10 ms frame size, as defined by ETSI EN 300 175-8 [8], clause 7.2.20. Compatible with LC3plus [10] operating in FBHR mode at 128 kbit/s, 160 kbit/s and 192 kbit/s.

PP audio type 7h (fullband 24 kHz loudspeaking device) [AA.AF.12]: Fullband loudspeaking device providing 24 kHz frequency range at bitrates 128 kbit/s, 160 kbit/s and 192 kbit/s for 10 ms frame size, as defined by ETSI EN 300 175-8 [8], clause 7.2.21. Compatible with LC3plus [10] operating in FBHR mode at 128 kbit/s, 160 kbit/s and 192 kbit/s.

PP audio type 7i (fullband 250 Hz (LFE) loudspeaking device) [AA.AF.13]: Fullband LFE loudspeaking device providing a frequency range from 0 Hz to 250 Hz at bitrate 32 kbit/s for 10ms frame size and bitrate 64 kbit/s for 5 ms frame size, as defined by ETSI EN 300 175-8 [8], clause 7.2.22. Compatible with LC3plus [10] operating in FBLFE mode at 32 kbit/s for 10 ms frame size and at 64 kbit/s for 5 ms frame size.

PP audio type 7j (20 kHz low-latency microphone device) [AA.AF.14]: Fullband 20 kHz low-latency microphone device. It provides 20 kHz frequency range and applies to microphone devices operating at a frame size of 2,5 ms, as defined by ETSI EN 300 175-8 [8], clause 7.2.23. Compatible with LC3plus [10] operating in FB mode at 128 kbit/s or 256 kbit/s for 2,5 ms frame size.

PP audio type 8a (ultraband 48 kHz headset device) [AA.AF.15]: Ultraband 48 kHz headset device providing a frequency range from 0 kHz to 48 kHz at bitrates 160 kbit/s, 192 kbit/s, 256 kbit/s and 320 kbit/s for 10 ms frame size, as defined by ETSI EN 300 175-8 [8], clause 7.2.24. Compatible with LC3plus [10] operating in UBHR mode at 160 kbit/s, 192 kbit/s, 256 kbit/s and 320 kbit/s for 10 ms frame size.

PP audio type 8b (ultraband 48 kHz loudspeaking device) [AA.AF.16]: Ultraband 48 kHz loudspeaking device providing a frequency range from 0 kHz to 48 kHz at bitrates 160 kbit/s, 192 kbit/s, 256 kbit/s and 320 kbit/s for 10 ms frame size, as defined by ETSI EN 300 175-8 [8], clause 7.2.25. Compatible with LC3plus [10] operating in UBHR mode at 160 kbit/s, 192 kbit/s, 256 kbit/s and 320 kbit/s for 10 ms frame size.

FP audio type 5 (VoIP, wideband, super-wideband, fullband or ultraband FP) [AA.AF.17]: DECT FP with a packet-data interface based on Internet Protocol and supporting the 7 kHz (wideband), 14 kHz (super-wideband), 20/24 kHz (fullband) or 48 kHz (ultraband) services, as defined by ETSI EN 300 175-8 [8], clause 7.3.7. Compatible with LC3plus [10] operating at any bit rate or frame size.

5.3 PHL service definitions

For the purposes of the present document, the following definitions shall apply:

2 level GFSK modulation [AA.P.1]: 2 level Gaussian Frequency Shift Keying (GFSK) modulation as defined by ETSI EN 300 175-2 [2], clause 5.

π/2-DBPSK modulation [AA.P.2]: 2 level Differential Binary Phase Shift Keying (DBPSK) modulation as defined by ETSI EN 300 175-2 [2], clause D.1.

π/4-DQPSK modulation [AA.P.3]: 4 level Differential Quaternary Phase Shift Keying (DQPSK) modulation as defined by ETSI EN 300 175-2 [2], clause D.2.

π/8-D8PSK modulation [AA.P.4]: 8 level Differential 8-Phase Shift Keying (D8PSK) modulation as defined by ETSI EN 300 175-2 [2], clause D.3.

Physical Packet P32 [AA.P.5]: Physical packet P32 (full slot) as defined by ETSI EN 300 175-2 [2], clause 4.4.2.

Physical Packet P64 [AA.P.6]: Variable capacity Physical packet P00j as defined by ETSI EN 300 175-2 [2], clause 4.4.3, with j = 640.

Physical Packet P80 [AA.P.7]: Physical packet P80 (double slot) as defined by ETSI EN 300 175-2 [2], clause 4.4.4.

Transmitted power management [AA.P.8]: Physical layer procedures for controlling the transmit power of an AAP device.

Fast hopping radio [AA.P.9]: Radio transceiver able to perform frequency change during the interval between two consecutive Physical Packets P32, P64 or P80.

Radio Receiver Category B [A.A.P.10]: Radio receiver meeting the requirements defined in ETSI EN 200 175-2 [2], annex G.

5.4 MAC service definitions

For the purposes of the present document, the definitions of ETSI EN 300 444 [9], clause 5.2 plus the following shall apply:

I_N_normal delay symmetric MAC service type [AA.M.1]: I_N_normal delay symmetric connection as defined in ETSI EN 300 175-3 [3], clause 5.6.2.1.

I_N_normal delay asymmetric MAC service type [AA.M.2]: I_N_normal delay asymmetric connection as defined in ETSI EN 300 175-3 [3], clause 5.6.2.2 (type 6: I_N_normal_delay (I_{NB}): limited error protection, fixed delay, fixed throughput).

I_N_normal delay with restriction in the handover space [AA.M.3]: I_N_normal delay service, either symmetric or asymmetric, with timing restrictions on the slots that can be used at handover, as defined in ETSI EN 300 175-3 [3], clause 10.8.3.2.2.

Advanced Connections [AA.M.4]: MAC Connection Oriented service providing connection between FT and PT. Advanced connections are able to support multiple bearers, bearers other than full slot, double simplex bearers, and any MAC service. The service includes the means for setting-up and releasing the required bearer(s).

Double Simplex Bearer Handover - Intra Cell [AA.M.5]: Internal MAC process whereby data transfer (C channel and I channel) is switched from one double simplex bearer to another in the domain of the same cell while maintaining the service to the DLC layer, as defined in ETSI EN 300 175-3 [3], clause 10.6.3.

Frequency Replacement - Intra Cell [AA.M.6]: Special case of a bearer handover procedure where an old bearer is replaced with a new bearer on the same cell which is located on the same time slot pair but uses a different frequency, as defined in ETSI EN 300 175-3 [3], clause 10.6.4.2.

Audio Data Transfer [AA.M.7]: MAC service ensuring the correct order of audio data arrival in cases where the audio frame is split across several MAC bearers, as defined in ETSI EN 300 175-3 [3], clause 10.8.3.2.1.

5.5 DLC service definitions

For the purposes of the present document, the definitions of ETSI EN 300 444 [9], clause 5.1 plus the following shall apply:

LU1 Transparent UnProtected service (TRUP) Class 0 [AA.D.1]: Transparent unprotected service, transmission Class 0 as defined by ETSI EN 300 175-4 [4], clause 11.2.

5.6 NWK feature definitions

For the purposes of the present document, the definitions of ETSI EN 300 444 [9], clause 4.1, plus the following shall apply:

PT Initiated Advanced Audio Call [AA.N.1]: Advanced audio call initiated by the PT.

FT Initiated Advanced Audio Call [AA.N.2]: Advanced audio call initiated by the FT.

Advanced Audio Call Release [AA.N.3]: Full release of an advanced audio call, initiated by PT or FT.

Codec Negotiation [AA.N.4]: Capability to negotiate the audio codec and bit rate to be used in a communication, based on the supported capabilities in both peers and the previsions included in the present document. This feature may require slot type change and change in number of bearers used in the connection.

Codec Switching [AA.N.5]: Capability to switch between different audio codec and bit rates during a call. This feature may require slot type change and change in number of bearers used in the connection.

5.7 Application feature definitions

For the purposes of the present document, the definitions of ETSI EN 300 444 [9], clause 4.3 plus the following shall apply:

Easy pairing registration [AA.A.1]: Ability to register a PT that is not registered to a FT by pressing a physical or logical button on the PT and on the FT.

Head tracking [AA.A.2]: Ability to provide an uplink data stream that gives information at a regular time interval on head orientation and head movement.

6 Profile specific requirements

6.1 General

Table 10 to Table 20 define the status of all protocol elements (i.e. features, services and procedures), which can be: mandatory, optional, conditional under the provision of another protocol element, outside the scope of the present document, or not applicable. The status is identified by the status designations defined in clause 6.2, and is described separately for FT and PT.

All optional elements shall be process mandatory according to the procedures described in the present document.

Protocol elements defined as mandatory, optional or conditional in this clause are further defined in the referenced DECT specification, or, if needed, in clause 7 of the present document.

The requirements of ETSI EN 301 406 [12] shall be met by all equipment conforming to the present document.

6.2 Specific conventions

6.2.1 Use of symbols in support status tables

The symbols defined in this clause are applied for procedures, features, and services in the present document if not explicitly otherwise stated. The interpretation of status columns in all tables is as follows:

- "M" (provision mandatory, process mandatory) means that the indicated feature service or procedure shall be implemented as described in the present document, and may be subject to testing.
- "O" (provision optional, process mandatory) means that the indicated feature, service or procedure may be implemented, and if implemented, the feature, service or procedure shall be implemented as described in the present document, and may be subject to testing.
- "N/A" (not-applicable) means that, in the given context the specification, the use of the indicated feature, service or procedure is meaningless or out of scope.
- "Cxxxx" (conditional) indicates that the status is given by a conditional expression defined at the bottom of the table.
- "I" (irrelevant) means that the implementation status of the indicated feature, service or procedure is out of the scope (provision optional, process optional) of the present document.

NOTE: The used notation is based on the notation proposed in ISO/IEC 9646-7 [i.3].

6.3 Advanced audio services support status

Depending on the device type, the requirements for audio support differ as given in Table 10, Table 11 and Table 12.

Table 10 specifies the audio codec and general audio feature requirements according to device types.

Table 10: Audio support for specific device types

Device type	Service or feature	Direction	Mono/Stereo (see note 1)	Reference	Status	
					PT	FT
Wireless speaker/Smart speaker/Wireless headphone	LC3plus codec, 16 kHz, 32 kbit/s, 1 ch, 10 ms [AA.AC.1]	Uplink	Mono	5.1	C1001	C1001
	LC3plus codec, 48 kHz, 64 kbit/s, 1 ch, 10 ms [AA.AC.3]	Downlink	Mono	5.1	M	M
			Stereo	5.1	O	M
	LC3plus codec, 48 kHz, 96 kbit/s, 1 ch, 10 ms [AA.AC.4]	Downlink	Mono	5.1	M	M
			Stereo	5.1	O	M
	LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 10 ms [AA.AC.5]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 5 ms [AA.AC.6]	Downlink	Mono	5.1	M	M
			Stereo	5.1	O	M
	LC3plus codec, 48 kHz, 160 kbit/s, 1 ch, 5 ms [AA.AC.7]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 5 ms [AA.AC.8]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 48 kHz, 32 kbit/s, 1 ch, 10 ms [AA.AC.18] (LFE)	Downlink	Mono	5.1	O	O
	LC3plus codec, 48 kHz, 64 kbit/s, 1 ch, 5 ms [AA.AC.19] (LFE)	Downlink	Mono	5.1	O	O
	LC3plus codec, 48 kHz, 128 kbit/s, 2 ch, 10 ms [AA.AC.20]	Downlink	Stereo	5.1	C1002	C1002
	LC3plus codec, 48 kHz, 256 kbit/s, 2 ch, 5 ms [AA.AC.21]	Downlink	Stereo	5.1	O	C1002
	Mono compatibility [AA.AF.1]	Downlink	N/A	5.2	O	M
	Maximum end-to-end delay [AA.AF.2]	Uplink/Downlink	N/A	5.2	M	M
	FP audio type 5 (VoIP, wideband, super-wideband, fullband or ultraband FP) [AA.AF.17]	Uplink/Downlink	N/A	5.2	N/A	M
Wireless gaming headset	LC3plus codec, 16 kHz, 32 kbit/s, 1 ch, 10 ms [AA.AC.1]	Uplink	Mono	5.1	M	M
	LC3plus codec, 32 kHz, 64 kbit/s, 1 ch, 10 ms [AA.AC.2]	Uplink	Mono	5.1	O	O
	LC3plus codec, 48 kHz, 64 kbit/s, 1 ch, 10 ms [AA.AC.3]	Uplink	Mono	5.1	O	O
	LC3plus codec, 48 kHz, 160 kbit/s, 1 ch, 5 ms [AA.AC.7]	Downlink	Stereo	5.1	O	O
	LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 5 ms [AA.AC.8]	Downlink	Stereo	5.1	O	O
	LC3plus codec, 48 kHz, 256 kbit/s, 2 ch, 5 ms [AA.AC.21]	Downlink	Stereo	5.1	M	M
	LC3plus codec, 48 kHz, 320 kbit/s, 2 ch, 2,5 ms [AA.AC.22]	Downlink	Stereo	5.1	M	M
	LC3plus codec, 48 kHz, 512 kbit/s, 2 ch, 2,5 ms [AA.AC.23]	Downlink	Stereo	5.1	O	O
	Mono compatibility [AA.AF.1]	Downlink	N/A	5.2	N/A	N/A
	Maximum end-to-end delay [AA.AF.2]	Uplink/Downlink	N/A	5.2	M	M
	FP audio type 5 (VoIP, wideband, super-wideband, fullband or ultraband FP) [AA.AF.17]	Uplink/Downlink	N/A	5.2	N/A	M

Device type	Service or feature	Direction	Mono/Stereo (see note 1)	Reference	Status	
					PT	FT
High-resolution headphone	LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 10 ms, high res. [AA.AC.11]	Downlink	Mono	5.1	M	M
			Stereo	5.1	O	M
	LC3plus codec, 48 kHz, 160 kbit/s, 1 ch, 10 ms, high res. [AA.AC.12]	Downlink	Mono	5.1	M	M
			Stereo	5.1	O	M
	LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 10 ms, high res. [AA.AC.13]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 96 kHz, 160 kbit/s, 1 ch, 10 ms, high res. [AA.AC.14]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 96 kHz, 192 kbit/s, 1 ch, 10 ms, high res. [AA.AC.15]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 96 kHz, 256 kbit/s, 1 ch, 10 ms, high res. [AA.AC.16]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	LC3plus codec, 96 kHz, 320 kbit/s, 1 ch, 10 ms, high res. [AA.AC.17]	Downlink	Mono	5.1	O	O
			Stereo	5.1	O	O
	Mono compatibility [AA.AF.1]	Downlink	N/A	5.2	N/A	N/A
	Maximum end-to-end delay [AA.AF.2]	Downlink	N/A	5.2	M	M
	FP audio type 5 (VoIP, wideband, super-wideband, fullband or ultraband FP) [AA.AF.17]	Uplink/Downlink	N/A	5.2	N/A	M
Low latency wireless microphone (see note 2)	LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 2,5 ms [AA.AC.9]	Uplink	Mono	5.1	M	M
	LC3plus codec, 48 kHz, 256 kbit/s, 1 ch, 2,5 ms [AA.AC.10]	Uplink	Mono	5.1	M	M
	Maximum end-to-end delay [AA.AF.2]	Uplink	N/A	5.2	M	M
	FP audio type 5 (VoIP, wideband, super-wideband, fullband or ultraband FP) [AA.AF.17]	Uplink/Downlink	N/A	5.2	N/A	M
C1001: If microphone supported then M, else N/A C1002: If stereo is supported then M, else O.						
NOTE 1: If stereo is defined for a single channel codec, then support of at least 2 instances of the codec are required. Further instances may also be supported, for example, for surround sound applications. NOTE 2: Professional microphones which do not use LC3plus are not included here because no requirements are mandatory for these devices.						

Table 11 defines several codec groups. For a given direction (uplink or downlink), if a codec within a group is supported by a device then all lower bit-rate codecs which are valid for that direction and in the same group shall also be supported. For example, if a device supports [AA.AC.8] in the downlink then [AA.AC.6] and [AA.AC.7] shall also be supported in the downlink.

NOTE: These groups can be used to reduce signalling overhead, see clause 7.6.10.

Table 11: Codec groups for signalling optimization

Type	Codec frame duration	Gross bitrate	Codec Group
Single channel - normal resolution			
AA.AC.1	10 ms	32 kbit/s	1
AA.AC.2	10 ms	64 kbit/s	
AA.AC.3	10 ms	64 kbit/s	
AA.AC.4	10 ms	96 kbit/s	
AA.AC.5	10 ms	128 kbit/s	
AA.AC.6	5 ms	128 kbit/s	2
AA.AC.7	5 ms	160 kbit/s	
AA.AC.8	5 ms	192 kbit/s	
AA.AC.9	2,5 ms	128 kbit/s	3
AA.AC.10	2,5 ms	256 kbit/s	
Single channel - high-resolution			
AA.AC.11	10 ms	128 kbit/s	4
AA.AC.12	10 ms	160 kbit/s	
AA.AC.13	10 ms	192 kbit/s	
AA.AC.14	10 ms	160 kbit/s	
AA.AC.15	10 ms	192 kbit/s	
AA.AC.16	10 ms	256 kbit/s	
AA.AC.17	10 ms	320 kbit/s	
Single channel - LFE			
AA.AC.18	10 ms	32 kbit/s	N/A
AA.AC.19	5 ms	64 kbit/s	N/A
Two channel			
AA.AC.20	10 ms	128 kbit/s	N/A
AA.AC.21	5 ms	256 kbit/s	N/A
AA.AC.22	2,5 ms	320 kbit/s	5
AA.AC.23	2,5 ms	512 kbit/s	

Table 12 specifies the PP audio type which shall be supported for a given device type and audio codec combination.

Table 12: PP audio type support according to device type and codec

Audio Codec	Headset		Loudspeaker		Standalone Microphone
	Downlink PP audio type	Uplink PP audio type (if present)	Downlink PP audio type	Uplink PP audio type (if present)	Uplink PP audio type
Single channel - normal resolution					
LC3plus codec, 16 kHz, 32 kbit/s, 1 ch, 10 ms [AA.AC.1]	N/A	2c [AA.AF.3]	N/A	4b [AA.AF.4]	N/A
LC3plus codec, 32 kHz, 64 kbit/s, 1 ch, 10 ms [AA.AC.2]	N/A	5a [AA.AF.5]	N/A	5b [AA.AF.6]	N/A
LC3plus codec, 48 kHz, 64 kbit/s, 1 ch, 10 ms [AA.AC.3]	7a [AA.AF.7]	7a [AA.AF.7]	7b [AA.AF.8]	7b [AA.AF.8]	N/A
LC3plus codec, 48 kHz, 96 kbit/s, 1 ch, 10 ms [AA.AC.4]	7a [AA.AF.7]	N/A	7b [AA.AF.8]	N/A	N/A
LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 10 ms [AA.AC.5]	7a [AA.AF.7]	N/A	7b [AA.AF.8]	N/A	N/A
LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 5 ms [AA.AC.6]	7a [AA.AF.7]	N/A	7b [AA.AF.8]	N/A	N/A
LC3plus codec, 48 kHz, 160 kbit/s, 1 ch, 5 ms [AA.AC.7]	7a [AA.AF.7]	N/A	7b [AA.AF.8]	N/A	N/A
LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 5 ms [AA.AC.8]	7a [AA.AF.7]	N/A	7b [AA.AF.8]	N/A	N/A
LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 2,5 ms [AA.AC.9]	N/A	N/A	N/A	N/A	7j [AA.AF.14]
LC3plus codec, 48 kHz, 256 kbit/s, 1 ch, 2,5 ms [AA.AC.10]	N/A	N/A	N/A	N/A	7j [AA.AF.14]
Single channel - high-resolution					
LC3plus codec, 48 kHz, 128 kbit/s, 1 ch, 10 ms, high res. [AA.AC.11]	7g [AA.AF.11]	N/A	7h [AA.AF.12]	N/A	N/A
LC3plus codec, 48 kHz, 160 kbit/s, 1 ch, 10 ms, high res. [AA.AC.12]	7g [AA.AF.11]	N/A	7h [AA.AF.12]	N/A	N/A
LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 10 ms, high res. [AA.AC.13]	7g [AA.AF.11]	N/A	7h [AA.AF.12]	N/A	N/A
LC3plus codec, 96 kHz, 160 kbit/s, 1 ch, 10 ms, high res. [AA.AC.14]	8a [AA.AF.15]	N/A	8b [AA.AF.16]	N/A	N/A
LC3plus codec, 48 kHz, 192 kbit/s, 1 ch, 10 ms, high res. [AA.AC.15]	8a [AA.AF.15]	N/A	8b [AA.AF.16]	N/A	N/A
LC3plus codec, 96 kHz, 256 kbit/s, 1 ch, 10 ms, high res. [AA.AC.16]	8a [AA.AF.15]	N/A	8b [AA.AF.16]	N/A	N/A
LC3plus codec, 96 kHz, 320 kbit/s, 1 ch, 10 ms, high res. [AA.AC.17]	8a [AA.AF.15]	N/A	8b [AA.AF.16]	N/A	N/A
Single channel - LFE					
LC3plus codec, 48 kHz, 32 kbit/s, 1 ch, 10 ms [AA.AC.18] (LFE)	N/A	N/A	7i [AA.AF.13]	N/A	N/A
LC3plus codec, 48 kHz, 64 kbit/s, 1 ch, 5 ms [AA.AC.19] (LFE)	N/A	N/A	7i [AA.AF.13]	N/A	N/A
Two channel					
LC3plus codec, 48 kHz, 128 kbit/s, 2 ch, 10 ms [AA.AC.20]	7c [AA.AF.9]	N/A	7c [AA.AF.9]	N/A	N/A
LC3plus codec, 48 kHz, 256 kbit/s, 2 ch, 5 ms [AA.AC.21]	7f [AA.AF.10]	N/A	7f [AA.AF.10]	N/A	N/A
LC3plus codec, 48 kHz, 320 kbit/s, 2 ch, 2,5 ms [AA.AC.22]	7f [AA.AF.10]	N/A	7f [AA.AF.10]	N/A	N/A
LC3plus codec, 48 kHz, 512 kbit/s, 2 ch, 2,5 ms [AA.AC.23]	7f [AA.AF.10]	N/A	7f [AA.AF.10]	N/A	N/A

6.4 Physical layer (PHL) requirements

6.4.1 PHL services

Advanced Audio Profile devices shall support the Physical layer (PHL) services described in Table 13.

Table 13: Physical layer service support

Item	Name of service	Reference	Support status	
			PT	FT
AA.P.1	GFSK modulation	5.3	M	M
AA.P.2	π/2-DBPSK modulation	5.3	O	O
AA.P.3	π/4-DQPSK modulation	5.3	O	O
AA.P.4	π/8-D8PSK modulation	5.3	O	O
AA.P.5	Physical packet P32	5.3	M	M
AA.P.6	Physical packet P64	5.3	M	M
AA.P.7	Physical packet P80	5.3	C1301	C1301
AA.P.8	Transmitted power management	5.3	O	O
AA.P.9	Fast hopping radio	5.3	O	O
AA.P.10	Radio receiver category B	5.3	O	O
C1301: If audio codec AA.AC.7, AA.AC.14, AA.AC.17 or AA.AC.22 supported then M, else O.				

The requirements of ETSI EN 300 444 [9], clause 11 also apply.

6.4.2 Modulation schemes

The modulation schemes defined in annex D of ETSI EN 300 175-2 [2] shall be supported as described in Table 14.

Table 14: Allowed combinations of modulation schemes

Modulation scheme	S-field	A-field	B + Z-field	Support status
1a	GFSK	GFSK	GFSK	M
2	π/2-DBPSK	π/2-DBPSK	π/4-DQPSK	O
3	π/2-DBPSK	π/2-DBPSK	π/8-D8PSK	O

6.5 MAC layer requirements

6.5.1 MAC layer services

Advanced Audio Profile devices shall support the MAC layer services given in Table 15.

Table 15: MAC services status

Service supported				
			Status	
Item no.	Name of service	Reference	PT	FT
AA.M.1	I_N_normal delay symmetric MAC service type	5.4	M	M
AA.M.2	I_N_normal delay asymmetric MAC service type	5.4	M	M
AA.M.3	I_N_normal delay with restriction in the handover space	5.4	C1501	O
AA.M.4	Advanced connections	5.4	M	M
AA.M.5	Double Simplex Bearer Handover, intra-cell	5.4	M	M
AA.M.6	Frequency Replacement, intra-cell	5.4	C1501	O
AA.M.7	Audio Data Transfer	5.4	M	M
GAP.M.1	General	5.2 [9]	M	M
GAP.M.2	Continuous broadcast	5.2 [9]	M	M
GAP.M.3	Paging broadcast	5.2 [9]	M	M
GAP.M.4	Basic connections	5.2 [9]	M	M
GAP.M.5	C_S higher layer signalling	5.2 [9]	M	M
GAP.M.6	Quality control	5.2 [9]	M	M
GAP.M.7	Encryption activation	5.2 [9]	M	M
GAP.M.8	Extended frequency allocation (note 1)	5.2 [9]	M	O
GAP.M.9	Bearer Handover, intra-cell	5.2 [9]	M	C1502
GAP.M.10	Bearer Handover, inter-cell	5.2 [9]	M	O
GAP.M.11	Connection Handover, intra-cell	5.2 [9]	M	C1503
GAP.M.12	Connection Handover, inter-cell	5.2 [9]	M	O
GAP.M.13	SARI support	5.2 [9]	M	O
GAP.M.14	Encryption deactivation	5.2 [9]	C1504	C1504
GAP.M.15	Re-keying	5.2 [9]	C1505	C1505
GAP.M.16	Early encryption	5.2 [9]	C1506	C1506
GAP.M.17	AES/DSC2 encryption (note 2)	5.2 [9]	O	O
NOTE 1: PTs not supporting these extra frequencies need only adapt scanning to allow continued use of the standard DECT frequencies.				
NOTE 2: IF implemented THEN NWK feature GAP.N.36 shall be implemented.				
C1501: If audio codec frame duration less than 10 ms supported (see clause 5.1) then M, else O.				
C1502: If service GAP.M.11 THEN O ELSE M.				
C1503: If service GAP.M.9 THEN O ELSE M.				
C1504: If feature GAP.N.29 OR GAP.N.28 THEN M ELSE I.				
C1505: If feature GAP.N.35 and NWK layer procedure "Re-keying during a call" are implemented THEN M ELSE O.				
C1506: If feature GAP.N.35 and NWK layer procedure "Early encryption" are implemented THEN M ELSE O.				

6.5.2 MAC layer service to procedure mapping

The MAC service to procedure mapping of ETSI EN 300 444 [9] (GAP), clause 6.8.3, applies with the changes and additional services shown in Table 16.

Table 16: MAC service to procedure mapping

Service/Procedure mapping				
			Status	
Service	**Procedure**	**Reference**	**PT**	**FT**
AA.M.1 I_N_normal delay symmetric MAC service type		5.4	M	M
	MAC layer procedures: general	7.4.1	M	M
	MAC Connection oriented service	5.6 [3]	M	M
	MAC Basic connection	5.6.1.1 [3]	M	M
	MAC Advanced connection	5.6.1.2 [3]	M	M
	I_N_normal delay symmetric MAC service type 2	5.6.2.1 [3]	M	M
AA.M.2 I_N_normal delay asymmetric MAC service type		5.4	M	M
	MAC layer procedures: general	7.4.1	M	M
	MAC Connection oriented service	5.6 [3]	M	M
	MAC Basic connection	5.6.1.1 [3]	M	M
	MAC Advanced connection	5.6.1.2 [3]	M	M
	I_N_normal delay asymmetric MAC service type 6	5.6.2.2 [3]	M	M
AA.M.3 I_N_normal delay with restriction in the handover space		5.4	O	O
	MAC Advanced connection	5.6.1.2 [3]	M	M
	I_N_normal delay MAC service type	5.6.2 [3]	M	M
	Operation with restriction in the handover space	10.8.3.2.2 [3]	M	M
AA.M.4 Advanced connections		5.4	M	M
	Setup of advanced connection - symmetric	7.4.6	M	M
	Setup of advanced connection - asymmetric	7.4.7	M	M
	Slot type modification	7.4.8	M	M
	Bandwidth modification	7.4.9	M	M
	Double simplex bearer setup	7.4.10	M	M
	Connection release	7.4.11	M	M
	Bearer release	7.4.12	M	M
AA.M.5 Double Simplex Bearer Handover, intra-cell		5.4	M	M
	Bearer handover - double simplex	7.4.14	M	M
AA.M.6 Frequency Replacement, intra-cell		5.4	C1601	O
	Frequency replacement - duplex	7.4.15	M	M
	Frequency replacement - double simplex	7.4.16	M	M
AA.M.7 Audio Data Transfer		5.4	M	M
	Audio data transfer	7.4.18	M	M
GAP.M.2 Continuous broadcast		5.2 [9]	M	M
	Downlink broadcast	7.4.4	M	M
	Higher Layer information FP broadcast	7.6.17	M	M

Service/Procedure mapping				
			Status	
Service	Procedure	Reference	PT	FT
GAP.M.3 Paging broadcast		5.2 [9]	M	M
	Paging broadcast	7.4.5	M	M
GAP.M.9 Bearer handover, intra-cell		5.2 [9]	M	C1602
	Bearer handover - duplex	7.4.13	M	M
GAP.M.10 Bearer handover, inter-cell		5.2 [9]	M	O
	Bearer handover - duplex	7.4.13	M	M
GAP.M.11 Connection handover, intra-cell		5.2 [9]	M	C1603
	Connection handover	7.4.17	M	M
GAP.M.12 Connection handover, inter-cell		5.2 [9]	M	O
	Connection handover	7.4.17	M	M
GAP.M.13 SARI support		5.2 [9]	M	O
	Downlink broadcast	7.4.4	M	M
	Higher Layer information FP broadcast	7.6.17	M	M
C1601: If audio codec frame duration less than 10 ms supported (see clause 5.1) then M, else O. C1602: If MAC service GAP.M.11 THEN O ELSE M. C1603: If MAC service GAP.M.9 THEN O ELSE M.				

6.6 DLC layer requirements

6.6.1 DLC layer services

Advanced Audio Profile devices shall support the DLC layer services given in Table 17.

Table 17: DLC services status

Service supported				
			Status	
Item no.	Name of service	Reference	PT	FT
AA.D.1	LU1 Transparent UnProtected service (TRUP) Class 0	5.5	M	M
GAP.D.1	LAPC class A service and Lc	5.1 [9]	M	M
GAP.D.2	C_S channel fragmentation and recombination	5.1 [9]	M	M
GAP.D.3	Broadcast Lb service	5.1 [9]	M	M
GAP.D.4	Intra-cell voluntary connection handover	5.1 [9]	M	C1701
GAP.D.5	Intercell voluntary connection handover	5.1 [9]	M	O
GAP.D.6	Encryption activation	5.1 [9]	M	M
GAP.D.7	LU1 TRUP Class 0/min_delay	5.1 [9]	N/A	N/A
GAP.D.8	FU1	5.1 [9]	M	M
GAP.D.9	Encryption deactivation	5.1 [9]	C1702	C1702
C1701: If service GAP.M.9 THEN O ELSE M. C1702: If feature GAP.N.29 OR GAP.N.28 THEN M ELSE I.				

6.6.2 DLC layer service to procedure mapping

The DLC service to procedure mapping of ETSI EN 300 444 [9] (GAP), clause 6.8.2, applies with the changes and additional services shown in Table 18.

Table 18: DLC service to procedure mapping

Service/Procedure mapping				
			Status	
Service	**Procedure**	**Reference**	**PT**	**FT**
AA.D.1 LU1 Transparent UnProtected service (TRUP) Class 0		5.5	M	M
	LU1 Transparent UnProtected service (TRUP) operation	11.2 [4]	M	M
	Class 0: No Lu_x retransmission or sequencing	14.2.3.1 [4]	M	M
	Class 0 procedures	14.3.2 [4]	M	M
	LLME U-plane establishment	9.9.1 [9]	M	M
GAP.D.7 LU1 TRUP Class 0/min_delay		5.1 [9]	N/A	N/A
	U-plane Class 0/min delay	9.9 [9]	N/A	N/A
GAP.D.8 FU1 DLC frame		5.1 [9]	M	M
	FU1 frame operation	7.5.2	M	M
	FU1 frame structure	12.2 [4]	M	M

6.7 NWK layer requirements

6.7.1 NWK layer features

Advanced Audio Profile devices shall support the NWK layer services given in Table 19. Note that GAP features which are not listed here are not applicable for Advanced Audio Profile devices but may be supported by devices which support both GAP and the Advanced Audio Profile.

Table 19: NWK features status

Service supported				
			Status	
Item no.	**Name of service**	**Reference**	**PT**	**FT**
AA.N.1	PT Initiated Advanced Audio Call	5.6	M	M
AA.N.2	FT Initiated Advanced Audio Call	5.6	M	M
AA.N.3	Advanced Audio Call Release	5.6	M	M
AA.N.4	Codec Negotiation	5.6	M	M
AA.N.5	Codec Switching	5.6	M	M
GAP.N.1	Authentication of PP	4.1 [9]	M	M
GAP.N.2	Location registration	4.1 [9]	M	O
GAP.N.3	On air key allocation (see note)	4.1 [9]	M	M
GAP.N.4	Identification of PP	4.1 [9]	M	O
GAP.N.5	ZAP (see note)	4.1 [9]	M	O
GAP.N.6	Encryption activation FT initiated	4.1 [9]	M	M
GAP.N.7	Subscription registration procedure on-air	4.1 [9]	M	M
GAP.N.8	Link control	4.1 [9]	M	M
GAP.N.9	Terminate access rights FT initiated (see note)	4.1 [9]	M	O
GAP.N.21	Partial Release	4.1 [9]	O	O
GAP.N.26	Authentication of FT	4.1 [9]	O	O
GAP.N.27	Encryption activation PT initiated	4.1 [9]	O	O
GAP.N.28	Encryption deactivation FT initiated	4.1 [9]	O	O
GAP.N.29	Encryption deactivation PT initiated	4.1 [9]	O	O
GAP.N.35	Enhanced security	4.1 [9]	O	O
GAP.N.36	AES/DSAA2 authentication	4.1 [9]	C1901	C1901
NOTE: This feature is required to be supported in the PT to guarantee the same level of security among all the PTs that operate in a system. The invocation of the feature is however optional to the FT.				
C1901: IF MAC service GAP.M.17 THEN M ELSE O.				

6.7.2 NWK layer feature to procedure mapping

The NWK feature to procedure mapping of ETSI EN 300 444 [9] (GAP), clause 6.8.1, applies with the changes and additional services shown in Table 20.

Table 20: NWK feature to procedure mapping

Feature/Procedure mapping				
			Status	
Feature	Procedure	Reference	PT	FT
AA.N.1 PT initiated advanced audio call		5.6	M	M
	PT initiated call request	7.6.3	M	M
	PT initiated call connection	7.6.4	M	M
AA.N.2 FT initiated advanced audio call		5.6	M	M
	FT initiated call request	7.6.6	M	M
	FT initiated call connection	7.6.7	M	M
AA.N.3 Advanced audio call release		5.6	M	M
	Normal call release	7.6.8	M	M
	Abnormal call release	7.6.9	M	M
AA.N.4 Codec Negotiation		5.6	M	M
	Exchange of codec list during registration and location registration	7.6.10	M	M
	Codec Negotiation during call establishment	7.6.11	M	M
	Slot type modification	7.6.13	M	M
	Bandwidth modification	7.6.14	M	M
	MAC layer advanced connection slot type modification	7.4.8	M	M
	MAC layer advanced connection bandwidth modification	7.4.9	M	M
AA.N.5 Codec Switching		5.6	M	M
	Codec Change	7.6.12	M	M
	Slot type modification	7.6.13	M	M
	Bandwidth modification	7.6.14	M	M
	MAC layer advanced connection slot type modification	7.4.8	M	M
	MAC layer advanced connection bandwidth modification	7.4.9	M	M
GAP.N.9 Authentication of the PP		4.1 [9]	M	M
	Authentication of PP using DSAA	8.24 [9]	M	M
	Authentication of PP using DSAA2	8.45.7 [9]	C2001	C2001
GAP.N.11 Location registration		4.1 [9]	M	O
	Location registration	8.28 [9]	M	M
	Location update	8.29 [9]	M	O
	Terminal Capability indication	7.6.15	M	M
GAP.N.12 On air key allocation		4.1 [9]	M	M
	Key allocation using DSAA	8.32 [9]	M	M
	Key allocation using DSAA2	8.45.9 [9]	C2001	C2001
GAP.N.13 Identification of PP		4.1 [9]	M	O
	Identification of PT	8.22 [9]	M	M
GAP.N.16 ZAP		4.1 [9]	M	O
	Obtaining access rights	8.30 [9]	M	M
	Terminal Capability indication	7.6.15	M	M
	Incrementing the ZAP value	8.26 [9]	M	M
	Authentication of FT using DSAA	8.23 [9]	O	M
	Authentication of FT using DSAA2	8.45.6 [9]	C2001	C2001
GAP.N.17 Encryption activation FT initiated		4.1 [9]	M	M
	Cipher-switching initiated by FT using DSC	8.33 [9]	M	M
	Cipher-switching initiated by FT using DSC2	8.45.10 [9]	C2002	C2002
	Storing the Derived Cipher Key (DCK)	8.27 [9]	M	M
GAP.N.18 Subscription registration user procedure on-air		4.1 [9]	M	M
	Obtaining access rights	8.30 [9]	M	M
	Terminal Capability indication	7.6.15	M	M

Feature/Procedure mapping				
			Status	
Feature	Procedure	Reference	PT	FT
GAP.N.19 Link control		4.1 [9]	M	M
	Indirect FT initiated link establishment	7.6.16	M	M
	Direct PT initiated link establishment	8.36 [9]	M	M
	Link release "normal"	8.37 [9]	M	M
	Link release "abnormal"	8.38 [9]	M	M
	Link release "maintain"	8.39 [9]	M	M
GAP.N.20 Terminate access rights FT initiated		4.1 [9]	M	O
	FT terminating access rights	8.31 [9]	M	M
	Authentication of FT using DSAA	8.23 [9]	O	M
	Authentication of FT using DSAA2	8.45.6 [9]	C2001	C2001
GAP.N.21 Partial release		4.1 [9]	O	O
	Partial release	8.9 [9]	M	M
	Terminal capability indication	8.17 [9]	M	M
GAP.N.26 Authentication of FT		4.1 [9]	O	O
	Authentication of FT using DSAA	8.23 [9]	M	M
	Authentication of FT using DSAA2	8.45.6 [9]	C2001	C2001
GAP.N.27 Encryption activation PT initiated		4.1 [9]	O	O
	Cipher-switching initiated by PT using DSC	8.34 [9]	M	M
	Cipher-switching initiated by PT using DSC2	8.45.11 [9]	C2002	C2002
	Storing the DCK	8.27 [9]	M	M
GAP.N.28 Encryption deactivation FT initiated		4.1 [9]	O	O
	Cipher-switching initiated by FT using DSC	8.33 [9]	M	M
	Cipher-switching initiated by FT using DSC2	8.45.10 [9]	C2002	C2002
GAP.N.29 Encryption deactivation PT initiated		4.1 [9]	O	O
	Cipher-switching initiated by PT using DSC	8.34 [9]	M	M
	Cipher-switching initiated by PT using DSC2	8.45.11 [9]	C2002	C2002
GAP.N.35 Enhanced security		4.1 [9]	O	O
	Encryption of all calls	8.45.1 [9]	M	M
	Re-keying during a call	8.45.2 [9]	O	O
	Early encryption	8.45.3 [9]	O	O
	Subscription requirements	8.45.4 [9]	M	M
GAP.N.36 AES/DSAA2 authentication		4.1 [9]	C2003	C2003
	Authentication of FT using DSAA2 (see note)	8.45.6 [9]	O	O
	Authentication of PP using DSAA2	8.45.7 [9]	M	M
	Authentication of user using DSAA2	8.45.8 [9]	M	M
	Key allocation using DSAA2	8.45.9 [9]	M	M
	Cipher-switching initiated by FT using DSC2	8.45.10 [9]	C2004	C2004
	Cipher-switching initiated by PT using DSC2	8.45.11 [9]	C2005	C2005
NOTE: The status of this procedure refers to its use as a standalone procedure. Note that the FT authentication is part of the Key Allocation procedure and, in this case, the status is M.				
C2001: If feature GAP.N.36 THEN M ELSE I. C2002: If feature GAP.N.36 and MAC service GAP.M.17 THEN M ELSE I. C2003: If MAC service GAP.M.17 THEN M ELSE O. C2004: If MAC service GAP.M.17 THEN M ELSE I. C2005: If (feature GAP.N.27 or feature GAP.N.29) and MAC service GAP.M.17 THEN M ELSE I.				

6.8 Application requirements

6.8.1 Application features

Advanced Audio Profile devices shall support the application features given in Table 21.

Table 21: Application features status

Feature supported			Status	
Item no.	Name of feature	Reference	PT	FT
AA.A.1	Easy pairing registration	5.7	O	O
AA.A.2	Head tracking	5.7	O	O
GAP.A.1	AC_bitstring_mapping	4.3 [9]	M	M
GAP.A.2	Multiple subscription registration	4.3 [9]	O	N/A
GAP.A.3	Manual entry of the PARK	4.3 [9]	O	O

6.8.2 Application feature to procedure mapping

The application feature to procedure mapping of ETSI EN 300 444 [9] (GAP), clause 6.8.1, applies with the changes and additional services shown in Table 22.

Table 22: Application feature to procedure mapping

Feature/Procedure mapping				
			Status	
Feature	Procedure	Reference	PT	FT
AA.A.1 Easy pairing registration		5.7	M	O
	General	7.7.2.1	M	M
	Searching mode request	7.7.2.2	M	N/A
	Base station limited registration mode	7.7.2.3	N/A	M
	Registration user feedback	7.7.2.4	O	O
AA.A.2 Head tracking		5.7	O	O
	General	7.7.3.1	M	M
GAP.A.1 AC to bitstring mapping		4.3 [9]	M	C2201
	AC to bitstring mapping	14.2 [9]	M	M
GAP.A.2 Multiple subscription registration		4.3 [9]	O	N/A
	Subscription control	14.1 [9]	O	N/A
GAP.A.3 Manual entry of the PARK		4.3 [9]	O	N/A
	Manual entry of the PARK	14.3 [9]	O	N/A
C2201: If feature GAP.N.9 OR GAP.N.12 OR GAP.N.26 THEN M ELSE N/A.				

7 Profile specific procedure descriptions

7.1 General

The following clauses define the process mandatory procedures which are in the scope of the Advanced Audio Profile. Each procedure (if appropriate) is divided into three parts:

a) normal (i.e. successful) case(s). This part defines the functions and respective protocol element values in normal operation;

b) associated procedure(s). This is an integral part of the actual procedure (if defined in the present document), i.e. if a procedure is being declared to be supported, the respective entity shall also support the associated procedures, e.g. timer management, in the clause following the description of the normal case;

c) exceptional case(s). This is an integral part of the actual procedure (if defined in the present document), i.e. if a procedure is being declared to be supported, the respective entity shall also support the exception handling defined in the clause following the description of the normal case.

All protocol elements listed in the following clauses are process mandatory, i.e. the FT and PT depending on their role in the procedure shall send or shall receive and process the relevant protocol elements as listed in the respective tables if not explicitly stated as being optional.

The primitives used in procedure descriptions are defined only for the purpose of describing layer-to-layer interactions. The primitives are defined as an abstract list of parameters, and their concrete realization may vary between implementations. No formal testing of primitives is intended. The primitive definitions have no normative significance.

7.2 Requirements regarding the audio transmission

7.2.1 General

The applicable requirements specified in ETSI EN 300 175-8 [8] shall be applied according to their status as defined in clause 6.3.

7.2.2 Audio codecs

The FT and PT shall support the LC3plus codec as specified in ETSI TS 103 634 [10] with configurations according to the device type as defined in clause 6.3.

7.2.3 Audio performance requirements

The FT and PT shall support the maximum end-to-end-delay as defined in clause 5.2.

The FT shall support FP audio type 5 as defined in clause 5.2.

The PT shall support the PP audio types according to its device type and audio codec support as defined in clause 6.3.

All requirements specified in ETSI EN 300 175-8 [8] and ETSI EN 300 176-2 [11] for the supported device types and codecs shall be supported.

7.3 Physical (PHL) layer requirements

7.3.1 General

All requirements specified in ETSI EN 300 444 [9] (GAP), clause 11, shall apply.

All requirements specified in ETSI EN 300 175-2 [2] and ETSI EN 301 406 [12] for the supported modulation types shall apply.

7.3.2 Modulation

The FT and PT shall support 2 level Gaussian Frequency Shift Keying (GFSK) modulation as defined in ETSI EN 300 175-2 [2], clause 5.

The FT and PT may support 2 level Differential Binary Phase Shift Keying (π/2-DBPSK) modulation as defined in ETSI EN 300 175-2 [2], clause D.1.

The FT and PT may support 4 level Differential Quaternary Phase Shift Keying (π/4-DQPSK) modulation as defined in ETSI EN 300 175-2 [2], clause D.2.

The FT and PT may support 8 level Differential 8-Phase Shift Keying (π/8-D8PSK) modulation as defined in ETSI EN 300 175-2 [2], clause D.3.

7.3.3 Slot type (Physical packets)

The FT and PT shall support Physical packet P32 (full slot) as defined in ETSI EN 300 175-2 [2], clause 4.4.2.

The FT and PT shall support Physical packet P00j (variable slot) as defined in ETSI EN 300 175-2 [2], clause 4.4.3, with a j value of j = 640.

The FT and PT may support Physical packet P80 (double slot) as defined in ETSI EN 300 175-2 [2], clause 4.4.4.

7.3.4 Transmitted power management

To avoid mutual interference between data terminals operating in different local DECT networks when using for the transmission most of the slots from a frame, control of the transmission power is recommended.

If transmission power control procedure is implemented, the requirements in ETSI EN 300 175-2 [2], annex E shall fully apply.

7.3.5 Fast hopping radio

The radio transceiver shall be able to perform any frequency change during the interval between two consecutive Physical Packets P32 (full slot) or P80 (double slot) if this feature is supported.

7.3.6 Radio receiver category B

The radio receiver shall fulfil the performance requirements defined in ETSI EN 300 175-2 [2], annex G if this feature is supported.

7.4 Medium Access Control (MAC) layer procedures

7.4.1 General

This clause specifies the additional MAC layer procedures, messages and information elements required for the Advanced Audio Profile which are not described in ETSI EN 300 444 [9] (GAP) or which incorporate modifications to the GAP specification.

7.4.2 MAC services

NOTE: This description, together with clause 7.4.3, replaces clause 10.1 of ETSI EN 300 444 [9] (GAP).

The FT and PT shall support the I_N_normal_delay symmetric service as defined in ETSI EN 300 175-3 [3], clauses 5.6.2.1 and 10.8.3.2.

The FT and PT shall support the I_N_normal_delay asymmetric service as defined in ETSI EN 300 175-3 [3], clauses 5.6.2.2 and 10.8.3.2.

The FT and PT need not support the I_N_minimum_delay symmetric service used in ETSI EN 300 444 [9] (GAP).

7.4.3 Frame formats and multiplexers

NOTE: This description, together with clause 7.4.2, replaces clause 10.1 of ETSI EN 300 444 [9] (GAP).

The FT and PT shall support the following frame formats:

- D-field mapping for the full slot structure (physical packet P32), as defined in ETSI EN 300 175-3 [3], clause 6.2.1.1.2.
- D-field mapping for the variable slot structure (physical packet P00j), as defined in ETSI EN 300 175-3 [3], clause 6.2.1.1.3, with a j value of j = 640.

The FT and PT may support the following frame format:

- D-field mapping for the double slot structure (physical packet P80), as defined in ETSI EN 300 175-3 [3], clause 6.2.1.1.1.

The FT and PT shall support A-field mapping A-MAP.

The FT and PT shall understand all A field tail identifications (a_0, a_1 and a_2) in the header field as defined in ETSI EN 300 175-3 [3], clauses 6.2.1.2 and 7.1.2.

The FT and PT shall support the following B-field field identifications (a_4, a_5 and a_6) as defined in ETSI EN 300 175-3 [3], clause 7.1.4:

- U-type: In, '000'B.
- No B-field, '111'B (shall only be used for dummy bearers).
- Long slot required, '101'B.

The FT and PT may support the following B-field field identifications (a_4, a_5 and a_6) as defined in ETSI EN 300 175-3 [3], clause 7.1.4:

- Double slot required, '010'B.

The FT and PT shall support T-MUX as defined in ETSI EN 300 175-3 [3], clause 6.2.2.1.

The FT and PT shall support B-field multiplex E/U MUX type U32a and U64a as defined in ETSI EN 300 175-3 [3], clause 6.2.2.2.

The FT and PT may support B-field multiplex E/U MUX type U80a as defined in ETSI EN 300 175-3 [3], clause 6.2.2.2.

The FT and PT shall support scrambling as defined in ETSI EN 300 175-3 [3], clause 6.2.4.

The FT and PT shall provide R-CRC generation and checking as defined in ETSI EN 300 175-3 [3], clause 6.2.5.2. The FT and PT shall provide X-CRC generation and checking as defined in ETSI EN 300 175-3 [3], clauses 6.2.5.3 and 6.2.5.4.

The PT shall support the normal duty cycle idle_locked mode as defined in ETSI EN 300 175-3 [3], clauses 11.3 and 4.3.1.

The FT and PT shall support primary scan procedure as defined in ETSI EN 300 175-3 [3], clause 11.8.

7.4.4 Downlink broadcast

7.4.4.1 General

NOTE: This procedure description replaces clause 10.2 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 9.1.1.

7.4.4.2 N_T messages

The same message defined in ETSI EN 300 444 [9] (GAP), clause 10.2.1 shall be used.

7.4.4.3 Q_T - static system information

The FT shall be capable of sending and the PT shall be capable of receiving and processing the Q_T message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.2, with the values shown in Table 23.

Table 23: Values used within static system info

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<Static system info>>	<Q_H>	0	
	<NR>	0, 1	PT shall support all values in order to gain lock. FT shall set to 1 in the reversed half of an asymmetric slot pair, otherwise the FT shall set to 0
	<SN>	0 to 11	PT shall support all values
	<SP>	0	PT shall support all values in order to gain lock. Half slot connections are not required to be supported by the PT
	<ESC>	0	PT may ignore and assume the value to be 0
	<Txs>	0	PT may ignore and assume the value to be 0
	<Ext-car>	0,1	PT shall support all values in order to keep in synchronization with the primary scan
	<RF-car>	1 to 1 023	The PT shall not use carriers which are not supported
	<SPR>	0	PT may ignore
	<CN>	0 to 9	PT shall support all values
	<SPR>	0	PT may ignore
	<PSCN>	0 to N	PT shall support values 0 to 9

7.4.4.4 Q_T - Fixed Part capabilities

The FT shall be capable of sending and the PT shall be capable of receiving and processing the Q_T message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.4, with the values shown in Table 24.

Table 24: Values used within FP capabilities

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<FP capabilities>>	<Q_H>	3	
	<a_{12}>	1	Extended FP Info
	<a_{15}>	0,1	Double slot (PT and FT shall support the value 1 if double slot is supported)
	<a_{17}>	1	Full slot
	<a_{23}>	1	Basic A-field setup
	<a_{24}>	1	Advanced A-field setup
	<a_{28}>	1	I_n normal delay
	<a_{31}>	1	Multibearer connections (PT and FT shall support the value 1 if multibearer connections are supported)

Higher layer information: The management entity in the FP supplies the MAC layer with a 16-bit SDU via the Management Entity (ME) SAP. The content of that SDU is placed in bits <a_{32}> to <a_{47}> of the Q_T message. At the PT the MAC layer passes the 16 bits out through the ME SAP to the management entity.

For the setting of the higher layer information bits see clause 7.6.17.2.

7.4.4.5 Q_T - Extended Fixed Part capabilities

The FT shall be capable of sending and the PT shall be capable of receiving and processing the Q_T message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.5, with the values shown in Table 25.

Table 25: Values used within Extended FP capabilities

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<FP capabilities>>	<Q_H>	4	
	<a_{20}>	0,1	Frequency replacement (PT and FT shall support the value 1 if frequency replacement is supported)
	<a_{23}>	1	Extended FP capabilities part 2

Higher layer information: The management entity in the FP supplies the MAC layer with a 23-bit SDU via the Management Entity (ME) SAP. The content of that SDU is placed in bits <a_{25}> to <a_{47}> of the Q_T message. At the PT the MAC layer passes the 23 bits out through the ME SAP to the management entity.

For the setting of the higher layer information bits see clause 7.6.17.3.

7.4.4.6 Q_T - Extended Fixed Part capabilities part 2

The FT shall be capable of sending and the PT shall be capable of receiving and processing the Q_T message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.11, with the values shown in Table 26.

Table 26: Values used within Extended FP capabilities part 2

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<FP capabilities>>	<Q_H>	0xC	
	<a_{12}>	1	Long slot j = 640
	<a_{22}>	0,1	Extended FP capabilities part 3. (PT and FT shall support the value 1 if high level modulation is supported)

Higher layer information: The management entity in the FP supplies the MAC layer with a 24-bit SDU via the Management Entity (ME) SAP. The content of that SDU is placed in bits <a_{24}> to <a_{47}> of the Q_T message. At the PT the MAC layer passes the 24 bits out through the ME SAP to the management entity.

For the setting of the higher layer information bits see clause 7.6.17.4.

7.4.4.7 Q_T - Extended Fixed Part capabilities part 3

If high level modulation is supported then the FT shall be capable of sending and the PT shall be capable of receiving and processing the Q_T message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.13, with the values shown in Table 27.

Table 27: Values used within Extended FP capabilities part 3

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<FP capabilities>>	<Q_H>	0xE	
	<a_{14} to a_{17}>	0x0, 0x2, 0x4, 0x6	High level modulation. (PT and FT shall support all values up to their maximum supported modulation level)

Higher layer information: The management entity in the FP supplies the MAC layer with a 24-bit SDU via the Management Entity (ME) SAP. The content of that SDU is placed in bits <a_{24}> to <a_{47}> of the Q_T message. At the PT the MAC layer passes the 24 bits out through the ME SAP to the management entity.

For the setting of the higher layer information bits see clause 7.6.17.5.

7.4.4.8 Q_T - SARI list contents

The FT may send and the PT shall be capable of receiving and processing (if broadcast by the FT) the Q_T SARI message as defined in ETSI EN 300 175-3 [3], clause 7.2.3.6, with same contents as defined by ETSI EN 300 444 [9] (GAP), clause 10.2.4.

This is relevant if the N_T message indicates SARI support.

7.4.5 Paging broadcast

7.4.5.1 General

NOTE: This procedure description replaces clause 10.3 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 9.1.3. SHORT page, ZERO page and FULL page formats shall be supported.

7.4.5.2 Short page, normal/extended paging

The fields shown in Table 28 and defined in ETSI EN 300 175-3 [3], clauses 7.2.4.1.2, 7.2.4.2 and 7.2.4.3, shall be supported by the PT and the FT.

Table 28: Values used within short page message

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<Short page message>>	<Extend flag>	0, 1	PT shall support all values. Optional for the FT to support value 1
	<B_S SDU length indication>	'001'B	PT and FT shall support short page messages
	<20 bits of B_S channel data>	All	Higher layer information
	<Information type>	0, 1, 2, 5, 9 and 14	The PT shall support values 0, 1, 2, 5 and 9. The PT shall support value 14 if double slots are supported. The FT shall support value 0 (see clause 7.4.5.5) if blind slot information for long slots is available. The FT shall support value 1 (see clause 7.4.5.5) if blind slot information for full slots is available. The FT shall support value 9 (see clause 7.4.5.6) if bearer handover information available. The FT shall support value 14 (see clause 7.4.5.6) if double slots are supported and blind slot information for double slots is available. Other values need not be supported by FT or PT
	<MAC layer information>	Corresponding information	Information type defined in the previous field

7.4.5.3 Zero page normal/extended paging

The fields shown in Table 29 and defined in ETSI EN 300 175-3 [3], clauses 7.2.4.1.3, 7.2.4.2 and 7.2.4.3, in the zero page message, shall be supported by the PT and the FT.

Table 29: Values used within zero page message

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<Zero page message>>	<Extend flag>	0, 1	PT shall support all values. Optional for the FT to support value 1
	<B_S SDU length indication>	'000'B	PT shall support zero length page messages. The FT shall support if "Blind slot information" included
	< 20 least significant bits of RFPI>	All	May be ignored by PT
	<Information type>	0, 1, 2, 5, 9 and 14	The PT shall support values 0, 1, 2, 5 and 9. The PT shall support value 14 if double slots are supported. The FT shall support value 0 (see clause 7.4.5.5) if blind slot information for long slots is available. The FT shall support value 1 (see clause 7.4.5.5) if blind slot information for full slots is available. The FT shall support value 9 (see clause 7.4.5.6) if bearer handover information available. The FT shall support value 14 (see clause 7.4.5.6) if double slots are supported and blind slot information for double slots is available. Other values need not be supported by FT or PT
	<MAC layer information>	Corresponding information	Information type defined in the previous field

7.4.5.4 Full page, normal/extended paging

The fields shown in Table 30 and defined in ETSI EN 300 175-3 [3], clauses 7.2.4.1.1 and 7.2.4.2, in the full page message, shall be supported by the PT and the FT.

Table 30: Values used within full page message

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<Full page message>>	<Extend flag>	0, 1	PT shall support all values. It is optional for the FT to support value 1
	<B_S SDU length indication>	'010'B	PT and FT shall support full page messages
	<36 bits of B_S channel data>	All	Higher layer information

7.4.5.5 Blind slot information

It is mandatory for RFPs that have blind slots due to technological limitations such as a slow synthesizer to periodically announce these blind slots (at least every 10 s). In the event the RFP announces blind slot information, such information may also include all blind slots due to an active bearer as well.

Not available (blind) slot means that the FT recommends the PT not to attempt a setup on this slot.

If the PT receives blind slot information, it is mandatory for that PT to use it in the process of channel selection. The PT does not have to wait for the blind slot information before making the channel selection.

FTs with blind slot limitations shall announce their blind slots using the field MAC layer information and the information types:

- 0 for long slots;
- 1 for full slots; and
- 14 for double slots (only if double slots are supported by the RFP).

The content of the MAC layer information field shall be as defined in ETSI EN 300 175-3 [3], clauses 7.2.4.3.2 (for long slot), 7.2.4.3.3 (for full slot) and 7.2.4.3.11 (for double slot).

7.4.5.6 Bearer handover information

It is mandatory for FTs not supporting bearer handover within the whole FT to periodically send the bearer handover information (at least every 10 s).

It is mandatory for PT to support the following values of field "Info type" (bits a_{36} to a_{39}) for "Bearer handover information" (value "9" of <Information type> in the P_T message, see Table 28 and Table 29): '0000', '0001', '0010' and '0011'.

NOTE: For double simplex bearers, bearer handover to other RFPs is not supported irrespective of the bearer handover information. See clause 7.4.14 for further details.

7.4.6 Setup of symmetric advanced connection, duplex bearer setup

7.4.6.1 General

NOTE: This procedure description replaces clause 10.4 of ETSI EN 300 444 [9] (GAP).

The symmetric connection setup procedure shall be performed as defined in ETSI EN 300 175-3 [3], clauses 10.2.4.1 and 10.2.4.2.

The "single bearer duplex connection of known service type" setup procedure described in ETSI EN 300 175-3 [3], clause 10.2.4.2 shall be used in all cases.

- PT initiated setup (all cases).
- FT initiated indirect setup (paging) (LCE code = '101'B).

The bearer setup procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 10.5.1.2.

The exchange of the messages "Attributes_T.req" and "Attributes_T.cfm" is mandatory in all cases. The PT shall send the "Attributes_T.req" message after reception of the "Bearer.cfm" as described in ETSI EN 300 175-3 [3], clause 10.5.1.2.1.

7.4.6.2 M_T messages

The fields shown in Table 31, Table 32 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.3 of in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 31: Values used within M_T message - Setup messages

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	0	Access_request
		4	Bearer_confirm
		5	Wait
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

Table 32: Values used within M_T message - Attributes_T_request/confirm

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	6	Attributes_T_request
		7	Attributes_T_confirm
	<ECN>	All	
	<LBN>	15	
	<up/down/sm/ss>	3	Duplex bearer in a single bearer connection or initial duplex bearer in a multibearer connection
	<ser type>	2 to 4	I_N_normal delay (I_{NB}), optionally with handover restriction
	<slot type>	0, 2, 3	Full, double or long with j = 640
	<C_F>	0	C_S only
	(B+Z) fields mod ext or MCS index	0	Extended coding not used
	adaptive code rate or MCS index	0	Adaptive rate not used
	A-field mod type	3	2 level only for A field
	(B+Z) fields mod. type	1, 2, 3	2, 4, or 8 level modulation for B and Z fields

7.4.6.3 Associated procedures

7.4.6.3.1 Timer T200 management

T200: Connection setup timer;

Value: Refer to ETSI EN 300 175-3 [3], annex A;

Start: At the creation of an MBC;

Stop: The TBC reports "bearer_established" or on request for MAC connection release.

7.4.6.3.2 Counter N200 management

N200: Max. number bearer setup re attempts during connection setup;

Value: Refer to ETSI EN 300 175-3 [3], annex A;

Start: ACCESS_REQUEST is sent;

Change: A new ACCESS_REQUEST within the same connection setup attempt is sent;

Clear: The TBC reports "bearer_established" or on request for MAC connection release.

7.4.6.4 Exceptional cases

7.4.6.4.1 Bearer setup attempt fails N200+1 times

Figure 1 shows the case when a bearer setup attempt fails N200+1 times.

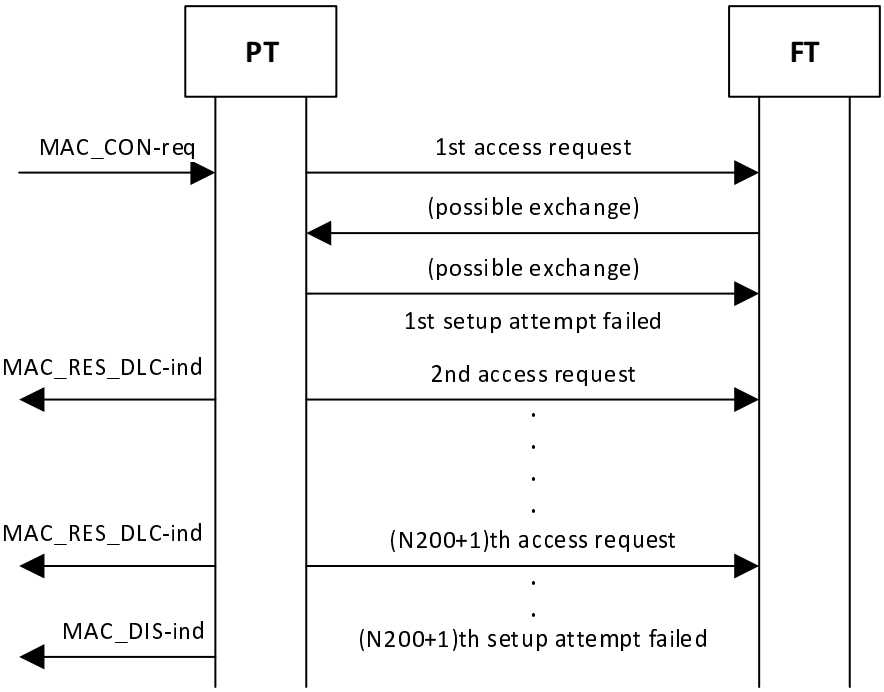


Figure 1: Bearer setup attempt fails N200+1 times

7.4.6.4.2 Timer T200 expiry

Figure 2 shows the case when the timer T200 expires.

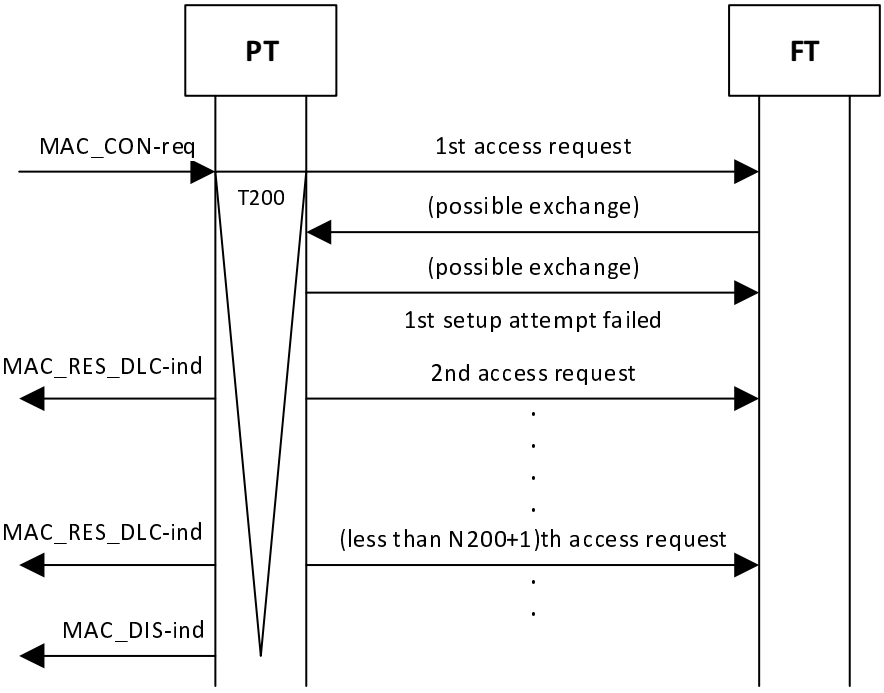


Figure 2: Timer T200 expiry

7.4.7 Setup of asymmetric advanced connection

7.4.7.1 General

The asymmetric connection setup procedure shall be performed as defined in ETSI EN 300 175-3 [3], clauses 10.2.4.1 and 10.2.4.3.

At establishment of the connection, a symmetric connection is initially established as described in clause 7.4.6. The duplex bearer established here is referred to as the pilot bearer for the asymmetric connection. During the subsequent codec negotiation, as described in clause 7.6.11, the connection is modified to become an asymmetric connection through the addition of double simplex bearers.

The steps in this procedure are as follows:

- A slot type modification of the duplex bearer takes place if needed according to the bearer configuration given in annex B. This procedure is described further in clause 7.4.8.
- An FT initiated bandwidth negotiation takes place. It is expected this shall succeed because the bandwidth is derived from the codec configuration which was either provided by or accepted by the PT. This is described further in clause 7.4.9.
- The FT initiates the required double simplex bearer establishments needed for the agreed bandwidth. This is described further in clause 7.4.10.

7.4.7.2 Associated procedures

The procedures for the handling of Timer T200 and counter N200, as described in clause 7.4.6.3, shall also be supported for asymmetric connections. The N200 counter applies per bearer in this case, as described in ETSI EN 300 175-3 [3], clause 10.2.4.3.0. Furthermore, the procedures for slot type modification (see clause 7.4.8), bandwidth modification (see clause 7.4.9) and double simplex bearer setup (see clause 7.4.10) shall be supported.

7.4.7.3 Exceptional cases

7.4.7.3.1 Bearer setup attempt fails N200+1 times

Failure to setup any of the required bearers after N200+1 attempts (per bearer) will result in connection release as described in clause 7.4.6.4.1 and ETSI EN 300 175-3 [3], clause 10.2.4.3.0.

7.4.7.3.2 Timer T200 expiry

Expiry of the T200 timer before successful connection setup will result in connection release as described in clause 7.4.6.4.2 and ETSI EN 300 175-3 [3], clause 10.2.4.3.0.

7.4.7.3.3 Insufficient bandwidth available

If the bandwidth modification procedure fails due to the minimum number of target bearers not being achieved, as described in clause 7.4.9, then the connection shall be released and the failure reported to higher layers as described in ETSI EN 300 175-3 [3], clause 10.2.4.3.0.

7.4.8 Slot type modification

7.4.8.1 General

After invocation of the NWK layer procedure for slot type modification (see clause 7.6.13), the modification shall be executed using the MAC layer procedure for slot type modification.

The MAC slot type change procedure shall be executed as described in ETSI EN 300 175-3 [3], clause 10.3.2.

The FT shall always initiate this procedure.

NOTE: In the case of a multibearer connection, the slot type modification is actually a combination of bandwidth modification and slot type modification procedures, as described in ETSI EN 300 175-3 [3], clause 10.3.2.2.4.

7.4.8.2 Failure of slot type modification

On failure of the slot type modification the initiating side shall not release the connection, but shall keep the existing slot type, and shall report the failure to higher layers. The NWK layer shall handle the case as described in clause 7.6.13.2.

7.4.9 Bandwidth modification

7.4.9.1 General

After invocation of the NWK layer procedure for bandwidth modification (see clause 7.6.14), or during connection setup for a multibearer connection, the modification shall be executed using the MAC layer procedure for bandwidth modification.

The MAC bandwidth change procedure shall be executed as described in ETSI EN 300 175-3 [3], clause 10.3.1.0.

The FT shall always initiate this procedure.

7.4.9.2 Mt Messages

The fields shown in Table 33 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.3, in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 33: Values used within M_T message - Bandwidth_T_request/confirm

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	8	Bandwidth_T_request
		9	Bandwidth_T_confirm
	<X_{Up}>	0 to 8	Excess number of simplex bearers, uplink
	<M_{Up}>	0 to 8	Minimum number of simplex bearers, uplink
	<T_{Up}>	0 to 8	Target number of simplex bearers, uplink
	<X_{Down}>	0 to 8	Excess number of simplex bearers, downlink
	<M_{Down}>	0 to 8	Minimum number of simplex bearers, downlink
	<T_{Down}>	0 to 8	Target number of simplex bearers, downlink
NOTE: The number of bearers required for a given codec bit rate is defined in annex B.			

7.4.9.3 Associated procedures

7.4.9.3.1 General

The overall procedure is as shown in Figure 3.

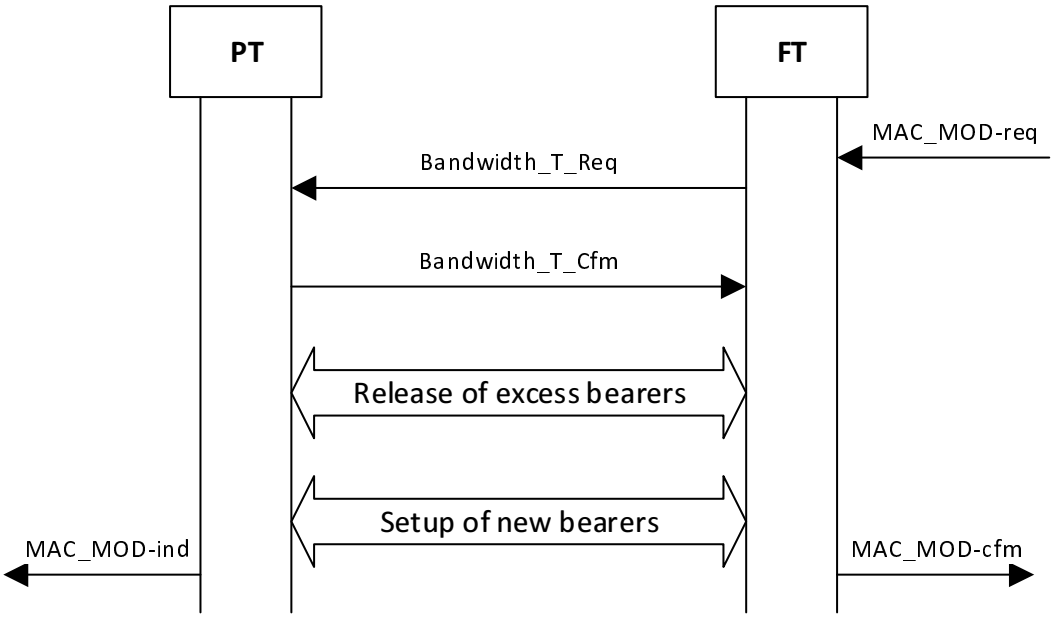


Figure 3: Bandwidth modification procedure

For details of the bearer release and setup procedures, refer to clauses 7.4.12 and 7.4.10 respectively.

7.4.9.3.2 Timer T211 management

T211: Connection modification timer;

Value: Refer to ETSI EN 300 175-3 [3], annex A;

Start: When the number of new bearers is less than the minimum number of required bearers;

Stop: The TBC for the last double simplex bearer reports "bearer_established" or on request for MAC connection release.

7.4.9.4 Exceptional cases

7.4.9.4.1 Timer T211 expiry

In case the minimum number of target bearers cannot be met before timer T211 expiry, the connection is released as shown in Figure 4.

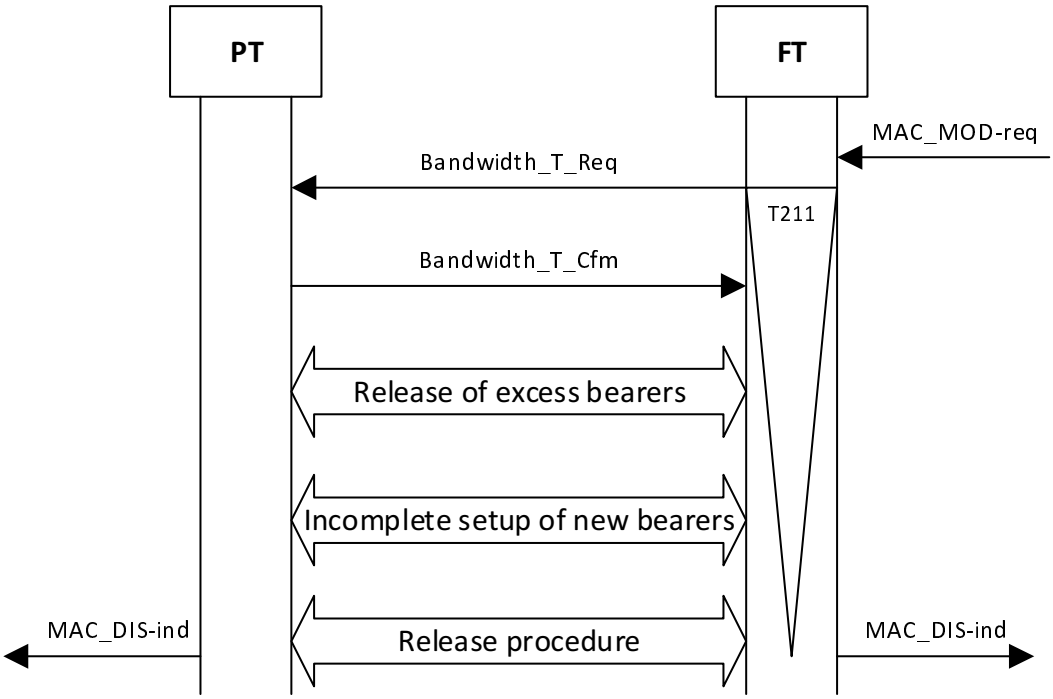


Figure 4: T211 expiry

7.4.10 Double simplex bearer setup

7.4.10.1 General

The double simple bearer setup is used to increase the bandwidth during a bandwidth modification procedure.

The steps in this procedure are as follows:

- Channel selection for the new bearers shall be performed by the FT as defined in ETSI EN 300 175-3 [3], clause 10.5.1.4.3. Optionally, the FT may additionally request the conditions seen at the PT via a QUERY_N channel list message.
- The FT initiates the required double simplex bearer establishments needed for the new agreed bandwidth. The double simplex bearer establishment is done according to the procedures defined in ETSI EN 300 175-3 [3], clause 10.5.1.4. For this application profile, only the following cases are supported:
  - Uplink double simplex bearer:
    - Direct setup initiated by LISTEN, as defined in ETSI EN 300 175-3 [3], clause 10.5.1.4.6.1.
  - Downlink double simplex bearer:
    - Direct setup initiated by START, as defined in ETSI EN 300 175-3 [3], clause 10.5.1.4.6.2.

NOTE: For a downlink double simplex bearer, the PT is the R-Side and the FT is the T-Side. For an uplink double simplex bearer, the FT is the R-Side and the PT is the T-Side.

- Encryption shall be handled according to Procedure 2: Synchronization at ACTIVE, as defined in ETSI EN 300 175-3 [3], clause 10.5.1.4.7.2

7.4.10.2 Mt Messages

The fields shown in Table 34, Table 35 and Table 36 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.3, in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 34: Values used within M_T message - Unconfirmed access request

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	3	Unconfirmed_access_request
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

Table 35: Values used within M_T message - Attributes_T_request

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	6	Attributes_T_request
	<ECN>	All	
	<LBN>	1 to 14	
	<up/down/sm/ss>	0, 1	Double simplex uplink or downlink
	<ser type>	2 to 4	I_N_normal delay (I_{NB}), optionally with handover restriction
	<slot type>	0, 2, 3	Full, double or long with j = 640
	<C_F>	0	C_S only
	(B+Z) fields mod ext or MCS index	0	Extended coding not used
	adaptive code rate or MCS index	0	Adaptive rate not used
	A-field mod type	3	2 level only for A field
	(B+Z) fields mod. type	1, 2, 3	2, 4, or 8 level modulation for B and Z fields

Table 36: Values used within M_T message - Channel list

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	10	Channel_list
	<RPN>	All	
	<command>	0	ACTIVE
		1	GOOD
		2	POOR
		4	QUERY_N
		6	LISTEN
		7	START
	<S/D>	0	Double simplex
	<SN>	All	
	<SP>	All	
	<CN>	All	
	<LBN>	1 to 14	

7.4.10.3 Associated procedures

7.4.10.3.1 Uplink double simplex bearer setup

The setup of each double simplex bearer shall follow the procedure defined in ETSI EN 300 175-3 [3], clause 10.5.1.4 with the additional restrictions defined in this clause.

The sequence and mapping of messages to the duplex and double simplex bearers shall be as shown in Figure 5. Other variations of the signalling are not supported.

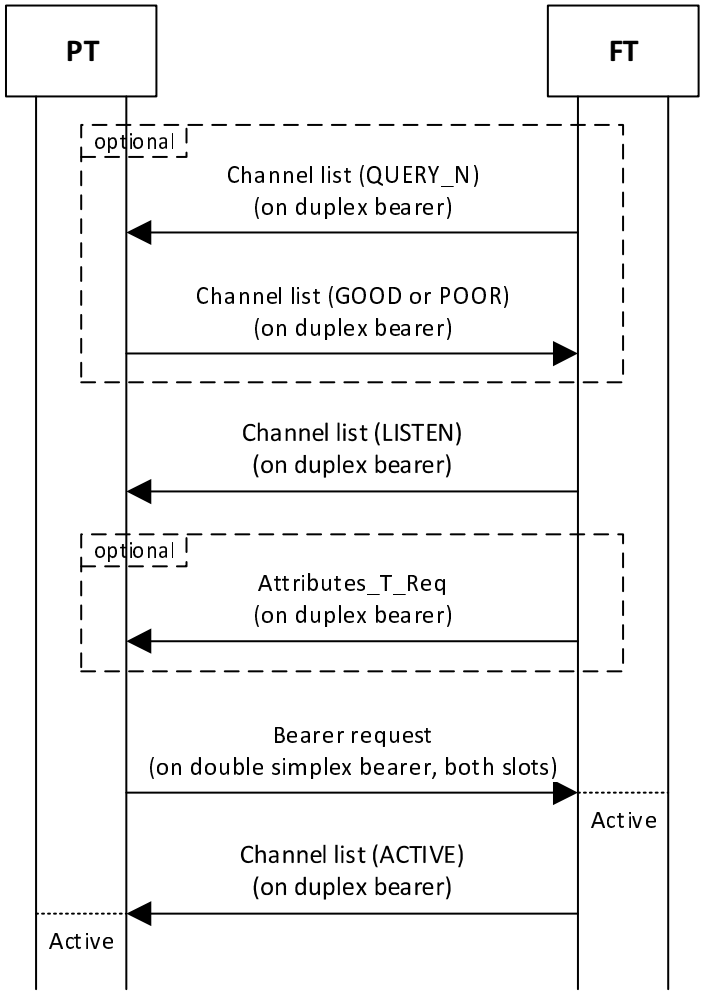


Figure 5: Uplink double simplex bearer setup

The use of the QUERY_N channel list message to determine the channel conditions at the PT is recommended in order to improve bearer setup performance.

If the FT transmits the Attributes_T_Req after the LISTEN channel list message, then the FT shall set the A_F field to 1 in the LISTEN channel list message. In this case the PT shall not begin transmission of the Bearer request until the attributes have been received.

NOTE 1: In most cases the Attributes_T_Req message is not required because the attributes are already known via the network layer CONNECTION ATTRIBUTES IE.

An Attributes_T_Cfm messages is not included in the sequence. Reception of the bearer request at the FT implicitly confirms reception of the attributes.

The bearer request message shall be transmitted on both slots of the double simplex bearer for a maximum of 3 frames. Reception of this message on both slots within the 3 frames is required for bearer establishment.

Encryption is synchronized using the Channel list (ACTIVE) message and shall start one frame after this message.

U-plane transmission shall begin only when all double simplex bearers required for the connection have become active.

NOTE 2: During connection establishment, the audio is only connected after all bearers are established and the connection is completed at the network layer. Hence, in the establishment case there is no valid audio data available when the bearer setup completes.

7.4.10.3.2 Downlink double simplex bearer setup

The setup of each double simplex bearer shall follow the procedure defined in ETSI EN 300 175-3 [3], clause 10.5.1.4 with the additional restrictions defined in this clause.

The sequence and mapping of messages to the duplex and double simplex bearers shall be as shown in Figure 6. Other variations of the signalling are not supported.

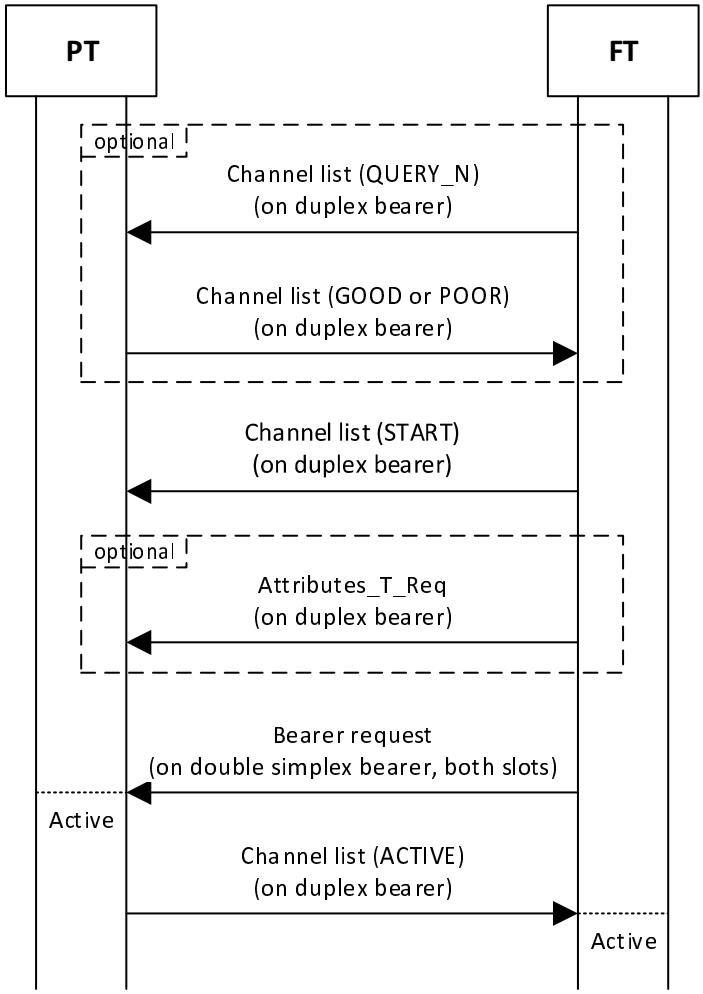


Figure 6: Downlink double simplex bearer setup

The use of the QUERY_N channel list message to determine the channel conditions at the PT is recommended in order to improve bearer setup performance.

If the FT transmits the Attributes_T_Req after the START channel list message, then the FT shall set the A_F field to 1 in the START channel list message.

NOTE 1: In most cases the Attributes_T_Req message is not required because the attributes are already known via the network layer CONNECTION ATTRIBUTES IE.

An Attributes_T_Cfm messages is not included in the sequence. Reception of the ACTIVE channel list message at the FT implicitly confirms reception of the attributes.

The bearer request message shall be transmitted on both slots of the double simplex bearer for a maximum of 3 frames. The first transmission may override the T-Mux algorithm while the subsequent transmissions shall follow it. Reception of this bearer request message on both slots within these 3 frames is required for bearer establishment.

Encryption is synchronized using the ACTIVE channel list message and shall start one frame after this message.

U-plane transmission shall begin only when all double simplex bearers required for the connection have become active.

NOTE 2: During connection establishment, the audio is only connected after all bearers are established and the connection is completed at the network layer. Hence, in the establishment case there is no valid audio data available when the bearer setup completes.

7.4.10.3.3 Timer T212 management

T212: Double simplex bearer setup acknowledge timer;

Value: Refer to ETSI EN 300 175-3 [3], annex A;

Start: At T-Side: Transmission of the first bearer request message
At R-Side: One frame after transmission or reception of the Channel list (LISTEN or START) message, or one frame after the Attributes_T_Req if present.

Stop: At T-Side: Reception of ACTIVE channel list message or POOR channel list message for the used channel,
At R-Side: Reception of a message other than the bearer request on the double simplex bearer, after transmission of the ACTIVE channel list message.
At T-Side or R-Side: On request for MAC connection release.

7.4.10.4 Exceptional cases

7.4.10.4.1 Timer T212 Expiry

If the bearer setup does not succeed before timer T212 expiry, the connection is released. An example of a case where the timer expires at the T-Side, resulting in unacknowledged release, is shown in Figure 7.

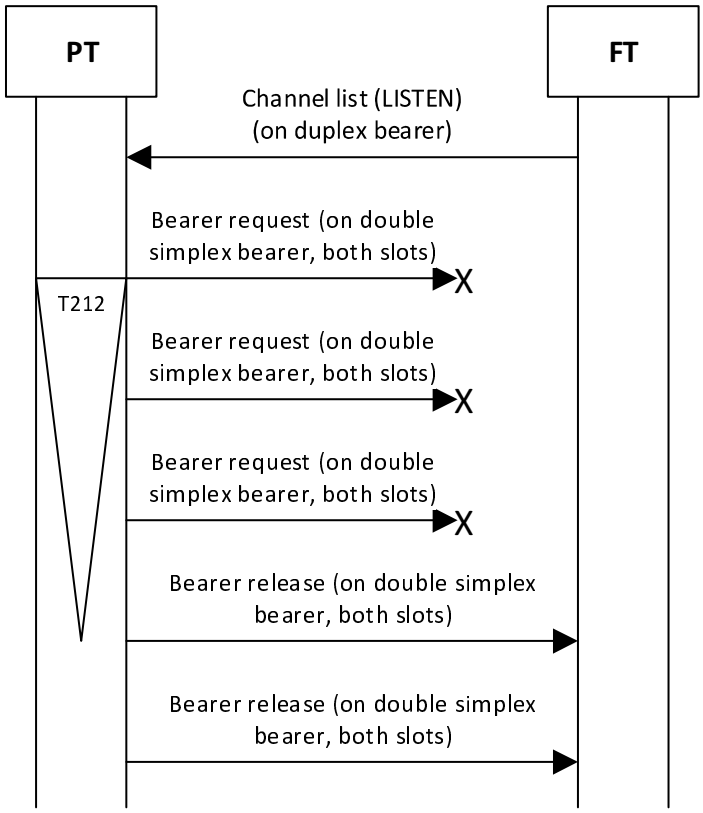


Figure 7: T212 expiry, T-Side example

An example of a case where the timer expires at the R-Side, resulting in acknowledged release, is shown in Figure 8.

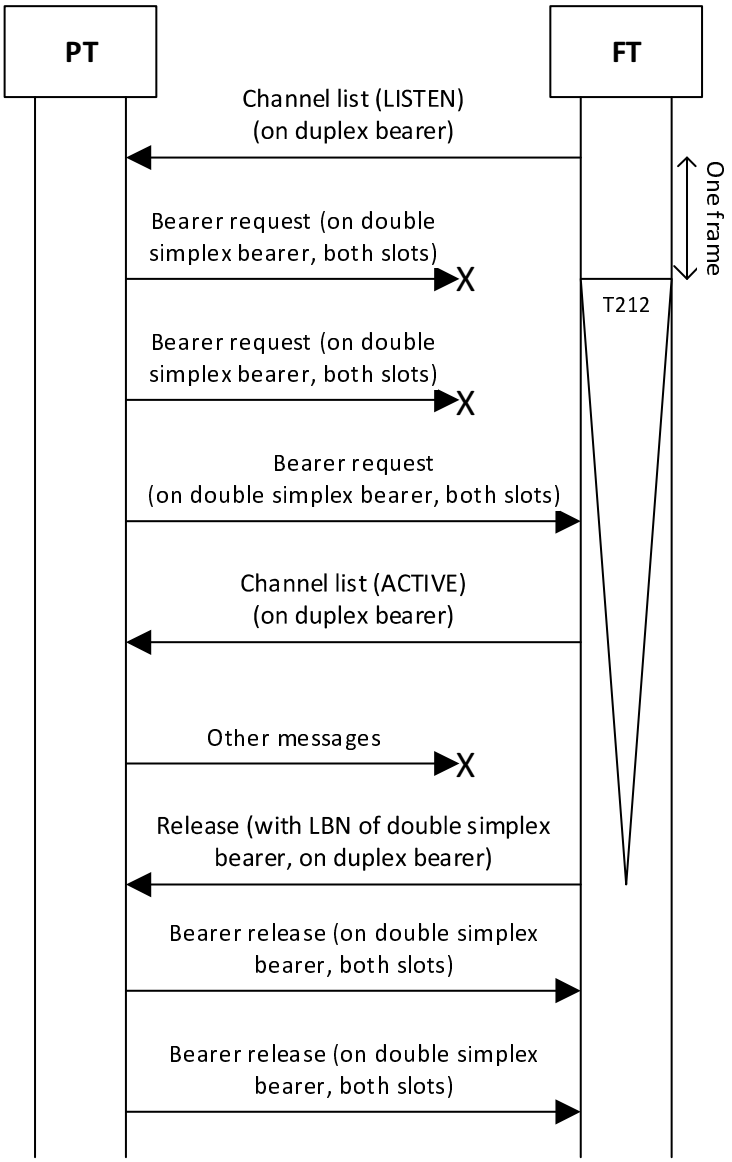


Figure 8: T212 expiry, R-Side example

7.4.10.4.2 Channel selection for uplink double simplex bearer fails at PT

Upon reception of a LISTEN channel list message, the PT shall check the channel is still acceptable before starting transmission, as defined in ETSI EN 300 175-3 [3], clause 11.4.2. If the channel is no longer acceptable, then is shall respond to the LISTEN channel list message with a POOR channel list message as shown in Figure 9.

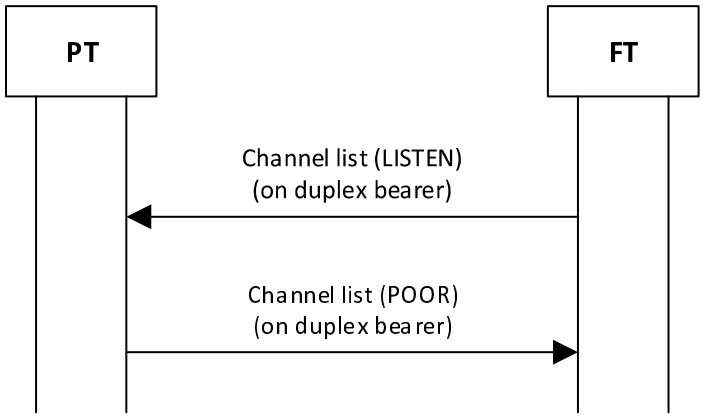


Figure 9: Channel selection failure at PT

NOTE: Setup attempts where no bearer setup message is transmitted do not count towards the number of setup attempts for the purpose of evaluating N200 or N201.

7.4.11 Connection release

7.4.11.1 General

NOTE 1: This procedure description replaces the connection related aspects of clause 10.5 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 10.4.

The procedure may be used if the connection is either basic or advanced. Unacknowledged bearer release shall always be used for the connection release procedure.

For an asymmetric connection, double simplex bearers cannot exist without a corresponding duplex bearer. Hence, if the duplex bearer of an asymmetric connection is released then:

- the T-side shall also perform an unacknowledged bearer release on the double simplex bearer(s)
- the R-side shall consider the double simplex bearers to be released

NOTE 2: This allows the R-side to release a connection without needing to perform acknowledged release of the double simplex bearers first.

7.4.12 Bearer release

7.4.12.1 General

NOTE: This procedure description replaces the bearer related aspects of clause 10.5 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clauses 10.7.2.

The procedure may be used if the connection is either basic or advanced. For duplex bearers, unacknowledged bearer release shall be used, while for double simplex bearers, acknowledged bearer release may also be required.

7.4.12.2 M_T message

The fields shown in Table 37 and defined in ETSI EN 300 175-3 [3], clauses 7.2.5.2 and 7.2.5.3 in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 37: Values used within M_T message

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	0	Basic connection control
		1	Advanced connection control
	<Command>	15	Release
	<FMID>	All	Basic connection control only
	<LBN>	All	Advanced connection control only
	<reason>	All	Advanced connection control only. See note.
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])
NOTE: For the Advanced Connection Release message, the sending side can use any applicable release reason (e.g. "unknown"), and the receiving side does not have to take specific action on the release reason.			

7.4.12.3 Associated Procedures

7.4.12.3.1 Unacknowledged Bearer Release

The procedure defined in ETSI EN 300 175-3 [3], clause 10.7.2.1, shall be used for release of a duplex bearer or release of a double simplex bearer from the T-side.

In the example of Figure 10 it is assumed that the bearer to be released is either a duplex bearer or an uplink double simplex bearer.

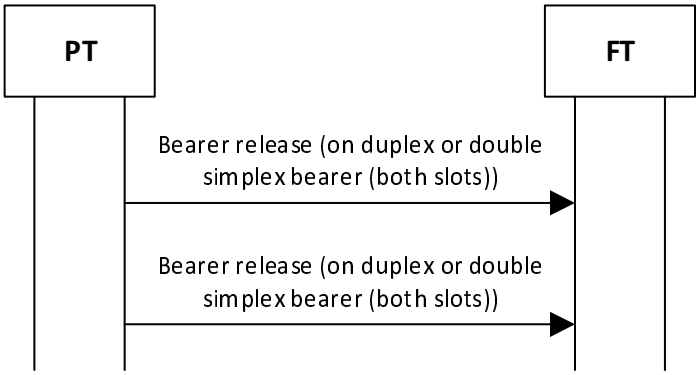


Figure 10: Unacknowledged bearer release, PT initiated example

7.4.12.3.2 Acknowledged Bearer Release

The procedure defined in ETSI EN 300 175-3 [3], clause 10.7.2.2, shall be used for release of a double simplex bearer from the R-side.

In the example of Figure 11 it is assumed that the bearer to be released is an uplink double simplex bearer.

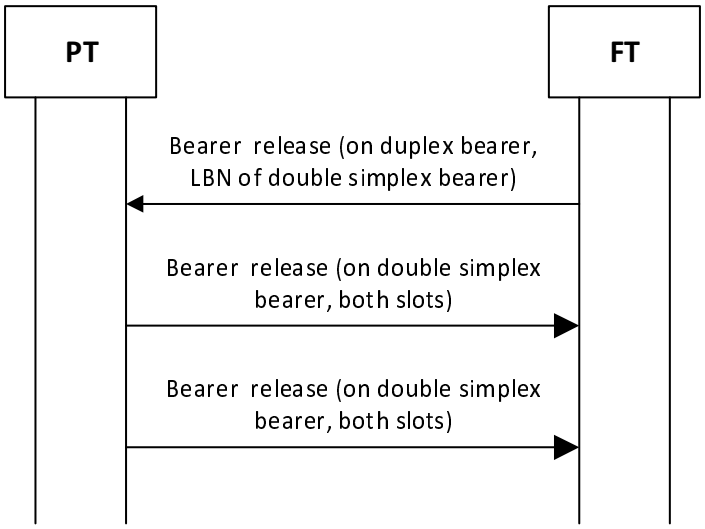


Figure 11: Acknowledged bearer release. FT initiated example

7.4.12.3.3 Timer T213 management

T213: Double simplex bearer setup release timer;

Value: Refer to ETSI EN 300 175-3 [3], annex A;

Start: At R-Side: Transmission of a bearer release message for a double simplex bearer, on the duplex bearer;

Stop: At R-Side: Reception of a bearer release message on the double simplex bearer.

7.4.12.4 Exceptional cases

7.4.12.4.1 T213 expiry

The procedure defined in ETSI EN 300 175-3 [3], clause 10.7.2.2, shall be used in case T213 expires, as shown in Figure 12.

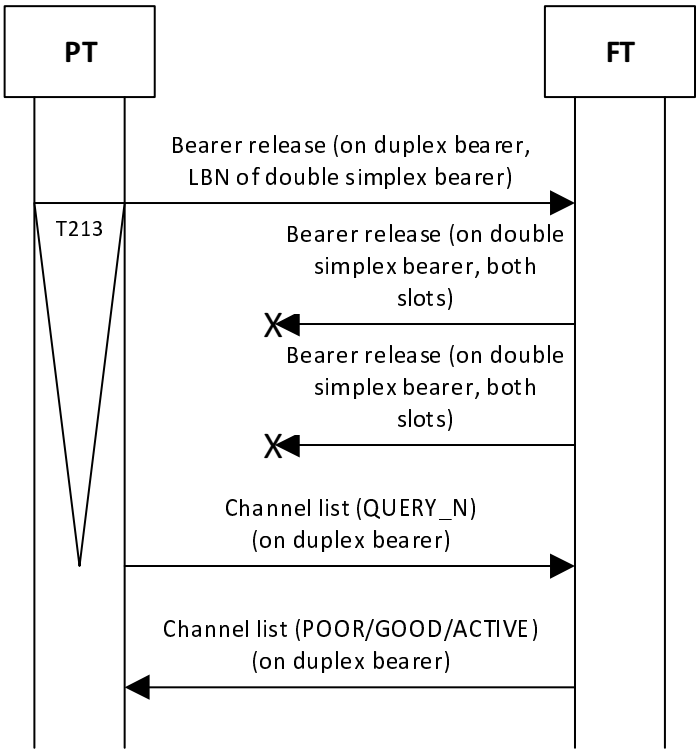


Figure 12: T213 expiry, example where double simplex release messages are lost

If an ACTIVE channel list message is received in response to the QUERY_N channel list message, then the acknowledged bearer release procedure shall be repeated (not shown in Figure 12).

7.4.13 Bearer handover - duplex

7.4.13.1 General

NOTE 1: This procedure description replaces clause 10.6 of ETSI EN 300 444 [9] (GAP).

The procedure may be initiated by the PT or the FT and shall be performed as defined in ETSI EN 300 175-3 [3], clauses 10.6.2 and 10.5.1.1.

NOTE 2: Duplex bearer handovers are typically initiated by the PT but may be initiated by the FT for slot administration purposes.

The procedure is equivalent for intra- and inter-cell handover.

The procedure may be used if the connection is either basic or advanced using symmetric bearers only. The proper value for the M_T header used for bearer setup shall be used.

If the FT initiates the handover, it shall use a LISTEN channel list message as defined in ETSI EN 300 175-3 [3], clauses 10.6.2.2.

The FT should not release the old bearer within 10 ms after the establishment of the new bearer.

7.4.13.2 M_T message

The fields shown in Table 38 and Table 39 and defined in ETSI EN 300 175-3 [3], clauses 7.2.5.2 and 7.2.5.3, in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 38: Values used within M_T message - bearer setup

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	0	Basic connection control
		1	Advanced connection control
	<Command>	1	Bearer_handover_request
		4	Bearer_confirm
		5	Wait
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

Table 39: Values used within M_T message - channel list

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	10	Channel_list
	<RPN>	All	
	<command>	2	POOR
		6	LISTEN
	<S/D>	1	Duplex
	<SN>	All	
	<SP>	All	
	<CN>	All	
	<LBN>	15	LBN of the duplex bearer

7.4.13.3 Exceptional cases

7.4.13.3.1 Channel selection for uplink duplex bearer fails at PT

Upon reception of a LISTEN channel list message in an FT initiated bearer handover, the PT shall check the channel is still acceptable before starting transmission, as defined in ETSI EN 300 175-3 [3], clause 11.4.2. If the channel is no longer acceptable, then it shall respond to the LISTEN channel list message with a POOR channel list message as shown in Figure 13.

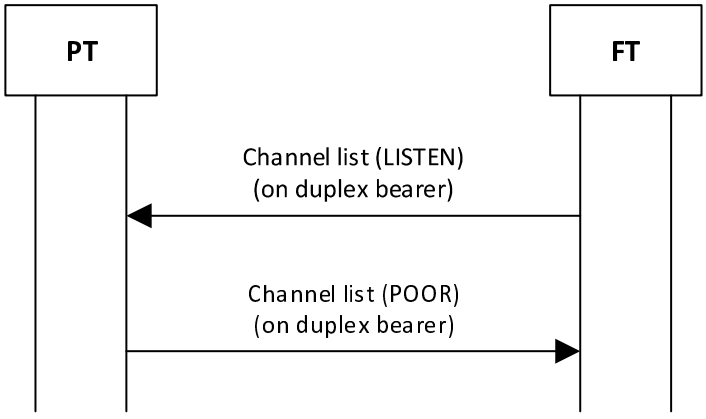


Figure 13: Channel selection failure at PT

NOTE: Setup attempts where no bearer setup message is transmitted do not count towards the number of setup attempts for the purpose of evaluating N201.

7.4.14 Bearer handover - double simplex

7.4.14.1 General

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clauses 10.6.3 and 10.5.1.4.

The procedure is only supported for intra-cell handover. Inter-cell handovers shall use connection handover to move all bearers to the new cell, see clause 7.4.17.

If the handover space is restricted, as configured in the <<CONNECTION-ATTRIBUTES>> IE (see ETSI EN 300 175-5 [5], clause 7.7.11), then the channel usage for handover shall be restricted as described in ETSI EN 300 175-3 [3], clause 10.8.3.2.2.

In this profile, handovers for double simplex bearers are always initiated by the FT. In addition, for a downlink double simplex bearer, the PT can request the FT to initiate a handover for a bearer using quality a control message.

7.4.14.2 M_T message

The fields shown in Table 40 to Table 43 and defined in ETSI EN 300 175-3 [3], clauses 7.2.5.3 and 7.2.5.5 in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 40: Values used within M_T message - Unconfirmed handover request

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	12	Unconfirmed_handover
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

Table 41: Values used within M_T message - Channel List

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	10	Channel_list
	<RPN>	All	
	<command>	0	ACTIVE
		1	GOOD
		2	POOR
		4	QUERY_H
		6	LISTEN
		7	START
	<S/D>	0	Double simplex
	<SN>	All	
	<SP>	All	
	<CN>	All	
	<LBN>	1 to 14	Shall be the LBN of the bearer to which the handover applies

Table 42: Values used within M_T message - Release for handover abort

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	15	Release
	<Info 1>	0	Not used
	<LBN>	1 to 14	Value of handover bearer
	<reason>	3	bearer setup or handover failed
		4	bearer handover successfully completed
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])
NOTE: For the Advanced Connection Release message, the sending side can use any applicable release reason (e.g. "unknown"), and the receiving side does not have to take specific action on the release reason.			

Table 43: Values used within M_T message - Quality control

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	3	Quality control
	<Command>	2	bearer handover/bearer replacement of the bearer
	<param 1: a_{16} to a_{19}>	15	Applies for requests from PT
	<param 1: LBN>	1 to 14	LBN of the bearer for which a handover is requested
	<param_2>	0	Not used

7.4.14.3 Associated Procedures

7.4.14.3.1 FT initiated bearer handover

FT initiated double simplex bearer handover uses the bearer establishment procedures defined in clause 7.4.10.3 with the following modifications:

- The bearer request message used shall be an unconfirmed handover request instead of an unconfirmed access request.
- The LBN used shall be the value of the bearer for which the handover is being performed.
- The QUERY_N channel list message shall be replaced by the QUERY_H channel list message.

Once the bearer has reached active state (see clauses 7.4.10.3.1 and 7.4.10.3.2) the audio data shall be duplicated on both double simplex bearers.

The R-side evaluates the new bearer and may decide to complete the procedure or to abort it and continue with the original bearer. If the handover completes then the unacknowledged release procedure described in clause 7.4.12.3.1 shall be used by the T-side to release the old bearer and the release reason shall be set to "bearer handover successfully completed". If the handover is aborted, then the acknowledged release procedure described in clause 7.4.12.3.2 shall be used to release the new bearer and the release reason used in both release messages shall be set to "bearer setup or handover failed".

The sequence and mapping of messages to the duplex and double simplex bearers shall be as shown in Figure 14 and Figure 15. Other variations of the signalling are not supported.

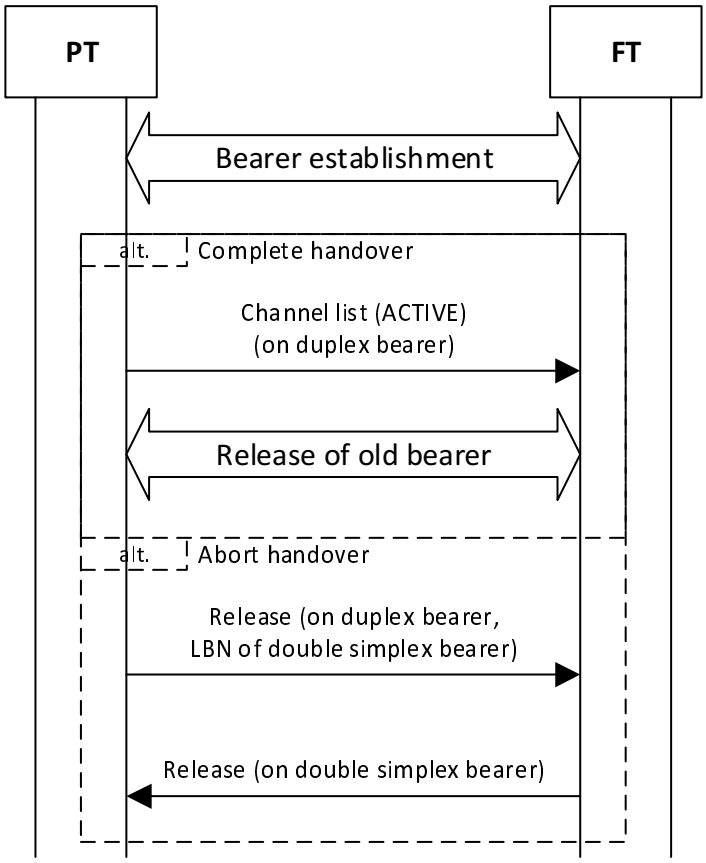


Figure 14: FT initiated downlink double simplex bearer handover

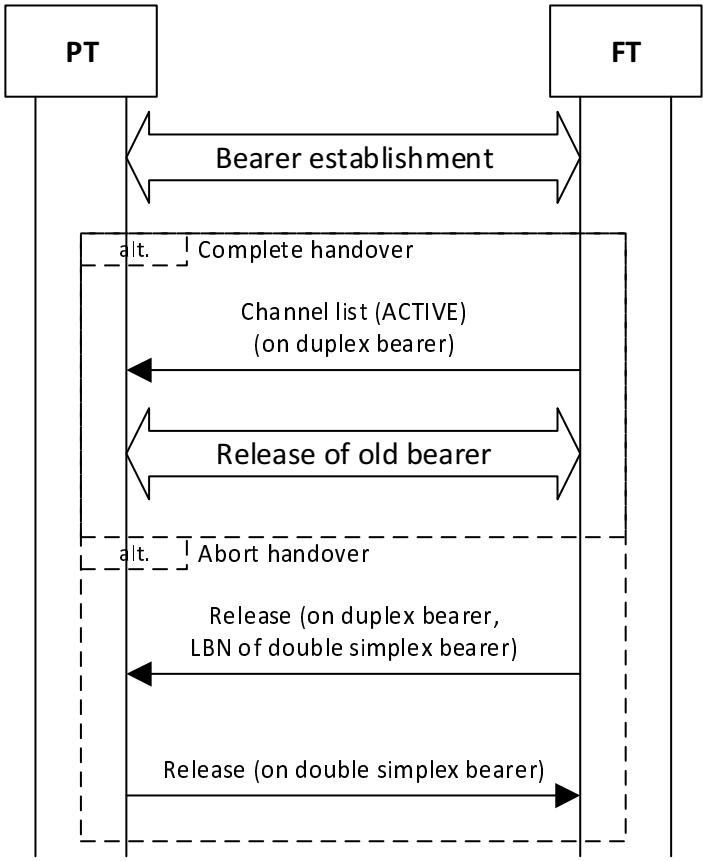


Figure 15: FT initiated uplink double simplex bearer handover

7.4.14.3.2 PT request for bearer handover

The PT can request a handover for a downlink double simplex bearer using a quality control message as described in ETSI EN 300 175-3 [3], clause 10.6.3.2. The FT may then perform the handover as described in clause 7.4.14.3.1 or may reject the attempt using a further quality control message.

The sequence and mapping of messages to the duplex and double simplex bearers shall be as shown in Figure 16. Other variations of the signalling are not supported.

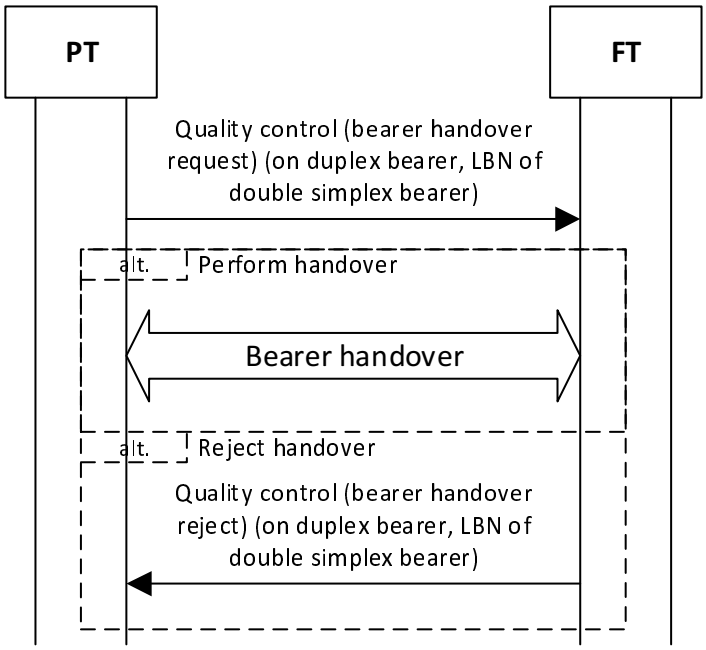


Figure 16: PT requested downlink double simplex bearer handover

7.4.15 Frequency replacement - duplex bearer

7.4.15.1 General

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 10.6.4.2.

The procedure is only supported for intra-cell operation. Inter-cell handovers shall use connection handover to move all bearers to the new cell, see clause 7.4.17.

NOTE: Frequency replacement has no fallback in case of failure. Hence, it is recommended to use bearer handover in preference to frequency replacement, except where no slots for handover are available.

Duplex bearer frequency replacements are always initiated by the PT.

7.4.15.2 M_T message

The fields shown in Table 44 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.5 in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 44: Values used within M_T message - Quality control frequency replacement

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	3	Quality control
	<Command>	9	Frequency replacement of the bearer identified by LBN to carrier CN on slot pair SN
	<param_1: LBN>	1 to14	LBN of the bearer for which a frequency replacement is requested
	<param_1: SN>	0 to 11	Slot number
	<param_2: a_{24} to a_{25}>	0 to 2	Request, confirm or grant
	<param_2: CN>	All	Carrier number

7.4.15.3 Associated Procedures

7.4.15.3.1 Duplex bearer frequency replacement

The procedure defined in ETSI EN 300 175-3 [3], clause 10.6.4.2 and shown in Figure 17, shall be used for duplex bearer frequency replacement.

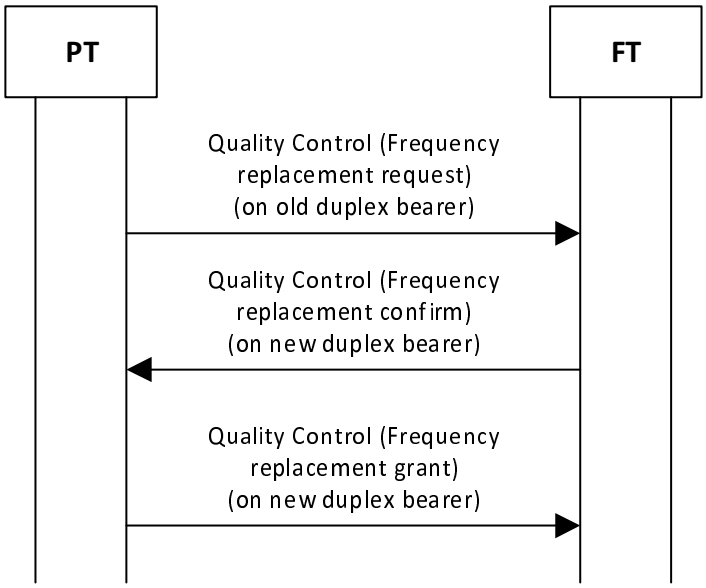


Figure 17: Duplex bearer frequency replacement

In the frame after transmission of the request, the PT shall switch reception to the new carrier. Upon reception of the confirm message the PT shall switch transmission to the new carrier.

In the frame after reception of the request, the FT shall switch both transmission and reception to the new carrier.

7.4.15.4 Exceptional cases

7.4.15.4.1 Frequency replacement confirm not detected

If, after N206 repetitions of the frequency replacement request, no confirm message is received, then the PT shall release the duplex bearer and the connection, and the higher layers shall be informed.

7.4.15.4.2 Frequency replacement grant not detected

If, after N207 repetitions of the frequency replacement confirm, no grant message is received, then the FT shall release the duplex bearer and the connection, and the higher layers shall be informed.

7.4.16 Frequency replacement - double simplex

7.4.16.1 General

The procedure shall be performed as defined in ETSI EN 300 175-3 [3], clause 10.6.4.2.

The procedure is only supported for intra-cell operation. Inter-cell handovers shall use connection handover to move all bearers to the new cell, see clause 7.4.17.

NOTE: Frequency replacement has no fallback in case of failure. Hence, it is recommended to use bearer handover in preference to frequency replacement, except where no slots for handover are available.

Double simplex bearer frequency replacements are always initiated by the FT. In addition, for a downlink double simplex bearer, the PT can request the FT to initiate a handover for a bearer using quality a control message (see clause 7.4.14.3.2) and this may result in a frequency replacement in case other slots for handover are not available.

7.4.16.2 M_T message

The fields shown in Table 44 and Table 45 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.5 in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 45: Values used within M_T message - Double simplex bearer request

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	1	Advanced connection control
	<Command>	12	Unconfirmed_handover
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

7.4.16.3 Associated Procedures

7.4.16.3.1 Double simplex bearer frequency replacement

The procedure defined in ETSI EN 300 175-3 [3], clause 10.6.4.2 and shown in Figure 18, shall be used for uplink double simplex bearer frequency replacement.

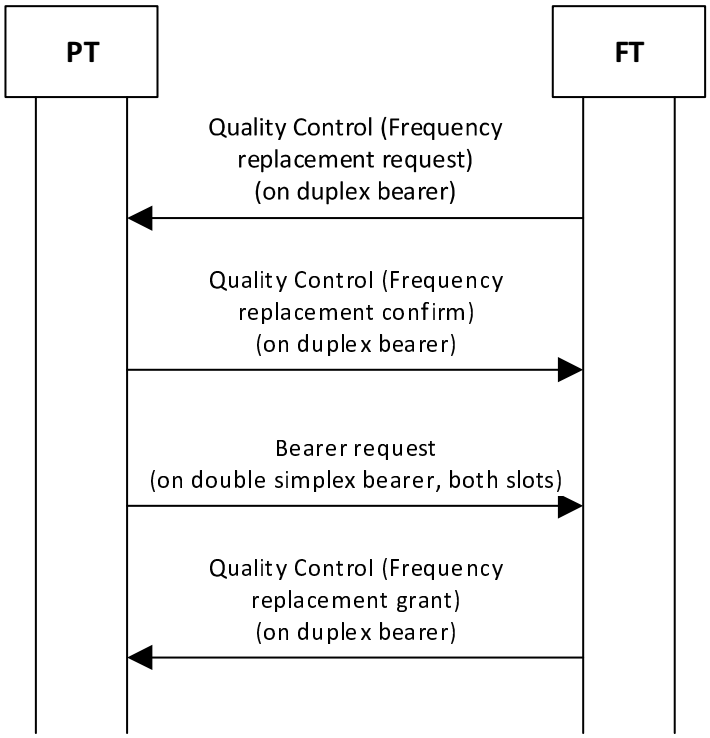


Figure 18: Uplink double simplex bearer frequency replacement

The procedure shown in Figure 19, shall be used for uplink double simplex bearer frequency replacement.

NOTE: Although the PT requests a handover in this scenario, the FT decides that a frequency replacement should be performed instead. This can happen if no suitable free slot is available for a handover.

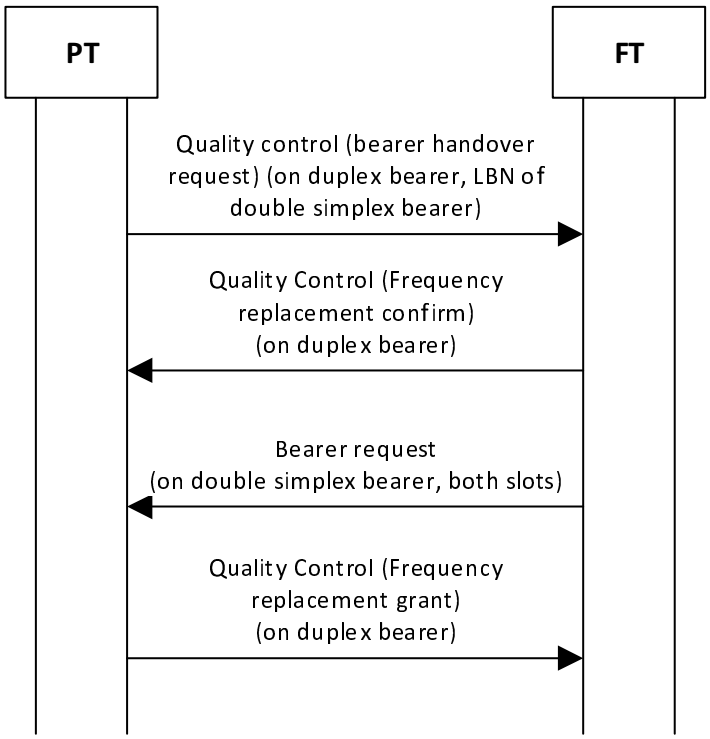


Figure 19: Downlink double simplex bearer frequency replacement

In both cases, the T side shall switch transmission and the R-side shall switch the reception from the old bearer to the new bearer in the frame after the confirm message has been sent.

7.4.16.3.2 Timer T212 management

Timer T212 is handled for frequency replacement in the same way as for bearer setup, where the frequency replacement request, confirm and grant replace the LISTEN, START and ACTIVE channel list messages respectively. See clause 7.4.10.3.3.

7.4.16.4 Exceptional cases

7.4.16.4.1 Timer T212 Expiry

Timer T212 is handled for frequency replacement in the same way as for bearer setup, see clause 7.4.10.4.1. Upon release of the bearer, a new bearer setup attempt may be started by the FT in order to reach the target bandwidth, as described in clause 7.4.9. Failure to setup a new bearer will result in connection release.

7.4.17 Connection handover

7.4.17.1 General

NOTE: This procedure description replaces clause 10.7 of ETSI EN 300 444 [9] (GAP).

The procedure consists of two steps:

- A connection establishment for the handover connection, using the procedures described in clauses 7.4.6 and 7.4.7.
- A release of the old connection as described in clause 7.4.11.

The procedure may be used if the connection is either basic or advanced. The proper value for the M_T header shall be used to indicate connection handover. In the case of a multi-bearer connection, this header shall be used for the pilot bearer of the new connection.

The procedure is equivalent for intra- and inter-cell handover.

7.4.17.2 M_T message

The fields shown in Table 46 and defined in ETSI EN 300 175-3 [3], clause 7.2.5.2 in the MAC control (M_T) message shall be supported by the PT and the FT.

Table 46: Values used within M_T message

MAC message	Field within the message	Standard values within the MAC message	Normative action/comment
<<M_T message>>	<M_T header>	0	Basic connection control
		1	Advanced connection control
	<Command>	2	Connection_handover_request. PT shall capable to send. FT shall be capable to process
		4	Bearer_confirm
		5	Wait
	<FMID>	All	
	<PMID>	All	(see clause 13.4 of ETSI EN 300 444 [9])

7.4.18 Audio data transfer

Audio data from the LC3plus codec shall be mapped to the bearers according to the audio configuration as described in annex B.

If multiple simplex bearers are required to carry a single audio frame then the audio frame shall be split into segments and assigned to bearers using according to LBN as described in ETSI EN 300 175-3 [3], clause 10.8.3.2.1.

In addition, the following rules apply:

- If the audio frame comprises data from more than one codec, e.g. for example two times AA.AC.4 for a stereo channel, then the codec frames shall be concatenated in the order of increasing downlink or uplink audio channel 'Value', as defined in clause A.2.1, prior to assigning the audio frame to the bearers. If a two channel codec is used, then the corresponding 'left' audio channel value shall be used for the concatenation ordering.
- If head tracking data is transmitted by a PT then it shall be appended after the audio channel data.
- For a 10 ms codec frame, the first segments shall be transmitted in the lower half frame and the last segments shall be transmitted in the upper half frame.
- For a 2,5 ms codec frame, the assignment to bearers shall be performed every 2,5 ms, not every 5 ms as specified in ETSI EN 300 175-3 [3], clause 10.8.3.2.1.

Examples of the mapping of audio data to bearers are given in annex D.

7.5 Data Link Control (DLC) layer procedures

7.5.1 General

This clause specifies the additional DLC layer procedures, messages and information elements which are required for advanced audio services not described in ETSI EN 300 444 [9] (GAP) or which incorporate modifications to the GAP specification.

7.5.2 FU1 frame operation

The procedure shall be performed as defined in ETSI EN 300 175-4 [4], clauses 12.1 and 12.2. The following text together with the associated clauses define the mandatory requirements with regard to the present document.

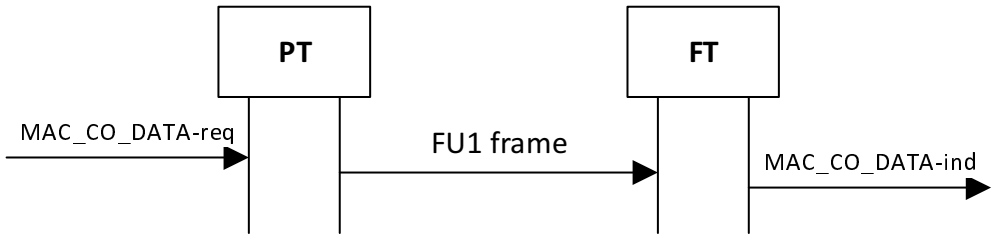


Figure 20: Sending a FU1 frame

NOTE: The case when FT initiates differs only in the notations.

The length of a FU1 frame will be k = 40 (full slot), k = 80 octets (long slot), or k = 100 octets (double slot) according to the audio service configuration.

One complete frame shall be submitted to/from MAC layer included in a MAC_CO_DATA-req(ind) primitive (see Figure 20).

7.6 Network (NWK) layer procedures

7.6.1 General

This clause specifies the additional NWK layer procedures, messages and information elements required in the Advanced Audio Profile which are not described in ETSI EN 300 444 [9] (GAP), or which incorporate modifications to the GAP specification.

This profile does not prevent any PT or FT from transmitting or receiving and processing any other NWK layer message or information element not specified in the profile. A PT or FT receiving an unsupported NWK layer message or information element, which it does not recognize, shall ignore it, as specified in ETSI EN 300 175-5 [5], clause 17.

7.6.2 Summary of PT initiated call messages

NOTE: This summary description replaces clause 8.1 of ETSI EN 300 444 [9] (GAP).

Figure 21 shows a summary of the PT initiated call related message sequence.

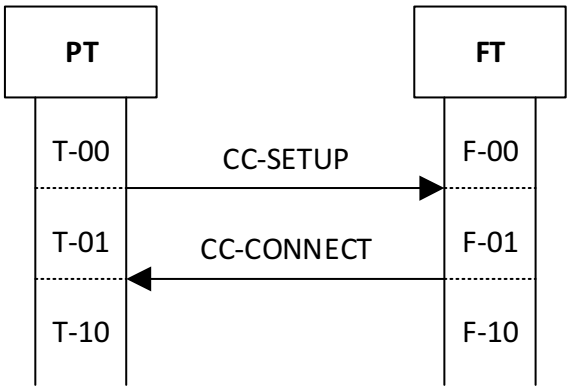


Figure 21: PT initiated call messages

7.6.3 PT initiated call request

7.6.3.1 Procedure

NOTE: This procedure description replaces clause 8.2 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clauses 9.3.1, 9.3.1.1 and 9.3.1.2. Figure 22 and Table 47 together with the associated clauses define the mandatory requirements with regard to the present document.

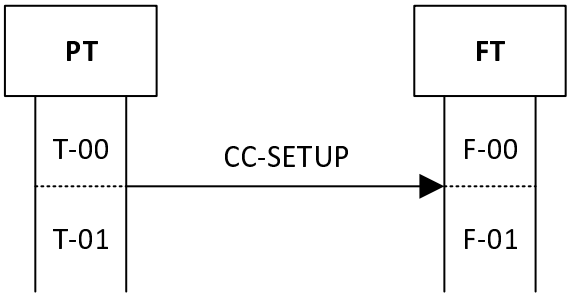


Figure 22: PT initiated call request

Table 47: Values used within the {CC-SETUP} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Portable identity>>	<Type>	0	International Portable User Identity (IPUI)
	<PUT>	All	Area dependent
	<PUN>	All	Area dependent
<<Fixed Identity>>			Shall always include the whole PARK including the non-significant bits
	<Type>	32	PARK
	<Length of identity value>	All	PARK Length Indicator (PLI)+1
	<ARC+ARD>	All	Area dependent

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Basic service>>	<Call class>	8	Normal call setup
	<Basic service>	F	Other
<<IWU-Attributes>>	<Coding Standard>	'01'B	Profile defined coding
	<Profile>	'10001'B	Advanced audio profile
	<Negotiation indicator>	'100'B	Exchanged parameter negotiation
	<Profile subtype>	'0000'B	Advanced audio profile 1
<< Connection attributes >>			Signifies the maximum capabilities of the sender for the requested call.
	< Type >	'001'B, '100'B	Symmetric only connection or Asymmetric frozen, according to annex B
	< Connection identity >	'0000'B	MAC connection is not yet established so set to 0000 (Not yet numbered)
	ext4	0,1	If 1 is indicated, the octets 4a, 4b and 4c shall not be included and their values shall be understood to be equal to the value set in octet 4
	< Maximum bearers (P ⇒ F direction) >	1 to 9	Set according to maximum codec requirement. See annex B. (note 1)
	ext4a	0, 1	If 1 is indicated, the octets 4b and 4c shall not be included and their values shall be understood to be equal to the values set in octets 4 and 4a respectively
	< Minimum bearers (P ⇒ F direction) >	1 to 9	Set according to minimum codec requirements. See annex B. (note 1)
	ext4b	0, 1	If 1 is indicated, the octets 4c shall not be included and its value shall be understood to be equal to the value set in octet 4b
	< Maximum bearers (F ⇒ P direction) >	1 to 9	Set according to maximum codec requirement. See annex B. (note 1)
	ext4c	1	
	< Minimum bearers (F ⇒ P direction) >	1 to 9	Set according to minimum codec requirements. See annex B. (note 1)
	< ext5 >	1	
	< Slot type >	'100'B, '001'B, '101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the maximum codec requirement, otherwise set to duplex bearer slot type. See annex B
	< MAC service >	'0001'B	I_{NB}; (I_N normal delay)
	< Ext6 >	1	
	< C_F channel attributes >	'000'B	C_F never (C_S only).
	< handover space for double simplex bearers >	0 to 4	Set according to implementation requirements
	< Ext7 >	1	
	< A-attributes >	'000'B	2-level modulation scheme.
	< B-attributes >	'000'B, '001'B, '010'B	2, 4 or 8 level modulation scheme

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Codec-List>> (notes 2 and 3)	<Length of Contents>	4 to (4 + (n × 3))	The length shall be set according to the number of codecs n in the list. (note 4)
	<Negotiation indicator>	'000'B	Negotiation not possible
	<Codec Identifier>	15 to 34	Selected codec
	<Direction>	'01'B, '10'B,'11'B	Direction to which the codec applies (note 5).
	<MAC and DLC service>	'0001'B	I_N normal delay
	<C plane routing>	'000'B	C_S only
	<Slot size>	'0001'B, '0100'B, '0101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the codec, otherwise set to duplex bearer slot type. See annex B
NOTE 1: If the CC-Setup message does not include a codec list, or the included codec list does not allow for a choice of codecs, then only octet 4 and optionally octet 4b shall be included and these shall be set according to the selected codec(s). NOTE 2: The Codec List information element is optional in this message. See clause 7.6.11. NOTE 3: The Codec List effectively includes up to 3 lists, one for downlink, one for uplink, and one for downlink LFE. The <Direction> field indicates the uplink/downlink aspect, while the <Codec Identifier> field indicates when an LFE is intended. NOTE 4: Only one codec is shown in this table, but multiple (maximum) 7 codecs can be listed. NOTE 5: If a codec is used for downlink and uplink, it shall be listed two times, once for each direction.			

7.6.3.2 Associated procedures

7.6.3.2.1 Timer P-<CC.03> management

<CC.03>: CC setup timer;

value: refer to ETSI EN 300 175-5 [5], annex A;

start: a {CC-SETUP} message has been sent;

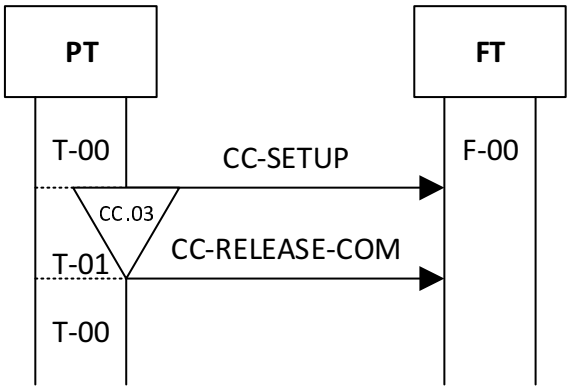
stop: an indication for release or reject from the IWU or for link release from the DLC layer is received. A {CC-CONNECT} or {CC-RELEASE-COM} message is received;

restart: FT may restart it at any time by sending a {CC-NOTIFY} message (see ETSI EN 300 444 [9], clause 6.9.6).

7.6.3.3 Exceptional cases

7.6.3.3.1 Timer P-<CC.03> expiry

The abnormal call release procedure shall be used (see clause 7.6.9) as shown in Figure 23.



NOTE: FT may not be answering because of some FT problems or because the {CC-SETUP} message has been lost or corrupted. The same result will occur if the eventual FT answer has been lost or corrupted.

Figure 23: Timer P<CC.03> expiry

For the values used within the {CC-SETUP} see Table 47. For the contents of {CC-RELEASE-COM} message, see Table 51.

7.6.3.3.2 PT releases the PT initiated call request

The normal call release procedure shall be used (see clause 7.6.8) as shown in Figure 24.

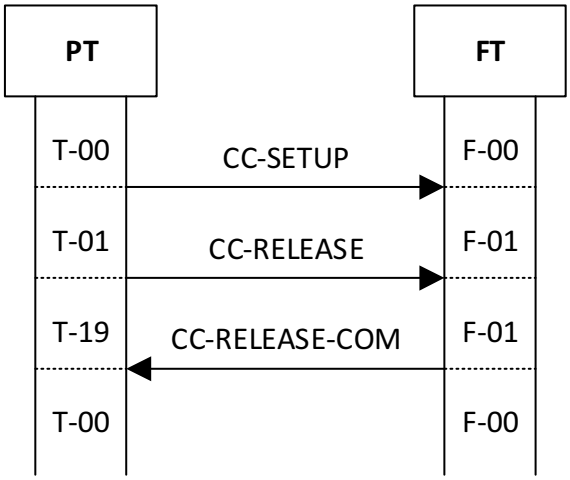
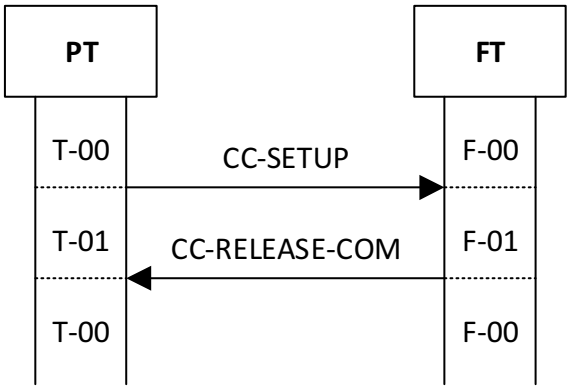


Figure 24: PT releases the PT initiated call request

For the values used within {CC-SETUP} see Table 47. For the contents of {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.3.3.3 FT rejects the PT initiated call request

The abnormal call release procedure shall be used (see clause 7.6.9) as shown in Figure 25.



NOTE: Either F-CC or the F-IWU may reject the call.

Figure 25: FT rejects the PT initiated call request

For the contents of {CC-RELEASE-COM} see Table 51.

The contents of an unacceptable {CC-SETUP} are outside the scope of the present document.

7.6.4 PT initiated call connection

NOTE: This procedure description replaces clause 8.6 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clauses 9.3.1.8 and 9.3.1.4. Figure 26 and Table 48 together with the associated clauses define the mandatory requirements with regard to the present document.

Before sending the {CC-CONNECT} message the FT shall connect the U-plane. On receipt of {CC-CONNECT} message the PT shall connect the U-plane.

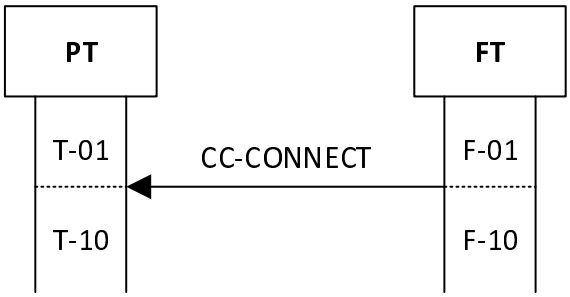


Figure 26: PT initiated call connection

Table 48: Values used within the {CC-CONNECT} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<< Connection attributes >>			Defines the capabilities used in this connection.
	< Type >	'001'B, '100'B	Symmetric only connection or Asymmetric frozen, according to the bearers required by annex B.
	< Connection identity >	'1xxx'B	Set to 1xxx with the 3 LSBs set to the LCN (= MAC ECN),
	ext4	0,1	If 1 is indicated, the octet 4b shall not be included and its value shall be understood to be equal to the value set in octet 4.
	< Maximum bearers (P ⇒ F direction) >	1 to 9	Set according to selected codec requirement, see annex B.
	ext4b	1	
	< Maximum bearers (F ⇒ P direction) >	1 to 9	Set according to selected codec requirement, see annex B.
	< ext5 >	1	
	< Slot type >	'100'B, '001'B, '101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the selected codec requirement, otherwise set to duplex bearer slot type, see annex B.
	< MAC service >	'0001'B	I_{NB}; (I_N normal delay)
	< Ext6 >	1	
	< C_F channel attributes >	'000'B	C_F never (C_S only).
	< handover space for double simplex bearers >	0 to 4	Set according to implementation requirements
	< Ext7 >	1	
	< A-attributes >	'000'B	2-level modulation scheme.
	< B-attributes >	'000'B, '001'B, '010'B	2, 4 or 8 level modulation scheme
<<Codec-List>>	<Length of Contents>	4, 7, 10	Up to three codecs can be indicated (note): • Uplink • Downlink • Downlink - LFE
	<Negotiation indicator>	'000'B	Negotiation not possible
	<Codec Identifier>	15-34	Selected codec
	<Direction>	'01'B, '10'B,'11'B	Direction to which the codec applies.
	<MAC and DLC service>	'0001'B	I_N normal delay
	<C plane routing>	'000'B	C_S only
	<Slot size>	'0001'B, '0100'B, '0101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the codec, otherwise set to duplex bearer slot type, see annex B.
NOTE: This table shows only one codec in the list, but up to three can be included. If multiple codecs are included in the list then the <Direction> field indicates the uplink/downlink aspect, while the <Codec Identifier> field indicates when an LFE is intended.			

7.6.5 Summary of FT initiated call messages

NOTE: This summary description replaces clause 8.11 of ETSI EN 300 444 [9] (GAP).

Figure 27 shows a summary of the FT initiated call related message sequence.

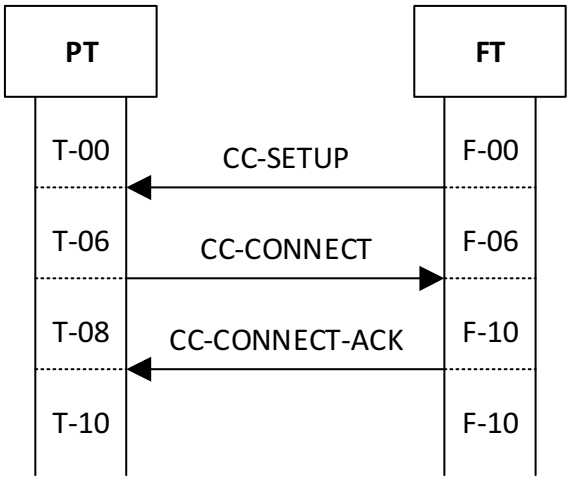


Figure 27: FT initiated call messages

7.6.6 Indirect FT initiated call request

7.6.6.1 Procedure

NOTE 1: This procedure description replaces clause 8.12 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clauses 9.3.2, 9.3.2.1 and 9.3.2.2. Figure 28 and Table 47 together with the associated clauses define the mandatory requirements with regard to the present document.

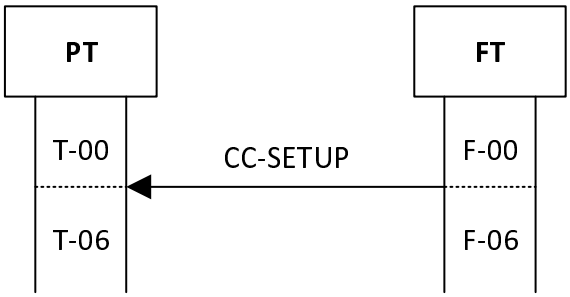


Figure 28: FT initiated call request

For values used within the CC-SETUP message, refer to Table 47.

NOTE 2: In order to transfer the {CC-SETUP} message a link between PT and FT is established. The FT can initiate this as described in clause 7.6.16.

7.6.6.2 Associated procedure

7.6.6.2.1 Timer F-<CC.03> management

<CC.03>: CC setup timer;

value: refer to ETSI EN 300 175-5 [5], annex A;

start: a {CC-SETUP} message has been sent;

stop: an indication for release from the IWU or for link release from the DLC layer is received. A {CC-CONNECT} or {CC-RELEASE-COM} message is received.

7.6.6.3 Exceptional cases

7.6.6.3.1 FT releases the FT initiated call request

The normal release procedure shall be used (see clause 7.6.8) as shown in Figure 29.

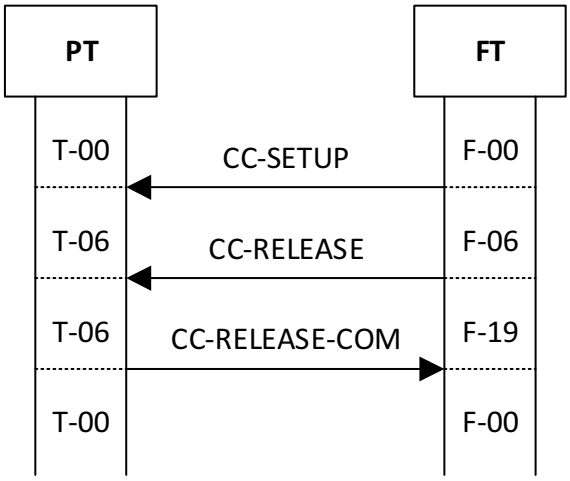
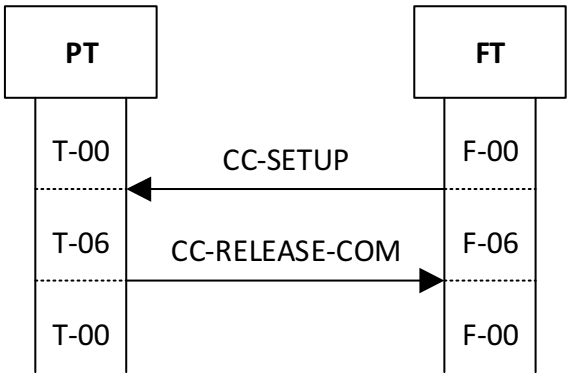


Figure 29: FT releases the FT initiated call request

For the values used within the {CC-SETUP} see Table 47. For the contents of {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.6.3.2 PT rejects the FT initiated call request

The abnormal release procedure shall be used (see clause 7.6.9) as shown in Figure 30.



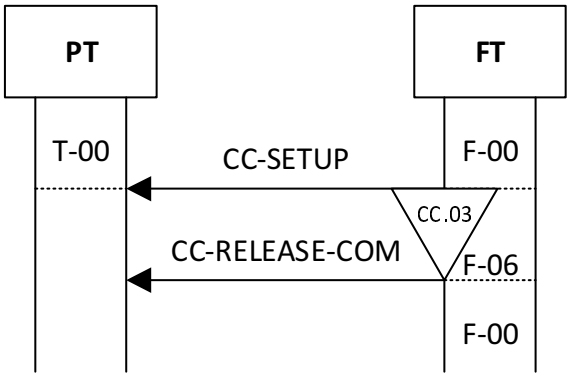
NOTE: Either PT-CC or PT-IWU may reject the call.

Figure 30: PT rejects the FT initiated call request

For the values used within the {CC-SETUP} see Table 47. For the contents of {CC-RELEASE-COM} message see Table 51.

7.6.6.3.3 Timer F-<CC.03> expiry

The abnormal release procedure shall be used (see clause 7.6.9) as shown in Figure 31.



NOTE: PT may not be answering because of some PT problems or because the {CC-SETUP} message has been lost or corrupted. The same result will occur if the eventual answer from the PT has been lost or corrupted.

Figure 31: Timer F<CC.03> expiry

For the values used within the {CC-SETUP} see Table 47. For the contents of {CC-RELEASE-COM} see Table 51.

7.6.7 FT initiated call connection

7.6.7.1 Procedure

NOTE: This procedure description replaces clause 8.15 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clause 9.3.2.8. Figure 32 and the following text together with the associated clauses define the mandatory requirements with regard to the present document.

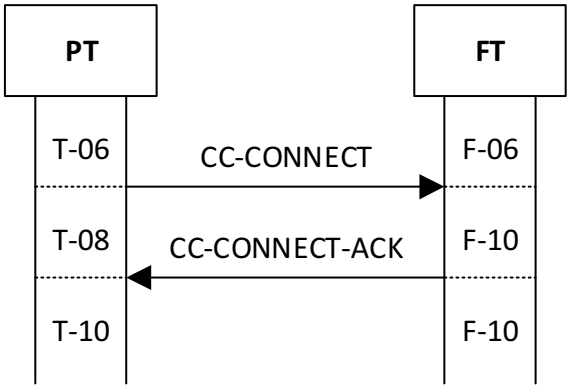


Figure 32: FT initiated call connection

For values used within the CC-CONNECT message, refer to Table 48. For values used within the CC-CONNECT-ACK message, refer to Table 49.

Table 49: Values used within the {CC-CONNECT-ACK} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
			All optional

7.6.7.2 Associated procedure

7.6.7.2.1 Timer P-<CC.05> management

<CC.05>: CC connect timer;

value: refer to ETSI EN 300 175-5 [5], annex A;

start: a {CC-CONNECT} message has been sent;

stop: an indication for release from the IWU or for link release from the DLC layer is received. A {CC-CONNECT-ACK} or {CC-RELEASE} message is received;

restart: FT may restart it at any time by sending a {CC-NOTIFY} message, (see ETSI EN 300 444 [9], clause 6.9.6).

7.6.7.3 Exceptional cases

7.6.7.3.1 FT releases the FT initiated call transaction

The normal release procedure shall be used (see clause 7.6.8) as shown in Figure 33.

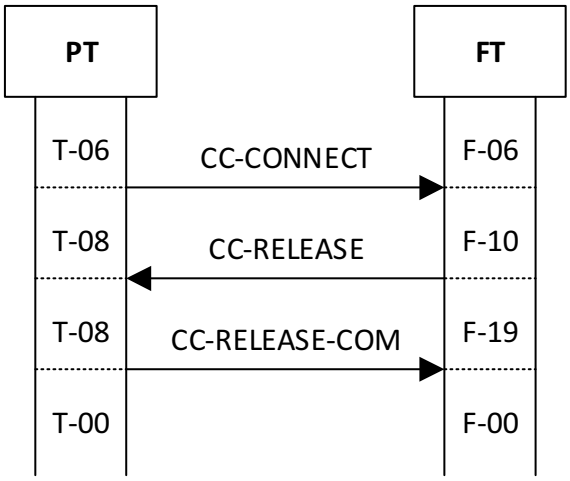


Figure 33: FT releases the FT initiated call transaction

For the values used within the {CC-CONNECT} see Table 48. For the contents of {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.7.3.2 PT releases the FT initiated call transaction

The normal release procedure shall be used (see clause 7.6.8) as shown in Figure 34.

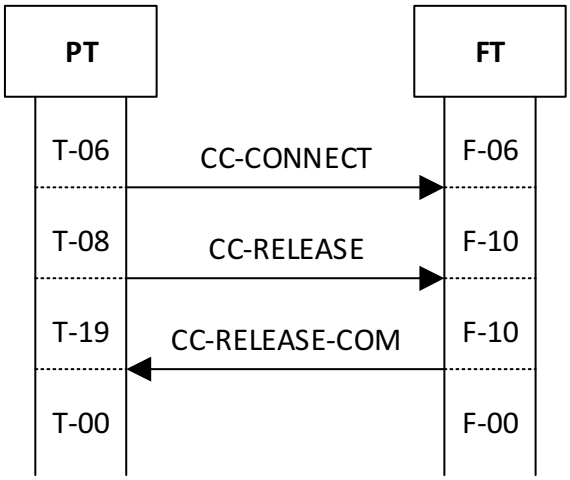
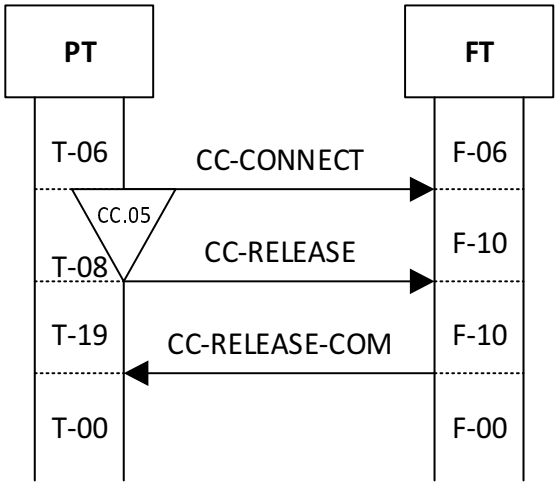


Figure 34: PT releases the FT initiated call transaction

For the values used within the {CC-CONNECT} see Table 48. For the contents of {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.7.3.3 Timer P-<CC.05> expiry

The normal release procedure shall be used (see clause 7.6.8) as shown in Figure 35.



NOTE: FT may not be answering because of some FT problems or because the {CC-CONNECT} message has been lost or corrupted. The same result will occur if the eventual answer from the FT has been lost or corrupted.

Figure 35: Timer P<CC.05> expiry

For the values used within the {CC-CONNECT} see Table 48. For the contents of {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.8 Normal call release

7.6.8.1 Procedure

NOTE: This procedure description replaces clause 8.7 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clauses 9.5.1 and 9.5.3. Figure 36, Figure 37, Table 50 and Table 51 together with the associated clauses define the mandatory requirements with regard to the present document.

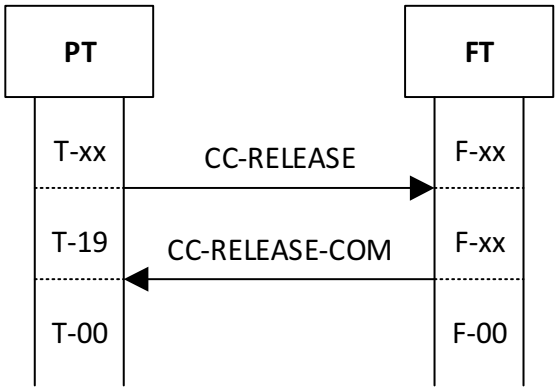


Figure 36: Normal call release, PT initiated

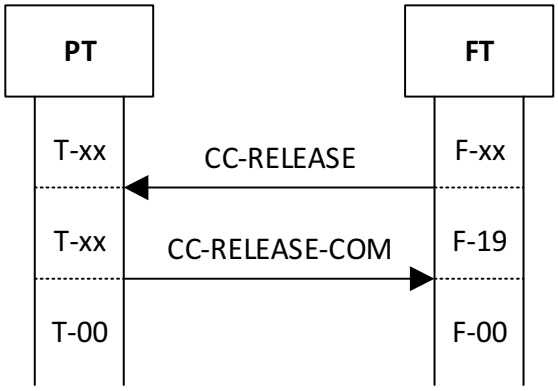


Figure 37: Normal call release, FT initiated

The PT is allowed to initiate this procedure in any state except T-00 or T-19.

The FT is allowed to initiate this procedure in any state except F-00 or F-19.

Table 50: Values used within the {CC-RELEASE} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
			All optional

Table 51: Values used within the {CC-RELEASE-COM} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
			All optional

7.6.8.2 Associated procedures

7.6.8.2.1 Timer P-<CC.02> management

<CC.02>: CC release timer;

value: refer to ETSI EN 300 175-5 [5], annex A;

start: a {CC-RELEASE} message has been sent;

stop: an indication for link release from the DLC layer is received. A {CC-RELEASE-COM} or a {CC-RELEASE} message is received;

restart: FT may restart it at any time by sending a {CC-NOTIFY} message (see ETSI EN 300 444 [9], clause 6.9.6).

7.6.8.2.2 Timer F-<CC.02> management

<CC.02>: CC release timer;

value: refer to ETSI EN 300 175-5 [5], annex A;

start: a {CC-RELEASE} message has been sent;

stop: an indication for link release from the DLC layer is received. A {CC-RELEASE-COM} or a {CC-RELEASE} message is received.

7.6.8.3 Exceptional cases

7.6.8.3.1 Release collisions

A release collision occurs when both sides send {CC-RELEASE} at the same time or a {CC-RELEASE} message has been received when the receiver is in "RELEASE PENDING" state due to loss of the first sent {CC-RELEASE} message. Figure 38 and Figure 39 show possible cases.

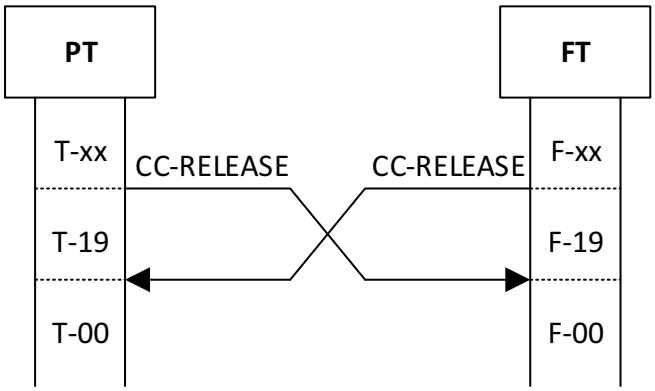


Figure 38: Both sides send {CC-RELEASE}

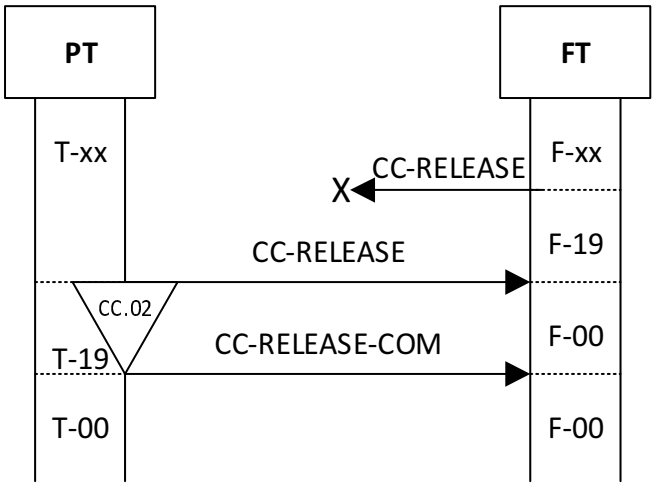
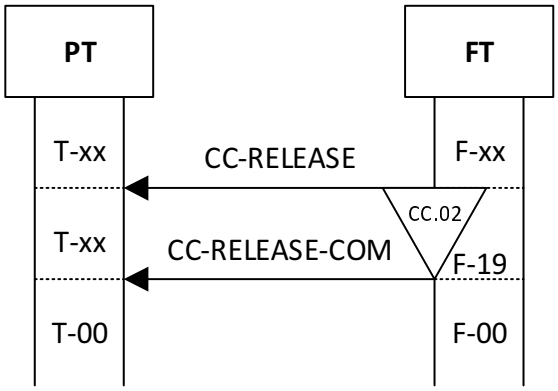


Figure 39: The {CC-RELEASE} sent by the FT has been lost

For the values used within the {CC-RELEASE} and {CC-RELEASE-COM} see Table 50 and Table 51.

7.6.8.3.2 Timer F-<CC.02> expiry

The handling of timer F<CC.02> expiry is shown in Figure 40.

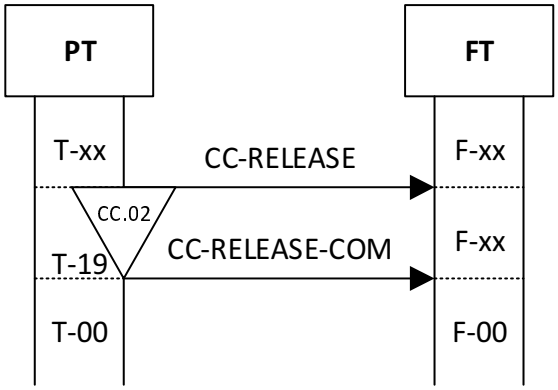


NOTE: PT may not be answering because of some PT problems or the {CC-RELEASE} sent by the FT or the eventual {CC-RELEASE-COM} message sent by the PT has been lost or corrupted.

Figure 40: Timer F<CC.02> expiry

For the values used within the {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.8.3.3 Timer P-<CC.02> expiry



NOTE: FT may not be answering because of some FT problems or the {CC-RELEASE} sent by the PT or the eventual {CC-RELEASE-COM} message sent by the FT has been lost or corrupted.

Figure 41: Timer P<CC.02> expiry

For the values used within the {CC-RELEASE} and {CC-RELEASE-COM} messages, see Table 50 and Table 51.

7.6.9 Abnormal call release

NOTE: This procedure description replaces clause 8.8 of ETSI EN 300 444 [9] (GAP).

The procedure shall be performed as defined in ETSI EN 300 175-5 [5], clause 9.5.2. Figure 42, Figure 43 and Table 52 together with the associated clauses define the mandatory requirements with regard to the present document.

The abnormal release is indicated by the unexpected receipt of a {CC-RELEASE-COM} message without a prior transmission of a {CC-RELEASE} message.

In state T19 {CC-RELEASE-COM} may also be sent without expiry of <CC.02>.

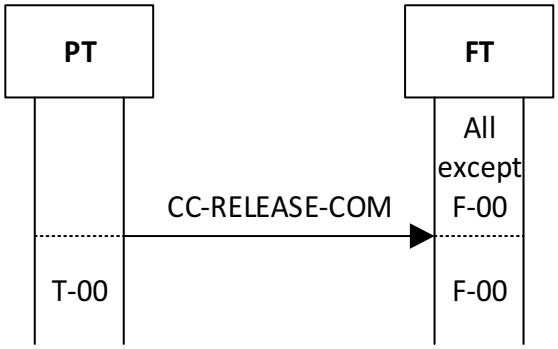


Figure 42: Abnormal call release, PT initiated

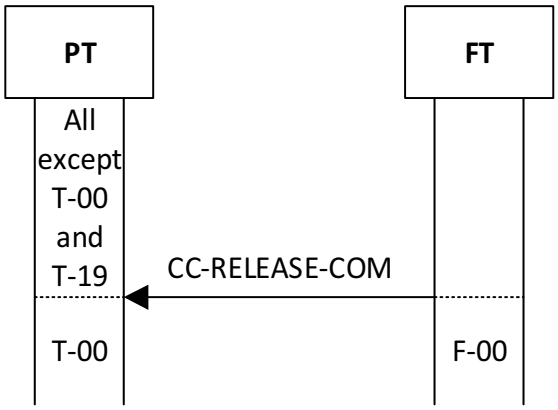


Figure 43: Abnormal call release, FT initiated

Table 52: Values used within the {CC-RELEASE-COM} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Release Reason>>	<Release Reason Code>	All optional	All optional

In the case that the FT did not recognize the PT by its <<Portable identity>> IE, it is recommended that the FT includes the <<Release reason>> IE in its {CC-RELEASE-COM} message with the Release Reason code "Unknown identity" (value '0A'H).

7.6.10 Exchange of codec list during registration and location registration

AAP devices shall include the IE << CODEC-LIST>> indicating the supported codecs in the following messages:

{ACCESS-RIGHTS-REQUEST}, {ACCESS-RIGHTS-ACCEPT}

{LOCATE-REQUEST}, {LOCATE-ACCEPT}

In order to minimize the number of codecs that need to be included in the <<CODEC-LIST>>, it is only necessary to indicate the highest audio bandwidth mode that is supported by the implementation for a given direction (uplink/downlink) within each of the codec groups shown clause 6.3, Table 11.

The transmitting side shall always indicate "Codec Negotiation possible" (value '001'B) in the IE <<CODEC LIST>> if more than one codec is supported.

7.6.11 Codec negotiation during call establishment

For AAP devices supporting more than one codec, codec negotiation shall be supported as described in this clause.

The IE <<CODEC-LIST>> shall be added in CC-SETUP if a new list of codecs is needed on a call by call basis. This may be useful when requesting a new codec (codec different from the location/registration phase) or changing the priorities within the list of codecs.

Sending the IE <<CODEC-LIST>> in CC-SETUP is not necessary in case the most recent list sent during registration/location registration is still the valid one.

The receiving side chooses the codec(s) based upon the list provided.

For a PT initiated call, the FT chooses the codec(s) upon reception of the CC-SETUP and initiates a bandwidth change and/or a slot type modification for the selected codec(s), see annex B. Once these procedures are complete, the CC-CONNECT is sent to the PT containing the chosen codec(s). The CC-CONNECT contains the same IE <<CODEC-LIST>>, but only one codec per direction shall be in the list.

For an FT initiated call, the PT chooses the codec and notifies this to the FT with the CC_CONNECT. The CC-CONNECT contains the same IE <<CODEC-LIST>>, but only one codec per direction shall be in the list. The FT then initiates a bandwidth and/or slot type modification as required for the selected codec(s), see annex B. The CC-CONNECT-ACK indicates completion of the codec configuration to the PT.

For an FT initiated call, in the case where the FT is unable to achieve the required bandwidth or slot type modification, the FT may switch to a mandatory codec configuration and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the required codec(s). On receiving this message, the PT shall also switch back to this codec configuration and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the required codec(s). The FT shall then send the CC-CONNECT-ACK.

The initiating side shall always indicate "Codec Negotiation possible" (value '001'B) in the IE <<CODEC LIST>> if more than one codec is supported.

Figure 44 and Figure 45 show the sequences for PT and FT initiated procedures respectively.

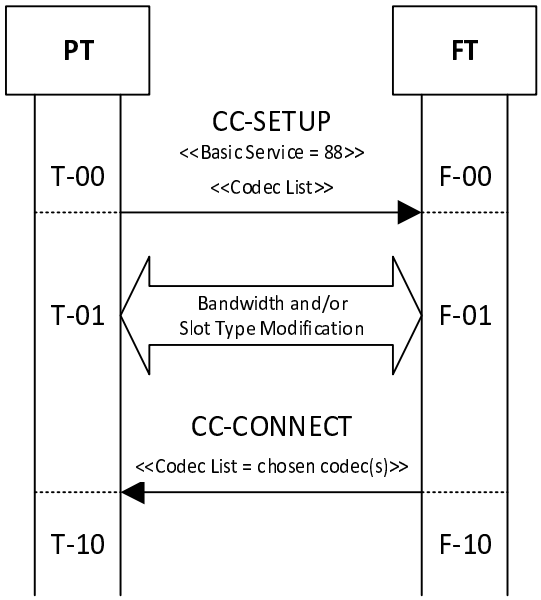


Figure 44: Codec Negotiation during PT initiated call setup

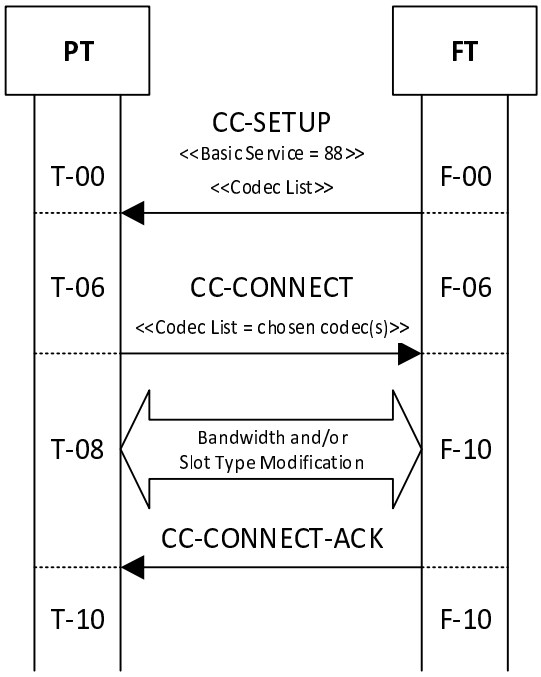


Figure 45: Codec Negotiation during FT initiated call setup

Preferred codec selection: in some cases, the result of the codec negotiation might be already known by the initiating side before the call is established. In order to speed up the negotiation procedure in those cases, the system should select a preferred codec by doing the following:

- The initiating side should select a slot format compatible with the preferred codec in order to save a further slot type modification:
  - In case of FT initiated call setup, the FT should page the PT directly in the slot format corresponding to this codec.
  - In case of PT initiated call setup, the PT should set up a slot type corresponding to this codec.
- If using a call by call codec negotiation, the initiating side should change the priorities within the list of codecs by specifying the preferred codec(s) in first position in the list(s) sent with the {CC-SETUP}. The IE << CODEC-LIST>> shall contain at least the mandatory codecs (i.e. a codec list with only the preferred codec(s) is not allowed by the present document).
- The receiving side should choose the preferred codec(s) of the initiating side in a response message.

7.6.12 Codec change

7.6.12.1 General

For AAP devices supporting more than one codec, codec change shall be supported as described in this clause in CC-state ACTIVE.

To change the codec the initiating side sends a {CC-SERVICE-CHANGE} including the IE<<CODEC-LIST>> and the IE<<SERVICE-CHANGE-INFO>> as shown in Table 53.

The receiving side shall either accept or reject the change.

Neither {CC-SERVICE-ACCEPT} nor {CC-SERVICE-REJECT} shall not contain the IE <<CODEC-LIST>>.

In case the change is accepted, the FT initiates a bandwidth and/or slot type modification at MAC layer if necessary.

Having switched to the new codec(s) and performed bandwidth and/or slot type modification if necessary, both sides shall indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> indicating the active codec(s), as shown in Table 54.

In the case where the FT is unable to achieve the required bandwidth or slot type modification, the FT shall switch back to the old codec(s) and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec(s). On receiving this message, the PT shall also switch back to the old codec(s) and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec(s).

Each side shall mute its receiving audio path, if present, at sending/receiving {CC-SERVICE-ACCEPT}.

Receiving {IWU-INFO} shall be a trigger for each side that it may unmute its receiving audio path, if present.

The service change for audio codec change is always followed with sending {IWU-INFO} from both sides. A new service change shall not be initiated until both sides have sent {IWU-INFO}.

The initiating side shall always indicate "Codec Negotiation possible" (value '001'B) in the IE <<CODEC LIST>>.

Figure 46 and Figure 47 show the sequences for successful and unsuccessful codec changes respectively.

NOTE: CC-SERVICE-ACCEPT and CC-SERVICE-REJECT have no content after the message type so are not described further here.

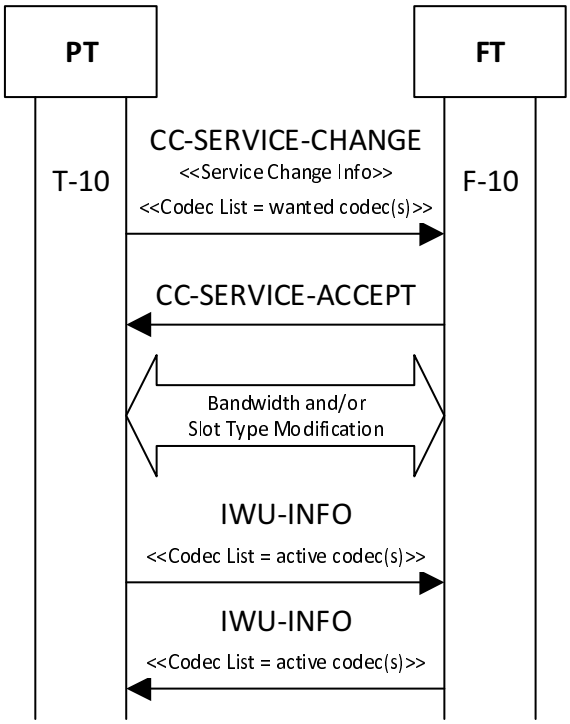


Figure 46: Successful Codec Change

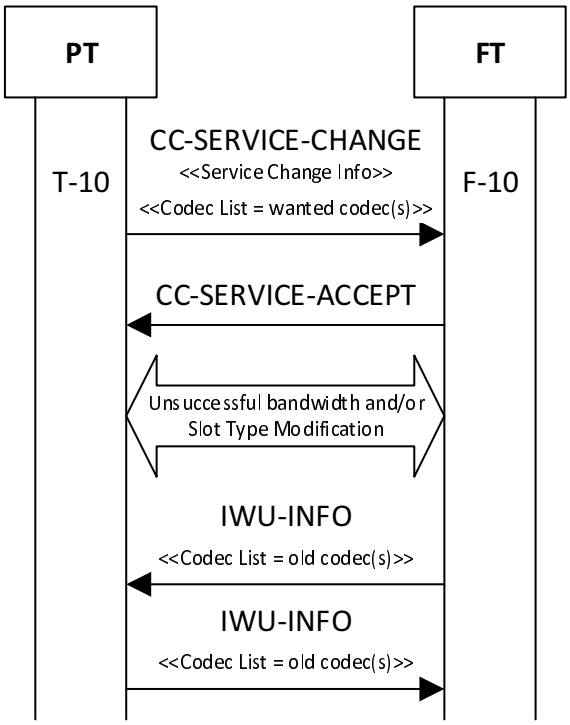


Figure 47: Unsuccessful Codec Change

Table 53: Values used within the {CC-SERVICE-CHANGE} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Service Change Info>>	<Coding standard>	'00'B	DECT standard coding
	<M>	'1'B	Master
	<Change mode>	'1101'B	Audio codec change
<<Codec-List>>			
	<Length of Contents>	4, 7, 10	Up to three codecs can be indicated (note): • Uplink • Downlink • Downlink - LFE
	<Negotiation indicator>	'000'B	Negotiation not possible
	<Codec Identifier>	15 to 34	Selected codec
	<Direction>	'01'B, '10'B,'11'B	Direction to which the codec applies.
	<MAC and DLC service>	'0001'B	I_N normal delay
	<C plane routing>	'000'B	C_S only
	<Slot size>	'0001'B, '0100'B, '0101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the codec, otherwise set to duplex bearer slot type, see annex B
NOTE: This table shows only one codec in the list, but up to three can be included. If multiple codecs are included in the list then the <Direction> field indicates the uplink/downlink aspect, while the <Codec Identifier> field indicates when an LFE is intended.			

Table 54: Values used within the {IWU-INFO} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Codec-List>>	<Length of Contents>	4, 7, 10	Up to three codecs can be indicated (note): • Uplink • Downlink • Downlink - LFE
	<Negotiation indicator>	'000'B	Negotiation not possible
	<Codec Identifier>	15 to 34	Selected codec
	<Direction>	'01'B, '10'B,'11'B	Direction to which the codec applies
	<MAC and DLC service>	'0001'B	I_N normal delay
	<C plane routing>	'000'B	C_S only
	<Slot size>	'0001'B, '0100'B, '0101'B	Full slot; long slot. j = 640; double slot. If double simplex bearers are used then set according to the double simplex bearer slot type for the codec, otherwise set to duplex bearer slot type, see annex B
NOTE: This table shows only one codec in the list, but up to three can be included. If multiple codecs are included in the list then the <Direction> field indicates the uplink/downlink aspect, while the <Codec Identifier> field indicates when an LFE is intended.			

7.6.13 Slot type modification

7.6.13.1 General

If a codec change requires a modification in duplex bearer slot type, the MAC slot type modification procedure shall be executed as described in clause 7.4.8 and ETSI EN 300 175-3 [3], clause 10.3.2.

The FT shall always initiate this procedure.

NOTE: In the case of a multibearer connection, the slot type modification is actually a combination of bandwidth modification and slot type modification procedures, as described in ETSI EN 300 175-3 [3], clause 10.3.2.2.4.

7.6.13.2 Failure of slot type modification

On failure of the slot type modification the initiating side shall, where possible, not release the call but switch back to the previously active codec and indicate so to the receiving side by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec. On receiving this message, the receiving side shall also switch back to the old codec and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec.

This can happen both after Service Negotiation and after Service Change. After Service Change the previously active codec shall be restored. After Service Negotiation a mandatory codec fitting to the previous slot format shall be used.

7.6.14 Bandwidth modification

7.6.14.1 General

If the codec change requires a bandwidth modification, the MAC bandwidth modification procedure shall be executed as described in in clause 7.4.9 and ETSI EN 300 175-3 [3], clause 10.3.1.

The FT shall always initiate this procedure.

7.6.14.2 Failure of bandwidth modification

On failure of the bandwidth modification the initiating side shall, where possible, not release the call but switch back to the previously active codec and indicate so to the receiving side by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec. On receiving this message, the receiving side shall also switch back to the old codec and indicate so by sending {IWU-INFO} including the IE <<CODEC-LIST>> with the old codec.

This can happen both after Service Negotiation and after Service Change. After Service Change the previously active codec shall be restored. After Service Negotiation a mandatory codec fitting to the previous slot format shall be used.

7.6.15 Terminal capability indication

NOTE: This procedure description replaces clause 8.17 of ETSI EN 300 444 [9] (GAP).

The PT shall send the <<Terminal capability>> and <<IWU-to-IWU>> information elements and the FT shall be able to receive them at least in {ACCESS-RIGHTS-REQUEST} and when location registration is supported in the {LOCATE-REQUEST}.Table 55 and Table 56 list the allowed values in these information elements.

Table 55: Values used within the <<TERMINAL CAPABILITY>> information element

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Terminal capability>>	<Tone capability>	All	
	<Display capability>	All	
	<Echo parameters>	All	For devices without bidirectional audio, set to 0.
	Slot type capability	'0xX1xXx0' X = [0,1]	Long slot (j = 640) and/or Double slot shall be supported if required by the supported bit rates of the device according to annex B.
	Ambient noise Rejection (N-REJ)	All	
	Adaptive volume control (A-VOL)	All	
	<Profile indicator_5>	[0,2,3,4]	Set according to supported modulation types.
	<Profile indicator_7> bit 5	'xxXxxxx'B X = [0,1]	Support or no support of "Re-keying" and "default cipher key early encryption mechanism".
	<Profile indicator_11>	'xxxXXxx'B X = [0,1]	Support of advanced audio profile microphone and/or speaker/headphone.
	DSAA2 (Octet 5)	[0,1]	Support (or not support) of the DSAA2 (see ETSI EN 300 175-7 [7] and note 1).
	DSC2 (Octet 5)	[0,1]	Support (or not support) of the DSC2 (see ETSI EN 300 175-7 [7] and note 2).
NOTE 1: This bit needs only to be understood by FTs supporting feature GAP.N.36. NOTE 2: This bit needs only to be understood by FTs supporting MAC service GAP.M.17.			

Table 56: Values used within the <<IWU-to-IWU>> information element

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<IWU-to-IWU>>	< Protocol Discriminator>	0x27	Advanced audio profile configuration description
	<Audio device information>	All	
NOTE: See clause A.2.1 for details of this information element.			

The IWU-to-IWU IE may indicate that the PT supports multiple audio channels. In this version of the specification, it is assumed that at connection establishment the FT will configure an audio codec for each audio channel supported by the PT. Negotiation of the number of channels to be provided is not supported and is for further study.

If the PT supports head tracking, it shall indicate the supported format(s) in the IWU-to-IWU IE.

7.6.16 Indirect FT initiated link establishment

7.6.16.1 General

NOTE: This procedure description replaces clause 8.35 of ETSI EN 300 444 [9] (GAP).

The procedure (shown in Figure 48) shall be performed as defined in ETSI EN 300 175-5 [5], clauses 14.2.1 and 14.2.3. The following text together with the associated clauses define the mandatory requirements with regard to the present document.

FT and PT shall support FULL format with TPUI for the {LCE-REQUEST-PAGE} message. When the FT request for a link establishment is successfully received by the intended PT, the PT shall initiate direct PT link establishment (see clause 8.36 of ETSI EN 300 444 [9] (GAP)).

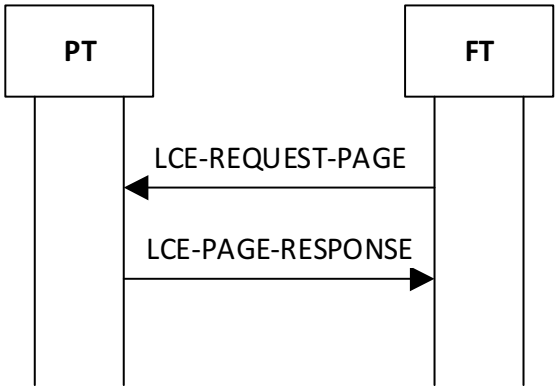


Figure 48: Indirect FT initiated link establishment

7.6.16.2 Paging messages

7.6.16.2.1 LCE-REQUEST-PAGE message

FULL paging format with TPUI address structure, as defined in ETSI EN 300 175-5 [5], clause 8.2.2 shall be used, with content as shown in Table 57 .

Table 57: Values used within the {LCE-REQUEST-PAGE} message in case of FULL paging format with TPUI

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<LCE Header>>	<W>	All	
	<LCE-header>	'000'B	The '0' value shall be used when only C-plane is required (e.g. MM procedures). The PT shall support a follow on call on the same link even if value '0' was used during initial paging
		'100'B	The '100' value shall be used for all services (irrespective of the MAC service to be used, that will be defined in the Attributes negotiation)
<<Field 1>>	<Slot type>	'0001'B	Long slot 640: shall be used if the duplex bearer packet format is P64 as defined in annex B
		'0100'B	Full slot: shall be used if the duplex bearer packet format is P32 as defined in annex B
		'0101'B	Double slot: shall be used if the duplex bearer packet format is P80 as defined in annex B
<<TPUI Address>>	<complete TPUI Address>	All	Complete (20 bits) TPUI address of the PT
<<Field 2>>	<Setup info>		
		'0000'B	Default value: it will produce the PT response: Mt signalling Advanced Connection, Attributes_T negotiation mandatory (see ETSI EN 300 175-5 [5], clause 8.2.4.3)
<<Field 3>>	<Additional discriminator>	'0000'B	Default value
NOTE: Values in the fields/information elements corresponding to services/implementation alternatives not supported or to optional features not implemented do not need to be supported.			

7.6.16.2.2 LCE-PAGE-RESPONSE message

This message shall be as defined in ETSI EN 300 175-5 [5], clause 6.3.7.1 with content as shown in Table 58.

Table 58: Values used within {LCE-PAGE-RESPONSE} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Protocol discriminator>>	<LCE messages>	'0000'B	
<<Transaction identifier>>	<LCE>	'0000'B	Only '0000' value allowed for LCE (1 transaction)
<<Message Type>>	<LCE-PAGE-RESPONSE>	'01110001'B	
<<Portable identity>>			Depends upon subscription records
	<Type>	'0000000'B	IPUI
	<PUT>	All	
	<PUN>	All	
<<Fixed identity>>			Parameters depend upon subscription records
	<Type>	32	PARK
	<Length of identity value>	All	PLI+1
	<ARC+ARD>	All	

7.6.16.3 Associated procedure

7.6.16.3.1 Timer F-<LCE.03> management

There shall be separate instances of a <LCE.03> timer corresponding to each IPUI identity that has been paged with {LCE-REQUEST-PAGE} message.

<LCE.03>: {LCE-REQUEST-PAGE} message re submission timer;

Value: Refer to ETSI EN 300 175-5 [5], annex A;

Start: A {LCE-REQUEST-PAGE} message is sent;

Stop: A {LCE-PAGE-RESPONSE} message with a matching IPUI or a release from the higher entity is received.

7.6.16.4 Exceptional cases

7.6.16.4.1 The IPUI received in the {LCE-PAGE-RESPONSE} does not match

This LCE-PAGE-REJECT message shall be used as defined in ETSI EN 300 175-5 [5], clause 6.3.7.2 and Figure 49 with content as shown in Table 59.

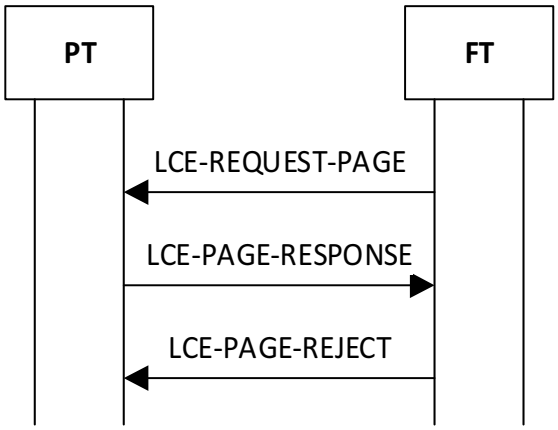


Figure 49: The IPUI received in the {LCE-PAGE-RESPONSE} does not match

Table 59: Values used within the short format {LCE-PAGE-REJECT} message

Information element	Field within the information element	Standard values within the field/information element	Normative action/comment
<<Protocol discriminator>>	<LCE messages>	'0000'B	
<<Transaction identifier>>	<LCE>	'0000'B	Only '0000' value allowed for LCE (1 transaction)
<<Message Type>>	<LCE-PAGE-REJECT>	'01110010'B	
<<Portable identity>>			It shall be the full IPUI of the PT that is rejected
	<Type>	'0000000'B	IPUI
	<PUT>	All	
	<PUN>	All	

The unwanted link shall immediately be released using the Link release 'normal' procedure (see clause 8.37 of ETSI EN 300 444 [9]).

The {LCE-PAGE-REJECT} message shall be sent by a DL_DATA-req primitive via the S-Service Access Point (SAP) (SAP Identifier (SAPI) = '0') using the same Data Link Endpoint Identifier (DLEI) as indicated by the DL_ESTABLISH-ind carrying the {LCE-PAGE-RESPONSE}. This FT reply shall also use the same transaction value as used by the PT in the {LCE-PAGE-RESPONSE} message.

7.6.16.4.2 Timer <LCE.03> expiry

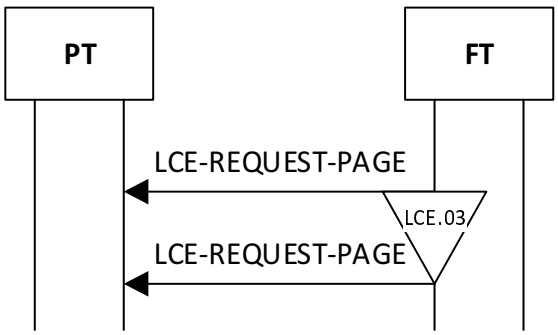


Figure 50: Timer <LCE.03> expiry

If timer <LCE.03> expires before the wanted link is established, the LCE may resubmit the {LCE-REQUEST-PAGE} message (see Figure 50) in which case the link shall remain in the "ESTABLISH-PENDING" state. Resubmitted messages shall only be issued at a lower priority than other outstanding B-format messages. A message may be resubmitted a maximum of N300 times before it is discarded.

NOTE: N300 is an application specific value. Recommended value for these audio applications is three (3).

7.6.16.4.3 Release from the higher entity

If the higher entity indicates that the link resources are no longer required, the LCE shall immediately delete the outstanding IPUI and stop the corresponding timer <LCE.03>.

7.6.17 Higher layer information FP broadcast

7.6.17.1 General

The FT and PT shall support the broadcast of Higher Layer capabilities as part of Q_T MAC broadcast messages (see clause 7.4.4).

The broadcast attributes are a small set of NWK layer and DLC layer capabilities (jointly known as "higher layer capabilities") that shall be broadcast regularly as part of the MAC layer broadcast service. See ETSI EN 300 175-5 [5], annex F.

RFPs belonging to the same location area shall broadcast the same values of higher layer attributes (see ETSI EN 300 175-5 [5], annex F) at any given time.

The PT shall be capable to read and interpret at least the following broadcast attributes codings during the locking procedure. In the locked state the PT may assume them as static.

FT and PT shall support the following values of "Higher Layer capabilities" information attributes.

7.6.17.2 Higher layer information in standard FP broadcast (Q_H= 3)

Table 60 shows the higher layer information attributes in standard FP broadcast.

Table 60: Higher layer information attributes in standard FP broadcast (Q_H = 3)

Bit Number	Attribute	Value	Note
a_{36}	DECT Standard Authentication (DSAA) required	1	
a_{37}	DECT Standard Cipher (DSC) supported	1	
a_{38}	Location registration supported	0,1	See location update procedure, clause 8.29 of ETSI EN 300 444 [9] (GAP) as an exception
a_{44}	Access rights requests supported	0,1	The FP can toggle this bit to enable or disable on air subscription
a_{46}	Connection handover supported	0,1	

7.6.17.3 Higher layer information in Extended FP broadcast (Q_H = 4)

Table 61 shows the higher layer information attributes in standard FP broadcast.

Table 61: Higher layer information attributes in extended FP broadcast (Q_H = 4)

Bit Number	Attribute	Value	Note
a_{41}	Asymmetric bearers supported	1	

7.6.17.4 Higher layer information in Extended FP broadcast part 2 (Q_H = 12)

Table 62 shows the higher layer information attributes in extended FP broadcast part 2.

Table 62: Higher layer information attributes in Extended FP broadcast part 2 (Q_H = 11)

Bit Number	Attribute	Value	Note
a_{42}	Support of "Re-keying" and "early encryption"	0,1	See clauses 8.45.2 and 8.45.3 of ETSI EN 300 444 [9]
a_{43}	DSAA2 supported	0,1	See ETSI EN 300 175-7 [7] and clause 8.45 of ETSI EN 300 444 [9]
a_{44}	DSC2 supported	0,1	See ETSI EN 300 175-7 [7], clause 8.45 of ETSI EN 300 444 [9] and note
NOTE: The support of the DECT Standard Cipher #2 (DSC2) requires the support of the DECT Standard Authentication Algorithm #2 (DSAA2).			

7.6.17.5 Higher layer information in Extended FP broadcast part 3 (Q_H = 14)

Table 63 shows the higher layer information attributes in extended FP broadcast part 3.

Table 63: Higher layer information attributes in Extended FP broadcast part 3 (Q_H = 14)

Bit Number	Attribute	Value	Note
a_{36}	Support of advanced audio profile microphone	0,1	This bit indicates support of an LC3plus based microphone with 10 ms codec frame duration, as used for smart speakers or headsets.
a_{37}	Support of advanced audio profile low latency microphone	0,1	This bit indicates support of an LC3plus based microphone with 2,5 ms codec frame duration.
a_{38}	Support of advanced audio profile speaker or headphone	0,1	
a_{39}	Support of advanced audio profile high-resolution headphone	0,1	
a_{40}	Support of advanced audio profile gaming headset	0,1	

7.7 Application procedures

7.7.1 General

This clause specifies the additional application layer procedures, messages and information elements required the advanced audio profile, which are not described in ETSI EN 300 444 [9] (GAP), or which incorporate modifications to the description given in that specification.

NOTE: The main functional application is out of the scope of the present document.

7.7.2 Easy pairing procedures

7.7.2.1 General

The easy pairing feature simplifies the registration process by not requesting any PIN code from the user when the PIN code is set to the default '0000' value.

When this feature is implemented, related procedures shall be valid at first power-on of an unregistered PT and at any additional further registrations.

The PT will systematically try to register with the default '0000' PIN code. In the case of failure, the PT will automatically switch back to the GAP PIN code registration feature process and corresponding procedures (see ETSI EN 300 444 [9]).

From a security point of view, successful easy pairing is equivalent to default '0000' PIN code registration which is less secure than any non-'0000' PIN code registration. As a consequence, for easy pairing registration, the user should be instructed to monitor the registration user feedback (see clause 7.7.2.4).

7.7.2.2 Searching mode request

The access rights procedure triggered by the user on the PT causes it to actively search for an FT broadcasting 'Access rights requests supported' capability bit (Higher layer capabilities bit a_{44} = 1, see ETSI EN 300 175-5 [5], clause F.1 and ETSI EN 300 444 [9], annex A. The searching mode shall be limited by the timer P<AP.02>.

When an FT is found in subscription mode, the PT shall start the access rights procedure using the '0000' value for the authentication code. If the FT rejects the access rights, the PT may prompt the user to enter the PIN code, or may use a pre-programmed PIN code which could be entered at the FT. The PT may then initiate a new access rights request with the same FT using the supplied PIN entered value for the authentication code.

The sequences for these procedures are shown in Figure 51 and Figure 52.

NOTE: When performing easy pairing registration, it is assumed that the PT is in close proximity to the FT, and therefore the PT will receive a stronger signal from that FT. The PT can use RSSI readings to speed up the search for the desired FT. For example:

1) Measure the RSSI level on each channel.

2) Synchronize on the FT with the highest RSSI value.

3) Wait for the a_{44} bit to check if it is set.

4a) If a_{44} is set, start the access rights procedure.

4b) If a_{44} is not set, put the RFPI on a barred list and go to step 2 (or 1) to find another FT.

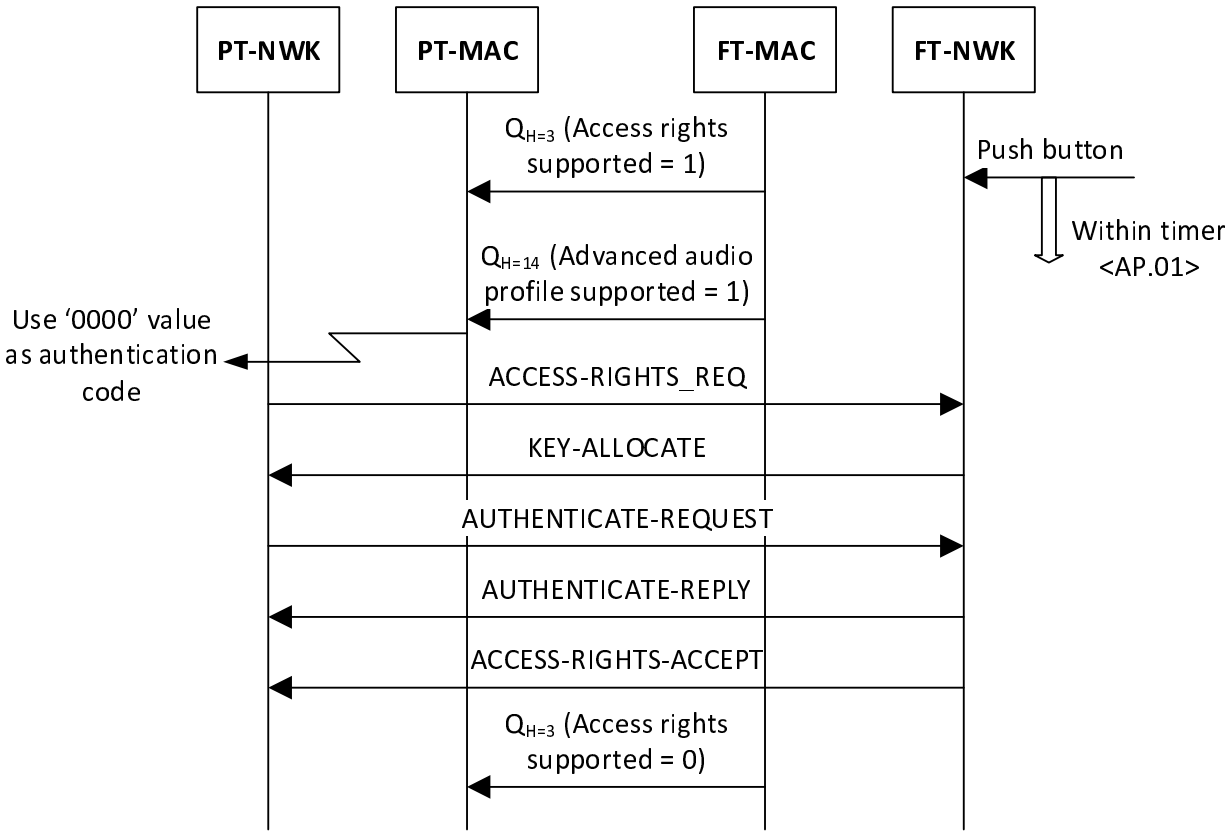


Figure 51: Easy pairing when PIN is set to default '0000' value

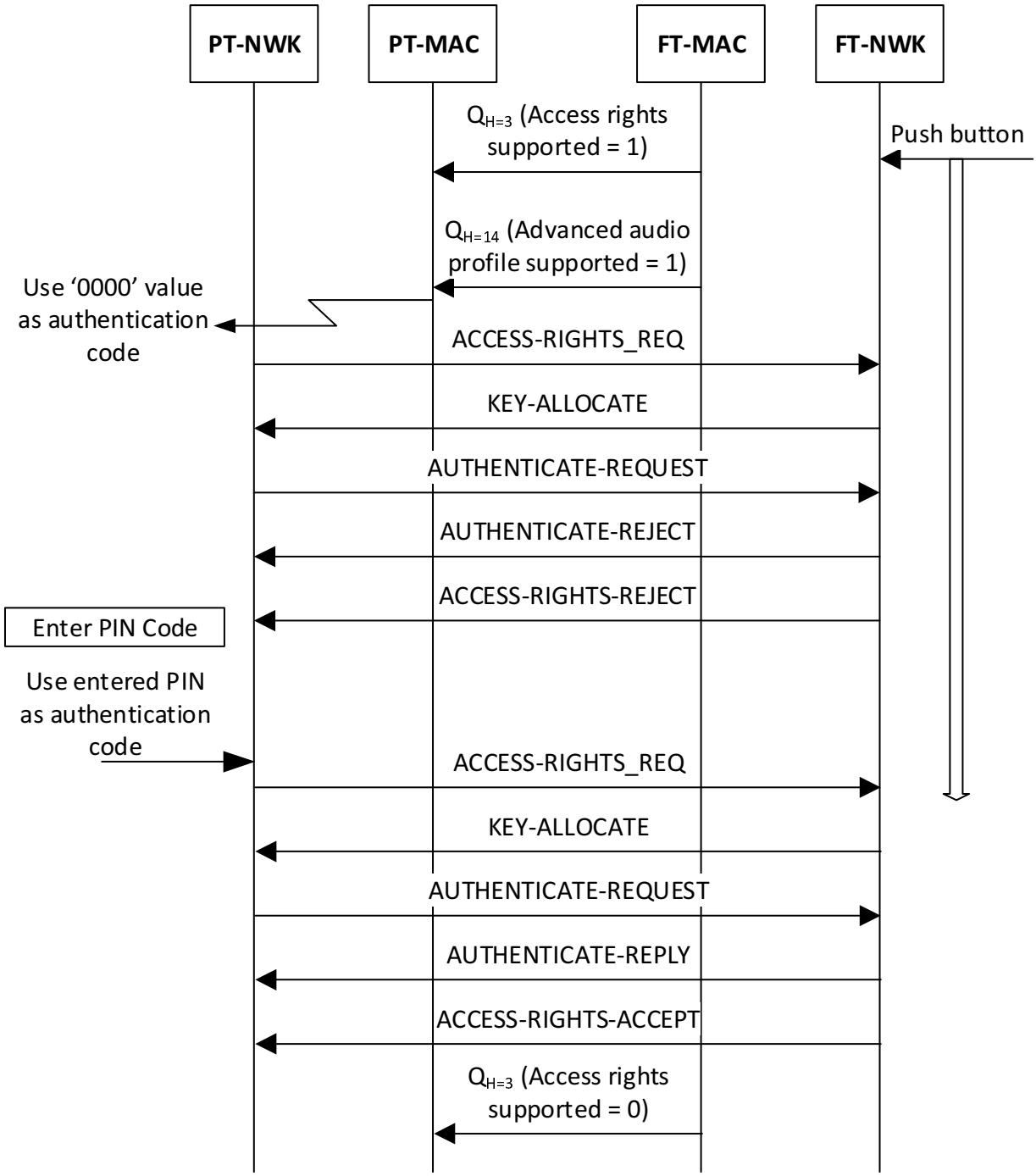


Figure 52: Easy pairing when PIN is not set to default '0000' value: switching back to PIN entry

In Figure 51 and Figure 52, the $Q_{(H=14)}$ message "Advanced audio supported" refers to the any of the AAP capability bits (a_{36} to a_{40}) in the Extended FP broadcast part 3 message, see clause 7.6.17.5.

7.7.2.3 Base station limited registration mode

The FP shall have a physical or a logical button to trigger the access rights procedure.

When the button is pressed on the FT, the FT shall set its broadcasting 'Access rights requests supported' capability bit to enable the on-air subscription (see clauses 7.6.17.2 and 7.8.2).

When the access rights procedure is successfully completed or when timer F<AP.01> expires, this bit shall be cleared.

Additionally, for security reasons the FT should implement the following behaviour: before timer expiry, the FT may clear this bit and stop the timer if a fixed number of unsuccessful PIN code registration attempts has been reached.

Nevertheless, the FT shall support at least one more registration attempt if easy pairing procedure failed before clearing the bit to be compatible with easy pairing registration procedure clause 7.7.2.2.

For security reasons, the FT shall perform no more than one successful access rights procedure during the subscription mode.

7.7.2.4 Registration user feedback

In order to improve the security, the FT and the PT shall give a feedback to the user of the registration process through a user interface (for example a display, an LED or a buzzer).

The feedback given on the user interface of the PT and the FT shall be as a minimum the following status of the registration process with the following states:

- Registration in progress state:
  - Condition of entrance: the PT is looking for or is locked onto an FT in subscription mode and the protocol is exchanging messages.
  - Recommended user action: wait for protocol to finish.
- Registration error state:
  - Condition of entrance: some error occurred, such as failed to find a peer device, or to complete the access rights procedure (e.g. authentication failed).
  - Recommended user action: wait then try again.
- Registration success state:
  - Condition of entrance: protocol procedure is complete and successful.
  - Recommended user action: try to make an audio connection.

EXAMPLE: Find below typical cases where the registration error state is reached:

- PT side: failed to find the peer device during search mode timer.
- PT side: access rights procedure failed (for example due to wrong PIN code).
- FT side: no device successfully registered when running the base station limited registration mode procedure.

NOTE: On the FT side, if the access rights procedure fails, the FT should wait until the Access Rights supported attributes' capability bit is cleared (registration mode ended) to indicate the error state. This is necessary to ensure correct support of the easy pairing procedure in the specific case where FT uses a non-default '0000' PIN code.

The proposed user feedback with corresponding user interface allows the user to check that registration on the correct FP was successful. This offers additional security especially in the case of the easy pairing procedure which is less secure than the PIN code registration procedure.

The user should be aware that during the registration mode an unwanted PT could join the FT. The user should be instructed to monitor the user interface, especially to check the success indication on both sides for security considerations. This verification will prevent the PT from joining an FT that was not selected or to prevent another PT from joining the selected FT.

The type of user interface is left free to implementers. For example, the user interface could be a display on the FT side and an LED on the PT side. It could also be an audio tone indication or any other richer user interface (displays on both sides for example).

7.7.3 Head tracking

7.7.3.1 General

The head tracking feature adds an uplink data channel to provide the user's head orientation and movement to the FT application.

Support of the head tracking channel shall be indicated by the PT in the terminal capabilities (see clause 7.6.15) using the <<IWU-to-IWU>> IE (see clause A.2.1).

If the FT supports the head tracking channel it shall indicate the head tracking channel format to use by passing the <<IWU-to-IWU>> IE (see clause A.2.1) containing the selected format each time it transmits the <<CODEC-LIST>> IE (see clauses 7.6.10, 7.6.11 and 7.6.12). If the PT receives this IE along with the <<CODEC-LIST>> IE it shall transmit the head tracking channel using the format provided otherwise it shall not transmit the head tracking channel.

If the head tracking channel is transmitted by the PT it shall be appended to the audio channel data as described in clause 7.4.18.

Negotiation of the head tracking channel format is not supported in the present document.

NOTE: Only a basic use case with proprietary coding is covered by this version of the standard. This feature is for further study.

7.8 Management procedures

7.8.1 General

This clause specifies the additional management procedures required for advanced audio services which are not described in ETSI EN 300 444 [9] (GAP), clause 13, or which incorporate modifications to the GAP specification.

The advanced audio profile PT shall be capable of reading and interpreting at least the following broadcast attributes codings during the locking procedure. In the locked state the PT may assume them as static.

7.8.2 Broadcast attributes management

7.8.2.1 Procedure

NOTE: This procedure description replaces clause 13.6 of ETSI EN 300 444 [9] (GAP).

RFPs belonging to the same location area shall broadcast the same values of higher layer attributes (see ETSI EN 300 175-5 [5], annex F) at any given time.

The advanced audio profile PT shall be capable of reading and interpreting at least the following broadcast attributes codings during the locking procedure. In the locked state the PT may assume them to be static.

7.8.2.2 Higher layer capabilities

Table 64 shows the higher layer capabilities that shall be understood by the PT.

Table 64: Broadcast attributes interpretation by the PT: Higher layer capabilities

Bit Number	Attribute	Value	Note
a_{36}	DECT Standard authentication (DSAA) required	0,1	
a_{37}	DECT Standard Cipher (DSC) supported	0,1	
a_{38}	Location registration supported	0,1	See location update procedure, clause 8.29 of ETSI EN 300 444 [9] (GAP) as an exception.
a_{44}	Access rights requests supported	0,1	The FP can toggle this bit to enable or disable on air subscription.
a_{46}	Connection handover supported	0,1	

7.8.2.3 Extended higher layer capabilities

Table 65 shows the extended higher layer capabilities that shall be understood by the PT.

Table 65: Broadcast attributes interpretation by the PT: Extended higher layer capabilities

Bit Number	Attribute	Value	Note
a_{41}	Asymmetric bearers supported	1	

7.8.2.4 Extended higher layer capabilities (part 2)

Table 66 shows the extended higher layer capabilities (part 2) that shall be understood by the PT.

Table 66: Broadcast attributes interpretation by the PT: Extended higher layer capabilities (part 2)

Bit Number	Attribute	Value	Note
a_{42}	Support of "Re-keying" and "early encryption"	0,1	See ETSI EN 300 444 [9], clauses 8.45.2, 8.45.3 and notes 1 and 2.
a_{43}	DSAA2 supported	0,1	See ETSI EN 300 175-7 [7] and ETSI EN 300 444 [9], clause 8.45.
a_{44}	DSC2 supported	0,1	See ETSI EN 300 175-7 [7] and ETSI EN 300 444 [9], clause 8.45 and note 3.
NOTE 1: Only FT implementations supporting the procedures in clause 8.45.2 of ETSI EN 300 444 [9] "Re-keying during a call" and in clause 8.45.3 of ETSI EN 300 444 [9] "Early encryption" or supporting the feature GAP.N.36 (AES/DSAA2 authentication) are required to broadcast the "Extended Higher layer capabilities (part 2)".			
NOTE 2: Only PT implementations supporting the procedures in clause 8.45.2 of ETSI EN 300 444 [9] "Re-keying during a call" and in clause 8.45.3 of ETSI EN 300 444 [9] "Early encryption" or supporting the feature GAP.N.36 (AES/DSAA2 authentication) need to understand the "Extended Higher layer capabilities (part 2)".			
NOTE 3: The support of DECT Standard Cipher #2 (DSC2) requires the support of the DECT Standard Authentication Algorithm #2 (DSAA2).			

7.8.2.5 Extended higher layer capabilities (part 3)

Table 67 shows the extended higher layer capabilities (part 3) that shall be understood by the PT.

**Table 67: Broadcast attributes interpretation by the PT:
Extended Higher layer capabilities (part 3)**

Bit Number	Attribute	Value	Note
a_{36}	Support of advanced audio profile microphone	0,1	Only the bits relevant for the device type supported by the PT need be understood.
a_{37}	Support of advanced audio profile low latency microphone	0,1	
a_{38}	Support of advanced audio profile speaker or headphone	0,1	
a_{39}	Support of advanced audio profile high-resolution headphone	0,1	
a_{40}	Support of advanced audio profile gaming headset	0,1	

Annex A (normative): Parameters and information elements

A.1 Parameters

A.1.1 Application timers

The application timer values shall be as follows:

<AP.01> **Subscription mode timer.**

FT value: 120 seconds.

PT value: Not used.

Start: Subscription mode has been requested by the user and bit a_{44} of "higher layer capabilities", "Access rights requests supported", has been set.

Stop: As soon as on-air subscription procedure is successful or bit a_{44} of "higher layer capabilities", "Access rights requests supported", is cleared.

<AP.02> **Searching mode timer.**

FT value: Not used.

PT value: 120 seconds.

Start: Searching mode has been requested by the user: listen and wait for bit a_{44} of "higher layer capabilities", "Access rights requests supported".

Stop: As soon a as on-air subscription procedure is successful.

A.2 Information elements

A.2.1 <<IWU-to-IWU>>

The base standard ETSI EN 300 175-5 [5] defines the basic structure of the <<IWU-to-IWU>> IE. The actual payload data is Advanced Audio Profile specific.

When the Protocol Discriminator value is "Advanced Audio Profile" the format of the IE is as given in Table A.1.

Table A.1: IWU-to-IWU information field for Protocol Discriminator value "Advanced Audio Profile"

Bit:	8	7	6	5	4	3	2	1	Octet:
	0	<< IWU to IWU>> (0x77)							**1**
	Length of Contents (L)								**2**
	1	S/R	Protocol Discriminator (0x27 Advanced Audio Profile Configuration Description)						**3**
									4
	Audio device information								
									L+2

The "Audio device information" contains a list of the characteristics of the device and shall be interpreted as follows:

Bit:	8	7	6	5	4	3	2	1
	Type			Value				

The coding of the Type field is as follows:

Type Coding:

Bits	**8 7 6**	**Meaning**
	0 0 0	Downlink audio channel
	0 0 1	Uplink audio channel
	0 1 0	Uplink head tracking channel

All other values reserved

Value coding if Type is "Downlink audio channel":

Bits	**5 4 3 2 1**	**Meaning**
	0 0 0 0 0	Mono
	0 0 0 0 1	Left ear (headphone)
	0 0 0 1 0	Right ear (headphone)
	0 0 0 1 1	Front left
	0 0 1 0 0	Front right
	0 0 1 0 1	Front centre
	0 0 1 1 0	LFE-1
	0 0 1 1 1	Back left
	0 1 0 0 0	Back right

All other values reserved

Value coding if Type is "Uplink audio channel":

Bits	**5 4 3 2 1**	**Meaning**
	0 0 0 0 0	Mono
	0 0 0 0 1	Left
	0 0 0 1 0	Right

All other values reserved

Value coding if Type is "Uplink head tracking channel":

Bits	**5 4 3 2 1**	**Meaning**
	0 0 0 0 0	Proprietary, 16kbit/s, 10 ms frame period (note 1)
	0 0 0 0 1	Proprietary, 32kbit/s, 10 ms frame period (note 1)

All other values reserved

NOTE: The content of the proprietary formats is outside of the scope of the present document.

A.2.2 Coding of the Information Element <<IWU-ATTRIBUTES>>

The << IWU-ATTRIBUTES>> Information Element (see table A.2) is used during call setup to indicate an Advanced Audio Profile call.

The base standard ETSI EN 300 175-5 [5] defines the basic structure of the IE, and the present document describes the profile-specific structure.

Table A.2: IWU-to-IWU information field for Protocol Discriminator value "Advanced Audio Profile"

Bit:	8	7	6	5	4	3	2	1	Octet:
	0	<< IWU-ATTRIBUTES >>							**1**
	Length of Contents (L)								**2**
	1	0	1	Profile					**3**
	1	Negotiation indicator			Profile subtype				**4**

Coding Standard (octet 3):

Bits 7 6 Meaning
0 1 Profile Defined Coding

Profile (octet 3):

Bits 5 4 3 2 1 Meaning
1 0 0 0 1 Advanced Audio Profile

Negotiation indicator (octet 4):

Bits 7 6 5 Meaning
0 0 0 Negotiation not possible
1 0 0 Exchanged parameter negotiation
All other values not used or reserved.

Profile subtype (octet 4):

Bits 4 3 2 1 Meaning
0 0 0 0 Advanced audio profile version 1
All other values reserved.

Annex B (normative): Mapping of audio codec configurations to MAC layer bearers

B.1 General

The type and number of MAC bearers used for an advanced audio connection shall be configured as described in this annex. The configurations in this clause refer to a single direction of data transfer only. In case of bidirectional codec data, the duplex bearer shall be shared between both directions and any double simplex bearers shall be configured independently.

If head tracking data is transmitted, then it shall be included in the codec gross bit rate used in tables B.1 to B.3. For example, if a 64 kbit/s audio channel is used together with a 16 kbit/s head tracking channel, then the codec gross bit rate shall be considered to be 80 kbit/s.

B.2 GFSK or π/2-DBPSK modulation

For B fields using GFSK or π/2-DBPSK modulation, the mapping of codec configuration to MAC bearers shall be as shown in Table B.1.

Table B.1: Audio codec bit rate to MAC layer bearer mapping - GFSK or π/2-DBPSK

Codec gross bit rate (kbit/s) (see note)	Codec frame duration (ms)	Duplex bearer packet format	Duplex bearer used for audio data	Number of double simplex bearers	Double simplex bearer packet format	Comments
16	10	P32	N	0	N/A	Actual data rate 32 kbit/s. Only used for standalone 16 kbit/s head tracking channel.
32	10	P32	Y	0	N/A	
48	10	P64	Y	0	N/A	Actual data rate 64 kbit/s. Only used for 32 kbit/s audio plus 16 kbit/s head tracking channel.
64	10	P64	Y	0	N/A	
80	10	P80	Y	0	N/A	Only used for 64 kbit/s audio plus 16 kbit/s head tracking channel.
96	10	P32	Y	1	P32	
128	10	P32	N	1	P64	
160	10	P32	N	1	P80	
192	10	P64	Y	1	P64	
256	10	P32	N	2	P64	
320	10	P32	N	2	P80	
384	10	P32	N	3	P64	
64	5	P32	N	1	P32	
128	5	P32	N	1	P64	
160	5	P32	N	1	P80	
192	5	P32	N	3	P32	
256	5	P32	N	2	P64	
320	5	P32	N	2	P80	
384	5	P32	N	3	P64	
128	2,5	P32	N	2	P32	
256	2,5	P32	N	2	P64	
320	2,5	P32	N	2	P80	
512	2,5	P32	N	4	P64	
NOTE: In case of stereo using separate codecs for left and right, this rate is double the rate of a single codec. For example, for a stereo variant of AA.AC.4, the applicable rate here is (2 x 96 kbit/s) = 192 kbit/s.						

B.3 π/4-DQPSK modulation

For B fields using π/4-DQPSK modulation, the mapping of codec configuration to MAC bearers shall be as shown in Table B.2.

Table B.2: Audio codec bit rate to MAC layer bearer mapping - π/4-DQPSK

Codec gross bit rate (kbit/s) (note 1)	Codec frame duration (ms)	Duplex bearer packet format (note 2)	Duplex bearer used for audio data	Number of double simplex bearers	Double simplex bearer packet format	Comments
16	10	P32	N	0	N/A	Actual data rate 64 kbit/s. Only used for standalone 16 kbit/s head tracking channel
32	10	P32	Y	0	N/A	Actual data rate 64 kbit/s
48	10	P32	Y	0	N/A	Actual data rate 64 kbit/s. Only used for 32 kbit/s audio plus 16 kbit/s head tracking channel
64	10	P32	Y	0	N/A	
80	10	P64	Y	0	N/A	Actual data rate 128 kbit/s. Only used for 64 kbit/s audio plus 16 kbit/s head tracking channel
96	10	P64	Y	0	N/A	Actual data rate 128 kbit/s
128	10	P64	Y	0	N/A	
160	10	P80	Y	0	N/A	
192	10	P32	N	1	P64	Actual data rate 256 kbit/s
256	10	P32	N	1	P64	
320	10	P32	N	1	P80	
384	10	P64	Y	1	P64	
64	5	P32	N	1	P32	Actual data rate 128 kbit/s
128	5	P32	N	1	P32	
160	5	P32	N	1	P64	Actual data rate 256 kbit/s
192	5	P32	N	1	P64	Actual data rate 256 kbit/s
256	5	P32	N	1	P64	
320	5	P32	N	1	P80	
384	5	P32	N	2	P64	Actual data rate 512 kbit/s
128	2,5	P32	N	2	P32	Actual data rate 256 kbit/s
256	2,5	P32	N	2	P32	
320	2,5	P32	N	2	P64	Actual data rate 512 kbit/s
512	2,5	P32	N	2	P64	

NOTE 1: In case of stereo using separate codec for left and right, this rate is double the rate of a single codec. For example, for a stereo variant of AA.AC.4, the applicable rate here is (2 x 96 kbit/s) = 192 kbit/s.
NOTE 2: The duplex bearer packet format shall be the larger of those required for uplink and downlink configurations. If not used for carrying audio data, the modulation scheme used for the duplex bearer B field may be configured to use π/2-DBPSK.
NOTE 3: Where possible, it is not recommended to use codec gross bit rates which result in a data rate higher than the original codec gross bit rate.

B.4 π/8-D8PSK modulation

For B fields using π/8-D8PSK modulation, the mapping of codec configuration to MAC bearers shall be as shown in Table B.3.

Table B.3: Audio codec bit rate to MAC layer bearer mapping - π/8-D8PSK

Codec gross bit rate (kbit/s) (note 1)	Codec frame duration (ms)	Duplex bearer packet format (note 2)	Duplex bearer used for audio data	Number of double simplex bearers	Double simplex bearer packet format	Comments
16	10	P32	N	0	N/A	Actual data rate 96 kbit/s. Only used for standalone 16 kbit/s head tracking channel.
32	10	P32	Y	0	N/A	Actual data rate 96 kbit/s
48	10	P32	Y	0	N/A	Actual data rate 96 kbit/s. Only used for 32 kbit/s audio plus 16 kbit/s head tracking channel.
64	10	P32	Y	0	N/A	Actual data rate 96 kbit/s
80	10	P32	Y	0	N/A	Actual data rate 96 kbit/s. Only used for 64 kbit/s audio plus 16 kbit/s head tracking channel.
96	10	P32	Y	0	N/A	
128	10	P64	Y	0	N/A	Actual data rate 192 kbit/s
160	10	P64	Y	0	N/A	Actual data rate 192 kbit/s
192	10	P64	Y	0	N/A	
256	10	P32	Y	1	P32	Actual data rate 288 kbit/s
320	10	P32	N	1	P64	Actual data rate 384 kbit/s
384	10	P32	N	1	P64	
64	5	P32	N	1	P32	Actual data rate 192 kbit/s
128	5	P32	N	1	P32	Actual data rate 192 kbit/s
160	5	P32	N	1	P32	Actual data rate 192 kbit/s
192	5	P32	N	1	P32	
256	5	P32	N	1	P64	Actual data rate 384 kbit/s
320	5	P32	N	1	P64	Actual data rate 384 kbit/s
384	5	P32	N	1	P64	
128	2,5	P32	N	2	P32	Actual data rate 384 kbit/s
256	2,5	P32	N	2	P32	Actual data rate 384 kbit/s
320	2,5	P32	N	2	P32	Actual data rate 384 kbit/s
512	2,5	P32	N	2	P64	Actual data rate 768 kbit/s

NOTE 1: In case of stereo using separate codec for left and right, this rate is double the rate of a single codec. For example, for a stereo variant of AA.AC.4, the applicable rate here is (2 x 96 kbit/s) = 192 kbit/s.
NOTE 2: The duplex bearer packet format shall be the larger of those required for uplink and downlink configurations. If not used for carrying audio data, the modulation scheme used for the duplex bearer B field may be configured to use π/2-DBPSK.
NOTE 3: Where possible, it is not recommended to use codec gross bit rates which result in a data rate higher than the original codec gross bit rate.

Annex C (informative): Rate-distortion curves for LC3plus

An overview of the absolute audio quality is provided in Figure C.1 based on the metric Objective Difference Grade (ODG) estimated using PEAQ [i.5]. The set of audio material consists of music items typically used for BS.1116 [i.4] tests. Figure C.1 should be used as guidance for selecting appropriate LC3plus configurations for certain use cases.

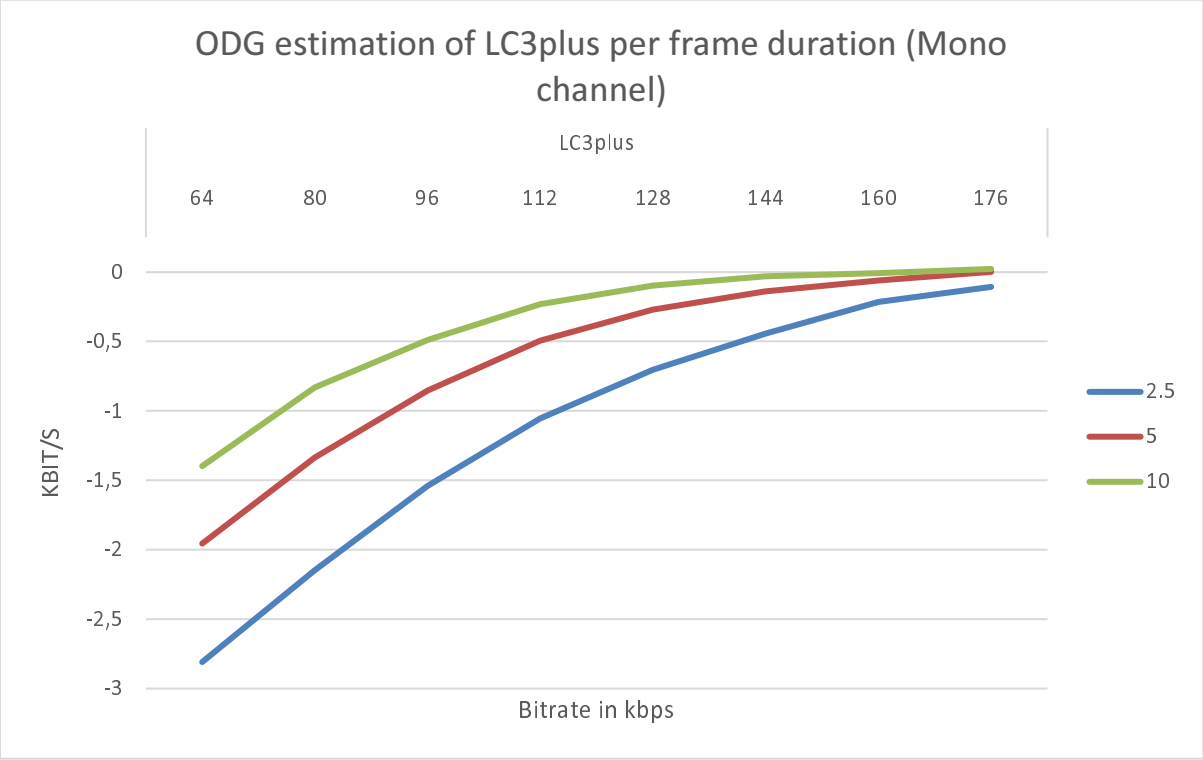


Figure C.1: Estimating the absolute audio quality of LC3plus depending on bit rate and frame duration (2,5, 5 and 10 ms)

The following can be concluded from Figure C.1:

- Compared to the LC3plus operation at 10 ms frame duration, the 5 ms frame duration requires ca. 20 % higher data rate to achieve the same level of quality.
- Compared to the LC3plus operation at 10 ms frame duration, the 2,5 ms frame duration requires ca. 60 % higher data rate to achieve the same level of quality.

Annex D (informative): Audio codec data to MAC bearer mapping examples

D.1 General

This annex gives some examples to show the order of audio codec data mapping to MAC bearers.

D.2 Single channel cases

D.2.1 Double simplex bearer, 10 ms codec frame

In the example of Figure D.1 the LBN value is not relevant. The data is just split at the half frame boundary.

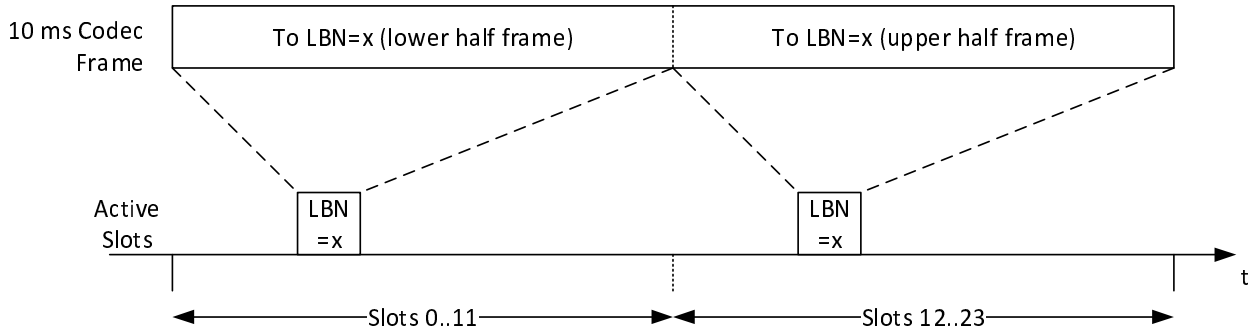


Figure D.1: Audio data mapping, 10 ms codec frame to double simplex bearer

D.2.2 Duplex plus double simplex bearer, 10 ms codec frame

The mapping in this case depends on where the transmission takes place. For an FT transmission the duplex bearer transmits in the lower half frame and the mapping would be as in Figure D.2. For a PT transmission the duplex bearer transmits in the upper half frame and the mapping would be as in Figure D.3. In both cases, the duplex bearer always gets the latter data in the half frame because it always has the maximum LBN value. This would also be the case if the duplex bearer transmission preceded the double simplex transmission (not shown in this example).

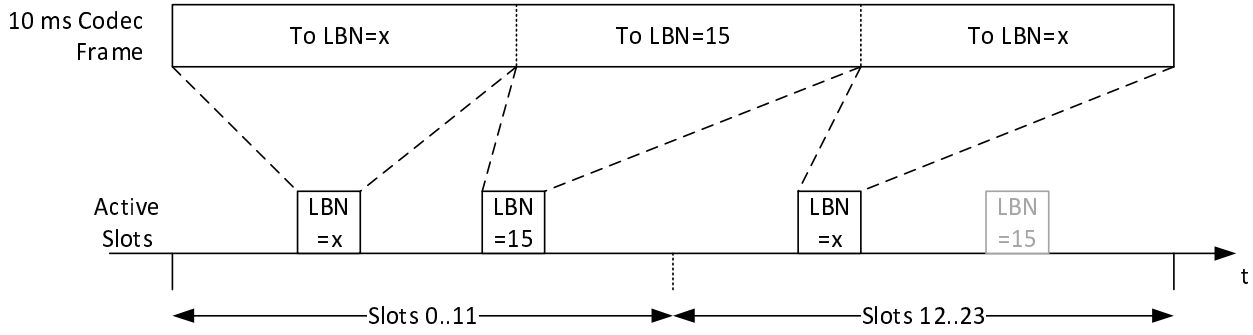


Figure D.2: Audio data mapping, 10 ms codec frame to duplex plus double simplex bearer, FT transmission

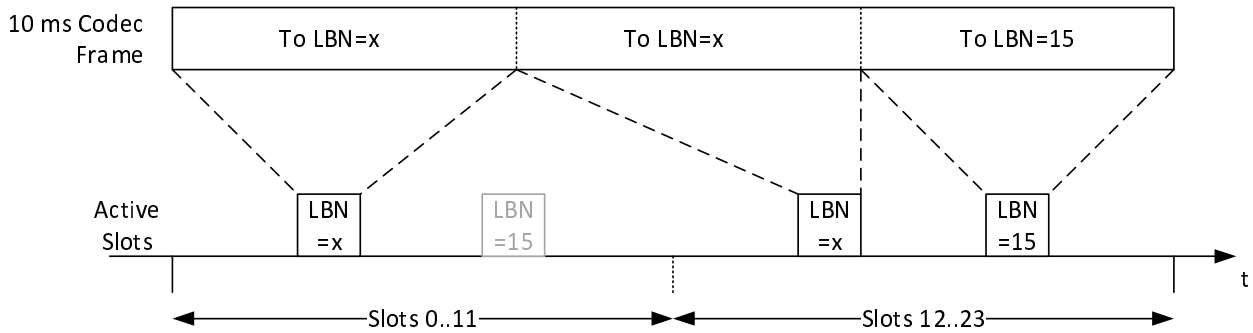


Figure D.3: Audio data mapping, 10 ms codec frame to duplex plus double simplex bearer, PT transmission

D.2.3 Two double simple bearers, 10 ms codec frame

In the example of Figure D.4 the codec data is split into four parts. The first two are sent in the lower half frame while the second two are sent in the upper half frame. Within each half frame, the LBN determines the order of data transmission. The first audio data is transmitted using the bearer with lowest LBN value. In this example it means that the audio data order on the air interface is not sequential. However, as both receiver and transmitter use the same ordering rules, the data would still be decoded in the correct order.

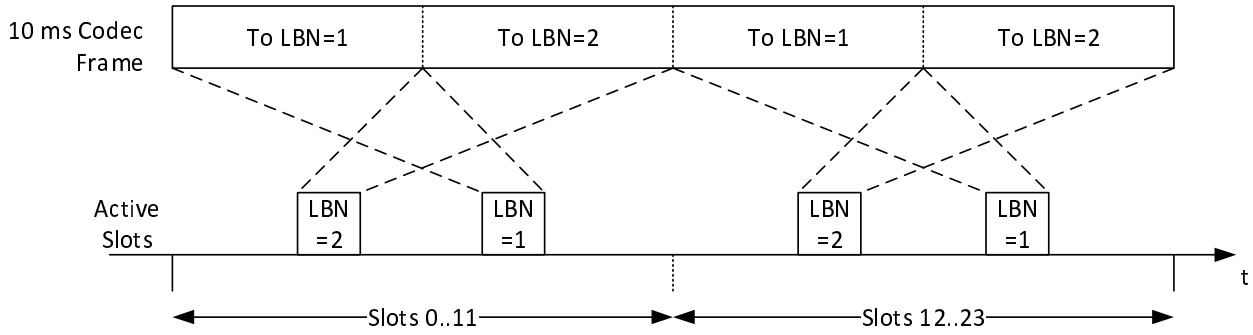


Figure D.4: Audio data mapping, 10 ms codec frame to two double simplex bearers

D.2.4 Two double simple bearers, 5 ms codec frame

In the example of Figure D.5 the codec is delivering a new frame for each DECT half frame. Ordering within the half frame is according to increasing LBN and in this example this is the same as the audio codec data order.

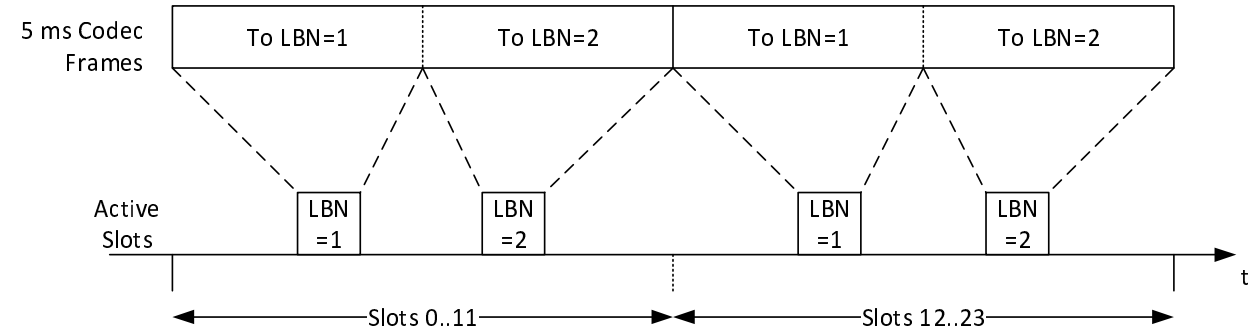


Figure D.5: Audio data mapping, 5 ms codec frame to two double simplex bearers

D.2.5 Two double simple bearers, 2,5 ms codec frame

In the example of Figure D.6 the codec is delivering a new frame for each quarter DECT frame. As there is only one transmission per codec frame, no specific ordering is required and the LBN order is irrelevant.

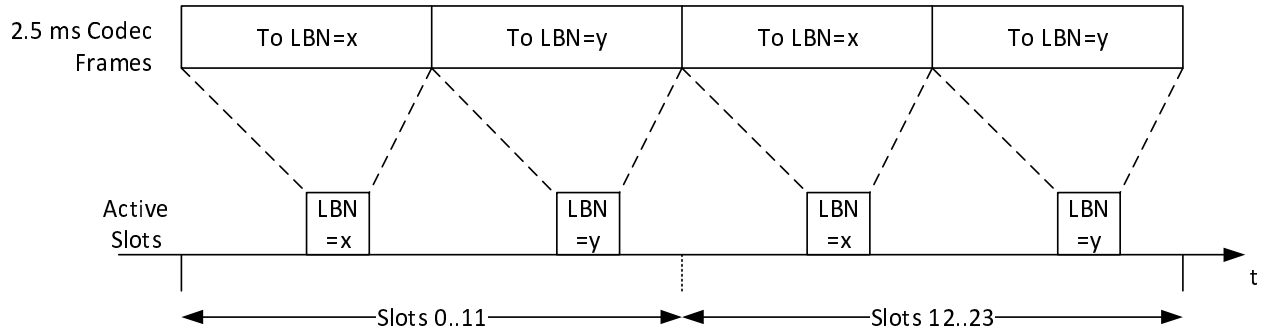


Figure D.6: Audio data mapping, 2,5 ms codec frame to two double simplex bearers

D.3 Multiple channel cases

D.3.1 Double simplex bearer, 10 ms codec frame, 2 channels

In the example of Figure D.7 two codec frames, e.g. a left and right channel, are sent together. The ordering of these codec frames within a DECT frame is done according to increasing 'Downlink audio channel' Value parameter as defined in clause A.2.1. Note that this case does not apply if a stereo codec is used, e.g. AA.AC.20, where the two channels are combined within the same LC3plus codec data.

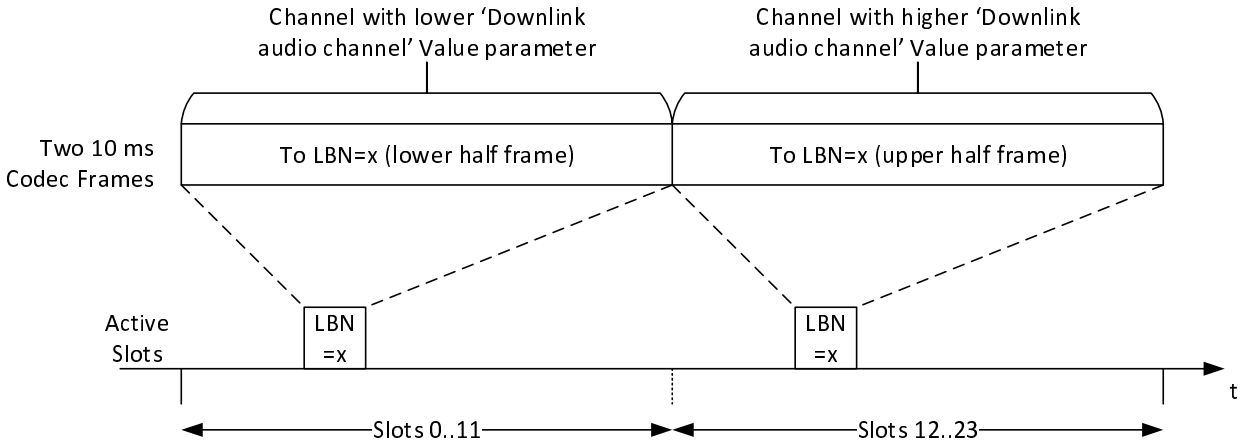


Figure D.7: Audio data mapping, 10 ms codec frame, 2 channels to double simplex bearer

D.3.2 Duplex plus double simplex bearer, 10 ms codec frame, 2 channels

As in the previous example, the two channels are first ordered according to the 'Downlink audio channel' Value parameter. Then, they are split into two half frames. The order within the half frame then depends on the LBN. In this example, as there are three parts to the transmission, a single packet includes parts of two channels. For an FT transmission the duplex bearer transmits in the lower half frame and the mapping would be as in Figure D.8. For a PT transmission the duplex bearer transmits in the upper half frame and the mapping would be as in Figure D.9.

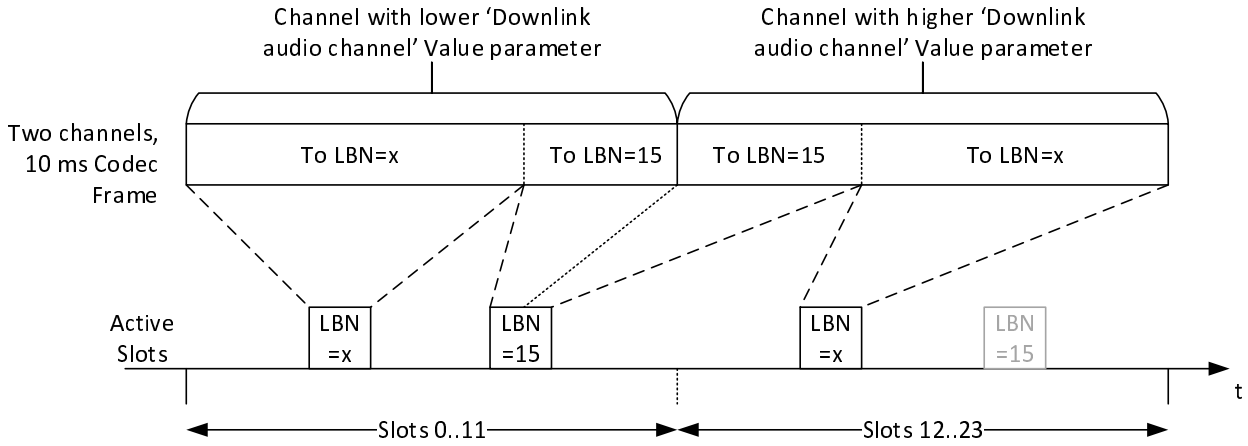


Figure D.8: Audio data mapping, 10 ms codec frame, 2 channels to duplex plus double simplex bearer, FT transmission

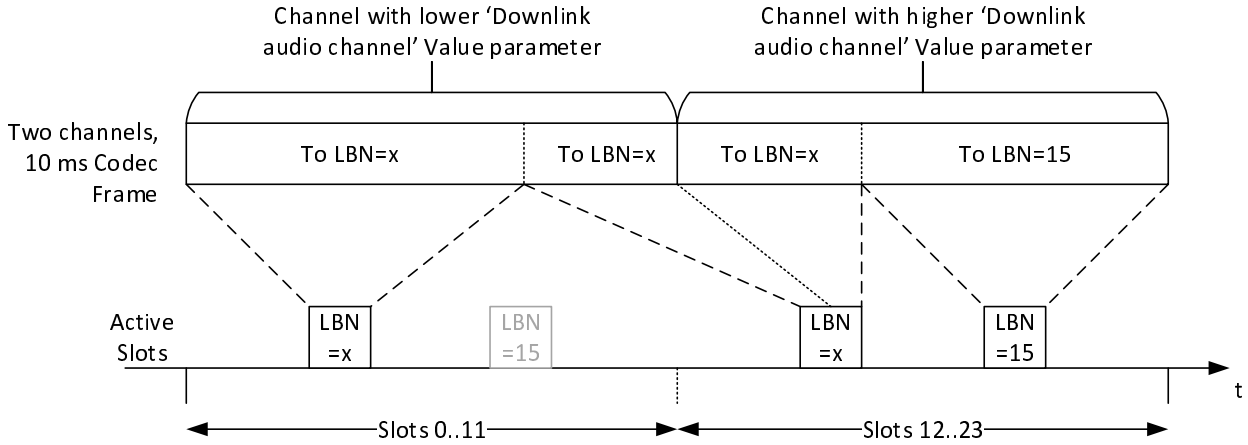


Figure D.9: Audio data mapping, 10 ms codec frame, two channels to duplex plus double simplex bearer, PT transmission

D.3.3 Two double simple bearers, 10 ms codec frame, 2 channels

In the example of Figure D.10, the ordering leads to one channel being transmitted entirely in the lower half frame and the other entirely in the upper half frame. Within each half frame, the data is stored according to increasing LBN, leading to a change of order on the air interface n this example.

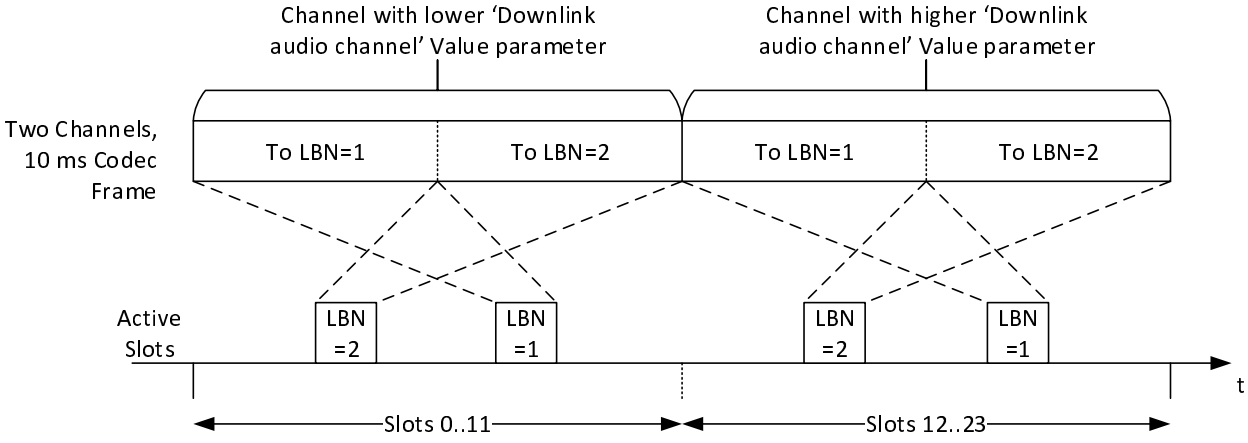


Figure D.10: Audio data mapping, 10 ms codec frame, two channels to two double simplex bearers

D.3.4 Two double simple bearers, 5 ms codec frame, 2 channels

In the example of Figure D.11 the ordered channels are mapped to the bearers within the half frame according to increasing LBN.

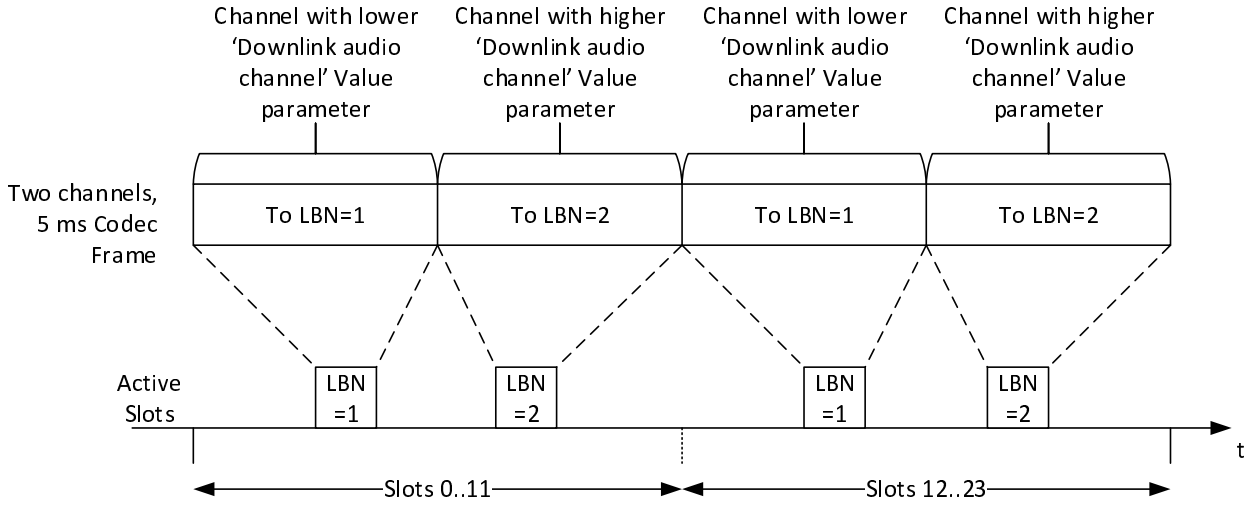


Figure D.11: Audio data mapping, 5 ms codec frame, two channels to two double simplex bearers

D.3.5 Two double simple bearers, 2,5 ms codec frame, 2 channels

In the example of Figure D.12 the ordered channels are directly mapped to the bearers within the quarter frame.

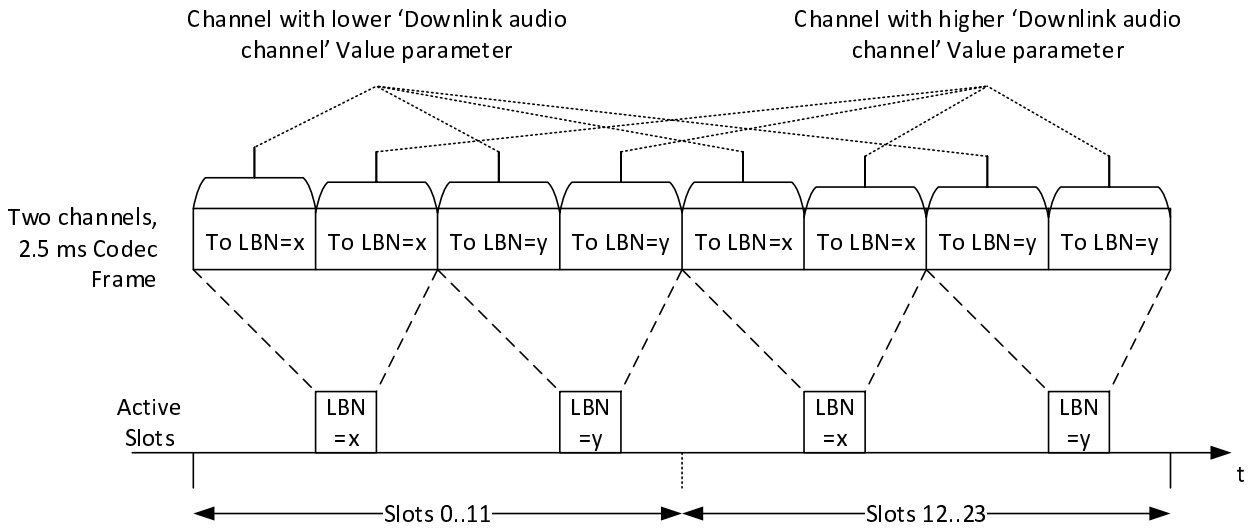


Figure D.12: Audio data mapping, 2,5 ms codec frame, two channels to two double simplex bearers

D.3.6 Two double simple bearers, 10 ms codec frame, 3 channels

In the example of Figure D.13, there are three channels so after ordering they do not map directly to bearers. Hence, some packets will contain data from more than one channel.

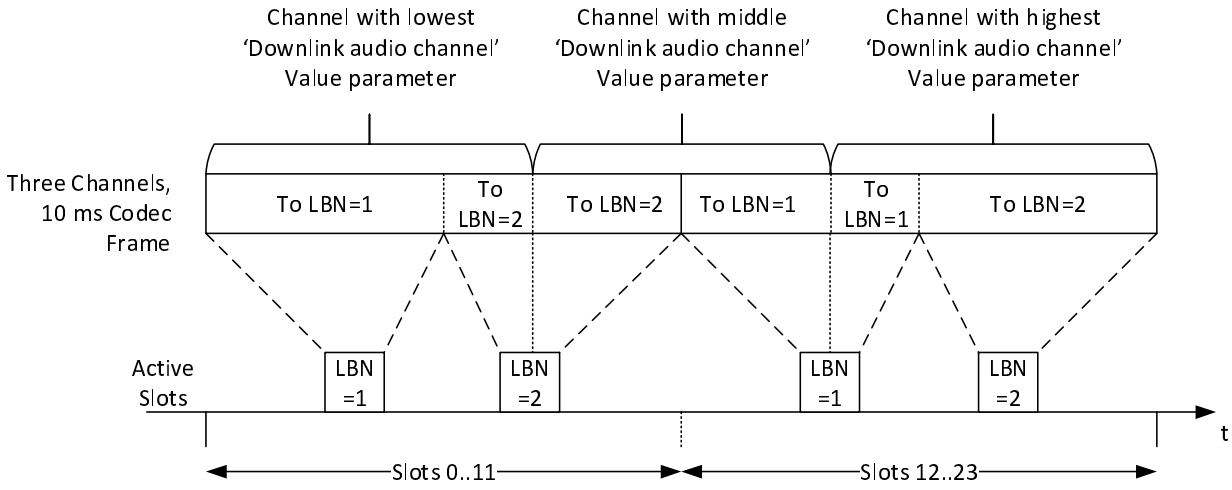


Figure D.13: Audio data mapping, 10 ms codec frame, three channels to two double simplex bearers

Annex E (informative): Maximum end-to-end delay definition

The maximum end-to-end delay is derived as shown in Figure E.1.

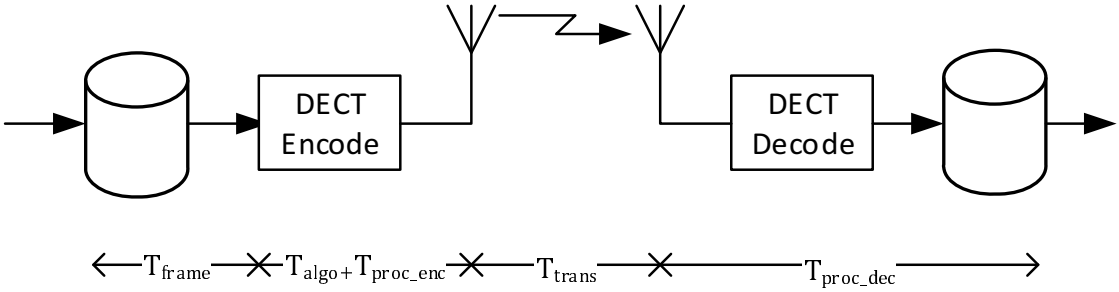


Figure E.1: End-to-end delay

The end-to-end delay is measured from the point where the first linear PCM sample of an encoder input frame enters the encoder, to the point where the same sample exits the decoder output interface. It consists of the following delay components:

T_{frame}: LC3plus codec frame duration (2,5 ms, 5 ms, or 10 ms)

T_{algo}: LC3plus algorithmic delay (lookahead), fixed at 2,5 ms

T_{proc_enc}: LC3plus encoder maximum processing time

T_{trans}: DECT transmission delay

T_{proc_dec}: LC3plus decoder maximum processing time

The maximum total delay $T_{end\text{-}to\text{-}end}$ is then:

$T_{end\text{-}to\text{-}end} = T_{frame} + (T_{algo} + T_{proc\_enc}) + T_{trans} + T_{proc\_dec}$

$T_{end\text{-}to\text{-}end} = T_{algo} + 4 \cdot T_{frame}$ (where $T_{trans} = T_{frame}$ and $T_{proc\_enc} = T_{proc\_dec} = T_{frame}$)

$T_{end\text{-}to\text{-}end} = 2{,}5 \text{ ms} + 4 \cdot T_{frame}$

History

Document history		
V1.1.1	January 2022	Publication