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Technical Report

Digital Enhanced Cordless Telecommunications (DECT); Implementing DECT Fixed Wireless Access (FWA) in an arbitrary spectrum allocation

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Foreword

This Technical Report (TR) has been produced by ETSI Project Digital Enhanced Cordless Telecommunications (DECT).

The present document provides a guide on how to implement and test DECT FWA (WLL) systems operating at frequencies outside the frequency bands described in TBR 6 [9].

1 Scope

The present document is a guide how to implement and test Digital Enhanced Cordless Telecommunications (DECT) FWA (WLL) systems operating at frequencies outside the frequency-bands described in TBR 6 [9]. The need to have this arises if DECT equipment is to be adapted to national frequency allocations that differ from the basic 1 880 MHz to 1 900 MHz DECT frequency band. This includes not only the radio frequency band around 1,9 GHz, as stated in [19], but also the radio frequency bands for Fixed Services within 2 200 MHz to 105 GHz and has special focus on applications in the 3,4 GHz to 3,7 GHz band.

The present document is thereby also a guide for approval of such DECT systems in the above mentioned countries.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

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

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

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

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

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

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

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

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

[9] TBR 6: "Digital Enhanced Cordless Telecommunications (DECT); General terminal attachment requirements".

[10] ETS 300 765-1: "Digital Enhanced Cordless Telecommunications (DECT); Radio in the Local Loop (RLL) Access Profile (RAP); Part 1: Basic telephony services".

[11] ETS 300 765-2: "Digital Enhanced Cordless Telecommunications (DECT); Radio in the Local Loop (RLL) Access Profile (RAP); Part 2: Advanced telephony services".

[12] ETR 308: "Digital Enhanced Cordless Telecommunications (DECT); Services, facilities and configurations for DECT in the local loop".

[13] ETR 310: "Digital Enhanced Cordless Telecommunications (DECT); Traffic capacity and spectrum requirements for multi-system and multi-service DECT applications co-existing in a common frequency band".

[14] ETR 178: "Digital Enhanced Cordless Telecommunications (DECT); A high level guide to the DECT standardization".

[15] TBR 22: "Attachment requirements for terminal equipment for Digital Enhanced Cordless Telecommunications (DECT) Generic Access Profile (GAP) applications".

[16] 91/287/EEC: "Council Directive of 3 June 1991 on the frequency band to be designated for the coordinated introduction of digital European cordless telecommunications (DECT) into the Community".

[17] 91/288/EEC: "Council Directive of 3 June 1991 on the frequency band to be designated for the coordinated introduction of digital European cordless telecommunications (DECT) into the Community".

[18] 90/388/EEC: "Commission Directive of 28 June 1990 on competition in the markets for telecommunications services".

[19] TR 101 159 (V1.2): "Digital Enhanced Cordless Telecommunications (DECT); Implementing DECT in an arbitrary spectrum allocation".

[20] EN 301 021: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Time Division Multiple Access (TDMA); Point-to-multipoint DRRS in Frequency Division Duplex (FDD) bands in the range 3 GHz to 11 GHz".

3 Definitions and abbreviations

3.1 Definitions

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

Fixed Part (DECT Fixed Part) (FP): A physical grouping that contains all of the elements in the DECT network between the local network and the DECT air interface.

Portable Part (DECT Portable Part) (PP): A physical grouping that contains all elements between the user and the DECT air interface. PP is a generic term that may describe one or several physical pieces.

3.2 Abbreviations

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

CTA	Cordless Terminal Adapter
CTR	Common Technical Regulation
DAS	DECT Access Site
DCS	Dynamic Channel Selection
DECT	Digital Enhanced Cordless Telecommunications
ERO	European Radio communications Office
EUT	Equipment Under Test
FDD	Frequency Division Duplex
FP	Fixed Part
FS	Fixed Service
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access

GAP	Generic Access Profile
GPS	Global Positioning System
ISDN	Integrated Services Digital Network
LOS	Line Of Sight
P-MP	Point-to-Multipoint
POTS	Plain Old Telephone Service
PP	Portable Part
PSTN	Public Switched Telephone Network
RAP	RLL Access Profile
RF	Radio Frequency
RFP	Radio Fixed Part
RLL	Radio in the Local Loop
TBR	Technical Basis for Regulation
TDD	Time Division Duplex
TE	Terminal Equipment
WLL	Wireless Local Loop
WRS	Wireless Relay Station

NOTE: FWA, RLL and WLL cover almost the same concept. FWA is the ITU term and has therefore been used wherever possible and suitable in this document. RLL is used in the DECT standards and most other ETSI references. WLL is used in new documents.

4 Introduction to DECT services and applications

DECT is a general radio access technology for wireless telecommunications. It is a high capacity digital technology, for a wide cell radii ranging from a few meters to several kilometres, depending on application and environment. It provides telephony quality voice services, and a broad range of data services, including Integrated Services Digital Network (ISDN) and packet data. It can be effectively implemented in a range from simple residential cordless telephones up to large systems providing a wide range of telecommunications services, including FWA (WLL).

The DECT instant or continuos dynamic channel selection, provides effective coexistence of uncoordinated installations of private and public systems on the common designated DECT frequency band, and avoids any need for traditional frequency planning. See ETR 310 [13] for further explanation.

Figure 1 gives a high level graphic overview of applications and features of DECT.

A list of all ETSI standards and ETSI technical reports for DECT are given in ETR 178 [14]. Annex A of ETR 178 [14] contains a list of the essential standards and reports.

The DECT standardization has developed a modern and complete standard within the area of cordless telecommunications.

The European wide allocation of the frequency band 1 880 MHz to 1 900 MHz, has been reinforced by the Council Directive 91/287/EEC [16]. Many other countries world-wide have also adopted spectrum allocation for DECT.

DECT carriers have been defined for the whole spectrum range 1 880 MHz to 1 937 MHz in the basic DECT standards EN 300 175, parts 1 to 8 [1] to [8] and TBR 6 [9]. This allows DECT services to be introduced in countries where the basic DECT frequencies 1 880 MHz to 1 900 MHz are not available.

For rapid introduction of DECT, Common Technical Regulations (CTRs) have been established for DECT relating to harmonized DECT standards, Technical Bases for Regulation (TBRs) and ENs. TBRs contain the technical requirements of a CTR. Approval to a CTR gives access to a single European market through a simplified legal procedure.

The Council Recommendation 91/288/EEC [17] recommends that the DECT standard should meet user requirements for residential, business, public pedestrian and radio in the local loop applications. The standard should also provide compatibility and multiple access rights to allow a single handset to access several types of systems and services, e.g. a residential system, a business system and one or more public systems. The public applications should be able to support full intersystem European roaming of DECT handsets. The DECT standard provides these features. Of special importance is RAP [10], [11] and the Generic Access Profile (GAP) and the related TBR 22 [15], which define common mobility and interoperability requirements for private and public DECT speech services. For a more comprehensive overview of the DECT standardization see ETR 178 [14].

The European Commission has elaborated an amendment of Directive 90/388/EEC [18] on competition in the market for telecommunications services. This Directive defines DECT as an important alternative to the wired Public Switched Telephone Network (PSTN)/ISDN network access. Furthermore any restriction on the combination of DECT with other mobile technologies are to be withdrawn.

The emerging deregulation of fixed services will also speed up fixed-mobile convergence in service offerings from operators. The different DECT interoperability profile standards are designed to facilitate provision of mixtures of fixed and mobile services through a single infrastructure.

Recognizing that DECT FWA in the frequency band 1 880 MHz to1 937 MHz has been already specified in standards EN 300 175 [8], TBR 6 [9], and TR 101 159 [19], the aim of the present document is to provide technical requirements that can be applied for DECT FWA approval in countries having FWA/PMP spectrum allocation in frequency bands for Fixed Services within 2 200 MHz to 105 GHz. The present document consists of references to the relevant ETSI DECT standards (TBR 6 [9]) and amendments required for application in a general spectrum allocation band.

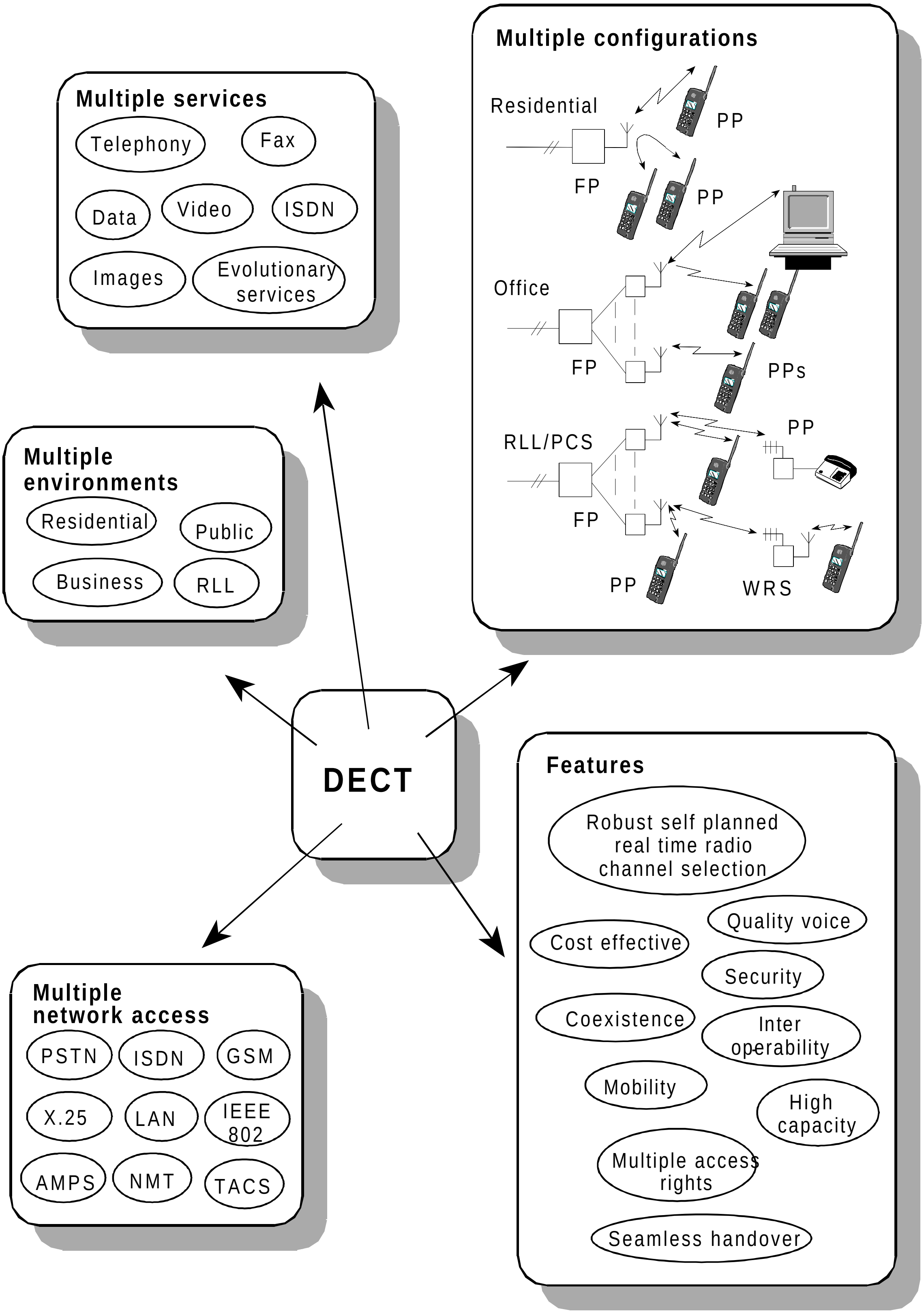
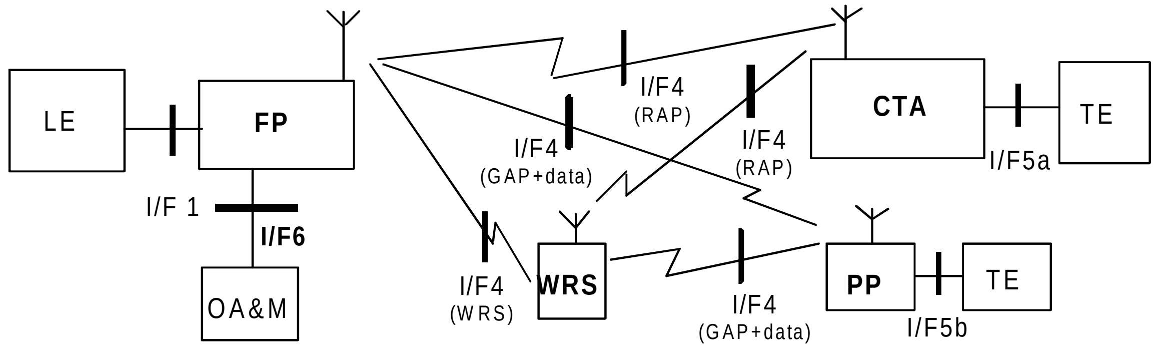


Figure 1: Overview of DECT applications and features

4.1 Services and spectrum efficiency of DECT Fixed Wireless Access (FWA) applications

The reference model for DECT Radio in the Local Loop (RLL) (FWA) systems is presented in figure 2.



TE:	Terminal Equipment.	I/F1:	Local exchange to FP Interface.
FP:	Fixed Part.	I/F4:	DECT air Interface.
WRS:	Wireless Relay Station.	I/F5a:	CTA to terminal Interface.
CTA:	Cordless Terminal Adapter.	I/F5b:	PP to terminal Interface.
PP:	Portable Part.	I/F6:	OA&M Interface.

Figure 2: DECT RLL (FWA) reference model

Depending on whether the end-user uses a CTA or a PP, the IF/4 interface can be either RLL Access Profile (RAP) or GAP-compliant. The services facilities and configurations (see ETR 308 [12]) focuses on RAP and describes the services available at IF/1 that are expected to be provided at IF/5a. The OA&M facilities defined in RAP are only the ones that require information to be transported over the RAP air interface. It should be noted that effective radio ranges achieved in the DECT FWA application using CTAs, will be considerably greater than when DECT is used in the mobile mode. The signal path is more consistent, it is often line-of- sight and base stations and CTAs may use high gain antennas, whose directionality also reduces multipath signals.

DECT provides high capacity FWA services with typically 40 to 150 E average traffic per DECT Access Site (DAS), in a 20 MHz allocation. The DAS may be highly sectored and are deployed in cellular pattern. 10 to 22 dBi antennas are used.

For low traffic density scenarios, the capacity is not an issue, but the range is. High gain directive antennas and WRSs are often applied in order to increase the range of the links. The service and facilities description for DECT FWA requires a range up to several kilometres for a DECT radio link. A Line Of Sight (LOS) range of about 5 km is feasible with 12 dBi antennas at each end and reasonable antenna heights. Thus adding a WRS, could double the range.

The DECT standard advance timing of the CTAs increases the range up to typically 17 km with maintained TDD guard space. LOS ranges of 10 to 15 km are thus to a CTA or to a pool of WRSs in a remote village. This however requires high antenna gain (larger antennas) and higher antenna installation.

The DECT ISDN service monitors the ISDN layer 3 information, and allocates DECT bearer resources only when and as required by the specific instant ISDN services. The ISDN speech service has the same spectrum efficiency as the POTS speech service, and transmitting a specific amount of data (e.g. a document) via ISDN is much more spectrum efficient and loads in average the radio devices less than via POTS (modem). For packet data, transmission over the Data Port is much more spectrum efficient and loads in average the radio devices much less than any modem service or ISDN service.

4.2 Up-banding of DECT

20 MHz as typically available around 1,9 GHz could be insufficient not to limit the future potential market for DECT FWA. It should therefore also be possible to have up-banded DECT systems applied to frequency bands for Fixed Services where more spectrum is available. Annex A shows examples of radio frequency bands for Fixed Services (e.g. FWA/PMP) within 2 200 MHz to 105 GHz.

The regulatory regimes around the world for these bands are traditionally tailored for Frequency Division Duplex (FDD) applications, but Time Division Duplex (TDD) applications are also used. Although most regulators are expected to allow both TDD and FDD systems, it is important to define both TDD and FDD applications of DECT to allow for a most flexible approach to different regulatory regimes. The present document defines up-banding with TDD and/or FDD. Annex B shows that TDD is the preferred application. If the spectrum allocated to an operator is a paired band, the natural solution is to apply TDD to each of the paired spectrum parts.

4.2.1 Partial up-banding

By partial up-banding is meant that the main traffic is carried in the 1,9 GHz band, but that an integrated PMP service is provided within the same system by up-banding (in the radio module) some of the RFP to CTA/WRS links. This can be used both to provide increased range to remote customers, and to off-load the 1,9 GHz spectrum for spectrum demanding office customers.

By adding a 2 GHz to, for example, 3,5 GHz, 10,4 GHz or 18 GHz simple (external) converter to the radios of part of the FP and CTAs and/or WRS, part of the DECT links may provide integrated P-MP services. These higher frequency links may provide very narrow antenna beams with small antennas. This can be used to provide a link to a pool of WRS in a remote village (increased range). It will also be very efficient for concentrated high traffic transfer to residential block houses and (medium sized and larger) offices, where not range, but capacity is the main requirement. For the latter service, the DECT LU8 service is very suitable. It provides a low-delay protected (by forward error correction) transparent 64 kbps service. Six such 64 kbps trunks are provided by a single radio CTA.

4.2.2 Full up-banding

It is also possible to deploy complete DECT FWA systems within a band for Fixed Services in 2 200 MHz to 105 GHz.

For instance, the 3,5 GHz band is an obvious candidate. Regulators in several countries are opening spectrum in this band for FWA (WLL) and PMP applications. Therefore regulators need a document on requirements on up-banded DECT FWA applications, to avoid that the regulatory regimes are written in a way that excludes DECT applications.

4.3 The DECT FWA standards

4.3.1 The DECT RAP standard, ETS 300 765

The DECT RAP standard, ETS 300 765, is divided into two parts:

a) Part 1 [10] "Basic telephony services", which includes Plain Old Telephone Service (POTS) services (unprotected 32 kbit/s ADPCM), a (protected) 64 kbit/s PCM bearer service and over-the-air OA&M services;

b) Part 2 [11] "Advanced telephony services" specifies 2B+D ISDN services (possible 30B + D in the future) and a data port for broadband (up to 552 kbit/s) packet data services.

4.3.2 The new DECT modulation options

The new DECT modulation options (on Public Enquiry spring 1998) will enable:

- 2 and 3 times higher user data rate on a standard time slot;
- improved sensitivity (-95 dBm to –97 dBm including coherent demodulation);
- uncritical Non Line Of Sight installation by coherent equalizer option;
- more than15 km ranges;
- meets ITU IMT-2000 service requirements for short range mobile systems and for fixed access;
- Wireless Local Loop (WLL) services and features competitive with those of third generation technologies.

DECT FWA is *spectrum efficient* and very suitable for POTS services, general *ISDN services* and *Internet* and other packet data services in residential and *office* applications. DECT offers a unique platform for future multimedia and fixed/mobile integration services.

5 Requirements

Requirements for FWA applications around 1,9 GHz are found in ETSI TR 101 159 [19], where DECT is specified for the whole frequency range 1 880 MHz to 1 938 MHz.

The present document is limited to up-banded DECT applications within 2 200 MHz to 105 GHz.

Clause 5 defines the minimum required functions and parameters for DECT equipment operating in the frequency band F_L to F_U. F_L defines the lower edge of the assigned frequency band and F_U defines the upper edge of the frequency band.

The frequency carriers to be used can be software controlled by the DECT base stations. They are indicated in a broadcast message to the portables. The DECT fixed part (base station) broadcast messages indicate the locally relevant carrier numbers to ensure that portables and FWA subscriber units do set up calls only within the locally allocated band F_L to F_U.

New or modified bands F_L to F_U can locally be defined when needed.

DECT equipment should be capable of working on all assigned carriers within the assigned band. This normally provides the most efficient use of the spectrum, but it is possible to limit specific applications, or a specific system, to part of the spectrum, if this is suitable due to local circumstances.

The technical requirements are contained in TBR 6 [9] together with the amendments which are defined in this clause.

5.1 Definition of access channels, bearers

The different types of DECT bearers are defined in the time domain. Each bearer is also related to a specific carrier frequency number c and to a specific RF-band number (see EN 300 175-3 [3], subclause 7.2.3.3.1).

5.1.1 Definition of Fc, Fd, Fcu and Fcd

The following carrier frequency definitions apply:

$Fc = Fg + c \times 1{,}728$ MHz,

where c = 10, 11, 12, ..., 32

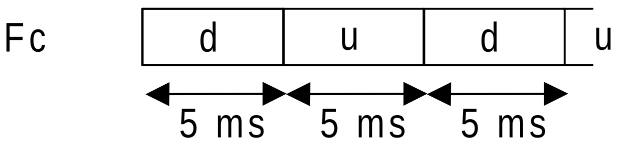
and Fg is a nominal DECT carrier frequency (see TBR 6 [9], subclause 7.1).

Each specific RF-band number shall have Fg defined, and also fd if FDD operation shall be applied.

Fcd = Fc and Fcu = Fc - fd. fd is the duplex separation, and can be a positive or a negative number, where this number may be multiple of 1,728 MHz.

5.1.2 TDD

For TDD, the carrier number c relates to a specific carrier frequency Fc used for both the up-link and down-link parts of a bearer.



d indicates down link and **u** indicates up link. Each d and u field is further divided into 12 time slots.

Figure 3: TDD frame structure

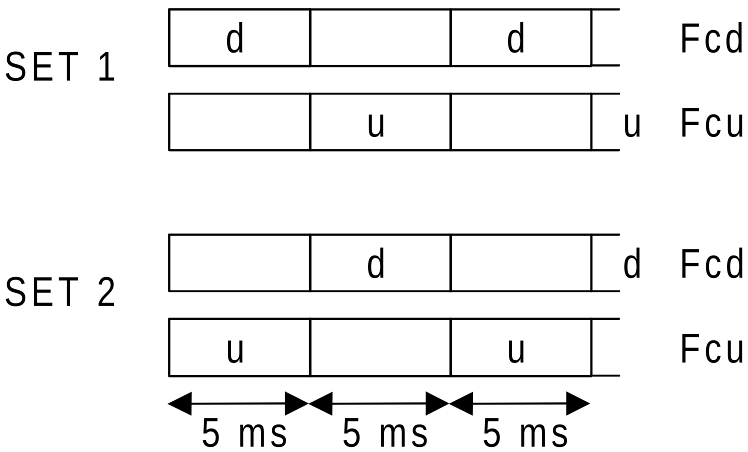
5.1.3 FDD

For FDD a different definition of the carrier number c is required.

Here the carrier number c relates to a specific pair of carrier frequencies Fcu and Fcd. All pairs have the same duplex frequency separation, fd, typically 50 MHz to 100 MHz or more. The up-links use carrier Fu and the down-links carrier Fd. The time relation between up-links and down-links of a bearer is the same as for the TDD case. Thus the same burst mode controllers are used for TDD and FDD. Thus for simplex and duplex bearers the down-links are defined for the first 5 ms of a frame, and the up-links for the last 5 ms, and the time separation between the two parts of a duplex bearer is 5 ms.

5.1.3.1 Time domain offset for low cost spectrum efficient FDD applications

Due to combined time and frequency separation for FDD duplex bearers, only half the time domain will be utilized for each carrier Fcu and Fcd. Thus half of the capacity is unused. The remaining half can be utilized by having two sets of base stations with 5 ms offset between the Global Positioning System (GPS) derived time references for the two sets. Thus every second base station site shall belong to the same set. This fully avoids the need for expensive duplex filters for simplex and duplex bearer services (symmetric) in base sites with several RFPs. In this case handover between base sites need special attention if required.



d indicates down-link and **u** indicates up-link. Blank field indicates unused area in the time domain.

Figure 4: The base stations of Set 2 have the time reference, offset by 5 ms relative to Set 1

5.2 Dynamic Channel Selection (DCS) algorithms

FDD operation does not require any changes to the DECT DCS algorithms. The DCS algorithms are identical for TDD and FDD. Only the bearer definitions have to be expanded according to subclause 5.1.

5.3 Antenna diversity algorithms

In stationary and low mobility TDD applications, the fading on up- and down-links are correlated. Therefore it is possible to use quality information from one direction to influence the antenna selection for the other direction. Such a correlation does not exist for FDD, whereby it is essential to strictly relate the selection procedure to each link separately. The DECT standard provides the required messages to implement this. This is not a regulatory issue.

5.4 Operator codes, carrier number and RF-band definitions

A globally unique Operators Code has to be obtained from ETSI (see EN 300 175-6 [6]).

Spectrum allocations in this band are normally assigned each to a single operator. Therefore there is no need to standardize the carrier and band number assignments for these bands.

Each system however needs to define the carrier numbers internally.

RF-band number 31 (see EN 300 175-3 [3], subclause 7.2.3.3.1) should be used for propitiatory system carrier frequency definitions. ETSI may standardize carrier and band numbers upon local request for interoperability by a regulator.

5.5 Carrier control

The frequency carriers to be used should be software controlled by the DECT base stations. They are indicated in a broadcast message to the portables. The DECT fixed part (base station) broadcast messages indicate the locally relevant carrier numbers to ensure that portables and FWA subscriber units do set up calls only within the locally allocated band F_L to F_U. New or modified bands F_L to F_U can locally be defined when needed.

DECT equipment should be capable of working on all assigned carriers within the assigned band. This normally provides the most efficient use of the spectrum, but it is possible to limit specific applications, or a specific system, to part of the spectrum, if this is suitable due to local circumstances.

5.6 General requirements related to TBR 6

A summary of the main technical requirements of TBR 6 [9] is given in table 1.

Table 1

Parameter	Characteristic/ Value	Reference
accuracy and stability of Radio Frequency (RF) carriers	RFP: ± 50 kHz PP: ± 100 kHz	7.2, 7.3, 7.4, 7.5
packet timing jitter	± 1 µs	8.3
reference timing accuracy of a Radio Fixed Part (RFP)	max 10 ppm	8.4
packet transmission accuracy of a PP	5 ms ± 2 µs	8.5
transmission burst	power-time template	9
transmitted power	250 mW to 4W (note)	10 (note)
RF carrier modulation	digital modulation	11
unwanted emissions due to modulation	emission mask	12.2
unwanted emissions due to transmitter transient	emission mask	12.3
unwanted emissions due to intermodulation	1 µW	12.4
spurious emissions when allocated a transmit channel	250 nW below 1 GHz 1 µW above 1 GHz	12.5
radio receiver sensitivity	-83 dBm at BER = 10^{-3}	13.1
radio receiver reference BER	10^{-5} at -73 dBm	13.2
radio receiver interference performance	BER < 10^{-3}	13.3
radio receiver blocking	See table 2	13.4
radio receiver intermodulation performance	BER < 10^{-3}	13.6
spurious emissions when the PP has no allocated transmit channel	2 nW	13.7
efficient use of the radio spectrum	channel handling	17.1, 17.2, 17.3
antennas with directivity	12 dBi to 30 dBi (note)	H.2 (note)
NOTE: Amended to align with requirements that are typical for Fixed Services within 2 200 MHz to 105 GHz. Subject to local regulations. See subclause 5.7.1.		

The test cases in table 1 shall be performed, where relevant, on the two supported carriers nearest to the band edges and on one carrier inside the band. The applicant shall declare the band edge limits F_L and F_U and the carriers supported. Where relevant, adjustment for the actual frequency is required for TBR 6 requirements expressed as field strength (see TBR 6 [9], subclause 6.1.1).

For the blocking requirements, table 2 shall be applied instead of the requirements given in table 12 of TBR 6 [9].

Table 2

Frequency (f)	Continuous wave interferer level For conducted measurements dBm
25 MHz ≤ f < F_L - 100 MHz	-23
F_L - 100 MHz ≤ f < F_L - 5 MHz	-33
$\|f - F_C\|$ > 6 MHz	-43
F_U + 5 MHz < f ≤ F_U + 100 MHz	-33
F_U + 100 MHz < f ≤ 105 GHz	-23

The Equipment Under Test (EUT) shall operate on the declared frequency allocation with the low band edge F_L MHz and the high band edge F_U MHz.

5.7 Flexible generic regulatory requirements for applications of Fixed Services within 2 200 MHz to 105 GHz

Frequency bands within the range 2 200 MHz to 105 GHz are today in many countries allocated to the Fixed Service (FS) and thereby opened to Point-to-Multipoint (P-MP) FWA applications. See annex A. The utilization in the bands are often subject to sharing on a co-primary basis with other services, such as the terrestrial FS and the Fixed Satellite Service (FSS) space to Earth.

The regulatory regimes around the world for these bands are traditionally tailored for Frequency Division Duplex (FDD) applications, but Time Division Duplex (TDD) applications are also used. Although most regulators are expected to allow both TDD and FDD systems, it is important to explicitly state this in the regulatory documents. Annex B shows that TDD is the preferred application for up-banded DECT. An applicable unpaired sub-band may be used, or if the spectrum assigned to an operator is a paired band, the natural solution is to apply TDD to each of the sub-bands.

5.7.1 The generic regulatory environment

The current standards and regulations in the frequency bands in the range 2 200 MHz to 105 GHz are vague in some areas and too detailed in others.

Modulation type, bit rates, transparency requirements and other interoperability related parameters do not belong to the generic regulatory requirements. Factors like packet data over the air and Dynamic Channel Selection, DCS, are much more important to the customer satisfaction, and to the efficient use of the spectrum, than strict limits on for instance type of modulation or receiver sensitivity, which appear in some proposals for regulatory regimes.

Too stringent or irrelevant regulatory requirements will limit the evolution of services and economics within the deployed spectrum.

Below are listed some important issues for FWA applications that should be reflected in the national regulatory regimes:

- *the possibility to use frequency blocks of appropriate size, instead of pre defined sub-bands, adapted to a certain bandwidth in a given frequency channel arrangement;*
- *the free choice of duplex regime, to users and operators (see annex B);*
- *basically limit generic requirements to output power (note 1), out of assigned band emissions (note 2), and antenna gain (note 3).*

NOTE 1: Output power may be up to typically 4 W.

NOTE 2: The up-banded DECT meets with large margin the out of assigned band emission limits due to spurious and modulation normally applied for fixed services in the range 2 200 MHz to 105 GHz. See annex B.

NOTE 3: Large freedom to apply antenna gain, typically up to 22 dBi and beyond.

Annex A (informative): Examples of DECT FWA applications in frequency band allocations for Fixed Services within 2 200 MHz to 105 GHz

A.1 Radio frequency bands for DECT Fixed Wireless Access (FWA) applications in the range 2 200 MHz to 105 GHz

Following the ongoing work within European Radio communications Office (ERO) and the intentions of the draft European table of frequency allocations and utilization, the following general tentative frequency bands, or parts thereof, may be considered, but not limited to, for future FWA applications.

Table A.1

2 200 to 2 483,5 MHz	
2 483,5 to 2 500 MHz	
2 500 to 2 520 MHz	
2 520 to 2 690 MHz	
3 400 to 4 200 MHz	see clause A.2
5 150 to 5 250 MHz	
5 250 to 5 300 MHz	
10,15 to 10,68 GHz	
17,10 to 17,70 GHz	
24,25 to 26,5 GHz	
27,6 to 29,5 GHz	
31,8 to 33,4 GHz	
37,0 to 39,5 GHz	
40,0 to 43,5 GHz	
47,2 to 50,2 GHz	
50,4 to 51,4 GHz	
59,0 to 63 GHz	
74,0 to 75,5 GHz	
84,0 to 86,0 GHz	

The regulatory regimes around the world for these bands are traditionally tailored for Frequency Division Duplex (FDD) applications, but Time Division Duplex (TDD) applications are also used. Although most regulators are expected to allow both TDD and FDD systems, up-banded DECT applications have been defined both for TDD and FDD operation to allow for a most flexible approach to different regulatory regimes. Annex B shows that TDD is the preferred application. If the spectrum allocated to an operator is a paired band, the natural solution is to apply TDD to each of the paired spectrum parts.

A.2 FWA in frequency bands in the range 3 400 MHz to 4 200 MHz

The frequency bands in the range 3 400 MHz to 4 200 MHz are today in many countries allocated to the Fixed Service (FS) and thereby opened to Point-to-Multipoint (P-MP) FWA applications. The utilization in the bands are often subject to sharing on a co-primary basis with other services, such as the terrestrial FS and the Fixed Satellite Service (FSS) space to Earth. Accordingly the frequency arrangement will be account of in detail.

Furthermore, the current standards and regulations in the frequency bands in the range 3 400 MHz to 4 200 MHz are vague in some areas and too detailed in others. Thus the comments on essential requirements for a generic national specification listed in subclause 5.7 above do really apply for this frequency band.

A.2.1 Block allocations arrangement

A.2.1.1 Block allocation arrangement 50 MHz in CITEL countries

In the CITEL countries P-MP systems may be operated in the ranges 3 400 MHz to 3 600 MHz. Where a frequency duplex allocation is required, the spacing between the lower edges of the paired sub-bands may be 50 MHz. The edges of each sub-band are specified as follows:

3 400 MHz to 3 600 MHz

Block A,C

Lower sub-band:	3 400 to 3 425	MHz
Upper sub-band:	3 450 to 3 475	MHz

Block B,D

Lower sub-band:	3 425 to 3 450	MHz
Upper sub-band:	3 475 to 3 500	MHz

Block E,G

Lower sub-band:	3 500 to 3 525	MHz
Upper sub-band:	3 550 to 3 575	MHz

Block F,H

Lower sub-band:	3 525 to 3 550	MHz
Upper sub-band:	3 575 to 3 600	MHz

A.2.1.2 Block allocation arrangement 100 MHz in CITEL countries

In the CITEL countries, P-MP systems may be operated in the ranges 3 400 MHz to 3 500 MHz and 3 500 MHz to 3 600 MHz. Where a frequency duplex allocation is required, the spacing between the lower edges of the paired sub-bands may be 100 MHz. The edges of each sub-band are specified as follows:

3 400 MHz to 3 600 MHz

Block A, E

Lower sub-band:	3 400 to 3 425	MHz
Upper sub-band:	3 500 to 3 525	MHz

Block B, F

Lower sub-band:	3 425 to 3 450	MHz
Upper sub-band:	3 525 to 3 550	MHz

Block C, G

Lower sub-band:	3 450 to 3 475	MHz
Upper sub-band:	3 550 to 3 575	MHz

Block D, H

Lower sub-band:	3 475 to 3 500	MHz
Upper sub-band:	3 575 to 3 600	MHz

A.2.1.3 Block allocation arrangements recommended in the CEPT countries

Where a block assignments are required, a block may be defined as follows:

Block allocation arrangement 50 MHz in CEPT countries

In the CEPT countries, P-MP systems may be operated in the ranges 3 410 MHz to 3 500 MHz and 3 500 MHz to 3 600 MHz. Where a frequency duplex allocation is required, the spacing between the lower edges of the paired sub-bands may be 50 MHz. The edges of each sub-band are defined as follows:

3 410 MHz to 3 500 MHz

Lower sub-band:	$0{,}25\,N + 3\,410$ to $0{,}25\,(N + k) + 3\,410$	MHz MHz
Upper sub-band:	$0{,}25\,(N + 200) + 3\,410$ to $0{,}25\,(N + k + 200) + 3\,410$	MHz MHz
$1 \le k \le 160;\ 0 \le N \le 159;\ k + N \le 160$		

3 500 MHz to 3 600 MHz

Lower sub-band:	$0{,}25\,N + 3\,410$ to $0{,}25\,(N + k) + 3\,410$	MHz MHz
Upper sub-band:	$0{,}25\,(N + 200) + 3\,410$ to $0{,}25\,(N + k + 200) + 3\,410$	MHz MHz
$1 \le k \le 200;\ 360 \le N \le 559;\ k + N - 360 \le 200$		

In the tables above, k defines the width of each sub-band and N defines the lower edge of each sub-band.

P-MP equipment may be used having a frequency duplex spacing other than exactly 50 MHz. However, such equipment may conform to the limits of the sub-band allocation as defined above.

Block allocation arrangement 100 MHz

Where a frequency duplex allocation is required, the spacing between the lower edges of each paired sub-band shall be 100 MHz. The edges of each sub-band are defined as follows:

Lower sub-band:	$0{,}25\,N + 3\,410$ to $0{,}25\,(N + k) + 3\,410$	MHz MHz
Upper sub-band:	$0{,}25\,(N + 400) + 3\,410$ to $0{,}25\,(N + k + 400) + 3\,410$	MHz MHz
$1 \le k \le 360;\ 0 \le N \le 359;\ k + N \le 360$		

In the table above, k defines the width of each sub-band and N defines the lower edge of each sub-band.

P-MP equipment may be used having a duplex spacing other than exactly 100 MHz. However, such equipment should conform to the limits of the block allocation as defined above.

Annex B (informative): Feasibility of DECT FWA TDD applications in frequency band allocations for Fixed Services within 2 200 MHz to 105 GHz

The regulatory regimes around the world for these bands are traditionally tailored for Frequency Division Duplex (FDD) applications, but Time Division Duplex (TDD) applications are also used. Although most regulators are expected to allow both TDD and FDD systems, up-banded DECT applications have been defined, in section 5 of the present document, both for TDD and FDD operation to allow for a most flexible approach to different regulatory regimes. Both TDD and FDD applications are feasible.

In this annex is explained why the TDD application is to be preferred. The FDD version has been introduced not to exclude up-banded DECT applications for the case a regulator for some reason, e.g. tradition or politics, is hesitant towards TDD.

The explanation why TDD is preferred for up-banded DECT is divided into two parts, the TDD system features and the coexistence with adjacent band FWA systems using FDD.

B.1 TDD system features compared to FDD

For duplex connections isolation is required between up-link and down-link transmissions. In TDD systems this is made in the time domain. In FDD systems this is made in the frequency domain.

Good time domain isolation is cheep and simple to implement. Good frequency domain isolation is more costly and more difficult to implement (filters and broader band antennas). There is an important cost argument in favour of TDD.

Synchronization in the time domain is important for large FWA/PMP TDD systems. GPS provides low-cost accurate synchronization where required (specified in the DECT standards).

Furthermore, due to the reciprocity theorem, TDD systems provide a basic high correlation between the up-and down-link radio paths of a duplex connection. This is not true for FDD systems. This high correlation for TDD systems apply for stationary and quasi-stationary applications as indoor systems, out-door pedestrian systems and of course FWA systems. (The important criteria is that the radio channel shall not change during the short time interval between up- and down-link transmission, 5 ms for DECT. Thus the correlation disappears as the movement speed of the subscriber unit increases.)

Thus for TDD it is only needed to measure on one link (up- or down-link) to get a reliable channel estimate also for the link in the other direction. With the same performance for base station antenna diversity and for the Dynamic Channel Selection procedures in general, this leads to less delay and less need for signalling between base and subscriber unit and to less filter costs compared to FDD. It may also be interesting to note that if an equalizer is required for some application, for TDD this can be implemented at the base station only by using pre-distortion techniques in the transmitters to compensate for the known down-link radio channel time dispersion. FDD systems need equalizers in each subscriber unit. Flexible asymmetric services are also easier to implement with TDD. Again there are important cost and system feature arguments favouring the use of TDD.

It is of course also possible to list advantages for FDD, but the conclusion is that TDD for many applications has advantages on cost and system features, and should not be excluded in regulatory regimes for Fixed Services (FWA/PMP).

Below is further shown that the coexistence performance between adjacent FDD and TDD systems and between two adjacent FDD systems, are very similar for FWA/PMP applications. Thus there is no reason to exclude TDD applications.

B.2 Coexistence of DECT FWA TDD applications in frequency band allocations for Fixed Services

In this section we are studying the potential interference between two FWA systems operating in adjacent frequency bands. See figure B.1.

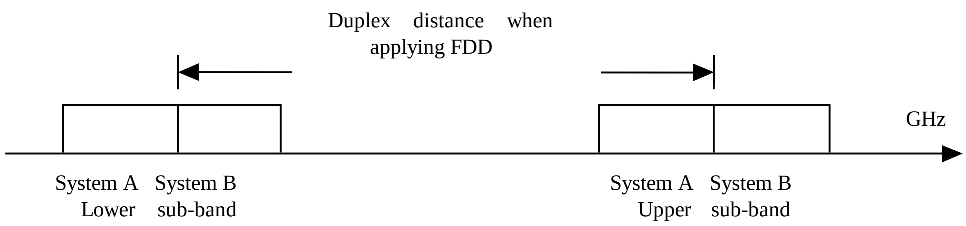


Figure B.1: Adjacent allocations for FWA systems A and B

It can be supposed that the important potential interference can only occur between the two lower (subscriber unit transmit band if FDD) or between the two higher sub-bands (base station transmit band if FDD).
Furthermore, for FWA or PMP systems, typically line of site, LOS, installations are used, and the transmit power and antenna gain are typically very similar for the subscriber units and the base stations.

B.2.1 The prime source to interference is the emissions due to modulation

It is important to understand that it is emissions due to modulation that is the prime source to interference in adjacent bands, typically up to 30 MHz outside the own system allocation. For instance spurious emission levels are not relevant and shall not be used. This is clearly shown by the figures B.2 and B.3.

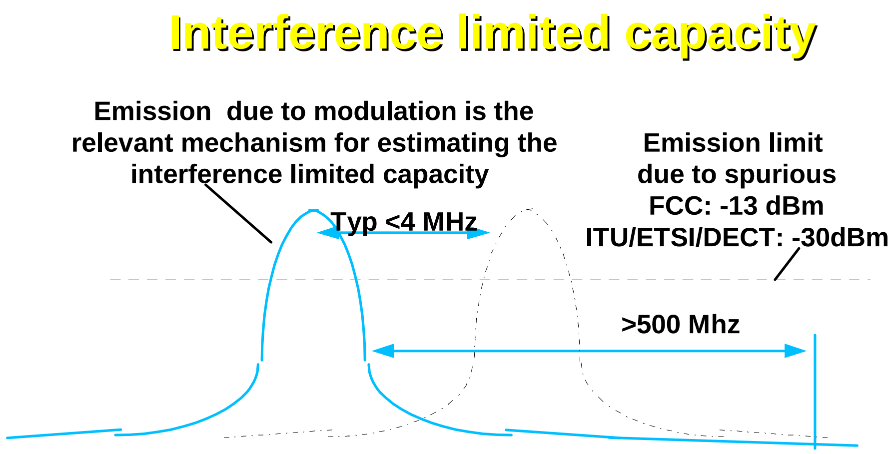


Figure B.2: Emissions due to modulation, and not spurious, are the prime source to interference between systems allocated in adjacent bands

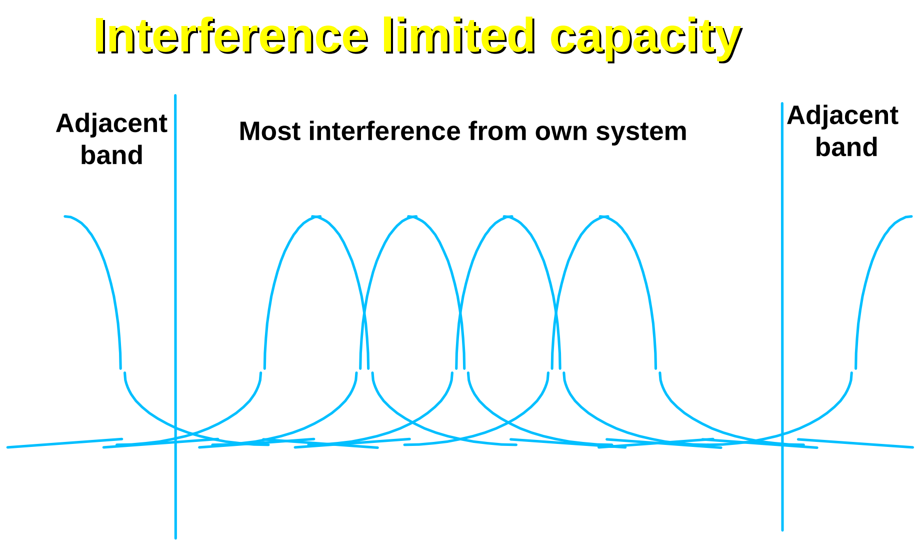


Figure B.3: Most interference to a system comes from the own system. Only a small part comes from the adjacent systems

Figure B.3 shows that most interference to a system comes from the own system, and that only a small part comes from the adjacent system. This interference comes from the emissions due to modulation.

Thus it is the level of the emissions due to modulation that needs to be analysed.

B.2.1.1 Requirements of emissions due to modulation

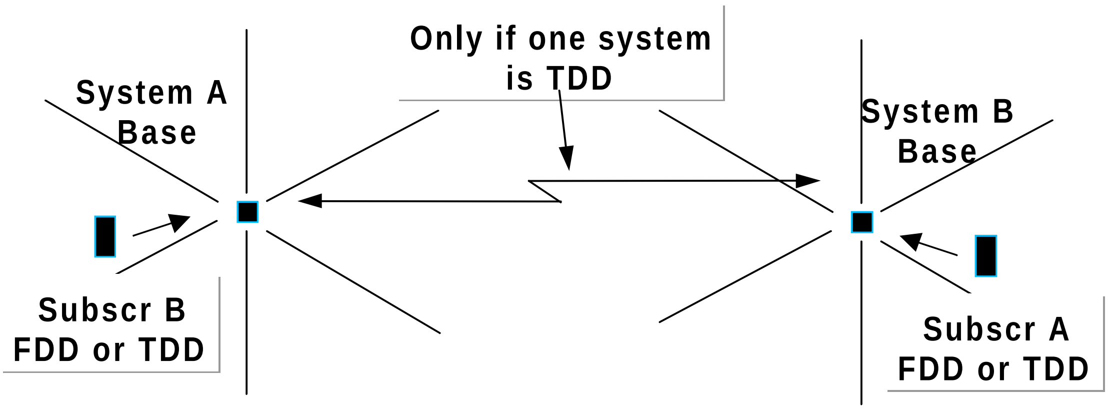
Standards under preparation and available standards, as e.g. EN 301 021 [20], has no more than 45 to 50 dB as the highest attenuation level in the modulation spectrum mask requirements.

DECT has as much as 70 dB as the highest attenuation level in the modulation spectrum mask requirements. Measurement on DECT equipment in production where also the effects of transients are included in the modulation mask measurements the level is typically reduced to about 68 dB.

The conclusion is that DECT TDD equipment will typically provide about 20 dB lower relative interference levels into adjacent sub-bands than typically required by available requirements for FWA/PMP in the range 3 GHz to 11 GHz.

B.2.2 Probability of interference (supposing similar power and similar out-of-sub-band attenuation for modulation spectrum mask for FDD and TDD systems)

Figure B.4 shows the potential *interference to base receivers* of two FWA or PMP systems A and B. Both systems are assumed to consist of several cells (base station sites). They are operating in adjacent bands (figure B.1), but are covering the same geographical area. If for instance system B uses TDD, it is supposed that TDD is used in each of the two sub-bands for system B. The systems are owned by different operators and may use different technologies and may have different business cases. Therefore it is very realistic to assume that cell sizes are not co-ordinated between the operators and that no co-ordination is made on having common base station sites. Therefore the scenario in figure B.4 is very realistic, where, supposing a certain minimum subscriber density, there will always be subscriber stations from one system very close (100 m) to each base station of the other system.



NOTE: The interference from subscriber stations from one system to base stations from the other system always occur between FDD systems as well as between a TDD and an FDD system. If one of the systems is a TDD system, then a potential interference between bases shall be added, as shown in figure B.4.

Figure B.4: Typical example where FDD subscriber to base may cause higher interference than TDD base to FDD base interference

It should be recalled that for FWA or PMP systems, typically line of site, LOS; installations are used, and that the transmit power and antenna gain are typically very similar for the subscriber units and the base stations. Therefor the EIRP from bases and subscriber stations will be very similar, and we can assume that interference both from relevant subscriber stations and from TDD bases of one system to the base stations of the other system is typically line of sight.

Four observations are made:

a) The distance between the closest bases is fixed, but the distance to the closest interfering subscriber station, having the same EIRP as a base, is normally much closer (100 m). Thus the highest interference levels will come from subscriber stations (FDD or TDD) and not from the TDD base. (Base station separation within an FWA or PMP network is typically 1 to 10 km.)

b) In the case where system B is a TDD system, the interference to the FDD base (A) from a TDD connection to the subscriber station (B) comes half the time from the subscriber station (B) and half the time from the base (B). In the case the System B is an FDD system, the interference to the FDD base (A) from an FDD connection to the subscriber station (B) comes all the time from the subscriber station (B).

c) Thus, in average, depending on how close the actual subscriber station (B) is to the base (A), the interference potential, or the probability of interference, will be about the same between two FDD systems as between an FDD and a TDD system, supposing similar attenuation of the modulation spectrum mask in the adjacent sub-bands.

d) As seen from the information above, it is not critical if TDD or FDD is used, but it is important to have as good as possible attenuation of the modulation spectrum mask in the adjacent sub-bands. Thus there is no reason to exclude TDD applications. Especially up-banded TDD DECT is very suitable, since DECT has a much better attenuation of the modulation spectrum mask in the adjacent sub-bands, than required by available standards.

NOTE: There are other issues that have influence on the interference probability. Generally the average interference probability between systems is low, around 1 %. But there can be local (stationary or temporary) probability peaks. It is for instance impossible to predict how close to a base (A) a subscriber stations (B) will be installed, or how much traffic this subscriber unit will carry. Therefore all modern professional FWA or PMP systems have (or should have) intra-cell handover in the frequency domain to provide escapes from local interference, and keep also the local interference probability on an acceptable level. If efficient intra-cell handover is not provided or as a complement to this, it is always possible to use the traditional procedure to locally plan not to use carriers close to the band edge in a certain sector of a base station with higher interference potential. These means for providing escapes from local interference of course apply to all potential interferers shown in figure B.4. Another factor that influence the probability of interference, is subscriber station power control. Analysis do however show that having power control or not only influence the probability by a factor of 2, due to the fact that all subscriber stations close to the cell edge (range limit) will anyhow act as having no power control. A factor of 2 corresponds to twice as much interference, or 3 dB in the attenuation level of the modulation spectrum mask. 3 dB is of limited importance compared to all other factors, DECT has anyhow a large margin in the attenuation level of the modulation spectrum mask (see B.2.1.1).

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