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Technical Report

Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Synchronous Digital Hierarchy (SDH); High capacity DRRS carrying SDH signals (1 x STM-1) in frequency bands with about 30 MHz channel spacing and using Co-Channel Dual Polarized (CCDP) operation

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ETSI Secretariat

Postal address

F-06921 Sophia Antipolis Cedex - FRANCE

Office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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c= fr; a=atlas; p=etsi; s=secretariat

Internet

secretariat@etsi.fr
http://www.etsi.fr

Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

1 Scope

1.1 General considerations

The present status of standardisation of "High capacity digital radio-relay systems carrying 1 x Synchronous Transport Module -1 (STM-1) signals and operating in frequency bands with about 30 MHz channel spacing and alternated arrangements" is given in ETS 300 234 [5]. Only channel arrangements with cross-polar adjacent channels are covered. The technical specifications given in ETS 300 234 [5] are based to a large extend on the data contained in Recommendation CEPT Recommendation T/L 04-04 [3] dealing with 140 Mbit/s systems operating in RF-channels about 30 MHz wide. However, the increase in transport bit rate from 140 to 155 Mbit/s and the new STM-1 signal format were taken into account. Typical system solutions are based on multilevel modulation schemes with about 64 or 128 modulation states and some kind of error correction coding. The spectrum efficiency achievable in the so called interleaved channel arrangement considered above is limited to about 5 bit/s/Hz.

The use of Co-Channel Dual Polarized (CCDP) systems offers the possibility of doubling the efficiency of use of those portions of the radio spectrum currently used with an interleaved channel plan. With the increasing liberalisation of telecommunications world-wide the amount of spectrum available to an operator and the traffic capacity that can be carried by a given bandwidth becomes increasingly important.

The main differences between conventional Adjacent Channel Dual Polarized (ACDP) systems and CCDP-systems are:

1) the lack of Cross Polar Discrimination (XPD) between adjacent channels operated co-polar and separated by about 30 MHz. Therefore it is necessary to introduce a tighter Tx-spectrum mask and a more narrow Rx-selectivity mask to achieve sufficient Net Filter Discrimination (NFD);

2) in addition to dispersive fading and thermal noise which are decisive for the performance of ACDP systems "internal" co-channel Cross Polar Interference (XPI) arises in CCDP systems. XPI may be suppressed by use of an electronic Cross Polarisation Interference Canceler (XPIC).

Practical experience and theoretical considerations ([8] to [10]) lead to the result that a CCDP system equipped with XPIC can be operated with only very small degradation of performance as compared to a conventional ACDP system.

A list of appropriate technical parameters will be given in following sections. These technical parameters are based as far as possible on ETS 300 234 [5]. The most important areas of modification as compared to ETS 300 234 [5] are the following:

1) spectral emission mask;

2) relative receiver selectivity;

3) co-channel and adjacent channel sensitivity;

4) relation between Bit Error Ratio (BER) and Rx-power;

5) system signature;

6) requirements on the XPIC;

7) requirements on the XPD-properties of the antennas.

1.2 Remarks on performance of CCPD-systems

1.2.1 XPIC Improvement Factor (XIF)

$(C/XPI)_{th}$ depends on XIF. XIF is defined by the ratio between the C/I-threshold (BER=10^{-3}) measured without XPIC to the C/XPI-threshold (same BER) measured with XPIC.

$XIF = (C/I)_{th} - (C/XPI)_{th}$

The figure which is relevant for planning considerations is the "Interference Fade Margin (IFM)" (see [9]) given by the equation:

$IFM = XPD_0 + Q + XIF - (C/I)_{th} = XPD_0 + Q - (C/XPI)_{th}$

with:

XPD_0: Cross polarization discrimination via hop and antennas under normal propagation conditions.

Q: Virtual XPD-improvement factor at F=0 dB.

XIF in case of flat fading (rain model):

$(C/XPI)_{th} \approx 5$ dB (compare [9]).

Assuming $(C/I)_{th}$ = 26 dB for 128 QAM and 30 dB for 256 QAM results in XIF = 21 dB for 128 QAM and 25 dB for 256 QAM.

XIF in case of dispersive fading (multipath model):

$(C/XPI)_{th} \approx 9$ dB (compare [9])

Assuming again the $(C/I)_{th}$ values cited above this results in XIF = 17 dB for 128 QAM and 21 dB for 256 QAM.

NOTE: While XIF depends on the modulation scheme, the interference fade margin IFM which is directly relevant for system planning depends on $(C/XPI)_{th}$. This latter parameter depends on the number of taps and the dynamic range of the tap coefficients of the XPIC and approximately not on the modulation scheme. The important consequence is that diffferent modulation schemes perform equally well if the same XPIC structure is assumed.

1.2.2 Antenna-XPD

The measured effective cros-polar discrimination XPD_0 should be at least the same as specified in ETS 300 234 [5], subclause 10.1.1 for ACDP systems. That is XPD > 28 dB on typical hops, i.e. 50 km at frequencies below 10 GHz, 25 km at 13/14 GHz and 18 km at 15 GHz.

NOTE: That critical hops may require higher values of XPD.

Modern XPD-improved antennas provide XPD > 35 dB within the 1 dB contour of the pattern. Experience shows (compare [9], [10]) that with these antennas typically $XPD_0 + Q = 50$ dB can be achieved. In connection with a (C/XPI)-threshold of 9 dB an interference fade margin of 41 dB results which is approximately not dependend on hop length. Obviously this IFM tends to be higher than typical thermal fade margins (normally below 40 dB for 50 km hop length and decreasing with increasing length). Thus we can expect that frequency reuse gives rise to only marginal decrease of system performance.

A direct comparison between ACDP systems and CCDP systems is possible and interesting. Obviously the parameter "NFD" (typical 15 dB in ACDP using 64QAM) which is relevant in ACDP systems is replaced by XIF (typical 21 dB in CCDP using 256QAM) which is of the same relevance for IFM (compare subclause 1.2 or [9], [10]) in a CCDP-system. Due to the threshold difference of about 6 dB between 64QAM and 256QAM the figures NFD = 15 dB and XIF = 21 dB are equivalent. Therefore the positive experience with BER-perfomance gained in ACDP-systems already in use make it almost sure that CCDP systems with the parameters specified here will perform equally well.

The same consideration applies to systems using 128QAM.

1.3 Characterisation and measurement of XPIC-performance

As said before, an XPIC may be used to combat depolarization effects caused by multipath propagation and/or rain attenuation. The XPIC behaviour is proposed to be described by three characteristic value:

1) the asymptotic (or residual) XPD which is the limiting value of C/I achieved at the output of the XPIC for large values of C/I at the receiver inputs;

2) the XPD improvement factor XIF in case of flat crosstalk and co-channel fading (rain model);

3) the XPD improvement factor XIF in case of dispersive co-channel fading and dispersive crosstalk (multipath model).

In case of multipath propagation the "flat model" is no longer applicable. An XIF value which is conservative with respect to planning calculations ca be defined and measured as follows:

In both trasmission channels (HH and VV) a notch depth is adjusted to find the depth of signature specified for the system and used to estimate outage due to dispersive fading. The notch frequencies are varied over the signal band and shifted parallel with the same frequency difference as compared to carrier frequency. The same notch depth, allocated at band center frequency, is assumed for crosstalk (HV and VH). From XPIC analisys this situation is known to be especially critical.

1.4 Systems characteristics

The present document describes characteristics for Digital Radio-Relay Systems (DRRS) with a channel capacity of 1 x STM-1 designed to operate in defined bands up to 15 GHz utilising co-channel dual polarised arrangements with about 30 MHz copolar channel spacing.

Compatibility requirements are limited to allowing operation of digital and analogue channels on the same route. This category also includes parameters providing compatibility with existing radio relay network.

The parameters therefore fall into two categories:

a) those that are required to provide compatibility between channels from different sources of equipment on the same route. This category also includes parameters providing compatibility with the existing radio-relay network;

b) parameters defining the transmission quality of the proposed systems.

Two possible baseband interfaces have to be considered:

- one for STM-1 signals (electrical and/or optical) in accordance with ITU-T Recommendations G.703 [1] and G.957 [2];

- one for 140 Mbit/s plesiochronous signals (only electrical), according to ITU-T Recommendations G.703 [1].

Two different solutions have been presented. To take into account the development of CCDP systems it was initially intended to develop a new standard covering CCDP-systems in frequency bands with about 30 MHz channel spacing. However, it proved soon that there were propagated two rather different system concepts.

System A, based on 128QAM modulation format.

System B, based on 256QAM modulation format.

Obviously both system concepts show relative merits and disadvantages as compared to the competing system. In the following both system variants are introduced briefly. The basic characteristics and potential problems relevant to each system are described.

1.4.1 System A

System A is based on 128 QAM modulation schemes. Basic characteristics are derived from the specifications for systems operating in the same bands with AP arrangements. The specified system allows the transmission of a 1xSTM-1 signal plus an overall redundancy from about 8% to about 17% (depending on the specific channel spacing) to include the possibility of using 128 QAM constellations in conjunction with different coding schemes (Block codes, TCM, MLC, etc.) and possibly additional overhead.

As a consequence, basic characteristics are well established.

CCDP operation imposes more stringent requirements, with respect to AP operation, on adjacent channel interference specification (i.e. NFD).

It is recognised that for correct operation, a NFD of at least 40 dB should be achieved.

For channel spacing of 30 MHz, 29,65 MHz and 29 MHz, this can be reached with moderate roll-off factors (e.g. 0,25). For the 28 MHz channel spacing, a roll-off factor of about 0,2 is required.

In any case, these roll-off factors can be obtained with pulse shaping filters of moderate complexity (e.g. 28 tap FIR filters).

Ideally, CCDP operation requires branching systems with spacing of filter centre frequencies on the same polarisation, down to 28 MHz.

This solution can be implemented even in the absence of a theoretical guard band between the adjacent spectra.

A specific solution, which was investigated in some detail, is described by the following technical parameters (7 GHz/28 MHz channel spacing):

- symbol frequency = 23,926 MHz;
- roll-off factor = 0,21;
- branching network type: band-pass filters and circulators;
    1) total in-band attenuation [Tx+Rx+Circulators (full band system)] ≤ 5,5 dB;
    2) total gain variation within Nyquist bandwidth ≤ 1,5 dB;
    3) total group delay variation within Nyquist bandwidth after IF equalization ≤ 20 ns;
- compensation of gain variation and residual group delay (Tx+Rx) with 28 tap baseband Tx FIR filter.

Alternately, a more common solution to this problem is to implement a split branching for the even and the odd channels, followed by a 3 dB loss hybrid. This leads to an overall practical loss of about 9 dB (6 dB of additional Tx+Rx loss with respect to AP systems), with consequent reduction of the available system gain.

This disadvantage can be overcome by increasing the Tx transmitted power when necessary.

In systems equipped with space diversity, part of the branching loss (3 dB) can be recovered by transmitting separately on the two antennas the even and the odd channels, respectively. In fact, in this case, the use of the 3 dB loss Tx hybrid can be avoided.

On the Rx side a preamplifier can be used to compensate for the hybrid loss, if necessary.

In presence of multipath fading, the actual values of NFD are modified, with respect to the values obtained in nominal propagation conditions. This is due to different frequency selective distortions on the main signal and on the corresponding adjacent channels. This happens, with different modalities, either when using one or two Tx antennas.

However it has been shown that the degradation due to this effect does not seem critical.

Relevant parameters concerning system A are reported in following subclauses.

1.4.2 System B

System B is based on 256 QAM modulation schemes. Consequently system B requires to operate with Rx power levels which are 2 or 3 dB higher than those of system A.

An advantage of system B is the possibility to connect co-polarised channels even with 28 MHz spacing to Tx and Rx antenna by use of an appropriate branching network.

A solution which was investigated in detail is described by the following technical features and parameters:

- roll-off factor r = 0,23;
- frequency gap between spectra = 3 MHz;
- branching network type:
    - contiguous multiplexer with five cavities;

  - in band attenuation 1,2 dB (13 GHz);
  - gain variation within Nyquist bandwidth (± 10,2 MHz) is 0,76 dB;
  - group delay variation within Nyquist bandwidth is 29 ns;
- compensation of gain and group delay of Tx and Rx branching networks is a 38 tap FIR filter in Tx baseband.

Advantages of branching:

a) no loss of RF power by use of 3 dB couplers on Tx and Rx side;

   and/or

b) no need to connect adjacent channels with different Tx antennas which might give rise to high differential fading;

   and/or

c) no need to use a Rx preamplifier with increased gain to compensate for coupler loss.

2 Informative references

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case 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] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".

[2] ITU-T Recommendation G.957: "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy".

[3] CEPT Recommendation T/L 04-04: "Harmonisation of 140 Mbit/s digital radio relay systems for operation below 10 GHz utilising 64 QAM at about 30 MHz spacing".

[4] ITU-R Recommendation F.635-3: "Radio-frequency channel arrangements based on a homogeneous pattern for radio-relay systems operating in the 4 GHz band".

[5] ETS 300 234: "Transmission and Multiplexing (TM); High capacity digital radio-relay systems carrying 1 x STM-1 signals and operating in frequency bands with about 30 MHz channel spacing and alternated arrangements".

[6] ITU-R Recommendation SM.329-7: "Spurious emissions".

[7] ITU-R Recommendation F.1191:"Bandwidths and unwanted emissions of digital radio-relay systems".

[8] 22nd European Microwave Conference, Finland (1992): "140 Mbit/s 32QAM XPIC Trial Results. (U.Casiraghi, L.Saini, P.Vitali)".

[9] SBMO International Microwave Conference Brazil (1993), Volume I, pp 167-172: "Performance of Co-channel dual Polarized Systems with Modern Antenna Design. Influence of Antenna-XPD and XPIC-Improvement Factor. (M.Glauner, M.Biester)".

[10] Fourth European Conference on Radio Relay Systems, Edinburgh (1993), pp 167-174: "The benefit of cross-polar co-channel operation in digital radio networks. (K. Vogel, K.-J. Friederichs)".

3 Abbreviations

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

ACDP	Adjacent Channel Dual Polarised
AP	Alternated Pattern
ATPC	Automatic Transmit Power Control
BB	Baseband
BER	Bit Error Ratio
CCDP	Co-Channel Dual Polarized
C/I	Carrier to Interference (ratio)
IF	Intermediate Frequency
LO	Local Oscillator
L6	Lower 6 (GHz frequency band)
NFD	Net Filter Discrimination
QAM	Quadrature Amplitude Modulation
ppm	parts per million
RF	Radio Frequency
RX I/P	Receiver Input level
SDH	Synchronous Digital Hierarchy
SOH	Section OverHead
STM-1	Synchronous Transport Module Level 1 (155,52 Mbit/s)
TMN	Telecommunication Managment Network
TWT	Travelling Wave Tube
XIF	Cross polarisation Improvement Factor
XPD	Cross Polar Discrimination
XPIC	Cross Polar Interference Canceller

4 Network and system considerations

See clause 4 of ETS 300 234 [5].

5 General characteristics

5.1 Frequency bands and channel arrangements

4 GHz

ITU-R Recommendation F.635-3 [4], with 30 MHz channel spacing. The centre gap between transmitter and receiver is 80 MHz.

For other bands see ETS 300 234 [5], subclause 5.1.

5.2 Modes of operation

The mode of operation is CCDP for all frequency bands up to 15 GHz.

In defining system characteristics for CCDP systems it should be taken into account that in the branching network there may be losses included which will reduce the overall system gain by 3 to 6 dB.

5.3 Types of installation

See ETS 300 234 [5], subclause 5.3.

5.3.1 Environmental conditions

See ETS 300 234 [5], subclause 5.3.1.

5.3.2 Electromagnetic compatibility conditions

See ETS 300 234 [5], subclause 5.3.2.

5.3.3 Mechanical dimensions

See ETS 300 234 [5], subclause 5.3.3.

5.3.4 Power supply

See ETS 300 234 [5], subclause 5.3.4.

5.4 TMN interface

See ETS 300 234 [5], subclause 5.4.

5.5 Block diagram

The reference points are shown in figure 1. These points are reference points only and not necessarily measurement points.

The receiver diversity path shown in the block diagram refers only to combining techniques.

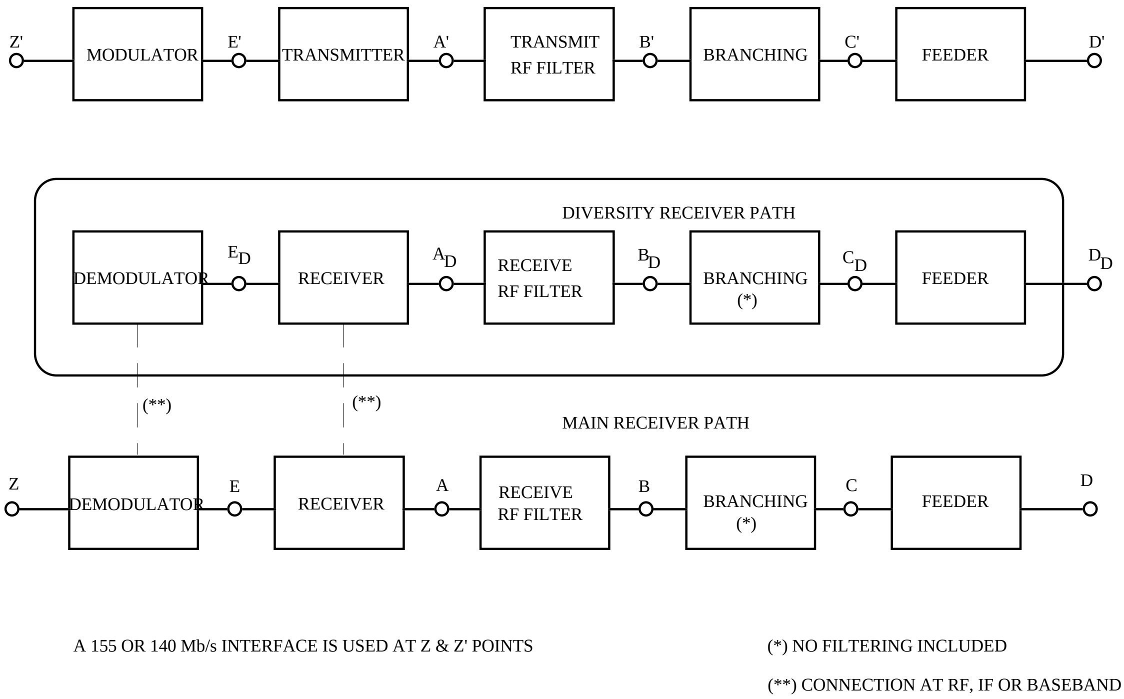

Figure 1: Block diagram

5.6 Intermediate frequency

If any, the Intermediate Frequency (IF) should be 70 MHz or 140 MHz.

5.7 Local oscillator arrangements

See subclause 5.7 of ETS 300 234 [5].

6 Transmitter characteristics

6.1 Output power

The value of output power (nominal and tolerance) referred to point B' should be in the ranges shown in the table 1 not including the Automatic Transmit Power Control (ATPC).

Table 1

Class A	+ 21 dBm	+ 26 dBm
Class B	+ 26 dBm	+ 31 dBm
Class C	+ 29 dBm	+ 34 dBm
Class D	+ 34 dBm	+ 38 dBm
NOTE: Equipments of different output power classes are not considered to require individual type approval. However this is subject to individual national agreement.		

For **indoor** installation, the tolerance value around the nominal value is ± 1 dB.

For **outdoor** installation, the tolerance value around the nominal value is ± 2 dB.

6.2 Automatic Transmit Power control (ATPC)

ATPC can be useful in many circumstances, especially:

- to improve analogue / digital compatibility in the case of antennas with poor XPD performance or in the case of high nominal output power for the DRRS;
- to reduce digital to digital distant interference between hops which re-use the same frequency;
- to improve compatibility with both digital and analogue systems at nodal stations;
- to reduce the effects of up-fading propagation conditions on the system.

ATPC is an optional feature which is aimed at driving the TX power amplifier output level from a proper minimum in case of normal propagation up to a maximum value which is defined by the relative class of output power and the complete fulfilment of all the specifications defined in the present document.

The ATPC range is the power interval from the nominal output power level to the lowest power amplifier output level (at point B') with ATPC. The minimum ATPC output power level should be specified, to facilitate analogue to digital compatibility. The value is under study. Use of ATPC with CCDP systems requires further investigation to ensure that co-channel and adjacent channel C/I ratios and residual BER performance characteristics remain acceptable under all conditions of the ATPC range.

6.3 RF spectrum masks

The three main factors considered in recommending a mask are as follows:

a) control of interference into analogue channels operating on the adjacent channel allocation;

b) control of interference into digital channels between systems of different manufacturers operating on the adjacent channel allocation on different polarisation of the same antenna;

c) different transmitter characteristics.

It is believed that any system conforming to a CCDP standard would also be compatible with analogue or digital channels on the adjacent channel allocation.

The spectrum masks proposed in figures A.1a and A.1b for all frequency bands considered is based on a level of compatibility required which is identical to that considered in CEPT Recommendation T/L 04-04 [3] and ETS 300 234 [5]. Channels of systems defined in the present document adjacent to systems according to the above referenced specifications should be used only cross polarised and without frequency-reuse.

The spectrum masks marked (a) in figures A.2a, A.2b and A.3a should be verified directly by measurement (referenced to point B'). Since it is not possible to directly measure attenuation values up to 105 dB and 110 dB respectively, values above 65 dB should be verified by adding a measured filter characteristic to the spectrum measured at reference point A'.

Masks should be measured with a modulating baseband signal given by a Pseudo Random Binary Sequence 2^{23} - 1 in the case of 140 Mbit/s signal or an STM-1 test signal, to be defined.

The masks are referenced to an output power equal to the nominal value.

RF emitted spectrum masks, for the various frequency bands and for the two systems, are shown in figures A.1a, A.1b, A.2a and A.2b.

As far as innermost channels are concerned, the shown masks are relevant only to cross-polar connected channels, typical for operation with two antennas. For single antenna operation, the required de-coupling of the even and odd channels summing hybrid and circulators and relevant spectrum masks are under study.

NOTE: Due to the more stringent requirements than that of the Alternated Pattern (AP) systems, the given masks are indicative. Actual systems should provide a NFD of adequate value (e.g. 40 dB and 43 dB respectively for system A and system B. Final values are still under study) that could be derived from direct computation or measurement on the actual emitted spectrum.

The spectrum analyser settings for application to the RF spectrum masks defined by figures are:

i) IF Bandwidth 100 kHz;

ii) Total Sweep Width 100 MHz;

iii) Total Scan Time 50 s;

iv) Video Filter Bandwidth 0,1 kHz.

6.4 Spectral lines at the symbol rate

The power level of spectral lines at a distance from the channel centre frequency equal to the symbol rate should be less than -37 dBm.

6.5 Spurious emissions

It is necessary to define spurious emissions from transmitters for two reasons:

a) to limit interference into systems operating wholly externally to the system (external emissions) which limits are referred by ITU-R Recommendations SM.329-7 [6] and F.1191 [7];

b) to limit local interference within the system where transmitters and receivers are directly connected via the filter and branching systems (internal emission).

This leads to two sets of spurious emission limits where the specific limits given for 'internal' interference are required to be no greater than the 'external' level limits at point B' for indoor systems and C' for outdoor systems, where a common TX/RX duplexer is used.

6.5.1 Spurious emissions-external

According to ITU-R Recommendation SM. 329-7 [6] and the application to fixed service provided by ITU-R Recommendation F.1191 [7] the external spurious emissions are defined as emissions at frequencies which are removed from the nominal carrier frequency more than ± 250% of the relevant Channel Spacing (CS).

The frequency range in which the spurious emission specifications apply is 9 kHz to 110 GHz or second harmonic if higher. However for practical measurements, spurious emissions up to the fifth harmonic of the fundamental frequency should be measured, provided that this does not exceed 26 GHz. For those systems with a fundamental frequency above 13 GHz, spurious emissions up to only the second harmonic should be measured.

NOTE: When waveguide is used between reference point A and C, the length of which is higher than twice the free space wavelength of cut-off frequency (Fc), the lower limit of measurement will be increased to 0,7 Fc and to 0,9 Fc when the length is higher than four times the same wavelength.

The levels of spurious emissions should be expressed in terms of the mean power, supplied by the transmitter to the antenna feeder line at the frequencies of the spurious emission concerned, within a defined reference bandwidth. Consequently "noise-like" emissions, are intended not to be exceeded in any elementary reference bandwidth.

The limit values measured at reference point C' are:

6.5.1.1 Within ± 250% of the relevant channel spacing

The emission includes in this range only fundamental and out of band emissions which should be in accordance with the spectrum mask and the limits required by subclauses 6.3 and 6.4.

6.5.1.2 Outside the band of ± 250% of the relevant channel spacing

NOTE: For the purpose of the spectrum analyser measurement, the start (or the stop) frequency at the exclusion bandwidth edges should be higher (or lower) than the frequency boundariy by an amount equal to BWr/2.

Emissions failing from 9 kHz to 21,2 GHz:

- -50 dBm in any 1 kHz reference bandwidth (from 9 kHz to 150 kHz);
- -50 dBm in any 10 kHz reference bandwidth (from 150 kHz to 30 MHz);
- -50 dBm in any 100 kHz reference bandwidth (from 30 MHz to 1 GHZ);
- -50 dBm in any 1 MHz reference bandwidth (from 1GHz to 21,2 GHz).

Emissions falling from 21,2 to 110 GHz:

- -30 dBm in any 1 MHz reference bandwidth.

6.5.2 Spurious emissions-internal

The levels of the spurious emissions from the transmitter, referenced to point B' are specified below.

Spurious emission relative to channel assigned frequency	Specification limit	Controlling factor
+ IF (local oscillator frequency)	< -60 dBm	Within half band digital to analogue
+ 2 x IF (unwanted sideband)	< -90 dBm	Other half band digital into digital
+ IF, + 3 x IF (unwanted sideband at 2nd IF harmonic)	< -90 dBm	Other half band digital into digital
The level of all other spurious signals should be:		
	< -90 dBm	If spurious signal frequency falls within receiver half band
	< -60 dBm	If spurious signal frequency falls within transmitter half band

For digital systems without branching network (i.e. with duplexer) the limit for the spurious signals mentioned above should be < - 70 dBm.

6.6 Radio frequency tolerance

Maximum RF frequency tolerance should not exceed ± 30 ppm for all frequency bands considered. This limit includes both long term and short term ageing effects.

6.7 Return loss at point C'

Minimum return loss should be not less than 26 dB at point C' for indoor systems.

7 Receiver characteristics

In specifying receiver characteristics, it is intended that, when meaningful and unless otherwise specified, the receiver under test of the, say horizontal polarisation, should operate interfered, at a level simulating an XPD of 28 dB (see subclause 11.2), by a similar system on the vertical polarisation of the same channel , in nominal propagation conditions.

7.1 Local oscillator frequency tolerance

Maximum local oscillator frequency tolerance (if applicable) should not exceed that value defined in subclause 7.6. This limit includes both long term and short term ageing effects.

7.2 Receiver image rejection

For the frequency bands below 10 GHz the receiver image rejection should be the same as that given in CEPT Recommendation T/L 04-04 [3] and ETS 300 234 [5], that is:

- > 120 dB for 4 GHz and 7 GHz bands;
- > 100 dB for L6 and 8 GHz bands;
- > 90 dB for 13 GHz and 15 GHz bands.

7.3 Spurious emissions

7.3.1 Spurious emissions-external

The frequency range in which the spurious emission specifications apply is 9 kHz to 110 GHz however for conformance test measurement may be, limited to the 2nd harmonic frequency.

NOTE: When waveguide is used between reference point A and C, the length of which is higher than twice the free space wavelength of cut-off frequency (Fc), the lower limit of measurement will be increased to 0.7 Fc and to 0.9 Fc when the length is higher than four times the same wavelength.

Spurious emissions shall not exceed the follwing levels at reference point C:

Emissions faling from 9 kHz to 21,2 GHZ:

- -50 dBm in any 1 kHz band (from 9 kHz to 150 kHz);
- -50 dBm in any 10 kHz band (from 150 kHz to 30 MHz);
- -50 dBm in any 100 kHz band (from 30 MHz to 1 GHz);
- -50 dBm in any 1 MHz band (from 1 GHz to 21,2 GHz);

Emssions falling from 21,2 to 110 GHz:

- -30 dBm in any 1 MHz band.

7.3.2 Spurious emissions-internal

For spurious emissions which fall at the local oscillator frequency provisional limits of <-125 dBm for the 7 GHz band and <-110 dBm for all other bands should apply (referenced to point B).

The required level will be the total average level integrated over the bandwidth of emission under consideration.

7.4 Input level range

The lower limit for the receiver input level should be given by the threshold level for BER 10^{-3}. The upper limit for the receiver input level, where a BER of 10^{-3} may not be exceeded should be -17 dBm, a BER of 10^{-10} may be exceeded for levels greater than -21 dBm. When ATPC is used the maximum input level for BER < 10^{-10} may be relaxed to -30 dBm.

These limits should apply without interference and are referenced to point B.

7.5 Overall receiver selectivity

In order to control transmit/receive interference between the innermost channels of the band, it is necessary to define an additional spectrum mask for the inner edge of the receiver operating in this part of the band.

Figures A.3a and A.3b propose masks for the overall relative receiver sensitivity for the inner edges of the innermost L6 GHz (system A) and for frequency bands with 28 MHz channel spacing and 56 MHz centre gap (system B) respectively. The receiver selectivity may be evaluated by calculating the effect of the receiver filter response on the received signal.

The final requirements are under study.

7.6 Return loss at point C

Minimum return loss measured at point C should be better than 26 dB for indoor systems.

8 System characteristics without diversity

8.1 Equipment background BER

Equipment background BER is measured under simulated conditions over an artificial hop with an adjacent channel interference of C/I= -3 dB, and with a signal level at point B which is between 15 dB and 40 dB above the lower level which gives BER=10^{-3}. In a measurement period of 24 hours the number of bit errors should be less than 10 (BER≤ 10^{-12}).

8.2 BER as a function of receive input level (dBm)

The reference point for the definition of the BER curve as a function of receiver input level is point B.

In table 2 the BER value given may be exceeded at signal levels lower than those specified. (For this present document these levels can therefore be considered as the minimum acceptable performance standard or, the maximum receiver threshold levels).

Table 2

Frequency	<10 GHz	7 GHz	13 GHz	13 GHz	14/15 GHz	14/15 GHz
BER	System A	System B	System A	System B	SystemA	System B
10^{-3}	-71 dBm	-68 dBm	-70 dBm	-67 dBm	-69,5 dBm	-66,5 dBm
10^{-6}	-67 dBm	-64 dBm	-66 dBm	-63 dBm	-65,5 dBm	-62,5 dBm
10^{-10}	-63 dBm	-60 dBm	-62 dBm	-59 dBm	-61,5 dBm	-58,5 dBm

NOTE: The limits for System A are required when the connection to the same antenna port of even and odd channels, spaced about 30 MHz on the same polarisation, is made with a 3 dB hybrid coupler placed at reference point C. When alternatively, for the above purpose, narrow-band branching filters solution is used, these limits may be 1,5 dB higher.

8.3 Interference sensitivity

8.3.1 Co-channel "external" interference sensitivity

The following specifications applies to "external" interferers from similar systems but from a different route (nodal interferer).

For the frequency bands given under subclause 5.1. the limits of the co-channel interference sensitivity for the systems A and B should be as given in figures A.4a and A.4b respectively.

8.3.2 Adjacent channel interference sensitivity

For the frequency bands given under subclause 5.1 the limits of the adjacent-channel interference sensitivity for the systems A and B should be as given in figures A.5a and A.5b respectively.

8.4 Distortion sensitivity

For a delay of 6,3 ns and a BER of 10^{-3} the width of the signature should not exceed ± 17 MHz for system A and ± 13 MHz for system B relative the channel assigned frequency and the depth should not be less than 14 dB for both types of systems.

For a delay of 6,3 ns and a BER of 10^{-6} the width of the signature should not exceed ± 20 MHz for system A and ± 15 MHz for system B relative the channel assigned frequency and the depth should not be less than 11 dB for both types of systems.

These limits are valid for both minimum and non-minimum phase cases.

The limits specified should also be verified by the loss-of-synchronisation and re-acquisition signatures.

The sensitivity to dynamic fading is under study.

9 System characteristics with diversity

Space, angle and frequency diversity techniques are applicable. In this clause only combining techniques are considered.

9.1 Differential delay compensation

It should be possible to compensate for differential absolute delays due to antennas, feeders and cable connections on the two diversity paths. The limit is at least 75 ns of differential absolute delay.

9.2 BER performance

When both receiver inputs (main and diversity, point B and B_D) are fed with the same signal level at an arbitrary phase difference, input level limits for specified BER values should be:

- 2,5 dB below for IF or baseband combining systems;
- 1,5 dB below for RF combining systems;
- those given under subclause 8.2 for the case without diversity.

9.3 Interference sensitivity

Under study.

9.4 Distortion sensitivity

Under study.

10 Branching, feeder and antenna requirements

The parameters and values specified in subclauses 10.2 to 10.5 are essential prerequisites for the system specification given in the present document.

10.1 Antenna radiation pattern envelopes

There are differing frequency management methods, differing traffic requirements and densities across European countries therefore the selection of a particular standard will be the responsibility of the administration in conjunction with the user and other relevant parties.

Further study is required on this subject.

10.2 Cross-Polar Discrimination (XPD)

The value of XPD specified should be the same as in the AP arrangements in the same frequency bands, that is XPD ≥ 28 dB, allowing the use of the same antennas.

It must be noted that some critical hops could require greater values of XPD.

Further study is required on this subject.

10.3 Intermodulation products

Each intermodulation product caused by different transmitters linked to the same antenna should be less than -110 dBm referenced to point C with an output power relevant to the Classes A to D (table 1) per transmitter.

10.4 Interport isolation

Not less than 40 dB.

10.5 Return loss

Not less than 24 dB at the feeder flange (points C, C') with antenna connected.

10.6 Antenna / equipment / feeder flanges

When wave guides are required IEC PDR type flanges (rectangular) should be used as below:

Frequency Band [GHz]	4	L6	7	8	13	14	15
PDR Flange Type	40	70	70/84	84	120	140	14

11 Cross polar interference sensitivity

This clause covers specific aspects of the performance of the system in presence of cross polarisation interference not covered in the previous clauses.

11.1 Co-channel "internal" interference sensitivity in flat fading conditions

For frequency bands given under subclause 5.1, the limits of the co-channel "internal" interference sensitivity for systems A and B should be as in figures A.6a and A.6b respectively. Values of XIF used for curves in these figures have been derived from subclause 1.3.

11.2 Co-channel "internal" interference sensitivity in dispersive fading conditions

The subject is still under study. A preliminary procedure for evaluating XPIC performance in this conditions is given in subclause 1.3.

Annex A: Figures

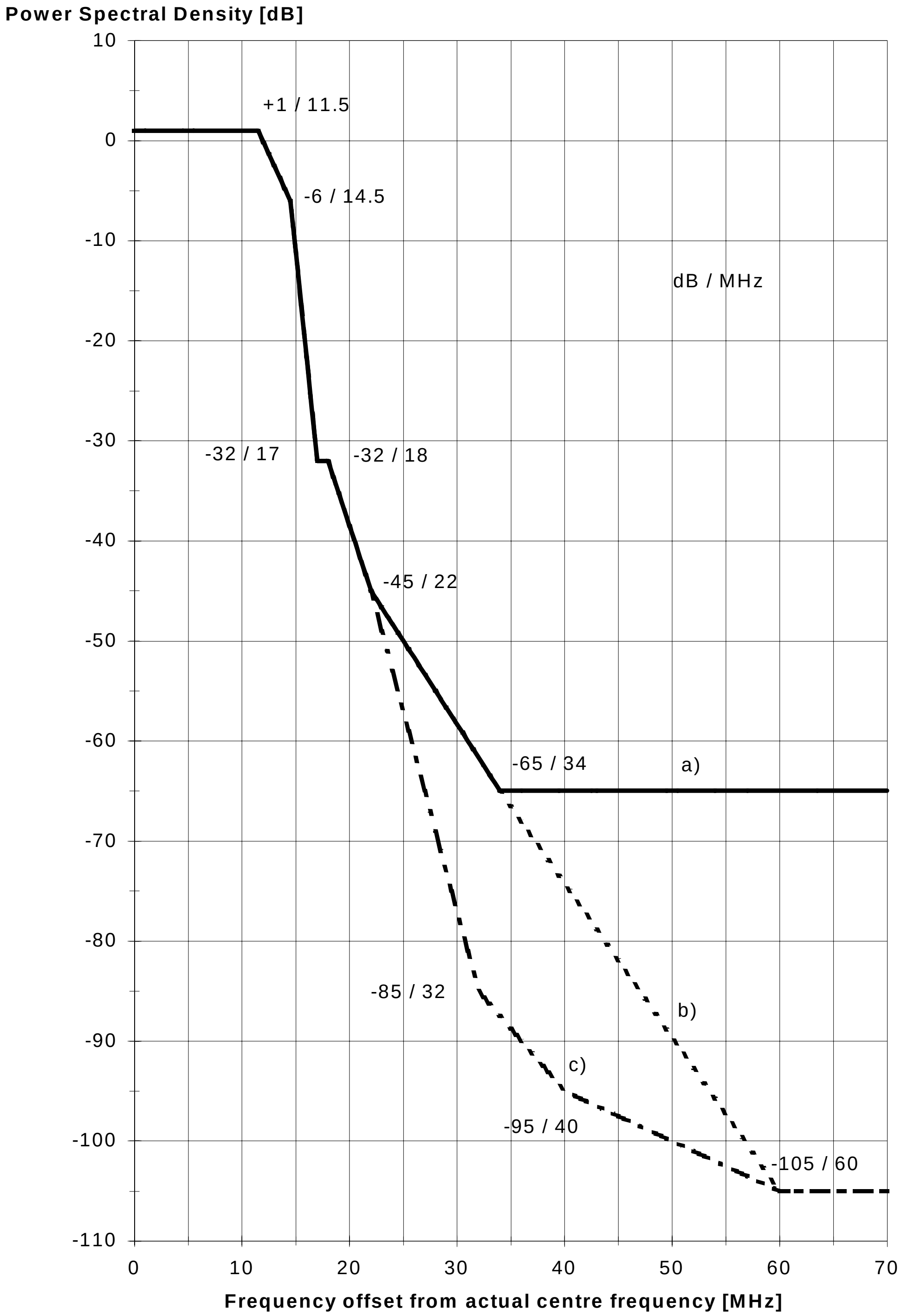

Figure A.1a: Spectrum masks for normal channels (b) for frequency bands with 29, 29,65 and 30 MHz spacing, and inner edges of innermost channels (c) for L6 GHz band. System A

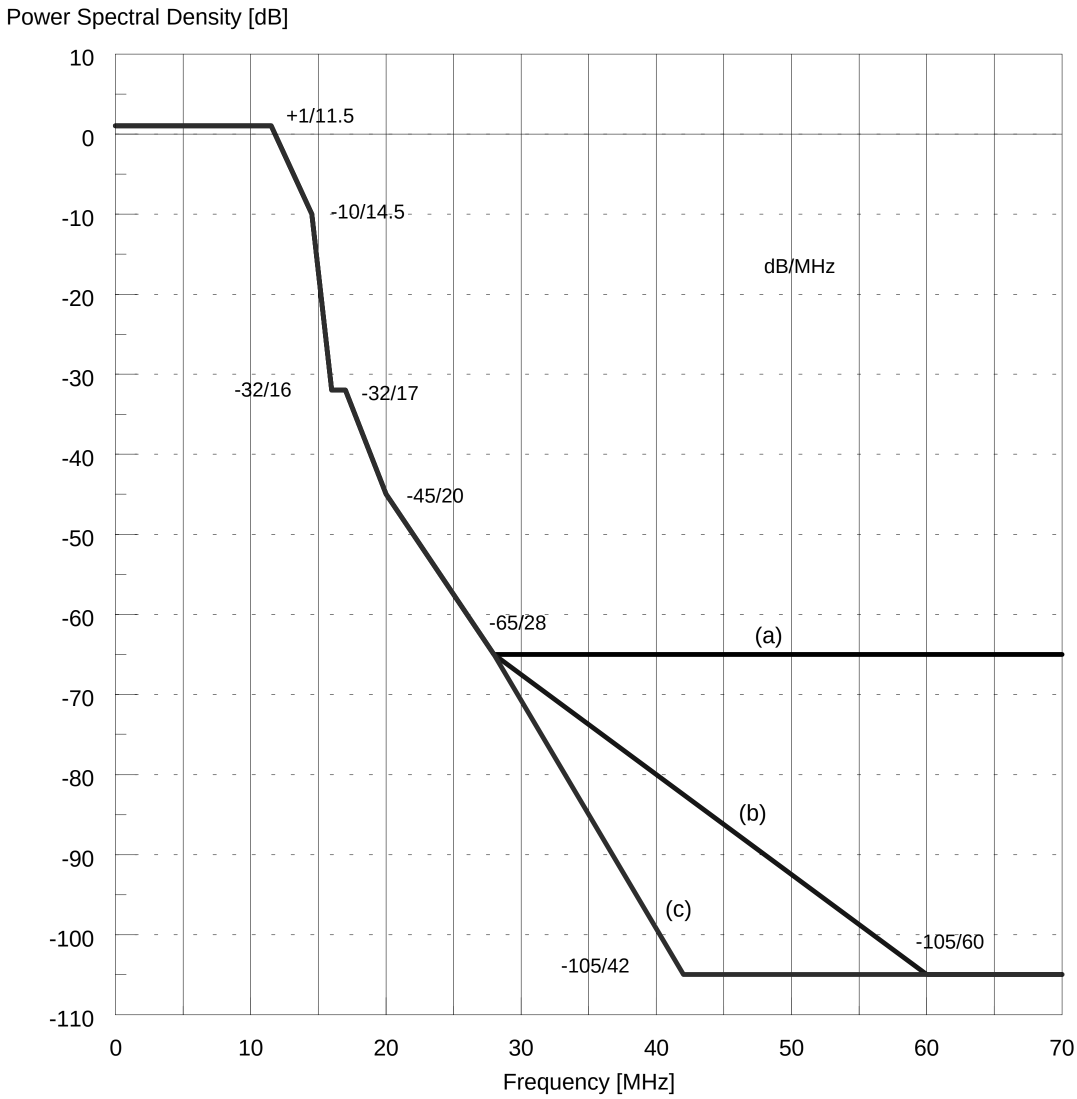

Figure A.1b: Spectrum masks for normal channels (b) and inner edges of innermost channels (c) for frequency bands with 28 MHz spacing and 56 MHz centre gap. System A

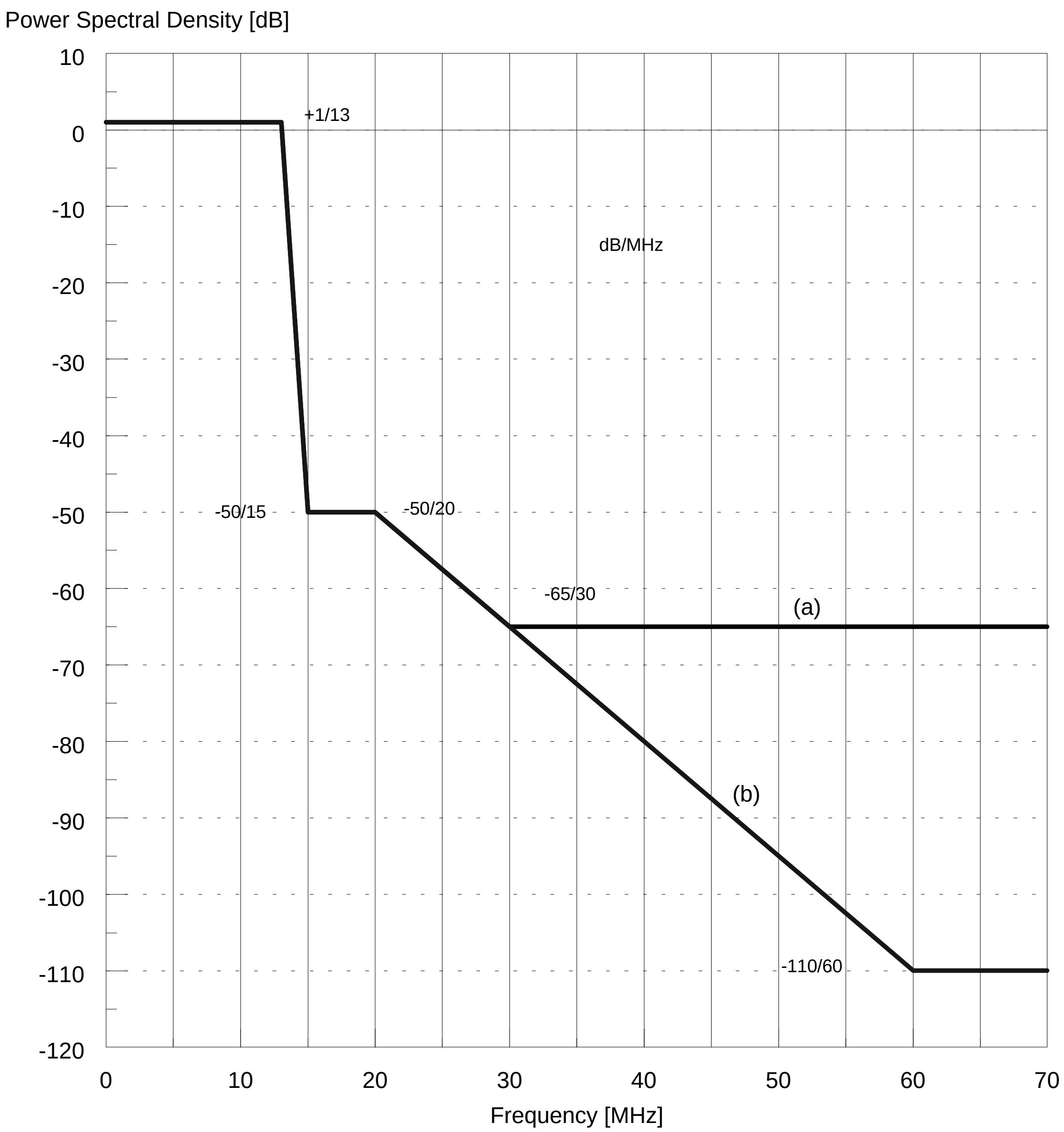

Figure A.2a: Spectrum masks for the normal channels for frequency bands with channel spacing of 28 MHz. System B

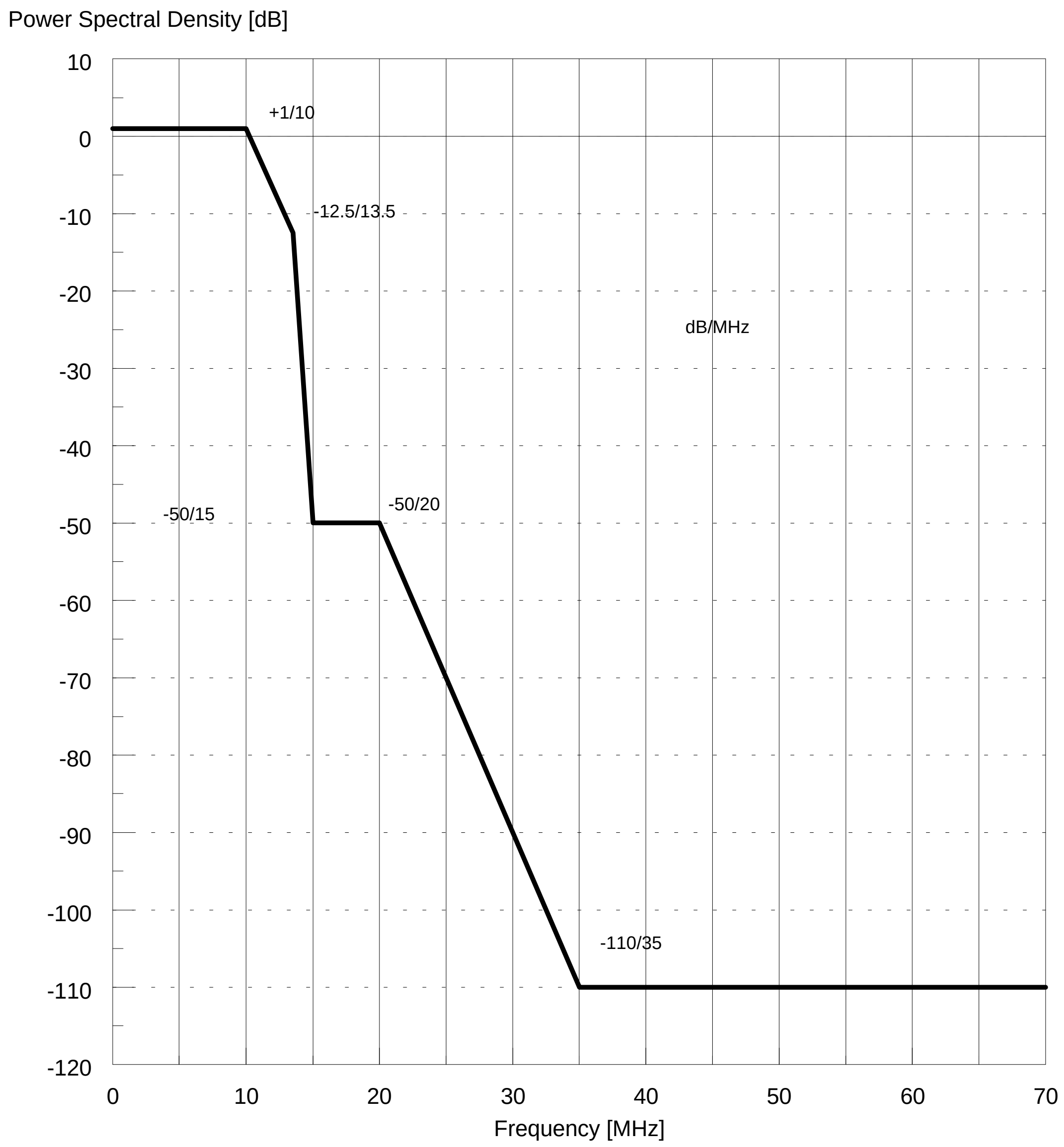

Figure A.2b: Spectrum masks for the inner edges of innermost channels in the L6 GHz band and 56 MHz centre gap in the 7 GHz band. System B

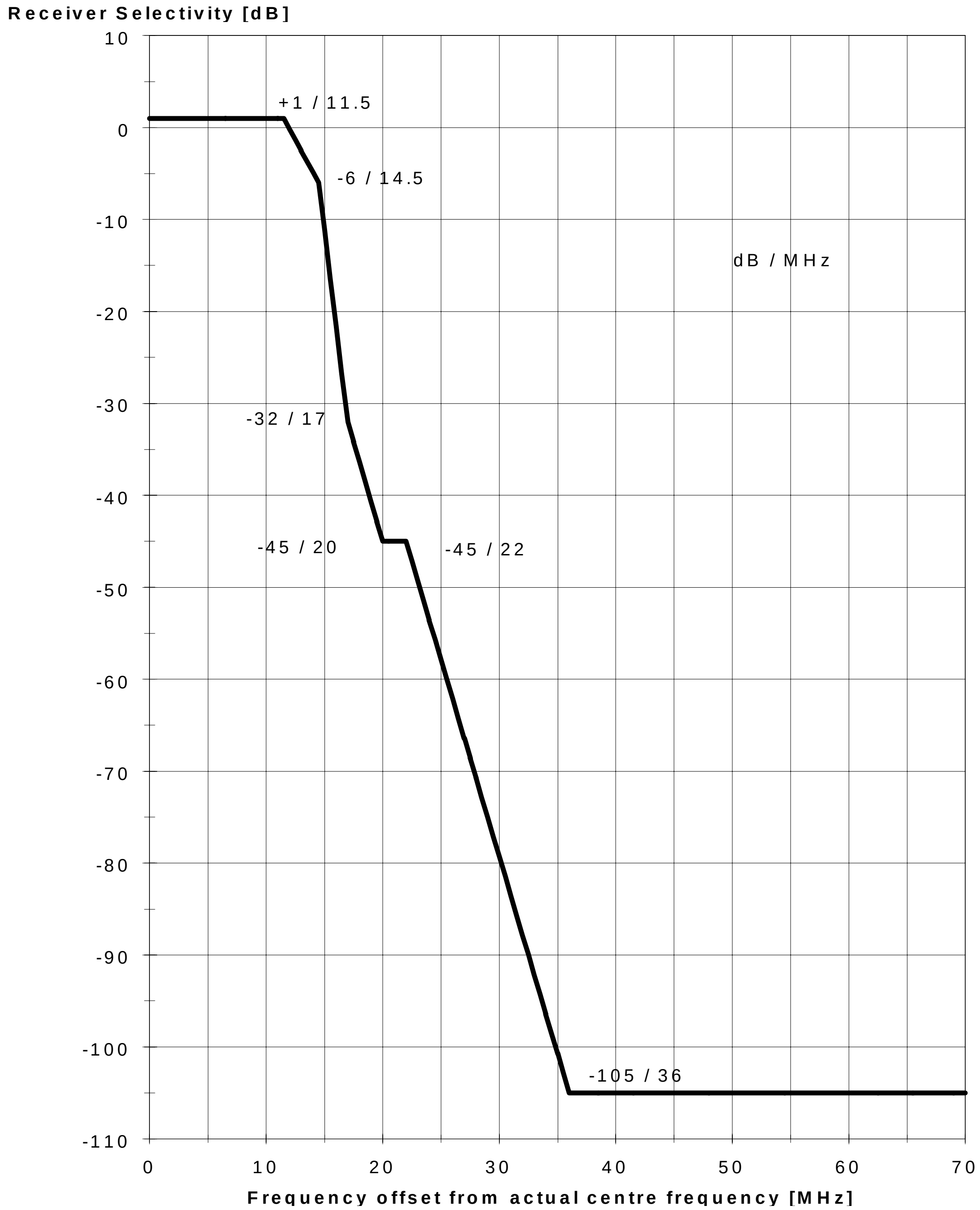

Figure A.3a: Limits for the receiver selectivity for the inner edges of innermost channels in the L6 GHz band. System A

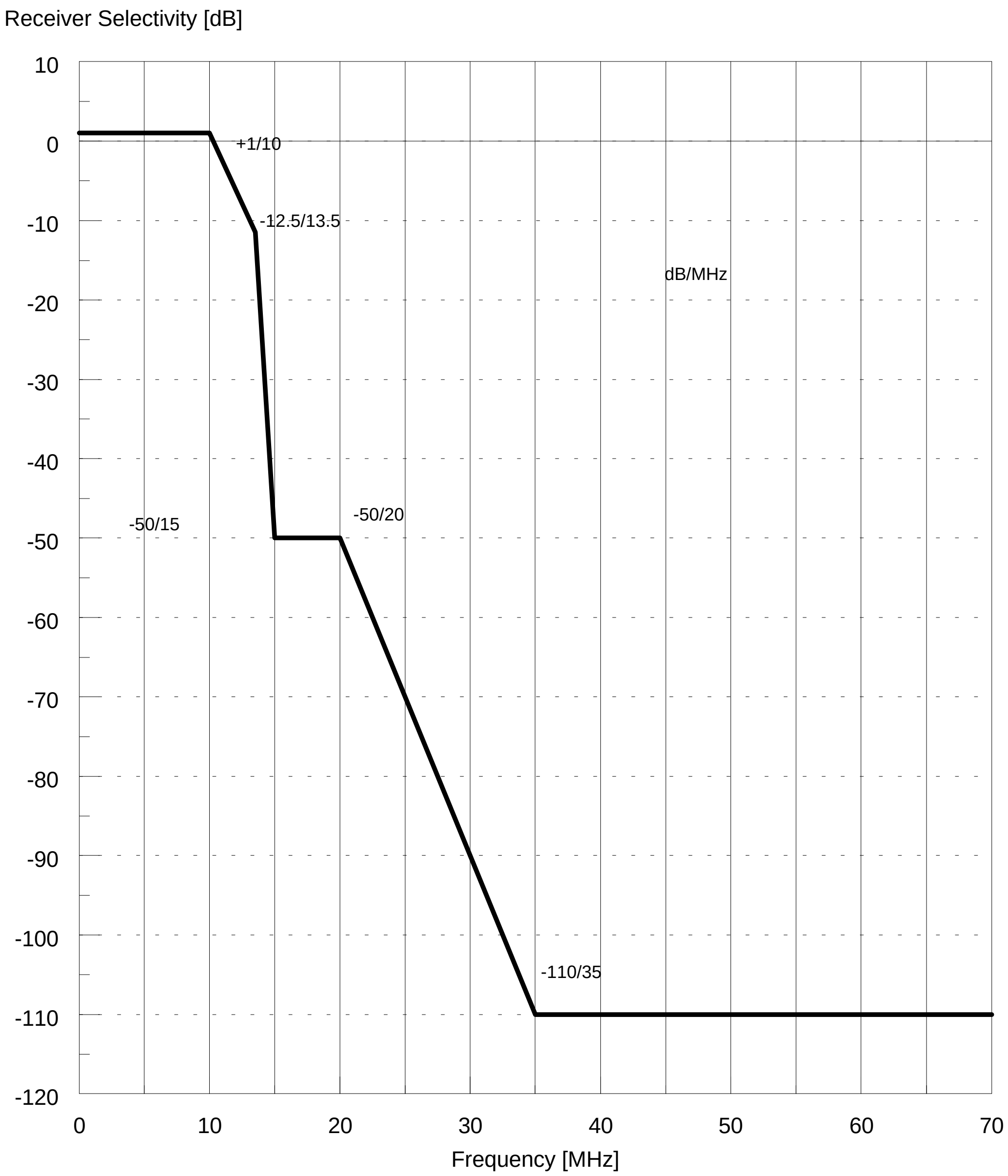

Figure A.3b: Limits for the receiver selectivity for the inner edges of innermost channels in the L6 GHz band and in the 7 GHz band with 56 MHz centre gap. System B

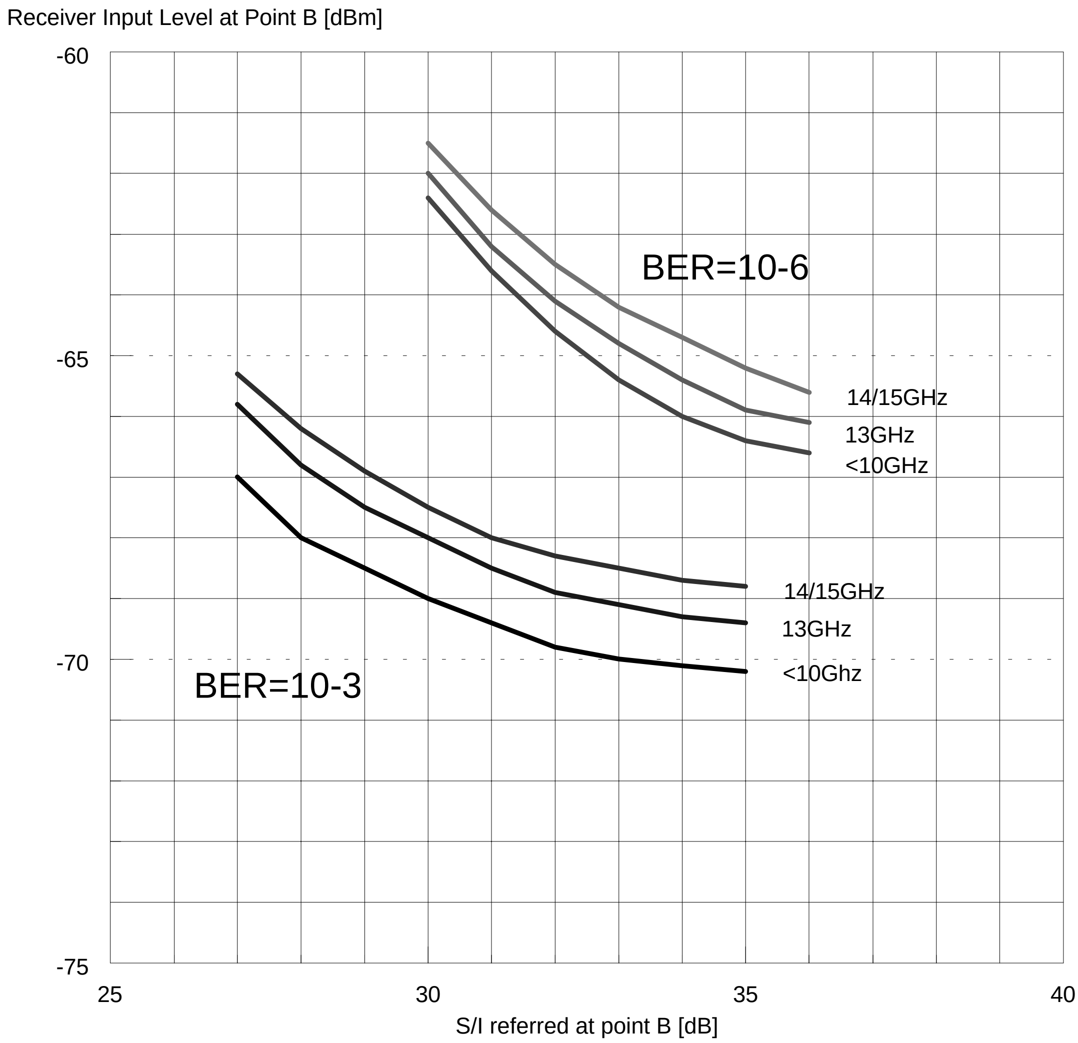

Figure A.4a: Co-channel digital "external" interference sensivity masks. System A

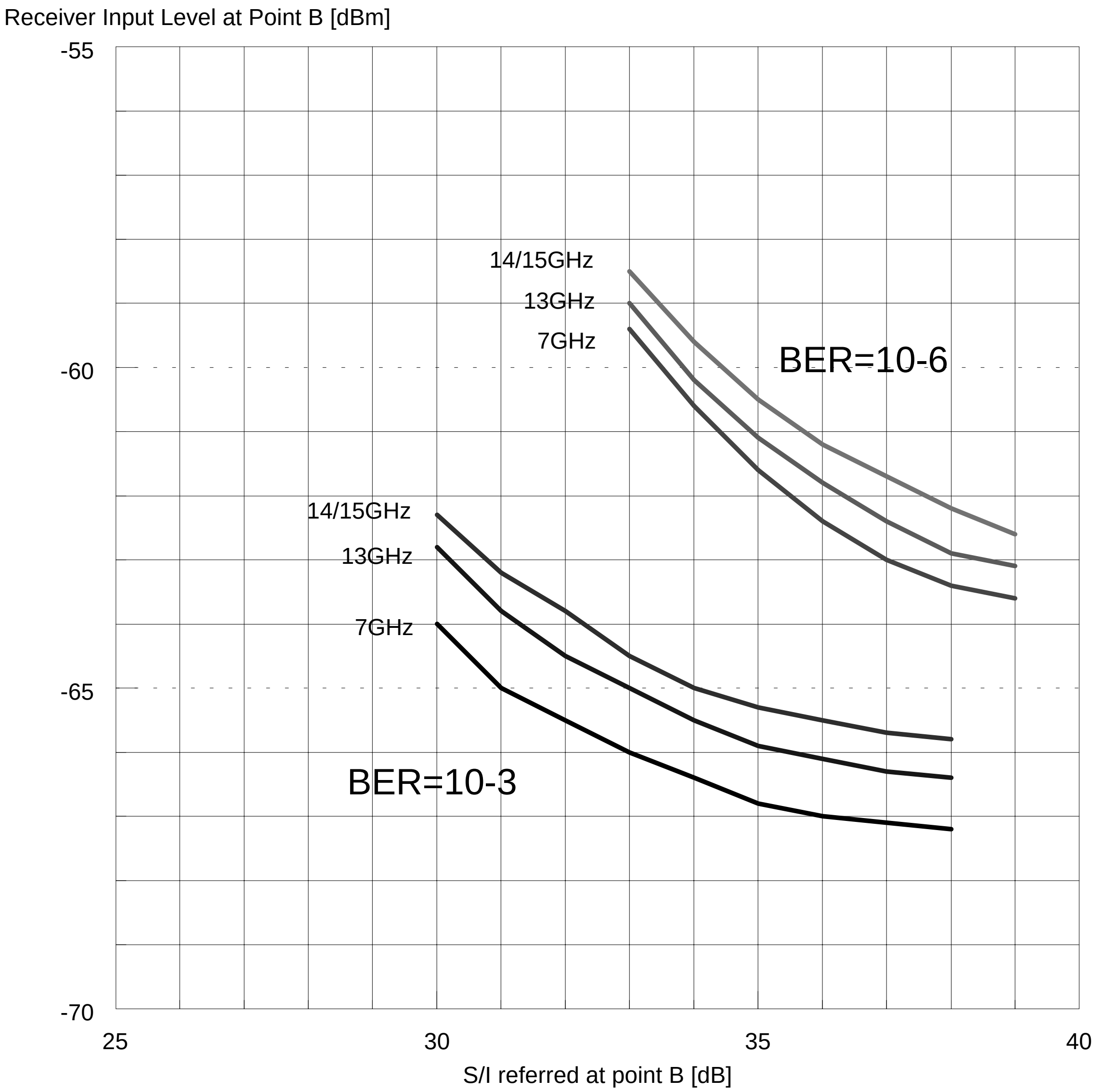

Figure A.4b: Co-channel "external" digital interference sensivity masks. System B

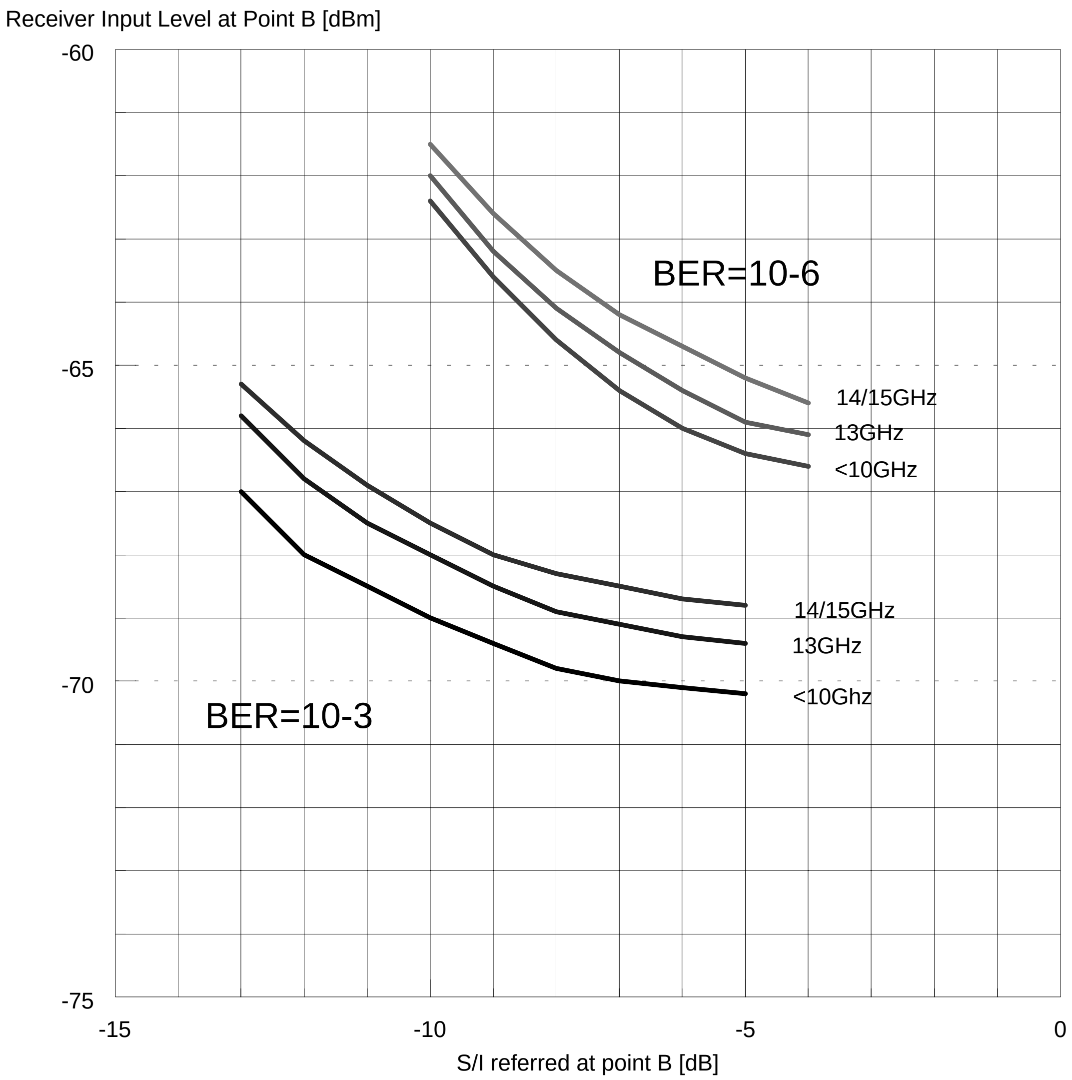

Figure A.5a: Adjacent-Channel digital interference sensivity masks. System A

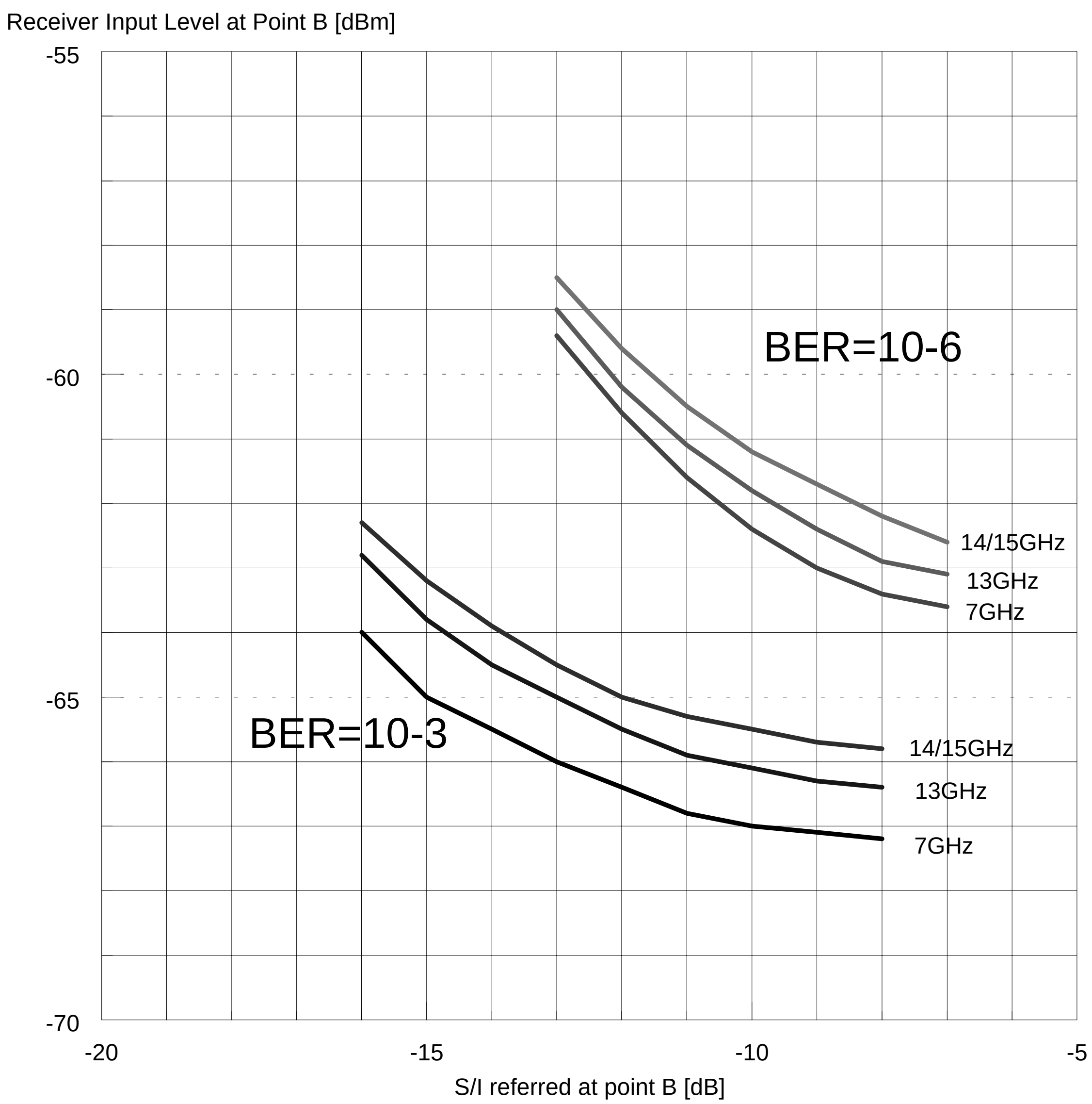

Figure A.5b: Adjacent-Channel digital interference sensivity masks. System B

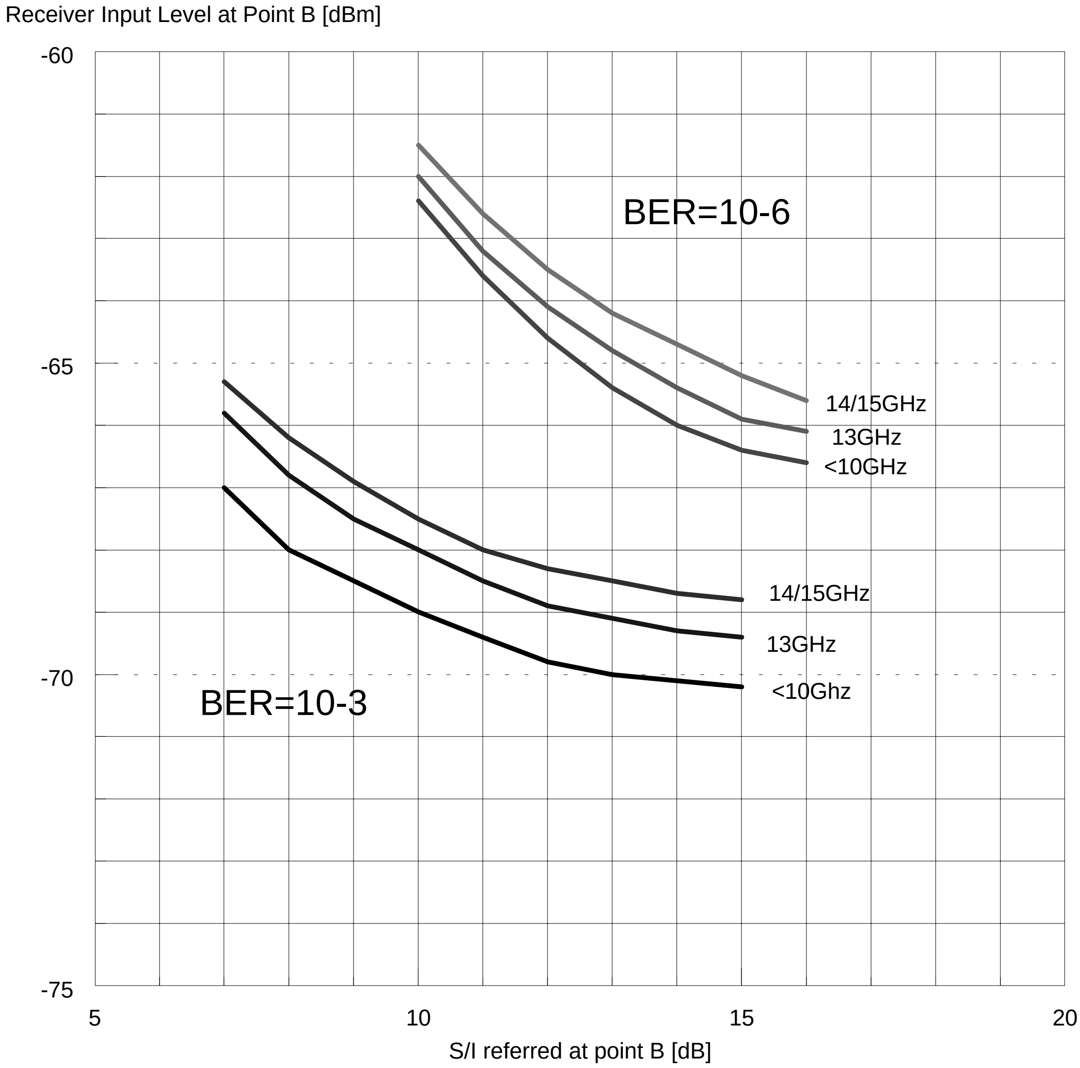

Figure A.6a: Co-Channel "internal" digital interference sensivity masks. System A

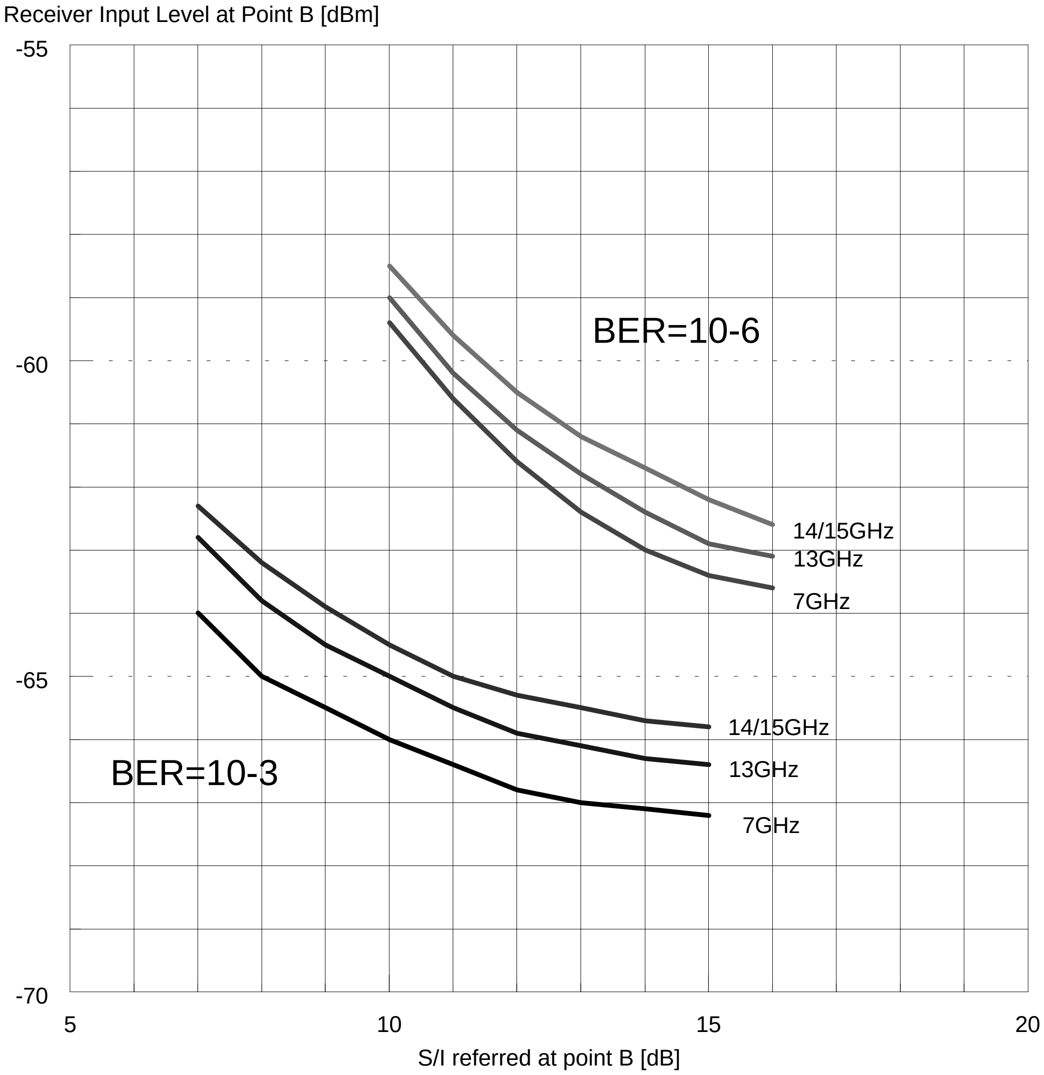

Figure A.6b: Co-Channel "internal" digital interference sensivity masks. System B

Annex B: Bibliography

The following material, though not specifically referenced in the body of the present document, gives supporting information.

- ITU-R Recommendation F.382-6: "Radio-frequency channel arrangements for radio-relay systems operating in the 2 and 4 GHz bands".
- ITU-R Recommendation F.383-5: "Radio-frequency channel arrangements for high capacity radio-relay systems operating in the lower 6 GHz band".
- ITU-R Recommendation F.386-4: "Radio-frequency channel arrangements for radio-relay systems operating in the 8 GHz band".
- ITU-R Recommendation F.497-5: "Radio-frequency channel arrangements for radio-relay systems operating in the 13 GHz frequency band".
- ITU-R Recommendation F.636-3: "Radio-frequency channel arrangements for radio-relay systems operating in the 15 GHz band".
- ITU-R Recommendation F.750-2: "Architectures and functional aspects of radio-relay systems for SDH-based networks".
- ITU-R Recommendation F.385-6: "Radio-frequency channel arrangements for radio-relay systems operating in the 7 GHz band".
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- ITU-T Recommendation G.774: "Synchronous Digital Hierarchy (SDH) management information model for the network element view".
- ITU-T Recommendation G.784: "Synchronous digital hierarchy (SDH) management".
- ETS 300 019, Parts 1 and 2: "Equipment engineering; Environmental conditions and environmental tests for telecommunications equipment".
- ETS 300 119: "Equipment Engineering [EE]; European telecommunication standard for equipment practice".
- ETS 300 385 : "EMC standard for DRRS fixed service".
- ETS 300 132: "Equipment engineering; Power supply interface at the input to telecommunications equipments".
- ETS 300 635: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH); Radio specific functional blocks for transmission of Mx STM-N".
- ETS 300 645: "Transmission and Multiplexing (TM); Synchronous Digital Hierarchy (SDH) radio relay equipment; Information model for use on Q-interfaces".
- R.Valentin, H.-G.Giloi, K.Metzger; "Co-Channel Cross-Polarized Operation of Digital Radio Systems"; Third European Conference on Radio Relay Systems (3rd ECRR);Paris-France, Dec. 17-20, 1991, pp 309-313.

History

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