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Subject: Initial first draft for a supplement to the ECC report [xxx] on future possibilities for the digitalisation of Band II; Technical Elements and Parameters for Digital Terrestrial Broadcasting in Band II

Summary:

A small drafting group met in order to further develop the Technical Supplement to ECC Report141. This meeting was held at the BBC London on 24-25 November 2010 with the following participants:

Roland Beutler (SWR Germany)
Hanns Wolter (Club DAB, Italy)
Mike Hate (BBC World Service Consultant)
Nigel Laflin (BBC Distribution)
Darko Ratkaj (EBU)
Jean-Jaqcues Guitot (ANFR, France)
Steve Ripley (Ofcom, UK)

The results of the meeting are provided in document FM45(10)221bis. The document was further reviewed by the ECO in order to be transferred in the ECC format for an ECC Report.

Proposal:

FM PT45 is requested to consider the attached version of the 'Initial first draft for a supplement to the ECC report 141 on future possibilities for the digitalisation of Band II' as the starting point for further development of this report.

Background:

In its Terms of Reference FM PT45 is mandated to:

Study future possibilities for the digitalisation of sound broadcasting, taking into account:

- the necessary technical criteria and parameters for candidate digital sound broadcast systems;
- the associated regulatory issues
- compatibility with services in adjacent bands

Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

Intial first draft for a supplement to the ECC Report 141

future possibilities for the digitalisation of band II
Technical elements and parameters for dital terrestrial broadcasting in Band II

xxx, xxx xxxx

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LIST OF ABBREVIATIONS

Abbreviation	**Explanation**
CEPT	European Conference of Postal and Telecommunications Administrations
DRM	Digital Radio Mondiale
FM	Frequency Modulation
FX	Fixed Reception
ILS	Instrument Landing System
IRT	Institut für Rundfunktechnik GmbH (Broadcast Technology Institute), Munich, Germany
MMN	Man-Made Noise
PI-H, PO-H	Portable Handheld Reception
PI	Portable Indoor Reception
PL	Primary Lower
PO	Portable Outdoor Reception
PR	Protection Ratio
PU	Primary Upper
QAM	*Quadrature amplitude modulation*
QPSK	*Quadrature Phase Shift Keying*
T-DAB	Terrestrial-Digital Audio Broadcasting
VHF	*Very high frequency*

Initial first draft for a supplement to the ECC Report 141
on future possibilities for the digitalisation of Band II
Technical Elements and Parameters for Digital Terrestrial Broadcasting in Band II

Introduction

Any conceivable introduction of digital terrestrial broadcasting in Band II can be achieved on the basis of sharing the spectrum with existing FM services only. To this end, appropriate sharing criteria need to be adhered to. Relevant technical parameters in this context are summarized in this supplement to ECC Report 141 [1].

FM frequency allocation in Band II may be used for digital terrestrial broadcasting services with characteristics that may be different from those appearing in the GE84 Plan [2] but within the envelope of their Plan entry or aggregate entries under the provisions of GE84, and that their administrations agree that any such use will be afforded protection to the levels defined by the interfering field strengths as arising from their frequency allocations, taking into account any relevant bilateral agreements. This means any such alternative usage of Band II frequencies must not produce more interference nor claim more protection than the corresponding frequency allocation of GE84.

Common Network Planning Parameters

In this chapter the network planning parameters are described that are valid for all the terrestrial digital broadcasting systems as common basis for the later calculation of the individual parameters for network planning, as the minimum median field strength levels, of the named systems.

Reception Modes

Three different basic reception modes can be distinguished, fixed, portable and mobile, with four subdivisions in the portable reception mode.

Fixed Reception (FX)

Fixed reception is defined as reception where a receiving antenna mounted at roof level is used. In calculating the field strength levels for fixed antenna reception, a receiving antenna height of 10 m above ground level is assumed.

A location probability of 70% is assumed to obtain a good reception situation.

Portable Reception

In general, portable reception means a reception where a portable receiver with an attached or built-in antenna is used outdoors or indoors at no less than 1.5 m above ground level.

A location probability of 95% is assumed to obtain a good reception situation.

Two receiving locations will be distinguished:

- **Indoor reception** with a reception place in a building

- **Outdoor reception** with a reception place outside a building

Within these receiving locations two opposed receiving conditions will be distinguished additionally due to the great variability of portable reception situations with different receiver-/antenna-types and also different reception conditions:

- **Portable reception:** This situation models the reception situation with good reception conditions for both situations indoor and outdoor, resp., and a receiver with an omnidirectional VHF antenna pattern. **A suburban area** is assumed in this case.
- **Portable handheld reception:** This situation models the reception situation under difficult conditions using a receiver with an external ad hoc antenna (e.g. wire to an earpiece). **An urban area** is assumed in this case

Portable Outdoor Reception (PO)

Portable outdoor reception is defined as reception by a portable receiver with battery supply and an attached or built-in antenna. The receiving antenna height is assumed to be 1.5 m above ground level.

Portable Indoor Reception (PI)

Portable indoor reception is defined by a portable receiver with stationary power supply and a build-in (folded)-antenna or with a plug for an external antenna. The receiver is used indoors at no less than 1.5 m above floor level in rooms on the ground floor and with a window in an external wall. It is assumed that optimal receiving conditions will be found by moving the antenna up to 0.5 m in any direction and the portable receiver is not moved during reception and large objects near the receiver are also not moved.

Portable Handheld Reception (PI-H, PO-H)

This portable reception mode is defined as reception by a portable handheld receiver with battery supply and an external antenna as given in EBU-TECH 3317 [3] for both reception situations indoor and outdoor, respectively. The antenna gain figure for the antenna is based on measurements made at the IRT.

Mobile Reception (MO)

Mobile reception is defined as reception by a receiver in motion also at high speed (up to 300 km/h) with a matched antenna situated at no less than 1.5 m above ground level. In order to guarantee good reception a location probability of 99% is required.

The gain of car antenna against half-wave dipole positioned at the same height depends on the car antenna design, car configuration and reception direction. Averaged antenna gain is expected not lower than -6 dB. For the calculation of planning parameters the value of -2.2 dBd is assumed.

Correction Factors for Field Strength Predictions

Rec. ITU-R P.1546 [4] forms the basis of a field strength prediction method applicable for the broadcasting services amongst other services. Predictions can be made from 30 MHz up to 3000 MHz within a path distance of 1 to 1000 km; percentage of time of 1 to 50%; and for various transmitting antenna heights. The method draws a distinction between paths over land, cold seas and warm seas, makes due allowance for location variability for land area-service predictions and takes account of local clutter surrounding the receiving location. It also provides procedures for handling negative effective transmitting antenna heights and mixed-path propagation (i.e. with combinations of land and sea).

The wanted field strength level values predicted with [ITU-1546] refer always to the median value at a receiving location with a receiving antenna in 10 m high above ground level. This antenna height is a generic value, used as stated only in rural or suburban areas, with constructions or vegetation below 10m height. Otherwise the wanted field strength values are predicted at the average construction or vegetation height at the receiving location. The true receiving antenna height influences the height loss correction factor.

To take into account different receiving modes and circumstances into network planning correction factors have to be included to carry the minimum receiver input power level or the minimum field strength level over to the median minimum field strength level for predictions with Rec. ITU-R P.1546 [4].

Reference Frequency

The planning parameters and correction factors for the VHF band II (87.5 – 108 MHz) are calculated for the **reference frequency of 100 MHz**.

Antenna Gain

The antenna gain G_D [dBd] references to a half-wave dipole.

Antenna Gain for Fixed Reception (FX)

ITU-GE84 does not provide a figure of antenna gain for fixed reception. For future planning it is recommended that an omnidirectional antenna pattern with a gain of 0 dBd is used - see Table 2.1.

Table 1: Omnidirectional antenna gain for fixed reception

Antenna gain G_D for fixed reception	[dBd]	0

Antenna Gain for Portable Reception (PO, PI)

ITU-GE84 does not provide a figure of antenna gain for portable reception. However following the provisions of GE06 an antenna gain of -2.2 [dBd] for standard portable receiver planning is assumed - see Table 2.

Table 2: Antenna gain for portable reception

Antenna gain G_D for portable reception	[dBd]	-2.2

Antenna Gain for Portable Handheld Reception (PO-H, PI-H)

ITU-GE84 does not provide a figure of antenna gain for portable handheld reception. However, the antenna gain in VHF Band II can be calculated from the antenna gain G_D in VHF band III (200 MHz) starting from the figures as given by EBU-TECH 3317.

Receiver integrated antenna for Band III: G_D = -17 dBd

External antenna (telescopic or wired headsets) in Band III: G_D = -13 dBd

Adapted antenna (for mobile reception) in Band III: G_D = -2.2 dBd

The details of the calculation can be found in Annex AAA.

The antenna gains G_D [dB] for portable handheld reception modes with an external antenna in VHF band II and VHF band III are given in Table 3.

Table 3: Antenna gains GD for portable handheld reception

Frequency	[MHz]	100	200
Antenna gain G_D for receiver integrated antenna	[dBd]	-23.02	-17
Antenna gain G_D for external antenna (Telescopic or wired headsets)	[dBd]	-19.02	-13
Gain variation ΔG referenced to 200 MHz	[dB]	-6.02	0

Antenna Gain for Mobile Reception (MO)

ITU-GE84 does not provide a figure of antenna gain for mobile reception. However following the provisions of GE06 an antenna gain of -2.2 [dBd] for mobile receiver planning is assumed - see Table 4.

Table 4:Antenna gain G_D for mobile reception

Antenna gain G_D for mobile reception	[dBd]	-2.2

Feeder Loss

The feeder loss L_f expresses the signal attenuation from the receiving antenna to the receiver's RF input. Since ITU-GE84 does not contain any information on feeder loss, the same calculation methodology as in ITU-GE06 is proposed (see Annex BBB for more details).

The proposed cable length l for the different reception modes and the respective feeder losses L_f for the different reception modes are given in Table 5.

Table 5: Cable length l and feeder losses L_f for the reception modes

		Reception mode		
		Fixed reception (FX)	Portable reception (PO, PI, PO-H, PI-H)	Mobile reception (MO)
Cable length l	[m]	10	0	2
Feeder loss L_f	[dB]	1.4	0.0	0.28

Height Loss Correction Factor

For portable reception a receiving antenna height of 1.5 m above ground level (outdoor and mobile) or above floor level (indoor) is assumed.

The propagation prediction method usually provides field strength values at 10 metres. To correct the predicted value from 10 metres to 1.5 m above ground level a height loss factor L_h [dB] has to be applied.

Height loss in Band II can be calculated using Rec. ITU-R P.1546 [4]. In Band II a height loss of [x] dB is assumed.

The height loss correction factor L_h for all reception modes is given in Table 6.

Table 6: Height loss correction factor L_h for different reception modes

Reception mode	Height loss correction factor L_h	
All	*[XX]*	[dB]

Building Penetration Loss

The ratio between the mean field strength inside a building at a given height above ground level and the mean field strength outside the same building at the same height above ground level expressed in [dB] is the mean building penetration loss.

The **mean building penetration loss** L_b in VHF band III is given in ITU-GE06 and EBU-3317 as 9 dB, which is proposed to be used for VHF band II, too.

The **standard deviation of the building penetration loss** σ_b is always given by 3 dB.

The mean building penetration loss L_b and standard deviation $_b$ are given in Table 7.

Table 7: Building penetration loss L_b and standard deviation $_b$

Mean building penetration loss L_b	[dB]	9
Standard deviation of the building penetration loss σ_b	[dB]	3

Allowance for Man-made Noise

Allowance for Man-made Noise for Fixed, Portable and Mobile Reception

The allowance for man-made noise, MMN [dB], takes into account the effect of the man-made noise received by the antenna on the system performance. The details of the calculation of MMN can be found in Annex CCC.

In GE06 [5] MMN at 200 MHz is considered to be 2 dB and the receiver noise figure F_r is given as 7 dB for T-DAB radios. Herewith the antenna noise factor f_a at 200 MHz can be calculated by 5.92 dB as reference value. This is basis to deduce MMN at 100 MHz and 65 MHz for different frequencies and fixed, portable, and mobile reception as given in Table 8.

Table 8: Man-made noise allowance MMN for fixed, portable and mobile reception

Frequency	[MHz]	100	200
Antenna noise figure change ΔF_a referenced to 200 MHz	[dB]	8.34	0
Receiver noise figure F_a	[dB]	7	7
Antenna noise figure F_a	[dB]	14.26	5.92
MMN allowance for fixed, portable and mobile reception	**[dB]**	**7.87**	2.0

Allowance for man-made noise for portable handheld reception

The antenna gain is the product of directivity and efficiency. Details of the calculation can be found in Annex DDD.

The man-made noise for Band II and portable handheld reception modes, taking the receiver noise figure as 7 dB, are given in Table 9.

Table 9: Man-made noise allowance MMN for portable handheld reception mode (external antenna)

Frequency	[MHz]	100
Handheld antenna gain G_D	[dBd]	-19
Efficiency η		0.0138
Calculated MMN allowance	[dB]	0.30
MMN allowance for portable handheld reception	[dB]	0.00

In the further calculations the allowance for man-mad-noise is specified to 0 dB due to the very low calculated values.

Implementation Loss Factor

Implementation loss of the non ideal receiver is considered in the calculation of the minimum receiver input power level with an additional implementation loss factor L_i of 3dB, cf. Table 10. This value takes into account the characteristics of today's receivers.

Table 10: Implementation loss factor L_i

Implementation loss factor L_i	[dB]	3

Location correction factor

The random variation of the received signal RMS field strength with location due to terrain irregularities and the effect of obstacles in the near vicinity of the receiver location is modelled by a statistical distribution (typically log normal) over a specified macro-scale area (typically a square with an edge length of 100 m to 200 m).

GE06 provides the definition of location corrections factors both for indoor and outdoor receiving locations. [copy and past tables from sections 3.4.5.1/2] In addition, allowance for rapid flat fading is required for a narrow band channel. This gives rise to having an additional margin of 4.6 dB to the location correction factor. a margin depending to the bandwidth of the signal of 4.6 dB at 120 kHz has to be added

[NOTE: This is RAVIS text, I have no idea where to put it, do we need a section on standard deviations? And if yes, can there be different values for different systems? Isn't that rather a wave propagation issue than a system issue????????????

These values of the standard deviation take into account only the effects of slow fading, but not the effects of fast fading. Therefore it must be ensured that the measurements to determine the minimum C/N value consider the effects of the fast fading. Otherwise a margin depending to the bandwidth of the signal of 4.6 dB at 120 kHz has to be added.

The standard deviation calculated for RAVIS in accordance witn ITU-R Recommendation P.1546-4 [4] for mobile reception in urban environment with $K = 1.2$ ($_L = 1.2 + 1.3\cdot 2 = 3.8$) and for rural areas with $K = 0.5$ ($_L = 0.5 + 1.3\cdot 2 = 3.1$) are given in Table 2.4-1. Taking into account large areas and multipath variation causing fading of field strength, the ITU-R Recommendation P.1546-4 propose to use averaged values of $_L$ for planning (ITU-R Recommendation P.1546-4, Annex 5, sec. 12, table 2), also given in Table 11.

Table 11: Standard Deviation $_L$ for RAVIS

Frequency	100 MHz	100 MHz, for digital systems planning	100 MHz, for analogue systems planning
urban and suburban locations	3.1 dB	5.5 dB	8.3 dB
suburban locations	3.8 dB		

The fading margin E_L from point to point for 10%, 5% and 1% bad reception (= 1.28, = 1.65 and = 2.33 accordingly) is given in Table 12.

Table 12: Fading margin E_L from point to point for RAVIS

Percentage of areas with bad reception	10%	5%	1%	1% for planning with average $_L$ = 5.5 dB
urban and suburban locations	3.97 dB	5.12 dB	7.22 dB	12.8 dB
suburban locations	4.86 dB	6.27 dB	8.85 dB	

[Following test to be checked against 3.4.5.3 of GE06]

[Location Correction Factor for the Wanted Field Strength Level

Taking into account the different location probabilities for the reception modes a location correction factor C_l [dB] pooling all margins related to the wanted RMS field strength level E can be defined as follows:

(2)

The combined standard deviation σ_c takes into account the standard deviation σ_m of the wanted RMS field strength level E and, in the case of indoor reception, the standard deviation of the building penetration loss, σ_b , respectively. Since the statistics of the received wanted field strength level E for macro-scale and the statistics of the building attenuation can be assumed to be statistically uncorrelated, the combined standard deviation σ_c is calculated by:

(3)

Combined Location Correction Factor for Protection Ratios

The combined location correction factor CF in [dB] is used to convert the basic protection ratio PR_{basic}, valid for the wanted field strength and the nuisance field strength, both referring to a location probability of 50%, to the protection ratio $PR(p)$ corresponding to the needed percentage p [%] of locations for the wanted service [ITU-GE06].

; for (4)

with (5)

where σ_w and σ_n, both in [dB], denote the standard deviation of location variation for the wanted signal for the nuisance signal, respectively.]

Polarization Discrimination

In principal it is possible to take advantage of polarization discrimination for fixed reception. ITU-GE84 does not take into account polarization discrimination in the planning procedure for VHF band II, except in specific cases with the agreement of administrations concerned. In such cases, a value of 10 dB was used for orthogonal polarization discrimination.

For the planning procedures of digital sound broadcasting systems in the VHF band II no polarization discrimination shall be taken into account for all reception modes.

Calculation of Minimum Median Field Strength Level

The calculation of the minimum median field strength level at 10 m above ground level for 50% of time and for 50% of locations is given in Appendix 3.4 of chapter 3 to annex 2 of GE06. For completeness the details can also be found in Annex EEE.

Calculation of the Resulting Sum Field Strength of Interferers

To calculate the resulting interfering sum field strength level from several signal sources E_{sum} the simplified multiplication method [ITU-R Report BS.945] shall be applied according to [ITU-GE84]. [Consider GE06 approach which used simple power sum]

Determination of Protection Ratios for FM interfered with by Digital Systems

[NOTE: A practicable and reproducible measurement procedure has to be defined that is valid anyhow for all named digital systems for the determination of the protection ratios for FM interfered with by one digital system. Hybrid modes and digital only modes has to be considered].

Minimum field strength requirements for the Digital Terrestrial Broadcasting Systems

The methodology to determine the minimum field strengths to ensure proper receiver functionality for the various transmissions mode options for each of the systems is provided in the following sections. From this the transmission link budget will provide the necessary transmission powers to cover a required area.

Digital Radio Mondiale (DRM)

The DRM standard provides configurations for broadcast frequencies below 30 MHz as well as for broadcast frequencies above 30 MHz in Mode ‘E’ (often referred to as 'DRM+'), including the VHF Band II. The parameters and statements given in this annex refer to the latter set of DRM configurations.

System parameters of DRM

DRM Signal Parameter

Two different modulations in DRM mode E are considered here, cf. Table 13.

The first one is a low protected DRM signal which is defined by the set of parameters:

Robustness Mode E, MSC Mode 0 (16-QAM), SDC Mode 1 (code rate = 0.25), MSC Protection level 2 (code rate = 1/2), MSC equal error protection, net bit rate 149.1 kbit/s.

The second modulation represents a high protected DRM signal with the parameters:

Robustness Mode E, MSC Mode 4 (4-QAM), SDC Mode 1 (code rate = 0.25), MSC Protection level 1 (code rate = 1/3), MSC equal error protection, net bit rate 49.7 kbit/s.

Table 13: MSC code rates for DRM

DRM signal	High protected	Low protected
MSC mode	11 - 4-QAM	00 - 16-QAM
MSC protection level	1	2
MSC code rate	1/3	1/2
SDC mode	1	1
SDC code rate	0.25	0.25
Bit rate approx.	49.7 kbit/s	149.1 kbit/s

DRM Receiver Related Parameters

Minimum C/N Ratio in different Channel Models for DRM

[ETSI-DRM] gives a required $(C/N)_{min}$ for a transmission in VHF band II to achieve an average coded bit error ratio BER = 110^{-4} [bit] after the channel decoder for different channel models, cf. Table 14.

Table 14: $(C/N)_{min}$ for DRM in [ETSI-DRM] with different channel models

	$(C/N)_{min}$ [dB] for	
Channel model	**4-QAM, R= 1/3**	**16-QAM, R= 1/2**
Channel 7 (AWGN)	1.3	7.9
Channel 8 (Urban@60km/h)	7.3	15.4
Channel 9 (Rural)	5.6	13.1
Channel 10 (Terrain obstructed)	5.4	12.6
Channel 11 (Hilly terrain)	5.5	12.8
Channel 12 (SFN)	5.4	12.3

In this document a receiver implementation margin of 3 dB is added leading to the $(C/N)_{min}$ for the calculation of the planning parameters for different reception modes, cf. Table 15.

Table 15: $(C/N)_{min}$ for calculation of the planning parameters

	$(C/N)_{min}$ [dB] for		
Channel model	**4-QAM, R= 1/3**	**16-QAM, R= 1/2**	**Reception mode**
Channel 7 (AWGN)	4.3	10.9	Fixed reception (FX)
Channel 8 (Urban)	10.3	18.4	Portable reception (PO, PI, PO-H, PI-H)
Channel 11 (Hilly terrain)	8.5	15.8	Mobile reception (MO)

Receiver Noise Figure

In [ITU-GE06] a receiver noise figure of 7 dB is been used for both DVB-T and T-DAB. For having cost effective DRM receiver solutions the receiver noise figure F is assumed to be F = 7 dB too.

Receiver Noise Input Power

With B = 100 kHz and T = 290 K, the thermal receiver noise input power level P_n for DRM yields

(6)

Based on the above equations, the minimum receiver input power level can be calculated for both 16-QAM and 4-QAM, cf. Table 16 and Table 17.

Table 16: Minimum receiver input power level $P_{s,min}$ for 4-QAM, R=1/3

Reception mode			**Fixed (FX)**	**Portable (PO, PI, PO-H, PI-H)**	**Mobile (MO)**
Receiver noise figure	F	[dB]	7	7	7
Receiver noise input power level	P_n	[dBW]	-146.98	-146.98	-146.98
Representative minimum C/N ratio	$(C/N)_{min}$	[dB]	4.3	10.3	8.5
Minimum receiver input power level	$P_{s,min}$	**[dBW]**	**-142.68**	**-136.68**	**-138.48**

Table 17: Minimum receiver input power level $P_{s,min}$ for 16-QAM, R=1/2

Reception mode			**Fixed (FX)**	**Portable (PO, PI, PO-H, PI-H)**	**Mobile (MO)**
Receiver noise figure	F	[dB]	7	7	7
Receiver noise input power level	P_n	[dBW]	-146.98	-146.98	-146.98
Representative minimum C/N ratio	$(C/N)_{min}$	[dB]	10.9	18.4	15.8
Minimum receiver input power level	$P_{s,min}$	**[dBW]**	**-136.08**	**-128.58**	**-131.18**

DRM+ Frequency Raster

The DRM+ frequencies can be positioned in a 100 kHz raster in Band II. The nominal centre carrier frequencies are, in principle, integral multiples of 100 kHz [ITU-GE84].

SFN Operation Capability

DRM can operate in Single Frequency Networks (SFN). The maximum transmitter distance that has to go below to prevent self interferences depends on the length of the OFDM guard interval. The maximum transmitter distance is calculated with the maximum echo delay which is given by.

$$D_{echo(max)} \text{ [km]} = T_g \cdot c_0$$

with: $c_0 = 300 \cdot 10^3$ [km/s],

and T_g = 0.25 [ms], the duration of the guard interval.

Since the length T_g of the DRM guard interval is 0.25 ms, the maximum echo delay, and, therefore, the maximum transmitter distance, yields 75 km.

In this calculation cliff edge behaviour of DRM in the SFN is assumed which still has to be proved.

Minimum Median Field Strength Level

Based on the parameters and equations in chapter 2, the minimum median field strength level for different reception modes can be calculated for both 16-QAM and 4-QAM, cf. Table 18 and Table 19.

[Figures need to be revised and checked]

Table 18: Minimum median field strength level E_{med} for 4-QAM, R = 1/3

DRM modulation				4-QAM, R = 1/3		
Reception mode	FX	PI	PI-H	PO	PO-H	MO

Minimum receiver input power level	$P_{s.min}$ [dBW]	-142.68	-136.68	-136.68	-136.68	-136.68	-138.48
Antenna gain	G_D [dBd]	4.00	-2.20	-19.02	-2.20	-19.02	-2.20
Effective antenna aperture	A_a [dBm^2]	4.70	-1.50	-18.32	-1.50	-18.32	-1.50
Feeder-loss	L_c [dB]	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	ϕ_{min} [dBW/m^2]	-145.97	-135.17	-118.35	-135.17	-118.35	-136.69
Minimum field strength level at receiving antenna	E_{min} [dB☒V/m]	-0.21	10.59	27.41	10.59	27.41	9.07
Allowance for man-made noise	P_{mmn} [dB]	7.87	7.87	0.00	7.87	0.00	7.87
Antenna height loss	L_h [dB]	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b [dB]	0.00	9.00	9.00	0.00	0.00	0.00
Location probability		70%	95%	95%	95%	95%	99%
Distribution factor	☒	0.52	1.64	1.64	1.64	1.64	2.33
Standard deviation of DRM field strength	☒$_m$ [dB]	3.80	3.80	3.80	3.80	3.80	3.80
Standard deviation of building penetration loss	☒$_b$ [dB]	0.00	3.00	3.00	0.00	0.00	0.00
Location correction factor	C_l [dB]	1.99	7.96	7.96	6.25	6.25	8.84
Minimum median field strength level	**E_{med} [dB☒V/m]**	**9.65**	**45.42**	**61.37**	**34.71**	**50.66**	**35.78**

Table 19: Minimum median field strength level E_{med} for 16-QAM. R = 1/2

DRM modulation		16-QAM *R* = 1/2					
Reception mode		FX	PI	PI-H	PO	PO-H	MO
Minimum receiver input power level	$P_{s.min}$ [dBW]	-136.08	-128.58	-128.58	-128.58	-128.58	-131.18
Antenna gain	G_D [dBd]	4.00	-2.20	-19.02	-2.20	-19.02	-2.20
Effective antenna aperture	A_a [dBm^2]	4.70	-1.50	-18.32	-1.50	-18.32	-1.50
Feeder-loss	L_c [dB]	1.40	0.00	0.00	0.00	0.00	0.28
Minimum power flux-density at receiving place	ϕ_{min} [dBW/m^2]	-139.37	-127.07	-110.25	-127.07	-110.25	-129.39
Minimum field strength level at receiving antenna	E_{min} [dB☒V/m^1]	6.39	18.69	35.51	18.69	35.51	16.37
Allowance for man-made noise	P_{mmn} [dB]	7.87	7.87	0.00	7.87	0.00	7.87
Antenna height loss	L_h [dB]	0.00	10.00	17.00	10.00	17.00	10.00
Building penetration loss	L_b [dB]	0.00	9.00	9.00	0.00	0.00	0.00
Location probability		70%	95%	95%	95%	95%	99%
Distribution factor	☒	0.52	1.64	1.64	1.64	1.64	2.33
Standard deviation of DRM field strength	☒$_m$ [dB]	3.80	3.80	3.80	3.80	3.80	3.80
Standard deviation of building penetration loss	☒$_b$ [dB]	0.00	3.00	3.00	0.00	0.00	0.00
Location correction factor	C_l [dB]	1.99	7.96	7.96	6.25	6.25	8.84
Minimum median field strength level	**E_{med} [dB☒V/m]**	**16.25**	**53.52**	**69.47**	**42.81**	**58.76**	**43.08**

HD Radio
HD Radio System Parameters
HD Radio Receiver Related Parameters
Minimum C/N Ratio in different Channel Models for DRM+
Receiver Noise Figure
Receiver Noise Input Power
HD Radio Frequency Raster
SFN Operation
Minimum Wanted Field Strength Used for Planning

The required field strength depends on the target receiver and nature of the usage. The most demanding requirements are expected to be exhibited by portable receivers when used indoor, in urban areas.

For planning purpose, driven by practical considerations as mentioned here, the minimum wanted field strength is assumed to be 50dBuV/m at 1.5m above ground. Although not typically addressed by Rec. ITU-R 1546-4, additional data point may be considered in conjunction of location probability of [80%]. For such case, the minimum wanted field strength is assumed to be 56.5dBu.

[NOTE: link budget calculation to be provided]

RAVIS

[NOTE: the structure of this chapter should be the same as for DRM. Also the relevant values should be inserted.]

RAVIS Radio System Parameters
RAVIS Radio Receiver Related Parameters
Minimum C/N Ratio in different Channel Models for DRM+
Receiver Noise Figure
Receiver Noise Input Power
RAVIS Radio Frequency Raster
SFN Operation
Minimum Wanted Field Strength Used for Planning

The minimum field strength is defined firstly by signal-to-noise ratio (C/N). For digital signal in 100 kHz bandwidth the modelled minimum values $(C/N)_{min}$, that provide BER = 10^{-4} for different operating environment, are given in ETSI ES 201 980 V3.1.1 (2009-08) [7], Annex A, tables A.2, A.3.

The digital receiver noise level E_N at receiver input in 100 kHz bandwidth is not higher than 10 dB. In this case the needed field strength may be calculated as follows:

$E_{min} = E_N + (C/N) + E_L + E_a + E_{add}$, *dB,*

where E_a – decrease of field strength when car antenna is used, E_{add} – the other losses (in feeder, etc.).

Particularly, for portable or mobile reception in urban environment for 1% bad reception areas in 16-QAM operation mode (ignoring E_{add}):

$E_{min} = 10 + 15.4 + 8.85 + 6 = 40.25$ dB.

In this case the field strength at 10 m height, that corresponds to initial parameters of calculation method, should be 10 dB greater. Calculated in this way (not taking into account E_{add}) minimum median field strength levels at 10 m and 1.5 m above ground level for urban environment, 99% location probability, mobile reception are given in Table 20.

Table 20: Minimum median field strength level for RAVIS mobile reception, urban environment, 99% location probability

RAVIS radiofrequency channel bandwidth, kHz		100	200	250
Minimum medium field strength level at receiving location 10 m above ground level and at receiving antenna location 10 m above ground level, dBV/m	QPSK modulation	32.15	35.15	36.15
	16-QAM modulation	40.75	43.75	44.75
Minimum median field strength level at receiving location 10 m above ground level and at receiving antenna location 1.5 m above ground level, dBV/m	QPSK modulation	42.15	45.15	46.15

	16-QAM modulation	50.75	53.75	54.75

Similarly to the results in the Table 2-4.3, for rural areas with E_L = 7.22 dB (Table 20) the results are given in the Table 21.

Table 21: Minimum median field strength level for RAVIS mobile reception, rural areas, 99% location probability

RAVIS radiofrequency channel bandwidth, kHz		100	200	250
Minimum median field strength level at receiving location 10 m above ground level and at receiving antenna location 10 m above ground level, dBV/m	QPSK modulation	30.52	33.52	34.52
	16-QAM modulation	38.62	41.62	42.62
Minimum median field strength level at receiving location 10 m above ground level and at receiving antenna location 1.5 m above ground level, dBV/m	QPSK modulation	40.52	43.52	44.52
	16-QAM modulation	48.62	51.62	52.62

Minimum field strength values for planning with averaged value $_L$ = 5.5, proposed in ITU-R Recommendation P.1546-4 (Annex 5, sec. 12, table 2), are given in the Table 23 (E_L = 12.8 dB according to Table 20).

[NOTE: in doc 195 there is an additional table having the same number and label ut ??? different entries check tables!!!]

T-DAB

Initially, T-DAB was considered as a candidate system for digital terrestrial audio broadcasting in Band II as a successor of FM. However, this option is no longer pursued. Information for the planning of T-DAB is available within the original Wiesbaden 95 documentation and also the GE06 documentation.

Sharing Parameters

FM

Spectrum masks for FM in VHF band II as minimum transmitter requirement are given in [?]. The vertices of the symmetric spectrum mask for FM transmitters are given in [ETSI-FM]. Note that the spectrum masks are defined for a resolution bandwidth of 1 kHz.

FM spectrum masks are included in the figures for spectrum masks in section 4 as references, respectively. [NOTE: check consistency of used FM spectrum masks]

DRM+

Out-of-Band Emissions

Spectrum masks for DRM+ in VHF band II are given in Figure 1 and Table 22.

Figure 2: Spectrum masks for FM and DRM+ in VHF band II

Table 22: Spectrum masks for FM and DRM in VHF band II

Spectrum mask (100 kHz channel) / relative level for FM			Spectrum mask (100 kHz channel) / relative level for DRM	
Frequency offset [kHz]	Level [dBc]/[1 kHz]		Frequency offset [kHz]	Level [dBc]/[1 kHz]
0	0		0	-20
50	0		50	-20
100	0		60	-50
181.25	-65		181.25	-65
200	-80		200	-80
300	-85		300	-85
400	-85		400	-85
500	-85		400	-90

HD Radio

Out-of-Band Emissions

The out-of-band spectral emission mask for HD Radio transmissions, using a single digital band, is given in *Table 23* and Figure 3 below , in reference to the FM radio broadcast spectral mask, as indicated in the ETSI EN 302 018-1 [8].

Table 23: Out-of-band spectrum mask for HD Radio transmissions in Band II

Frequency Offset [kHz]	**Level [dBc/1 kHz]**
± 50 kHz	-20
± 57.5 kHz	-53
± 100 kHz	-62
± 150 kHz	-90
± 500 kHz	-90

Figure 3: Out-of-band spectrum mask for HD Radio transmissions in Band II

RAVIS

Out-of-Band Emissions

The spectrum mask for RAVIS transmission (for three types of channel bandwidth) compared to spectrum mask for analogue FM (according to ETSI EN 302 018-1) is given in Table 24 and Figure 1.

RAVIS spectrum masks are fitting into analogue FM spectrum mask.

Frequency offset, kHz		Relative level, dBr/kHz		
	Analogue FM	RAVIS, 100 kHz	RAVIS, 200 kHz	RAVIS, 250 kHz
0	0	-20	-20	-20
50	0	-20	-20	-20
70	0	-50	-20	-20
100	0	-70	-20	-20
120			-50	-20
125				-20
145				-50
150			-70	
175				-70
200	-80	-80	-80	-80
300	-85	-85	-85	-85
400	-85	-85	-85	-85

Table 24: Spectrum Mask for RAVIS transmission

[NOTE: missing values will be provided]

Figure 4: Spectrum Mask for RAVIS transmission

Protection Ratios

The values of protection ratios are given as:

Basic protection ratio PR_{basic} for a wanted signal interfered with by an unwanted signal at 50% location probability

Combined location correction factor *CF* as a margin that has to be added to the basic protection ratio for a wanted signal interfered with by an unwanted signal for the calculation of protection ratios at location probability greater as 50%. The formula for the calculation is given in chapter 2.2.8.2.

Corresponding protection ratio *PR(p)* for a wanted digital signal interfered with by an unwanted signal at location probability greater than 50% taking into account the respective location probability of the corresponding reception modes that have higher protection requirements due to the higher location probability to be protected.

Protection Ratios for FM

FM interfered with by DRM

The protection ratios for FM interfered with by DRM are given in Table 25.

Table 25: Protection ratios PR_{basic} for FM interfered with by DRM

Frequency offset	[kHz]	0	± 100	± 200	± 300	± 400
Basic protection ratio	PR_{basic} [dB]	50	38			

[NOTE: the former given protection ratios in the adjacent channels from 200 kHz up to 400 kHz have to be retreated due to different values out of laboratory measurements and field trials.]

FM interfered with by HD Radio

[NOTE: further information is provided and maybe also other explanations are needed as well. The values of the protection ratios of FM interfered with by HD-Radio are given later but should be moved to here]

The protection ratios for FM interfered with by HD-Radio are given in Table 26.

Table 26: Protection ratios PR_{basic} for FM interfered with by HD-Radio

Frequency offset	[kHz]	0	± 100	± 200	± 300	± 400
Basic protection	PR_{basic} [dB]					

FM interfered with by RAVIS

[The protection ratios for FM interfered with by RAVIS are given in Table 27.

Table 27: Protection ratios PR_{basic} for FM interfered with by RAVIS

Frequency offset	[kHz]	0	± 100	± 200	± 300	± 400
Basic protection	PR_{basic} [dB]					

The results of calculation of relative protection ratios taking into account ITU-R Recommendation BS.412-9 [9] are given in the Table 28 (for 200 kHz RAVIS channel bandwidth).

Frequency offset, kHz	0	200	300	400
FM (stereo) interfered by RAVIS, dB	6	-33	-46	-59

Table 28: Relative protection ratios between RAVIS and FM services

Protection Ratios for DRM+

DRM interfered with by DRM

[Why do the figures for PR stop at 200 kHz?]

Table 29: Basic protection ratios PR_{basic} for DRM interfered with by DRM

Frequency offset	[kHz]	0	± 100	± 200
For DRM (4-QAM, *R* = 1/3)	PR_{basic} [dB]	4	-16	-40
For DRM (16-QAM, *R* = 1/2)	PR_{basic} [dB]	10	-10	-34

Table 30: Combined location correction factor *CF* for DRM interfered with by DRM

Location probability *p*		70%	95%	99%
Combined location correction factor **in urban and suburban area**	*CF* [dB]	2.82	8.84	12.50
Combined location correction factor **in rural area**	*CF* [dB]	2.30	7.21	10.20

Table 31: Corresponding protection ratios *PR*(p) to reception modes for DRM (4-QAM, *R* = 1/3) interfered with by DRM

Frequency offset	[kHz]	0	± 100	± 200
Fixed reception (FX)	*PR(p)* [dB]	6.82	-13.18	-37.18
Portable reception (PO, PI, PO-H, PI-H)	*PR(p)* [dB]	12.84	-7.16	-31.16
Mobile reception (MO)	*PR(p)* [dB]	16.50	-3.50	-27.50

Table 32: Corresponding protection ratios *PR*(p) to reception modes for DRM (16-QAM, *R* = 1/2) interfered with by DRM

Frequency offset	[kHz]	0	± 100	± 200
Fixed reception (FX)	*PR(p)* [dB]	12.82	-7.18	-31.18
Portable reception (PO, PI, PO-H, PI-H)	*PR(p)* [dB]	18.84	-1.16	-25.16
Mobile reception (MO)	*PR(p)* [dB]	22.50	2.50	-21.50

DRM interfered with by FM

Table 33: Basic protection ratios *PR*basic for DRM interfered with by FM

Frequency offset	[kHz]	0	± 100	± 200
For DRM (4-QAM, *R* = 1/3)	PR_{basic} [dB]	11	-13	-54
For DRM (16-QAM, *R* = 1/2)	PR_{basic} [dB]	18	-9	-49

Table 34: Combined location correction *CF* factor for DRM interfered with by FM

Location probability *p*		70%	95%	99%
Combined location correction factor **in urban and suburban area**	*CF* [dB]	4.79	15.02	21.24
Combined location correction factor **in rural area**	*CF* [dB]	4.65	14.57	20.61

Table 35: Corresponding protection ratios *PR*(p) to reception modes for DRM (4-QAM, *R* = 1/3) interfered with by FM stereo

Frequency offset	[kHz]	0	± 100	± 200
Fixed reception (FX)	*PR(p)* [dB]	13.82	-10.18	-51.18
Portable reception (PO, PI, PO-H, PI-H)	*PR(p)* [dB]	19.84	-4.16	-45.16
Mobile reception (MO)	*PR(p)* [dB]	23.50	-0.50	-41.50

Table 36: Corresponding protection ratios *PR*(p) to reception modes for DRM (16-QAM, *R* = 1/2) interfered with by FM stereo

Frequency offset	[kHz]	0	± 100	± 200
Fixed reception (FX)	*PR(p)* [dB]	20.82	-6.18	-46.18
Portable reception (PO, PI, PO-H, PI-H)	*PR(p)* [dB]	26.84	-0.16	-40.16
Mobile reception (MO)	*PR(p)* [dB]	30.50	3.50	-36.50

Protection Ratios for HD Radio

HD Radio interfered with by HD Radio

The protection ratio requirements for the wanted digital signal Primary Upper (PU) interfered with by a digital signal PU are provided in Table 37.

Table 37: Protection ratio for HD Radio PU signal interfered with HD Radio PU signal

Frequency offset from Digital signal [kHz]	**0**	**±100**	**±200**	**±300**	**±400**
Digital signal PU interfered by digital signal PU [dB]	8	-18	-50	-67	-67

HD Radio interfered with by FM

[NOTE: further information is provided and maybe also other explanations are needed as well]

Interference to the desired analogue signal may be caused by the partially overlapping digital signal or by the combination of the digital signal and the pre-existing adjacent analogue host signal. The requirements are shown for one digital band Primary Lower (PL), when interfering with the desired analogue signal. The same requirements should be separately applied for an additional digital band PU, when present. Figure 5 illustrates the interfering signal and power adjustments to the digital band. It is shown for explanation only and does not attempt to provide accurate signal levels. Figure 5 demonstrates that while the adjacent analogue host signal may act as a dominating interference on one side of the desired analogue signal, the digital signal power may have noticeable room for adjustments without noticeably further affecting the desired analogue signal.

Figure 5: Illustrated desired analogue signal and scalable digital power Hybrid HD Radio signal to meet protection requirements.

Table 38: Protection ratio for analogue FM interfered with HD Radio PL signal

Digital signal frequency offset [kHz]	**- 150**	**- 50**	**+ 50**	**+ 150**	**+ 250**	**+ 350**
Analogue host frequency offset [kHz]	0	+ 100	+200	+ 300	+ 400	+ 500
FM mono interfered by PL added to analogue host , where the host (only) complies with BS. 412-9 (mono) [dB]	-3	39	33	-3	-20	-40
FM stereo interfered by PL added to analogue host , where the host (only) complies with BS. 412-9 (stereo) [dB]	7	49	43	0	-13	-40
FM stereo interfered by PL only [dB]	0	39	39	0	-13	-40

The protection ratio requirements for analogue FM signal interfered with by HD Radio PL signal, with and without pre-existing analogue host, are provided in Figure 5 For the cases where the digital band (PL) is assumed to be added to a pre-existing interfering analogue host (Hybrid configuration), it is assumed that the interfering analogue signal separately complies with Rec. ITU-R BS.412-9 [9] protection requirements.

Figure 6: Illustrated desired Hybrid signal and analogue signal interference

Interference to the desired digital signal (PU) may be caused by an analogue signal partial overlap. The protection requirements are indicated for one digital band (PU), when interfered by an adjacent analogue signal. The same requirements should be separately applied for an additional digital band (PL), when present. Figure 6 is shown for explanation only and does not attempt to provide accurate signal levels. Figure 6 demonstrates that the placement of the desired digital signal, which is independent of the actual presence of the desired analogue host, allows the interfering analogue signal to only partially overlap with that digital signal.

Frequency offset from Digital signal [kHz]	**- 150**	**- 50**	**+ 50**	**+ 150**	**+ 250**	**+ 350**
Frequency offset from Analogue host [kHz]	0	+ 100	+200	+ 300	+ 400	+ 500
Digital signal PU interfered by FM (stereo) analogue signal [dB]	-33	10	10	-33	-60	-60

Table 39: Protection ratio for HD Radio PU signal interfered by analogue signal

The protection ratio requirements for digital signal (PU) interfered with by analogue FM signal, are provided in Table 39.

Protection Ratios for RAVIS

[NOTE : information on other bandwidth will be provided later]

RAVIS interfered with by RAVIS

Intra-service protection ratios for RAVIS (200 kHz channel bandwidth) are given in Table 40.

Frequency offset, kHz	0	200	300	400
RAVIS with QPSK modulation interfered by RAVIS, dB	8	-12	-54	-57
RAVIS with 16-QAM modulation interfered by RAVIS, dB	14	-6	-48	-51

Table 40: Protection ratios between RAVIS services for 200 kHz channel bandwidth

RAVIS interfered with by FM

Inter-service protection ratios for RAVIS (200 kHz channel bandwidth) and analogue FM are given in Table 41.

Frequency offset, kHz	0	200	300	400
RAVIS with QPSK modulation interfered by FM (stereo) , dB	13	-11	-54	-57
RAVIS with 16-QAM modulation interfered by FM (stereo) , dB	18	-9	-48	-51
FM (stereo) interfered by RAVIS, dB				

Table 41: Protection ratios between RAVIS and FM services

Sharing Criteria with Other Services

Sharing Criteria with Aeronautical Radionavigation Services above 108.0 MHz

DRM

Above the VHF band II broadcasting band, aeronautical radio navigation services are located. The interference potential of a DRM signal into these services is not higher than the one of FM signals. [need a link to the evidence]

HD Radio

HD Radio signal in VHF band II allows for the co-existence with aeronautical services above VHF band II. Details for co-existence with VOR and ILS services are provided.

Radio Signal and VOR Reception

The interference caused by HD Radio signal to VOR reception is assumed to similar to or less than the interference caused by analogue FM signals. [need a link to the evidence] However, there is a potential for some exceptions to that assumption. In order to mitigate these potential exceptions, the following guidelines are proposed:

In an area of expected reception of VOR signal operated at 108.0 MHz, the use of HD Radio digital band PU in combination with the analogue host is not recommended, when the radio signal host frequency is above 107.7 MHz.

In an area of expected reception of VOR signal operated at 108.2 MHz, the use of HD Radio digital band PU at power level > -21 dBc (relative to the host) in combination with the analogue host is not recommended, when the radio signal host frequency is 107.9 MHz.

HD Radio Signal and ILS Reception

The interference caused by HD Radio signal to ILS reception is assumed to be similar to or less than the interference caused by analogue FM signals. However, there is a potential for exceptions to that assumption. In order to mitigate these potential exceptions, the following guidelines are proposed:

In an area of expected reception of ILS signal operated at 108.1 MHz, the use of HD Radio digital band PU in combination with the analogue host is not recommended, when the radio broadcast host frequency is at 107.9 MHz.

It is noted that the guidelines above are expected to have minimal affect on planning consideration, due to the ILS operation procedures. These procedures are normally limited to a distance of 30 km from the ILS transmitter, at a radial of 5 degrees.

RAVIS

The potential interference from RAVIS to the aeronautical radionavigation services in the band above 108.0 MHz is not higher as the one of analogue FM service. [need a link to the evidence]

Sharing Criteria with Land Mobile Services below 87.5 MHz

[Need a link to the evidence for the claims below – that digital signals into other services is not higher than the one of FM signals]

DRM

Below the VHF band II broadcasting band, land mobile services with security tasks are located. The interference potential of a DRM signal into these services is not higher than the one of FM signals.

HD Radio

HD Radio signal in VHF band II allows co-existence with Land Mobile services below VHF band II. The interference caused by HD Radio signal to such services is assumed to be similar to or

less than the interference caused by analogue FM signals. However, there is a potential for some exceptions to that assumption. In order to mitigate these potential exceptions, the following guidelines are proposed:
In an area of expected reception of land mobile services operated at 87.3 MHz to 87.5 MHz, the use of HD Radio digital band PL in combination with the analogue host is not recommended, when the radio signal host frequency is at 87.6 MHz.
RAVIS
The potential interference from RAVIS to the land mobile services in the band below 87.5 MHz is not higher as the one of analogue FM service.

[ITU-GE06]
[ITU-GE84]

Calculation of the Antenna Gain for Portable Handheld Reception (PO-H, PI-H)

The antenna (linear) gain g in Band II can be calculated from the product of directivity d and efficiency η.
(7)
For lossless antennas the efficiency equals one and the gain equals the directivity.
Handheld portable reception antennas are very lossy, and therefore the gain is much lower than directivity. They are also short linear antennas, with small dimensions compared to wavelength, and have a constant directivity of about 1.5 (1.8 dBi or 0.4 dBd). The gain changes with frequency only due to efficiency.
To estimate the efficiency change with frequency a transmitting antenna is considered. That leads to the values for a receiving antenna also, because antennas are reciprocal; their directivity, efficiency and gain are the same as receiving or transmitting antenna.
To transfer the maximum energy from a port to an antenna or vice versa the antenna has to be matched to the port impedance. A matched antenna has an equivalent series circuit with radiation resistance R_r, antenna loss resistance and a matching circuit loss resistance. We consider the reactive part of the serial impedance as zero. The radiation resistance is small and the transmitted energy is dissipated mostly in the antenna loss resistance and the matching circuit. Only the energy in R_r is radiated. Combining all losses in R_L the antenna efficiency:
(8)
R_r can be neglected in the denominator, because R_r is much lower than R_L.
For the antenna length l << λ the radiation resistance magnitude is proportional to the square of the antenna length l relative to wavelength λ:
(9)
where λ was substituted by c/f, with c the light velocity.
If the antenna dimension is not changed, and it is considered that the losses in the antenna and the matching circuit does not change significantly in the frequency range of interest, the efficiency η_2 at a frequency f_2, compared to the efficiency η_1 at a frequency f_1, changes as follows:
= (10)
The same is true for the gain G [dB], since the directivity does not change.
Changing the frequency from f_1 to f_2 the gain changes with:
) [dB] (11)

Feeder Loss Calculation

The feeder loss L_f for fixed reception at 200 MHz is given in with 2 dB for 10 m cable length. The frequency dependent cable attenuation per unit length L'_f is given by the following equation:
(12)
with f as the respective frequency in [MHz].
The feeder loss value per unit length L'_f for 100 MHz is given in .

Table **Error! No text of specified style in document.**42
Feeder loss L'f per unit length

Feeder loss per unit length L_f	[dB/m]	0.14

The feeder loss L_f is given by
(13)
with l as the length of the feeder cable in [m].

calculation of man made noise for fixed, portable and mobile reception

The system equivalent noise figure F_s [dB] to be used for coverage calculations is calculated from the receiver noise figure F_r [dB] and MMN [dB]:
(14)
The allowance for man-made noise is calculated from an antenna noise factor f_a, which takes into account the man-made noise received by the antenna:
(15)
where f_r is the receiver noise factor:
(16)
and f_a is the antenna noise factor:
(17)
where F_a is the antenna noise figure.

The definition of the antenna noise figure and its mean values $F_{a,med}$ measured in rural, suburban and urban regions as a function of the frequency are given in [10]. The equation to calculate the antenna noise figure in suburban (residential) regions is given in [10] by:
(18)

Changing the frequency from f_1 to f_2, the antenna noise figure changes with:
(19)

CALCULATION OF MAN-MADE NOISE FOR PORTABLE HANDHELD RECEPTION

The lowest realistic directivity is the one of a short dipole (length l << λ) and it has the value 1.5 (1.8 dB_i). Any gain lower than 1.8 dBi (-0.4 dBd) is due to an antenna efficiency η lower than 1. The interference power at the receiver input is reduced accordingly and the MMN equation is:
(20)
The efficiency η can be calculated from the antenna gain G_D [dB], for gains lower than -0.4 dBd:

Calculation of Minimum Median Field Strength Level

According to [ITU GE06] the following steps have to be followed in order to calculate the minimum median field strength.

1. Determine the receiver noise input power level P_n

(21)
with: F: Receiver noise figure [dB]
k: Boltzmann's constant, $k = 1.38\ 10^{-23}$ [J/K]
T_0: Absolute temperature [K]
B: Receiver noise bandwidth [Hz]

2. Determine the minimum receiver input power level $P_{s,min}$

(22)

with: $(C/N)_{min}$: Minimum carrier-to-noise ratio at the DRM decoder input in [dB]

3. Determine the minimum power flux-density (i.e. the magnitude of the Poynting vector) at receiving place ϕ_{min}

(23)

with: A_a: Effective antenna aperture in [dBm^2]

L_f: Feeder loss in [dB]

4. Determine the minimum RMS field strength level at the location of the receiving antenna E_{min}

(24)

with , the characteristic impedance in free space, (25)

resulting in

(26)

5. Determine the minimum median RMS field strength level E_{med}

For the different receiving scenarios the minimum median RMS field strength is calculated as follows:

for fixed reception: $E_{med} = E_{min} + P_{mmn} + C_l$ (27)

for portable outdoor and mobile reception: $E_{med} = E_{min} + P_{mmn} + C_l + L_h$ (28)

for portable indoor reception: $E_{med} = E_{min} + P_{mmn} + C_l + L_h + L_b$ (29)]

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