International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.9964

Amendment 3

(02/2020)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Access networks – In premises networks

Unified high-speed wireline-based home networking transceivers – Power spectral density specification

Amendment 3

Recommendation ITU-T G.9964 (2011) – Amendment 3

International Telecommunication Union

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999
Metallic access networks	G.9700–G.9799
Optical line systems for local and access networks	G.9800–G.9899
In premises networks	**G.9900–G.9999**

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.9964

Unified high-speed wireline-based home networking transceivers – Power spectral density specification

Amendment 3

Summary

Recommendation ITU-T G.9964 specifies the control parameters that determine spectral content, power spectral density (PSD) mask requirements, a set of tools to support reduction of the transmit PSD, means to measure this PSD for transmission over telephone wiring, power line wiring and coaxial cable, as well as the allowable total transmit power into a specified termination impedance. It complements the system architecture and physical layer (PHY) specification in Recommendation ITU-T G.9960, and the data link layer (DLL) specification in Recommendation ITU-T G.9961, as well as the modifications and additions to these Recommendations specifying the multiple input/multiple output (MIMO) home networking transceiver in Recommendation ITU-T G.9963.

Amendment 1 adds support for a new profile for 200 MHz baseband coaxial.

Amendment 2 contains the specification of spectral content for 200 MHz OFB for telephone lines.

Amendment 3 includes the extension of the Recommendation to operate on an extended bandwidth over coaxial and phoneline mediums.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.9964	2011-12-16	15	11.1002/1000/11406
1.1	ITU-T G.9964 (2011) Amd. 1	2016-02-26	15	11.1002/1000/12579
1.2	ITU-T G.9964 (2011) Amd. 2	2016-09-30	15	11.1002/1000/12843
1.3	ITU-T G.9964 (2011) Amd. 3	2020-02-07	15	11.1002/1000/14029

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

		Page
1	Scope	1
2	References	1
3	Definitions	2
4	Abbreviations and acronyms	3
5	Transmit PSD mask	3
5.1	Sub-carrier masking	4
5.2	Power spectral density shaping	4
5.3	Notching of international amateur radio bands	5
5.4	Power spectral density ceiling	5
5.5	Notching of VDSL2 bands	6
6	Medium-dependent specification of spectral content	6
6.1	Specification of spectral content for telephone lines	6
6.2	Specification of spectral content for power lines	10
6.3	Specification of spectral content for coax	12
6.4	Termination impedance	17
6.5	Total transmit power	17
6.6	Receiver input impedance	18
Annex A		19
Annex B		20
Annex C		21
Annex D – International amateur radio bands		22
Annex E – Impact of ITU-T G.9960 on VDSL2 service		23
Appendix I – Additional radio frequency bands		24
Bibliography		26

Recommendation ITU-T G.9964

Unified high-speed wireline-based home networking transceivers – Power spectral density specification

Amendment 3

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.9964 (2011) plus Amendments 1 and 2.

1 Scope

This Recommendation specifies the control parameters that determine spectral content, power spectral density (PSD) mask requirements, a set of tools to support reduction of the transmit PSD, means to measure this PSD for transmission over telephone wiring, power line wiring and coaxial cable, as well as the allowable total transmit power into a specified termination impedance. It complements the system architecture and physical layer (PHY) specification in [ITU-T G.9960], and the data link layer (DLL) specification in [ITU-T G.9961] as well as the modifications and additions to these Recommendations specifying the multiple input/multiple output (MIMO) home networking transceiver in [ITU-T G.9963].

Amendment 1 adds support for a new profile for 200 MHz baseband coaxial.

Amendment 2 contains the specification of spectral content for 200 MHz OFB for telephone lines.

Amendment 3 includes the extension of the Recommendation to operate on an extended bandwidth over coaxial and phoneline mediums.

For the Profile 2 LPM on telephone lines, in the case where transmission is not limited to networks with increased shielding, such as those with shielded cables or where cables are buried underground, conformance of equipment with this Recommendation may not ensure compliance with specific national or regional regulation on electromagnetic compatibility when installations are taken into service.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.9960] Recommendation ITU-T G.9960 (2018~~1~~), *Unified high-speed wireline-based home networking transceivers – System architecture and physical layer specification.*

[ITU-T G.9961] Recommendation ITU-T G.9961 (2018~~0~~), *Unified high-speed wireline-based home networking transceivers – Data link layer specification*.

[ITU-T G.9963] Recommendation ITU-T G.9963 (2018~~1~~), *Unified high-speed wireline-based home networking transceivers – Multiple input/multiple output specification*.

3 Definitions

This Recommendation defines the following terms:

3.1 ~~*reserved* **bandplan**: A specific range of the frequency spectrum that is associated with only one domain. Multiple bandplans may be used in the same domain provided that any bandplan is either a subset or a superset of all other bandplans in the same domain. The bandplan is defined by a lower frequency and upper frequency except for radio frequency (RF), which is defined by a bandwidth and centre frequency.~~

3.2 **baseband**: A frequency band defined by an up-convert frequency FUC = 0 and an up-shift frequency FUS = FSC×N/2 (see Table 7-67 of [ITU-T G.9960]).

3.3 **domain**: A part of an ITU-T G.9960 home network comprising the domain master and all those nodes that are registered with the same domain master. In the context of this Recommendation, use of the term "domain" without a qualifier means "ITU-T G.9960 domain", and use of the term "alien domain" means "non-ITU-T G.9960 domain". Additional qualifiers (e.g., "power-line") may be added to either "domain" or "alien domain".

3.4 **domain master (DM)**: A node supporting the domain master functionality that manages (coordinates) all other nodes of the same domain (i.e., assigns bandwidth resources and manages priorities). Only one active domain master is allowed in a domain, and all nodes within a domain are managed (coordinated) by a single domain master. If a domain master fails, another node of the same domain, capable of operating as a domain master, should pick up the function of the domain master.

3.5 **home network**: Two or more nodes that can communicate with each other either directly or through a relay node at the physical layer, or through an inter-domain bridge above the physical layer. A home network consists of one or more domains. In the context of this Recommendation, use of the term "home network" means "ITU-T G.9960 home network". Use of the term "alien home network" means "non-ITU-T G.9960 home network". Use of the term "network" without a qualifier means any combination of "ITU-T G.9960 home network", "non-ITU-T G.9960 home network" and "access network". Use of the term "alien network" means any combination of "non-ITU-T G.9960 home network" and "access network".

3.6 **medium**: A wire-line facility, of a single wire class, allowing physical connection between nodes. Nodes connected to the same medium may communicate on the physical layer, and may interfere with each other unless they use orthogonal signals (e.g., different frequency bands, different time periods).

3.7 **node**: Any network device that contains an ITU-T G.9960 transceiver. In the context of this Recommendation, use of the term "node" without a qualifier means "ITU-T G.9960 node", and use of the term "alien node" means "non-ITU-T G.9960 node". Additional qualifiers (e.g., "relay") may be added to either "node" or "alien node".

3.7.1 **OFB profile**: Categorization of OFBs depending on the PHY frame format they use. Profile 1 OFBs use a normal PHY frame format for transmission of frames; Profile 2 OFBs use a high capacity header (HCH) PHY frame format for transmission of frames.

3.7.2 **operational frequency band (OFB)**: Range of frequencies that is allowed to be used by a node to communicate with another node of the domain.

3.8 **passband**: A frequency band defined by an up-convert frequency FUC = 0 and an up-shift frequency FUS >> FSC×N/2 (see Table 7-67 of [ITU-T G.9960])).

3.9 **radio frequency (RF)**: A frequency band defined by an up-convert frequency FUC > 0 and a centre frequency FC = FUC + FUS >> FSC×N/2 (see Tables 7-67 and 7-68 of [ITU-T G.9960]).

3.10 **sub-carrier (OFDM sub-carrier)**: The centre frequency of each OFDM sub-channel onto which bits may be modulated for transmission over the sub-channel.

3.11 sub-channel (OFDM sub-channel): A fundamental element of OFDM modulation technology. The OFDM modulator partitions the channel bandwidth into a set of parallel sub channels.

3.12 wire class: One of the classes of wire, having the same general characteristics: coaxial cable, home electrical-power wire, phone-line wire and Category 5 cable.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BB	BaseBand
CB	Coax Baseband
CRF	Coax Radio Frequency
DM	Domain Master
LPM	Limit PSD Mask
OFB	Operational Frequency Band
OFDM	Orthogonal Frequency Division Multiplexing
PB	Power-line Baseband
PHY	Physical Layer
PSD	Power Spectral Density
PSDC	PSD Ceiling
PSM	PSD Shaping Mask
RF	Radio Frequency
RPM	Regional PSDM Mask
SM	Sub-carrier Mask

5 Transmit PSD mask

Transmit PSD mask (TxPSD) is determined by a sub-carrier mask (SM), a PSD shaping mask (PSM), a notching of international amateur radio bands defined in this clause, the limit PSD mask (LPM) defined for each particular medium, and a regional PSD mask (RPM) if specified in a regional annex (see [ITU-T G.9960]). The same TxPSD shall be applied to all nodes in the domain.

For an ITU-T G.9960 transceiver, the PSD of the transmit signal at any frequency shall never exceed the transmit PSD mask. For an ITU-T G.9963 transceiver, the sum of PSDs of the two transmit signals transmitted from the two Tx ports at any frequency shall never exceed the TxPSD. The PSD of the transmit signal may be further limited by a PSD ceiling (PSDC) that is applied to nodes involved in a particular connection (clause 5.4).

The LPM (see clauses 6.1.2, 6.2.2 and 6.3.2) specifies the absolute limit of the transmit PSD. However, if an RPM is specified for a particular region, the absolute limit shall be the minimum level between the LPM and RPM at any given frequency. The SM, PSDC, and PSM provide further reduction and shaping of the transmit PSD using three mechanisms: sub-carrier masking (notching), PSD ceiling (limit on PSD level), and PSD shaping.

ITU-T G.9960 and ITU-T G.9963 transceivers shall support sub-carrier masking, notching of international amateur radio bands, and PSD ceiling. Support of PSD shaping is optional.

The transmit PSD mask shall comply with national and regional regulatory requirements.

The LPM is defined based on the assumption that measurements are made using equipment conforming to [b-IEC CISPR 16-1] specifications using an RMS detector with a "maximum hold" function and using a resolution bandwidth of 9 kHz for frequencies below 30 MHz and 120 kHz for frequencies above 30 MHz. In order to conform to [b-IEC CISPR 22] and make reliable measurements, ITU-T G.9960 transceivers shall be active at least 10% of the time and sustain the transmit power level for a minimum of 250 ms.

NOTE – In addition to the mechanisms described in this clause that provide absolute limits to the transmit PSD (both in-band and out-of-band), this Recommendation defines a mechanism of PSD ceiling that allows dynamic reduction of the transmit power for each particular connection to the minimum value that is sufficient to achieve the given QoS targets.

5.1 Sub-carrier masking

Sub-carrier masking shall be used to eliminate transmission on one or more sub-carriers. Sub-carrier masking is defined by a sub-carrier mask (SM). The transmit power of sub-carriers specified in SM shall be set to zero (linear scale). The SM shall override all other instructions related to the transmit power of the sub-carrier.

The SM is defined as a number of masked frequency bands. Each band is specified by a start sub carrier index *(x_L)* and a stop sub-carrier index (x_H), as $\{x_L, x_H\}$. An SM including *S* bands can be represented in the following format:

$$SM(S) = [\{x_{L1}, x_{H1}\}, \{x_{L2}, x_{H2}\}, \ldots \{x_{LS}, x_{HS}\}]$$

All sub-carriers within the band, i.e., with indices higher than or equal to xL and lower than or equal to xH, shall be switched off (transmitted with zero power).

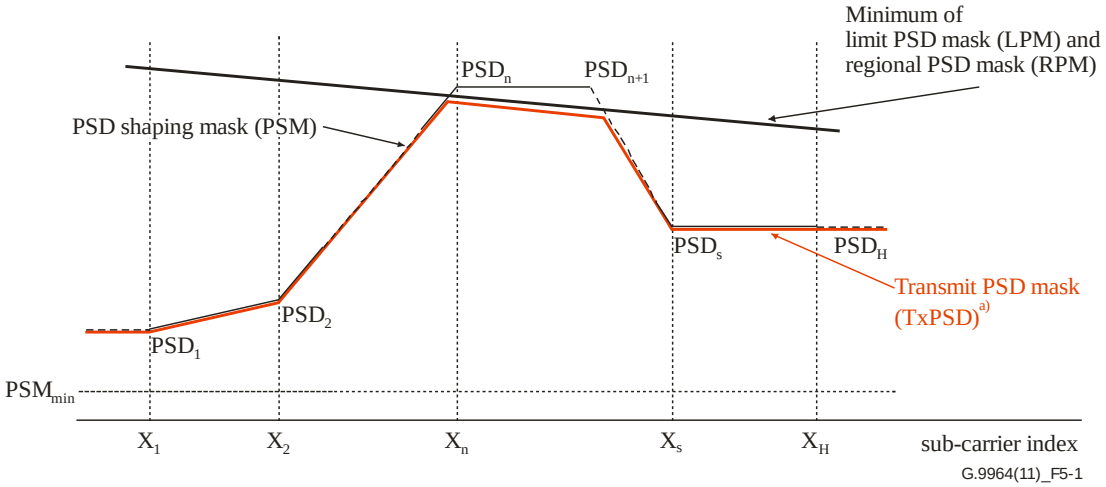
International amateur radio bands (see Annex D) are not a part of the SM. The node shall be capable of turning off one or more amateur radio bands.

NOTE – The SM is intended to incorporate masked sub-carriers that are defined by the regional annex to comply with local regulations, and masked sub-carriers that are defined by the user or service provider to facilitate local deployment practices.

5.2 Power spectral density shaping

Power spectral density (PSD) shaping allows transmit reduction of PSD in some parts of the spectrum, mainly for spectrum compatibility and coexistence with alien home network technologies. PSD shaping is specified by a PSD shaping mask (PSM).

PSM is defined on the frequency range between the lowest sub-carrier x_1 and the highest sub-carrier x_H, and consists of one or more frequency segments. The boundaries of the segments are defined by set breakpoints. Inside each segment, the PSD may either be constant or form a linear slope between the given PSD points (in dBm/Hz) with the frequency expressed in a linear scale, Figure 5-1.



a)Sub-carrier mask (SM) is not shown in this figure.

Figure 5-1 – Construction of transmit PSD mask

Each breakpoint of PSM is specified by a sub-carrier index x_n and a value of PSD_n at that sub carrier expressed in dBm/Hz, $\{x_n, PSD_n\}$. PSD_1 shall also apply to sub-carriers below $x1$ and PSD_H shall also apply to sub-carriers above xH. A PSM including S segments can be represented by (S+1) breakpoints in the following format:

$$PSM(S) = [\{x_1, PSD_1\}, \{x_2, PSD_2\} \ldots \{x_S, PSD_S\}, \{x_H, PSD_H\}]$$

A node supporting PSD shaping shall support up to 32 PSM breakpoints.

The maximum steepness of PSM slopes is for further study.

If one or more PSM breakpoints are set above the LPM or regional PSD mask (RPM), the transmit PSD mask shall be set to: TxPSD = min(PSM, LPM, RPM). All values of PSD_n of PSM breakpoints shall be set above PSM_{min}. The value of PSM_{min} shall not be more than 30 dB below the peak of the PSD shaping mask.

NOTE – PSM breakpoints do not have any relation with SM breakpoints; SM and notched international amateur radio bands always override the PSM if defined over the same indices.

5.3 Notching of international amateur radio bands

If an amateur radio band is masked, the sub-carriers with frequencies $(F_{AL} - F_{SC}) \leq f \leq (F_{HL} + F_{SC})$, where F_{AL} and F_{HL} are the low and the high frequency of the amateur radio band, as defined in Annex D, shall be turned off (zero power transmitted). In addition, for any node operating over a telephone line or power line, the PSD of the transmitted signal in all international amateur radio bands that are masked in the particular domain shall be at –85 dBm/Hz or lower.

The PSD slopes forming a notch are vendor discretionary.

5.4 Power spectral density ceiling

The PSD ceiling (PSDC) specifies the PSD level that is used to impose a limit (i.e., a ceiling function) on the transmit signal. The PSDC is independent of frequency and indicated by a single value in dBm/Hz. The valid range of PSDC values is from −50 dBm/Hz to −100 dBm/Hz in steps of 2 dB.

The PSDC shall be supported by all ITU-T G.9960 transceivers.

5.5 Notching of VDSL2 bands

Any node operating over a telephone line, coax, or power line, shall be able to reduce the PSD of the transmitted signal in one or more VDSL2 frequency bands to the levels appropriate for reliable transmission of VDSL2 signals, as defined in Annex E.

6 Medium-dependent specification of spectral content

6.1 Specification of spectral content for telephone lines

6.1.1 Control parameters

Table 6-1 shows the valid OFDM control parameters for various ~~bandplans~~ OFBs defined in telephone lines. The parameters are defined in [ITU-T G.9960].

Table 6-1 – OFDM control parameters for telephone lines

Domain type	**Telephone-line ~~baseband~~ (Note 5)**			
~~Bandplan name~~/OFB name	**Profile 1**			**Profile 2 (Note 6)**
	50 MHz-TB (Note 2)	**100 MHz-TB (Note 3)**	**200 MHz-TB (Note 4)**	
Minimum operational frequency	0 MHz	0 MHz	0 MHz	OF_{MIN}
Maximum operational frequency	50 MHz	100 MHz	200 MHz	OF_{MAX}
N	1024	2048	4096	$(OF_{MAX} - OF_{MIN})/F_{SC}$
F_{SC}	48.828125 kHz	48.828125kHz	48.828125 kHz	48.828125 kHz
S (Sampling frequency)	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$
N_{GI}	$N/32 \times k$ for k = 1,…,8 samples @ ~~50~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ ~~100~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ S~~200~~ Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ S Msamples/s
$N_{GI\text{-}HD}$	$N/4$ = 256 samples @ ~~50~~ S Msamples/s	$N/4$ = 512 samples @ ~~100~~ S Msamples/s	$N/4$ = 1024 samples @ ~~200~~ S Msamples/s	$N/4$ samples @ S Msamples/s
$N_{GI\text{-}DF}$	$N/4$ = 256 samples @ ~~50~~ S Msamples/s	$N/4$ = 512 samples @ ~~100~~ S Msamples/s	$N/4$ = 1024 samples @ ~~200~~ S Msamples/s	$N/4$ samples @ S Msamples/s
β	$N/32$ = 32 samples @ ~~50~~ S Msamples/s	$N/32$ = 64 samples @ ~~100~~ S Msamples/s	$N/32$ = 128 samples @ ~~200~~ S Msamples/s	$N/32$ samples @ S Msamples/s
F_{US}	25 MHz	50 MHz	100 MHz	$(OF_{MAX} - OF_{MIN})/2$
F_{UC}	0 MHz	0 MHz	0 MHz	OF_{MIN}
Sub-carrier indexing rule (Note 1)	Rule #1	Rule #1	Rule #1	Rule #1
NOTE 1 – See clause 7.1.4.1 of [ITU-T G.9960] for more details on sub-carrier indexing rules.				

Table 6-1 – OFDM control parameters for telephone lines

NOTE 2 – The range of sub-carrier frequencies is between 0 and 50 MHz.
NOTE 3 – The range of sub-carrier frequencies is between 0 and 100 MHz.
NOTE 4 – The range of sub-carrier frequencies is between 0 and 200 MHz.
NOTE 5 – Telephone-line baseband profile is also applicable to any other pair-based copper cable (e.g., Cat5)
NOTE 6 – OFMAX and OFMIN correspond to the maximum and minimum frequency that may be used during a Profile 2 OFB transmission. OFMAX – OFMIN shall be a multiple of 50 MHz

6.1.2 PSD mask specifications over telephone lines

The limit PSD mask (LPM) for operation over telephone lines (~~bandplans~~ 50 MHz-TB, 100 MHz-TB and 200 MHz-TB OFBs) shall be as presented in Figure 6-1 for ~~bandplans~~ 50 MHz-TB and 100 MHz-TB OFBs ~~and~~, Figure 6-1.1 for ~~bandplan~~ 200 MHz-TB OFB and Figure 6-1.2 for Profile 2 OFBs, with the values of frequencies f_L-f_H as presented in Tables 6-2 and 6-3.

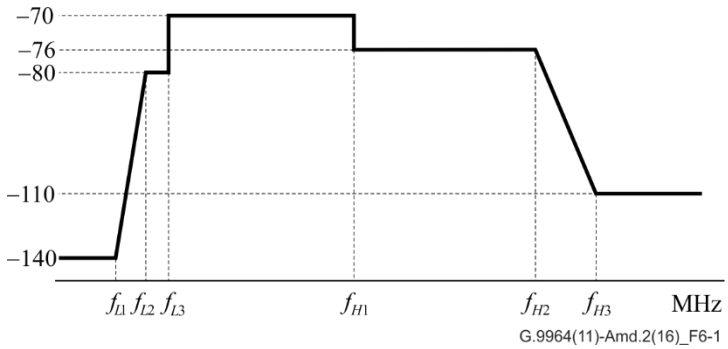


Figure 6-1 – Limit PSD mask for transmission over telephone lines (amateur radio-band notches are not shown)

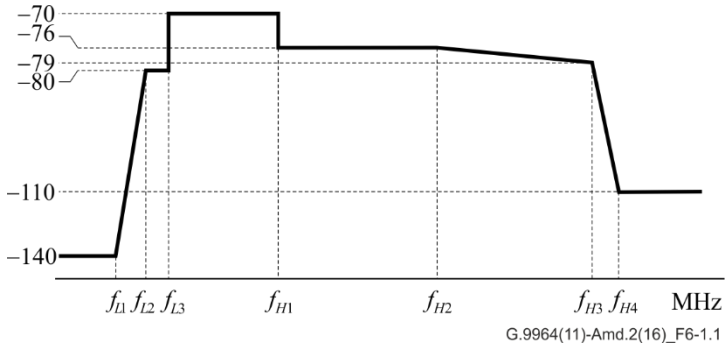


Figure 6-1.1 – Limit PSD mask for transmission over telephone lines (amateur radio-band notches are not shown)

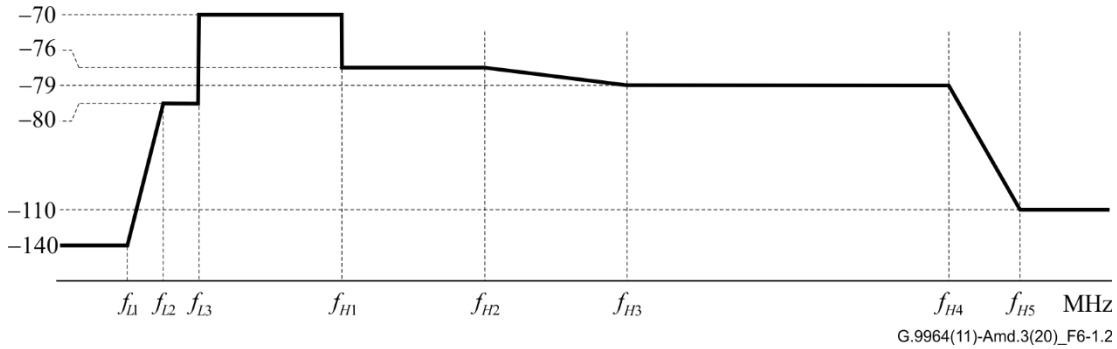


Figure 6-1.2 – Limit PSD mask for transmission over telephone lines (amateur radio-band notches are not shown)

The values of frequency spectrum parameters for 50 MHz-TB, 100 MHz-TB, ~~and~~ 200 MHz-TB and Profile 2 OFBs ~~are~~ are presented in Tables 6-2, 6-3, ~~and~~ 6-3.1 and 6-3.2, respectively. Intermediate points between those defined in Figures 6-1, ~~and~~ 6-1.1 and 6-1.2 shall be obtained by linear interpolation (in dB over linear frequency scale).

Table 6-2 – Parameters of limit PSD mask for the 50 MHz-TB ~~bandplan~~OFB

Parameters	Frequency, MHz	PSD, dBm/Hz	Note/Description
f_{L1}	1.7	−140	Provides protection of splitter-less ADSL
f_{L2}	3.5	−80	Coincides with the amateur radio band
f_{L3}	4.0		
$f_{L3} + \Delta F$	4.0 + ΔF	−70	ΔF is an arbitrary small positive value
$f_{H1} - \Delta F$	30 – ΔF	−70	ΔF is an arbitrary small positive value
f_{H1}	30	−76	
f_{H2}	50		
f_{H3}	60	−110	
NOTE – Sub-carriers above $f_{H2} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

Table 6-3 – Parameters of limit PSD mask for the 100 MHz-TB ~~bandplan~~OFB

Parameters	Frequency, MHz	PSD, dBm/Hz	Note/Description
f_{L1}	1.7	−140	Provides protection of splitter-less ADSL
f_{L2}	3.5	−80	Coincides with the amateur radio band
f_{L3}	4.0		
$f_{L3} + \Delta F$	4.0 + ΔF	−70	ΔF is an arbitrary small positive value
$f_{H1} - \Delta F$	30 – ΔF	−70	ΔF is an arbitrary small positive value
f_{H1}	30	−76	
f_{H2}	100		
f_{H3}	120	−110	
NOTE – Sub-carriers above $f_{H2} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

Table 6-3.1 – Parameters of limit PSD mask for the 200 MHz-TB ~~bandplan~~OFB

Parameters	Frequency, MHz	PSD, dBm/Hz	Note/Description
f_{L1}	1.7	−140	Provides protection of splitter-less ADSL
f_{L2}	3.5	−80	Coincides with the amateur radio band
f_{L3}	4.0		
$f_{L3} + \Delta F$	4.0 + ΔF	−70	ΔF is an arbitrary small positive value
$f_{H1} - \Delta F$	30 – ΔF	−70	ΔF is an arbitrary small positive value
f_{H1}	30	−76	
f_{H2}	100		
f_{H3}	200	−79	
f_{H4}	240	−110	
NOTE – Sub-carriers above $f_{H2} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

Table 6-3.2 – Parameters of limit PSD mask for Profile 2 OFBs

Parameters	Frequency, MHz	PSD, dBm/Hz	Note/Description
f_{L1}	1.7	−140	Provides protection of splitter-less ADSL
f_{L2}	3.5	−80	Coincides with the amateur radio band
f_{L3}	4.0		
$f_{L3} + \Delta F$	4.0 + ΔF	−70	ΔF is an arbitrary small positive value
$f_{H1} - \Delta F$	30 – ΔF	−70	ΔF is an arbitrary small positive value
f_{H1}	30	−76	
f_{H2}	100		
f_{H3}	200	−79	
f_{H4}	400	−79	
f_{H5}	480	−110	
NOTE – Sub-carriers above $f_{H2} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

NOTE 1 – When additional spectrum shaping is used as described in clause 5.2 (e.g., to provide spectrum compatibility, comply with wide-band power limit, or other), various parts of this PSD mask could be reduced by switching sub-carriers off or reducing their transmit power. Additional frequency notches may be applied if required.

NOTE 2 – VDSL2 is usually deployed using a service splitter ([b-ITU-T G.993.2] does not encourage splitterless VDSL2 installations). This allows the use of the ITU-T G.9960 spectrum down to f_{L3}. If splitterless VDSL2 is used, the low frequency of the ITU-T G.9960 spectrum shall be moved up and set above the upper downstream sub-carrier of VDSL2.

See clause 7.2.1 of [ITU-T G.9960] for further physical layer specification of operation over telephone lines.

6.1.3 Permanently masked sub-carriers

Sub-carriers 0-72 (inclusive) shall be permanently masked over telephone lines. They shall not be used for transmission (neither data nor any auxiliary information).

6.2 Specification of spectral content for power lines

6.2.1 Control parameters

Table 6-4 shows the valid OFDM control parameters for various ~~bandplans~~ OFBs defined in power lines. The parameters are defined in [ITU-T G.9960].

Table 6-4 – OFDM control parameters for power lines

Domain type	**Power-line baseband**		
~~**Bandplan**~~ **OFB name** ~~**Parameter**~~	**Profile 1**		
	25 MHz – PB (Note 3)	50 MHz – PB (Note 3)	100 MHz – PB (Note 3)
N	1024	2048	4096
F_{SC}	24.4140625 kHz	24.4140625 kHz	24.4140625 kHz
N_{GI}	$N/32 \times k$ for k = 1,…,8 samples @ 25 Msamples/s	N/32 × k for k = 1,…,8 samples @ 50 Msamples/s	N/32 × k for k = 1,…,8 samples @ 100 Msamples/s
$N_{GI\text{-}HD}$	N/4 = 256 samples @ 25 Msamples/s	N/4 = 512 samples @ 50 Msamples/s	N/4 = 1024 samples @ 100 Msamples/s
$N_{GI\text{-}DF}$	N/4 = 256 samples @ 25 Msamples/s	N/4 = 512 samples @ 50 Msamples/s	N/4 = 1024 samples @ 100 Msamples/s
β	N/8 = 128 samples @ 25 Msamples/s	N/8 = 256 samples @ 50 Msamples/s	N/8 = 512 samples @ 100 Msamples/s
F_{US}	12.5 MHz	25 MHz	50 MHz
F_{UC}	0 MHz	0 MHz	0 MHz
Sub-carrier indexing rule (Note 1)	Rule #1	Rule #1	Rule #1
NOTE 1 – See clause 7.1.4.1 for more details on sub-carrier indexing rules. NOTE 2 – The 25 MHz, 50 MHz and 100 MHz ~~bandplans~~ OFBs may be used by nodes operating in the same power-line baseband domain. NOTE 3 – The range of sub-carrier frequencies is between 0 and 2×F_{US} MHz.			

6.2.2 PSD mask specifications over power lines

The baseband limit PSD masks for operation over power lines shall be as presented in Figure 6-2 for the 25 MHz-PB, 50 MHz-PB and 100 MHz-PB with the values of frequencies fL-fH as presented in Table 6-5.

NOTE 1 – PSD levels may be further limited by EMC regulatory requirements.

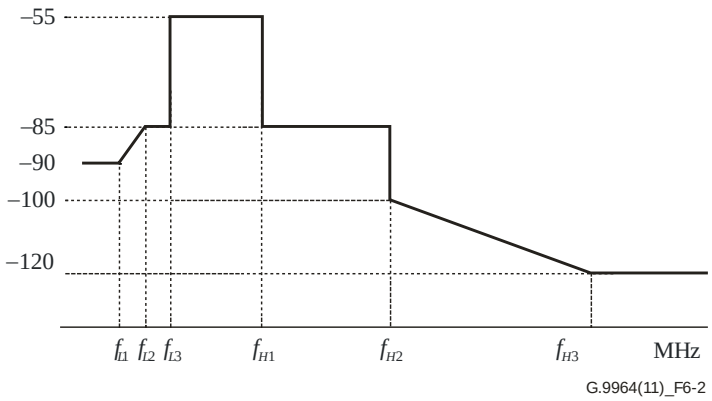


Figure 6-2 – Limit PSD mask for baseband transmission over power lines for 25 MHz-PB, 50 MHz-PB and 100 MHz-PB ~~bandplans~~ OFBs (amateur radio-band notches are not shown)

The values of frequency spectrum parameters for 25 MHz-PB, 50 MHz-PB and 100 MHz-PB are presented in Table 6-5. Intermediate points between those defined in Figure 6-2 are obtained by linear interpolation (in dB over linear frequency scale).

Table 6-5 – Parameters of limit PSD mask for the 25 MHz-PB, 50 MHz-PB, and 100 MHz-PB ~~bandplans~~OFBs

Parameters	Frequency (MHz)	PSD (dBm/Hz)	Note/Description
f_{L1}	1.1	–90	Additional reduction below 1.1 MHz is to reduce crosstalk into ADSL
f_{L2}	1.8	–85	Coincides with the amateur radio band
f_{L3}	2.0		
$f_{L3} + \Delta F$	$2.0 + \Delta F$	–55	ΔF is an arbitrary small positive value
$f_{H1} - \Delta F$	$30 - \Delta F$	–55	ΔF is an arbitrary small positive value
f_{H1}	30	–85	ΔF is an arbitrary small positive value
$f_{H2} - \Delta F$	$100 - \Delta F$		
f_{H2}	100	–100	
f_{H3}	250	–120	
NOTE – Sub-carriers above $f_{H2} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

NOTE 2 – If additional spectrum shaping is used, as described in clause 5.2 (e.g., to provide spectrum compatibility with VDSL2, or to comply with the wide-band power limit), various parts of this PSD mask could be reduced by switching sub-carriers off or reducing their transmit power. Additional frequency notches may be applied if required.

Sub-carriers with frequencies $(80 \text{ MHz} - F_{SC}) \leq f \leq (100 \text{ MHz} + F_{SC})$ shall be masked (zero power transmitted) via SM unless the usage of this band is allowed by the regional regulation.

See clause 7.2.2 of [ITU-T G.9960] for further physical layer specification of operation over power lines.

6.2.3 Permanently masked sub-carriers

For baseband transmissions, sub-carriers 0-74 (inclusive) shall be permanently masked over power lines. They shall not be used for transmission (neither data nor any auxiliary information).

6.3 Specification of spectral content for coax

6.3.1 Control parameters

Table 6-6 shows the valid OFDM control parameters for various ~~bandplans~~ OFBs defined in coax cable. The parameters are defined in [ITU-T G.9960].

Table 6-6 – OFDM control parameters for coax cables

Domain type	Coax baseband (Note 2)			Coax	Coax RF (Note 2)	
~~Bandplan name~~/OFB name ~~Parameter~~	Profile 1 OFBs			Profile 2 OFB (Note 10)	Profile 1 OFBs	
	50 MHz-CB (Note 4)	100 MHz-CB (Note 5)	200 MHz-CB (Note 9)		50 MHz-CRF (Note 6)	100 MHz-CRF (Note 7)
Minimum operational frequency~~N~~	0 MHz~~256~~	0 MHz~~512~~	0 MHz~~1024~~	OF_{MIN}	0 MHz~~256~~	0 MHz~~512~~
Maximum operational frequency	50 MHz	100 MHz	200 MHz	OF_{MAX}	50 MHz	100 MHz
F_{SC}	195.3125 kHz	195.3125 kHz	195.3125 kHz	48.828125 kHz	195.3125 kHz	195.3125 kHz
S (Sampling frequency)	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$	$N \times F_{SC}$
N_{GI}	$N/32 \times k$ for k = 1,…,8 samples @ ~~50~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ ~~100~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ ~~200~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ ~~50~~ S Msamples/s	$N/32 \times k$ for k = 1,…,8 samples @ ~~100~~ S Msamples/s
$N_{GI\text{-}HD}$	$N/4$ = 64 samples @ ~~50~~ S Msamples/s	$N/4$ = 128 samples @ ~~100~~ S Msamples/s	*$N/4$ = 256 samples @ ~~200~~ S Msamples/s*	$N/4$ samples @ S Msamples/s	$N/4$ = 64 samples @ ~~50~~ S Msamples/s	$N/4$ = 128 samples @ ~~100~~ S Msamples/s
$N_{GI\text{-}DF}$	$N/4$ = 64 samples @ ~~50~~ S Msamples/s	$N/4$ = 128 samples @ ~~100~~ S Msamples/s	*$N/4$ = 256 samples @ ~~200~~ S Msamples/s*	$N/4$ samples @ S Msamples/s	$N/4$ = 64 samples @ ~~50~~ S Msamples/s	$N/4$ = 128 samples @ ~~100~~ S Msamples/s
β	$N/32$ = 8 samples @ ~~50~~ S Msamples/s	$N/32$ = 16 samples @ ~~100~~ S Msamples/s	$N/32$ = 32 samples @ ~~200~~ S Msamples/s	$N/32$ samples @ S Msamples/s	$N/32$ = 8 samples @ ~~50~~ S Msamples/s	$N/32$ = 16 samples @ ~~100~~ S Msamples/s
F_{US}	25 MHz	50 MHz	100 MHz	$(OF_{MAX} - OF_{MIN})/2$	25 MHz	50 MHz
F_{UC}	0 MHz	0 MHz	0 MHz	OF_{MIN}	X (Note 3)	Y (Note 3)
Sub-carrier indexing rule (Note 1)	Rule #1	Rule #1	Rule #1	Rule #1	Rule #1 if X = Y, or rule #2 if X + 25 MHz = Y + 50 MHz (Note 8)	Rule #1 if X = Y, or rule #2 if X + 25 MHz = Y + 50 MHz (Note 8)

NOTE 1 – See clause 7.1.4.1 for more details on sub-carrier indexing rules.

NOTE 2 – The 50 MHz, 100 MHz and 200 MHz ~~bandplans~~ OFBs may be used by nodes operating in the same coax baseband domain. The same principle applies to 50 MHz and 100 MHz ~~bandplans~~ OFBs defined for coax RF domain.

Table 6-6 – OFDM control parameters for coax cables

NOTE 3 – The values of F_{UC} shall be selected from the valid set defined in Table 7-67 of [ITU-T G.9960] and may be subject to regional spectrum management rules (see regional annexes).
NOTE 4 – The range of sub-carrier frequencies is between 0 and 50 MHz.
NOTE 5 – The range of sub-carrier frequencies is between 0 and 100 MHz.
NOTE 6 – The range of sub-carrier frequencies is between X MHz and (X + 50) MHz.
NOTE 7 – The range of sub-carrier frequencies is between Y MHz and (Y + 100) MHz.
NOTE 8 – The specific indexing rule is specified in each regional annex.
NOTE 9 – The range of sub-carrier frequencies is between 0 and 200 MHz.
NOTE 10 – OFMAX – OFMIN shall be a multiple of 50 MHz

6.3.2 PSD mask specifications over coax

The limit PSD mask for operation over coax RF is presented in Figure 6-3 with the frequencies as presented in Table 6-7 (~~bandplan~~ 50 MHz-CRF OFB) and Table 6-8 (~~bandplan~~ 100 MHz-CRF OFB) where the bandwidth $BW = f_{H1} - f_{L3}$.

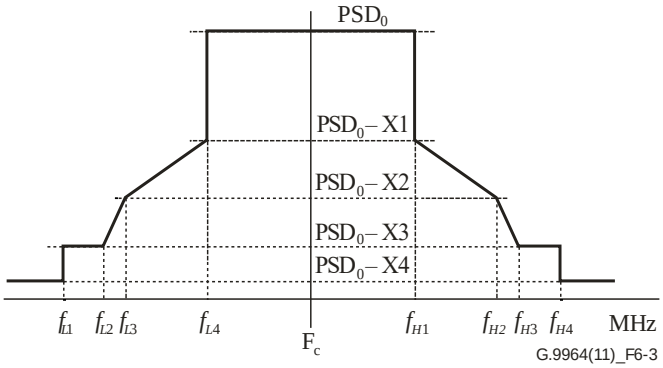


Figure 6-3 – Limit PSD mask of a single channel for RF transmission over coax

The proposed values of frequency spectrum parameters for coax are presented in Tables 6-7 and 6-8. It is assumed that intermediate points between those defined in Figure 6-3 are obtained by linear interpolation (dB over linear frequency scale).

Table 6-7 – Parameters of limit PSD mask over coax RF for the 50 MHz-CRF ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz) (Note 1)	Note/Description
$F_C - f_{L1}$	75	$PSD_0 - 50$	
$F_C - f_{L2}$	50	$PSD_0 - 45$	
$F_C - f_{L3}$	35	$PSD_0 - 40$	
$F_C - f_{L4}$	25	$PSD_0 - 20$	
	$f_{L4} + \Delta F$	PSD_0	ΔF is an arbitrary small positive value
F_C	$M \times 25$ MHz	PSD_0	
	$f_{H1} - \Delta F$	PSD_0	ΔF is an arbitrary small positive value
$f_{H1} - F_C$	25	$PSD_0 - 20$	
$f_{H2} - F_C$	35	$PSD_0 - 40$	
$f_{H3} - F_C$	50	$PSD_0 - 45$	

Table 6-7 – Parameters of limit PSD mask over coax RF for the 50 MHz-CRF ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz) (Note 1)	Note/Description
$f_{H4} - F_C$	75	$PSD_0 - 50$	
NOTE 1 – $PSD_0 = -68$ dBm/Hz NOTE 2 –Sub-carriers below $f_{L4} + \Delta F$, and above $f_{H1} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

Table 6-8 – Parameters of limit PSD mask over coax RF for the 100 MHz-CRF ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz) (Note 1)	Note/Description
$F_C - f_{L1}$	150	$PSD_0 - 50$	
$F_C - f_{L2}$	100	$PSD_0 - 45$	
$F_C - f_{L3}$	70	$PSD_0 - 40$	
$F_C - f_{L4}$	50	$PSD_0 - 20$	
	$f_{L4} + \Delta F$	PSD_0	ΔF is an arbitrary small positive value
F_C	$M \times 25$ MHz	PSD_0	
	$f_{H1} - \Delta F$	PSD_0	ΔF is an arbitrary small positive value
$f_{H1} - F_C$	50	$PSD_0 - 20$	
$f_{H2} - F_C$	70	$PSD_0 - 40$	
$f_{H3} - F_C$	100	$PSD_0 - 45$	
$f_{H4} - F_C$	150	$PSD_0 - 50$	
NOTE 1 – $PSD_0 = -68$ dBm/Hz NOTE 2 – Sub-carriers below $f_{L4} + \Delta F$, and above $f_{H1} - \Delta F$ shall not be used for transmission (neither data nor any auxiliary information).			

NOTE 1 – If additional spectrum shaping is used, as described in clause 5.2, the transmit PSD mask can be reduced in the relevant parts of this spectrum by switching sub-carriers off or reducing their transmit power.

NOTE 2 – In cases where more than one channel is established over the same coax cable, appropriate gaps between centre frequencies of the channels should be set to account values of the out-of-band PSD presented in Tables 6-7 and 6-8.

NOTE 3 – Out-of-band spurious signals at the output of a node operating over coax in RF mode are supposed to meet the limit PSD mask defined in Tables 6-7 and 6-8. The limit for total power of out-of-band spurious signals is for further study. The requirements for in-band spurious signals are for further study.

NOTE 4 – Specification of guard bands are for further study.

The limit PSD mask for operation over ~~baseband~~ Profile 1 coax OFBs (~~bandplans~~ 50 MHz-CB, 100 MHz-CB, 200 MHz-CB OFBs) is presented in Figure 6-4 with the frequencies and PSD levels presented in Table 6-9 (~~bandplan~~ 50 MHz-CB OFB), Table 6-10 (~~bandplan~~ 100 MHz-CB OFB), and Table 6-10.1 (~~bandplan~~ 200 MHz-CB OFB) where the bandwidth $BW = f_{H1} - f_{L2}$.

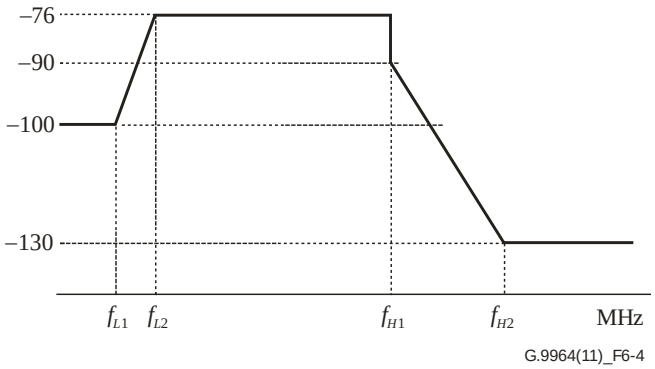


Figure 6-4 – Limit PSD mask of baseband coax (Profile 1 OFBs)

The intermediate points between those defined in Figure 6-4 are obtained by linear interpolation (dB over a linear frequency scale).

Table 6-9 – Parameters of limit PSD mask over coax for the 50 MHz-CB ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz)	Note/Description
f_{L1}	1	–100	
f_{L2}	5	–76	
$f_{H1} - \Delta F$	50 – ΔF	–76	ΔF is an arbitrary small positive value
f_{H1}	50	–90	
f_{H2}	70	–130	
NOTE – Sub-carriers above $f_{H1} - \Delta F$ shall not be used for transmission (neither of data nor of any auxiliary information).			

Table 6-10 – Parameters of limit PSD mask over coax for the 100 MHz-CB ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz)	Note/Description
f_{L1}	1	–100	
f_{L2}	5	–76	
$f_{H1} - \Delta F$	100 – ΔF	–76	ΔF is an arbitrary small positive value
f_{H1}	100	–90	
f_{H2}	140	–130	
NOTE – Sub-carriers above $f_{H1} - \Delta F$ shall not be used for transmission (neither of data nor of any auxiliary information).			

Table 6-10.1 – Parameters of limit PSD mask over coax for the 200 MHz-CB ~~bandplan~~OFB

Parameters	Frequency (MHz)	PSD (dBm/Hz)	Note/Description
f_{L1}	1	–100	
f_{L2}	5	–76	
$f_{H1} – \Delta F$	200 – ΔF	–76	ΔF is an arbitrary small positive value
f_{H1}	200	–90	
f_{H2}	280	–130	
NOTE – Sub-carriers above $f_{H1} – \Delta F$ shall not be used for transmission (neither of data nor of any auxiliary information).			

NOTE 5 – If additional spectrum shaping is used, as described in clause 5.2, the transmit PSD mask can be reduced in the relevant parts of this spectrum by switching sub-carriers off or reducing their transmit power.

See clause 7.2.3 of [ITU-T G.9960] for further physical layer specification of operation over coax.

The limit PSD mask for operation over Profile 2 coax OFBs is presented in Figure 6-4.1 with the frequencies and PSD levels presented in Table 6-10.2 where the bandwidth $BW = f_{H1} – f_{L2}$.

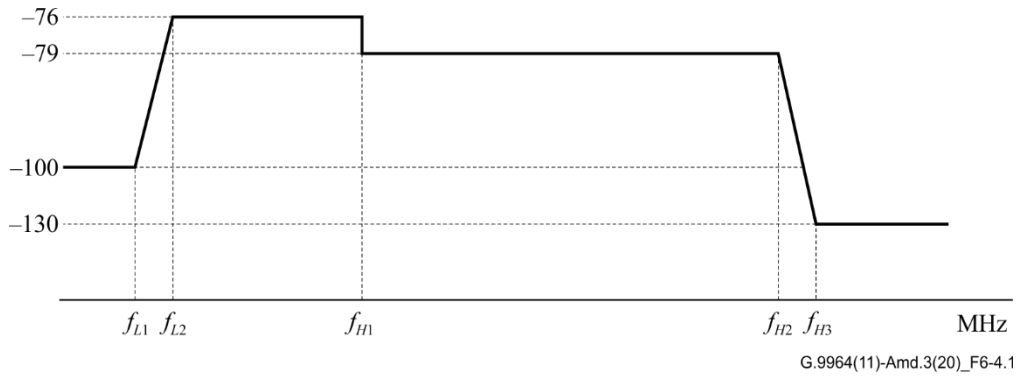


Figure 6-4.1 – Limit PSD mask of coax (Profile 2 OFBs)

The intermediate points between those defined in Figure 6-4.1 are obtained by linear interpolation (dB over a linear frequency scale).

Table 6-10.2 – Parameters of limit PSD mask over coax for Profile 2 OFBs

Parameters	Frequency (MHz)	PSD (dBm/Hz)	Note/Description
f_{L1}	1	–100	
f_{L2}	5	–76	
$f_{H1} – \Delta F$	200 – ΔF	–76	ΔF is an arbitrary small positive value
f_{H1}	200	–79	
f_{H2}	2000	–79	
f_{H3}	2200	–130	

NOTE 6 – If additional spectrum shaping is used, as described in clause 5.2, the transmit PSD mask can be reduced in the relevant parts of this spectrum by switching sub-carriers off or reducing their transmit power.

See clause 7.2.3 of [ITU-T G.9960] for further physical layer specification of operation over coax.

6.3.3 Permanently masked sub-carriers

For baseband transmissions, sub-carriers 0-10 (inclusive) shall be permanently masked over coax. They shall not be used for transmission (neither data nor any auxiliary information).

6.3.4 Coexistence on coax

Nodes on coax shall use specified detection and frequency agility capabilities and procedures to avoid interfering with alien home networks and other services (e.g., communication and broadcast services) operating on the same coax plant. Details of these capabilities and procedures will be specified in a future version of this Recommendation.

6.4 Termination impedance

The nominal values of termination (load) impedance for different types of media are defined in Table 6-11. The standard termination impedance shall be used for PSD and total transmit power measurement.

Table 6-11 – Standard termination impedance

Medium	Termination impedance
Baseband power line	100 Ohm
Telephone line	100 Ohm
Baseband coax	75 Ohm
RF coax	75 Ohm

6.5 Total transmit power

The total transmit power of the transceiver terminated with a standard termination impedance (see clause 6.4) shall not exceed the values presented in Table 6-12.

Table 6-12 – Total transmit power limit

Medium	~~Bandplan~~OFB	TX power limit (dBm)	Frequency range of measurement (MHz)
Baseband power line	50 MHz-PB	+20	0.005-100
	100 MHz-PB	+20	0.005-150
Telephone line	50 MHz-TB	+3	0.005-100
	100 MHz-TB	+4.5	0.005-150
	200 MHz-TB	+6	0.005-250
	Profile 2	$3 + 1.5\times\text{Log}_2(F/50)$	OF_{MAX}-OF_{MIN}
Baseband coax	50 MHz-CB	−1	0.005-100
	100 MHz-CB	+2	0.005-150
	200 MHz-CB	+5	0.005-300
	Profile 2	$-1 + 3\times\text{Log}_2(F/50)$	OF_{MAX}-OF_{MIN}
RF coax	50 MHz-RF	+5	$(F_{UC} – 100)$-$(F_{UC} + 100)$
	100 MHz-RF	+8	$(F_{UC} – 150)$-$(F_{UC} + 150)$
NOTE – $F=(OF_{MAX} – OF_{MIN})$ (see Tables 6-1, 6-4 and 6-6).			

6.6 Receiver input impedance

When operating on power-line medium and not transmitting, an implementing device shall present a minimum impedance of 40 ohm in the band from 1.8 MHz to 50 MHz measured between line (phase) and neutral terminals. It shall present a minimum impedance of 20 ohm in the ranges from 100 kHz to 1.8 MHz and from 50 MHz to 100 MHz.

Annex A

(This annex has been intentionally left blank.)

Annex B

(This annex has been intentionally left blank.)

Annex C

(This annex has been intentionally left blank.)

Annex D

International amateur radio bands

(This annex forms an integral part of this Recommendation.)

Table D.1 – International amateur radio bands in the frequency range 0-100 MHz

Band start (kHz)	Band stop (kHz)	SC_{START} (Note 1)	SC_{END} (Note 1)	SC_{START} (Note 2)	SC_{END} (Note 2)
1 800	2 000	73	82	36	41
3 500	4 000	143	164	71	82
7 000	7 300	286	300	143	150
10 100	10 150	413	416	206	208
14 000	14 350	573	588	286	294
18 068	18 168	740	745	370	373
21 000	21 450	860	879	430	440
24 890	24 990	1 019	1 024	509	512
28 000	29 700	1 146	1 217	573	609
50 000	54 000	2 047	2 212	1 023	1 106
69 900	70 500	2 863	2 888	1 431	1 444
14 4000	148 000	N/A	N/A	2 949	3 032
21 9000	22 5000	N/A	N/A	4 485	4 619
42 0000	450 000	N/A	N/A	8 601	9 217

NOTE 1 – Sub-carrier index is in terms of 24.4140625 kHz spacing (all power-line ~~bandplans~~OFBs)
NOTE 2 – Sub-carrier index is in terms of 48.828125 kHz spacing (all telephone line ~~bandplans~~OFBs) where SCSTART and SCEND refer to the start and stop indices of the masked sub-carriers, respectively, if the corresponding bands are masked.

Annex E

Impact of ITU-T G.9960 on VDSL2 service

(This annex forms an integral part of this Recommendation.)

This annex defines the means to reduce the impact of [ITU-T G.9960] on the VDSL2 service. The means vary depending on the type of medium and if the service shares the same wires with VDSL2 or is routed nearby. The actual VDSL2 frequency bands in which impact of ITU-T G.9960 transmission occurs, and the corresponding PSD reductions are also regionally specific and may be configured via the remote or local domain management system using the configuration parameters defined in this annex. Details are for further study.

Appendix I

Additional radio frequency bands

(This appendix does not form an integral part of this Recommendation.)

This appendix lists additional radio frequency bands where PSD reduction may be required by national regulations.

Table I.1 – International broadcast bands

Band start (kHz)	Band stop (kHz)
2 300	2 498
3 200	3 400
3 900	4 000
4 750	5 060
5 900	6 200
7 200	7 450
9 400	9 900
11 600	12 100
13 570	13 870
15 100	15 800
17 480	17 900
18 900	19 020
21 450	21 850
25 670	26 100

Table I.2 – Aeronautical mobile bands

Band start (kHz)	Band stop (kHz)
2 850	3 150
3 400	3 500
3 800	3 950
4 650	4 850
5 450	5 730
6 525	6 765
8 815	9 040
10 005	10 100
11 175	11 400
13 200	13 360

Table I.2 – Aeronautical mobile bands

Band start (kHz)	Band stop (kHz)
15 010	15 100
17 900	18 030
21 924	22 000
23 200	23 350

Table I.3 – Radio astronomy bands

Band start (kHz)	Band stop (kHz)
13 360	13 410
25 550	25 670

Bibliography

[b-ITU-T G.993.2] Recommendation ITU-T G.993.2 (2006), *Very high speed digital subscriber line transceivers 2 (VDSL2)*.

[b-IEC CISPR 16-1] IEC CISPR 16-1:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*.

[b-IEC CISPR 22] IEC CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2020