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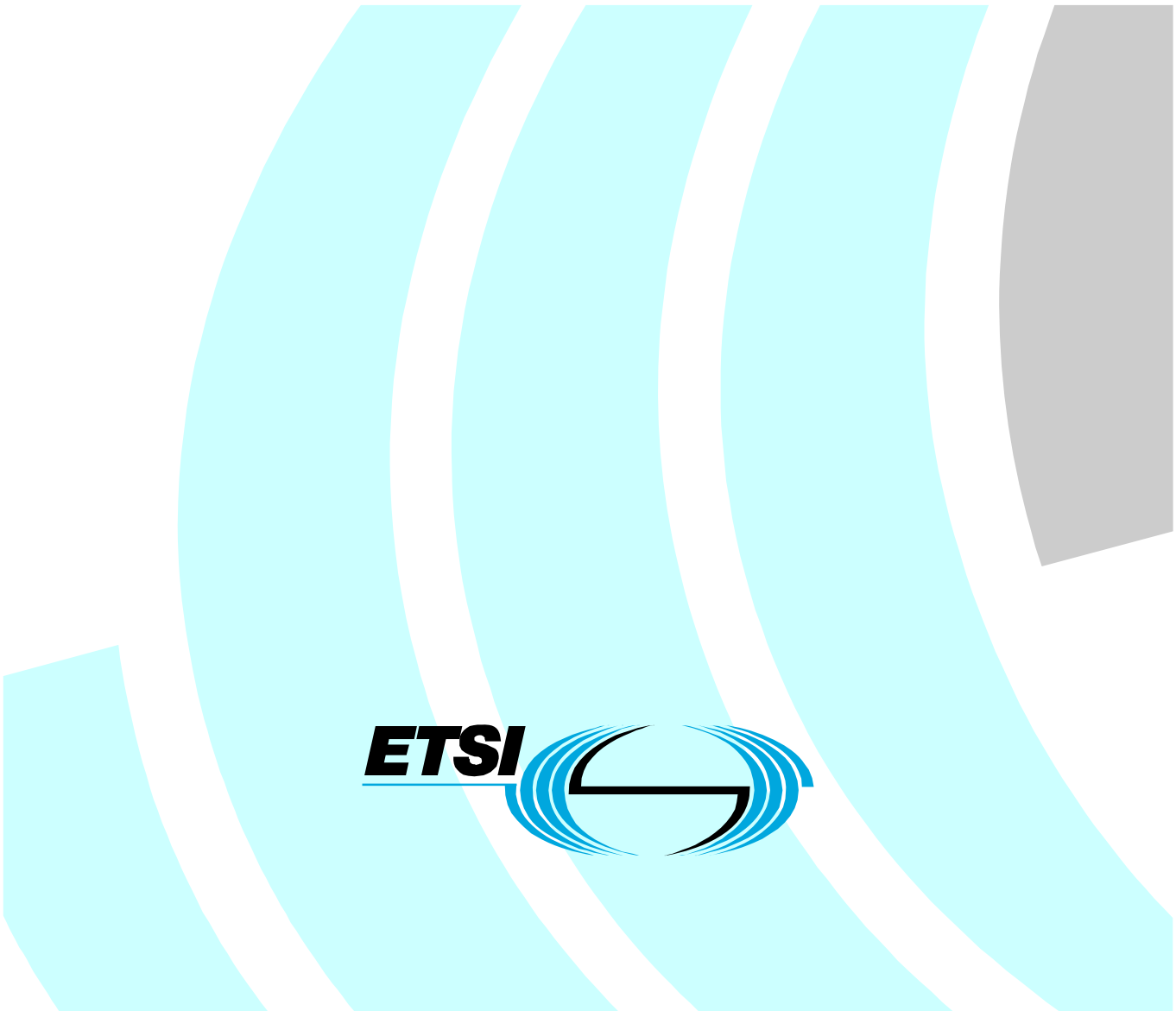
Technical Specification

PowerLine Telecommunications (PLT); Coexistence between PLT Modems and Short Wave Radio broadcasting services



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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Powerline Telecommunications (PLT).

Throughout the present document the term "broadcasting services" refers to "short wave radio broadcasting services".

Introduction

State of the art PowerLine Telecommunications (PLT) may cause coexistence limitations with broadcasting services. It is intended that PLT Modems compliant with the present document will provide less interference or greater orthogonality between broadcasting services and PLT Modems.

Requirements for the present document are:

- optimum reduction of interference between PLT and short wave radio broadcast;
- minimum impact on data throughput and QoS requirements of PLT.

The presence of broadcasting signals must be detected by PLT Modems by sensing the "noise" (including radio broadcast picked up on the mains cabling) at an electrical socket. Frequencies where short wave Radio broadcasting signals are identified must be omitted from the transmitted signal by inserting a notch into the transmitting spectrum. This automatic process is called "Smart Notching".

1 Scope

The present document specifies a mechanism for PLT modems to avoid possible coexistence difficulties between PLT and Short Wave radio broadcast.

Frequency allocation of the radio broadcasting services are defined by ITU-R Radio Regulations [1].

The mechanism described here is called "smart notching" whereby the PLT-spectrum mask is adjusted to avoid the use of frequencies which are found to be coincident with receivable broadcast signals.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ITU Radio Regulations, edition of 2004.

[2] ETSI ES 201 980 (V2.2.1): "Digital Radio Mondiale (DRM); System Specification".

[3] ITU-R Recommendation 560-3: "Radio-frequency protection ratios in LF, MF and HF broadcasting".

[4] ITU-R Recommendation BS.1615: ""Planning parameters" for digital sound broadcasting at frequencies below 30 MHz".

[5] ITU-R Recommendation BS.703: "Characteristics of AM sound broadcasting reference receivers for planning purposes".

[6] CISPR 16-1-1: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus".

[7] CISPR 16-1-2: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-2: Radio disturbance and immunity measuring apparatus - Ancillary equipment - Conducted disturbances".

[8] CISPR 22: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement".

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

Not applicable.

3 Definitions and abbreviations

3.1 Definitions

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

acceptable reception of radio service: human could understand what a speaking voice is trying to say

Class A device: PLT device as defined in CISPR 22 [8]

Class B device: PLT device as defined in CISPR 22 [8]

live: live contact (also known as phase, hot or active) carries alternating current from the power source to the equipment

measurement bandwidth: bandwidth used to specify limits and thresholds

NOTE: The resolution bandwidth a PLT modem uses to derive any signal level is implementation dependent. To compare the derived levels with the values given in this specification they must be converted to the measurement bandwidth.

neutral: neutral contact returns current from the equipment back to the power source or distribution panel

3.2 Abbreviations

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

AE	Auxiliary Equipment
AM	Amplitude Modulation
CE	Consumer Electronics
DRM	Digital Radio Mondiale

NOTE: See ES 201 980 [2] (http://www.drm.org/).

EUT	Equipment Under Test
PLT	PowerLine Telecommunications

NOTE: See http://portal.etsi.org/portal_common/home.asp?tbkey1=PLT.

PSD	Power Spectral Density
QoS	Quality of Service
SW	Short Wave

4 Detection of the presence of radio broadcasting signals

Radio broadcast signals transmitted with a high power from the antenna of a radio station will electromagnetically couple onto any wire, e.g. an electrical power grid.

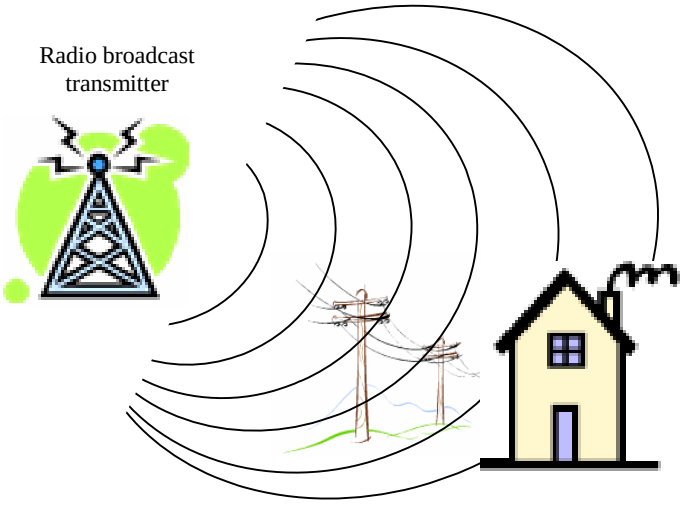

Figure 1: Example of ingress of radio signals into mains wiring in a house

Within the reception range of the radio broadcast signals the ingress of the broadcast signal can be detected.

Sensing the ingress magnitude at a PLT modem, e.g. at the socket between live and neutral line, enables the PLT modem to identify the presence of a radio broadcast signal that is receivable by a typical CE radio receiver. Figure 2 shows a "snapshot" measurement of the noise between live and neutral at a socket using a spectrum analyzer. Each "peak" (e.g. at 5 955 kHz or 6 075 kHz) visible in figure 2 shows the presence of an AM - SW Radio broadcast signal. A "rectangle" (e.g. around 5 990 kHz, marked in red dashed ellipse) shows the presence of a DRM radio station. The AM - SW Radio broadcast signals marked with the green dotted ellipses show acceptable reception quality using a typical consumer electronics SW radio receiver.

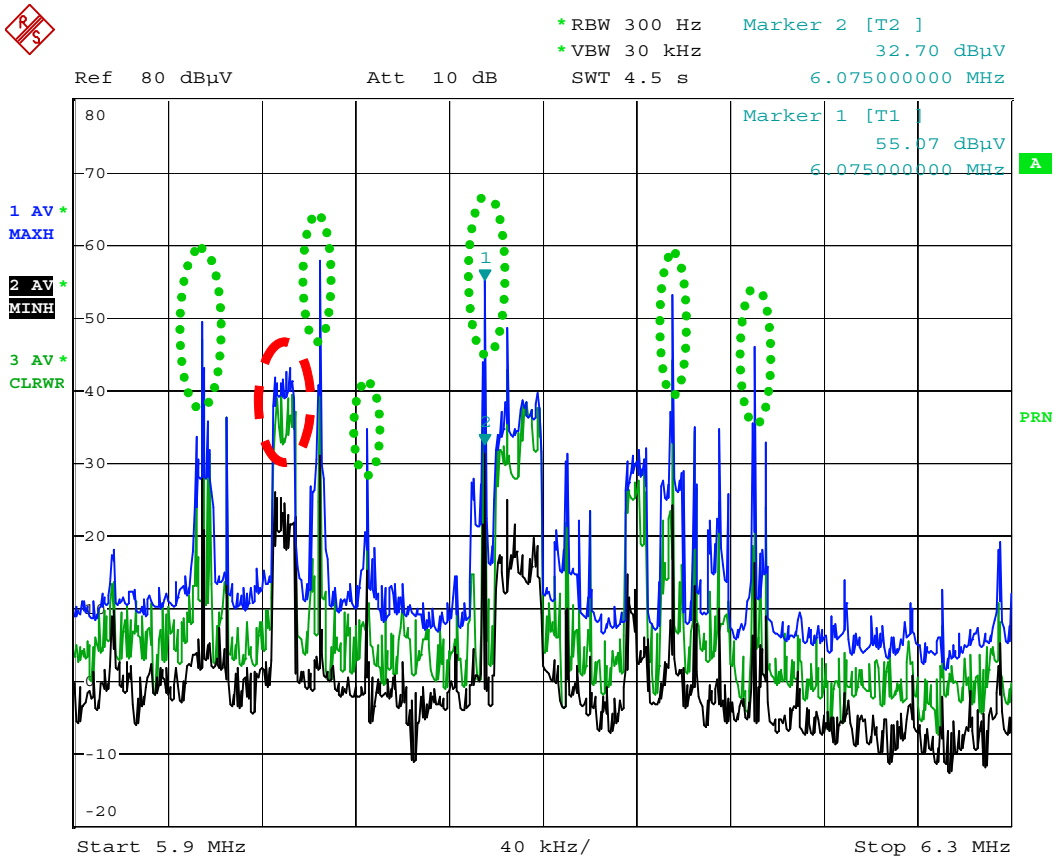

Figure 2: Example of a snapshot of ingress in the 49 m SW-Band at one location measured between live and neutral

The amplitude of SW radio broadcast signal ingress changes strongly with time and location. Also, the level of these signals depends on the location of the modem and the structure of the wiring of the electricity grid. The PLT modem will periodically sense the ingress and identify the presence of SW radio broadcast signal. The thresholds used for detecting receivable signals and the frequency of sensing are specified in clause 4.

4.1 Noise Floor

The Noise Floor shall be measured at adjacent frequencies lower and higher than the short wave Radio band given in table 1. The adjacent frequency block to be monitored shall be as wide as the Radio band allocation itself. The adjacent frequency blocks must be completely monitored by the PLT modems without any gaps. The noise floor is the median value of all measured values of the electrical energy in the adjacent frequency blocks on the powerline channel excluding all powerline communication signals. An individual noise floor level shall be calculated for each Radio broadcast band. The frequency locations and resolution bandwidth of the measured values is implementation dependent on the PLT modem.

A short impulsive noise e.g. caused by a light switch must not influence noise floor measurement.

4.2 Levels and Thresholds

Signal ingress shall be identified as a receivable radio broadcast service if the signal is at least:

Criterion (1): 14 dB above the noise floor

If criterion (1) is satisfied, the threshold level of ingress of a broadcast signal identified as receivable is:

Criterion (2): -95 dBm

Additionally PLT modems may limit the identification of a receivable radio broadcast service to such signals that are AM or DRM modulated including very low AM modulated signal (plain carrier or a silent period).

Noise floor and signal shall be measured between the live and neutral conductor at the socket to which the PLT modem is connected. The measurement shall be made using a spectrum analyser or measurement receiver specified and adjusted as in CISPR 16-1-1 [6] - average detector.

The threshold is defined to take into account the sensitivity of broadcast CE radio receivers and reception factor between the field and the signals on the mains. The measurement bandwidth and detectors specified here are for verification of the implementation of the present document, which is described in detail in clause 6. Resolution bandwidth and detectors used by the PLT modem are implementation dependent.

Taking into account the fading effects defined in ITU-R Recommendation BS.1615 [4] and the robustness of radio receivers (ES 201 980 [2]) the signal is considered to be present if Criterion (1) and (2) is exceeded in 30 % of time in any 10 seconds interval.

4.3 Timings

A radio broadcast signal shall be detected and the corresponding notch shall be activated by the PLT modem in no more than:

15 seconds

after the receivable radio broadcast service is actually present.

The notch shall remain active continuously for the whole time that the SW radio broadcast is present.

After the radio broadcast service has been identified as no longer receivable the notch shall still remain active for at least:

180 seconds

4.4 Frequencies

Radio frequencies are allocated to the broadcasting service under article 5 of the Radio Regulations [1]. In practice, HF broadcasts are to be found on frequencies outside these bands. Countries (Administrations) can, on a national basis allocate additional frequencies under article 4.4 of the Radio Regulations [1]. This practice is commonplace. A realistic assessment of the actual bands used for SW radio broadcasting is:

Table 1: The HF Broadcasting Bands

From (kHz)	To (kHz)
2 300	2 498
3 200	3 400
3 900	4 000
4 550	4 650
4 750	5 110
5 750	6 200
7 100	7 700
9 300	9 950
11 550	12 100
13 550	13 900
15 050	15 850
17 400	17 950
18 900	19 020
21 450	21 850
25 670	26 100

The automatic process of "Smart Notching" shall work at least in the frequency allocations defined in the table 1.

NOTE: Frequency bands requiring protection for compliance with the present document may be affected by future changes to regulatory requirements.

5 Notching the transmitted signals

If a radio broadcast service is identified as receivable within the frequency band defined above a notch shall be inserted into the transmitted spectrum of the powerline system.

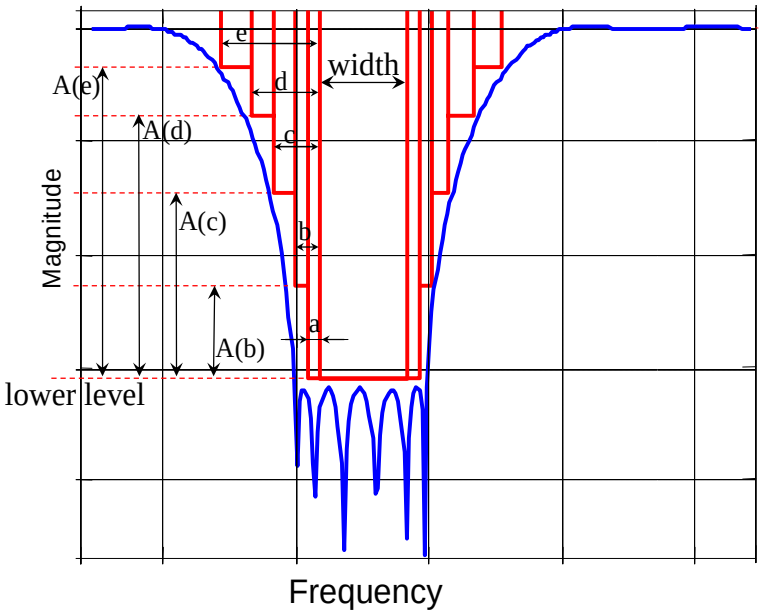

Figure 3: Definition of a notch

Powerline communication must avoid the usage of the bandwidth of an identified radio broadcast service. Therefore the minimum width of a notch must be at least 10 kHz (±5 kHz around the carrier frequency of the broadcast):

Criterion (3): Width > 10 kHz (plus the definitions of side slopes)

Usually, the channels of radio broadcast services are allocated with a minimum spacing of 5 kHz. Also, the centre frequency is a multiple of 5 kHz. If several neighbouring radio broadcast services are identified or a digital (DRM) service occupying more than a single conventional channel, the width of one notch should be scaled to integer multiples of 5 kHz.

Side slopes of the notch are defined in table 2 to avoid adjacent channel interference with respect to AM / DRM protection ratios as defined in ITU-R Recommendations BS.560-3 [3], BS.1615 [4] and BS.703 [5] from transmissions outside the notch. Spectrum mask is symmetrical to centre frequency.

Table 2: Definition of a notch: avoid adjacent carrier interference

	Frequency spacing	Distance from lower level of the notch: A(x)
1st step: a	2 kHz	0 dB
2nd step: b	10 kHz	≤ 25 dB
3rd step: c	20 kHz	≤ 35 dB
4th step: d	30 kHz	≤ 45 dB
5th step: e	400 kHz	≤ 50 dB

The lower level of a notch is defined in clause 6.4.

6 Verification of the implementations to the standard

The implementations of "Smart Notching" shall be verified using the following measurement method, apparatus, settings on a suitably calibrated spectrum analyzer and artificial signal ingress.

6.1 Measurement apparatus

Conformity with the present document shall be verified using the measurement apparatus shown in figure 4.

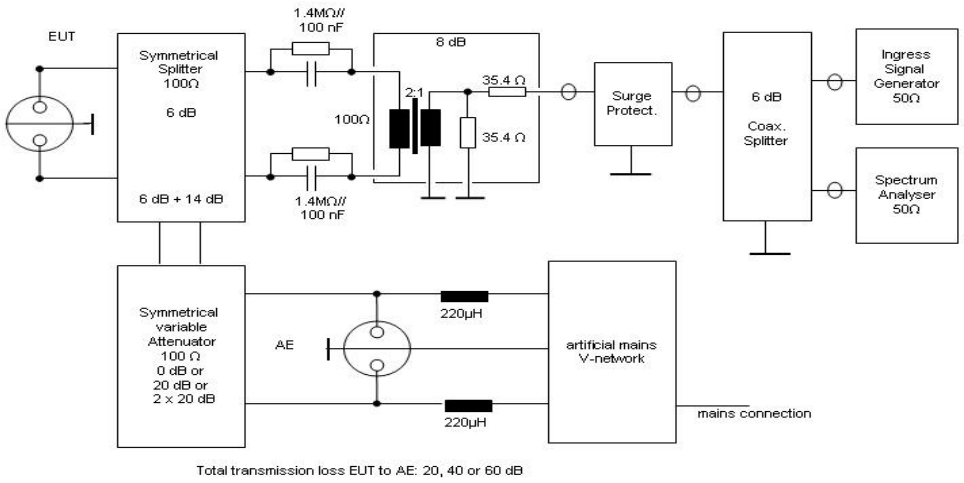

Figure 4: Measurement Apparatus

The PLT modem under test shall be plugged to the EUT socket. If needed the communication partner device shall be plugged to the AE socket. Power for the modems will be supplied via a mains connection. Verification shall be performed using 20 dB, 40 dB and 60 dB attenuation between both PLT devices. The whole apparatus shall be integrated in a shielded enclosure to avoid any ingress of any conducted or radiated unwanted signals. The Signal Generator injects an artificial signal at frequencies to be notched by the PLT modem. The Spectrum Analyzer measures the PLT communication signal as well as the ingress signal to enable monitoring of PLT modem behaviour.

The Coaxial Splitter, balun with impedance matching circuit and symmetrical splitter causes attenuation. Table 3 shows how much attenuation in dB is caused between PLT modems, Spectrum Analyzer and Ingress Signal Generator. The amplitude of the Ingress Signal Generator must be compensated by the attenuation value shown in table 3.

The measurement apparatus must provide common mode attenuation from EUT to all other connectors higher than 60 dB.

The measurement apparatus must be isolated from the mains using an artificial mains V-network as specified in CISPR 16-1-2 [7].

Table 3: Attenuation in the Measurement apparatus

	EUT 100 Ω	**AE 100 Ω**	**Ingress Signal Generator 50 Ω**	**Spectrum Analyzer 50 Ω**
EUT 100 Ω	0 dB	20 dB + Attenuator	20 dB	20 dB
AE 100 Ω	20 dB + Attenuator	0 dB	34 dB + Attenuator	34 dB + Attenuator
Ingress Signal Generator 50 Ω	20 dB	34 dB + Attenuator	0 dB	6 dB
Spectrum Analyzer 50 Ω	20 dB	34 dB + Attenuator	6 dB	0 dB

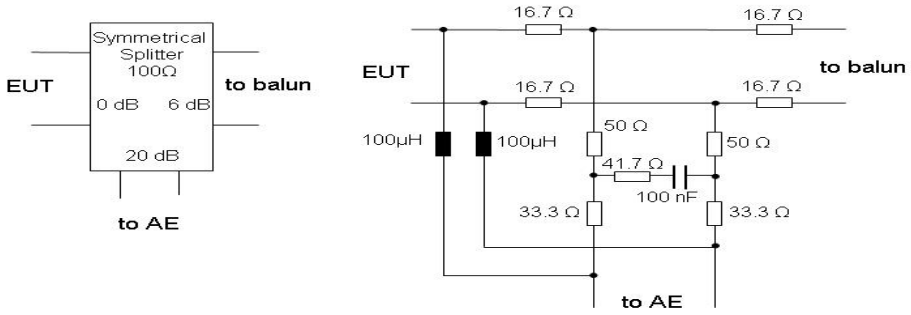

Figure 5: Symmetrical Splitter

The symmetrical splitter used in figure 4 is described in figure 5.

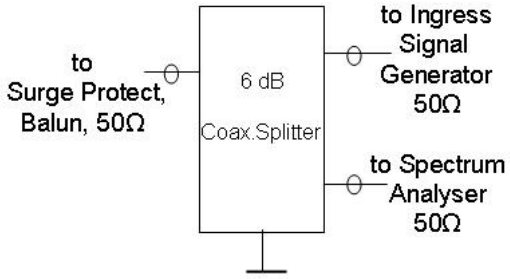

Figure 6: Coaxial Splitter

The coaxial splitter used in figure 4 is described in figure 6.

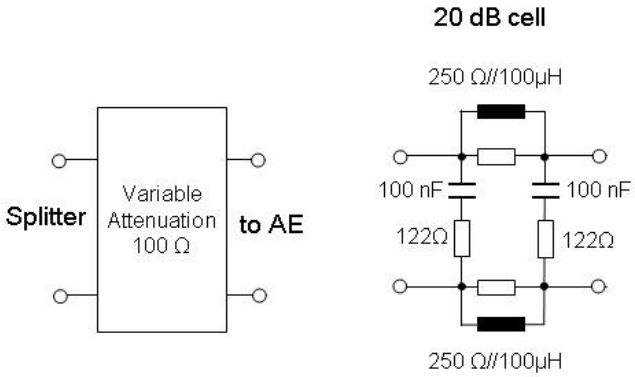

Figure 7: 20 dB Attenuator

The attenuator used in figure 4 is described in figure 7. E.g. for 40 dB attenuation two 20 dB attenuators can be used in series.

The realization of the measurement apparatus might differ from the schematics given above, however the attenuation values given in table 3 must be guaranteed.

6.2 Settings on Spectrum Analyzer

The spectrum analyzer shall be set to following settings:

- Centre Frequency: Carrier Frequency of Signal Ingress.
- Frequency Span: 200 kHz.
- Resolution Bandwidth: 300 Hz.
- Video Bandwidth: 3 kHz.
- Average Detector.

6.3 Artificial Signal Ingress

Signal ingress shall be one or several signals of

- AM-Radio: modulated with a 1 kHz sine wave, 30 % Modulation Depth; or
- DRM: ES 201 980 [2];

at various frequencies.

Strength of individual signals shall be equal to or higher than the level defined in clause 4.2.

6.4 Levels and thresholds at verification-bench

6.4.1 Level of signal ingress

Using the apparatus defined in clause 6.1 and the settings defined in clause 6.2, the thresholds given in clause 4.2 are verified by integrating the energy of the measured frequency points to a measurement bandwidth of 9 kHz (according to CISPR 16-1-1 [6]). Usually Spectrum Analyzers have a build in function to do this. The attenuation of the measurement apparatus must be added to the values from criterion (2).

The level of individual artificial signal ingress shall exceed these thresholds to enable a PLT modem to notch these frequencies.

6.4.2 Level of notch bottom

The lower level of the notch readable at the Spectrum Analyzer using the setting defined in clause 6.2 must be less than:

Criterion (4): -79 dBm (readout value) for Class A devices

Criterion (5): -89 dBm (readout value) for Class B devices

NOTE: The values to verify the lower level of the notch are not integrated to any measurement bandwidth.

6.5 Test procedure

The following test sequence shall be performed.

Prepare the artificial ingress signal with 20 individual signals within the frequency range defined in clause 4.4 and the communication spectrum of the EUT. Signal Level of the individual ingress shall be equal to or higher than that defined in criterion (2).

The test signal is specified in the electronic attachment ts_102578v010201p0.zip and annex A. It has AM/DRM signals included at the extreme frequencies inside an HF Broadcasting Band as well as a collection of 4 adjacent frequencies, one gap than another 2 adjacent frequencies allocated.

The PLT System shall transport maximum payload as a continuous transmission.

Tune the Spectrum Analyzer to Centre frequency of the 1st artificial ingress signal.

Switch artificial signal ingress on.

Monitor the Spectrum Analyzer to confirm that the PLT signal is notched at the centre frequency after the time specified in clause 4.3.

Tune to all other frequencies where artificial ingress signal is located.

Switch the artificial ingress signal off and monitor the Spectrum Analyzer, to confirm that the PLT signal is not reused within the time specified in clause 4.3.

Annex A (normative): Test signals

The test signal is specified in the electronic attachment ts_102578v010101p0.zip.

Test Signal modulates 20 individual signals within the HF Broadcasting Bands:

- 10 AM signals are modulated at the following frequencies:
  - 4,75 MHz, 5,9 MHz, 7,2MHz, 11,6MHz, 11,62 MHz, 11,65 MHz, 11,69 MHz, 15,1 MHz, 21,45 MHz, 25,67 MHz.
- 10 DRM signals are modulated at the following frequencies:
  - 4,89 MHz, 6,2MHz, 7,45 MHz, 11,61 MHz, 11,63 MHz, 11,66 MHz, 12,1 MHz, 15,8 MHz, 21,85 MHz, 26,1 MHz.

AM and DRM signals alternate in the frequency domain.

Frequencies are chosen to be located close to the margins of the HF Broadcasting Bands. They are slightly modified to fit into carrier spacing of 5 kHz and an integer number of wavelength (sin-waves) of the carrier frequency has to fit into total signal length.

A group of 4 adjacent carriers should be generated (11,6 MHz, 11,61 MHz, 11,62 MHz, 11,63 MHz), one gap (11,64 MHz), 2 more carriers (11,65 MHz, 11,66 MHz), 2 gaps (11,67 MHz, 11,68 MHz) and one more carrier (11,69 MHz).

The Sampling Frequency is 80 MHz. Total Signal Length is 2 133 760 samples (26,7 ms).

History

Document history		
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