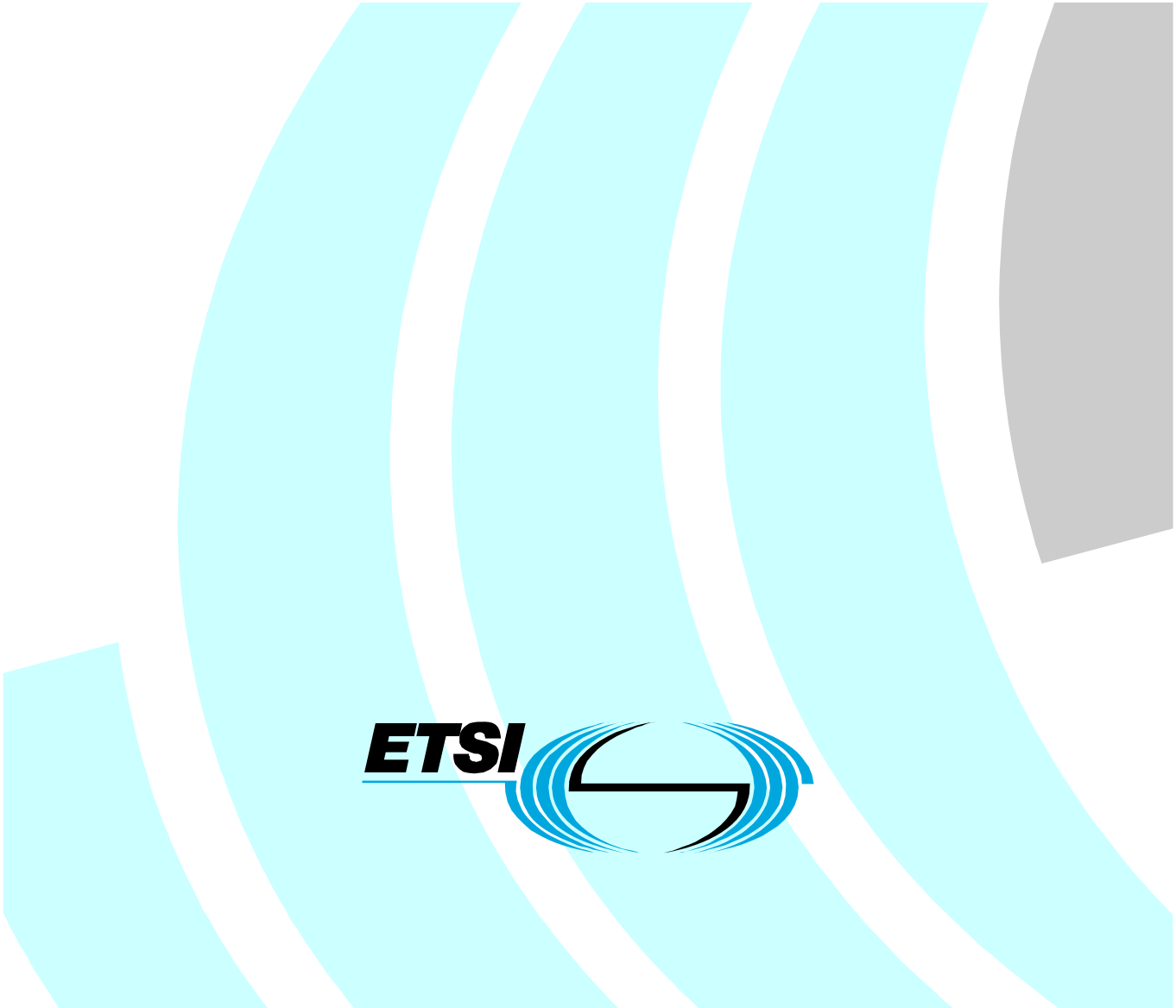
ETSI TR 102 616 V1.1.1 (2008-03)

Technical Report

**PowerLine Telecommunications (PLT);
Report from Plugtests™ 2007 on
coexistence between PLT and
short wave radio broadcast;
Test cases and results**



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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Powerline Telecommunications (PLT) (STF 332).

The present document is the report from a Plugtests™ event in 2007 on coexistence between PLT and short wave radio broadcast, and is structured in two parts as identified below:

Part 1: "Test cases";

Part 2: "Results".

Introduction

In order to verify draft TS 102 578 of Work Item 21 (WI21) [5] which deals with coexistence between PLT and short wave radio services including DRM (Digital Radio Mondiale) a Plugtests™ event was requested by many ETSI members.

During the coexistence Plugtests™ event different PLT modems from different vendors implementing the draft TS related to TS 102 578 will be evaluated. A Special Task Force (STF) 332 has been established to perform the Plugtests™ event.

The STF will validate the concept of 'Smart Notching' which is specified in TS 102 578 [5]. Measurements demonstrating the ingress of SW radio broadcasts to the electrical installation in a building will be made. Further, using real implementations of PLT modems the practicality of the draft TS will be verified. Verification of levels and thresholds will be carried out along with the performance of the coexistence implementations. Recommendations for possible improvement to the current draft TS 102 578 of Work Item 21(WI21) will be made as appropriate.

The tasks of the STF are in detail:

- validate or revise the thresholds and resolution bandwidths needed to detect ingress from a receivable radio broadcast;
- verify test bench levels and thresholds;
- provide feedback from implementations to the ongoing work in TS 102 578 [5] as well as to PLT modem implementers;
- check the feasibility of detecting and notching narrow bands;
- determine, if it is possible to detect SW radio ingress without demodulating signals by PLT PHY;
- determine probability of false detection by PLT modems;
- verify if there is a way of classifying the narrow band signals' source (radio station or switching power supply, or class D amp).

Therefore STF 332 will organize the Plugtests™event. At the execution of the Plugtests™ event any ETSI member is free to participate in the execution of any or all of the Plugtests™ event proposed in the present document.

1 Scope

Results of the verification of the proposed mechanism to improve coexistence between PLT and short wave radio broadcast.

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.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

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.

Not applicable.

2.2 Informative references

[1] ITU-R Radio Regulations, edition of 2004.

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

[3] ITU-R Recommendation BS.1284: "General methods for the subjective assessment of sound quality".

NOTE: See http://stason.org/TULARC/radio/shortwave/08-What-is-SINPO-SIO-Shortwave-radio.html.

[4] CISPR 16-1-1 (2006-11): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus".

[5] ETSI TS 102 578 (draft version of 12 October 2007): "PowerLine Telecommunications (PLT); Coexistence between PLT Modems and Short Wave Radio broadcasting services".

NOTE: See http://webapp.etsi.org/WorkProgram/Report_WorkItem.asp?WKI_ID=24584.

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

[7] ITU-R Recommendation P372: "Radio noise".

3 Abbreviations

3.1 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
HFCC	High Frequency Co-ordination Conference

NOTE: See http://www.hfcc.org.

LI	Level of Ingress (in dBm)
NHB	Noise higher frequency block (in dBm)
NLB	Noise lower frequency block (in dBm)
PLT	PowerLine Telecommunications

NOTE: See http://www.etsi.org/plt.

S	second
SINPO	Signal Strength, Interference, Noise, Propagation, Overall
SW	Short Wave

4 Test cases

4.1 Plugtests™ specification

There are 2 tests to be performed:

1) The concept, as specified in the current draft TS 102 578 [5] shall be verified.
Levels, Thresholds, Timing, definition of useable radio service reception quality, lower level and slopes of the notch, verification method, etc.
This test will be performed on 10th / 11th of October 2007 in Stuttgart area (Germany).
Revised values will be published by 17th of October 2007.

2) Tests with participants. Implementations from modem manufacturers will be verified versus this test specification.
These tests will be performed from 19th to 23rd of November 2007.

4.1.1 Verification of concept in a Building

4.1.1.1 Test environment

Test will be carried out in a private home. The detailed installation of the power infrastructure is unknown to test participants. The 300 kW SW radio broadcast station in Skelton (UK) will schedule some radio transmission according to the demands of this test. A Spectrum Analyser, Test Receiver and a selection of DRM and AM SW radio receivers are available to perform the tests. A calibrated active biconal antenna verifies the field strength in the air.

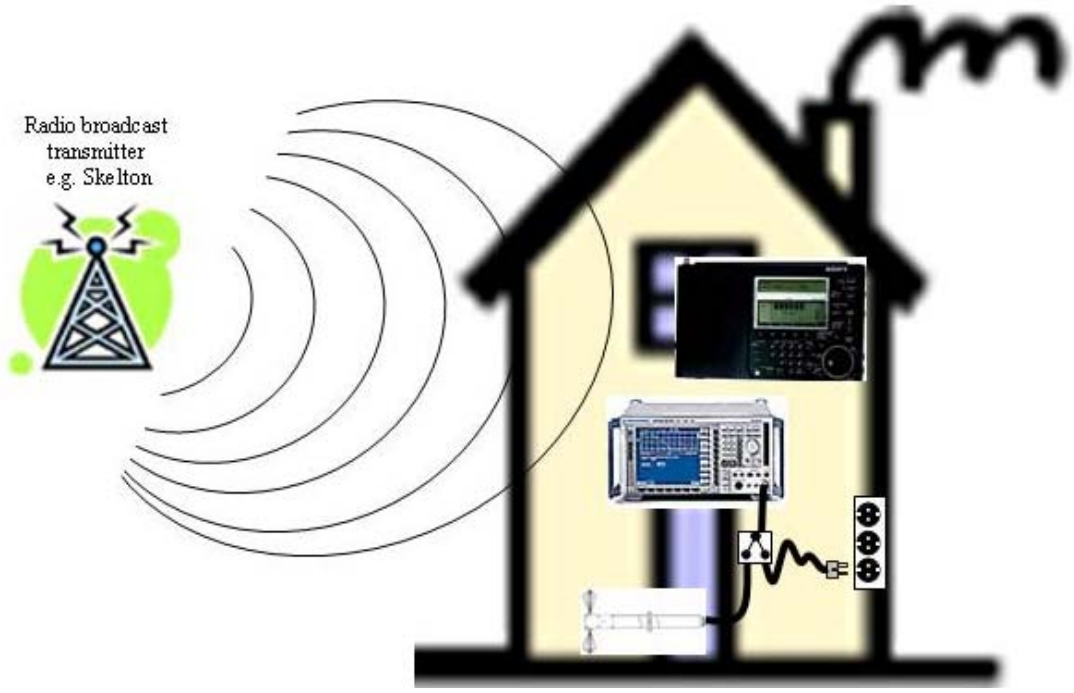

Figure 1: Test Setup in a private living unit

Equipment needed:

- CE SW Radio receiver:
  - AOR AR7030, Sony ICF-SW77, ICF-1000, Sangean ATS909, TECSUN 9700, etc.
- DRM: Roberts MP-40, etc.
- Cable snap ferrites.
- Spectrum Analyser, PLT coupler 50:100 Ω Impedance matching.
- Calibrated antenna in 1 MHz < f < 30 MHz, wooden tripod.
- Artificial white noise generator:
  - Coupler to feed noise to the mains grid.
  - Antenna to broadcast noise inside the building.

4.1.1.2 Verify Reception Quality of Radio Stations

This test will be done on the 10th of October 2007.

Using a SW radio receiver, scan the SW radio band and record the frequency, service name and reception quality wherever the automatic scan stops. Check for a good position of the receiver in the living unit and monitor the field strength there.

Connect the Spectrum Analyser to the mains (sequentially at several outlets) and measure the level of ingress of HF broadcast signals there. Do this process in turn 3 times and take the average from the numeric reading as result.

Classification for reception quality of AM stations shall be according to SINPO system [3]. The empirical rating of the signal quality will be done "democratically" by the three STF 332 experts. Tables 1 and 2 will be compiled during the tests.

Table 1: Reception quality, field strength and level of ingress of AM services

			Used AM Radio					In dBm				
Frequency in kHz	Station name	Field strength in dB (µV/m)	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall	Measured at outlet No: Level of Ingress noise levels of adjacent frequency block: Lower Block / Higher Block				
									1	2	3	4
6 123	Example AM	50	3	4	4	5	4	LI				
								NLB				
								NHB				
								LI				
								NLB				
								NHB				
								LI				
								NLB				
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								LI				
								NLB				
								NHB				
								LI				
								NLB				
								NHB				
								LI				
								NLB				
								NHB				

Classification for reception quality of DRM stations shall be done according the reception of a DRM channel:

- DRM Radio Stations using e.g. Roberts MP-40.

Table 2: Reception quality, field strength and level of ingress of DRM services

			Used DRM Radio	In dBm				
Frequency in kHz	Station name	Field strength in dB(μV/m)	Service receivable? Y/N	Measured at outlet No: Level of Ingress / noise levels of adjacent frequency block: Noise Lower Block / Noise Higher Block				
					1	2	3	4
	Example DRM	50	Y	LI	-75	-70	-69	-73
				NLB				
				NHB				
				LI				
				NLB				
				NHB				
				LI				
				NLB				
				NHB				
				LI				
				NLB				
				NHB				
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				NHB				
				LI				
				NLB				
				NHB				
				LI				
				NLB				
				NHB				
				LI				
				NLB				
				NHB				

After monitoring radio broadcast services at the Plugtests™ location, the HFCC Database (see http://www.hfcc.org) provides information on day and seasonal variations of reception quality. The HFCC Database may help to give an estimate of the necessity of notch parameters.

4.1.1.3 Revise thresholds, Level and Timings

Revise threshold of ingress as defined in draft TS 102 578 [5], where an ingress shall be identified as a receivable radio broadcast service, to create a notch.

Revise lower level of Notch defined in draft TS 102 578 [5], by feeding known noise level to the mains in vicinity of outlet where radio receiver is connected to. Record the level when reception quality gets worse (using SINPO).

Revise response timings defined in draft TS 102 578 [5] to activate notch and reuse the frequencies. Monitor fading behaviour in time domain of a transmission to the test location.

Schedule Skelton (UK) test broadcast transmission with 300 kW to monitor its field strength at various times in the test location. Compare it with 2nd location.

4.1.1.4 More Tests in the Building

If there is enough time at the test day, following tests shall be performed.

Check various receiver positions

Pick out smallest receivable service, verify reception quality using CE radio devices:

- AOR AR7030, Sony ICF-SW77, ICF-1000, Sangean ATS909, TECSUN 9700, etc.; and
- verify the field strength of this frequency at various locations in the building.

Check how far mains filters might remove interferences in Radio reception, when the receivers are powered by a mains adaptor.

Check level of interference to adjacent (neighbour) living unit.

4.1.1.5 Further tests to verify the concept in Lab / Anechoic chamber

This test will be done on the 11th of October 2007.

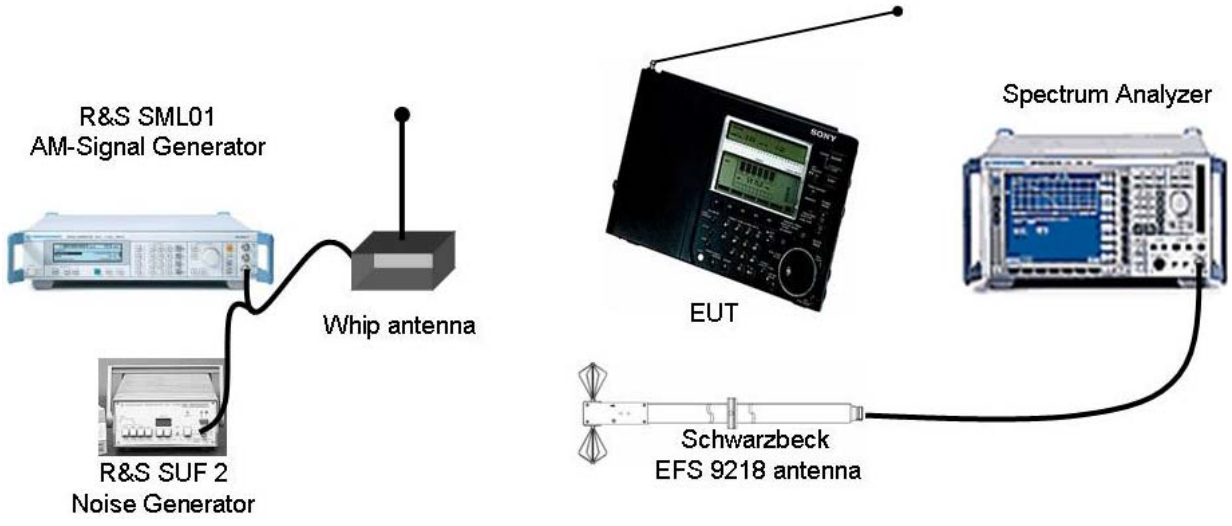

Figure 2: Test Setup anechoic chamber

Revise noise floor and relative level of ingress above noise floor defined in draft TS 102 578 [5] in an anechoic chamber. An AM signal with added noise will be generated and fed into the antenna input of a radio receiver. Check the SNR when the signal becomes an acceptable quality.

Check Consumer Electronic Radio devices when they identify a service as useable when scanning the band.

4.1.2 Laboratory Test with Participants

4.1.2.1 Test environment

Test will be done in a laboratory. Depending on organization and logistics of the Plugtests™ event the lab equipment might be transported into one of the private homes.

The tests will be carried out as described in the current draft of TS 102 578.

Equipment needed:

- Measurement apparatus.
- Ground plane, 1 m^2.
- Signal Ingress Generator:
  - Test signals known to participants: PLT43_TD_08 / PLT43_TD_09 TS102578_V1.1.8_VerifyPattern.
  - More Test signals not known to participants before tests:
    - more or less carriers, DRM and / or AM;
    - use other frequencies;
    - incl. noise.
- Spectrum Analyser.
- PLT Modems.
- Data traffic generation for PLT modems.

Specification of the unknown signals will be published after the Plugtests™event. Test Signals will be shared with participants, so these tests could be reproduced by participants in their laboratories.

4.1.2.2 Test Procedure

Follow the test procedure as described in TS 102 578 [5] (see clause Test Procedure).

Data throughput will be measured using IPERF: transmit UDP traffic monitoring packet loss and throughput

Modems will be connected to data source and sink via Ethernet plugs.

Table 3 will be compiled during the lab tests.

Table 3: Results sheet of TS 102 578 Laboratory tests

Participant A	Max PLT throughput without any notches in Mbit/s			Timing from switch on artificial ingress signal till notch is established in s	Max PLT throughput with notches in Mbit/s			Are all frequencies notched where a carrier ingress? Yes / No	Are more frequencies notched? (Where no carrier ingress?) Which?	Lower Level of the notch in dBm Readout value as described in current draft of TS 102 578	Timing from switch off artificial ingress signal till frequency is reused by PLT in s
	Attenuation from EUT to AE in dB				Attenuation from EUT to AE in dB						
	20	40	60		20	40	60				
Known signal PLT43_TD_08											
Unknown Signal A											
Unknown Signal B											
Unknown Signal C											

Record screen shot of Spectrum Analyser of each ITU-R Radio band.

Monitor notch slopes for checking AM- / DRM Protection ratios: Fine Sweep using Spectrum analyser on 1-2 notches.

Additionally the threshold at which notches are inserted may be measured by changing the power of artificial signal ingress.

4.1.3 Field-tests with Participants in Building

4.1.3.1 Test environment

Test environment includes everything as described in clause 4.1.1.1 (without biconal antenna).

Additionally the PLT modem equipment from participants is required.

Data throughput will be measured as described in clause 4.1.2.2.

4.1.3.2 Test procedure

Connect the PLT modems to (various combinations of) outlets in building.

Tune SW-radio DRM / AM to e.g. 5 frequencies as described in clause 4.1.1.2 and record reception quality of radio stations. (The 5 with the lowest power.) Table 4 will be compiled during the field tests in Buildings.

Table 4: Results sheet of TS 102 578 Field Tests in buildings

Participant A								
Without Smart Notching: PLT throughput in Mbit/s								
Frequency in kHz	**Station name**	**SINPO Signal**	**SINPO Interference**	**SINPO Noise**	**SINPO Propagation**	**SINPO Overall**	**Level of Ingress in dBm measured at outlet where PLT Modem is connected**	
							Tx Modem	**Rx Modem**
6 123	Example AM	2	3	3	5	3	-75	-70
Smart Notching active: PLT throughput in Mbit/s								
Frequency in kHz	**Station name**	**SINPO Signal**	**SINPO Interference**	**SINPO Noise**	**SINPO Propagation**	**SINPO Overall**	**Level of Ingress in dBm measured at outlet where PLT Modem is connected**	
							Tx Modem	**Rx Modem**
6 123	Example AM	5	5	5	5	5	-75	-70
Quick test for "false detections" of PLT modems: Are there any frequencies notched which does not coincident with a receivable SW radio broadcast?								
Schedule Skelton (UK) test broadcast transmission and monitor when PLT modem notches this frequency in s.								
Turn off Skelton (UK) test broadcast transmission and monitor when PLT reuses this frequency in s.								

5 Results

5.1 Plugtests™ specification

Two tests were performed:

1) The concept, as specified in the current draft of TS 102 578 [5] is verified.
i.e. Levels, Thresholds, Timing, definition of useable radio service reception quality, lower level and slopes of the notch, verification method, etc.
This test has been performed on 10th / 11th of October 2007 in Stuttgart area (Germany).
The following sites/buildings were visited to perform the tests:
- Dombovar Str 18, D-71394 Kernen.
- Hotel Unger Kronenstraße 17 70173 Stuttgart.
- Rosenstr 26 71364 Winnenden.
- Anechoic chamber.
Revised values have been published before 17th of October 2007.

2) Tests with participants. Two different systems were present, one using PLT modems with an extra algorithm running in an external PC and one PLT demonstrator system based on three PCs and external instrumental devices. The two systems have been verified versus this test specification.
These tests have been performed from 20th to 23rd of November 2007.
The following sites/buildings were visited to perform the tests with the prototype PLT systems:
- Dombovar Str 18, D-71394 Kernen.
- Hotel Steigenberger Graf Zeppelin, Stuttgart downtown.
- Hotel Ochsen, in Stuttgart Wangen.

5.1.1 Verification of concept in a Building

5.1.1.1 Test environment

The Tests have been carried out in one or more private homes. The detailed installation of the power infrastructure was unknown to the test participants before the tests. A 300 kW SW radio broadcast transmitter at the Skelton (UK) station has scheduled radio transmission according to the demands of this test. A Spectrum Analyser, Test Receiver and a selection of DRM and AM SW radio receivers were available to perform the tests. A calibrated active biconal antenna was used to verify the field strength in the air.

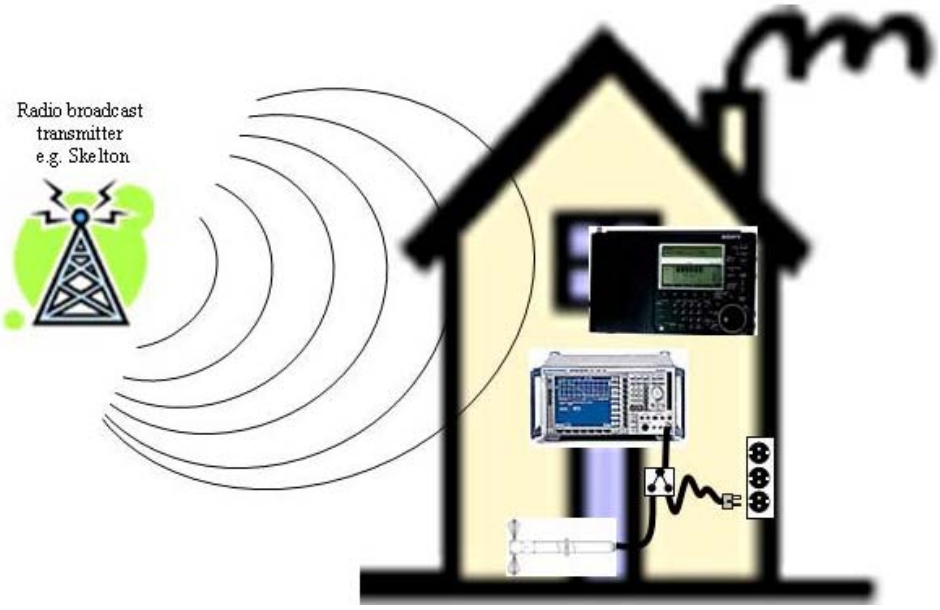

Figure 3: Test Setup in a private living unit

Equipment used:

- CE SW Radio receiver:
  - AOR AR7030, Sony ICF-SW77, ICF-1000, Sangean ATS909, TECSUN 9700, etc.
- DRM: Roberts MP-40, etc.
- Cable snap ferrites.
- Spectrum Analyser, PLT coupler 50:100 Ω Impedance matching.
- Test receiver.
- Calibrated antenna in 1MHz < f < 30MHz, wooden tripod.
- Artificial white noise generator:
  - Coupler to feed noise to the mains grid;
  - Antenna to broadcast noise inside the building.

5.1.1.2 Verify Reception Quality of Radio Stations

This test was carried out on the 10th and 11th of October 2007.

Using a SW radio receiver, the SW radio broadcasting bands were scanned and the frequency, service name and reception quality recorded wherever the automatic scan stopped. A "good" position for the receiver in the living unit was found and checked and the field strength monitored at this position.

The Spectrum Analyser was connected to the mains (sequentially at several outlets) and the level of ingress of HF broadcast signals measured. This process was repeated 3 times and the average from the numeric readings taken as the result.

Classification of reception quality of the AM stations was according to SINPO system [3]. The empirical rating of the signal quality was the result of a "democratic" vote by the three STF 332 experts. Tables 5 and 6 were compiled during the tests.

Unfortunately during execution of tests the transmission schedule of some services changed. Often it was found, that transmissions were switched off after receiving them with the radio and before verifying the level in the air or connected to the mains. Some fields in the following tables are therefore blank.

Many services showed a strong fading behaviour. This could be seen in the SINPO assessment of Propagation:

SINPO Propagation = 5: no apparent fading
SINPO Propagation = 4: fading was less than 3 dB
SINPO Propagation = 3: fading was less than 10 dB
SINPO Propagation = 2: fading was less than 20 dB
SINPO Propagation = 1: fading was more than 20 dB

The values listed in table 5 to table 10 show a one time shot of the level of this service.

NOTE: TS 102 578 [5] requires to notch a frequency if the threshold is passed once and to reuse a frequency if the ingress is lower than threshold longer than a specified time. There is a hysteresis specified when to establish a notch and when to reuse the frequency.

Table 5: Reception quality, field strength and level of ingress of AM services

Dombovar Str 18, D-71394 Kernen			Used AM Radio: Sony SW 1000						In dBm			
Frequency in kHz	Station name	Field strength in dB (µV/m)	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall		Measured at outlet No: (1, 2, 3, 4) Level of Ingress noise levels of adjacent frequency block: Lower Block / Higher Block			
									1	2	3	4
6 075	Deutsche Welle	65,6	2	4	4	2	3	LI	-63	-65	-52	-70
								NLB	-98	-95	-97	-102
								NHB	-93	-95	-96	-93
9 640	Skelton	71,8	5	3	3	3	3	LI				
								NLB	-104	-99	-98	-107
								NHB	-104	-103	-98	-108
9 545	German Language	48,2	3	3	2	2	2	LI	-68	-78	-70	-68
								NLB	-104	-99	-98	-107
								NHB	-104	-103	-98	-108
9 480	German Language	50,3	3	4	3	4	3	LI	-70	-75	-65	-63
								NLB	-104	-99	-98	-107
								NHB	-104	-103	-98	-108
9 430	Skelton 2	64,8	4	4	3	3	4	LI	-52	-58	-55	-55
								NLB	-104	-107	-98	-107
								NHB	-104	-107	-98	-108
6 155	Austrian Transmission	57,2	2	3	3	2	2	LI	-61		-53	-58
								NLB	-98	-95	-97	-102
								NHB	-93	-95	-96	-93

Table 5 is not a complete list. Due to time constraints it was not possible to note all SW radio services in this location.

Classification for reception quality of DRM stations was according the reception of a DRM channel.

Table 6: Reception quality, field strength and level of ingress of DRM services

Dombovar Str 18, D-71394 Kernen			Used DRM Radio: Roberts MP-40	In dBm				
Frequency in kHz	Station name	Field strength in dB(µV/m)	Service receivable? Y/N	Measured at outlet No: (1, 2, 3, 4) Level of Ingress / noise levels of adjacent frequency block: Noise Lower Block / Noise Higher Block				
					1	2	3	4
7 190	Radio Vatican	56,7	Y	LI				
				NLB	-97	-98	-98	-96
				NHB	-100	-98	-98	-99
7 275	Deutsche Welle Sometimes receivable	59,5	intermittent	LI	-82	-80	-78	-72
				NLB	-97	-98	-98	-96
				NHB	-100	-98	-98	-99
6 085	Bavaria 5	61,6	Y	LI	-75	-90	-74	-80
				NLB	-98	-95	-97	-102
				NHB	-93	-95	-96	-93

Table 6 is not a complete list. Due to time constraints it was not possible to note all SW radio services in this location.

Table 7: Reception quality, field strength and level of ingress of AM services

Hotel Unger Kronenstraße 17 70173 Stuttgart			Used AM Radio: Sony SW 1000						In dBm			
Frequency in kHz	Station name	Field strength in dB (µV/m)	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall		Measured at outlet No: (1, 2, 3, 4) Level of Ingress noise levels of adjacent frequency block: Lower Block / Higher Block			
									1	2	3	4
7 335	Skelton	56,4	3	3	3	3	3	LI	-84	-82	-84	-83
								NLB	-95	-93	-89	-95
								NHB	-97	-93	-91	-95
5 955	Radio Netherland	46,3	3	4	4	3	4	LI	-80	-76		
								NLB	-95	-91		
								NHB	-94	-91		
5 970	German	43	3	2	2	2	2	LI	-80	-85	-79	-82
								NLB	-95	-91	-81	-87
								NHB	-94	-91	-76	-95
9 420	Spanish	48	3	4	4	3	4	LI	-91	-85	-88	-90
								NLB	-90	-97	-93	-100
								NHB	-87	-91	-89	-98
9 465	Arabic(?)	58	2	1	1	2	1	LI	-93	-96	-91	-98
								NLB	-90	-97	-93	-100
								NHB	-87	-91	-89	-98
15 215	Eastern Europe	46	2	2	2	3	2	LI	-95	-82	-85	-89
								NLB	-103	-102	-100	-96
								NHB	-102	-102	-103	-101

Table 7 is not a complete list. Due to time constraints it was not possible to note all SW radio services in this location.

Table 8: Reception quality, field strength and level of ingress of DRM services

Hotel Unger Kronenstraße 17 70173 Stuttgart			Used DRM Radio: Roberts MP-40	In dBm				
Frequency in kHz	Station name	Field strength in dB(µV/m)	Service receivable? Y/N	Measured at outlet No: (1, 2, 3, 4) Level of Ingress / noise levels of adjacent frequency block: Noise Lower Block / Noise Higher Block				
					1	2	3	4
	No DRM receivable			LI				
				NLB				
				NHB				

Table 8 is not a complete list. Due to time constraints it was not possible to note all SW radio services in this location.

Table 9: Reception quality, field strength and level of ingress of AM services

Rosenstr 26 71364 Winnenden			Used AM Radio: Sony SW 1000						In dBm			
Frequency in kHz	Station name	Field strength in dB (µV/m)	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall		Measured at outlet No: (1, 2, 3, 4) Level of Ingress noise levels of adjacent frequency block: Lower Block / Higher Block			
									1	2	3	4
5 955	Radio Netherlands	72,5	4	5	4	4	4	LI	-50	-52	-54	
								NLB	-95	-98	-93	
								NHB	-93	-100	-92	
6 035	Netherland (?)	48	2	3	2	2	2	LI	-71	-68	-74	
								NLB	-95	-98	-93	
								NHB	-93	-100	-92	
6 075	DW	61	3	2	2	2	3	LI				
								NLB	-95	-98	-93	
								NHB	-93	-100	-92	
6 155	Austria	64	3	4	4	2	3	LI				
								NLB	-95	-98	-93	
								NHB	-93	-100	-92	
7 345	Lost in the meantime							LI				
								NLB	-100	-107	-101	
								NHB	-102	-109	-105	
9 420	?	52	3	4	3	3	3	LI				
								NLB	-104	-107	-103	
								NHB	-104	-105	-104	
9 545	(German)	41	2	4	3	2	3	LI	-90	-88	-82	
								NLB	-104	-107	-103	
								NHB	-104	-105	-104	
9 575	(French)	43	1	1	1	1	2	LI	-92	-93	-94	
								NLB	-104	-107	-103	
								NHB	-104	-105	-104	
9 710		36	1	1	1	1	2	LI				
								NLB	-104	-107	-103	
								NHB	-104	-105	-104	
11 645	(Italian, Czech)	43	1	1	1	1	1	LI	-75	-80	-77	
								NLB	-105	-104	-102	
								NHB	-106	-105	-101	
11 690	Not anymore measureable							LI				
								NLB	-105	-104	-102	
								NHB	-106	-105	-101	
11 785	(Chinese ?)	55	4	2	3	1	3	LI				
								NLB	-105	-104	-102	
								NHB	-106	-105	-101	
12 020	(Slovakia ?)	57	4	4	4	2	4	LI				
								NLB	-105	-104	-102	
								NHB	-106	-105	-101	

Rosenstr 26 71364 Winnenden			Used AM Radio: Sony SW 1000						In dBm			
Frequency in kHz	Station name	Field strength in dB (µV/m)	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall		Measured at outlet No: (1, 2, 3, 4) Level of Ingress noise levels of adjacent frequency block: Lower Block / Higher Block			
									1	2	3	4
12 035	(Spanish)	63	4	4	3	2	3	LI				
								NLB	-105	-104	-102	
								NHB	-106	-105	-101	
13 710	(Voice of America ?)	59	4	4	4	1	4	LI				
								NLB	-104	-102	-104	
								NHB	-104	-101	-105	
15 350	(Russian?)	55	3	2	2	2	2	LI				
								NLB	-105	-99	-106	
								NHB	-104	-105	-106	
15 380	(Arabic)	48	2	4	3	1	3	LI				
								NLB	-104	-102	-104	
								NHB	-104	-101	-105	
15 665	(Russian)	46	2	3	2	1	2	LI	-77	-100	-78	
								NLB	-104	-102	-104	
								NHB	-104	-101	-105	
15 760	(Greek or Turkish)	49	3	3	2	1	2	LI				
								NLB	-104	-102	-104	
								NHB	-104	-101	-105	
17 490	(English) Country Music	48	3	4	3	1	3	LI	-93	-74	-78	
								NLB	-105	-107	-108	
								NHB	-106	-107	-107	
17 650	Two stations	46	2	1		2	1	LI				
								NLB	-105	-107	-108	
								NHB	-106	-107	-107	
17 730	Very noise, but speech temporarily recognizable	36	1	2	1	1	1	LI				
								NLB	-105	-107	-108	
								NHB	-106	-107	-107	
17 740	Not anymore receivable							LI				
								NLB	-105	-107	-108	
								NHB	-106	-107	-107	
17 785	(French)	40	1	2	2	1	2	LI	-100	-96	-85	
								NLB	-105	-107	-108	
								NHB	-106	-107	-107	

Table 9 lists all SW radio services receivable in this location when the tests were performed. Due to the transmission schedule of some services it was not possible to note the ingress to the mains of all SW radio services in this location.

Table 10: Reception quality, field strength and level of ingress of DRM services

Rosenstr 26 71364 Winnenden			Used DRM Radio: Roberts MP-40	In dBm				
Frequency in kHz	Station name	Field strength in dB(µV/m)	Service receivable? Y/N	Measured at outlet No: (1, 2, 3, 4) Level of Ingress / noise levels of adjacent frequency block: Noise Lower Block / Noise Higher Block				
					1	2	3	4
6 085	B5	50		LI			-55	
				NLB	-95	-98	-93	
				NHB	-93	-100	-92	
6 175	RMC	46		LI		-75	-80	
				NLB	-95	-98	-93	
				NHB	-93	-100	-92	
7 325	Not receivable	40		LI				
				NLB	-100	-107	-101	
				NHB	-102	-109	-105	
13 810	DW	60		LI			-50	
				NLB	-104	-102	-104	
				NHB	-104	-101	-105	
5 990	RTL	48		LI			-66	
				NLB	-100	-107	-101	
				NHB	-102	-109	-105	
6 095	RTL	56		LI			-61	
				NLB	-100	-107	-101	
				NHB	-102	-109	-105	

Table 10 lists all SW radio services receivable in this location when the tests were performed.

The HFCC Database (http://www.hfcc.org/data/index.html) provides information on day and seasonal variations of reception quality. The HFCC Database may help to give an estimate of the necessity of notch parameters.

5.1.1.3 Revise thresholds, Level and Timings

Verify (and revise) threshold of ingress as defined in TS 102 578 [5], where an ingress shall be identified as a receivable radio broadcast service, to create a notch.

Verify (and revise) lower level of the Notch defined in TS 102 578 [5]. A known noise level was fed to the mains in the vicinity of the outlet where the radio receiver was connected. The level when reception quality was impaired (using SINPO) was recorded. Human ears were listening to see if the additional noise affected SW radio reception. For verification of the noise level a spectrum analyser using an average detector and 300 Hz resolution bandwidth was used.

Table 11: Effects on SW Radio reception at Hotel Unger, if additional noise was fed into the mains

Sony ICF-SW77 was tuned to 5 970 kHz (German Voice). Noise fed at -69 dBm (exactly the lower level of the notch for class B devices proposed in TS 102 578 [5]) was detectable with the ICF-SW77. Noise fed at -79 dBm was not detectable. If the ICF-SW77 was driven from its internal battery, noise at -59 dBm was hardly detectable. Lower noise levels were not detectable.
The Sony ICF-SW77 was tuned to 9 420 kHz (Spanish transmission). Noise fed at -63 dBm was detectable with the SW77. Noise fed at -66 dBm was not detectable.
The Sony ICF-SW77 was tuned to 15 215 kHz (any Eastern Europe transmission). Noise fed at -69 dBm was hardly detectable with the ICF-SW77. Lower noise levels were not detectable. If the SW77 was driven from its internal battery, noise at -59 dBm was hardly detectable. Lower noise levels were not detectable.

Table 12: Effects on SW Radio reception at Rosenstr, if additional noise is fed into the mains

Sony ICF-SW1000 was tuned to 6 075 kHz (Deutsche Welle). Noise fed at -69 dBm was not detectable with the SW1000: -59 dBm: not detectable -49 dBm: not detectable -39 dBm: only just detectable -34 dBm: heard -29 dBm: clearly heard Battery-operation: up to -39 dBm noise was not detectable
Sony ICF-SW1000 was tuned to 9 545 kHz (a German station). Noise fed at -69 dBm was not detectable: -59 dBm was hardly detectable Battery-operation: Noise with the level of -59 dBm was heard: -69 dBm: Not detectable
Sony ICF-SW1000 was tuned to 15 760 kHz (Greek or Turkish station). Noise fed at -69 dBm was not detectable: -64 dBm: hardly detectable -59 dBm: detectable Battery-operation: -64 dBm: hardly detectable -69 dBm: Not detectable

Response timings revised to activate notch and reuse the frequencies. Fading behaviour of the transmission was monitored in time domain at the test location.

Timings of draft TS 102578 [5] were considered to be correct but open to revision at the 2nd part of the Plugtests™ event where participants were present (for description of the 1st and 2nd part of this Plugtests™ event - see clause 5.1).

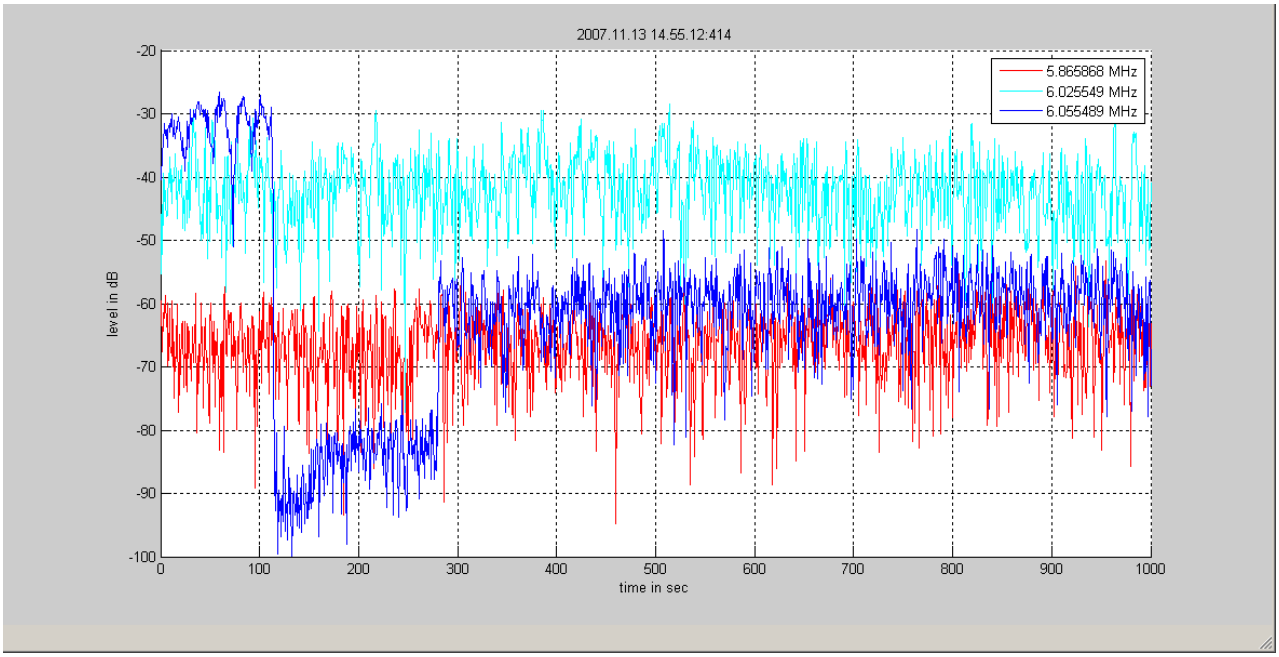

Figure 4: Fading of 3 SW radio broadcast services

Figure 4 shows the fading behaviour of SW radio transmissions in the time domain. The level of the receive signal may change by more than 30 dB within a few seconds.

Skelton (UK) test broadcast transmission was scheduled with 300 kW output to monitor its field strength at various times in the test location.

5.1.1.4 More Tests in the Building

The receiver has been paced close to the window, in the centre of the ledge or on a table next to the window.

In one building (Dombovarstr) a corner of the room which is located in the centre of the building was found to provide best reception quality. For SINPO assumption, the receivers were located in the so called "magic corner".

Pick out smallest receivable service and verify reception quality using CE radio devices:

- AOR AR7030, Sony ICF-SW77, ICF-1000, Sangean ATS909, TECSUN 9700, etc; and
- a measurement receiver with a biconical antenna to verify the field strength of this frequency at various locations in the building.

5.1.1.5 Further tests to verify the concept in Lab / Anechoic chamber

This test was performed on the 11th of October 2007.

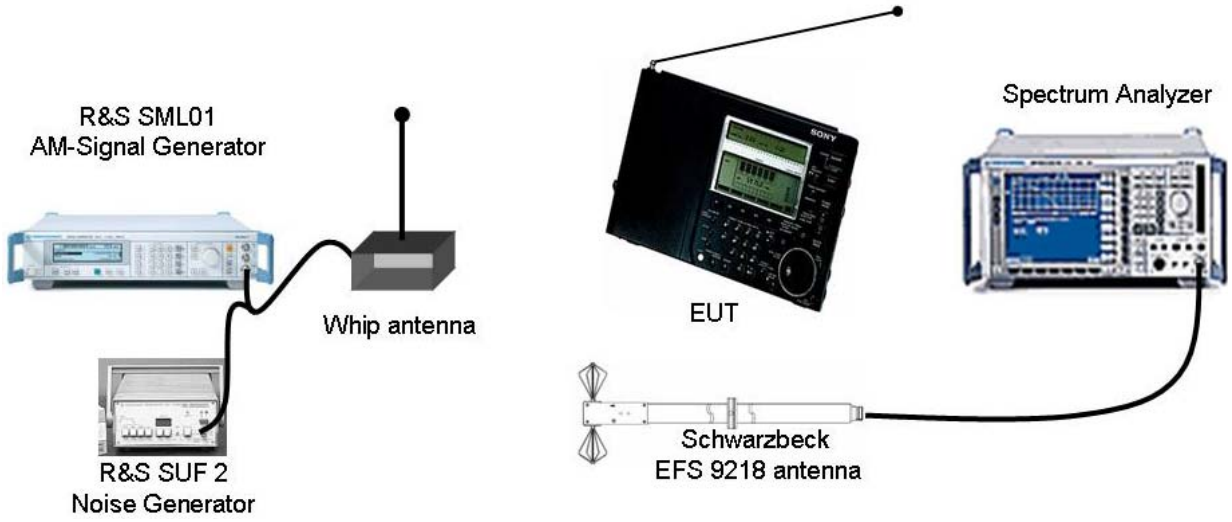

Figure 5: Test Setup anechoic chamber

The noise floor and relative level of ingress above noise floor has been revised in an anechoic chamber. An AM signal with added noise is generated and fed into the antenna input of a radio receiver. The SNR when the signal becomes an acceptable quality was recorded.

At the setup as depicted in Figure 5 an AM-service was found that a speaking voice was no more able to be understood (this frequency is no more worth to be notched by PLT) if the field of the AM service was 31,1 dB(µV/m) and the noise signal was 14,1 dB(µV/m), using a spectrum analyser or measurement receiver according to [4]. This results in an SNR of 17 dB.

Later, table 12 of the DRM specification (ES 201 980 (V2.2.1) [2] was reviewed and the relative threshold was increased to 14 dB. This is the required SNR of most robust DRM transmissions.

5.1.2 Laboratory Test with Participants

Foreword about the status of the equipment used for the Plugtests™ event:

Sony used a device called the "PLT Demonstrator system". This consists of 2 PCs equipped with additional hardware enabling the transmission of data via the mains wiring. The system was controlled via a 3rd computer running Matlab script to visualize status information such as throughput rates (based on carrier bitload estimation of a quasi error free transmission), information which carriers were notched, etc. The Sony system could be configured to transmit data in a pulse-pause mode so that interference was easily noticed by human ears.

The DS2 (Design of Systems on Silicon) system was based on 2 embedded PLT modems. The system could be remotely controlled from an external computer to monitor the status and initiate any status changes. The algorithm is not implemented yet in firmware, causing some extra time to communicate between the modems and the monitoring system. So the response is not as fast as it would be for a final implementation of the algorithm in the modem.

Both systems are prototypes to evaluate the efficiency of the "Smart Notching" concepts. Today's implementations are based on the current draft of TS 102 578 [5] from Oct 2007. Timings and thresholds (especially) will be optimized for final products.

5.1.2.1 Test environment

For logistical reasons the laboratory equipment was taken into one of the private homes.

The tests were carried out as described in the current draft of TS 102 578 [5], notably clause "Verification of the Implementations to the Standard".

Equipment used:

- Measurement apparatus.
- Ground plane, 1 m².
- Signal Ingress Generator.
    - Test signals known to participants: PLT43_TD_08 / PLT43_TD_09 TS102578_V1.1.8_VerifyPattern.
    - More Test signals not known to participants before tests:
        - more or less carriers, DRM and / or AM;
        - use other frequencies;
        - incl. noise.
- Spectrum analyser
- PLT Modems
- Data traffic generation for PLT modems

5.1.2.2 Test Procedure

The tests were performed according to the procedure described in TS 102 578 [5] (see clause "Test Procedure").

For DS2 modems data throughput was measured using IPERF: transmit UDP traffic monitoring packet loss and throughput. Modems were connected to data source and sink via Ethernet plugs.

Throughput of Sony system was recoded from the status information (based on carrier bit-load estimation of a quasi error free data transmission) given by the system itself.

Table 13: Results sheet of TS 102 578 Lab tests

Sony	**Max PLT throughput without any notches in Mbit/s: Phy level / UDP level**			**Timing from switch on artificial ingress signal till notch is established in s**	**Max PLT throughput with notches in Mbit/s Phy level / UDP level**			**Are all frequencies notched where a carrier ingress ? Yes / No**	**Are more frequencies notched? (Where no carrier ingress?) Which?**	**Lower Level of the notch in dBm Readout value as described in current draft of TS 102 578 [5]**	**Timing from switch off artificial ingress signal till frequency is reused by PLT in s**
	Attenuation from EUT to AE in dB				Attenuation from EUT to AE in dB						
	20	40	60		20	40	60				
Signal PLT43_TD_08	202 / 59	199 / 58	71 / 27	7 to enable all notches	199 / 58	184 / 56	90 / 33	Yes, see note 2	No, see note 3	-97, see screenshot, below	After 47 s the 1st notch (5,897 MHz) was removed. Other notches were removed later.
Signal PLT43_TD_08 plus one more signal ingress at 6 MHz				5 to enable the extra notch							52
Signal PLT43_TD_08 plus one more signal ingress at 17,6 MHz				4 to enable the extra notch							116

NOTE 1: Throughput of notched transmission was sometimes higher than without notches. This was caused by a non optimal implementation of the algorithm selecting the constellation of OFDM bit-loading.
NOTE 2: All carriers allocated by PLT43_TD_08 were detected except the carries in the 11 m band. These 2 carriers were notched only after the level of the ingress was increased by 4 dB.
NOTE 3: Time constraints during the Plugtests™ event meant that the laboratory test was not performed in an anechoic chamber but in a private building. The SW radio ingress was sufficiently strong, that signals were induced on the coaxial cables used for the tests. These signals showed higher levels than the thresholds defined in current draft of TS 102 578 [5]. Additional notches were monitored at 6,01 MHz as well than 17,61 MHz.

Figures 6 and 7 show screenshots from spectrum analyser monitoring:

- All notches installed for the verification signal PLT43_TD_08.
- Details of the notch at 15,1 MHz. The "needle" of the ingress is visible, as well.

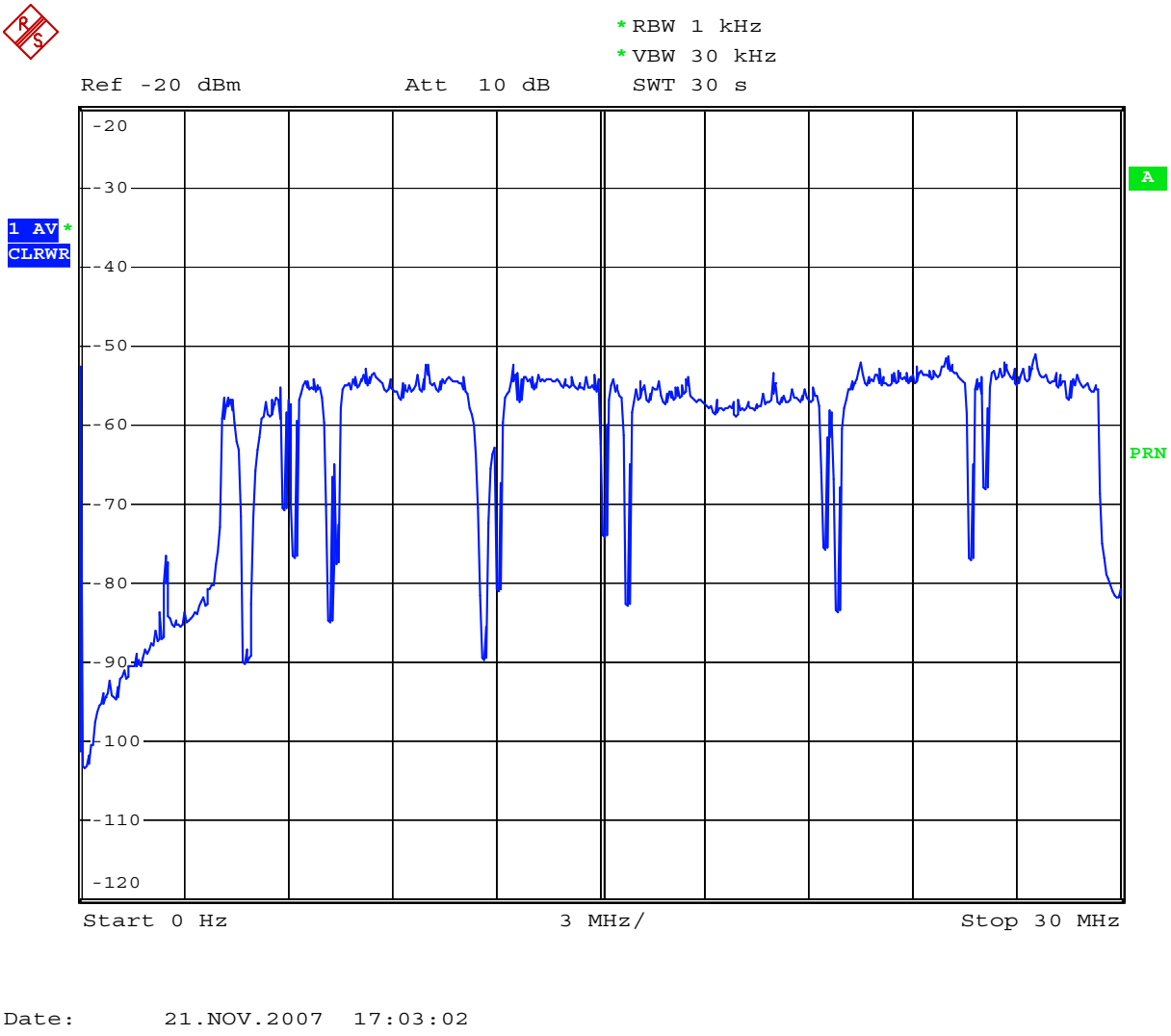

Figure 6: All notches installed for the verification signal PLT43_TD_08 (Sony system)

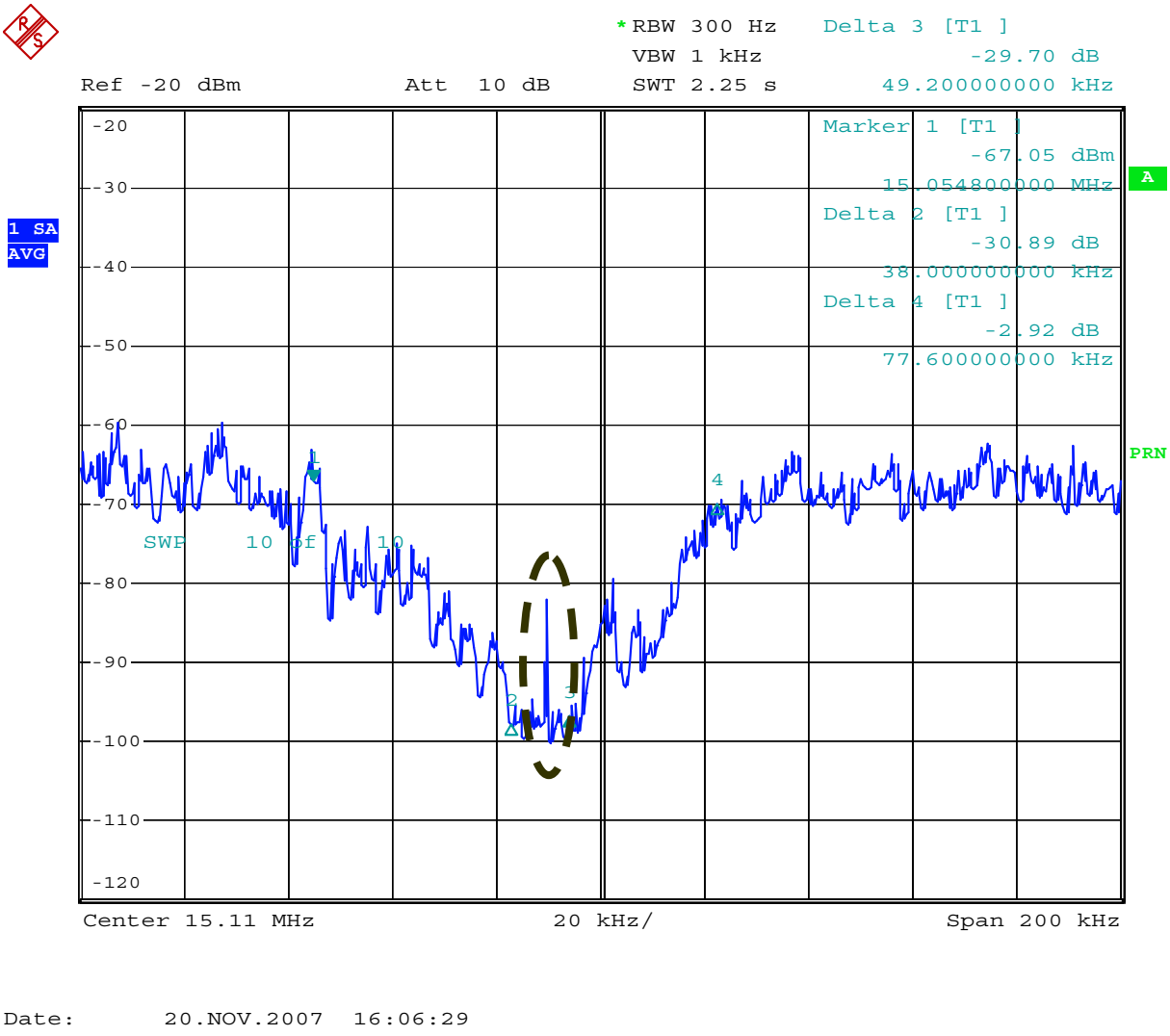

Figure 7: A PLT notch and signal ingress (dashed ring) at 15,1 MHz (Sony system)

Table 14: Results sheet of TS 102 578 Lab tests

DS2	Max PLT throughput without any notches in Mbit/s UDP level			Timing from switch on artificial ingress signal till notch is established in s	Max PLT throughput with notches in Mbit/s UDP level			Are all frequen-cies notched where a carrier ingress? Yes / No	Are more frequen-cies notched? (Where no carrier ingress?) Which?	Lower Level of the notch in dBm Readout value as described in current draft of TS 102 578 [5]	Timing from switch off artificial ingress signal till frequency is reused by PLT in s
	Attenuation from EUT to AE in dB				Attenuation from EUT to AE in dB						
	20	40	60		20	40	60				
Signal PLT43_TD_08	94	91	68	20 for all notches, see note	90	86	43	yes	no	-100, see screenshot, below	76, see note
Signal PLT43_TD_08 plus one more signal ingress at 17,6 MHz				20 to enable the extra notch							76
NOTE: The decision to set a notch was performed in an offline computing process. The timings to install a notch and to reuse the frequency are mainly defined by the performance of the communication between the modem and the remote control system. The intention is to include this firmware on the final products. It is expected to improve the timings. The detection process (monitoring the noise) does not "cost" any additional resource from data communication. Any additional HF signal ingress (independent of the number of notches to be added) will be protected by PLT modem within 20 s.											

The throughput rates were measured with IPRF. An average value of a 2 minutes data transmission was recorded.

Figures 8 and 9 show screenshots from the spectrum analyser monitoring all notches and details of the notch at 15,1 MHz.

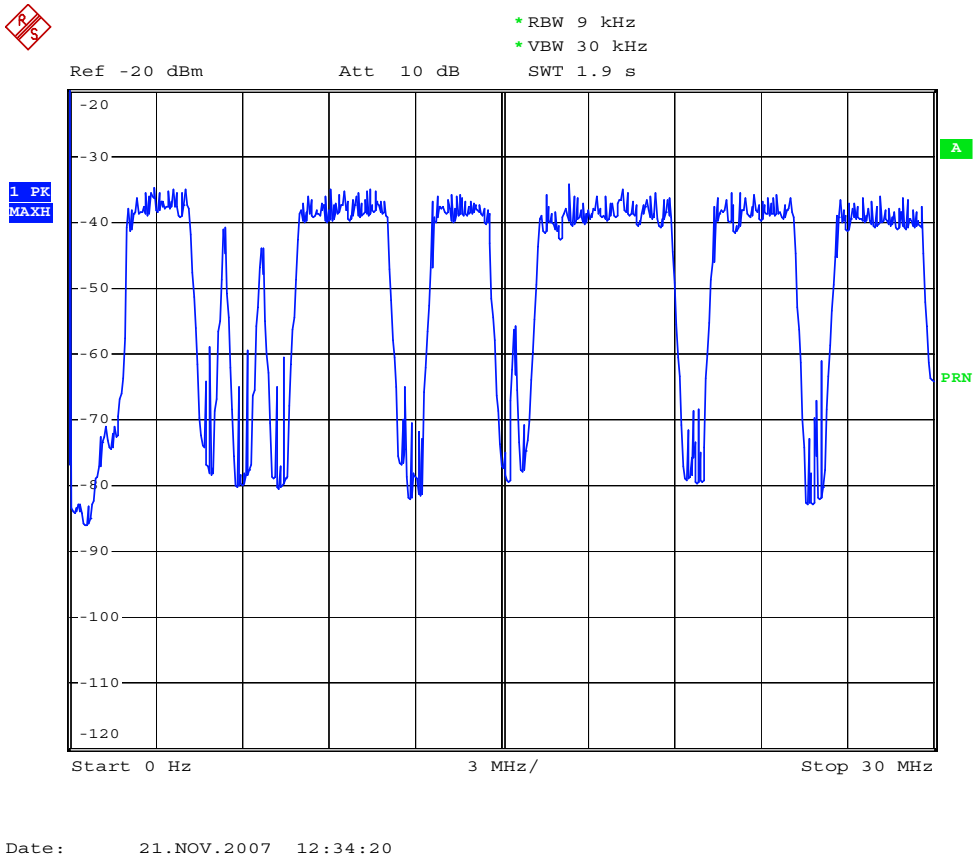

Figure 8: DS2 PSD including all notches for the lab tests with signal PLT43_TD_08. The ingress signal itself is visible inside the notches.

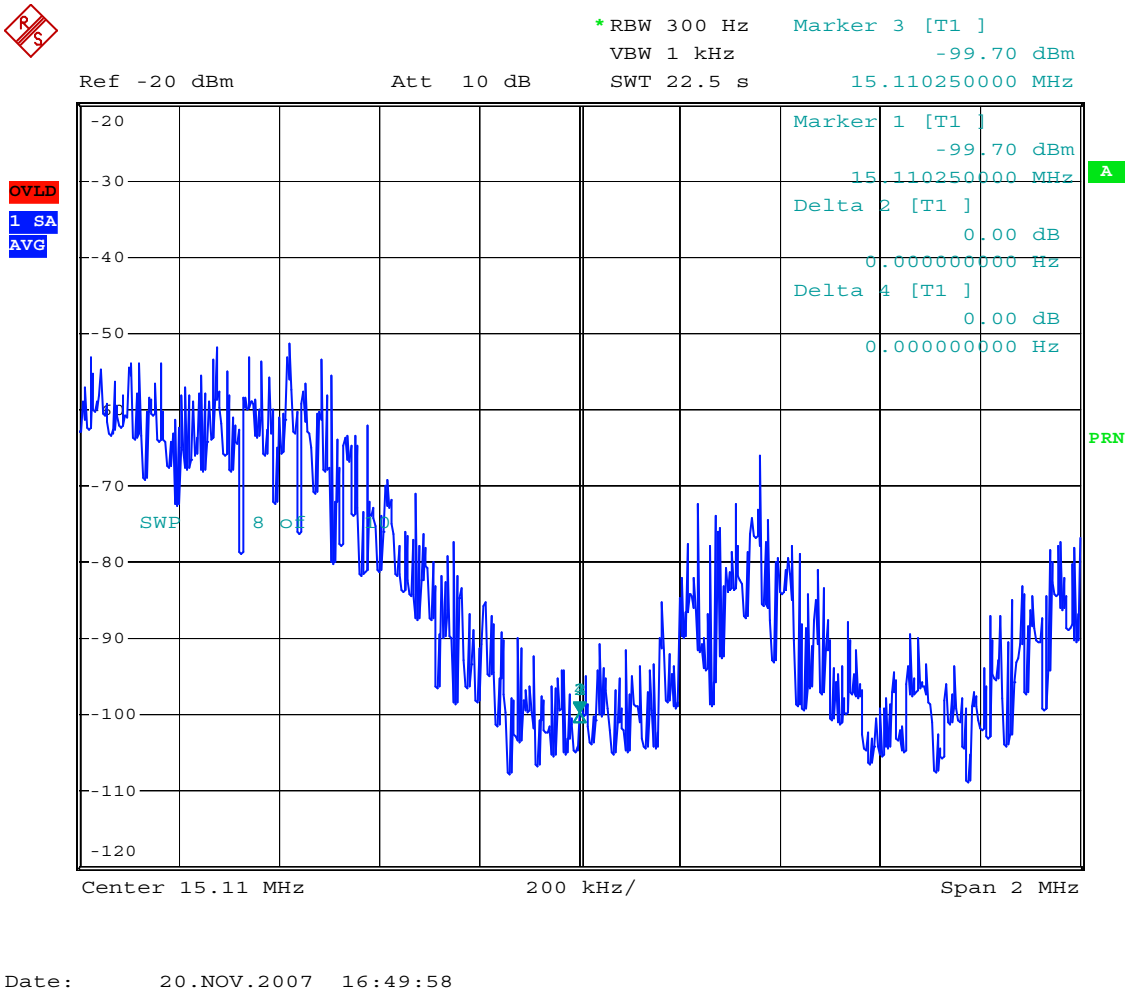

Figure 9: PLT notches (DS2 system)

5.1.3 Field-tests with Participants in Building

5.1.3.1 Test environment

The test environment includes everything as described in clause 5.1.1.1 of the present document.

Additionally the PLT modem equipment from participants was required.

Data throughput was measured as described in clause 5.1.2.2

5.1.3.2 Test procedure and results

The PLT modems were connected to (various combinations of) outlets in building.

The SW-radio DRM / AM were tuned to frequencies as described in clause 5.1.1.2 and reception quality of radio stations recorded. Table 8 was compiled during the field tests in Buildings. Tests were performed in the following steps:

1) A frequency scan was performed using a spectrum analyser connected to the calibrated antenna. All services with field strength larger than 40 dBµV/m were recorded.

2) A test receiver was tuned to the dedicated frequencies.

3) Level of ingress of the tuned frequency conducted to the mains was recorded.

4) The SINPO assessment was performed.

Due to the variation over time of the transmission environment as well the broadcast schedule it is difficult to perform reproducible measurements (see figure 4). The results shown below are a one time snapshot of services found at the location at the time when the Plugtests™ event was performed. Sometimes a service found during one of the early steps was not found during the later steps. Vice versa, when tuning the radio to perform the SINPO assessment, new services were found, that were not available at initial scans. Information about fading behaviour of HF transmissions can be found in ES 201 980 [2]. Information about broadcast scheduling is given in annex A.

Scan performed in Dombovarstr 18 in D-71394 Kernen, 20th of November 2007, 17:05:40h.

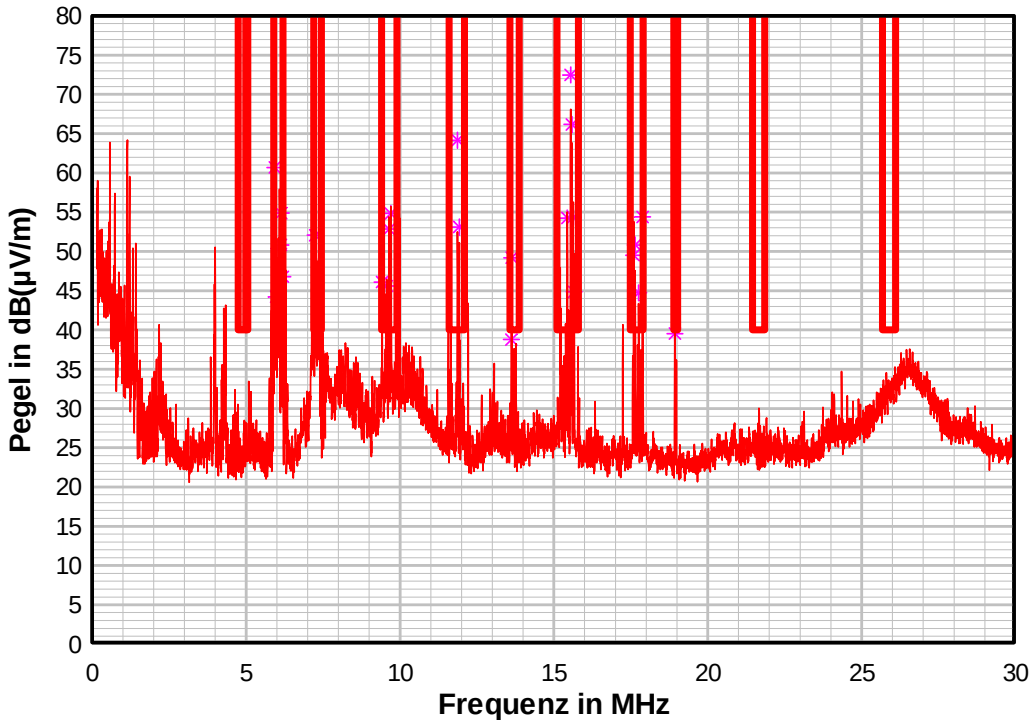

Figure 10: Frequencies scan of electrical field. ITU-R bands are marked

A test receiver according to [4] and an Average Detector were used for recording of the following values.

Table 15: List of SW services found during the tests at 17:00h

Frequency in kHz	Level in dB(µV/m)	Power conducted to the mains in dBm
5 930	60,7	-60
5 980	44,2	-68
5 990	service no more found	
6 065	36	-76
6 080	30	-85
6 130	50,8	-72
6 145	54,9	-69
6 195	46,8	-57
7 250	47	service no more found
7 350	service no more found	
9 420	46,1	-75
9 575	45,6	service no more found
9 645	52,9	service no more found
9 715	service no more found	
9 860	48	service no more found
11 655	service no more found	
11 870	64,1	service no more found
11 925	53,1	-63
13 620	38,8	-62
13 630	49,2	service no more found

The PLT system and the radio receiver were located in the same room. The outlets for both were connected to the same fuse by a single electrical path. This setup is a "worse case" scenario in terms of interferences from PLT to SW radio broadcast.

Table 16: Results sheet of TS 102 578 Field Tests in buildings: Sony system in Dombovarstr 18

Sony

Without Smart Notching: PLT throughput in Mbit/s: 199 Mbit/s (raw Phy rate) 58 Mbit/s on UDP layer

Frequency in kHz	Comment	Station name	SINPO Signal	SINPO Inter-ference	SINPO Noise	SINPO Propa-gation	SINPO Overall
	PLT could cause interference						
5 980			4	1	1		
6 065	Not possible to listen		2	1	1	2	2
6 080		Deutsche Welle	3	1	1	1	1
6 130		RFI	4	3	4	3	1
6 145		German	3	2	2	4	4
7 250		TVB (Chinese)	2	1	1	2	1

Smart Notching active: PLT throughput in Mbit/s: 195Mbit/s (raw Phy rate) 57 Mbit/s on UDP layer

Frequency in kHz	Comment	Station name	SINPO Signal	SINPO Inter-ference	SINPO Noise	SINPO Propa-gation	SINPO Overall
	If no comment, any interference from PLT was not noticed.						
5 930	No more receivable		4	3	3	2	3
5 980			2	1	2	2	1
6 065	Mix of 2 AM carriers, fading alternating	Dutch language	3	3	3	3	3
6 080		Deutsche Welle	4	4	4	4	4
6 130		RFI	3	3	3	3	3
6 145		German	2	3	3	2	3
7 250		TVB (Chinese)	4	3	3	2	3

Quick test for "false detections" of PLT modems:
Were any frequencies notched which did not coincide with a receivable SW radio broadcast?
At the test location only a switching power supply was identified causing interferences to PLT. This noise can sometimes cause a few false detections.

Skelton transmitter (UK) has produced test broadcast transmissions with frequency changes which allow the study of the mechanism of adding and releasing notches
The Skelton transmission toggled from 7 225 kHz to 7 320 kHz. There were 2 radios tuned to each frequency. In parallel there was a PLT transmission inside the building.

Event	Absolute Timings
Skelton transmitting on 7 225 kHz. 7 225 kHz was notched by PLT system. No interference could be observed at 7 225 kHz. Strong PLT interference was noticed at the radio tuned to 7 320 kHz.	Before trigger
Skelton transmission on 7 225 kHz was switched off	0 s
Skelton transmission on 7 320 kHz was switched on	13 s
AM modulation on 7 320 kHz starts	14 s
Interference from PLT to 7 320 kHz stops by inserting a notch	17 s
7 225 kHz was reused by PLT	69 s

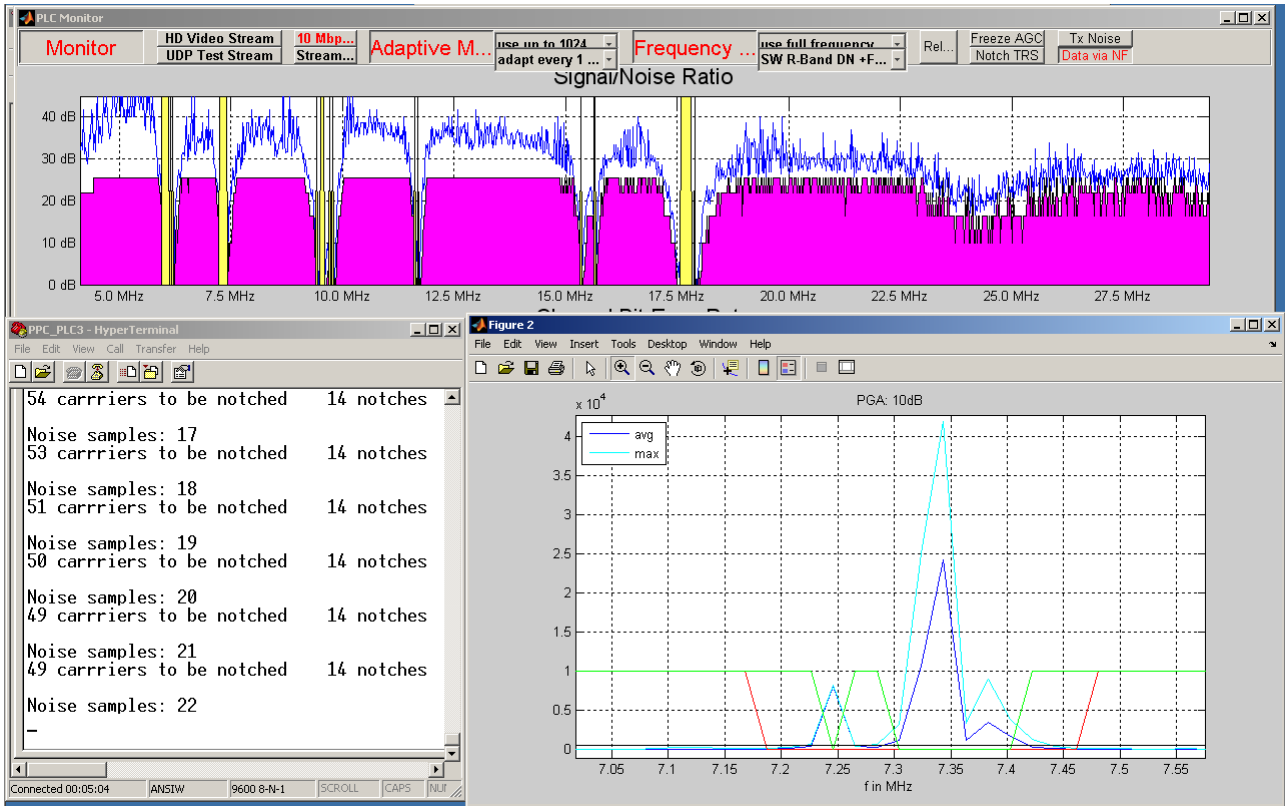

Figure 11: Screenshot of remote control user interface of Sony system

In the top part there is the channel SNR measurement of the PLT system and the selection of OFDM constellations is visible. Notched OFDM carriers are marked with a yellow column. The lower left shows some "debug" output. At the time the snapshot was recorded, 49 OFDM carriers were omitted. Some of the carriers were grouped to form a single notch. In total there were 14 notches. The lower right shows a noise measurement performed by the PLT system. The red line indicates the 41 m Band, the blue lines represent noise measurements (dark blue: average, light blue: max hold detector). If the green line goes down to 0 these frequencies are proposed to be notched. The frequency resolution bandwidth (which is equal to OFDM carrier spacing) is 19,53 kHz.

A new scan using the antenna was performed in Dombovarstr 18 in D-71394 Kernen, 20th of Nov 2007, 19:09:31h.

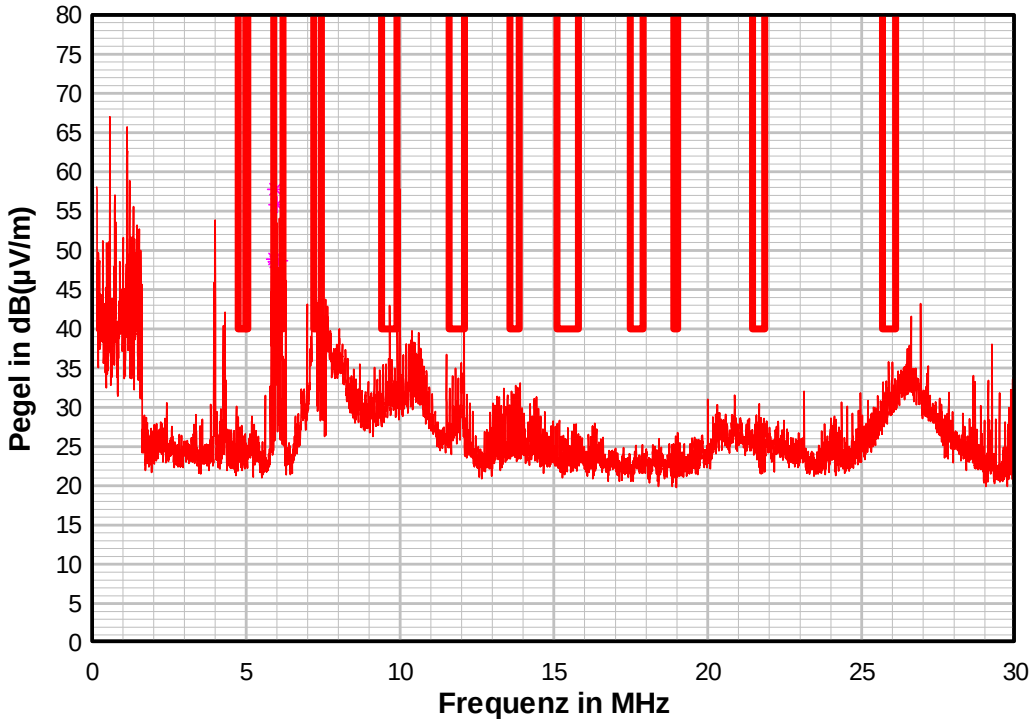

Figure 12: Electrical Field measured with EMI Test receiver

A test receiver according to [4] and an Average Detector were used for recording of the following values.

Table 17: List of SW services found during the tests at 19:00h

Frequency in kHz	Level in dB(µV/m)	Voltage conducted to the mains in dBm
3 950	43	-82
5 920	48,9	-56
5 960	57,8	-46
5 970	48,5	-48
6 000	55,8	-56
6 090	48,7	-55

At these tests, Reception of DRM was not checked in location Dombovar Str.

The median reception factor (Field measurement - conducted symmetric voltage) in Dombovar Str. 18 is 115,5 dB(µV/m) - dBm. This reception factor was derived from both tests (17:00h and 19:00h).

Again the PLT system as well the radio receiver was located in one room. The outlets were the devices were connected were all fused to a single electrical path. This setup is a "worse case" scenario in terms of interferences from PLT to SW radio broadcast.

Table 18: Results sheet of TS 102 578 Field Tests in buildings: DS2

DS2

Without Smart Notching: PLT throughput in Mbit/s: 91 UDP layer

Frequency in kHz	Comment	Station name	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall
	PLT could cause interference						
3 950		German	3	1	1	2	1
5 955		Deutsche Welle	3	1	1	3	1
5 970	At deep fading another Channel interfered.	Radio China International	4	2	2	2	2
6 090		German language	3	1	1	1	1
9 830		Arab language	4	1	1	3	1

Smart Notching active: PLT throughput in Mbit/s: 86 UDP layer

Frequency in kHz	Comment	Station name	SINPO Signal	SINPO Interference	SINPO Noise	SINPO Propagation	SINPO Overall
	If no comment, any interference from PLT was not noticed.						
3 950		German	3	4	4	2	3
5 955		Deutsche Welle	3	3	3	3	3
5 970		Radio China International	4	4	3	2	3
6 090	Interfered by other radio services	German language	3	2	2	1	2
9 830	Slight, interference is detected. There were other interference sources than PLT modems, as well. Quality is still acceptable.	Arab language	4	3	4	3	4

Quick test for "false detections" of PLT modems:
Any frequencies notched which did not coincide with a receivable SW radio broadcast?
At the test location only a switching power supply was identified causing interferences to PLT. This noise sometimes caused a few false detections.

Schedule Skelton (UK) test broadcast transmission and monitor when PLT modem notches this frequency in s:
This frequency change had no noticeable effect on the DS2 system because the relevant notch (covering frequencies in the 7 MHz band) had previously been set to be wide enough to cover the frequency step distance. Both frequencies were therefore already protected.
A test was scheduled, where the Skelton transmission at 7 320 kHz (Field: 43 dBµV/m and conducted to mains: 77 dBm) toggles on (3 min) and off (3 min) several times.
We monitored at test location:

Skelton action	PLT modem action	Time in h:min:sec from Trigger
Transmission on: Monitoring time: 30 s		0:00:00 Trigger
	Monitoring	0:00:34 - 0:00:40
	Monitoring	0:01:28 - 0:01:39
	Monitoring	0:02:50 - 0:02:56
Transmission off: Monitoring time: 120 s		0:03:05
	Monitoring	0:05:25 - 0:05:40
Transmission on		0:06:00
	Monitoring	0:08:05 - 0:08:13
Transmission off		0:08:57
	Monitoring	0:10:47 - 0:10:51
Transmission on		0:12:00
	Monitoring	0:13:05 - 0:13:10
	Monitoring	0:15:41 - 0:15:45

Evaluation of channel SNR and noise measurements (monitoring) was carried out periodically (monitoring time is set to 30 s or 120 s). During this monitoring some interference from PLT could be noticed. In a final product this monitoring will no more cause any interference.

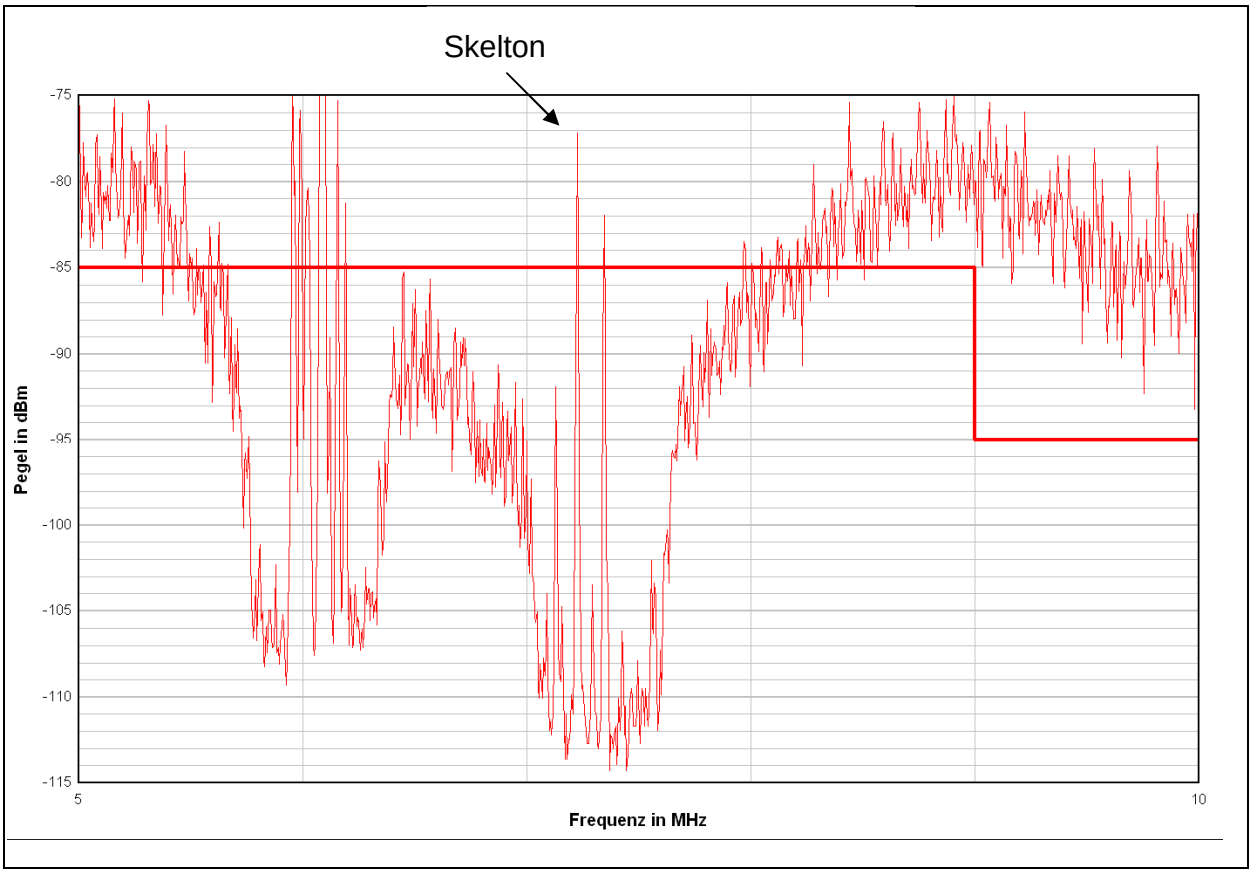

Figure 13: Ingress of Skelton transmission to the mains wiring. Notched PLT transmission is visible, as well.

Screenshot of DS2 system showing automatic detection of SW radio ingress:

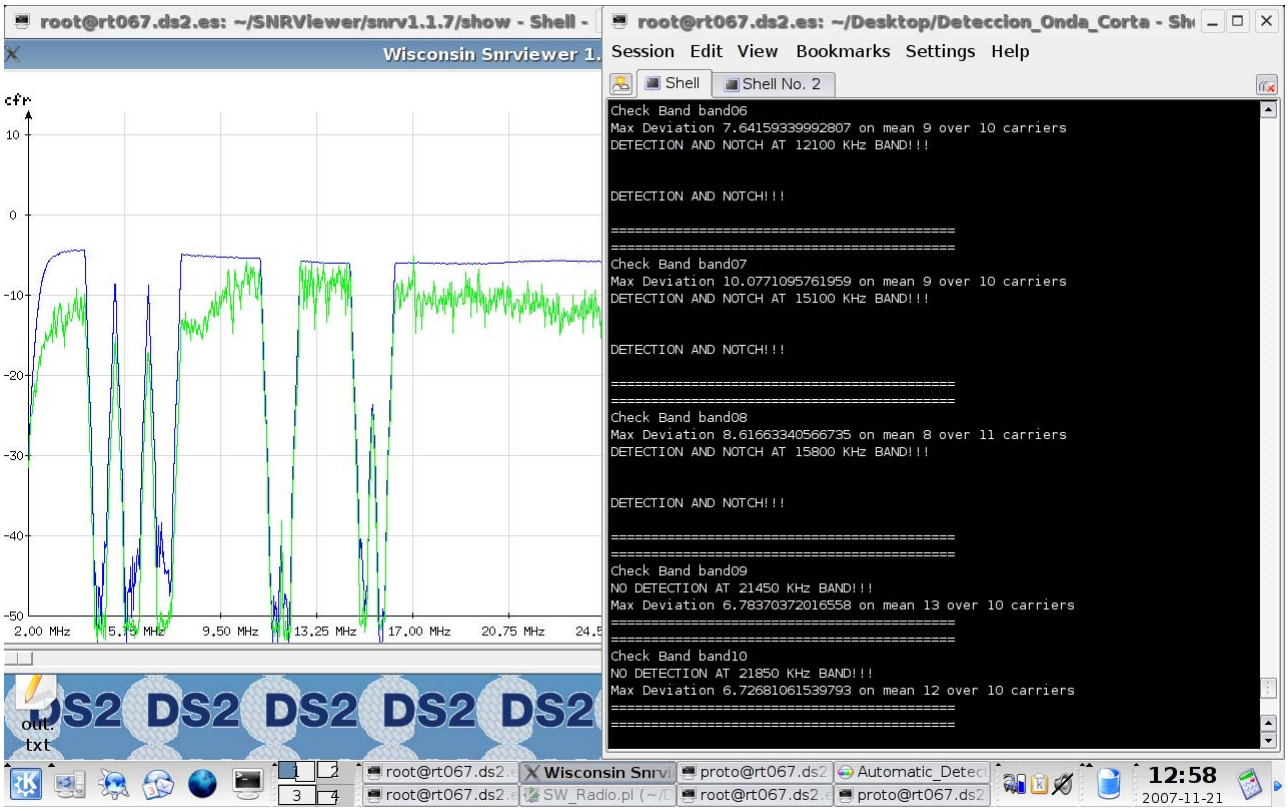

Figure 14: Screenshot of DS2 system

On the left side the channel condition is captured based on SNR measurement of the modems of current PLT transmission. The notch applied allows undisturbed ratio reception at the current location. On the right side there is the output of the algorithm which automatically checks the signal ingress (e.g. "check band 8"). Below there is a detection to verify that this is a radio broadcast signal and if "yes" a notch is set to protect it. This process is configurable to be repeated (e.g. 30 s). Another example shows that when the band 9 is checked, there is no detection and therefore no notch is set.

In the other locations, another procedure was chosen to identify all receivable radio stations:

Automatic frequencies scan using Sony ICF SW77. At the frequency where the automatic scan stopped the field strength in the air as well the level of ingress on the mains was recorded. SINPO assumption is performed with and without PLT on this service.

The automatic frequency scan was continued until all ITU-band are scanned.

Using this procedure the time period between recordings of electrical field and ingress on the mains wiring was much shorter. For statistical analysis, later only these values were considered.

22nd of November 2007, 10:02h in Hotel Steigenberger Graf Zeppelin, Stuttgart Room No. 226.

PLT system as well radio devices were located in the same room. The room was about 25 m².

A test receiver according to [4] and an Average Detector were used for recording of the following values.

Table 19: List of receivable radio broadcast services in Hotel Steigenberger Graf Zeppelin

Frequency in kHz	Level in dB(µV/m)	Power conducted to the mains in dBm
5 935	33	-81
5 955	38 fades down to 30	-84
6 025	35	-83
6 075	37	-86
6 155	52	-69
6 190	42	-86
7 225	44	-83
9 540	37	-81
9 725	40	-80
9 820	44	-79
13 725	32	-82
13 780	42	-78
13 855	24	-95
15 105	30	-80
15 225	37	-86
15 350	38	-89
15 385	42	-85
15 550	35	-84
17 490	was there and faded away	
17 585	41	-82
17 745	22	-98
17 895	27	< -100
13 620: DRM	29	-90
6 095 DRM	32	< noise level

The median reception factor (Field measurement - conducted voltage) in Hotel Steigenberger Graf Zeppelin is 120 dB(µV/m) - dBm.

Table 20: Results sheet of TS 102 578 Field Tests in buildings: Sony in Hotel Graf Zeppelin

Sony							
Without Smart Notching: PLT throughput in Mbit/s: 202 Mbit/s on Phy layer, 59 Mbit/s on UDP level							
Frequency in kHz	**Comment** Mostly PLT caused strong interference	**Station name**	**SINPO Signal**	**SINPO Inter-ference**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
5 935		Skelton	2	1	1	2	1
6 075		?	1	1	1	3	1
6 155		Radio Austria	3	1	1	3	2
7 225		Skelton	2	1	1	2	1
9 540	PLT Interference noticeable but speech still was understandable	German	1	1	2	2	2
9 725		German	2	1	1	3	1
9 820		Music	2	1	1	2	2
13 725		Spanish language	1	1	1	2	1
13 780		German	2	1	1	2	1
13 855		Arabic music	1	1	1	2	1
15 225		Probably Chinese	1	1	1	1	1
15 350			1	1	1	1	1
15 385		Spanish	1	1	1	1	2
15 550		Arabic	1	1	1	2	1
17 585		NHK Tokyo	2	1	2	1	2
17 745		Music	1	2	3	2	2
17 895		Koran	1	2	2	1	2
13 620		DRM: MOI Kuwait	1			1	1
6 095		DRM: RTL	1			1	1
Smart Notching active: PLT throughput in Mbit/s: 202 Mbit/s on Phy layer, 59 Mbit/s on UDP level							
Frequency in kHz	**Comment** If no comment, any interference from PLT was not noticed.	**Station name**	**SINPO Signal**	**SINPO Inter-ference**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
5 935	PLT was noticeable, but there were several other stronger interferences	Skelton	2	3	2	2	2
5 955	Signal was detected by PLT and notch inserted, as we wanted to perform SINPO tests, fading removed the signal to be no more receivable by ICF-SW77	Radio Nederland					
6 025	Signal was detected by PLT and notch inserted	?					1
6 075	PLT found the carrier to be notched as the fading got stronger		1	2	2	3	2
6 155	At the bottom of the fade, PLT was noticeable (happen seldom)	Radio Austria	3	2	2	3	3
6 190	Interference from HP portable computer noted. Audio modulation dept is very low SINPO overall is 1 without PLT active		2	1	1	?	1
7 225		Skelton	2	3	2	2	2
9 540		German	1	2	2	2	2
9 725		German	2	3	3	3	3
9 820		Music	2	2	1	2	2
13 725		Spanish language	1	3	2	2	2

Smart Notching active: PLT throughput in Mbit/s: 202 Mbit/s on Phy layer, 59 Mbit/s on UDP level							
Frequency in kHz	**Comment** If no comment, any interference from PLT was not noticed.	**Station name**	**SINPO Signal**	**SINPO Inter-ference**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
13 780		German	2	3	2	2	2
13 855	Sometimes detected by PLT: Hysteresis when to reuse the frequency by PLT should be expanded to 3 min.	Arabic music	1	2	2	2	2
15 105	PLT did not detect this ingress, because of high ground noise at the outlet being connected to. PLT was connected to another outlet, where the ingress was detected and notched.	English language (not BBC)					2
15 225	At deep fading PLT is noticeable. At a long deep fading PLT lost the notch. Hysteresis should be expanded.	Probably Chinese	1	1	2	1	2
15 350	Interference from PLT is noticeable. There are more interferences, even without PLT		2	1	2	1	2
15 385	PLT slightly noticeable	Spanish	1	2	3	1	2
15 550		Arabic	1	2	3	2	3
17 585		NHK Tokyo	2	2	2	1	2
17 745		Music	1	3	3	2	2
17 895		Koran	1	2	2	1	2
13 620	Dropouts noted without PLT No differences found between "without PLT" and "PLT with Notch"	DRM: MOI Kuwait					5, if receivable
6 095	Sometimes receivable without PLT No differences found between "without PLT" and "PLT with Notch"	DRM RTL					5, if receivable

Quick test for "false detections" of PLT modems:
Any frequencies notched which did not coincide with a receivable SW radio broadcast?
A false detection was sometimes noted at 6 025 kHz and 7 225 kHz.
A 2nd false detection of one carrier was found at 26 MHz.

At 11:00h Skelton test transmission changed from 5 935 kHz (Field: 37 dBµV/m Conducted -85 dBm) to 7 225 kHz PLT notched 5 935 kHz before the frequency change and 7 225 kHz (Field: 55 dBµV/m Conducted -75 dBm) after it.
At 13:00h Skelton test transmission changed from 7 225 kHz (Field: 47 dBµV/m Conducted -83 dBm) to 7 320 kHz (Field: 46 dBµV/m Conducted -78 dBm). Here timings of all actions monitored at the test location were recorded in detail:

Event	Absolute Timings
Both frequencies were already notched before the frequency change.	Before trigger
Skelton transmission on 7 225 kHz was switched off	0 s
Skelton transmission on 7 320 kHz was switched on	15 s
AM modulation on 7 320 kHz starts	17 s
7 225 kHz was reused by PLT	55 s

22nd of November 2007, 17:30h in Hotel Ochsen, Stuttgart - Wangen Room No. 303.

During the tests there was a high ground noise present in this location. The source of this noise could not be identified.

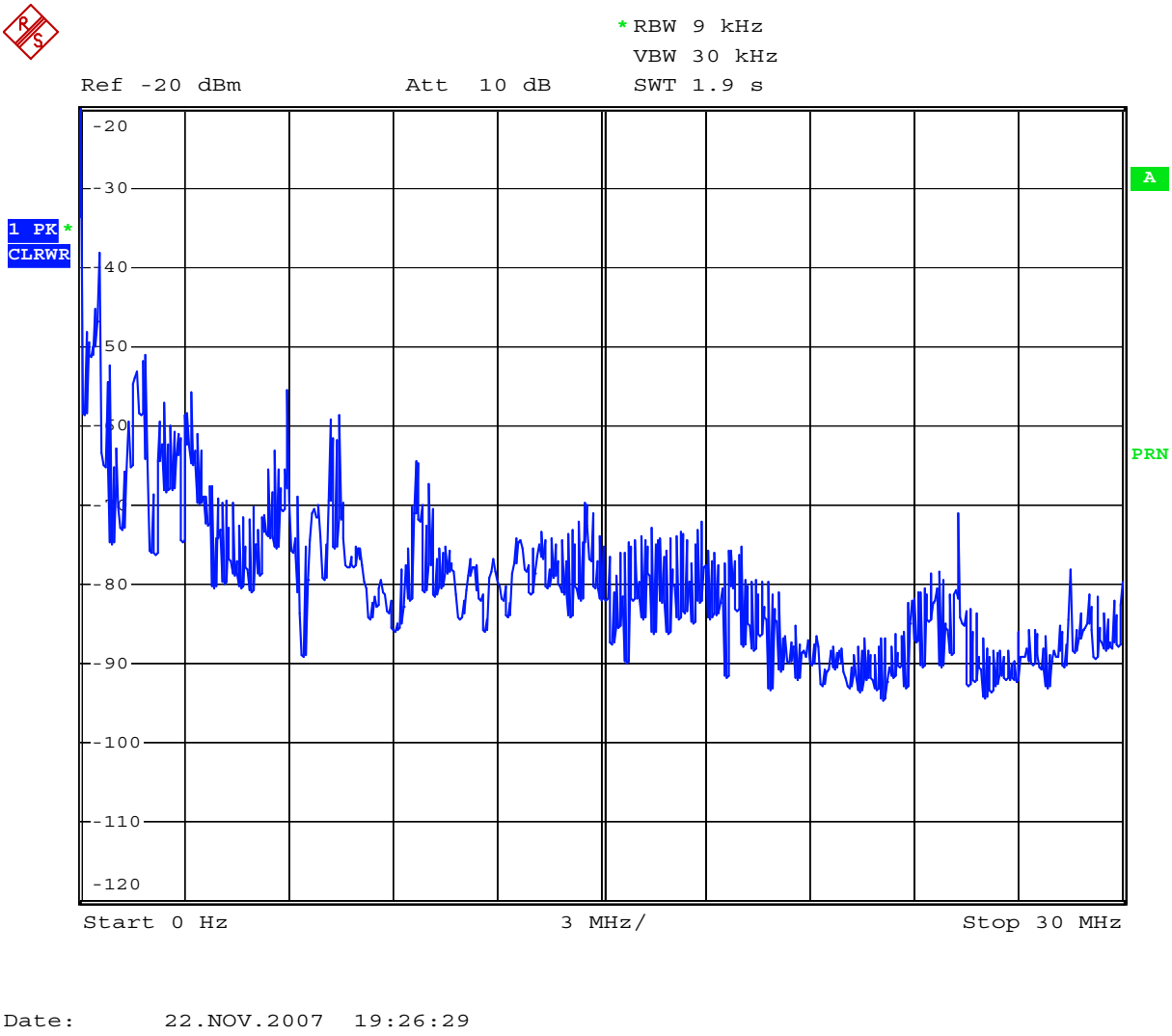

Figure 15: High noise floor in Hotel Ochsen

A test receiver according to [4] and an Average Detector were used for recording of the following values.

Table 21: List of receivable radio broadcast services in Hotel Ochsen

Frequency in kHz	Level in dB(µV/m)	Power conducted to the mains in dBm
5 915	48	-60
5 930	44	-70
5 955	43	-64
5 970	38	-70
5 985	35	-80
6 000	30	-80
6 025	39	-78
6 055	40	-67
6 065	35	-77
6 075	53	-56
6 120	43	-65
6 145	34	-75
7 195	38	-80
7 215	44	-71
7 225	37	-75
7 260	29	-85
7 275	36	-72
7 290	34	-75
7 320	33	-81
7 335	29	-80
7 350	30	-85
7 400	30	-83
7 450	52	-62
9 530	30	-80
9 580	25	-77
9 870	32	-78
11 755	25	<-85
11 975	28	<-85

The median reception factor (Field measurement - conducted voltage) in Hotel Ochsen is 111 dB(µV/m) - dBm.

Table 22: Results sheet of TS 102 578 Field Tests in buildings: Sony System in Hotel Ochsen

Sony							
Without Smart Notching active: PLT throughput in Mbit/s: 172 Mbit/s on Phy layer, 52 Mbit/s on UDP level							
Frequency in kHz	**Comment** Mostly PLT caused strong interference	**Station name**	**SINPO Signal**	**SINPO Inter-ference**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
5 915	No interference from PLT noticeable	Probably Slovak language	3	3	4	4	4
5 930		Probably Czech language	3	1	2	4	2
5 955		Radio Nederland	3	2	2	3	2
5 965		German	2	1	2	2	2
5 985		Greek	2	1	2	2	2
6 000		Music + Speech (Russian ?)	1	1	1	1	1
6 025		Arabic	2	1	1	2	1
6 055		German	2	2	2	3	2
6 065		Scandinavian	3	2	2	2	2
6 075	In deep fades, the language changes	German	5	2	3	4	3
6 120		Eastern Europe	3	2	2	3	2
6 145		?	1	1	1	2	1
7 195	Just out of ITU-Band	French	2	1	1	2	1

Sony							
Without Smart Notching active: PLT throughput in Mbit/s: 172 Mbit/s on Phy layer, 52 Mbit/s on UDP level							
Frequency in kHz	**Comment** Mostly PLT caused strong interference	**Station name**	**SINPO Signal**	**SINPO Inter-ference**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
7 215		BBC	2	1	1	2	1
7 225	2 AM station interfere	Arabic	2	2	3	1	1
7 260		Voice of America	2	1	1	1	1
7 275		Spanish	2	1	1	2	1
7 290		German	2	1	1	1	1
7 320		English	2	1	1	2	1
7 335		US-English	1	1	1	2	1
7 350		French	2	1	1	2	1
7 400		German	2	1	1	2	1
7 450		Spanish ?	2	1	1	3	1
9 535		Arabic	2	1	1	3	1
9 580		Arabic ?	1	2	2	2	2
9 870		Arabic	2	1	1	2	1
11 755		BBC	1	1	1	2	1
Smart Notching active: PLT throughput in Mbit/s: 168 Mbit/s on Phy layer, 51 Mbit/s on UDP level							
Frequency in kHz	**Comment** If no comment, any interference from PLT was not noticed.	**Station name**	**SINPO Signal**	**SINPO Interfe-rence**	**SINPO Noise**	**SINPO Propa-gation**	**SINPO Overall**
5 915		Probably Slovak language	3	3	4	4	4
5 930		Probably Czech language	3	4	3	4	4
5 955		Radio Nederland	3	4	2	3	3
5 965		German	2	2	2	2	2
5 985		Greek	2	2	2	2	2
6 000		Music + Speech	1	2	2	1	1
6 025		Arabic	2	2	2	2	2
6 055		German	2	4	3	3	3
6 065		Scandinavian	3	3	3	2	3
6 075	In deep fades, the received service changes	German	5	3	4	4	4
6 120		Eastern Europe	3	4	4	3	4
6 145		?	1	2	2	2	2
7 195	Just out of ITU-Band	French	2	2	2	2	2
7 215		BBC	2	4	4	2	3
7 225	2 AM station interfere	Arabic	2	2	3	1	1
7 260		Voice of America	2	1	2	1	1
7 275		Spanish	2	2	2	2	2
7 290	PLT slightly noticeable. 2 AM stations fading each other	German	2	1	1	1	1
7 320	PLT slightly noticeable	English	2	3	2	2	2
7 335	2 more stations in background	US-English	1	2	2	2	2
7 350		French	2	4	2	2	3
7 400		German	2	3	2	2	2
7 450		Spanish ?	2	3	2	3	3
9 535		Arabic	2	3	3	3	3
9 580		Arabic ?	1	2	2	2	2
9 870		Arabic	2	3	3	2	3
11 755		BBC	1	3	2	2	2

6 Statistical evaluation of Results

Electrical Field level measured at frequencies with receivable radio stations (measured with a calibrated antenna):

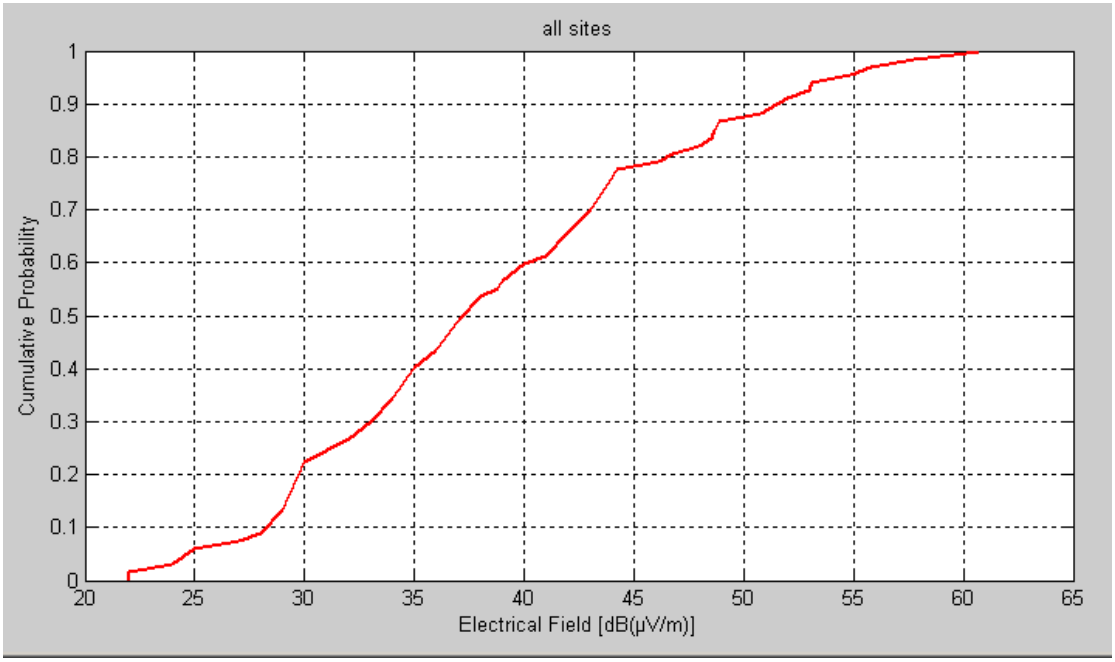

Figure 16: Cumulative Probability of level of electrical field of all sites

Signal level of the ingress of the identical frequencies as used for the evaluation of the electrical field measured with a 100 Ohm probe conducted to the mains:

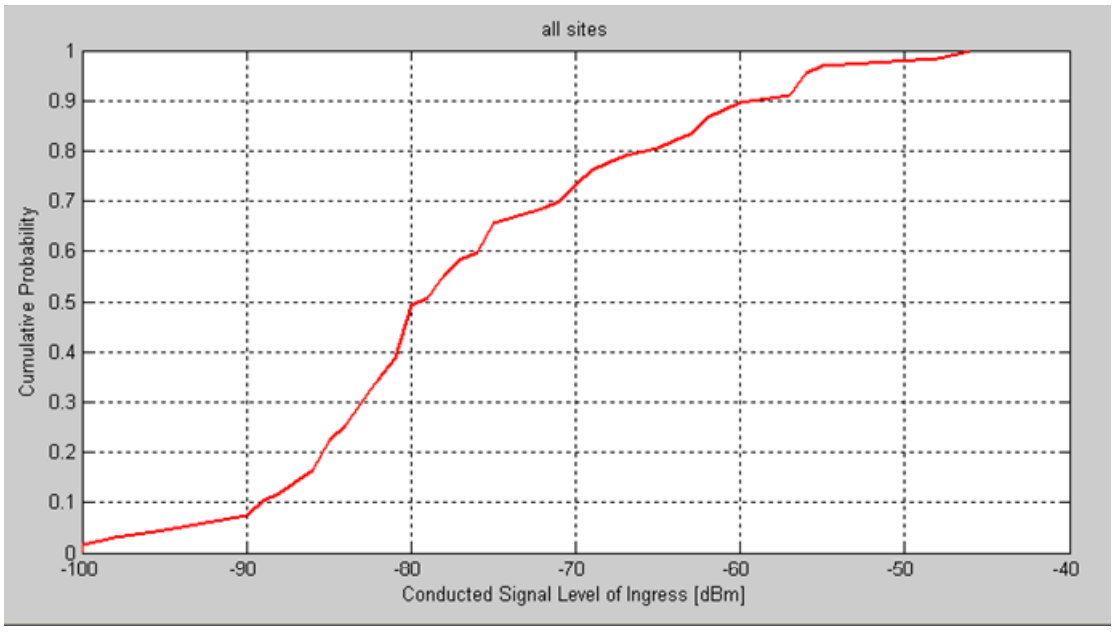

Figure 17: Cumulative Probability of level of Ingress

Reception Factor rf from field to the mains is defined:

$$rf = \frac{E}{U}$$

rf[dB(µV/m) - dBm] = E[dB(µV/m)] - U[dBm]

Median Reception factor:

- in Dombovar Str: 112,1 dB(µV/m) - dBm
- iIn Hotel Graf Zeppelin: 120 dB(µV/m) - dBm
- in Hotel Ochsen: 111 dB(µV/m) - dBm

Median Reception factor of all tests locations: 114 dB(µV/m) - dBm.
(derived from the ingress level and the field of 67 radio broadcast services).

The smaller this number the better is the antenna factor of the mains wiring.

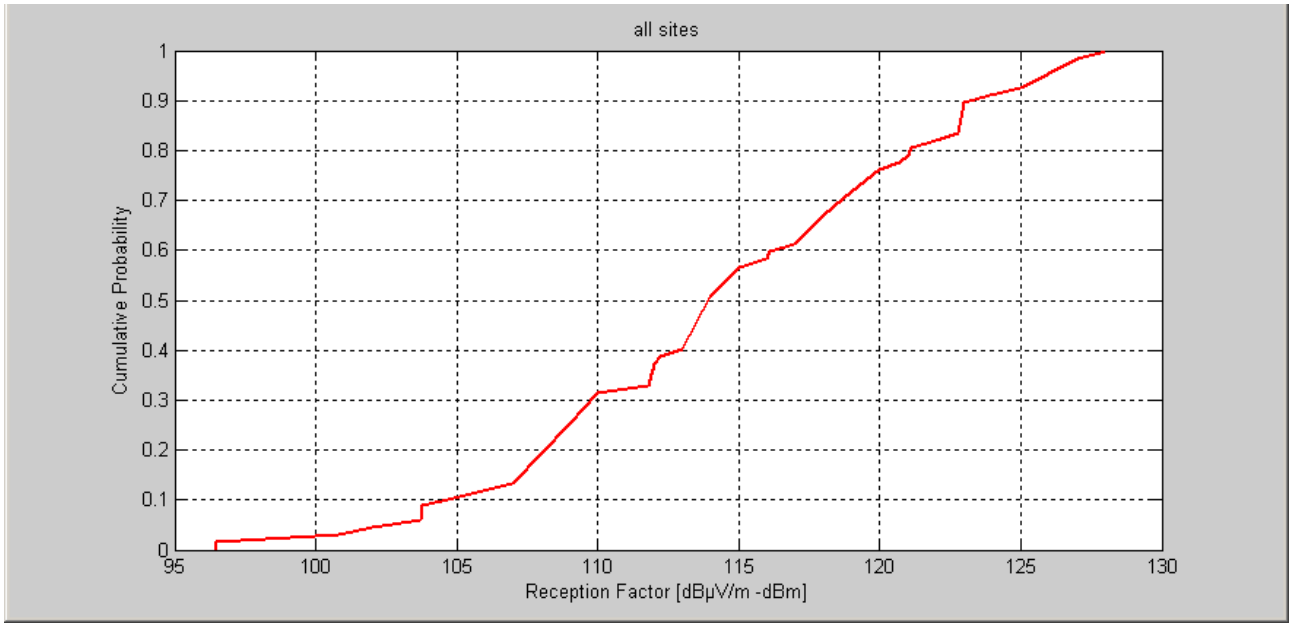

Figure 18: Cumulative Probability of reception factor of all sites

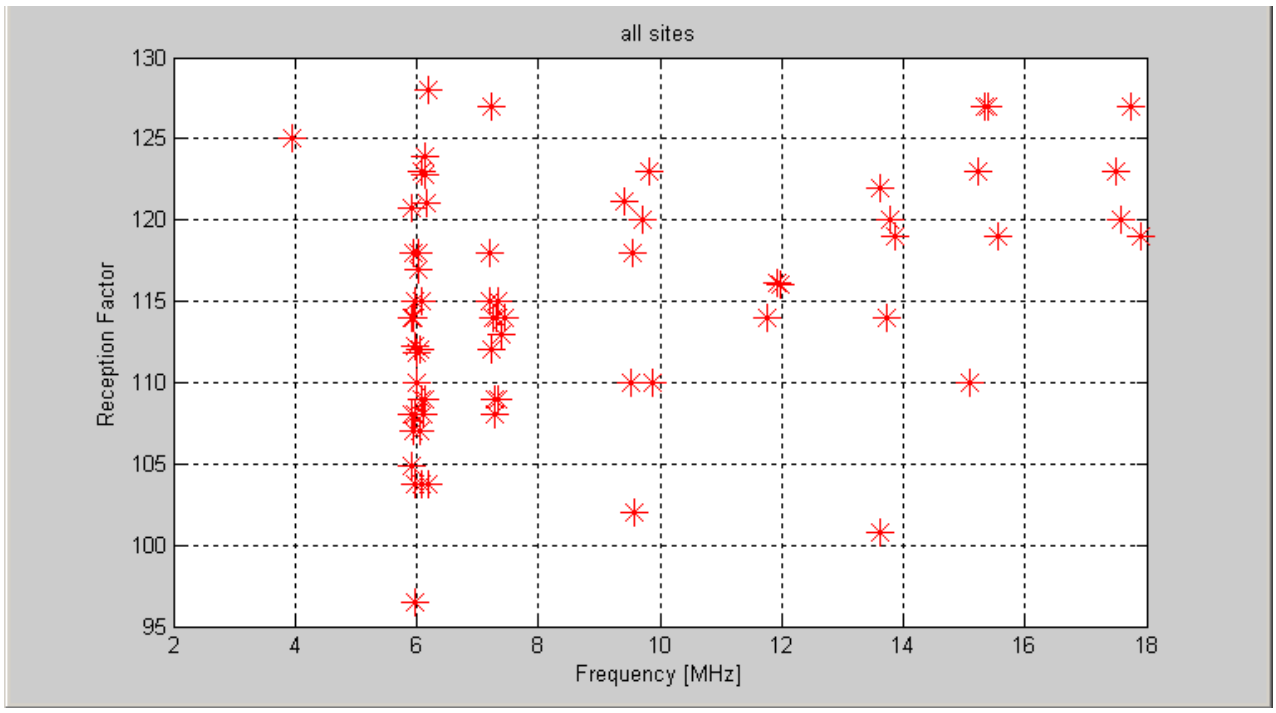

Figure 19: Measurements show no strong correlation between reception factor and frequency

Evaluation of the SINPO Overall assumption: Comparison of all received radio broadcast services. All locations, AM as well than DRM. In total 168 times SINPO assumption was performed. Figure 20 shows the efficiency of the adaptive dynamic notching concept. Human assessment of sound quality does not more show any difference if PLT is off or if PLT is on with the Smart Notching concept active. If PLT is under operation without any notches, many radio services move to an unusable assessment of the overall sound quality.

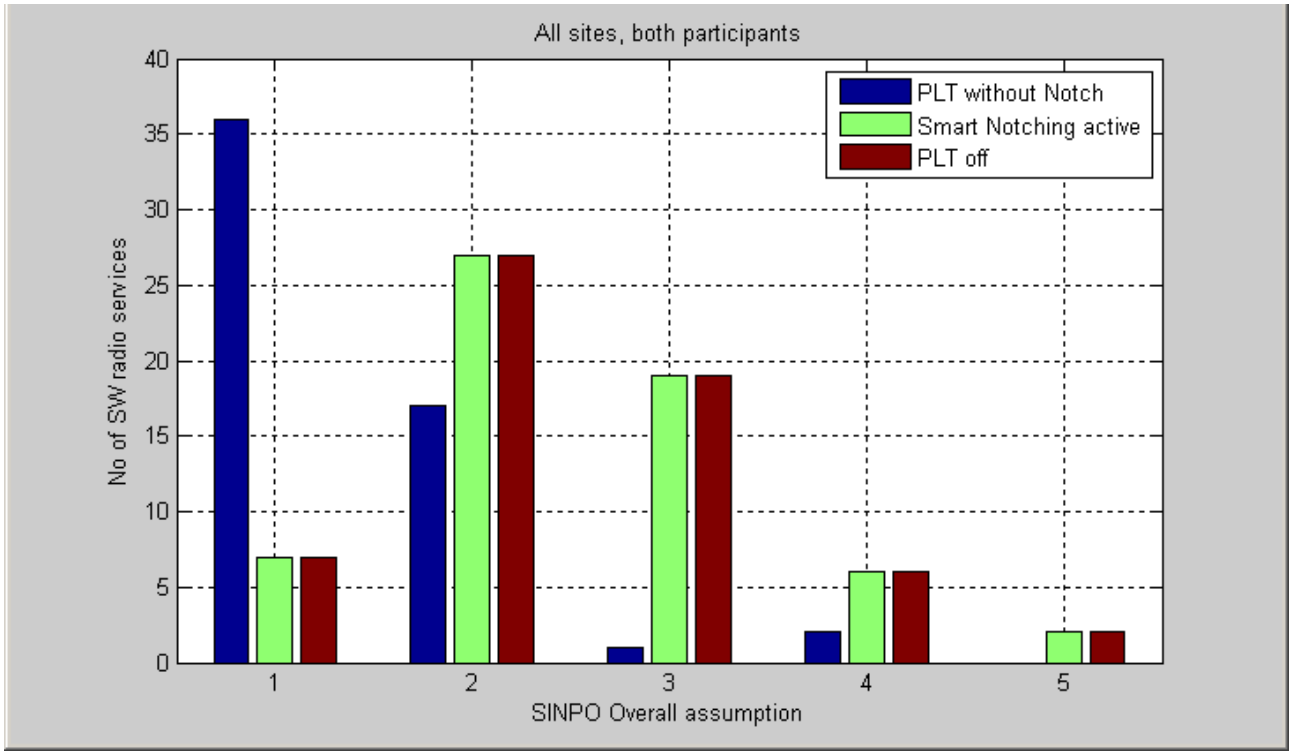

Figure 20: Histogram of SINPO Overall assumption of reception quality of SW radio broadcast

Annex A:
An Overview of Frequency Scheduling in HF Broadcasting

Unlike the other broadcast bands, HF broadcast channels are not allocated fixed frequencies. The propagation conditions in the HF bands mean that broadcast services must use different frequencies to accommodate these changes. The main ones are:

- Daily - to account for the different structure of the ionosphere (the ionization layers) between day and night.
- Seasonal - to accommodate structural changes in the ionosphere between summer and winter.
- Eleven Yearly - to accommodate changes in the structure of the ionosphere which follow the sunspot cycle.

It will be seen that the propagation conditions are critically dependent on the presence (or absence) and condition of he sun.

As continuous changes in frequency are a fact of life, an HF transmission on a specific frequency can be of any length between 15 minutes and 24 hours. One major HF broadcaster schedules its transmissions on the basis of a 15 minute grid throughout the day. Obviously, in one schedule the chances of every transmission changing frequency every 15 minutes is negligible although most switching junctions will be used somewhere on the network somewhere in the eleven year over all cycle. There are potentially, however, changes to the overall broadcasts frequency schedule every quarter of an hour.

Allocation of specific frequencies to individual broadcasters is organized under Article 12 of the Radio Regulations by co-ordination groups consisting of representatives of the broadcasters themselves. While many of these broadcasters compete with each other on programme content, there is every reason for them to co-operate in the field of frequency co-ordination. Lack of co-ordination would result in ineffective use of the frequency bands and no broadcaster being able to be heard because of interference from the others. The primary co-ordination body is called the HFCC (High Frequency Co-ordination Conference - www.hfcc.org) and this body publishes a new schedule covering all the participating broadcasters every six months.

While the six monthly schedule forms the basis of the broadcasting plan for the half year period additional changes can be made according to the co-ordination rules of the group. The idea of these rules is to avoid interference between broadcasters in the declared audience target area. Changes can be made in response to technical parameters - such s unforeseen changes in the ionosphere - or other broadcasting imperatives - such as natural disasters and other news events or even sporting fixtures.

It is important to note that the HF broadcasting bands are very crowded, particularly at peak listening times. This means that any one frequency might be in use by several broadcasters at the same time. Care is taken to ensure that the geographical separation of the transmitting stations, location of the target audiences and transmitting antenna characteristics are such that interference is minimized. However, it is not always possible to offer complete separation and so some interference, either co-channel or adjacent channel, is, unfortunately, inevitable.

Another way that broadcasters reduce interference is to use frequencies outside the broadcast bands. This can be done under article 4.4 of the Radio Regulations provided the host Administration consents and no harmful interference is caused to other users of the spectrum. This means that some of the actual frequencies used for broadcasting lie outside the broadcast band as defined in the Radio Regulations. A more realistic assessment of the actual bands which are used for broadcasting is:

From (kHz)	To (kHz)
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

Annex B:
Some pictures from the tests on 10th and 11th of October 2007

Figure 21: Mike Hate adjusting Biconal antenna in Dombovarstr. 18

Figure 22: Mike Hate and Prof Holger Hirsch checking field strength

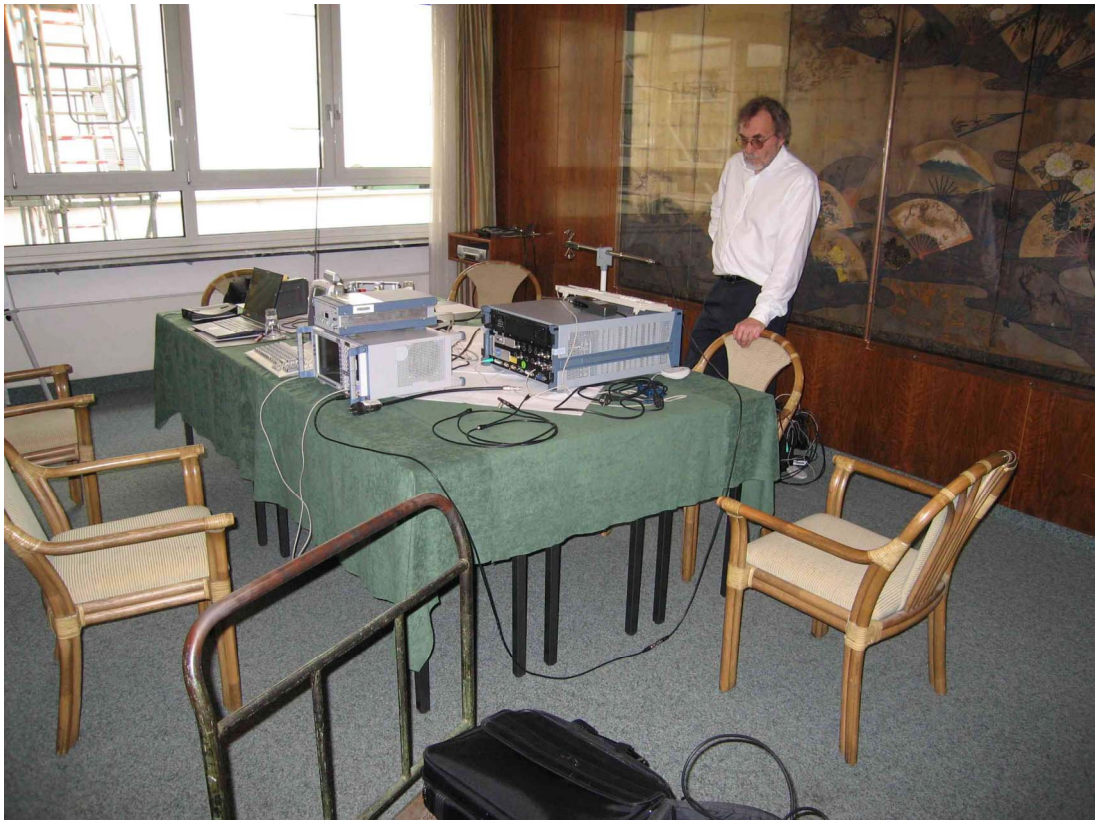

Figure 23: Test and measurement setup in Hotel Unger 1

Figure 24: Test and measurement setup in Hotel Unger 2

Figure 25: Measurement equipment in Rosenstr

Measurement equipment from the top to down:

- R&S SUF2: White noise generator to feed signals into the mains.
- R&S FSP Spectrum analyser to do frequency scans and calculate median values of noise blocks.
- R&S EMI tests receiver to perform measurements according to [4].

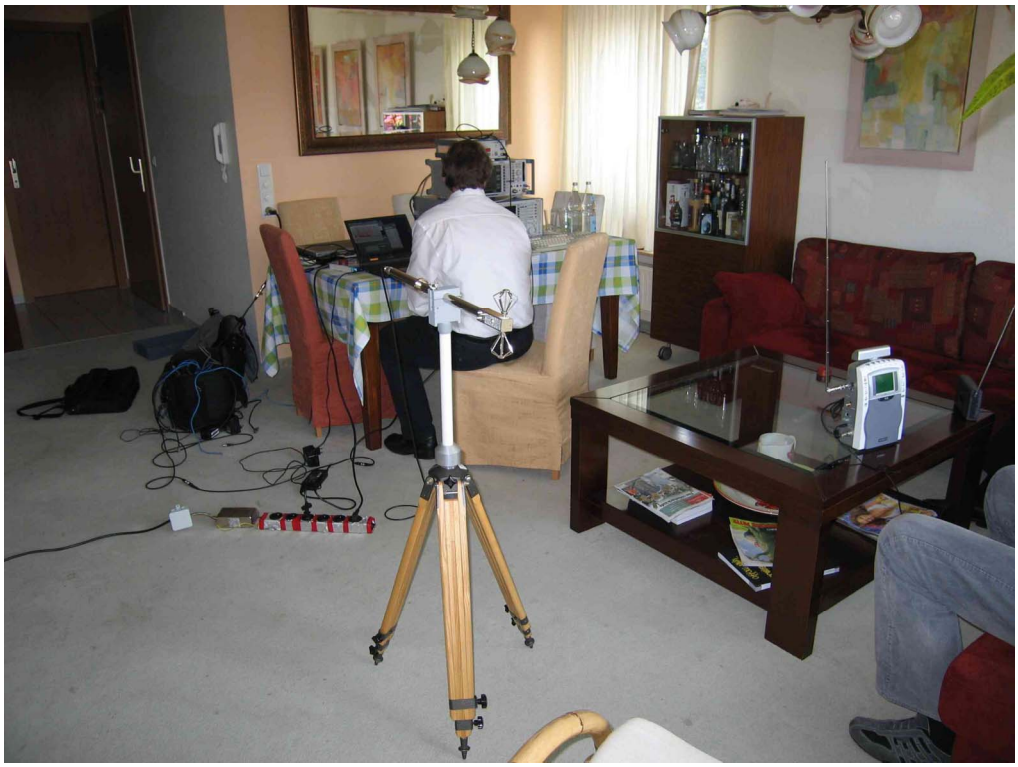

Figure 26: Biconal Antenna in Rosenstr.

Annex C:
Some pictures from the tests from 20th to 23rd of November 2007

Figure 27: Mike Hate checking DRM reception in Hotel Ochsen

Figure 28: Prof Holger Hirsch scanning frequencies

Figure 29: Hotel STEIGENBERGER GRAF ZEPPELIN

Figure 30: Mike Hate and Prof Holger Hirsch at SINPO evaluation

Figure 31: Performing the Plugtests™ event in Dombovarstr 18, Kernen

Figure 32: STF 332 and Plugtests™ participants (from left to right): Mike Hate (EBU), Prof Holger Hirsch (University Duisburg Essen), Serafin Arroyo (DS2), Pedro Gomez (DS2), Andreas Schwager (Sony)

Annex D:
Change history

D.1 Change history of the test cases part

Change history		
V0.0.1	17th of Aug 2007	Initial Plugtests™ specification
V0.0.2	20th of Aug 2007	Editorial
V0.0.3	22nd of Aug 2007	Editorial
V0.0.4	24th of Aug 2007	Editorial
V0.1.0	27th of Aug 2007	Version uploaded to ETSI PLT #43
V0.1.1	30th of Aug 2007	Picture added Test setup Isolation Chamber
V0.1.2	8th of Oct 2007	Bug fixed (date of tests) in clause 4
V0.1.1	October 2007	Pre-processed by the ETSI Secretariat ***editHelp!*** E-mail: mailto:edithelp@etsi.org
V3.0.0	4th of Dec 2007	Part 1 and Part 2 pasted into one document

D.2 Change history of the results part

Change history		
V0.0.1	17th of Aug 2007	Initial Plugtests specification
V0.0.2	20th of Aug 2007	Editorial
V0.0.3	22nd of Aug 2007	Editorial
V0.0.4	24th of Aug 2007	Editorial
V0.1.0	27th of Aug 2007	Version uploaded to ETSI PLT #43
V0.1.1	30th of Aug 2007	Picture added Test setup Isolation Chamber
V0.1.2	8th of Oct 2007	Bug fixed (date of tests) in Clause 4
V2.0.0	16th of Oct 2007	1st draft with test results
V2.0.1	14th of Nov 2007	Size of pictures shrink
V2.1.1	23rd of Nov 2007	Results from 2nd part of Plugtests™ event (with participants)
V2.1.2	25th of Nov 2007	Comments on test reports from MH and HH merged
V2.1.3	25th of Nov 2007	Comments on test reports from participants
V3.0.0	4th of Dec 2007	Part 1 and Part 2 pasted into one document

History

Document history		
V1.1.1	March 2008	Publication