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DVB-T2 ADVANCED FEATURES LAB TEST REPORT

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EXECUTIVE SUMMARY

This document describes the results of the laboratory tests carried out in TF11, for testing the T2 advanced features supported by the prototypes developed in TF10. In these tests the prototypes have been validated in a full T2 simulated chain, checking the HW interoperability of the equipment from different partners and validating that the prototypes fulfil the specifications defined in the standard.

These tests were carried out at the ABERTIS facilities in Barcelona (Spain), from 17th to 21st October 2011.

After a general introduction of the laboratory tests in section 1, the document is divided in 5 different sections, each one for each of the T2 advanced features that have been finally tested. From section 2 to section 6, the document describes the following tests carried out:

- PAPR Evaluation, in section 2.
- NULL FEFs Evaluation, in section 3.
- Multiple PLPs Evaluation, in section 4.
- SFN Evaluation, in section 5.
- T2-MI Evaluation, in section 6.

Each section starts with the description of the configuration modes and the channel models tested, in order to obtain the goals defined for the test. Afterwards, the prototypes under test are shown and the set-up of the equipment used to simulate the full T2 chain is described. The measurement methodology used in each test is also explained and the results of the test are presented by means of different tables. Finally, each section summarizes the main conclusions obtained in the test.



1	Introduction	5
2	PAPR Evaluation.....	6
2.1	Objectives.....	6
2.2	Prototypes under test.....	7
2.3	Set-up	8
2.4	Test Procedure.....	9
2.5	Results	9
2.6	Conclusions	11
3	Null FEFs Evaluation	12
3.1	Objectives.....	12
3.1	Prototypes under test.....	13
3.2	Set-up	13
3.3	Results	14
3.4	Conclusions.....	15
4	Multiple PLPs Evaluation.....	16
4.1	Objectives.....	16
4.2	Prototypes under test.....	17
4.3	Set-up	18
4.4	Test Procedure.....	18
4.5	Results	19
4.6	Conclusions	20
5	SFN Evaluation	21
5.1	Objectives.....	21
5.2	Prototypes under test.....	23
5.3	Set-up	24
5.4	Test Procedure.....	25
5.5	Results	26
5.6	Conclusions.....	29
6	T2-MI Evaluation	30
6.1	Objectives.....	30
6.2	Prototypes under test.....	30
6.3	Set-up	30
6.4	Test Procedure.....	31
6.5	Results	31
6.6	Conclusions.....	31
7	References	32



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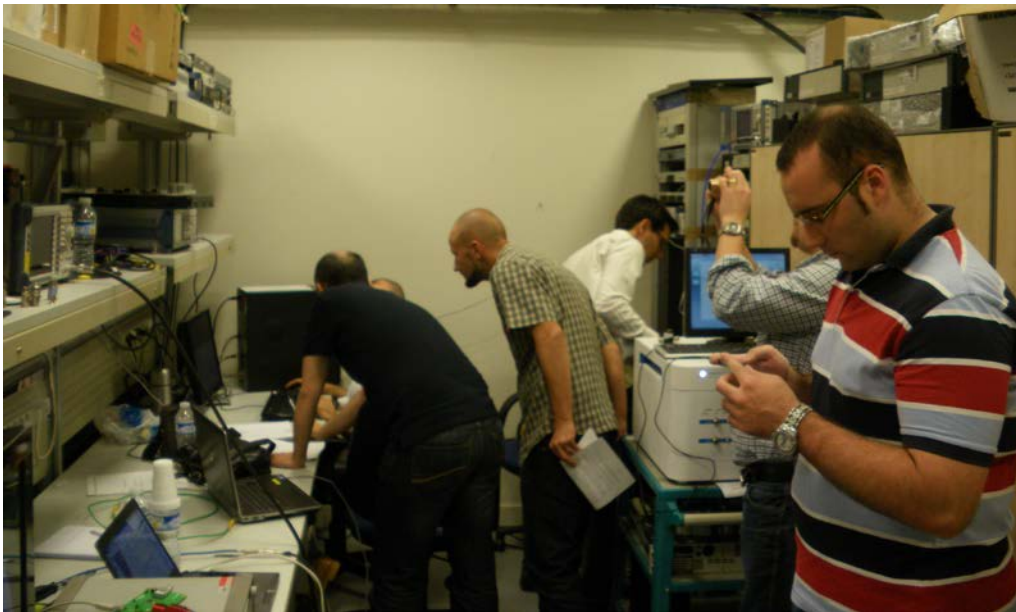
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1 INTRODUCTION

The laboratory sessions from TF11 were dedicated to the advanced features of the DVB-T2 system, such as the use of multiple PLPs, the insertion of null FEFs, the SFN performance, the PAPR reduction techniques and the T2-MI interface. The main goals were focused on testing the advanced features implemented by the prototypes developed in TF10.

The laboratory sessions were held in the Abertis facilities in Barcelona (Spain) in October 2011. Figure 1.1 shows the testing room.

Figure 1.1. Abertis testing room



Several companies contributed to these test sessions: Abertis Telecom, ENENSYS, Integrasys, iTeam-UPVLC, La Salle University, MIER Comunicaciones, SONY, Teamcast, Thomson-Broadcast, TUAS and the University from the Basque Country (UPV-EHU).

The laboratory test was divided into five main test sessions. These are:

- PAPR Evaluation
- NULL FEFs Evaluation
- Multiple PLPs Evaluation
- SFN Evaluation
- T2-MI Evaluation

In the following sections, a short description of the objectives, prototypes under test, set-up and test procedures followed in each session are presented. The results and conclusions obtained are also shown.

2 PAPR EVALUATION

2.1 Objectives

The main goals for testing this feature are:

- Test that the receivers ignore carriers used for TR, so they work properly when TR is used.
- Measure the PAPR reduction when TR is used for different FFT sizes.
- Measure how much the transmitting power can be increased for the same MER value when TR is used.

For these tests no channel simulation has been performed.

The FFT size is the configuration parameter that has the biggest influence in the PAPR reduction with TR, so this parameter will be changed to take all the possible values. The parameters related to the FFT size, as GI, Pilot Patterns or Extended mode have to be changed according to it, because not all the combinations are allowed. The combinations of these parameters to be tested are displayed in Table 2.2.

The number of the standard version has a big influence in the PAPR reduction algorithms, especially in the reduction of P2 bias. Modulators are expected to follow specification version 1.2.1 (value 0001 in T2_version field of L1 signalling).

In order to minimize the PAPR of P2 symbols all the available P2 bias reduction techniques should be used including the use of the P2 bias reduction cells. Also the number of data symbols of the T2 frame are maximized (the number of P2 symbols is minimized) to decrease the influence of the P2 symbols in the total PAPR of the signal.

The DVB-T2 configuration is based on the one proposed in NorDig Unified Test Specifications [1] and it is summarized in Table 2.1 and Table 2.2.

Table 2.1. DVB-T2 configuration for PAPR Evaluation (I).

Overall		PLP n'	
Length		PLP_ID	TBD
PLP	A	Type	Data type 1
FFTSIZE	Table 2	Modulation	64 QAM
GI	Table 2	Rate	2/3
Lf (Data symbols+P2s)	Table 2	FEC Type	64800
SISO/MISO	SISO	Rotated QAM	No
PAPR	TR/None	FEC blocks per interleaving frame	See Table 1.2
Null packet deletion	Disabled	Max FEC blocks per interleaving frame	
Frames per superframe	6	TI blocks per frame (N_TI)	3
Bandwidth	8MHz	T2 frames per Interleaving Frame (P_I)	1
Extended Carrier Mode	Extended	Frame Interval (I_JUMP)	1
Pilot Pattern	Table 2	Type of time-interleaving	0
L1 Modulation	64-QAM	Time Interleaving Length	3
Sub Slices per Frame		Input stage	
FEF	No	Mode	HEM
FEF Type		ISSY	Enabled
FEF Length		BUFS	
FEF Interval		Design delay (samples)	

FEF P1: S1 Value		Null packet deletion	Disabled
FEF P1: S2 Value		In Band Signalling	Disabled
FEF contents		Number of other PLPs in-band signalling	
TxSig FEF ID1		Number of NULL packets inserted each time (p)	
TxSig FEF ID2		Frequency of NULL packets insertion in packets (q)	
L1 Repetition	0		
Number of PLPs	1		
Number of RFs	1		
Number of AUXs	0		
TxSig AUX P			
TxSig AUX Q			
TxSig AUX R			
TxSig AUX ID			
Spec version	1.2.1		
Vclip	TBD		
Number of PAPR-TR iterations	TBD		
Vclip (ACE)			
L1_ACE_MAX	TBD		
NbiasCellsActive	TBD		

Table 2.2. DVB-T2 parameters for PAPR Evaluation (II).

Conf mode	FFT Size	Extended	GI	Pilot Pattern	Lf (Data symbols+P2s)	FEC blocks
1	1K	No	1/4	PP1	1755	122
2	2K	No	1/8	PP2	981	137
3	4K	No	1/16	PP4	512	151
4	8K	Yes	1/32	PP4	233	140
5	16K	Yes	1/32	PP4	114	138
6	32K	Yes	1/128	PP7	60	150

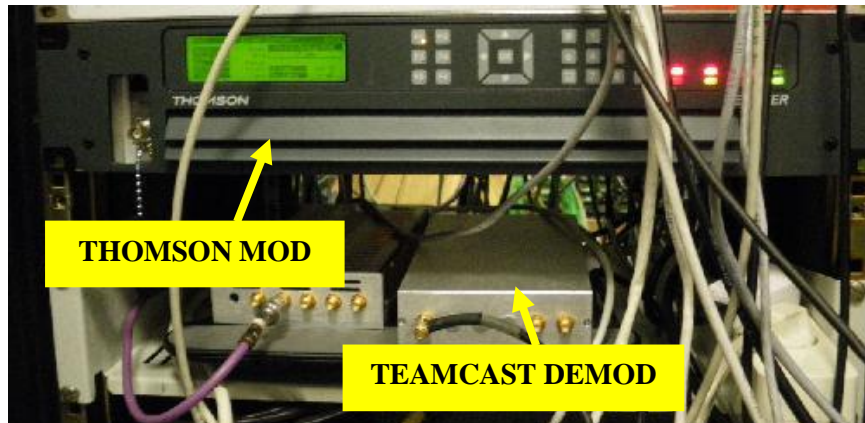
The selected channel for the PAPR Evaluation test session was channel 22 (482 MHz).

2.2 Prototypes under test

In this laboratory session, the TR technique was studied. In the transmission side, the Thomson modulator has been tested. In the reception side, the correct reception in the Teamcast demodulator was checked.

These prototypes are shown in Figure 2.1

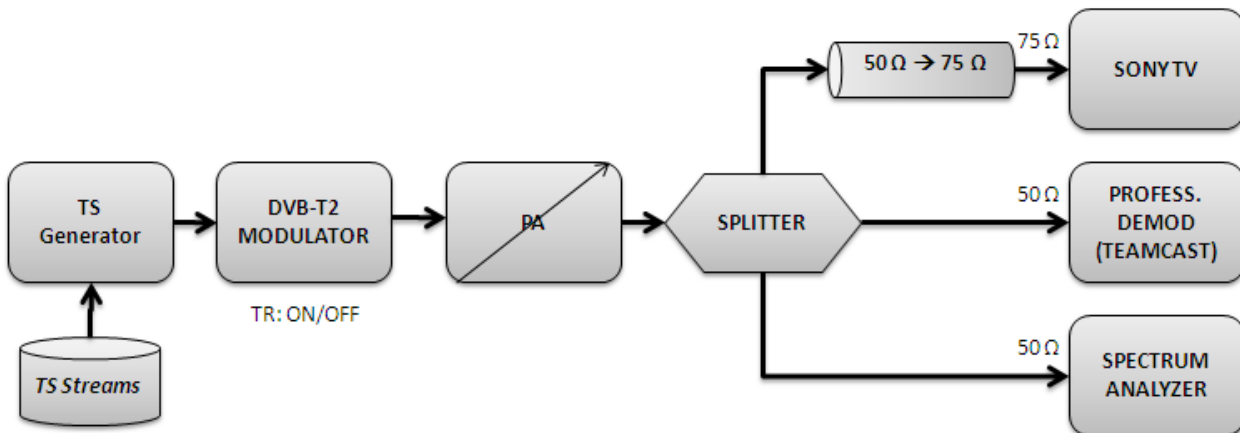
Figure 2.1. Prototypes under test in PAPR evaluation.



2.3 Set-up

The equipment for this test and the test set-up is sketched in Figure 2.2.

Figure 2.2. Test set-up for PAPR evaluation



It is important to highlight some parameters used by the modulator in the PAPR algorithm. These were:

- Number of iterations: 20.
- V_{clip} : 3.05

2.4 Test Procedure

The procedure for this test was:

1. Connect the devices as in figure 1.
2. Select the configuration.
3. Set TR PAPR reduction OFF.
4. Select the nominal amplifier power and measure MER and power levels at the demodulators.
5. Repeat the measurements with TR PAPR reduction ON.
6. Increase the amplifier power and measure again MER and power levels.
7. Compare the results when TR is OFF and ON
8. Repeat for the other DVB-T2 configurations.

2.5 Results

The results obtained are summarized in Table 2.3

Table 2.3. PAPR results

Test Conf	Mod	DeMod	Amp Pow (W)	Rx (dBm)	MER (dB)	TR	TR Gain (dB)
1	Thomson	Ana	100			0	
1	Thomson	TeamCast	100		35	0	
1	Thomson	Sony	100			0	
1	Thomson	Ana	100			1	
1	Thomson	TeamCast	100		35,5	1	0,5
1	Thomson	Sony	100			1	
1	Thomson	Ana	118			0	
1	Thomson	TeamCast	118		33	0	
1	Thomson	Sony	118			0	
1	Thomson	Ana	118			1	
1	Thomson	TeamCast	118		34	1	1
1	Thomson	Sony	118			1	
2	Thomson	Ana	100	-17,3		0	
2	Thomson	TeamCast	100	-19,9	35,3	0	
2	Thomson	Sony	100	-28	33	0	
2	Thomson	Ana	100	-17,3		1	
2	Thomson	TeamCast	100	-19,9	35,7	1	0,4
2	Thomson	Sony	100	-28	33,3	1	0,3
2	Thomson	Ana	118	-16,9		0	
2	Thomson	TeamCast	118	-19,2	33,5	0	
2	Thomson	Sony	118	-29	32,6	0	
2	Thomson	Ana	118	-16		1	

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2	Thomson	TeamCast	118	-19,2	34	1	0,5
2	Thomson	Sony	118	-28	33	1	0,4
3	Thomson	Ana	101	-17,2		0	
3	Thomson	TeamCast	101	-20	35,1	0	
3	Thomson	Sony	101	-28	33	0	
3	Thomson	Ana	101	-17,3		1	
3	Thomson	TeamCast	101	-20	35,7	1	0,6
3	Thomson	Sony	101	-28	33,6	1	0,6
3	Thomson	Ana	117	-16,7		0	
3	Thomson	TeamCast	117	-19,4	32,9	0	
3	Thomson	Sony	117	-28	31,1	0	
3	Thomson	Ana	117			1	
3	Thomson	TeamCast	117	-19,4	33,5	1	0,6
3	Thomson	Sony	117	-28	31	1	
4	Thomson	Ana	100	-17,1		0	
4	Thomson	TeamCast	100	-19,9	34,5	0	
4	Thomson	Sony	100	-28	30,3	0	
4	Thomson	Ana	100	-17,1		1	
4	Thomson	TeamCast	100	-20	34,9	1	0,4
4	Thomson	Sony	100	-28	30,8	1	0,5
4	Thomson	Ana	120			0	
4	Thomson	TeamCast	120	-19,3	33,5	0	
4	Thomson	Sony	120	-28	30	0	
4	Thomson	Ana	120	-16,3		1	
4	Thomson	TeamCast	120	-19,2	33,5	1	0
4	Thomson	Sony	120	-27	30,8	1	0
5	Thomson	It was not possible with Thomson modulator					
6	Thomson	Ana	100	-17,2		0	
6	Thomson	TeamCast	100	-20,1	35,7	0	
6	Thomson	Sony	100			0	
6	Thomson	Ana	100	-17,2		1	
6	Thomson	TeamCast	100	-20	35,7	1	0
6	Thomson	Sony	100			1	
6	Thomson	Ana	118	-16,5		0	
6	Thomson	TeamCast	118	-19,5	33,8	0	
6	Thomson	Sony	118			0	
6	Thomson	Ana	118	-16,5		1	
6	Thomson	TeamCast	118	-19,5	34,2	1	0,4
6	Thomson	Sony	118			1	

2.6 Conclusions

In a first term, according to these PAPR tests the use of TR techniques does not affect to the analyzed receivers and the received signal was decoded without problems.

On the other hand, the performed MER analysis denotes that the highest achieved gain using PAPR reduction techniques is with low FFT configurations. When the FFT size is increased, the gain that TR provides is lower. Otherwise, for the first configurations the gain is higher with the amplifier working at more power level. However, when the FFT size is raised, the best TR gain is achieved for the nominal power of the amplifier.

Finally, it should be noted that for the last configurations with the higher values FFTs sizes, the gain achieved by means of TR was close to 0 dB for both power settings.

3 NULL FEFs EVALUATION

3.1 Objectives

DVB-T2-Lite and DVB-NGH standards will certainly be deployed through existing DVB-T2 network. This will result in a T2 signal containing FEFs. The goal of this test was so to verify that T2 equipments are ready for transmission and reception of a T2 signal with FEFs. As T2-Lite FEFs are not available for the moment, this test was performed with “null FEFs”.

The DVB-T2 configuration considered for the test is based on the one proposed in NorDig Unified Test Specifications [1] and is summarized in Table 3.1.

Table 3.1. DVB-T2 configuration for Null FEFs Evaluation

Overall		PLP n'	
Length	62	PLP_ID	TBD
PLP	A	Type	Data type 1
FFTSIZE	32k	Modulation	256-QAM
GI	1/16	Rate	2/3
Lf (Data symbols+P2s)	62	FEC Type	64800
SISO/MISO	SISO	Rotated QAM	No
PAPR	TR	FEC blocks per interleaving frame	135,200
Null packet deletion	Disabled	Max FEC blocks per interleaving frame	
Frames per superframe	6	TI blocks per frame (N_TI)	3
Bandwidth	8MHz	T2 frames per Interleaving Frame (P_I)	1
Extended Carrier Mode	Extended	Frame Interval (I_JUMP)	1
Pilot Pattern	PP4	Type of time-interleaving	0
L1 Modulation	64-QAM	Time Interleaving Length	3
Sub Slices per Frame		Input stage	
FEF	Yes	Mode	HEM
FEF Type		ISSY	Enabled
FEF Length	588000	BUFS	
FEF Interval	6	Design delay (samples)	
FEF P1: S1 Value	2	Null packet deletion	Disabled
FEF P1: S2 Value	1	In Band Signalling	Disabled
FEF contents	NULL	Number of other PLPs in-band signalling	
TxSig FEF ID1		Number of NULL packets inserted each time (p)	
TxSig FEF ID2		Frequency of NULL packets insertion in packets (q)	
L1 Repetition	0		
Number of PLPs	1		
Number of RFs	1		
Number of AUXs	0		
TxSig AUX P			
TxSig AUX Q			
TxSig AUX R			
TxSig AUX ID			
Spec version	1.1.1		
Vclip			
Number of PAPR-TR			

iterations	
Vclip (ACE)	
L1_ ACE_MAX	
NbiasCellsActive	

The DVB-T2 signal shall contain “null FEF” with a FEF interval of 6 T2 frames. The size of the “null FEF” is 588000 samples (64.3125ms) and T2 frame size $L_f=62$ symbols (236.320ms). “Null FEF” means FEF without content resulting to a lower RF output power during the FEF compared to T2 frame.

The selected channel for the NULL FEFs Evaluation test session was channel 22 (482 MHz).

3.1 Prototypes under test

In this laboratory session, the “null FEF” compatibility of some DVB-T2 prototypes was verified. In the transmission side, the Teamcast modulator was tested. In the reception side, the Teamcast demodulator was considered.

These prototypes are shown in Figure 3.1

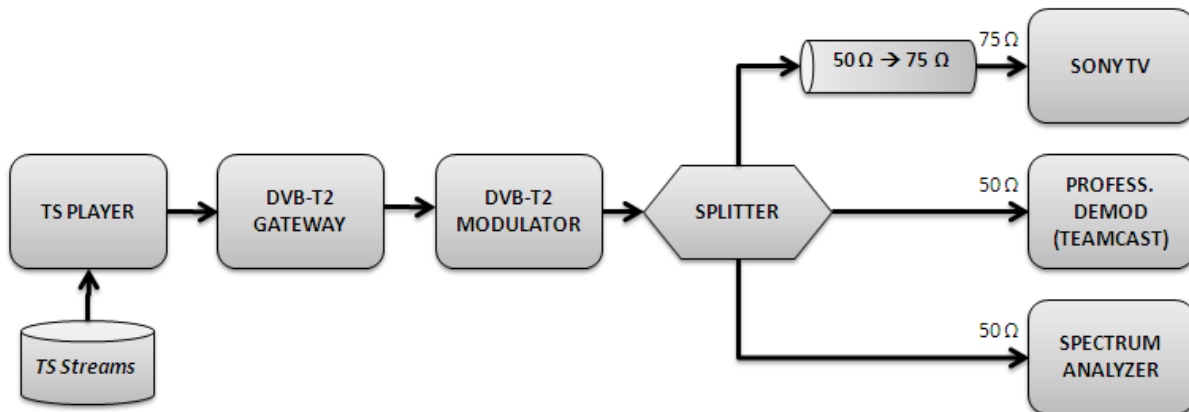
Figure 3.1. Prototypes under test in “Null FEF” evaluation.



3.2 Set-up

The test set up for “Null FEFs” evaluation is shown in Figure 3.2. A TS player is used to feed a T2-Gateway. The T2-Gateway transmits a T2-MI stream configured with “null FEF” to the modulator. The signal generated by the modulator is then observed through the professional demodulator, the Sony TV and a spectrum analyzer.

Figure 3.2. Test set-up for “null FEFs” evaluation



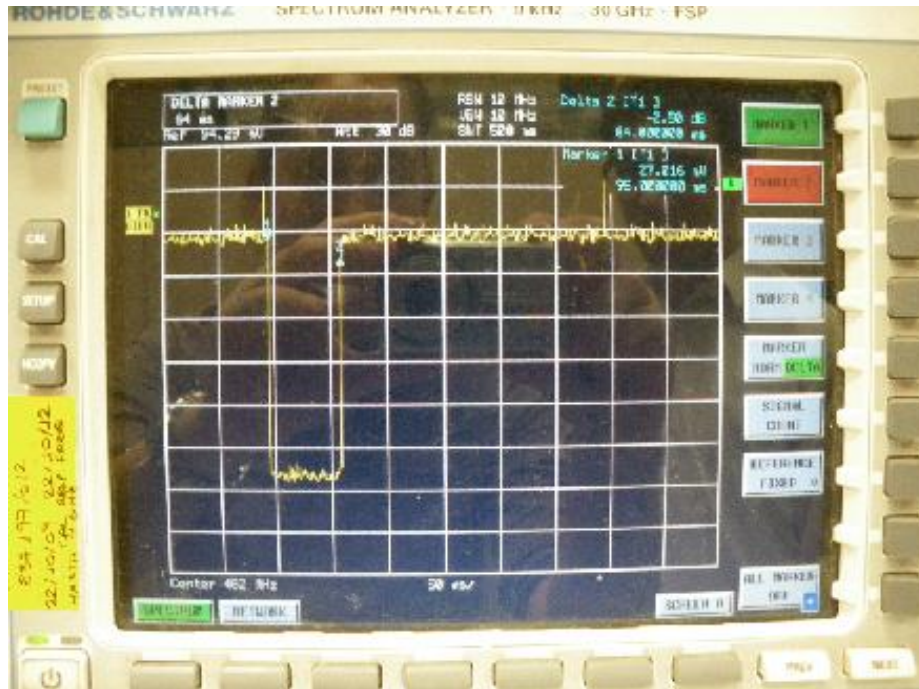
3.3 Results

The shape of the T2 signal, observed thanks to the spectrum analyzer, shows the insertion of null sections corresponding to the FEFs. The delay between two FEFs (Figure 3.3) and the length of one FEF (Figure 3.4) have been measured and correspond to the expected values.

Figure 3.3. T2 signal power distribution, FEF delay measure



Figure 3.4. T2 signal power distribution, FEF length measure



Correct decoding of the T2 signal has also been verified thanks to the Teamcast demodulator and the Sony TV. Due to the discontinuity of the signal, we have also observed that ISSY field is necessary to correctly decode the signal without any freeze of the video.

3.4 Conclusions

This test has highlighted the possibility to correctly receive and decode a T2 signal containing FEFs. Although the T2 signal is transmitted by bursts, synchronization of the receiver buffer through the analysis of ISSY fields allows to obtain a perfectly smoothed video at the output. To go further, the next step of FEF analysis should now consider T2-Lite FEFs.

4 MULTIPLE PLPs EVALUATION

4.1 Objectives

When multiple PLPs are used the processing complexity increases in both the transmitter and the receiver side, that is why some testing was needed to ensure that all steps, from the T2-gateway to the receiver, work correctly.

It was tested that the frame builder and de-builder perform their tasks according to the standard and that the signalling is correctly inserted, so the receiver could find and decode the different PLPs correctly.

Although the different sets of DVB-T2 configuration parameters that should have been used to validate this feature were VV400, VV413 and VV500, it was impossible to test all of them due to an incorrect operation of the gateway. Because of this, only VV413 was tested. The DVB-T2 configuration parameters are shown in Table 4.1.

Table 4.1. DVB-T2 configuration for Multiple PLP evaluation.

Overall		PLP 0	
Length	4 frames	PLP_ID	0
PLP	Multiple	Type	2
FFTSIZE	16K	Modulation	256QAM
GI	19/128	Rate	2/3
Lf (Data symbols+P2s)	60	FEC Type	64K
SISO/MISO	SISO	Rotated QAM	Non rot
PAPR	TR	FEC blocks per interleaving frame	29
Null packet deletion		Max FEC blocks per interleaving frame	29
Frames per superframe	2	TI blocks per frame (N_TI)	
Bandwidth	8MHz	T2 frames per Interleaving Frame (P_I)	
Extended Carrier Mode	No	Frame Interval (I_JUMP)	
Pilot Pattern	PP3	Type of time-interleaving	
L1 Modulation	QPSK	Time Interleaving Length	
Sub Slices per Frame	270	PLP 1	
FEF	No	PLP_ID	1
FEF Type		Type	2
FEF Length		Modulation	16QAM
FEF Interval		Rate	3/5
FEF P1: S1 Value		FEC Type	64K
FEF P1: S2 Value		Rotated QAM	Non rot
FEF contents		FEC blocks per interleaving frame	32
TxSig FEF ID1		Max FEC blocks per interleaving frame	32
TxSig FEF ID2		TI blocks per frame (N_TI)	
L1 Repetition	0	T2 frames per Interleaving Frame (P_I)	
Number of PLPs	2	Frame Interval (I_JUMP)	
Number of RFs	1	Type of time-interleaving	
Number of AUXs	0	Time Interleaving Length	
TxSig AUX P		Input stage	
TxSig AUX Q		Mode	HEM

TxSig AUX R		ISSY	Yes
TxSig AUX ID		BUFS	
Spec version	1.2.1	Design delay (samples)	
Vclip	No	Null packet deletion	
Number of PAPR-TR iterations		In Band Signalling	Type A
Vclip (ACE)		Number of other PLPs in-band signalling	
L1_ACE_MAX		Number of NULL packets inserted each time (p)	
NbiasCellsActive		Frequency of NULL packets insertion in packets (q)	

For these tests channel simulations were performed. The channels tested are shown in Table 4.2.

Table 4.2. Channel models for Multiple PLP evaluation.

SCENARIO	CHANNEL MODELS	OPTIONS
Fixed Reception	Gaussian - AWGN Ricean - F1 Rayleigh - P1	
Portable Reception	Pedestrian Indoor – PI Pedestrian Outdoor – PO	
Mobile Reception	Typical Urban – TU6	20km/h
SFN	0dB Echo	10 us and 95% GI

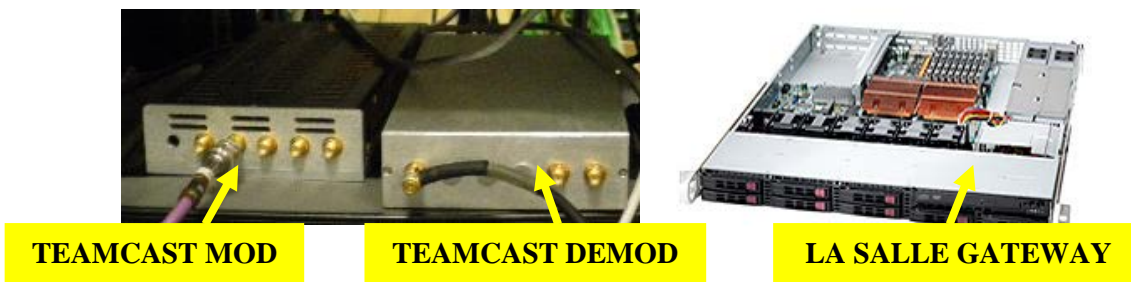
The selected channel for the Multiple PLPs Evaluation test session was channel 22 (482 MHz).

4.2 Prototypes under test

In this laboratory session, the multiple PLP performance of some DVB-T2 prototypes was analyzed. In the transmission side, the Teamcast modulator and La Salle gateway were tested. In the reception one, the Teamcast demodulator was verified.

These prototypes are shown in Figure 4.1

Figure 4.1. Prototypes under test in Multiple PLP evaluation.

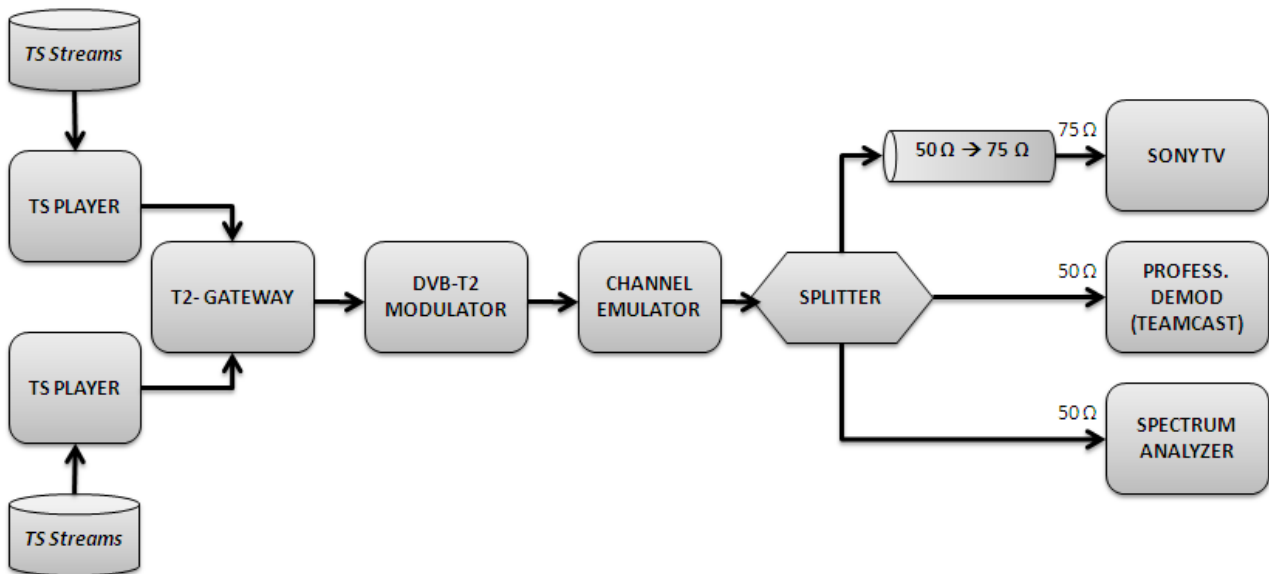


4.3 Set-up

The test set up for multiple PLP evaluation is shown in Figure 4.2. Two TS players were used to feed a T2-Gateway with two test streams. When using Multiple PLP to provide service-specific robustness, the T2-Gateway enabled all the modulators to generate the same data in a deterministic manner. Common network parameters were also set at the T2-Gateway. The T2-Gateway output was connected to a DVB-T2 modulator input, whose output was connected to a channel emulator. The channel emulator was used to simulate different channel conditions that could be perceived on the field. Its output was connected to DVB-T2 test receivers: SONY TV, DVB-T2 capable professional measurement equipment and a spectrum analyzer using a power splitter, as it is shown in Figure 4.2.

The channel emulator was used to simulate different channel conditions that could be perceived on the field. Its output was connected to DVB-T2 test receivers: SONY TV, DVB-T2 capable professional measurement equipment and a spectrum analyzer using a power splitter, as it is shown in Figure 4.2.

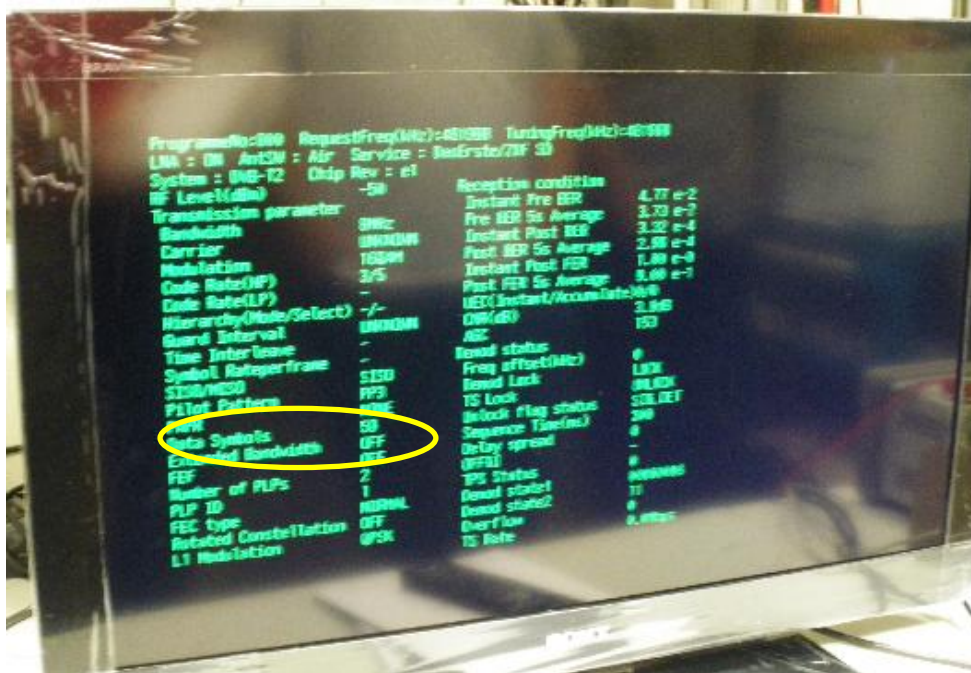
Figure 4.2. Test set-up for Multiple PLP evaluation



4.4 Test Procedure

The threshold criteria for DVB-T and DVB-T2 performance measurements is typically defined as Quasi Error Free (QEF) reception. That corresponds to $BER=10^{-11}$ at the TS data level at the input of MPEG-2 demultiplexer. For a practical reason the threshold criteria of DVB-T2 Multiple PLP evaluation is set as $BER=10^{-7}$ after LDPC decoder or alternatively as an accepted subjective test result of 30 s error free decoded video. Because of that, the required C/N was measured at the QEF point. This point was reached considering a correct demodulation with no visible errors during 30s on SONY TV for each PLP, as it is shown in Figure 4.3.

Figure 4.3. Correct demodulation of more than one PLP



The measurement methodology of C/N performance was:

1. Measure the cable losses and connectors that will be used in the test set-up.
2. Connect the test set-up.
3. Set the gateway according to the VV parameter sets
4. Each of the PLPs within the signal should be demodulated and checked that video and sound can be received correctly.
5. Adjust the C/N until QEF point is reached using 0.1-0.5dB steps when adjusting C/N and validate the required C/N.
6. Change the test parameters or channel profile and repeat the previous steps.

4.5 Results

The C/N at the QEF point was measured for the VV413 DVB-T2 configuration parameters and for different channel profiles. The C/N ratios obtained in Teamcast demodulator and SONY TV are summarized in Table 4.3.

Table 4.3. Multiple PLP Performance

<i>Channel model</i>	<i>PLP</i>	<i>C/N Teamcast DEMOD</i>	<i>C/N SONY</i>
<i>Gaussian channel</i>	0	18,8	18,8
	1	8,1	8,1
<i>Ricean channel</i>	0	19,5	19,6
	1	8,8	8,8
<i>Rayleigh Channel</i>	0	21,8	21,8
	1	10,7	10,7
<i>Pedestrian Indoor</i>	0	26	26
	1	14,7	14,7
<i>Pedestrian Outdoor</i>	0	25,8	25,8
	1	15,4	15,4
<i>TU6 (20km/h)</i>	0	X	X
	1	20,7	23,1
<i>0dB echo (10us)</i>	0	21,9	21,9
	1	11	11
<i>0dB echo (95% GI)</i>	0	25,3	25,1
	1	10,7	10,7

4.6 Conclusions

These results show that the frame builder and de-builder perform their tasks according to the standard and that the signalling is properly inserted, so both receivers could find and decode the different PLPs correctly. The DVB-T2 gateway also works correctly with two PLP with different configuration modes. By this way, it has been demonstrated that it is possible to use correctly different robustness levels in different PLPs at the same time.

The C/N ratio with different channel profiles was calculated and the results were as expected. The C/N ratio was higher for the PLP whose configuration was less robust and for those channel profiles with more multipaths and no direct sight.

5 SFN EVALUATION

5.1 Objectives

The target was to define appropriate test cases and carry out laboratory tests in order to get information about the SFN performance of the DVB-T2 prototypes which were evaluated. The gathered test results have been analyzed and they may provide relevant information for DVB-T2 network planners.

Different attenuation-delay profiles have been tested to check the influence of these parameters on the SFN gain.

DVB-T2 standard provides a huge amount of possible network configuration parameter sets. A subset of DVB-T2 test parameters have been selected in order to carry out the planned test cases within a reasonable time. The selection of test parameters, was based on the most interesting DVB-T2 service scenarios. The aim was that despite the limited number of test parameters a good overview of DVB-T2 SFN performance could be achieved.

The selected test cases are based on the NorDig Unified Test Specifications [1]. Two configuration modes with fixed reception parameters, which are shown in Table 5.1 and 5.2, were considered.

Table 5.1. DVB-T2 configuration for SFN evaluation (fixed reception parameters).

Overall		PLP n'	
Length		PLP_ID	0
PLP		Type	1
FFTSIZE	32K	Modulation	256QAM
GI	1/32	Rate	See Table 4.2
Lf (Data symbols+P2s)	60	FEC Type	64K
SISO/MISO	SISO	Rotated QAM	Non rot
PAPR	No	FEC blocks per interleaving frame	196
Null packet deletion	No	Max FEC blocks per interleaving frame	
Frames per superframe	2	TI blocks per frame (N_TI)	3
Bandwidth	8MHz	T2 frames per Interleaving Frame (P_I)	1
Extended Carrier Mode	Ext	Frame Interval (I_JUMP)	1
Pilot Pattern	PP4	Type of time-interleaving	0
L1 Modulation	64QAM	Time Interleaving Length	3
Sub Slices per Frame	1	Input stage	
FEF	No	Mode	
FEF Type		ISSY	
FEF Length		BUFS	
FEF Interval		Design delay (samples)	
FEF P1: S1 Value		Null packet deletion	
FEF P1: S2 Value		In Band Signalling	
FEF contents		Number of other PLPs in-band signalling	
TxSig FEF ID1		Number of NULL packets inserted each time (p)	
TxSig FEF ID2		Frequency of NULL packets insertion in packets (q)	
L1 Repetition			
Number of PLPs	1		
Number of RFs			

Number of AUXs	
TxSig AUX P	
TxSig AUX Q	
TxSig AUX R	
TxSig AUX ID	
Spec version	
Vclip	
Number of PAPR-TR iterations	
Vclip (ACE)	
L1_ ACE_MAX	
NbiasCellsActive	

Table 5.2. Differences between the two DVB-T2 configuration for SFN evaluation with fixed reception parameters

Configuration mode	Code-rate
Fixed 1	2/3
Fixed 2	4/5

Other four configuration modes with mobile reception parameters were also considered. These four configuration modes are shown in Table 5.3 and 5.4.

Table 5.3. DVB-T2 configuration for SFN evaluation (mobile reception parameters).

Overall		PLP n'	
Length		PLP_ID	
PLP		Type	1
FFTSIZE	8K	Modulation	64QAM
GI	See Table 4.4	Rate	See Table 4.4
Lf (Data symbols+P2s)	TBD	FEC Type	16K
SISO/MISO	SISO	Rotated QAM	rot
PAPR	No	FEC blocks per interleaving frame	See Table 4.4
Null packet deletion	No	Max FEC blocks per interleaving frame	
Frames per superframe	2	TI blocks per frame (N_TI)	2
Bandwidth	8MHz	T2 frames per Interleaving Frame (P_I)	1
Extended Carrier Mode	Ext	Frame Interval (I_JUMP)	1
Pilot Pattern	See Table 4.4	Type of time-interleaving	0
L1 Modulation	64QAM	Time Interleaving Length	2
Sub Slices per Frame	1	Input stage	
FEF	No	Mode	
FEF Type		ISSY	
FEF Length		BUFS	
FEF Interval		Design delay (samples)	
FEF P1: S1 Value		Null packet deletion	
FEF P1: S2 Value		In Band Signalling	
FEF contents		Number of other PLPs in-band signalling	
TxSig FEF ID1		Number of NULL packets inserted each time (p)	

TxSig FEF ID2		Frequency of NULL packets insertion in packets (q)	
L1 Repetition			
Number of PLPs	1		
Number of RFs			
Number of AUXs			
TxSig AUX P			
TxSig AUX Q			
TxSig AUX R			
TxSig AUX ID			
Spec version			
Vclip			
Number of PAPR-TR iterations			
Vclip (ACE)			
L1_ACE_MAX			
NbiasCellsActive			

Table 5.4. Differences between the four DVB-T2 configuration for SFN evaluation with mobile reception parameters

Configuration mode	GI	Pilot Pattern	Code-rate	FEC blocks
Mobile 1	1/8	PP2	2/3	408
Mobile 2	1/8	PP2	3/4	408
Mobile 3	1/4	PP1	2/3	407
Mobile 4	1/4	PP1	3/4	407

For these tests channel simulations were performed. The channels considered are shown in Table 5.5.

Table 5.5. Channel models for SFN evaluation.

SCENARIO	CHANNEL MODELS	OPTIONS
Fixed Reception	Gaussian - AWGN Ricean - F1 Rayleigh - P1	
Mobile Reception	TU6	20km/h and 30km/h

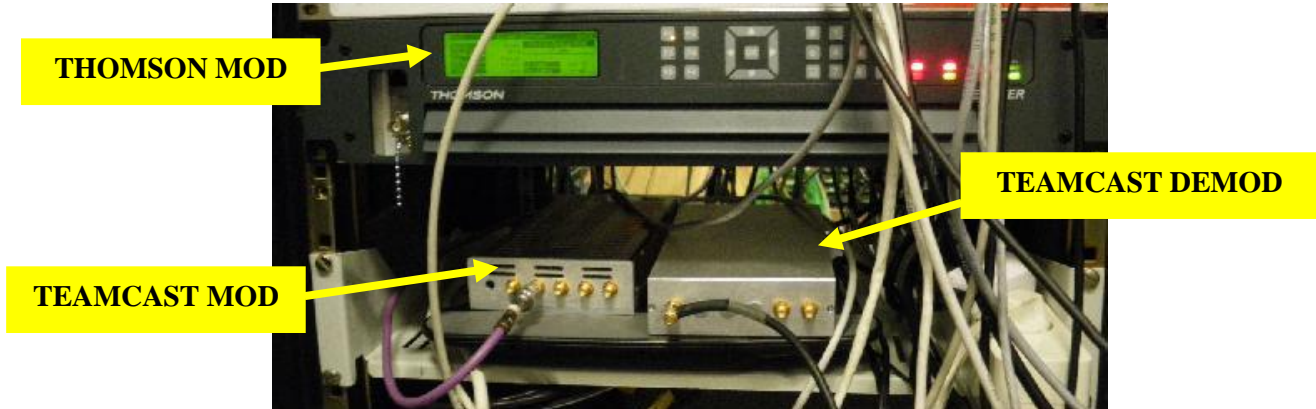
The selected channel for the SFN Evaluation test session was channel 22 (482 MHz).

5.2 Prototypes under test

In this laboratory session, the SFN performance of some DVB-T2 prototypes was analyzed. Two modulators were used in order to simulate a SFN in the laboratory. One of them was Thomson modulator and the other one was Teamcast modulator. In the reception side, the Teamcast demodulator was verified.

These prototypes are shown in Figure 5.1.

Figure 5.1. Prototypes under test in SFN evaluation.

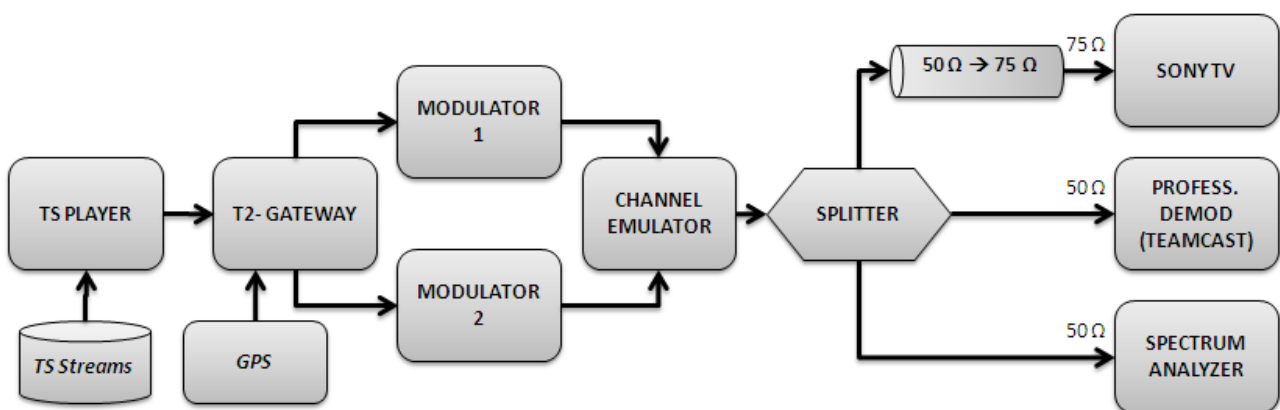


5.3 Set-up

A TS player was used to feed a T2-Gateway with a test stream. The T2-Gateway was required to set a DVB-T2 timestamp for synchronization purposes. The T2-Gateway was connected with an external GPS that provides a reference signal to the T2-Gateway and the DVB-T2 modulators. Common network parameters were also set at the T2-Gateway.

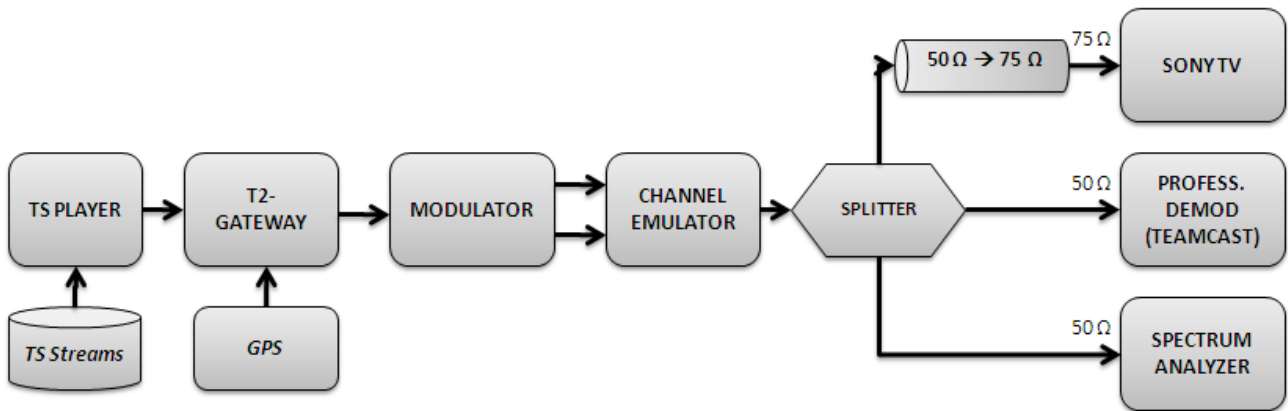
In the tests with DVB-T2 fixed configuration modes, as it is shown in Figure 5.2, the T2-Gateway output was connected to two DVB-T2 modulators inputs, whose outputs were connected to a channel emulator.

Figure 5.2. Test set-up for SFN evaluation with fixed reception parameters



However, in the tests with DVB-T2 mobile configuration modes, only one modulator was used, due to the fact that it was impossible to work correctly with the mobile configuration modes using the second modulator. Because of that, Figure 5.3 shows the set-up in these cases, where only one modulator was used. The DVB-T2 RF signals were given by RF output and RF monitoring output and were also connected to a channel emulator.

Figure 5.3. Test set-up for SFN evaluation with mobile reception parameters

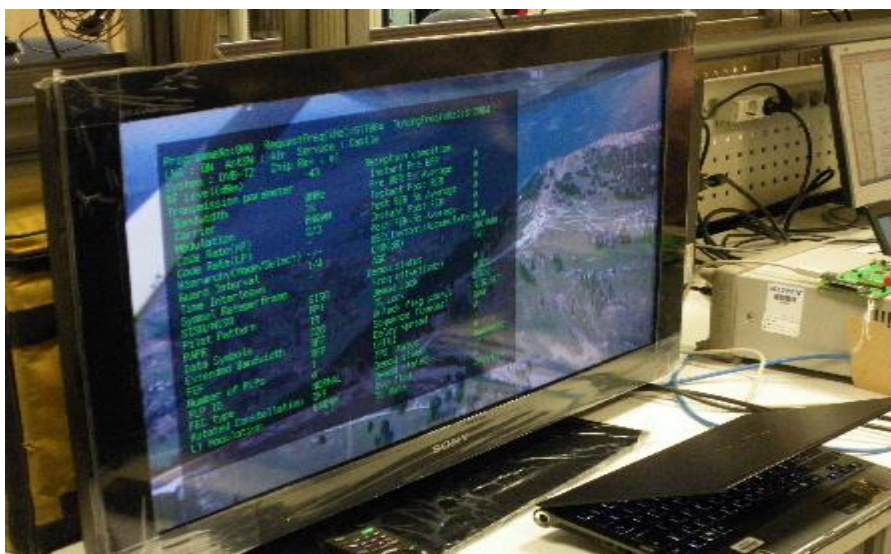


Not only was the channel emulator used to simulate different channel conditions that could be perceived on the field, but it also adds both signals. The channel emulator output was connected to DVB-T2 test receivers: SONY TV, DVB-T2 capable professional measurement equipment and a spectrum analyzer using a power splitter, as it is shown in Figure 5.2 and 5.3.

5.4 Test Procedure

The threshold criteria for DVB-T and DVB-T2 performance measurements is typically defined as Quasi Error Free (QEF) reception. That corresponds to $BER=10^{-11}$ at the TS data level at the input of MPEG-2 demultiplexer. For a practical reason the threshold criteria of DVB-T2 SFN evaluation is set as $BER=10^{-7}$ after LDPC decoder or alternatively as an accepted subjective test result of 30 s error free decoded video. Because of that, the required C/N was measured at the QEF point. This point was reached considering a correct demodulation with no visible errors during 30s on SONY TV, as it can be seen in Figure 5.4.

Figure 5.4. Subjective test of 30s error free decoded video on SONY TV



The measurement methodology of C/N performance was:

1. Measure the cable losses and connectors that will be used in the test set-up.
2. Connect the test set-up.
3. Set the test parameters and channel profile.
4. Synchronize both transmitters.
5. Adjust the C/N until QEF point is reached using 0.1-0.5dB steps when adjusting C/N and validate the required C/N.
6. Change the test parameters or channel profile and repeat the previous steps.

5.5 Results

The tested channels were formed by two main paths; the relative amplitude and delay between them were changed to have an echo at fixed delay. The maximum tested delay depends on the Guard Interval (GI) duration. The delay was varied from 10 us up to 95% guard interval duration. The relative amplitude of the second path was adjusted to 0dB, 3dB and 10dB.

The C/N at the QEF point was measured for the different DVB-T2 configuration parameters and channel profiles. The C/N measured for the fixed configuration modes are summarized in Table 4.6 and 4.7, showing the results for Fixed 1 and Fixed 2 configurations, respectively.

As it is shown in Table 5.6, Gaussian, Ricean and Rayleigh channel profiles were first analyzed with a short delay between both paths (10us). A posterior analysis with a longer delay between paths (95% guard interval) was started, but only for the Gaussian channels profile.

Table 5.6. SFN Performance with Fixed 1 configuration mode

Channel model	1 st Tx Att (dB)	1 st Tx Delay (μ s)	2 nd Tx Att (dB)	2 nd Tx Delay (μ s)	C/N
Gaussian channel (delay 10us)	0	0	0	10	22
	0	0	3	10	21
	0	0	10	10	19,4
	3	0	0	10	21
	10	0	0	10	19,4
Ricean channel (delay 10us)	0	0	0	0	22,8
	0	0	0	10	22,4
	0	0	3	10	21,6
	0	0	10	10	20,9
	3	0	0	10	21,9
	10	0	0	10	20,4
	20	0	0	10	19,5
Rayleigh channel (delay 10us)	0	0	0	0	25,6
	0	0	0	10	25,4
	0	0	3	10	24,3
	0	0	10	10	22,4
	3	0	0	10	24,4
	10	0	0	10	22,4

<i>Gaussian channel (delay 95% GI)</i>	0	0	0	106,4	21,8
	0	0	3	106,4	21
	0	0	10	106,4	19,5
	3	0	0	106,4	21
	10	0	0	106,4	19,4

For the Fixed 2 configuration mode, Gaussian, Ricean and Rayleigh channel profiles were analyzed with a long delay between both paths (95% guard interval). As the C/N results were high, a worse case with a shorter delay was not considered. The results are summarized in Table 5.7.

Table 5.7. SFN Performance with Fixed 2 configuration mode

<i>Channel model</i>	<i>1st Tx Att (dB)</i>	<i>1st Tx Delay (μs)</i>	<i>2nd Tx Att (dB)</i>	<i>2nd Tx Delay (μs)</i>	<i>C/N</i>
<i>Gaussian channel (delay 95% GI)</i>	0	0	0	0	26,5
	0	0	0	106,4	27,5
	3	0	0	106,4	25,3
	10	0	0	106,4	23
<i>Ricean channel (delay 95% GI)</i>	0	0	0	0	33,5
	0	0	0	106,4	28,1
	3	0	0	106,4	26,1
	10	0	0	106,4	23,5
<i>Rayleigh channel (delay 95% GI)</i>	0	0	0	0	X
	0	0	0	106,4	X
	3	0	0	106,4	X
	10	0	0	106,4	27,2

In the case of mobile reception, the C/N measured for Mobile 1, 2, 3 and 4 configuration modes are summarized in Table 5.8, 5.9, 5.10 and 5.11, respectively. In these cases, the results simulating a Gaussian channel with a long delay between both paths was studied.

The TU6 channel at two speeds was also considered. However, as a correct decodification was impossible by the demodulators, only the TU6 channel at 20km/h was analyzed in the following analysis.

Table 5.8. SFN Performance with Mobile 1 configuration mode

<i>Channel model</i>	<i>1st Tx Att (dB)</i>	<i>1st Tx Delay (μs)</i>	<i>2nd Tx Att (dB)</i>	<i>2nd Tx Delay (μs)</i>	<i>C/N</i>
<i>Gaussian channel (delay 95% GI)</i>	0	0	0	0	12
	0	0	0	106,4	18
	3	0	0	106,4	16,6
	10	0	0	106,4	14,9
<i>TU6 (20km/h)</i>	0	0	0	0	21,3
	0	0	0	106,4	24,9
	3	0	0	106,4	24,9
	10	0	0	106,4	25,1

TU6 (30km/h)	0	0	0	0	21,9
	0	0	0	106,4	X
	3	0	0	106,4	X
	10	0	0	106,4	X

Table 5.9. SFN Performance with Mobile 2 configuration mode

Channel model	1 st Tx Att (dB)	1 st Tx Delay (μ s)	2 nd Tx Att (dB)	2 nd Tx Delay (μ s)	C/N
Gaussian channel (delay 95% GI)	0	0	0	0	13,5
	0	0	0	106,4	20,9
	3	0	0	106,4	18,6
	10	0	0	106,4	16,5
TU6 (20km/h)	0	0	0	0	24,5
	0	0	0	106,4	28,8
	3	0	0	106,4	27,4
	10	0	0	106,4	27,3

Table 5.10. SFN Performance with Mobile 3 configuration mode

Channel model	1 st Tx Att (dB)	1 st Tx Delay (μ s)	2 nd Tx Att (dB)	2 nd Tx Delay (μ s)	C/N
Gaussian channel (delay 95%)	0	0	0	0	12
	0	0	0	212,8	18,7
	3	0	0	212,8	16,8
	10	0	0	212,8	15,2
TU6 (20km/h)	0	0	0	0	25
	0	0	0	212,8	X
	3	0	0	212,8	X
	10	0	0	212,8	31

Table 5.11. SFN Performance with Mobile 4 configuration mode

Channel model	1 st Tx Att (dB)	1 st Tx Delay (μ s)	2 nd Tx Att (dB)	2 nd Tx Delay (μ s)	C/N
Gaussian channel (delay 95%)	0	0	0	0	13.6
	0	0	0	212,8	21.2
	3	0	0	212,8	18.6
	10	0	0	212,8	16.7
TU6 (20km/h)	0	0	0	0	X
	0	0	0	212,8	X
	3	0	0	212,8	X
	10	0	0	212,8	X

5.6 Conclusions

These results show the use of a T2-Gateway to control two DVB-T2 transmitters to configure a SFN.

The measurements show the increase in the C/N requirements due to the SFN reception especially when the signals coming from different transmitters arrive at similar power level.

In some test cases the correct reception could not be achieved at any C/N value, so those DVB-T2 configurations should be avoided and substituted by a more robust one when the tested channels are expected to occur in real implementations.

6 T2-MI EVALUATION

6.1 Objectives

The objective is to know in a first time if some simple cases of error in T2-MI packets are detected by modulators or excitors and which is their impact on TV reception.

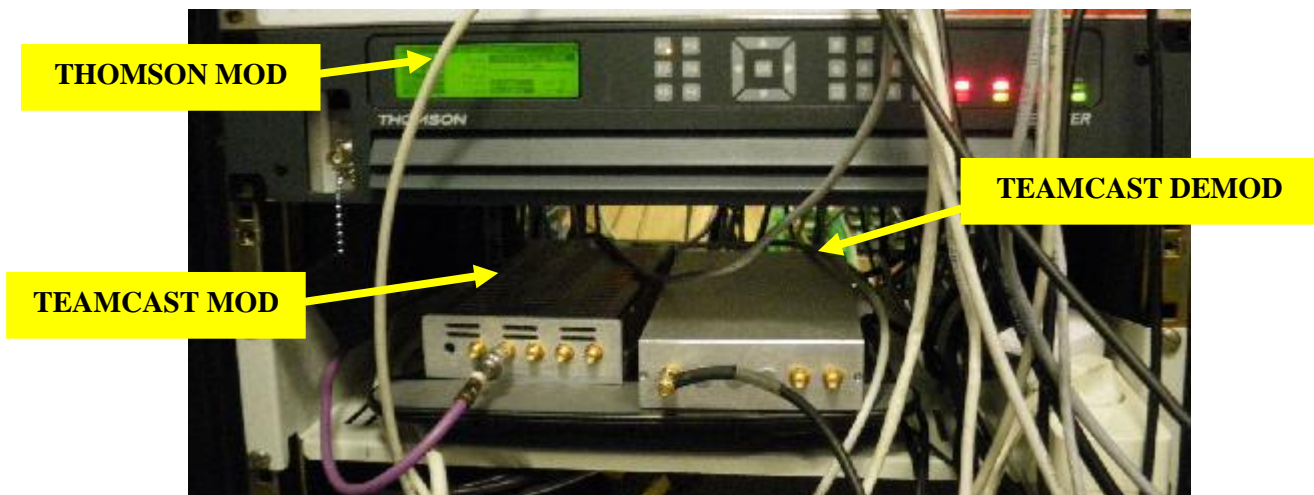
The selected channel for the T2-MI Evaluation test session was channel 22 (482 MHz).

6.2 Prototypes under test

Two modulators were checked. One of them was Thomson modulator and the other one was Teamcast modulator.

In the reception side, the Teamcast demodulator was used to check if there were errors in the reception side. These prototypes are shown in Figure 6.1.

Figure 6.1. Prototypes under test in T2-MI evaluation.



6.3 Set-up

From a pre-recorded T2-MI file, four files have been generated by means of the Thomson Broadcast T2-MI error inserter software. The following errors have been inserted (one type of error by file):

- 0x20 packet type field replaced by 0xFF in more than 3000 successive T2-MI packets
- 0x10 packet type field replaced by 0xFF in more than 3000 successive T2-MI packets
- 1 packet counter by 1000 replaced by 0 in about 10000 successive T2-MI packets
- CRC replaced by 0 in 50 successive T2-MI packets

A computer drives a Dektec player in order to feed ASI input of Teamcast modulator and Thomson Broadcast exciter by playing T2-MI pre-recorded files.
The Sony TV receiver allows to see video impact.

6.4 Test Procedure

The test has been done for each modulator or exciter.

The procedure is the following:

- Playing of the original file (without inserted errors) to see modulator or exciter analysis and to see video.
- Playing erroneous files to check modulator or exciter error detection and video impact on TV receiver

6.5 Results

The results obtained are summarized in Table 6.1.

Table 6.1. Results of the detection of the insertion of errors in T2-MI packets

<i>Error</i>	<i>Teamcast modulator</i>		<i>Thomson Broadcast exciter</i>	
	<i>Error detection</i>	<i>TV impact</i>	<i>Error detection</i>	<i>TV impact</i>
0x20 packet type	Error synthesis with no detail	None	None	None
0x10 packet type	None	None	None	None
Packet counter	Error synthesis with no detail	few seconds cut	None	few seconds cut
CRC	None	None	None	None

6.6 Conclusions

T2-MI error detection is inexistent or incomplete.



7 REFERENCES

[1] NorDig; “NorDig Unified Test Specifications for Integrated Receiver Decoders”, Ver 2.2, November 2010.