



**Digital Video Broadcasting (DVB);
Measurement guidelines for DVB systems;
Amendment for T2-MI (Modulator Interface)**

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**Digital Video Broadcasting (DVB);
Measurement guidelines for DVB systems;
Amendment for the DVB-T2 system**

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11 Measurements for the second generation terrestrial (DVB-T2) system

11.1 Introduction

The DVB-T2 system as it is addressed in the following clauses and sub-clauses, spans from the input Interface A to the output Interface D. Both these interfaces carry MPEG2 Transport Streams ("TS").

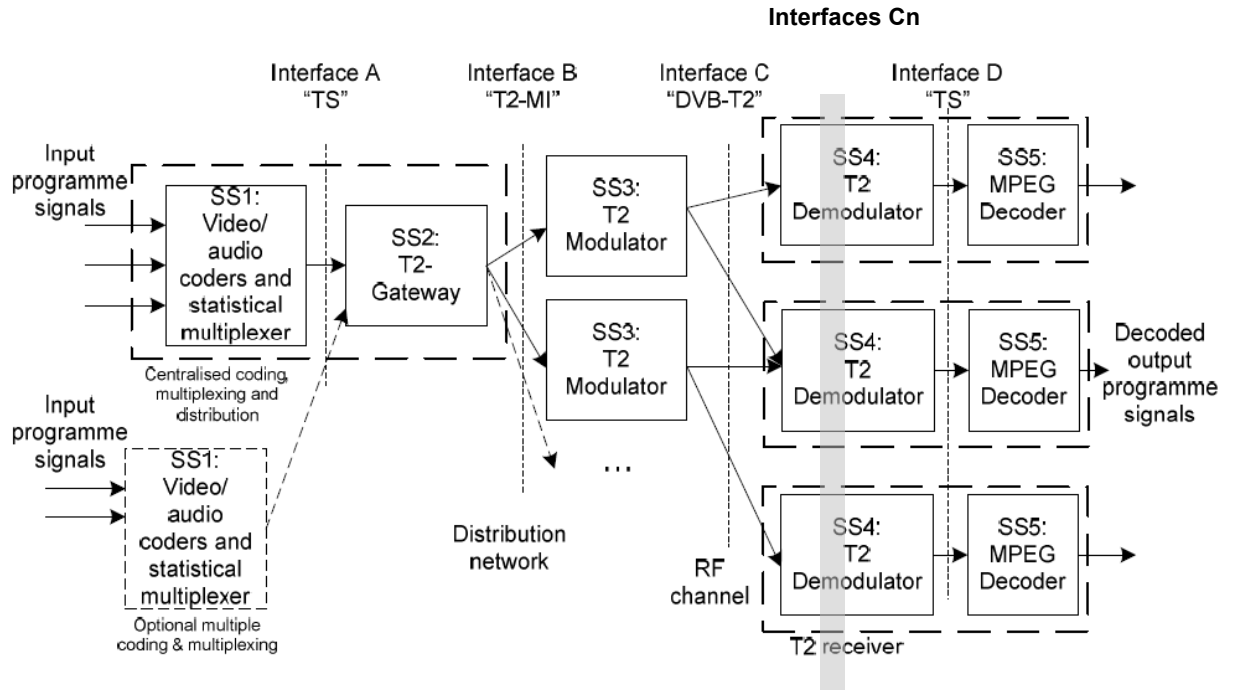


Figure 11-1: Block diagram of a typical DVB-T2 chain [4]

The following clauses and sub-clauses specify a number of tests and measurements at the interfaces A, B, C, Cn and D.

For measurements at Interface A and D, see clause 5 [5], for the parameters measured at the other interfaces see sub-clauses below. The Interfaces Cn are introduced in addition to the interfaces defined in [4] to accommodate all specified measurements for DVB-T2.

With regard to the signalling, it is recommended that a measurement instrument should display the signalled information as readable text and abbreviations.

11.2 Measurements at the DVB-T2 Modulator Interface (T2-MI)

Please refer to:

Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems; Amendment for T2-MI (Modulator Interface), DVB Document A14-1, July 2011, and the respective up-dates

11.3 Measurements for DVB-T2 baseline system

This clause lists a number of measurements for the DVB-T2 baseline system. The parameters are mainly measured at interface C "DVB-T2" or at interface C1 "T2-IQ" as in Figure 11-1.

A list of the main application area of the DVB-T2 measurement parameters described in this clause is given in Table 11.1.

The measurements 6.1 „System availability“ (Interface D in a DVB-T2 system, Figure 11-3) and 6.2 „Link availability“ (Interface C5 in a DVB-T2 system, Figure 11-3) are also applicable.

Table 11.1 DVB-T2 measurement parameters and their application area

Measurement parameter	Transmitter	Network	Receiver	In-service measurement ¹ .
11.3.1 RF measurements	X			X
11.3.1.1 RF frequency accuracy	X	X		X
11.3.1.2 RF occupied bandwidth	X		X	X
11.3.2 Selectivity			X	
11.3.3 AFC capture range			X	
11.3.4 Phase noise of Local Oscillators (LO)	X		X	
11.3.5 RF/IF signal power	X	X	X	X
11.3.6 MISO Group Power Ratio	X	X	X	X
11.3.7 Noise Power	X	X	X	X ²
11.3.8 RF and IF spectrum	X		X	X
11.3.9 Receiver sensitivity/ dynamic range for a Gaussian channel			X	
11.3.10 Linearity characterization (shoulder attenuation)	X			X
11.3.11 Power efficiency	X			X
11.3.12 PAPR effect	X			
11.3.13 P1 Symbol Error Rate			X	X
11.3.14 BER before LDPC (inner) decoder			X	X
11.3.15 Number of LDPC iterations			X	X
11.3.16 BER before BCH (outer) decoder			X	X
11.3.17 Baseband Frame Error Rate BBFER			X	X
11.3.18 Errored Second Ratio ESR			X	X
11.3.19 IQ signal analysis	X		X	X
11.3.19.2 Modulation Error Ratio (MER)	X	X	X	X
11.3.19.3 Signal to Interference Noise Ratio (SINR)	X	X	X	X
11.3.19.4 Carrier Suppression (CS)	X			X
11.3.19.5 Carrier Phase	X			X
11.3.19.6 Amplitude Imbalance (AI)	X			X
11.3.19.7 Quadrature Error (QE)	X			X
11.3.20 SFN synchronisation		X		X
11.3.21 L1 signalling error	X		X	X
11.3.22 RMS Delay-Spread (RMS-DS)		X	X	X
11.3.23 Maximum Excess Delay (MED)		X	X	X
11.3.24 Receiver Buffer Model (RBM) validation test			X	
11.3.25 Relative power Level during the non-P1 part of the FEF (RLF_non_P1)		X		X

¹ The term 'In-service measurement' is understood as a measurement that does not require a specific test signal but can be carried out with a normal DVB-T2 signal.

² As an In-service measurement in an unoccupied channel, the measurement of Noise Power can provide an overview of the man-made noise conditions in a certain channel or frequency band.

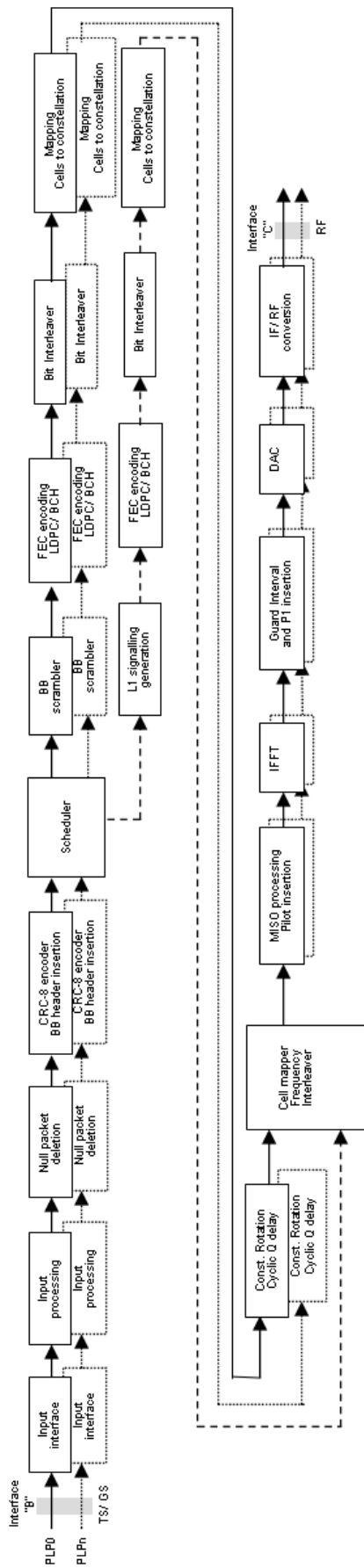


Figure 11-2: Simplified block diagram of a DVB-T2 transmitter

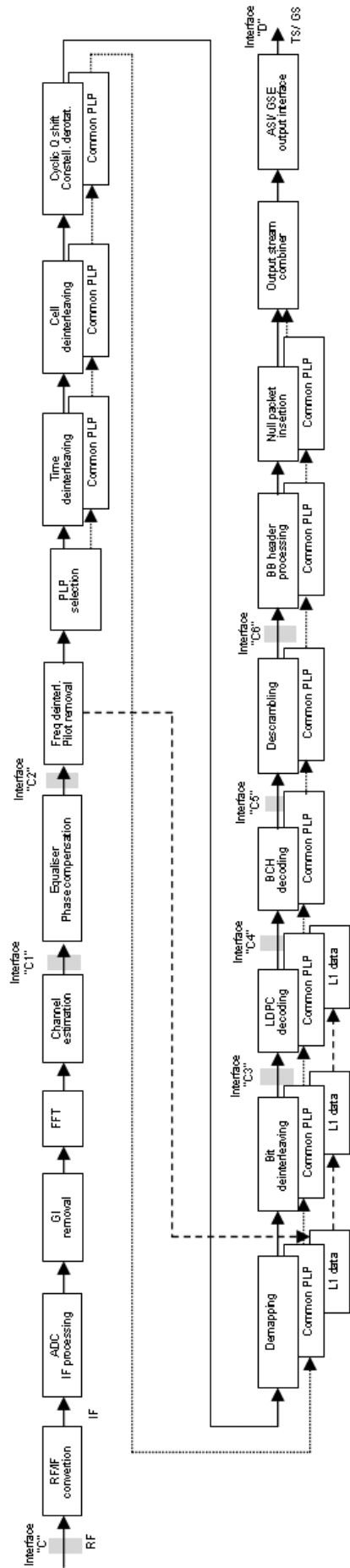


Figure 11-3: Simplified block diagram of a DVB-T2 receiver

11.3.1 RF measurements

The measurement of some basic parameters of the DVB-T2 OFDM signal may be carried out at the RF layer with a test receiver, a spectrum analyser or similar instruments.

11.3.1.1 RF frequency accuracy

Purpose	Successful processing of OFDM signals requires that certain carrier frequency accuracy be maintained at the transmitter. Specific network operations modes such as SFN require high accuracy of the carrier frequency.
Interface	C
Method	<p>The measurement of the RF frequency accuracy determines the centre frequency of the signal, i.e. the positioning of the signal in the RF channel³.</p> <p>a) Spectrum analyser method: the centre frequency is derived from the frequencies measured for the continual pilots and/ or the edge pilots.</p> <p>b) Test receiver method: the centre frequency is derived from the digital samples after the test receiver has synchronised to the incoming DVB-T2 signal. In this case, the accuracy is typically expressed as 'Carrier Offset' and given in Hz or ppm.</p>
Reference	Clause 9.2.4, 9.2.5 [T2]

11.3.1.2 RF occupied bandwidth

Purpose	The measurement of the occupied bandwidth allows the verification of the correct sampling frequency at the modulator.
Interface	C
Method	<p>The occupied bandwidth is calculated from the measurements of the frequencies of the edge pilots and/ or continual pilots of the DVB-T2 signal.</p> <p>a) Spectrum analyser method: if the frequency of the edge carriers is known then the related values for the occupied bandwidth may be calculated. Denoting the edge pilot frequencies as F_{\min} and F_{\max} the occupied bandwidth is appropriately $OB = F_{\max} - F_{\min} + 1/T_U$.</p> <p>b) Test receiver method: the occupied bandwidth is derived from the digital samples after the test receiver has synchronised to the incoming DVB-T2 signal.</p>
Reference	Clause 9.2.5 [T2]

11.3.2 Selectivity

Purpose	To identify the capability of the receiver to reject out-of-channel interference.
Interface	The measurement of the signal input level and the interferer shall be carried out at the interface C, using interface C3 or C4 for the BER monitoring.

³ In any case, the usage of a high-precision reference frequency, e.g. 10 MHz, may be helpful.

Method The input power is adjusted to 10 dB above the minimum input power as defined in "Receiver sensitivity" (see subclause 11.3.9). The C/I threshold needed for QEF operation should be measured as a function of the frequency of a CW interferer.

The failure point is defined as ESR5.

ESR (Errored Second Ratio) is defined in 11.3.18. One errored second during a time interval of 20 seconds is given as ESR5 (5 % of the seconds are errored).

Alternatively, the QEF point is used that is defined as BER after LDPC = 10^{-7} . Since this measurement is time-consuming, the BER after LDPC = 10^{-4} is measured and the associated C/N value is increased by 0.2 dB. This corresponds to a BER after BCH = 10^{-11} .

Reference Clause 6.1.2 [T2]

11.3.3 AFC capture range

Purpose To determine the frequency range over which the receiver will acquire overall lock.

Interface C for the application of the test signal; C1 or C2 for the test of receiver synchronization

Method A signal is applied to the input of the receiver, at a level 10 dB above the minimum input power as defined in "Receiver sensitivity" (see subclause 11.3.9). The signal is frequency shifted in steps (from below and above) towards a nominal value, whilst forcing the receiver to re-acquire after each step.

Correct reception is assumed if after each step:

- a) the receiver can synchronise to the applied DVB-T2 signal, or if this is not indicated,
- b) the failure point is defined as ESR5.

ESR (Errored Second Ratio) is defined in 11.3.18. One errored second during a time interval of 20 seconds is given as ESR5 (5 % of the seconds are errored).

Alternatively, the QEF point is used that is defined as BER after LDPC = 10^{-7} . Since this measurement is time-consuming, the BER after LDPC = 10^{-4} is measured and the associated C/N value is increased by 0.2 dB. This corresponds to a BER after BCH = 10^{-11} .

Reference Clause 5.1.7 [T2]

11.3.4 Phase noise of Local Oscillators (LO)

Purpose Phase noise can be introduced at the transmitter, at any frequency converter or by the receiver.

In an OFDM system the phase noise can cause Common Phase Error (CPE) which affects all carriers simultaneously, and which can be minimised or corrected by using the continual pilots. However the noise-like Inter-Carrier Interference (ICI) cannot be corrected.

This measurement may be useful for manufacturing, incoming inspection and maintenance of modulators, transmitters, up/ down converters and receivers, either professional or consumer type.

Interface Any access to Local Oscillators (LO), in transmitters, converters and receivers.

Method Phase noise can be measured with a spectrum analyser, a vector analyser or a phase noise test set.

Reference n/a

11.3.5 RF/IF signal power

Purpose Signal power, or wanted power, measurement is required to set and check signal levels at the transmitter and receiver sites.

Interface C

Method The signal power of a DVB-T2 signal is defined as the mean power of the signal as would be measured with a thermal power sensor. In the case of received signals care should be taken to limit the measurement to the bandwidth at the wanted signal. When using a spectrum analyser or a calibrated receiver, it should integrate the signal power within the nominal bandwidth of the signal ($n \times f_{\text{SPACING}}$) where n is the number of carriers.

Note that some spectrum analyser may not automatically compensate for the applied Resolution Bandwidth so that a manual correction may be applicable.

Reference n/a

11.3.6 MISO Group Power Ratio

Purpose The MISO Group Power Ratio (MGPR) is required to check the presence of both MISO Groups within a network.

Interface C

Method The MGPR is defined as the RF signal power for MISO Group 1 divided by the RF signal power for MISO Group 2.

NOTE: The value should be given in dB. The MGPR may be negative if the signals of MISO Group 2 are received with higher input level than the signals of MISO Group 1. The MGPR takes the value of $\pm\infty$ in the presence of one MISO Group.

For the display of the power levels of the paths of both MISO groups, the use of different colours for the figures or the diagram components (e.g. power level over delay) is recommended.

Reference Clause 9.1 [T2]

11.3.7 Noise power

Purpose Noise is a significant impairment in a transmission network.

Interface C (RF or IF)

Method The noise power (mean power), or unwanted power, can be measured with a spectrum analyser (out of service). The noise power is specified using the occupied bandwidth of the OFDM signal ($n \times f_{\text{SPACING}}$) where n is the number of carriers.

NOTE: The Carrier-to-Noise ratio C/N should be calculated as the ratio of the signal power, measured as described in subclause 11.3.5, to the noise power, measured as described in this subclause.

Reference n/a

11.3.8 RF and IF spectrum

Purpose To avoid interfering with other channels, the transmitted RF spectrum should comply to a spectrum mask, which is defined for the terrestrial network. If the spectrum at the modulator output is defined by a spectrum mask, the same procedure can be applied to the IF signal (with no pre-correction active).

Interface C (RF or IF)

Method This measurement is usually carried out with a spectrum analyser. The spectral density of a terrestrial DVB signal is defined as the long-term average of the time-varying signal power per unity bandwidth (i.e. 1 Hz). Values for other bandwidths can be achieved by proportional increase of the values for unity bandwidth.

To avoid regular structures in the modulated signal a non-regular, e.g. a Pseudo-Random Binary Sequence (PRBS) is applied as an input signal to the modulator.

For the resolution bandwidth, the recommended values should not exceed 30 kHz. Preferred values are approx. 3 kHz. The measurement should be Noise-normalised to 3 kHz.

Reference Clause 10 [T2]

11.3.9 Receiver sensitivity/ dynamic range for a Gaussian channel

Purpose For network planning purposes, the minimum and maximum input powers for normal operation of a receiver have to be determined.

Interface Test signals are applied and measured at interface C; interfaces C3 or C4 are used for the monitoring of BER or PER.

Method The minimum and maximum input power thresholds for QEF reception shall be measured.

The failure point is defined as ESR5.

ESR (Errored Second Ratio) is defined in 11.3.18. One errored second during a time interval of 20 seconds is given as ESR5 (5 % of the seconds are errored).

Alternatively, the QEF point is used that is defined as BER after LDPC = 10^{-7} . Since this measurement is time-consuming, the BER after LDPC = 10^{-4} is measured and the associated C/N value is increased by 0.2 dB. This corresponds to a BER after BCH = 10^{-11} .

The dynamic range is the difference of the input power between the measured values in dB.

Reference Clause 6.1.2 [T2]

11.3.10 Linearity characterization (shoulder attenuation)

Purpose The shoulder attenuation can be used to characterize the linearity of an OFDM signal.

Interface C

Method The following procedure is applied to the measured RF spectrum of the transmitter output signal:

- a) Identify the maximum value of the spectrum by using a resolution bandwidth at

approximately 10 times the carrier spacing.

b) Place declined, straight lines connecting the measurement points at 300 kHz and 700 kHz from each of the upper and lower edges of the spectrum. Draw additional lines parallel to these, so that the highest spectrum value within the respective range lies on the line.

c) Subtract the power value of the centre of the line (500 kHz away from the upper and lower edge) from the maximum spectrum value of (a) and note the difference as the "shoulder attenuation" at the upper and lower edge.

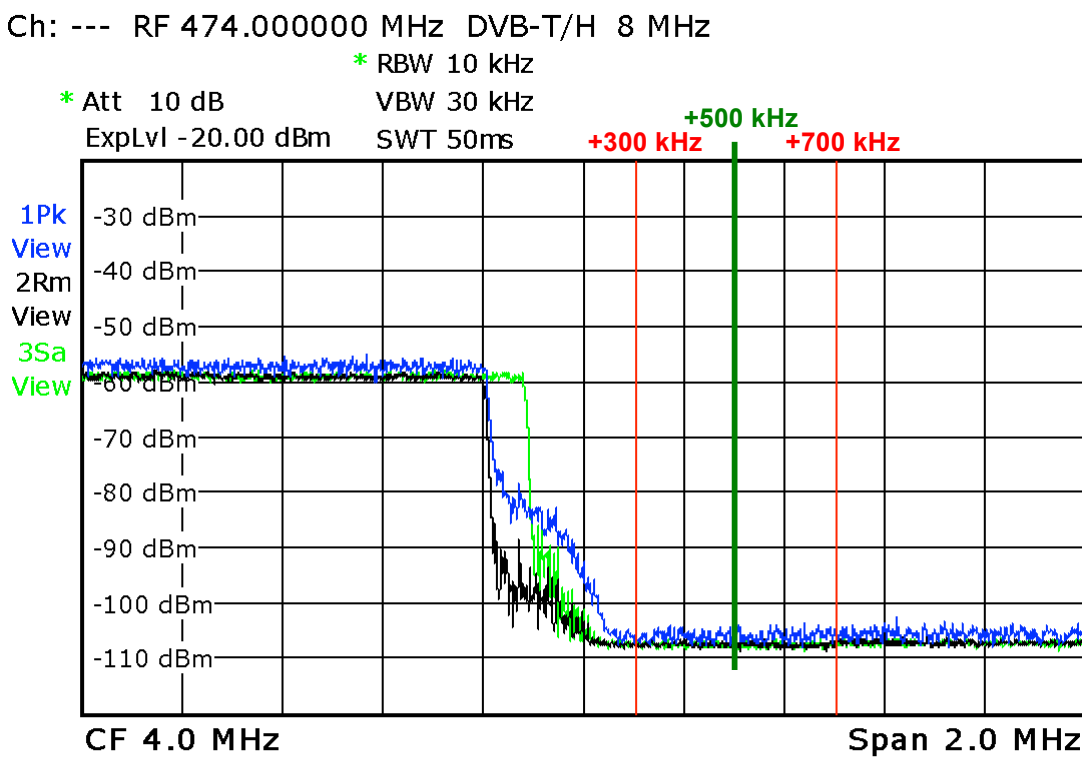
d) Take the worst case value of the upper and lower results from (c) as the overall "shoulder attenuation".

Note: for a quick overview the value at e.g. 500 kHz can be measured directly provided that coherent interferers are not present.

The method described here is used for DVB-T2 signals with a nominal channel width of 5, 6, 7, 8 or 10 MHz. The reference frequency points are the same for non-extended and extended modes (for reasons of protection of adjacent channels).

The recommended method is the same as for DVB-T for reason of comparability.

If a spectrum mask is used, it should be always the spectrum mask of the non-extended mode, even if the signal uses extended bandwidth. For DVB-T2 signals with a nominal channel width of 1.7 MHz an appropriate spectrum masks has to be defined. If such a spectrum mask is not specified, the measurement points should be set 150 kHz below or above the respective edge carrier.



(blue: 2k, black: 32k, green: 32k ext.)

11.3.11 Power efficiency

Purpose	To compare the overall efficiency of DVB transmitters.
Interface	C
Method	Power efficiency is defined as the ratio of the DVB output power to the total power consumption of the chain from TS input to the RF signal output including all necessary equipment for operation such as blowers, transformers etc. (and is usually quoted in % terms). The operational channel and the environmental conditions need to be specified.
Reference	n/a

11.3.12 PAPR effect

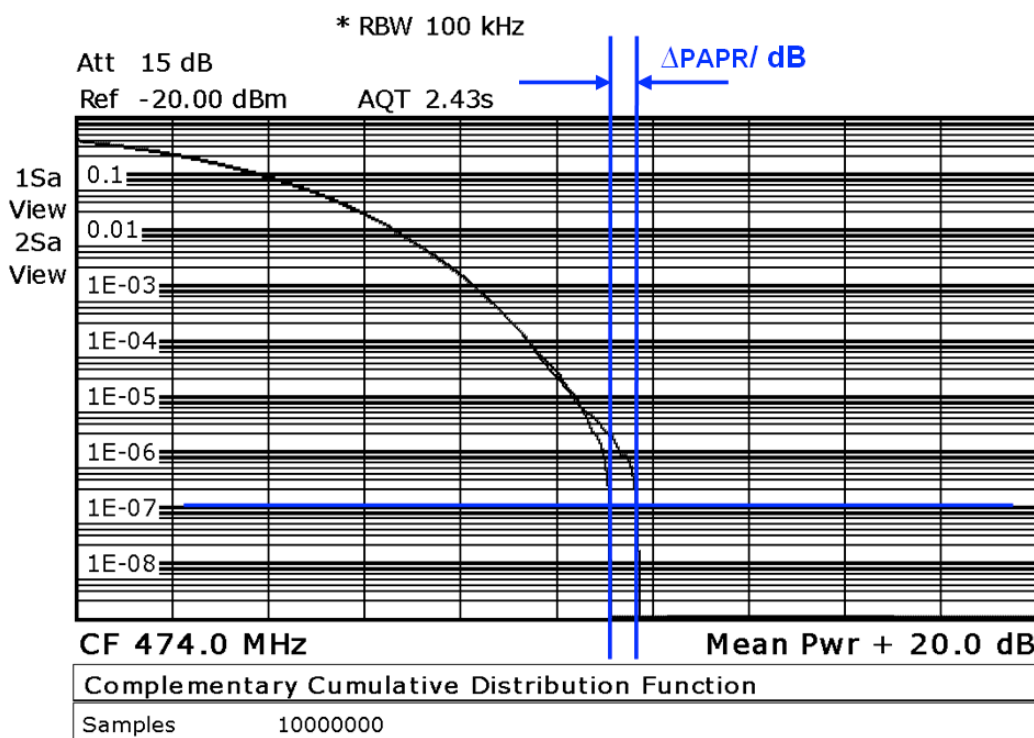
Purpose	To measure the PAPR effect in the OFDM signal by applying one of the PAPR methods (ACE Active Constellation Extension or TR Tone Reservation). The method is to measure the performance difference without the PAPR technique and with the PAPR. The parameters of interest are the power increase, CCDF, MER performance increase.
Interface	C (modulator output, transmitter output)
Method	CCDF effect (modulator output)

Note that the CCDF impact shall be measured before the amplification in order to measure the effect of amplifier saturation.

Comparison of CCDF charts (cumulative complementary distribution function) and indicating the difference in dB in the CCDF chart for a specified probability (e.g. 10^{-7}).

Special attention should be given to the requirement that the instrument settings shall not be changed between the two measurements (with and without PAPR) and no overload or clipping is effecting the OFDM signal.

The number of samples for such a comparison should be $\geq 10^7$.



Reference Clause 9.6 [T2]

At transmitter output :

Power increase: Signal Mean power is first measured before and after the PAPR is applied. For the tone reserved carriers, it means that it is measured with empty tone reserved carriers (before PAPR is applied) and after PAPR is applied. The power increase must be kept as low as possible.

MER improvement: MER is first measured before and after the PAPR is applied. For the tone reserved carriers, it means that it is measured with empty tone reserved carriers (before PAPR is applied) and after PAPR is applied. For ACE case, MER measurement method must follow the procedure described in Annex xxx.

11.3.13 P1 Symbol Error Rate

Purpose This measurement gives an indication of the P1 Symbol Error rate.

Interface C5

Method The data transmitted within the S1 and S2 field are decoded and compared to the correct data. A P1 symbol is erroneous, if at least one bit error within the S1 or the S2 field occurred. The measurement of this variable allows an estimation of the T2 signal level if the actual payload data is not decodable.

The correct values of the S1 and S2 field can e.g. be obtained by the S1/S2 field transmitted within the L1-Pre data.

Reference Clause 6.1.2 [T2]

11.3.14 BER before LDPC (inner) decoder

Purpose This measurement gives an in-service indication of the un-coded performance of the transmitter.

Since the residual BER contributions from transmitter and (test) receiver contribute to the result of this measurement, the contribution of the (test) receiver should be negligible when validating a transmitter.

Interface C3

Method The BER before LDPC is measured separately for each PLP. It allows the identification of sporadic bit errors in a transmitter output signal.

The averaging period for the calculation of the BER before LDPC should be set so that sporadic bit errors are not averaged out.

Reference Clause 6.1.2 [T2]

11.3.15 Number of LDPC iterations

Purpose This measurement gives an in-service indication of the quality of the received signal and the computational resources activated for the LDPC decoder.

Since the result of this measurement is largely dependent on the actual LDPC decoder implementation, results can only be compared when taken from the same test instrument.

Interface C3

Method The number of LDPC iterations is measured separately for each PLP.

The end of the iterations is reached when the number of remaining errors is lower or equal than the error correction capability of the following BCH decoder, or when the maximum number of LDPC iterations is reached.⁴

An error-free signal requires a minimum of one iteration of the LDPC decoder.

The average of the Number of LDPC iterations should be calculated over 1 second, and the maximum value during 1 second should also be displayed together with the average value.

In case the data rate is very low and frames of the respective PLP are received at longer intervals, periods for averaging and display of maxima should be set accordingly.

Reference Clause 6.1.2 [T2]

11.3.16 BER before BCH (outer) decoder

Purpose The BER is the primary parameter which describes the quality of the digital transmission link. It provides a quick indication of potential problems, especially in cases where sporadic errors would lead only to small increases of BER after BCH.

Interface C4

⁴ It is recommended to provide an indication if the LDPC decoder does not converge.

Method The BER before BCH is measured separately for each PLP. The calculation can be based on the re-encoded signal that is available after the BCH decoder.

The BER is defined as the ratio between erroneous bits and the total number of transmitted bits. The time interval for this calculation should be definable.

Reference Clause 6.1.1 [T2]

11.3.17 Baseband Frame Error Rate BBFER

Purpose To gain information about the number of baseband frames which are effected by bit errors.

Interface C5

Method The BBFER is measured separately for each PLP.

A Baseband Frame is erroneous, if an uncorrectable error has been discovered and indicated by the error flag by the BCH decoder. The parameter is either given as a ratio or as the number of erroneous BB frames per second.

Reference Clause 5.1.7 [T2]

11.3.18 Errored Second Ratio ESR

Purpose To obtain statistical information about the link quality.

Interface C5

Method Time intervals of the length of 1 second are defined according to the system clock reference. Those seconds during which a Baseband Frame Error occurred are marked as 'errored'. The ratio of Errored Seconds to the total time elapsed or to a period set by the test receiver is indicated as ESR. In practice, a time interval of 20 seconds is used.

Reference Clause 5.1.7 [T2]

11.3.19 IQ signal analysis

11.3.19.1 Introduction

The IQ analysis can be applied on single carriers of the OFDM signal as well as on groups of carriers. If a group of carriers is evaluated all received symbols of this group can be superimposed in order to obtain the respective measurement parameters or the constellation diagram.

The definitions for the I/Q related parameters are based on the following assumptions:

- a constellation diagram of M symbol points and K carriers under consideration with $0 < K \leq K_{MAX} + 1$ and $K_{MAX} + 1$ is the total number of active OFDM carriers;
- a measurement sample of N data points, where N is sufficiently larger than $M \times K$ to deliver the wanted measurement accuracy; and
- the co-ordinates of each received data point j being $I_j + \delta I_j$, $Q_j + \delta Q_j$ where I and Q are the co-ordinates of the ideal symbol point and δI and δQ are the offsets forming the error vector of the data point (as long as the respective carrier is a "useful" one).

11.3.19.2 Modulation Error Ratio (MER)

Purpose To provide a "figure of merit" analysis for L1 Signalling data and each PLP of the DVB-T2 signal, typically at a transmitter output (for assessing the quality of the transmitted signal) or

in a fixed location in a SFN (for identifying severe distortions in the set-up of the transmitters forming the SFN).

Interface C2 (i.e. after equalisation)

Method The carrier frequency of the OFDM signal and the symbol timing are recovered. Origin offset of the centre carrier (e.g. caused by residual carrier or DC offset), Quadrature Error (QE) and Amplitude Imbalance are not corrected.

A time record of N received symbol co-ordinate pairs $(\tilde{I}_j, \tilde{Q}_j)$ is captured.

For each received symbol, a decision is made as to which symbol was transmitted. The error vector is defined as the distance from the ideal position of the chosen symbol (the centre of the decision box) to the actual position of the received symbol.

This distance can be expressed as a vector $(\delta I_j, \delta Q_j)$.

The sum of the squares of the magnitudes of the ideal symbol vectors is divided by the sum of the squares of the magnitudes of the symbol error vectors. The result, expressed as a power ratio in dB, is defined as the MER.

$$MER = 10 \times \log_{10} \left\{ \frac{\sum_{j=1}^N (I_j^2 + Q_j^2)}{\sum_{j=1}^N (\delta I_j^2 + \delta Q_j^2)} \right\} dB$$

It should be reconsider that MER is just one way of computing a "figure of merit" for a vector modulated signal. Another "figure of merit" calculation is Error Vector Magnitude (EVM). MER and EVM are closely related and one can generally be computed from the other.

Error Vector Magnitude (EVM) is defined as:

$$EVM_{RMS} = \sqrt{\frac{\frac{1}{N} \sum_{j=1}^N (\delta I_j^2 + \delta Q_j^2)}{S_{max}^2}} \times 100\%$$

Where I and Q are the ideal co-ordinates, δI and δQ are the errors in the received data points. N is the number of data points in the measurement sample. S_{max} is the magnitude of the vector to the outermost state of the constellation.

For both parameters, MER and EVM, the display of the values as a function of frequency or carrier number can be very helpful.

11.3.19.3 Signal to Interference Noise Ratio (SINR)

Purpose To provide a "figure of merit" analysis for L1 Signalling data and each PLP of the DVB-T2 signal with special focus on field measurements where the MER is not applicable.

Interface C1 (i.e. before equalisation)

Method The carrier frequency of the OFDM signal and the symbol timing are recovered. Origin offset of the centre carrier (e.g. caused by residual carrier or DC offset), Quadrature Error (QE) and Amplitude Imbalance are not corrected.

A time record of N received complex QAM cells \tilde{d}_j is captured at the input of the cell de-interleaver without equalization. For each received QAM cell, a decision is made which

QAM symbol \hat{d}_j was transmitted. This value is then multiplied by the estimated channel transfer function \hat{H}_j , which defines the ideal position of the received QAM cell. The absolute squared value $|\hat{H}_j \cdot \hat{d}_j|^2$ defines its signal power. In the absence of any disturbance, the value $\hat{H}_j \cdot \hat{d}_j$ should ideally match \tilde{d}_j . The absolute squared value of the delta equals the interference plus noise power. The result, expressed as a power ratio in dB:

$$SINR = 10 \times \log_{10} \left\{ \frac{\sum_{j=1}^N |\hat{H}_j \cdot \hat{d}_j|^2}{\sum_{j=1}^N |\hat{H}_j \cdot \hat{d}_j - \tilde{d}_j|^2} \right\} dB$$

It should be mentioned that the SINR is very similar to the MER, except that no equalization to the input data is performed. This avoid the effect of noise amplification in frequency selective channels.

The display of the SINR values as a function of frequency or carrier number can be very helpful.

11.3.19.4 Carrier Suppression (CS)

Purpose A residual carrier is an unwanted coherent signal added to the centre carrier of the OFDM signal. It may have been produced by DC offset voltages of the modulating I and/ or Q signal or by crosstalk from the modulating carrier within the modulator.

Interface C2

Method Search for systematic deviations of all constellation points of the centre carrier and isolate the residual carrier. Calculate the Carrier Suppression (CS) from the formula:

$$CS = 10 \times \log_{10} \left(\frac{P_{sig}}{P_{RC}} \right)$$

where P_{RC} is the power of the residual carrier and P_{sig} is the power of the centre carrier of the OFDM signal (without residual carrier).

11.3.19.5 Carrier Phase (CPh)

Purpose The measurement of the phase of the residual carrier which is an unwanted coherent signal added to the centre carrier of the OFDM signal, allows for an automatic and efficient calibration of a modulator which optimises the Carrier Suppression (CS).

Interface C2

Method This parameter describes the phase of a not perfectly suppressed carrier (see Carrier Suppression). When the Carrier Suppression is infinite, a carrier phase cannot be measured.

The reference for the Carrier Phase is the I axis. A residual carrier that is directed towards positive I values has the carrier phase of 0°. A residual carrier that is directed towards positive Q values has the carrier phase of 90°.

11.3.19.6 Amplitude Imbalance (AI)

Purpose To separate the QAM distortions resulting from Amplitude Imbalance (AI) of the I and Q signal from all other kind of distortions.

Interface C2

Method Calculate the I and Q gain values v_I and v_Q from all points in a constellation diagram eliminating all other influences.

Calculate Amplitude Imbalance (AI) from v_I and v_Q

$$AI = \begin{cases} \left(\frac{v_I}{v_Q} - 1 \right) \times 100\% & \text{if } v_I \geq v_Q \\ \left(1 - \frac{v_Q}{v_I} \right) \times 100\% & \text{if } v_Q > v_I \end{cases}$$

$$v_I = \frac{1}{M} \sum_{i=1}^M \frac{I_i + (\bar{d}_i)_I}{I_i}$$

$$(\bar{d}_i)_I = \frac{1}{N} \sum_{j=1}^N \delta I_j \quad (\text{I-component of } d_i \text{ as given in subclause 9.18.3 System Target Error})$$

$$v_Q = \frac{1}{M} \sum_{i=1}^M \frac{Q_i + (\bar{d}_i)_Q}{Q_i}$$

$$(\bar{d}_i)_Q = \frac{1}{N} \sum_{j=1}^N \delta Q_j \quad (\text{Q-component of } d_i \text{ as given in subclause 9.18.3 System Target Error})$$

$$(\bar{d}_i)_I + (\bar{d}_i)_Q = \bar{d}_i$$

11.3.19.7 Quadrature Error (QE)

Purpose The phases of the two carriers feeding the I and Q modulators have to be orthogonal. If their phase difference is not 90° a typical distortion of the constellation diagram results.

Interface C2

Method Search for the constellation diagram error shown in Figure 11-4 and calculate the value of the phase difference $\Delta\varphi = \varphi_1 - \varphi_2$ after having eliminated all other influences and convert this into degrees:

$$QE = \frac{180^\circ}{\pi} \times (\varphi_1 - \varphi_2) \text{ [}^\circ\text{]}$$

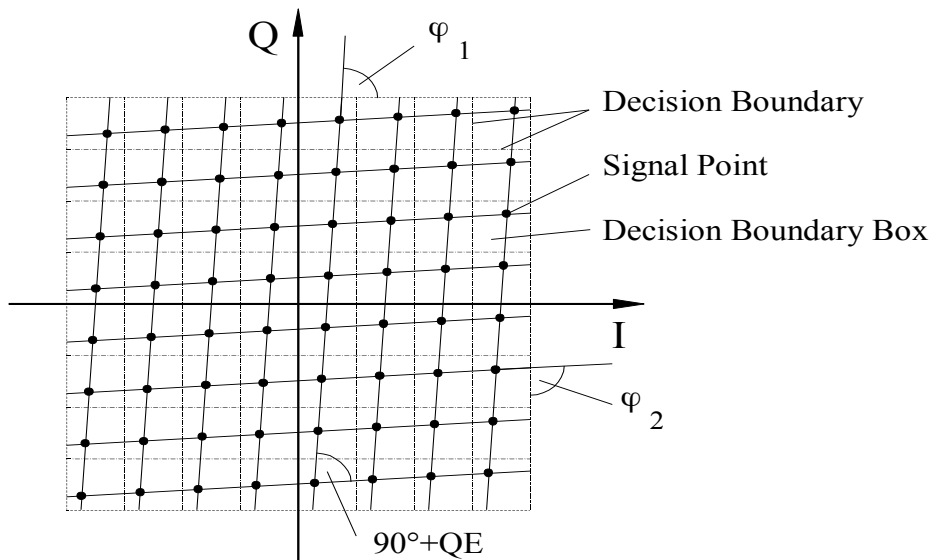


Figure 11-4: Distortion of constellation diagram resulting from I/Q Quadrature Error (QE)

11.3.20 SFN synchronisation

Purpose To measure and adjust the signal delay of an OFDM transmitter to a given value so that the transmitters in an SFN can be synchronized.

Interface C1

Method Based on a sufficient number of I/Q samples, the channel response of the received DVB-T2 signal is calculated.

The measurement of the SFN synchronisation depends on the location where this measurement is executed.

The SFN synchronisation is related to two independent parameters:

a) Time synchronisation: All signals received from the certain transmitters at the location of interest shall be received within the Guard Interval. It is the task of the network planning that also echoes from these signals will not infringe this rule.

Method: The complex channel impulse response is measured. In addition, the Guard Interval is indicated. Also pre-echoes are taken into account correctly, according to the positioning of the FFT window. The indication of the Guard Interval shall always start with the start of the FFT window position.

b) Frequency synchronisation: The center frequency of all signals received from the certain transmitters shall be within a certain limit. In practice, 1 Hz has been established as a good and practicable target value for this limit in case of an 8 MHz channel and an 8k FFT size. For other channel bandwidth and other FFT sizes, e.g. 16k and 32k signals, a proportionally higher accuracy may be required.

The SFN frequency offset can be calculated as a relative value. It shall be referenced to the signal path that provides the maximum power.

Method: The complex channel impulse response is measured from which the frequency offset of each echo is derived and indicated. Also pre-echoes have to be taken into account

correctly. A positive SFN frequency offset value means that the local center frequency of the related echo is higher than the local center frequency of the reference signal.

11.3.21 L1 signalling error

Purpose	The consistency of the L1 data is essential for the successful decoding of the DVB-T2 signal by the receiver.
Interface	C3
Method	The receiver checks the CRC within the corresponding L1-pre and L1-post data.

11.3.22 RMS Delay-Spread (RMS-DS)

Purpose	The performance of OFDM based systems depends on the characteristics of the transmission channel. The extent of the multipath propagation of the transmission channel is characterized by means of the root means square (RMS) of the channel delay spread.
Interface	C1
Method	The RMS Delay-Spread is directly measured from the channel impulse response. It is calculated from all i multipath components with power P_i and excess delay τ_i that exceed a specified power threshold (e.g. -15 dB, -20 dB, -25 dB) with respect to the strongest component. The excess delay (or delta) τ_i is defined as the delta of the multipath component i with respect to the strongest signal component.

The calculation should be limited to the Guard Interval to avoid ambiguities.

$$\tau_{RMS} = \sqrt{\frac{1}{\sum_{i=1}^n P_i} \cdot \sum_{i=1}^n (\tau_i^2 P_i) - \tau_d^2} \text{ with } \tau_d = \frac{\sum_{i=1}^n (\tau_i P_i)}{\sum_{i=1}^n P_i}$$

11.3.23 Maximum Excess Delay (MED)

Purpose	The performance of OFDM based systems depends on the characteristics of the transmission channel. The largest multipath delay of the transmission channel is characterized by means of the Maximum Excess Delay (MED).
Interface	C1
Method	The Maximum Excess Delay is directly measured from the channel impulse response. It is defined as the maximum delay τ_{max} of all multipath components that exceed a specified power threshold of e.g. -15 dB, -20 dB, -25 dB with respect to the strongest component. The maximum excess delay τ_{max} is defined with regard to the first arrived component above the specified power threshold.

11.3.24 Receiver Buffer Model (RBM) validation test

Purpose This test applies a test stream for an out-of-service test to the receiver to validate the proper functioning of the receiver buffer.

Interface C

Method A DVB-T2 signal is applied to the input of a DVB-T2 receiver. This DVB-T2 signal contains a test stream (e.g. V&V number 7xx). The test stream is generated (typically in the T2 gateway) and includes a modified Common PLP.

The modified Common PLP for this test does not contain the tables and service information as usual, but an externally applied video/ audio test stream.

The failure point is defined as ESR5.

ESR (Errored Second Ratio) is defined in 11.3.18. One errored second during a time interval of 20 seconds is given as ESR5 (5 % of the seconds are errored).

11.3.25 Relative power level during the non-P1 part of the FEF (RLF_non_P1)

Purpose The purpose of the test is to measure the average power level of the non-P1 signal (excluding the rise time/fall time between the P1 and adjacent waveforms) of the FEF relative to the power of the T2 signal, excluding the FEF.

This procedure allows for in-service⁵ measurements of co-channel interference (CCI) when empty FEFs are applied.

Interface C

Method The DVB-T2 system makes it possible to broadcast a FEF part carrying a non-T2 waveform at potentially another power level, including an empty FEF. Empty FEF means null power during non-P1 part of the FEF.

A DVB-T2 signal is generated including a FEF part, which contains some other waveform than DVB-T2, e.g. T2 TX-SIG or an empty FEF. During the FEF period the power level of the non-P1 part of the FEF is measured. In addition the power level of the DVB-T2 signal (excluding the FEF part) is measured.

A fast enough power sensor gated properly, or a spectrum analyser capable for channel power measurements, or a DVB-T2 receiver can be used for this measurement.

⁵ Note that DVB-T2 receivers of the 1st generation should ignore FEFs.

A. Informative Annex :The measurement of MER under ACE

When ACE method means Active Constellation Extension, it uses outer point constellation points of the useful carriers to reduce the Peak to Average value of the DVB-T2 signals. It is an option of the DVB-T2 standard and it is used for example in the L1 signalling parameters since the second revision of the standard.

When ACE is applied on a COFDM signal, the professional receiver is not capable of referring to the theoretical reference point in order to measure the modulation error distance as in the formula.

The problem is to find a solution that allows MER measurement on carriers when Active Constellation Extension is used on a DVB-T2 signal.

- 1- Enable Active constellation point
- 2- Disable ACE on some carriers based on a circular mask pattern. The number of useful carriers is less than 1% in order not to impact the Peak to Average Ratio of the final signal
- 3- This method is a test mode located in the modulation part implementing ACE algorithm. The receiver can recover the MER based on the mask pattern definition.

The ACE method is defined in section 9.6.1 of [4].

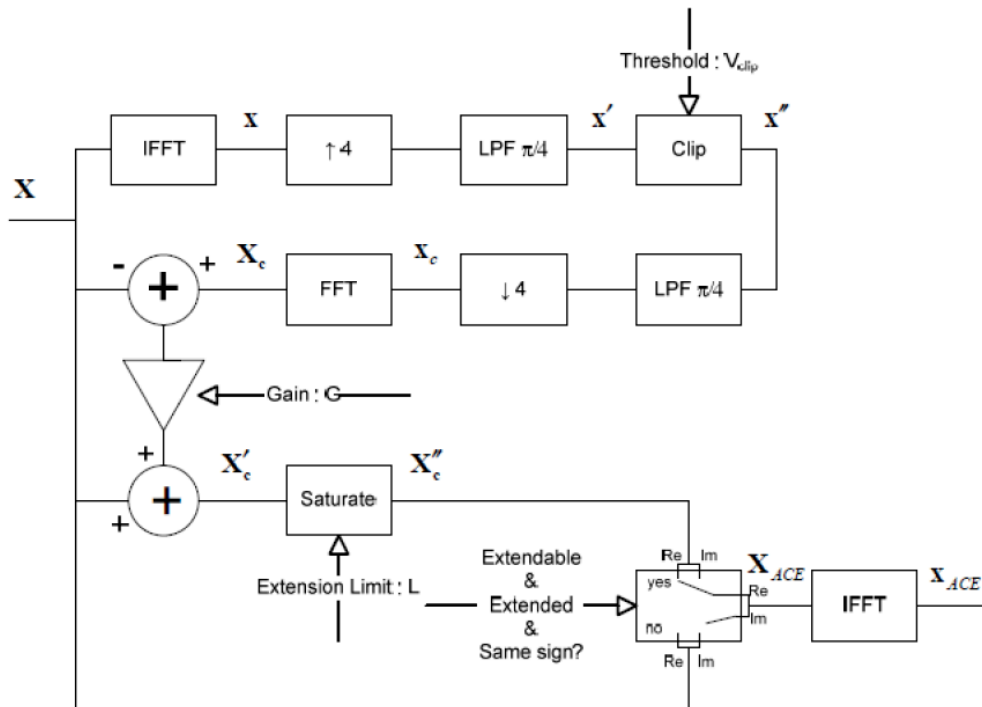


Figure 49: Implementation of the Active Constellation Extension algorithm

extracted from [4]

In the block diagram above, “extendable” signification is modified from the DVB-T2 spec [4], clause 9.6.1, in order to add a circular mask pattern exclusion.

Standard definition of "extendable":

A component is defined as extendable if it is an active cell (i.e. an OFDM cell carrying a constellation point for L1 signalling or a PLP), and if its absolute amplitude is greater than or equal to the maximal component value associated to the modulation constellation used for that cell; a component is also defined as extendable if it is a dummy cell, a bias balancing cell or an unmodulated cell in the Frame Closing Symbol.

For the test mode, the text is adjusted :

A component is defined as extendable if it is an active cell (i.e. an OFDM cell carrying a constellation point for L1 signalling or a PLP), and if its absolute amplitude is greater than or equal to the maximal component value associated to the modulation constellation used for that cell; a component is also defined as extendable if it is a dummy cell, a bias balancing cell or an unmodulated cell in the Frame Closing Symbol. **In test mode, active cells corresponding to the mask pattern index position list are not extended.**

The circular mask pattern is changed for each new T2 frame symbol in order to measure MER for all the carriers.

The mask pattern $M[]$ for ACE is defined as follows.

```
Idx=Frame Idx mod 100;
```

```
i=0;
```

```
While (idx<Cuseful)
```

```
{
```

```
Idx=mod(Idx+div(Cuseful /100), Cuseful)
```

```
M[i]=Idx;
```

```
i++;
```

```
}
```

For a given frame index, where Idx provides the carrier position and $M[]$ is the mask pattern containing index position is ascendant form defined for a Frame number $FrameIdx$.

Where $Cuseful$

$Cuseful = Cdata$ for data symbols

$Cuseful = CP2$ for P2 symbols

$Cuseful = CFC$ for Frame closing symbols

B. References

- [1] ETSI TS_102773 v131: Digital Video Broadcasting (DVB); Modulator Interface (T2-MI) for a second generation digital terrestrial television broadcasting system (DVB-T2), January 2012.
- [2] ETSI TS 102 034: Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks, August 2009.
- [3] SMPTE 2022-1: Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks, May 2007.
- [4] A122_DVB-T2_dEN_302755v010301.pdf: Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2); DVB Document A122; July 2011.
- [5] ETSI TR 101 290 V1.2.1: Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems, 2001-05.