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Methods of measurement for digital network — Performance characteristics of terrestrial digital multimedia transmission network

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The UK participation in its preparation was entrusted to Technical Committee EPL/103, Transmitting equipment for radio communication.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Méthodes de mesure applicables aux réseaux numériques - Caractéristiques de performance des réseaux de transmission numériques multimédia terrestres
(CEI 62553:2012)

Messverfahren für digitale Netze - Leistungskenndaten von terrestrischen digitalen Multimedia-Sendernetzen
(IEC 62553:2012)

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Foreword

The text of document 103/89/CDV, future edition 1 of IEC 62553, prepared by IEC/TC 103 "Transmitting equipment for radiocommunication" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62553:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2013-10-01
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-01-01

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Endorsement notice

The text of the International Standard IEC 62553:2012 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 62273-1	2007	Methods of measurement for radio transmitters - Part 1: Performance characteristics of terrestrial digital television transmitters	EN 62273-1	2007
ISO/IEC 13818-1 + A1 + A2 + A3 + A4 + A5 + A6	2007 2007 2008 2009 2009 2011 2011	Information technology - Generic coding of moving pictures and associated audio information: Systems	-	-
ETSI TR 101 190	-	Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects	-	-
ETSI TS 101 191	-	Digital Video Broadcasting (DVB); DVB mega-frame for Single Frequency Network (SFN) synchronization	-	-
ETSI TR 102 377	-	Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines	-	-
ARIB STD-B31	-	Transmission system for digital terrestrial television broadcasting	-	-

CONTENTS

METHODS OF MEASUREMENT FOR DIGITAL NETWORK –

Performance characteristics of terrestrial digital multimedia transmission network

1 Scope

When a transmission network for digital terrestrial television broadcasting (DTTB) is being deployed, new networking technologies such as the Single Frequency Network (SFN) can be employed excelling the conventional analogue TV systems. However, new technical evaluation parameters are introduced for installing SFN systems. In addition new quality evaluation methods are also established in order to achieve stable and high-quality broadcasting services avoiding the cliff effect, which is one of the typical phenomena in the digital transmission that the signal quality is abruptly degraded when the received C/N becomes just lower than a specific value representing the system limit.

Given the background described above, this International Standard has the purposes of

- establishing measuring methods that enable the objective evaluation of the performance of transmission networks so as to make stable DTTB services a reality,
- establishing a technical baseline, such as a definition of technical terms, to standardize measuring methods.

The measurement methods described in this standard are intended for digital terrestrial television transmission network test and validation. The measurement methods for digital terrestrial transmitter are not included in this standard. These methods are described in IEC 62273-1.

This standard does not give any regulations and/or mandatory requirements. The specifications and requirements defined for each system have priority over this standard. However, there may be some cases where details are not specified in each individual specification or different systems should be evaluated under a common measurement method. The purpose of this standard is to provide a common technical baseline that makes measurement results comparable in all cases.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62273-1:2007, *Methods of measurement for radio transmitters – Performance characteristics of terrestrial digital televisiont transmitters*

ISO/IEC 13818-1:2007, *Information technology – Generic coding of moving pictures and associated audio information: Systems*

Amendments 1 to 6

TR 101 190, *Digital video broadcasting (DVB); implementation guidelines for DVB Terrestrial services;Transmission aspects*

TS 101 191*, Digital video broadcasting (DVB); DVB mega-frame for Single Frequency Network (SFN) synchronization*

TR 102 377*, Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines*

ARIB STD-B31, *Transmission system for digital terrestrial television broadcasting*

3 Terms and abbreviations

ADC	Analog to Digital Converter
ARIB	Association of Radio Industries and Businesses
ASI	Asynchronous Serial Interface
ATM	Asynchronous Transfer Mode
BER	Bit Error Ratio
C/N	Carrier to Noise rate
CPU	Central Processing Unit
DTTB	Digital Terrestrial Television Broadcasting
DVB	Digital Video Broadcasting
DVB-H	DVB Handheld
DVB-T	DVB Terrestrial
D/U	Desired to Undesired Signal Ratio
END	Equivalent Noise Degradation
ETSI	European Telecommunication Standards Institute
FFT	Fast Fourier Transform
GPS	Global Positioning System
IF	Intermediate Frequency
IFFT	Inverse Fast Fourier Transform
IIP	ISDB-T Information Packet
IP	Internet Protocol
ISDB-T	Integrated Services Digital Broadcasting – Terrestrial
ISI	Inter Symbol Interference
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JEITA	Japan Electronics and Information Technology Industries Association
MER	Modulation Error Ratio
MFN	Multi-Frequency Network
MIP	Mega-frame Initialization Packet
MMSE	Minimum Mean Square Error
MPEG	Moving Picture Experts Group
OFDM	Orthogonal Frequency Division Multiplex
PCR	Program Clock Reference
PCR_AC	PCR Accuracy
PCR_FO	PCR Offset
PCR_OJ	PCR Overall Jitter
PDH	Plesiochronous Digital Hierarchy

PRBS	Pseudo Random Binary Sequence
PID	Packet Identifier
PLL	Phased Locked Loop
PN	Pseudo Random Noise
QAM	Quadrature Amplitude Modulation
RBW	Resolution Bandwidth
RF	Radio Frequency
RS	Reed-Solomon
SDH	Synchronous Digital Hierarchy
SFN	Single Frequency Network
SP	Scattered Pilot signal
SPI	Synchronous Parallel Interface
STL	Studio to Transmitter Link
STS	Synchronization Time Stamp
TMCC	Transmission and Multiplex Configuration Control signal
TS	Transport Stream
TTL	Transmitter to Transmitter Link
TV	TeleVision
UHF	Ultra-High Frequency (300 MHz to 3 000 MHz)
UI	Unit Interval
VBW	Video Bandwidth
VHF	Very High Frequency (30 MHz to 300 MHz)
VLAN	Virtual Local Area Network

4 General conditions of measurement

4.1 Definitions and classifications of digital terrestrial TV transmission network

4.1.1 General

The digital terrestrial broadcasting transmission networks defined in this standard consist of two or more Digital Tv transmitters, relay lines (SDH or PDH contribution link: e.g. satellite, ATM radio, ATM optical fibre, IP Ethernet VLAN), broadcast-wave relay stations (called Gap-Filler or Transposer) through which the same broadcasting program is transmitted. Figure 1 shows an example of the transmission network.

The network is classified in 4.1.2 and 4.1.3 according to the following conditions

a) Assigned frequencies of each transmitter station which compose the network.

b) Signal transmission method between transmitter stations.

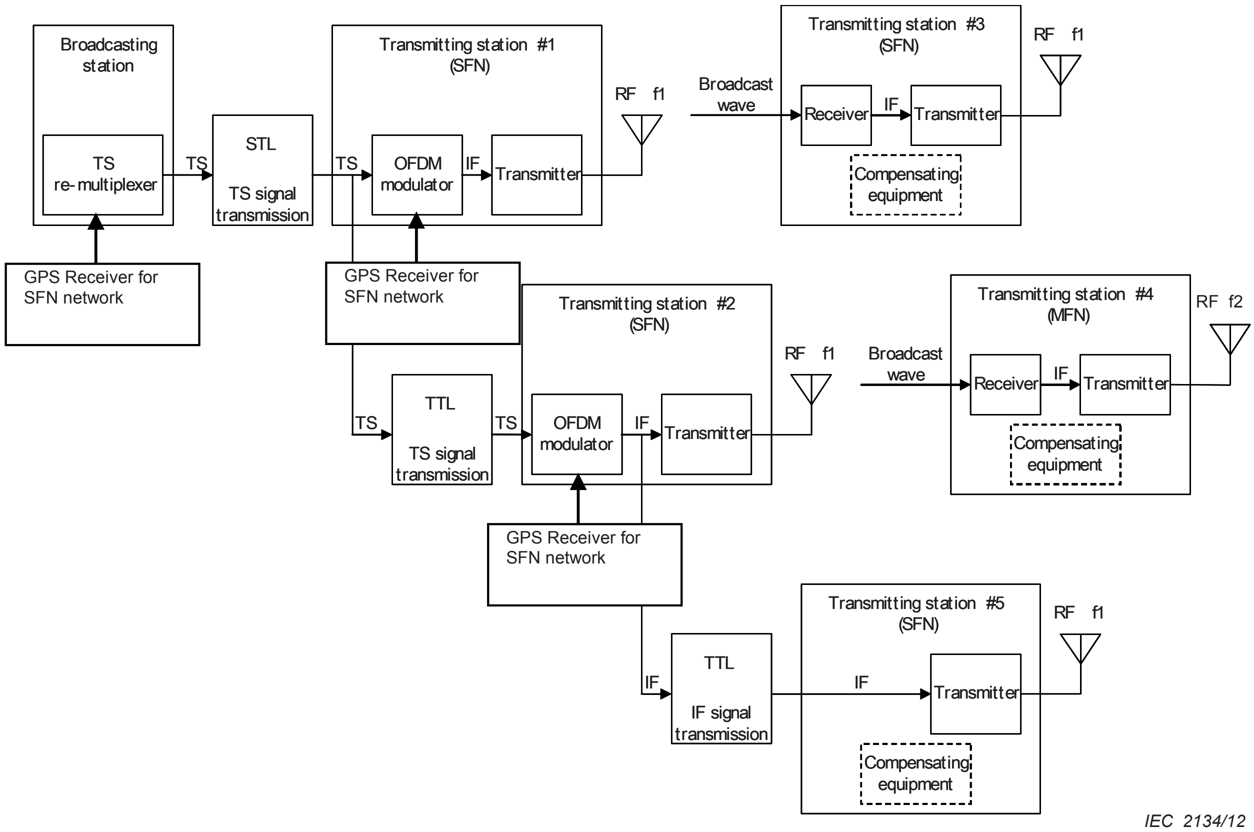


Figure 1 – Example of transmission network

4.1.2 Network classification for transmitting frequencies

SFN: Transmission network which is composed by plural transmitter stations whose assigned frequencies are the same. In Figure 1, transmitter stations, which are marked #1,#2,#3, and #5 and use the same transmitting frequency f1, compose the SFN.

MFN: transmission network which is composed by plural transmitter stations whose assigned frequencies are different. In Figure 1, #2 transmitter stations whose assigned frequency is f1 and #4 transmitter station whose assigned frequency is f2 compose the MFN.

In case of SFN, transmission parameters of each transmitter station should satisfy the following conditions:

a) The difference of transmitted frequency of each station should be within a specified range.
b) If necessary, the difference of sampling frequency of transmitted OFDM signals of each station should be within a specified range.
c) Waveform of transmitted signals means the channel modulation of each station should be the same. It means that the data contents of modulation of each station should be the same.
d) The difference of transmission timing of each transmitter station should be within a specified range.
e) The synchronized operation of each station shall be necessary. For synchronized operation, GPS time reference is used as a network reference signal or network should be locked to GPS time reference.

4.1.3 Network classification on useable contribution links for signal transport system between stations

Different contribution links for signal transport system between stations are investigated and mentioned in Table 1.

Table 1 – Classification of contribution link

Contribution link	Transmission system	Signal
STL(Studio to Transmitter Link)	Transport Stream transmission system	Digitalized Broadcast program and control information(note)
	IF transmission system	Modulated OFDM signal(note)
TTL(Transmitter to Transmitter Link)	Transport Stream transmission system	Digitalized Broadcast program and control information(note)
	IF transmission system	Modulated OFDM signal(note)
Broadcast wave relay	Broadcast wave relay system	Modulated OFDM signal(note)
NOTE Refer to 4.2.2 for signal form.		

4.2 Signal form

4.2.1 TS signal form

Signal form in which digitalized broadcast program contents and control information are multiplexed. For details of signal format, the following documents should be referred.

- DVB-T/H system: ETSI TR 101 190, ETSI TR 102 377
- ISDB-T system: ARIB STD-B31 Operational Guideline chapter 5.5

4.2.2 IF signal form

OFDM signal which is modulated by digitalized broadcast signal. For details of signal format, the following documents should be referred.

- DVB-T system: ETSI TR 101 190, ETSI TR 102 377
- ISDB-T system; ARIB STD-B31 Main body

4.3 Test signals and auxiliary signals for measurement

4.3.1 Test signals

As test signals for measurement, the following signals can be used. The broadcasting Transport Stream signal used for on-air services, or the equivalent broadcasting Transport Stream signal in it, or the OFDM signal used for on-air.

The specifications of the test signals should be specified for each system, but unless specified, for OFDM signal, the following transmission parameter set should apply, see Tables 2 and 3:

Table 2 – Parameter set of OFDM signal for test in ISDB-T system

Parameter	Value
Channel bandwidth	6 MHz
Number of carriers	8k
Guard interval ratio	1/8
Time interleave (see note)	I=2
Carrier modulation	64QAM
Coding rate of inner code	3/4 or 7/8
NOTE Apply for ISDB-T system.	

Table 3 – Parameter set of OFDM signal for test in DVB-T/H system

Parameter	Value
Channel bandwidth	6 MHz / 7 MHz / 8 MHz
Number of carriers	8k
Guard interval ratio	1/8
Time interleave(see note)	Native
Carrier modulation	64QAM
Coding rate of inner code	2/3
NOTE Apply for DVB-T/H system.	

4.3.2 Auxiliary signals for measurement

4.3.2.1 General

For measurement of signal delay, the auxiliary signals shown below are used.

4.3.2.2 Reference signal

a) 10 MHz signal; 10 MHz reference signal which is synchronized to GPS.

b) Sample clock pulse (see note); reference signal which is synchronized to Broadcast TS signal or sample clock signal of OFDM signal.

NOTE For 6 MHz ISDB-T system, its frequency is 512/63 MHz.

4.3.2.3 1 pps signal

Used for signal delay measurement within 1 s, unless specified, leading edge of 1 pps signal and up edge of 10 MHz sine wave signal should coincide.

1 pps signal and 10 MHz reference signal are obtained by making use of Reference signal generator with GPS synchronization.

4.3.2.4 Frame sync. Signal

Frame sync. Signal is extracted from frame synchronization information multiplexed in broadcast TS signal described in 4.2.1. In case of OFDM signal, frame sync. signal is regenerated from demodulator timing recovery circuit.

Frame sync. Signal may be used as a reference signal for signal delay measurement. The relationship between frame sync. Signal and sample clock should be specified for each system.

In addition, it is possible to widen the measurement range to more than 1 frame, by making use of the following information which is multiplexed in Transport stream.

- DVB-T system: mega-frame information, refer to ETSI TS 101 191.
- ISDB-T system: frame identification signal, refer to ARIB STD-B31.

5 Methods of measurement for signal delay time

5.1 Scope

Management of signal delay in transmission network is one important issue for SFN operation in Digital Terrestrial Broadcasting Network. In this clause, measurement methods for signal delay of transmission lines and equipments, and for relative delay time difference between different transmission links are described. Signal delay of video and audio encoder/decoder is out of scope.

5.2 Definition of signal delay time

5.2.1 Delay time

As shown in Figure 2 a), delay time should be defined as the delay time between input signal and output signal of same transmission link.

Kinds of signal type of input/output are described in Table 4.

5.2.2 Relative delay time difference

As shown in Figure 2 b), relative delay time difference should be defined as the relative time difference between outputs of different transmission links.

Kinds of signal type of input/output are described in Table 4.

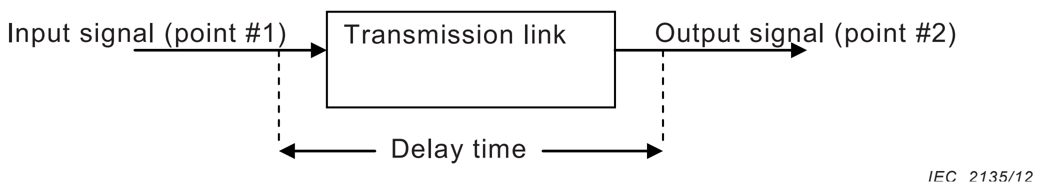


Figure 2 a) – Delay time definition

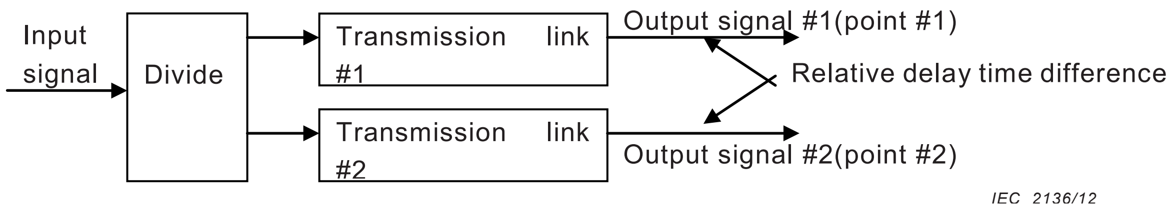


Figure 2 b) – Definition of relative delay time difference

Figure 2 – Delay time and relative delay time difference definitons

Table 4 – Combination of signal type

Measurement item	Measurement point #1	Measurement point #2
Delay time	Broadcast TS signal	Broadcast TS signal
	Broadcast TS signal	OFDM signal
	OFDM signal	OFDM signal
Relative delay time difference	Broadcast TS signal	Broadcast TS signal
	OFDM signal	OFDM signal

NOTE See details for signal type in Clause 4.

5.3 Direct/indirect measurement

5.3.1 General

As defined in 5.2, both signal delay and relative delay time difference are given as the time difference between measurement point #1 and #2.

Two measurement systems are considered according to the compared signal. One is direct comparison of signals of #1 and #2; this measurement system is defined as direct measurement system in this standard. On the other hand, the signal timing of points #1 and #2 are measured by making use of common reference signal, this measurement system is defined as indirect measurement system in this standard.

Details of these two systems are described below.

5.3.2 Direct measurement system

Measurement method in which signals at two measuring points are directly compared and measured delay time in this method, input signal is defined as reference signal and output signal is defined as measured signal. Concept of this method is shown in Figure 3a).

5.3.3 Indirect measurement system

Measurement method in which the common reference signal is used as a reference of signal delay measurement. As shown in Figure 3b), each measured signal at each measuring point is compared by reference signal and measure the time difference between reference signal and measured signal at each measuring points. The time difference of measurement results is defined as delay time in this method.

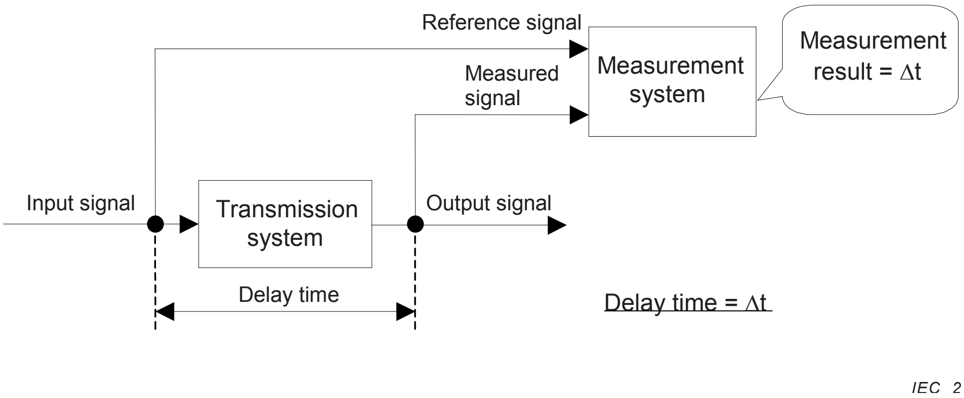


Figure 3a) – Direct measurement method

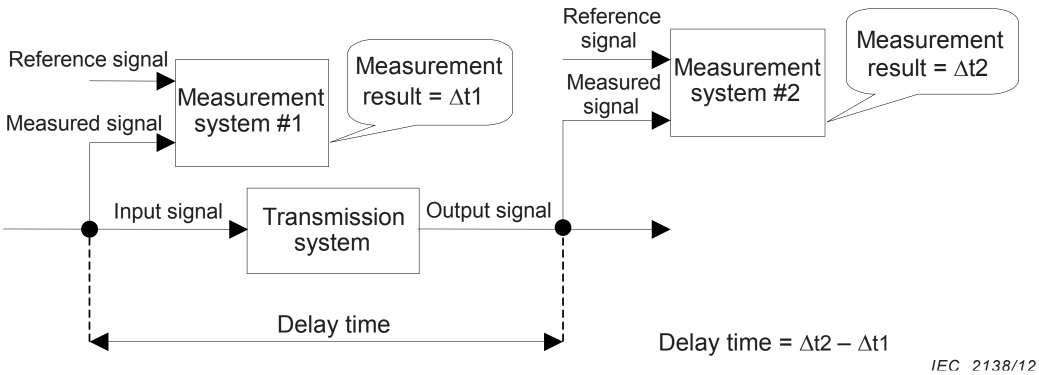


Figure 3b) – Indirect measurement method

Figure 3 – Direct and indirect measurement method

5.4 Measurement place

The measurement system is defined regarding measurement place.

Places of measurement of points #1 and #2 are in same place, this case is defined as measurement in same place. Measurement of signal delay of transmission equipment is one of these types.

On the other hand, places of measurement of points #1 and #2 are in different place, this case is defined as measurement in different places. Measurement of transmission time difference of different station is one of these types.

5.5 Classification of measurement system

According to the parameters defined in 5.2 through 5.4, measurement systems are classified into 16 cases shown in Table 5.

Examples and measurement systems of each case are described below:

a) Case 1: this is a typical case as a measurement of transmission delay of TS transmission line and/or TS transmission equipment in same station. An example of measurement system is shown in Clause A.1.

b) Case 2: signal delay of OFDM modulator is the typical case. The input signal format is TS, and output format is OFDM modulated RF signal. In this case, frame synchronization timing of both signals are compared. An example of measurement system is shown in Clause A.1.

c) Case 3: this is typical case as a measurement of transmission delay of RF transmission line and/or RF transmission equipment in same station. An example of measurement system is shown in Clause A.1.

d) Case 4: This is as case 3, but measurement method is different. An example of measurement system is shown in Clause A.2

e) Case 5: this is typical case as a measurement of transmission delay of TS transmission link between different stations. Common frame sync. Signal is used as reference signal. In this case, time difference of reference signal at different positions should be exactly measured before. An example of measurement system is shown in Clause A.3.

f) Case 6: this is typical case as a measurement of transmission delay of RF transmission link between different stations. Common frame sync. Signal is used as reference signal. In this case, time difference of reference signal at different position should be exactly measured before. An example of measurement system is shown in Clause A.3.

g) Case 7: this is typical case as a measurement of transmission delay of TS transmission link between different stations. 1 pps signal of GPS is used as reference signal. An example of measurement system is shown in Clause A.3.

h) Case 8: this is typical case as a measurement of transmission delay of RF transmission link between different stations. 1 pps signal of GPS is used as reference signal. An example of measurement system is shown in Clause A.4.

i) Case 9 – case 12: in case that different TS/RF transmission links are used as redundant, the time difference of different transmission outputs should be measured in the same station. The measurement systems are similar to case 1 – case 4,

j) Case 13 – case 16: these are popular in transmission network composed by different TS/RF transmission links to different stations. These measurement systems are used to verify the time difference of different stations. The measurement systems are similar to case 5 – case 8.

For cases 13 and 14, time difference of reference signal (frame sync. signal) at different places may be measured by 1 pps signal, or other method previously.

Table 5 – Classification of measurement system for signal delay time

Case	Definition (note 1)	Measurement place(note 2)	Signal format #1	Signal format #2	Direct/ indirect (note 3)	Reference Signal (note 4)	Measured timing format (note 5)	remarks
1	Delay time measurement	Same place	TS	TS	direct	Input A	Frame timing of measured signal	See Clause A.1
2			TS	OFDM				
3			OFDM	OFDM				
4			OFDM	OFDM			(note 6)	See Clause A.2
5		Different place	TS	TS	indirect	frame Sync. signal	Frame timing of measured signal	See Clause A.3
6			OFDM	OFDM				
7			TS	TS		1 pps signal		See Clause A.4
8			OFDM	OFDM				(note 7) See Clause A.4
9	Relative delay time difference	Same place	TS	TS	direct	Input A	Frame timing of measured signal	See Clause A.1
10			TS	OFDM				
11			OFDM	OFDM				
12			OFDM	OFDM			(note 6)	See Clause A.2
13		Different place	TS	TS	indirect	frame Sync. signal	Frame timing of measured signal	See Clause A.3
14			OFDM	OFDM				
15			TS	TS		1 pps signal		See Clause A.4
16			OFDM	OFDM				(note 7) See Clause A.4

NOTE 1 See 5.2 for definition.

NOTE 2 See 5.4 for measurement place.

NOTE 3 See 5.3 for measurement methods.

NOTE 4 Reference signal is defined in 5.3.

NOTE 5 Signal format for delay time measurement.

NOTE 6 In cases 4 and 12, direct comparison of 2 signals for delay time measurement.

NOTE 7 For accurate measurement, new technology is proposed in Clause A.5 of this standard.

6 Methods of measurement for performances of radio wave relay station

6.1 Scope

A broadcast wave relay station is important to cover the area where radio wave field strength of main station is not strong enough for receiver. As an example, Gap filler is one of this type of stations. This station type is useful because another frequency resource and/or transmission link is not necessary, and also possible to reduce infrastructure cost.

But, in this type of network, relay station receives and re-transmits the signal. Therefore, signal degradation caused by the rebroadcasting should be accumulated. For this reason, it is important to measure and estimate total signal quality for this type of network.

6.2 Measurement diagram and measurement items

6.2.1 General

Measurement diagram and measurement items shall be specified for each system. But unless specified, the following will be used.

6.2.2 Measurement diagram

Measurement diagram of relay station should be classified following two cases, according to the purpose of measurement/evaluation.

a) Measurement for the performances of received signal of relay station

In case of measurement for the performances of relay station only, the measurement diagram shown in Figure 4 should be applied.

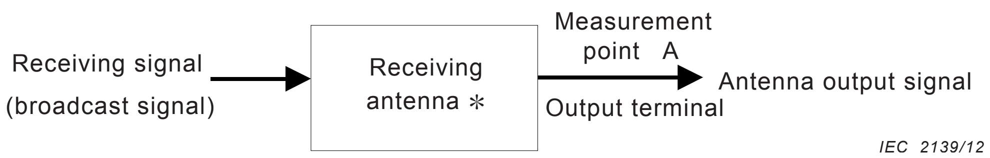
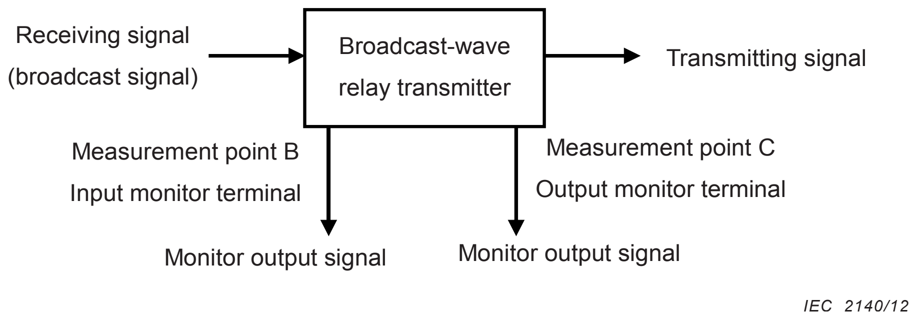


Figure 4 – Measurement diagram of received signal of relay station (case a))

b) Measurement for the performance of transmission network chain

In case of measurement for the performances of transmission network chain, the measurement diagram shown in Figure 5 should be applied.



NOTE The signal to be measured is RF signal.

Figure 5 – Measurement diagram of relay station (case b))

6.2.3 Measurement items

Measurement items should be specified for each system, but unless specified, measurement items given in Table 6 may be referred.

In Table 6, measurement methods which are common for ones specified in IEC 62273-1 are marked. For these methods, details should refer to IEC 62273-1.

In addition, these methods given in Table 6, can be applicable for the measurement of received signal quality.

Table 6 – An example of measurement items for Relay station

Measurement item	Relay station only (note 1)	Input signal quality (note 2)	Signal quality through relay station (note 3)	Note (method of measurement)
(General characteristics of transmitter)				
Frequency	X		X	See 5.1 of 62273-1
Output power	X		X	See 5.2 of 62273-1
Spurious domain emission	X		X	See 5.3 of 62273-1
Out of band emission	X		X	See 5.4 of 62273-1
Occupied bandwidth	X		X	See 5.5 of 62273-1
Power consumption	X			See 5.6 of 62273-1
(Input and output signal characteristics)				
Shoulder	X			See 6.1 of 62273-1
MER	X	X	X	See 6.2 of 62273-1
BER; case 1 (note 4)	X			See 6.3 of 62273-1
BER; case 2 (note 5)		X	X	See 6.3.1 of this standard
END(note 6)	X	X	X	See 6.4 of 62273-1
Phase noise	X			See 6.5 of 62273-1
Amplitude frequency characteristics	X	X	X	See 6.3.3 of this standard
Delay profile		X		See 6.3.4 of this standard
Phase jitter	X	X	X	See 6.3.5 of this standard

NOTE 1 Measurement point: Figure 4 case a).

NOTE 2 Measurement point: Figure 5 case a).

NOTE 3 Measurement point: Figure 5 case b).

NOTE 4 Measurement method with PN signal.

NOTE 5 Simple measurement method using broadcast signal.

NOTE 6 For measurement of received signal END, it should be considered that receiving signal may imply noise component. Therefore, the method of measurement for received signal is described in 6.3.2 of this standard.

6.3 Methods of measurement

6.3.1 General

In this subclause, methods of measurement which are not defined in IEC 62273-1 are described.

6.3.2 BER (case 2)

6.3.2.1 Definition

BER measurement of digital transmitter is defined in IEC 62273-1, 6.3.

But this method requests PN code as test signal. For this reason, BER measurement method defined in IEC 62273-1 cannot be applied during transmitter operation.

But, in case of maintenance of a part of network, it is necessary to measure the network quality in operation period simultaneously.

Considering the above situation, BER measurement methods which are applicable during transmitter operation are described (see Figure 6).

6.3.2.2 Methods of measurement

Two methods are applicable.

a) Method to use Null Packet of broadcast signal.

   Null packets are inserted to data packets stream to adjust the transmission speed. Data byte area of Null Packets is set to 0”. As data byte area of Null packets are known, bit error rate of received signal can be measured to count the difference bits at the output of decoder portion of receiver.

   An example of measurement method is described in B.1.1.

b) Simplified method to compare input signal and re-coded signal.

   At receiver portion, BER is measured to compare the pre-decoded signal and post-decoded and re-encoded signal, and next to count the number of different bits.

   An example of measurement method is described in B.1.2.

This method is not always accurate in case that error correcting function does not work well. Therefore, it is necessary to check that error correcting function operates well.

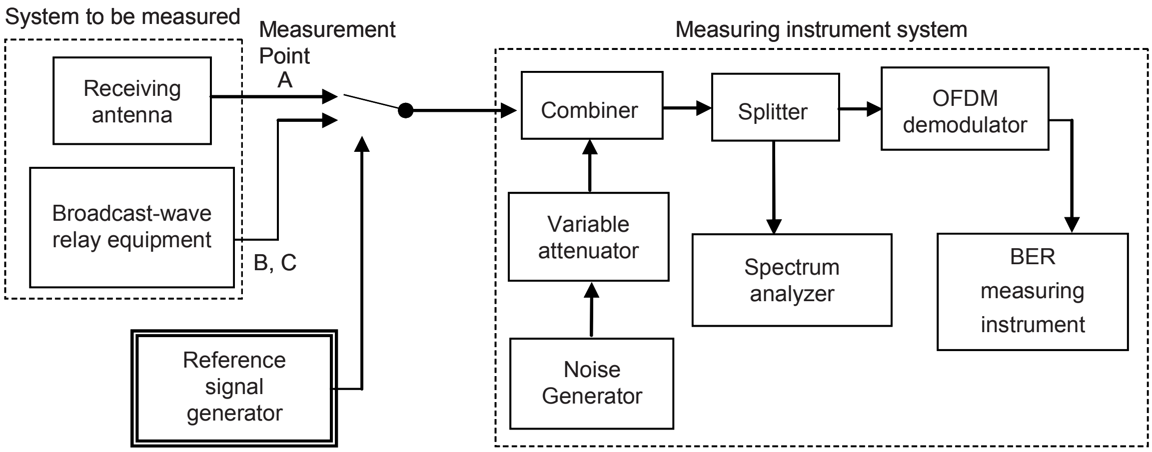


Figure 6 – BER- Measurement method

6.3.3 Equivalent noise degradation (END)

6.3.3.1 General

END is one important measure to evaluate the broadcast-wave relay network quality and received signal quality by replacing to equivalent Gaussian noise level which gives the same signal quality impairments due to any kind of the causes of deteriorations such as interference, non-linearity , multi-path, etc.

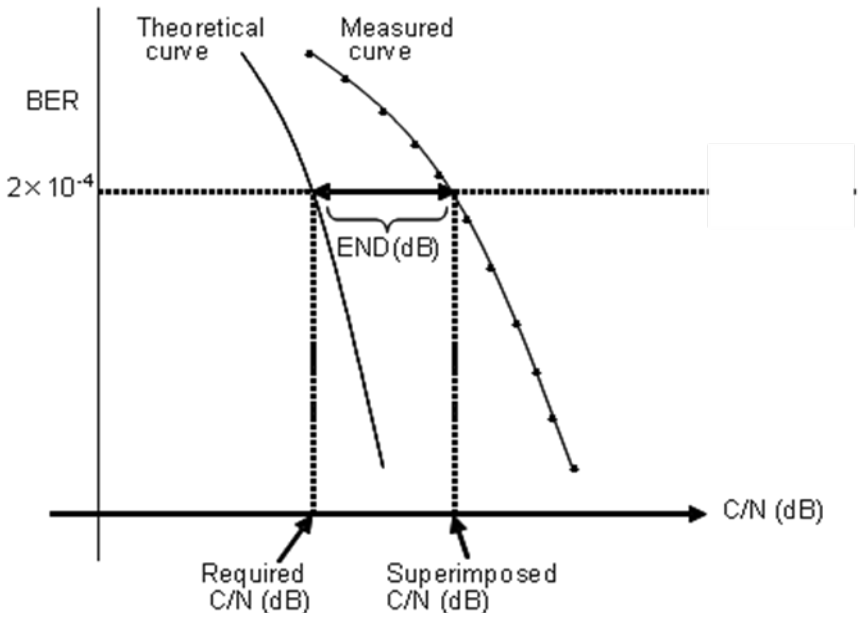
ENF(Equivalent noise floor) is another measure to evaluate the signal quality, in case the degradation of signal quality is little.

NOTE In some cases, the term Equivalent C/N is used.

6.3.3.2 Definition

In Figure 7 , C/N at 2×10^{-4} of theoretical curve is defined as Required C/N(dB)(see note), and C/N at 2×10^{-4} of measured curve is defined as Superimposed C/N(dB) END(dB) is defined in the following formula as the difference between Required C/N(dB) and Superimposed C/N(dB).

NOTE Required C/N is different for transmission system and transmission parameter sets. Refer to Annex A of EN 300 744 for the required C/N of DVB-T system, for ISDB-T system, refer to Annex A.1.5 of JEITA digital terrestrial network handbook..



IEC 2142/12

Figure 7 – Definition of END

END (dB) $=CN_{add}(dB) - CN_r(dB)$

Here: $CN_{add}(dB)$:Superimposed C/N(dB), $CN_r(dB)$:Required C/N(dB)

In case that the inherent degradation of OFDM demodulator which is used for measuring instrument is not negligible, END(dB) is given in the following formula:

$$END\ (dB) = -10\log_{10}(10\text{^}(-CN_{add}/10) + 10\text{^}(-CN_{fix}/10)) - CN_r(dB)$$

Here: CN_{fix} (dB): inherent degradation of OFDM demodulator

ENF is defined as the ratio of signal power (C) to the additionally superimposed Gaussian noise power (N) which gives the same BER as that brought by all of the deterioration causes. The relationship between END and ENF at BER of 2×10^{-4} is introduced in the following formula:

$$ENF(dB) = -10\log_{10}(10\text{^}(-CN_r/10) + 10\text{^}(-(CN_r+END)/10))$$

From the above formulas, measurement of $CN_{add}(dB)$ and CN_{fix} (dB) is necessary to calculate END(dB) and ENF(dB).

For the methods of measurement for $CN_{add}(dB)$ and CN_{fix} (dB), examples are shown in Clause B 2.

6.3.4 Amplitude frequency characteristics

6.3.4.1 Measurement system

Figure 8 shows the set-up for measuring the amplitude-frequency characteristics.

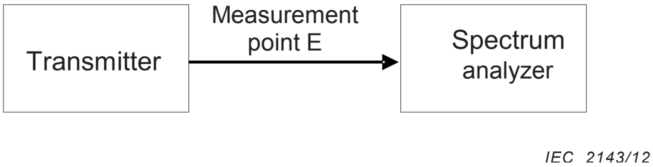


Figure 8 – Measurement diagram of amplitude-frequency characteristics

6.3.4.2 Methods of measurement

a) Connect a spectrum analyzer to a monitor point of the mask filter output.
b) Measure the amplitude-frequency response using the spectrum analyzer.
c) The setting of the spectrum analyzer should be as follows, and the averaging function may be used if necessary.

Table 7 – Example of the parameter set of spectrum analyzer

Centre frequency	SPAN	RBW	VBW	Detect mode
Centre frequency of modulated wave	6 MHz	30 kHz	300 Hz	Positive peak detection

6.3.5 Delay profile

6.3.5.1 Definition

In broadcast wave relay network, signal degradation such as amplitude-frequency distortion and inter-symbol interference is caused by multi-path propagation. In addition, in case of SFN (single frequency network) operation, relative time difference of plural signals sent from different transmitters should be within specified time interval.

Delay profile measurement is necessary to verify above situation.

6.3.5.2 Method of measurement

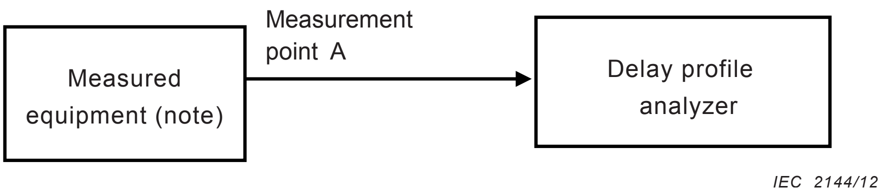


Figure 9 – Measurement block diagram of delay profile

Measurement diagram is shown in Figure 9.

Delay profile analyzer may be prepared for each system. Delay profile calculation process is described in Clause B-3.

6.3.6 Phase jitter

6.3.6.1 Purpose

Inaccuracies of the symbol clock concerning absolute frequency, frequency drift and jitter may introduce inter-symbol interference. Additionally, the accuracy of transmitted clock references like the Program Clock Reference (PCR) can be influenced. Therefore the degradation of signal quality due to symbol clock inaccuracies has to be negligible. Symbol clock jitter and accuracy can be degraded if the symbol clock is directly synthesized from an unstable TS data clock. For this reason, the measurement should be performed while the transmitter is driven by TS to ensure a worst case measurement is obtained.

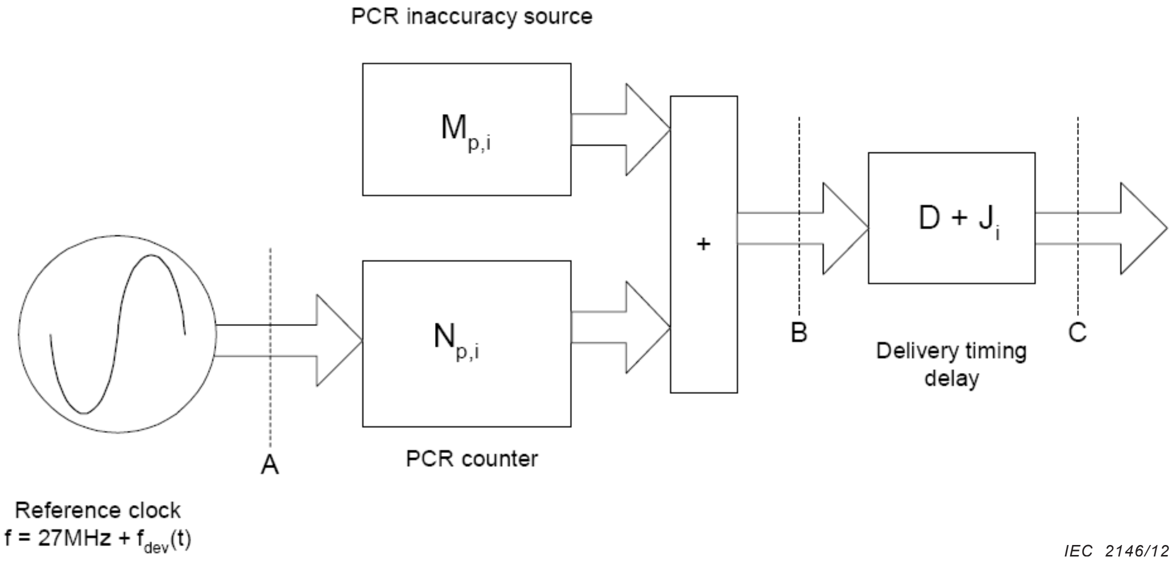
6.3.6.2 Interface

IEC 2145/12

Measurement item	Measurement point #1	Measurement point #2
Phase jitter	Broadcast Transport Stream signal	Broadcast Transport Stream signal

6.3.6.3 Method

For measurements of the absolute frequency, frequency wander and timing jitter are of interest. A PLL circuit can be used for synchronization to the symbol clock and according to the loop bandwidth, timing jitter is suppressed and low frequency drift (wander) is still present at the output of the loop oscillator. Jitter can be measured with an oscilloscope by triggering with the extracted clock. Jitter is usually expressed as a peak-to-peak value in UI (Unit Interval) where one UI is equal to one clock cycle (Tsymbol). For measurements of the absolute frequency and frequency wander the output of the clock extractor can be used or the symbol clock directly using an appropriate frequency counter.



IEC 2146/12

Figure 10 – Reference model

Reference points are indicated by dashed lines, see Figure 10. This is a model of an encoder/multiplexer (up to reference point B) and a physical delivery mechanism or communications network (between reference points B and C). The components of the model to the left of reference point B are specific to a single PCR PID. The components of the model to the right of reference point B relate to the whole Transport Stream. Measuring equipment can usually only access the TS at reference point C.

The model consists of a system clock frequency oscillator with a nominal frequency of 27 MHz, but whose actual frequency deviates from this by a function: fdev (p, t). This function depends on the time (t) and is specific to a single PCR PID (p). The Frequency Offset PCR_FO measures the value of fdev (p, t).

The Drift Rate PCR_DR is the rate of change with time of fdev (p, t).

The system clock frequency oscillator drives a PCR counter which generates an idealized PCR count, Np, i. p refers to the specific PCR PID p and i refer to the bit position in the transport stream. To this is added a value from a PCR inaccuracy source, Mp,i to create the PCR value seen in the stream, Pp,i. The simple relationship between these values is:

$$Pp,i = N\,p,i + M\,p,i \tag{1}$$

Mp,i represents the Accuracy PCR_AC.

The physical delivery mechanism or communications network beyond point B introduces a variable delay between the departure time Ti and the arrival time U_i of bits:

$$U_i - T_i = D + J_i \tag{2}$$

In the case of a PCR, U_i is the time of arrival of the last bit of the last byte containing the PCR base (ISO/IEC13818-1, 2.4.3.5). D is a constant representing the mean delay through the communications network. Ji represents the jitter in the network delay and its mean value over all time is defined to be zero. J_i+ Mp,i is measured as the Overall Jitter PCR_OJ.

In the common case where the Transport Stream is constant bitrate, at reference point B the Transport Stream is being transmitted at a constant bitrate R nominal. It is important to note that in this reference model this bitrate is accurate and constant; there is no error contribution from varying bitrate. This gives us an additional equation for the departure time of packets:

$$T_i = T_0 + \frac{i}{R_{nom}} \tag{3}$$

T0 is a constant representing the time of departure of the zero'th bit. Combining formulas 2 and 3 we have for the arrival time:

$$U_i = T_0 + \frac{i}{R_{nom}} + D + J_i \tag{4}$$

NOTE PCR_accuracy_error.

The accuracy of ±500 ns is intended to be sufficient from system clock.

This test should only be performed on constant bitrates TS as defined in ISO/IEC 13818-1, 2.1.7. This measurement refers to the physical layer of TS interconnection.

7 Methods of measurement for performances of signal quality improvement instrument used in radio wave relay station

7.1 General

In transmission network chain composed by broadcast radio wave relay network, signal degradation should be accumulated. To improve signal quality of transmission network chain, several kinds of compensators (see note) may be introduced into network chain.

Figure 11 shows the conceptual diagram of relay station using compensators.

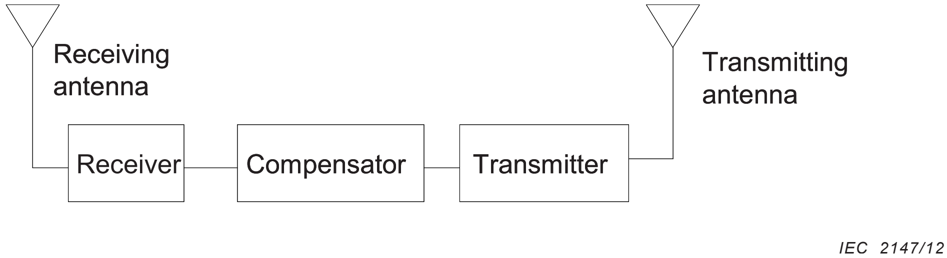


Figure 11 – Conceptual diagram of relay station using a compensator

In this clause, classification of compensators and methods of measurement for compensators are described.

NOTE In this standard, the term compensator is used.

7.2 Classification of signal quality improvement instrument

Several types of compensators are proposed. Table 8 shows examples of compensators.

Table 8 – Compensators used in digital terrestrial broadcasting relay network

No.	Equipment name	Main function
1.	Loop-back canceller	It compensates the transmitted signal's degradation caused by the coupling between transmission and reception antennas of a SFN station. This equipment also improves the equivalent C/N of the relay transmitter and prevents an oscillation caused by the coupling.
2.	Diversity receiver	It compensates degradation of received signals due to multi-path and fading.
3.	Co-channel interference canceller	It compensates degradation of received signals due to co-channel interference.
4.	C/N reset equipment	It compensates degradation of received signals caused by multi-stage relay and the other various causes.

NOTE See Annex C for details of principle operation of each equipment.

7.3 Measurement diagram and measurement condition

The compensators described in Table 8 have different functions, different measurement conditions and input/output signal form. Therefore, measurement items should be classified into two groups, one is a group of common measurement items, the other is a group of different measurement items for each equipment.

Common measurement items and measurement methods are described in 7.4 Measurement items and measurement methods which should be defined for each instrument are described in 7.5.

7.4 Common measurement items

Common measurement items for different type of compensators are shown in Table 9 below.

In Table 9, measurement methods which are specified in IEC 62273-1 and 6.3 are marked. For these methods, details should refer to these standards.

Table 9 – Examples of measurement items for signal quality improvement instrument

(note 1)

Measurement item	Loop-back canceller	Diversity receiver	Co-channel interference canceller	Remarks (method of measurement)
(General characteristics of transmitter)				
Input/output frequency	X	X	X	See 5.1 of 62273-1
Input/output power	X	X	X	See 5.2 of 62273-1
Spurious domain emission	X	X	X	See 5.3 of 62273-1
Out of band emission	X	X	X	See 5.4 of 62273-1
Occupied bandwidth	X	X	X	See 5.5 of 62273-1
Power consumption	X	X		See 5.6 of 62273-1
(Input and output signal characteristics)				
Shoulder	X	X	X	See 6.1 of 62273-1
MER	X	X	X	See 6.2 of 62273-1
Amplitude frequency characteristics	X	X	X	See 6.3.3 of this standard
END	X	X	X	See 6.4 of 62273-1 and 6.3.2 of this standard
Delay profile	X	X		See 6.3.4 of this standard
Delay time difference between branch		X	X	(note 2)

NOTE 1 Methods of measurement for C/N reset equipment are different from other compensators because of the difference of output signal format. But, items of (1) input signal frequency, (2) input signal level, (3)input impedance, (4) power dissipation are common for others.

NOTE 2 Diversity receiver and co-channel interference canceller have plural input branches (receiving antenna and receiver) and the output of these branches are combined under specified function. Therefore, delay time difference of each branch should be managed within specified range. The methods of measurement described in 5.3 may be adopted for this propose.

7.5 Methods of measurement for each kind of compensator

Each kind of compensators defined in Table 8 has different functions, therefore, methods of measurement for each compensator should be different.

According to the difference of function, measurement methods of each compensator are different.

Principles of each compensator and measurement methods are described in Annex C.

Annex A
(informative)

Examples of measurement methods for signal delay

A.1 Examples of direct measurement method for signal delay and relative delay time difference

A.1.1 Scope

In this Annex, examples of measurement systems which are defined as cases 1, 2, 3 and 9, 10, 11 in 5.5 are given.

A.1.2 Measurement system

a) Measurement diagram

Figure A-1 shows the measurement diagram for the delay time of same transmission circuit.

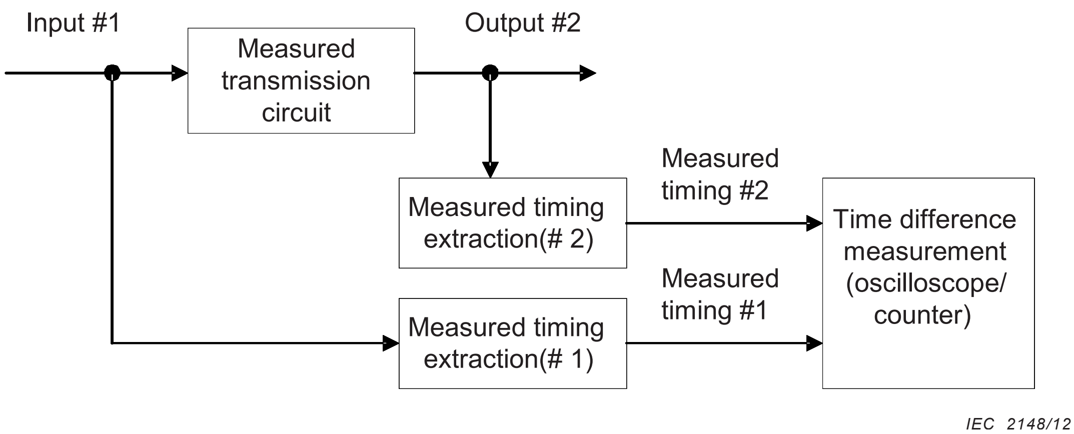


Figure A.1 – General measurement system for cases 1 to 3

Signal format of #1 and #2, measured timing extraction circuits are different for each case.

See Table A.1 for signal format and extraction circuits.

Table A.1 – Signal format and timing extraction of each case

Items	Cases 1 and 9	Cases 2 and 10	Cases 3 and 11
#1 signal format	TS signal	TS signal	OFDM signal
#2 signal format	TS signal	OFDM signal	OFDM signal
Extraction #1	Frame sync. signal recovery	Same as left	OFDM demodulator
Extraction #2	Frame sync. signal recovery	OFDM demodulator	OFDM demodulator

NOTE Details of measured timing extraction circuits are explained in A 1.4 of this Annex.

A.1.3 Measurement procedure

a) The signals of each measurement points #1 and #2 are extracted and put into measured timing extraction circuits #1 and #2.

b) Each measured timing signals #1 and #2 are recovered at each measured timing extraction circuit #1 and #2 and fed to the time difference measurement circuit.

c) Measure the time difference of two timing signals by using the time difference measurement circuit, such as Oscilloscope and/or counter.

A.1.4 Extraction of measured timing signals

Examples of measured timing extraction circuits are described below.

a) Measured timing extraction circuits from TS signal (Figure A.2)

This circuit is composed of converter for ASI-SPI and detection logic.

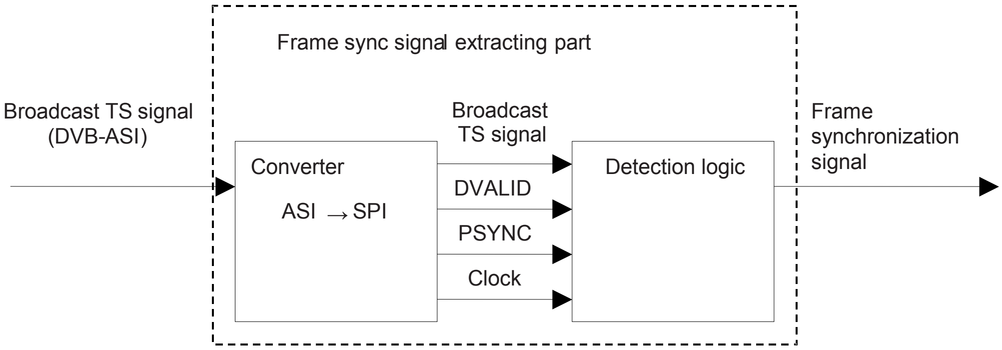


Figure A.2 – Example of frame sync signal extracting part

The process of frame synchronization signal extraction is as follows

1) ASI-SPI conversion device.

   DVB-ASI signal is converted into DVB-SPI signal.

   The converted signal is a broadcast TS signal-data continuous, parallel state. The data rate depends on each system.

2) Detection logic.

   Detection logic detects the information for synchronization and transmission time, then regenerates frame synchronization signal which is synchronized to frame timing of broadcast TS signal. Specification of this circuit is different according to transmission system. Examples are shown below.

   (DVB-T system):
   ETSI TS 101 191
   (ISDB-T system)

   Detect either of following information which are multiplexed into broadcast TS signal (see note)

   i) frame_indicator and/or frame_head_packet_flag multiplexed in Dummy byte.

   ii) IIP packet pointer in IIP(ISDB-T Information Packet), which is specified in ARIB STD-B31.

NOTE The broadcast TS signal is the interface format between multiplexer and OFDM modulator, defined in ARIB STD-B31.

b) Measured timing extraction circuits from OFDM signal

Figure A.3 shows an example of OFDM demodulator configuration which outputs frame synch.

It is composed of tuner/ analogue-to-digital converter, FFT, the synchronous recovery circuit , the frame synchronization word detector and frame identification circuit. To extend measurement range to more than 1 frame length, the information of frame synchronization polarity can be used.

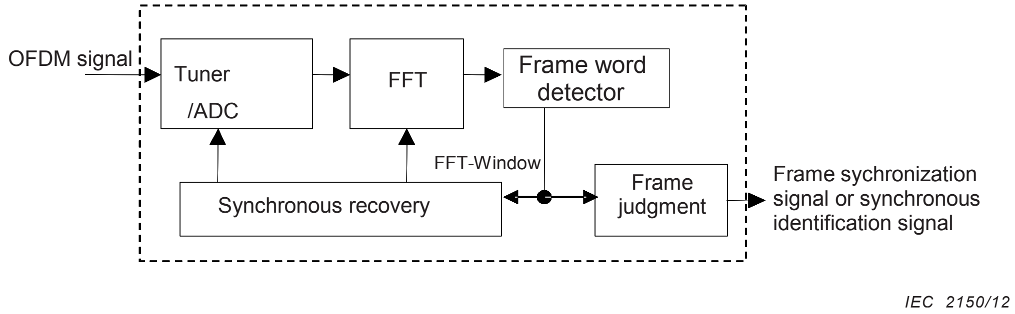


Figure A.3 – Example of OFDM demodulator for frame timing extraction

A.1.5 Limitation of measurement range

a) In cases using only frame synchronization signal for measurement,.the measurement range is limited within one frame or less.

b) In cases using the frame identification information with frame synchronization signal, using together, the measurement range may be extended up to 2 or 4 frames.(see note). For ISDB-T system, synchronization identification of IIP is usable. In this case, it is possible to identify every 2 frame.

c) By using STS (synchronization_time_stamp) information with frame synchronization signal, the measurement range may be extended up to 1 s.

NOTE For DVB-T system, frame number of tps_mip is usable. In this case, it is possible to identify every 4 frames.

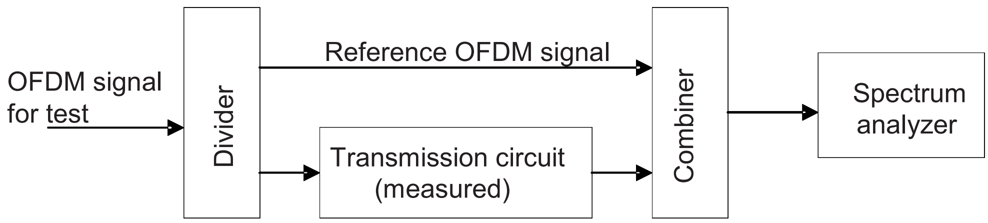
A.2 Direct measuring method for OFDM signals

A.2.1 Scope

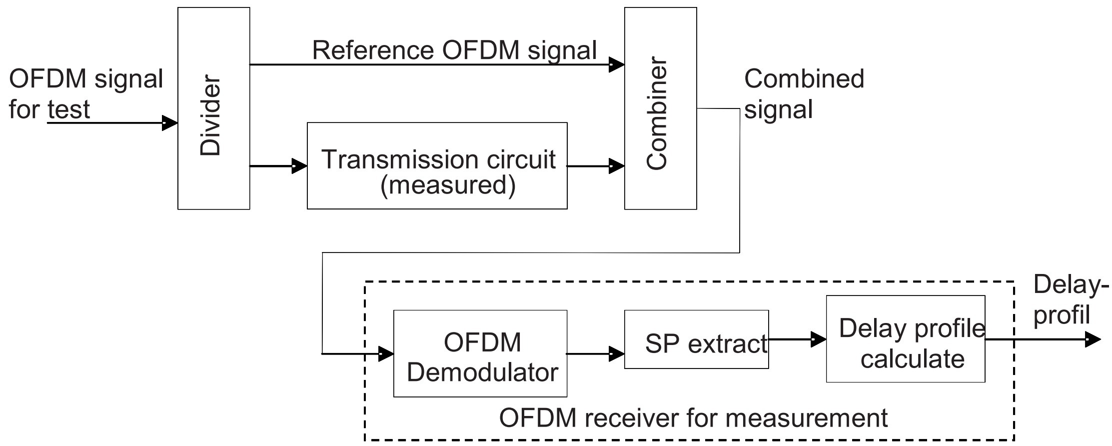
In this clause, examples of measurement systems which are defined as cases 4 and 12 in 5.5 are given.

A.2.2 Measurement system

The block diagram described below is the measuring circuit for time delay of transmission circuit. Figure A.4 (a) shows the spectrum analyzer method, and Figure A.4 b) shows the delay profile method. Equipment list for measurement is also shown in Table A.2.



a) Spectrum analyzer method



b) Delay profile method

Figure A.4 – Block diagram of direct measurement methods for time delay of OFDM signal

Table A.2 – Equipment list for measurement

Equipment	Functions, performances	Remarks
Power divider	Divide OFDM signal	
Power combiner	Combine 2 OFDM signal	
Spectrum analyzer	Measure the amplitude frequency characteristics of combined OFDM signal	

a) Measurement method using spectrum analyzer.

The typical amplitude-frequency characteristics of combined OFDM signal are as indicated in Figure A.5. Frequency span between dips indicated as symbol fd (Hz) in Figure A.5 is equal to the reciprocal of delay time td (s).

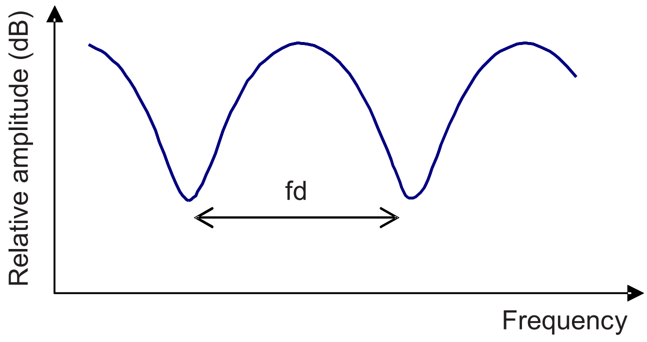


Figure A.5 – Example of frequency characteristics of combined signal

b) Measurement method using delay profiles.

The frequency characteristics of the combined signal can be calculated using the scattered pilot signals as the sampling data of OFDM signal. Delay profile is calculated as an Inverse Fourier Transform of this frequency characteristic. Delay profile indicates the time difference of combined OFDM signals shown in Figure. A.6.

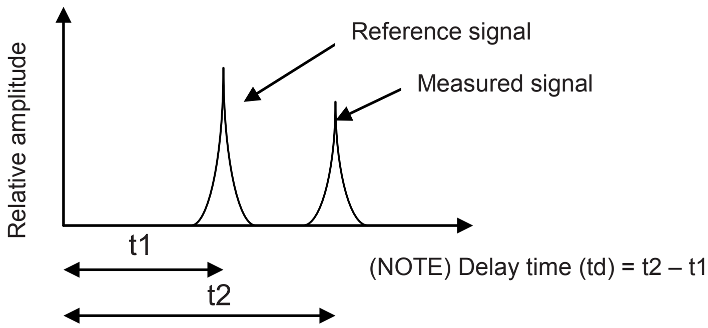


Figure A.6 – Example of delay profile of combined signal

A.2.3 Limitation of measurement range

a) Spectrum analyzer method.

This method can only be available in following conditions.

1) The waveform of two signals should be exactly the same.
2) The relative time difference should be within guard interval length. But in case that the relative time difference is long, the noise caused by Inter Symbol Interference(ISI) increases. For this reason, measurement should be done carefully in this occasion.

b) Delay profile method

This method can only be available in the following conditions.

1) At least, mode and guard interval length of 2 OFDM signals shall be the same.
2) The relative time delay of 2 OFDM signals should be within guard interval length.

A.3 Examples of indirect measurement method for signal delay and relative delay time difference with Frame sync. signal as the reference

A.3.1 Scope

In this clause, examples of measurement system which are defined as cases 5,6,13 and 14, in 5.5 are given.

A.3.2 Measurement system

Figure A.7 shows an example of measurement system for delay time and relative time delay difference by common frame sync. Signal.

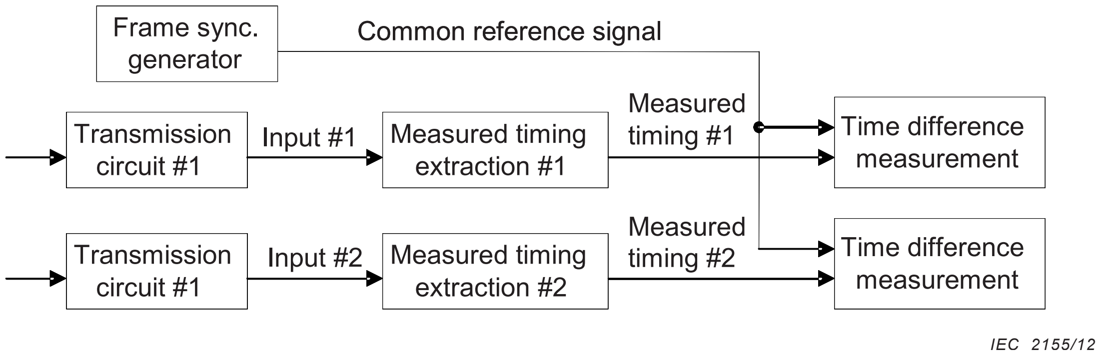


Figure A.7 – General measurement system for cases 5,6,13 and 14

According to signal formats of #1 and #2, measured timing extraction circuit should be selected. See Table A.1 in this annex for the relationship between signal format and measured timing extraction circuit

A.3.3 Measurement method

a) Measure the time difference between reference signal and measured timing for both signals #1 and #2.(in Figure A.8, indicated as $\Delta t1$ and $\Delta t2$).

b) After measurement of time difference, calculate propagation delay time Δt according to the following formula. The relationship between Δt,$\Delta t1$,$\Delta t2$ is shown in Figure A.8
$t = \Delta t1 - \Delta t2$

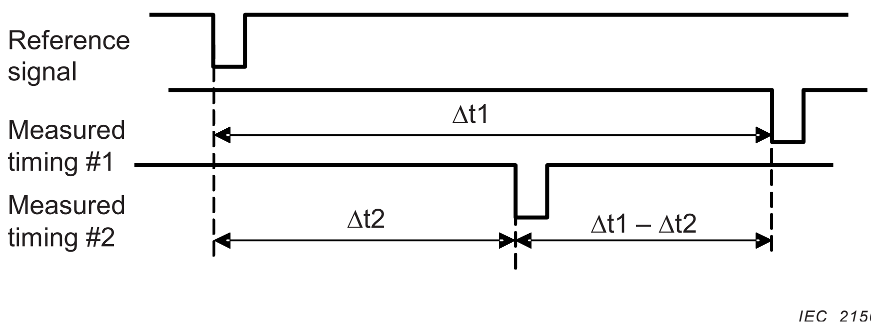


Figure A.8 – Timing chart for signal delay measurement

A.3.4 Measurement range

a) In case that only frame synchronization signal is used, time delay of one frame or less can be measured.

b) In case that frame synchronization identification signal is used together, time delay of two frames or less can be measured for ISDB-T system.

In case of DVB-T system, the measurement range can be extended to four frames.

A.4 Examples of indirect measurement method for signal delay and relative delay time difference with 1 pps signal as the reference signal

A.4.1 Scope

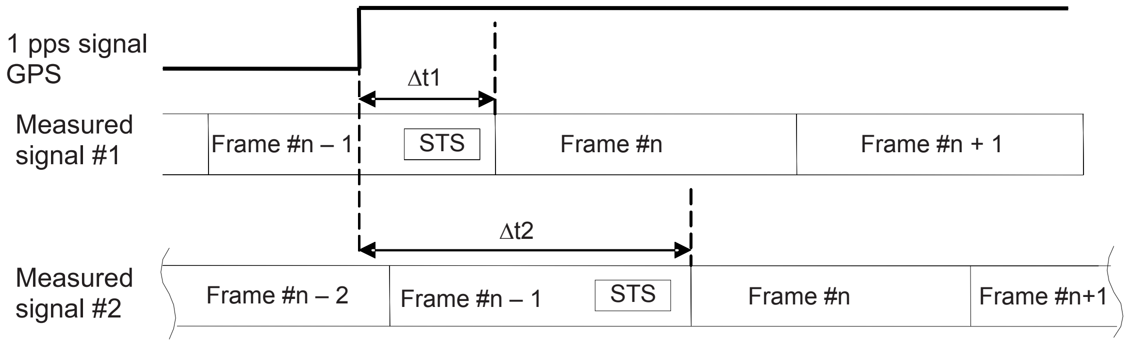
In this clause, examples of measurement system which are defined as cases 7,8 ,and 15,16 in 5.5 are given.

A.4.2 Measurement principle

a) Measurement for the signal delay of TS signal

1) In case of the signal delay between studio to transmitter station (case 7 of Table 5)

At studio site, the time difference between the latest pulse of 1 pps signal derived from GPS signal and the preceded start of frame synchronization is defined as STS (Synchronization Time Stamp). The information of STS is multiplexed into Transport Stream sent to transmitter site.



Δt1 Difference between 1 pps signal and frame timing of signal #1

Δt2 Difference between 1 pps signal and frame timing of signal #2

IEC 2157/12

Figure A.9 – Principle of measurement using 1 pps signal

Figure A.9 shows the relation of 1 pps signal derived from GPS and Transport Stream at studio site (measured signal #1) and transmitter site(measured signal #2). Δt1 shown in Figure A.9 is the time difference at studio site and defined as STS. This data is written in STS area of Transport Stream. On the other hand, at transmitter site, Δt2, defined as the time difference between 1 pps signal derived from GPS and start timing of frame synchronization of received Transport stream.

The timing of 1 pps signal derived from GPS is the same even though at a different place, Therefore, I pps signals derived from GPS can be used as common reference signals. So, the time difference between Δt2 and Δt1, defined as Δt, is the same as the transmission delay between studio site and transmitter site.

Δt2 is measured at transmitter site, on the other hand, Δt1 can be known at transmitter site to decode STS information which is multiplexed into Transport Stream.

The signal delay time between studio site and each transmitter site can be measured by the measurement method described in item 1).

Therefore, the relative delay time difference between different transmitter stations can be measured by the following formula

Δt-different station = Δt-station 1 – Δt-station 2

NOTE In ISDB-T system, data packet for network management is named IIP (ISDB-T Information Packet), STS is one of these management data, and written into IIP. Details of IIP are defined in ARIB STD-B31.

A.4.3 Measurement system

Figure A.10 shows an example of measurement system for delay time and relative time delay difference by common 1 pps signal provided from GPS receiver.

According to measured signal format, measured timing extraction circuit should be selected.

See Table A.1 for the relationship between signal format and measured timing extraction circuit.

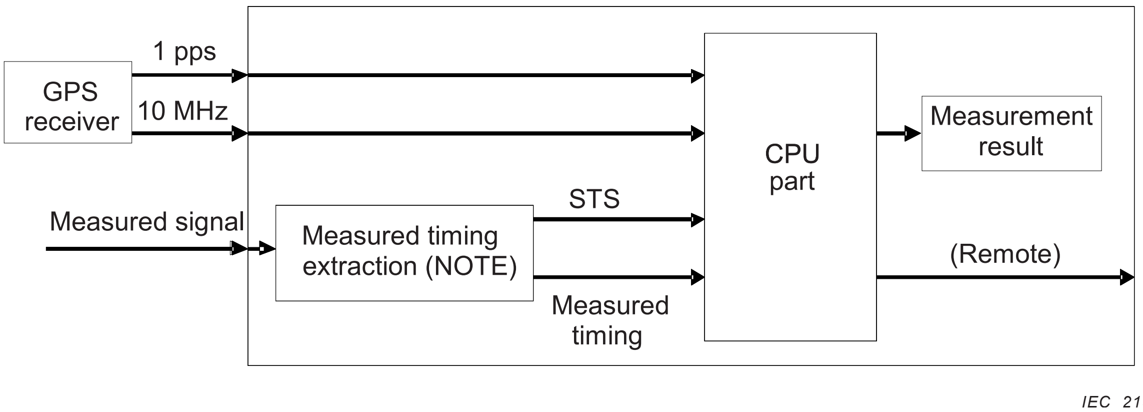


Figure A.10 – General measurement system for cases 7, 8 and 15,16

A.4.4 Limitation of measurement

Measurement range is as much as 1 s.

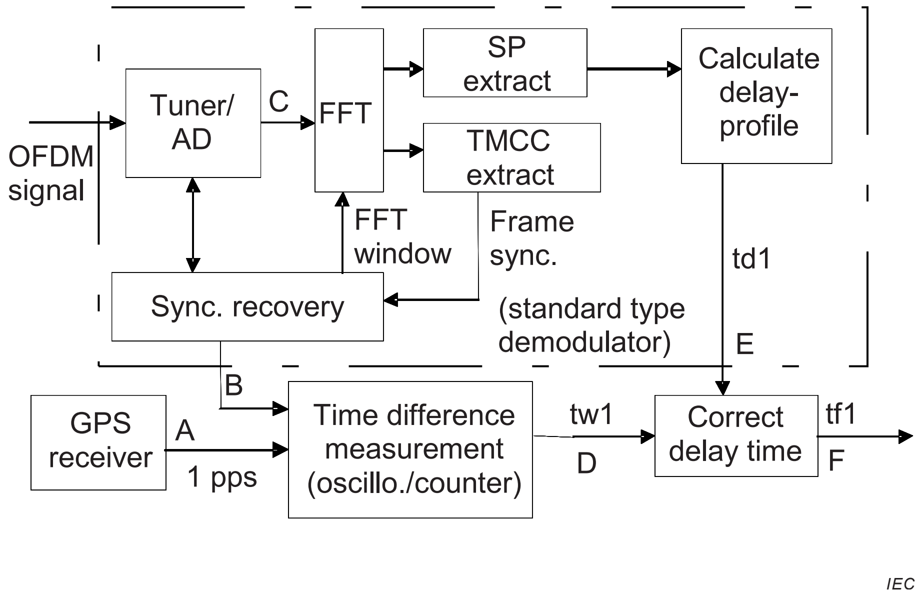
A.5 Management of OFDM signal by correcting FFT window timing with delay profile

A.5.1 Scope

Corresponding to the indirect methods defined in 5.3, one of measuring methods for delay-time of which time reference is either 1pps signal or frame sync. Signal is described. This method is effective for measuring the OFDM signal delay time which is defined as the time difference between 1 pps signal and the front end of OFDM signal. In addition, it is possible to measure the time difference between plural transmitter output signals by calculating each delay time.

A.5.2 Measurement system

An example of measuring system for delay time is shown in Figure A.11, and equipment list is shown in Table A.3.



Key

A Time reference

B FFT window timing of first symbol of OFDM frame

C OFDM signal at the FFT input

D Time difference of (A) and (B)

E Time difference of (B) and (C)

F Delay time measurement result

Figure A.11 – Measurement system for delay time (time reference is 1pps signal of GPS)

Table A.3 – Equipment list for delay time measurement

Equipment	Functions, performances, etc.	Remarks
OFDM demodulator for measurement	Demodulate OFDM signal, and output the FFT window timing of the front end of OFDM frame.	Include the calculation function of delay profile
GPS receiver	Output the subsidiary signal(1pps signal and 10 MHz)	In case of frame sync. for time reference, this is not required
Time difference measuring equipment	Measure the time difference of two signals. Oscilloscope and/or counter	

NOTE The correction of delay time shown in Figure A.11 is not the hardware, but the function. For this reason, this is not listed in Table A.3.

A.5.3 Measuring method

a) Measure the time difference, tw1, which is indicated as D in Figure A.11, between 1pps signal (A in Figure A.11) and the front end of FFT window of first symbol in OFDM frame (B in Figure A.11).

b) Measure the time difference, td1 which is indicated as E in Figure A.11, between the front end of FFT window and the front end of effective symbol of OFDM signal (indicated as C in Figure A.11).

c) The delay time of OFDM signal (tf1) is calculated by following formula, where, tw1 and td1 are data measured by above process, and, td-rf is the signal processing time delay of RF tuner located in the OFDM demodulator, which was measured by the factory test. (see note 1). Tg is the guard interval length of OFDM signal、which can be defined by transmission parameter of OFDM signal (see note 2).

tf1=tw1 + td1 – (td-rf) + Tg

NOTE Signal processing delay, td-rf, may be measured by network analyzer at the factory test.

In case the reference timing point of OFDM frame is defined as the front end of guard interval of first OFDM symbol, the guard interval length indicated should be added

The timing relation of each signal is shown in Figure A.12 below.

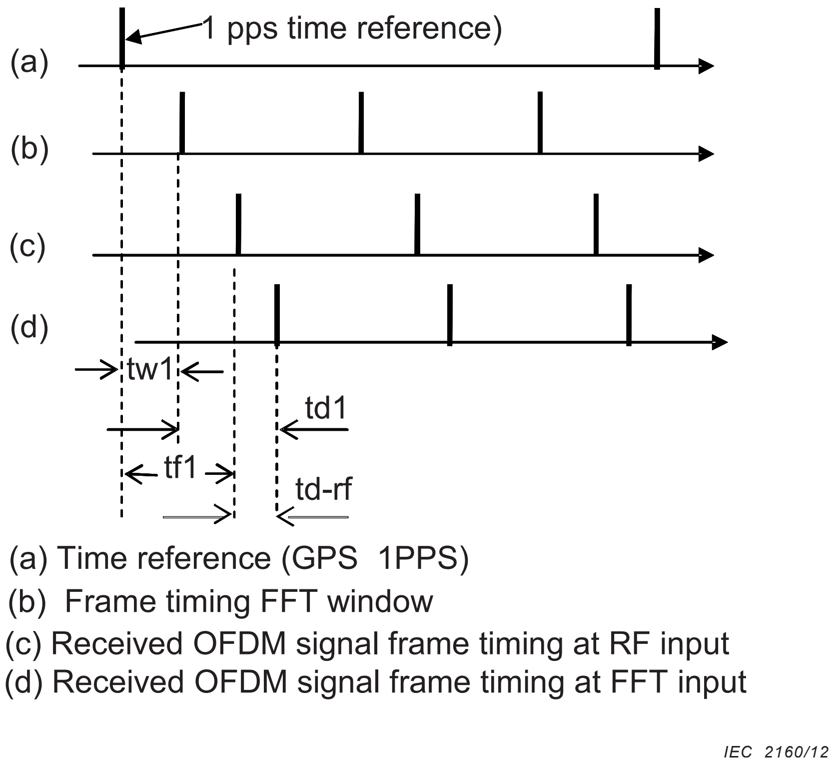


Figure A.12 – Timing relation of each signals

A.5.4 Measurement range

Same as Clause A.4.

A.5.5 Estimated measurement error

In this method, delay time, tf1, is calculated by the formula in A.5.3 above. Parameters in that formula, tw1, td1, td-rf, are independent of each other, therefore, these errors may affect the measurement accuracy for time delay.

For tw1, reference signal of 1 pps signal is set by 10 MHz clock, the error of tw1 will be within 100 ns or less. For td1, this data is calculated by delay-profile which is processed by FFT sampling clock, therefore, error of td1 will be within twice of the reciprocal of FFT sampling clock. For 6 MHz ISDB-T system, 8,1 MHz sampling clock is used, therefore, error of td1 may be equal to250 ns.

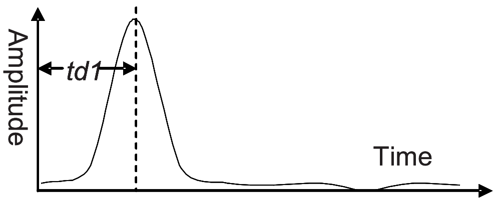
For td-rf, which may be measured at factory test, therefore, its error may be decided by the measurement accuracy of network analyzer, it is about 100 ns, therefore, this error may be estimated around 100 ns.

As mentioned above, the error of time delay, tf1, should be estimated considering the estimated error of each parameter.

A.5.6 Technical principle of measurement

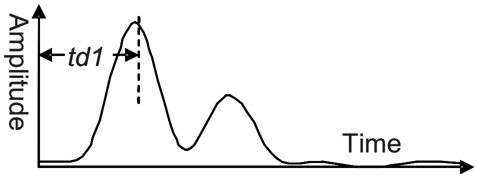
The delay profile of OFDM signal is calculated by inverse Fourier transform of the frequency characteristics of OFDM signal, which is given by scattered pilot signal as sampling point.

Figure A.13 shows the delay profile of OFDM signal. Figure A.13 a) shows the case of single path, and Figure A.13b) shows the case of multi-path. As shown in Figure A.13, td1, which is the time difference between time=0 and the peak of delay profile, is equal to the time difference between the front end of FFT window and the front end of effective symbol. Therefore, it is possible to measure accurately the front edge of effective symbol of OFDM frame by correcting the frame synchronization timing by td1 defined above.



a) Single path case

IEC 2161/12



b) Multi path case

IEC 2162/12

Figure A.13 – Delay profile of OFDM signal

As shown in Figure A.13 b), in case of multi-path condition, each path is indicated separately, the delay of main path can be measured even though under multi-path condition.

Annex B
(informative)

Examples of measurement methods for signal quality of relay stations

B.1 BER

B.1.1 General

In this Annex, two measurement methods which are available during operation are explained.

For the methods to use PRBS signal, refer to IEC 62273-1 for details.

a) BER measurement using Null Packets.
b) Simplified method.

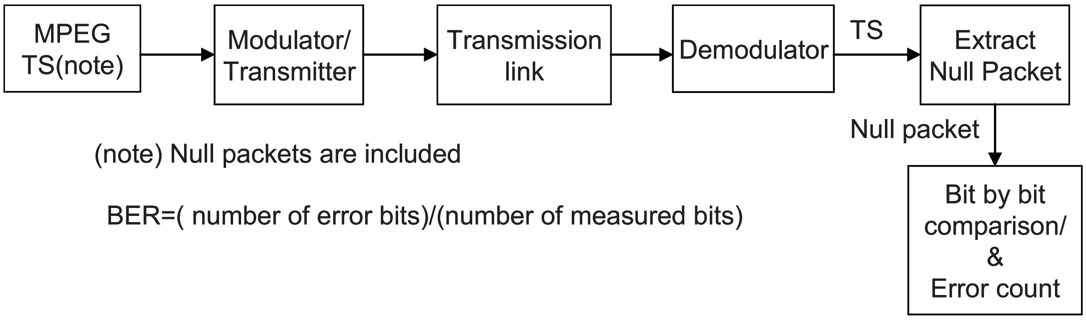
B.1.2 BER measurement using Null Packets

In digital terrestrial broadcasting, null packets are inserted into Transport Stream (TS) to adjust transmission data rate. Null Packets are not used for information data transmission, therefore, data area of Null Packets can be used for BER measurement.

In Table B.1, an example of Null Packets is shown.

Table B.1 – Definition of Null Packet (in case of ISDB-T)

Syntax	No. of bits	Value
Null_transport_packet () }		
Sync_byte	8	“01000111”
Transport _error_indicator	1	“0”
Payload_unit_start_indicator	1	“0”
Transport_priority	1	“0”
PID	13	“1111111111111”
Transport_scrambling_control	2	“00”
Adaptation_field_control	2	“01”
Continuity_counter	4	“0000”
For (i=0;i<N;I++){		
Data byte	8	“00000000”(note)
}		
}		
NOTE All “1” is also available.		



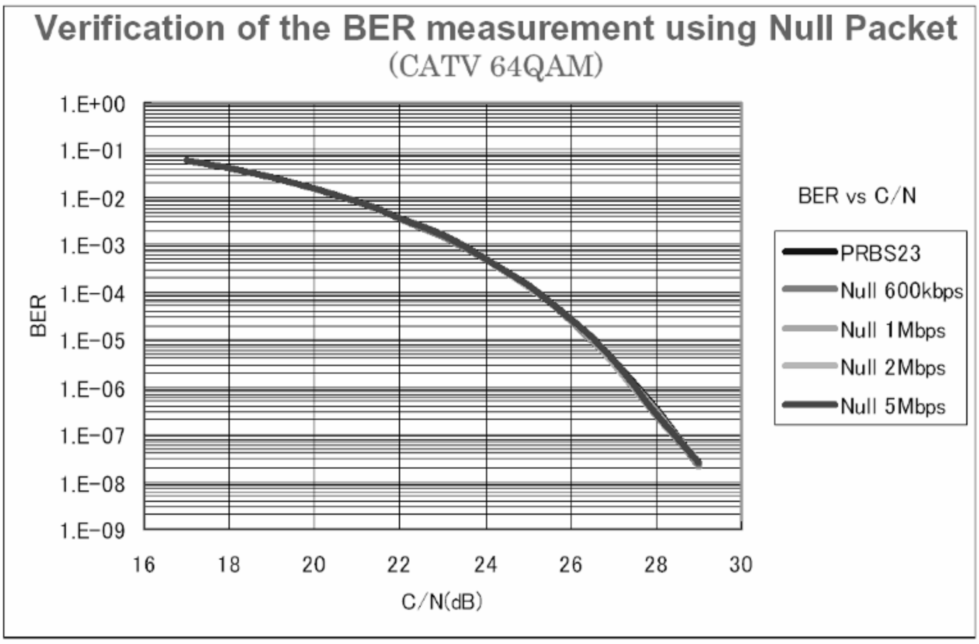
IEC 2163/12

Figure B.1 – BER measurement conceptual diagram for Null Packet method

As shown in Table B.1, data values of data byte area are known, it is possible to detect data error by making use of these data. Measurement diagram is shown in Figure B.1.

Figure B.2 shows the measurement result of BER by both PRBS method and Null Packets method.

As shown in Figure B.2, if the number of sample data is sufficient, Null Packets method gives reliable measurement results.



IEC 2164/12

Figure B.2 – Examples of measurement result by Null Packet method

But, usable number of bits for Null Packet method is few compared to PRBS method. Therefore, it needs a long period to measure BER by Null Packet method. For example, the number of samples in Null Packet data area is 10^5, it takes 10 s to get 10^6 samples.

Method to compare the data before correction and the data after correction: it is possible to measure BER by comparing the data before correction and the data after correction.

When all the error data are corrected by error correction circuit, the number of times of input and output data mismatch of error correction circuit is equal to the number of error bits.

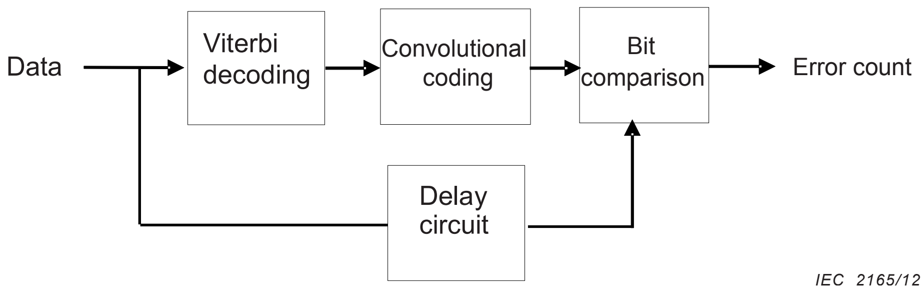
Therefore, BER is calculated by the following formula.

BER= number of mismatched bits)/ (number of total bits)

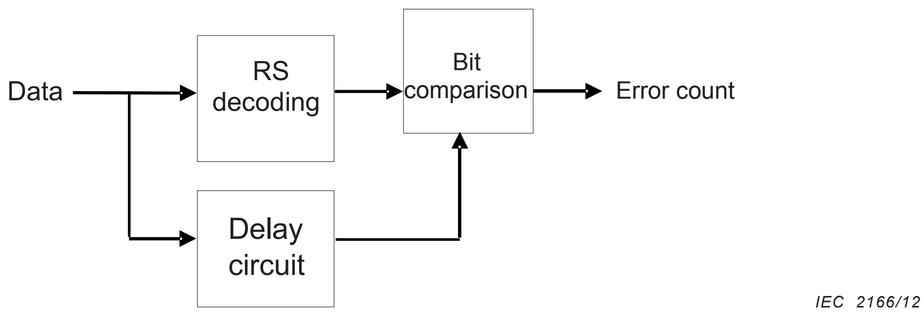
Two cases are shown in Figure B.3.

- For the BER measurement before Viterbi decoding, case a) is used, on the other hand,
- Case b) shows the BER measurement before RS decoding

Note that, in case that error correction process does not work correctly, the measured data by this method is not reliable.



a) BER measurement before Viterbi decoding



b) BER measurement before RS decoding

Figure B.3 – Method to compare the data before/after correction

B.2 END

B.2.1 General

As described in 6.3.2.1, END is calculated by making use of measured data of Superimposed C/N and inherent degradation of OFDM demodulator which are defined in 6.3.2.1.

In this annex, an example of measuring method for Superimposed C/N and inherent degradation of OFDM demodulator is shown.

B.2.2 Example of measuring method for Superimposed C/N

In this example, superimposed noise power is measured at the outside of the signal bandwidth by spectrum analyzer. Therefore, the following conditions should be satisfied for the measurement.

– The superimposed noise power should be measured at out-of-band as far as the noise is considered to be the same as that at in-band.
– Input signal level of a spectrum analyzer should be -40 dBm or more in order to make the noise generated in the analyzer relatively negligible.

a) Measurement system

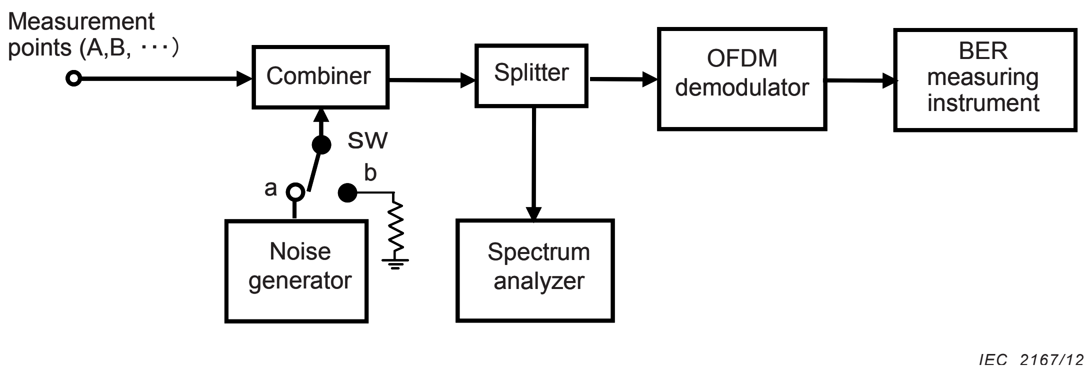


Figure B.4 – Superimposed C/N measurement system

b) Measurement of signal power and superimposed Gaussian noise power

1) Measurement of noise power (N_0) inherently contained in the signal

At first, measure the noise power contained in measured signal.

i) Turn the SW to the position “b” and set the marker of a spectrum analyzer at noise floor.

ii) Measure the noise power per 1Hz (dBm/Hz)

iii) Calculate noise power of Equivalent noise bandwidth (see note) according to the following formula:

NOTE Refer to IEC 62273-1 Table 3 for equivalent noise bandwidth of each system.

Noise power(No) (dBm) = Noise power/Hz(dBm/Hz) + $10\log_{10}$ (Equivalent noise Bandwidth(Hz))

As an example, the spectrum analyzer parameter set for 6MHz ISDB-T is shown in Table B.2 below.

Table B.2 – Example of noise power measurement parameters (6 MHz ISDB-T)

Center frequency	Span	RBW	VBW	Channel BW	Averaging
Center frequency of measured channel	10 MHz	100 kHz	1 kHz	5,6 MHz	30 times

2) Superimpose the Gaussian noise.
   i) Turn the SW to the position “a” and superimpose the Gaussian noise on the signal to be measured by using a noise generator.
   ii) Adjust the output level of the noise generator so that BER becomes 2×10^{-4} after Viterbi decoding.

In cases when the measurement should be done in operation, it is impossible to apply the usual BER measurement method defined in 6.3 of IEC 62273-1. In this situation, BER measurement methods defined in 6.3.1 of this standard shall apply.

3) Measurement of signal power (C_{meas}).
   i) Measure the power of the signal to be measured (C_{meas} (dBm)) using a spectrum analyzer.

As an example, the spectrum analyzer parameter set for 6MHz ISDB-T is shown in Table B.3 below.

Table B.3 – Example of signal power measurement parameters (6 MHz ISDB-T)

Center frequency	Span	RBW	VBW	Channel BW	Averaging
Center frequency of measured channel	10 MHz	30 kHz	300 kHz	5,6 MHz	30 times

4) Measurement of superimposed Gaussian noise power (N_{meas}).
   i) The parameter set of spectrum analyzer should be the same as that described in item 1) above.
   ii) Set the marker of a spectrum analyzer at noise floor of out-of-band.
   iii) Measure the noise power per 1 Hz (dBm/Hz).
   iv) Calculate superimposed noise power of Equivalent noise bandwidth by the same calculation process described in (1)i).

c) Correction of the signal power and the superimposed Gaussian noise power

The measured signal power of C_{meas} contains superimposed Gaussian noise power of N_{meas}.

In addition the measured N_{meas} also contains noise power of N_0. Hence, the correction signal power and superimposed noise power should be made according to following calculation process:.

$$C'_{meas}\text{ (dBm)} = 10\log_{10} (10\text{^} (C_{meas}/10) - 10\text{^} (N_{meas} /10))$$

$$N'_{meas}\text{ (dBm)} = 10\log_{10} (10\text{^} (N_{meas}/10) - 10\text{^} (N_0 /10))$$

where, C'_{meas} is the corrected signal power;

N'_{meas} is the corrected superimposed Gaussian noise power;

C_{meas} is the measured signal power, which contains $N_{meas;}$

N_{meas} is the measured superimposed Gaussian noise power, which contains $N_{0;}$

N_0 is the noise power inherently contained in the signal to be measured.

d) Calculation of superimposed C/N (CN_{add}(dB)

The superimposed C/N is calculated from the corrected signal power and noise power calculated in item c) above.

CN_{add} (dB) = C'_{meas}(dB) - N'_{meas}(dB)

B.2.3 An example of measuring method for inherent degradation due to OFDM demodulator

As described in 6.3.2, inherent degradation of OFDM demodulator may degrade END measurement accuracy. In order to improve the measurement accuracy, it is desirable to take it into account. The degree of the degradation can be measured by following process.

a) Measurement system

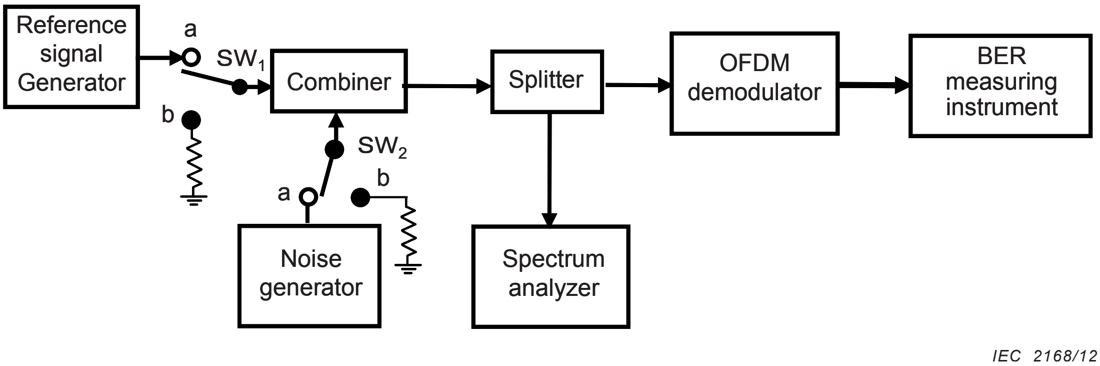


Figure B.5 – Inherent degradation of OFDM demodulator measurement system

b) Measuring method of CN_{fix}

1) Set a reference signal generator as shown in Figure B.5.
2) Turn the SW1 to the position "a" and turn the SW2 to the position "a". Adjust the output level of the noise generator so that BER becomes 2×10^{-4} after Viterbi decoding.
3) Turn the SW2 to the position "b" and measure the signal power (C_{meas} (dBm)) using a spectrum analyzer. Measurement method is the same as described in above item B.2.2 b) 3).

   In this case, it is not necessary to correct the measured value because the internal noise of the reference signal generator is as small as negligible.
4) Turn the SW1 to the position "b" and turn the SW2 to the position "a". Measure the superimposed Gaussian noise power (N_{meas}(dBm)). Measurement method is the same as described in above item B.2.2 b)4).
5) Calculate Superimposed C/N (CN_{add}(dB)) from the formula below.

   CN_{add}(dB) = $C_{meas} - N_{meas}$
6) Using the following formula, calculate the inherent noise degradation of OFDM demodulator(CN_{fix}(dB)).

   C/N_{fix} (dB) = −10log10 (10^ (−CN_r/10)−10^ (−CN_{add} /10))

where CN_r is the required C/N (dB).

B.3 Delay profile

The measurement of delay profile is necessary to estimate transmission characteristics and measure the received signal quality at the front end of relay station.

Denoting the received signal as $r(t)$, the ideal ISDB-T signal as $s(t)$, and the impulse response of the transmission path as $h(t)$, the following relationship holds.

$$r(t) = \int_{-\infty}^{\infty} s(t) h^*(t-\tau) d\tau \quad \text{(B.1)}$$

(The asterisk * indicates a conjugated complex number.) Furthermore, denoting the respective frequency characteristics as $R(j\omega)$, $H(j\omega)$ and $S(j\omega)$, the following relation also holds.

$$R(j\omega) = H(j\omega) \cdot S(j\omega) \quad \text{(B.2)}$$

Sample points of $H(j\omega)$ can be obtained from the pilot signal (SP: Scattered Pilot signal or CP: Continual Pilot signal) in the received signal and its ideal signal. Then, $h(t)$ can be obtained by Fourier transform of $H(j\omega)$. From $h(t)$, the delay profile $\tau(t)$ is obtained by using the following formula.

$$\tau(t) = 10 \ \log_{10} \left| h(t + t_D) \right|^2 \quad [\text{dB}] \quad \text{(B.3)}$$

Here, the time t_D at which $\left| h(t) \right|^2$ is maximum is taken as the timing of the desired wave.

In Figure B.6, the calculation process of delay profile is shown.

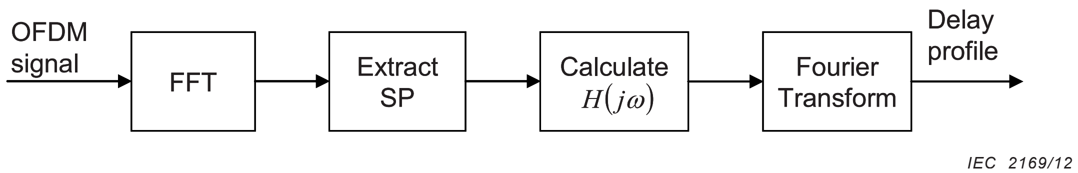


Figure B.6 – Calculation process of delay profile

Annex C
(normative)

Principle and methods of measurement of compensators

C.1 Loop-back canceller

C.1.1 Outline of loop-back canceller

For digital transmission network whose relay stations operate same frequency (Single Frequency Network), the input signal frequency and output signal frequency of broadcast signal relay station are the same; therefore, the loop-back interference may be caused by the coupling between the transmitting antenna and receiving antenna.

The loop-back canceller is an equipment to reduce the interference to an allowable level in order to avoid harmful degradation and oscillation.

Generally, loop-back canceller has a function to reduce the coupling loop interference. Signal process is as follows.

a) Calculate delay time, amplitude and phase, by analyzing received signal.
b) Generate a replica signal of coupling loop characteristics, by using the calculated parameters.
c) Reduce coupling loop interference signal, by subtracting replica signal from received signal.
d) Attenuate transmitting signal temporarily at oscillation.
e) Increase transmitting power slowly at re-start transmitting.

In case of unstable condition, attenuate transmitting signal level temporarily.

C.1.2 Methods of measurement for performances of loop-back canceller

The performance of loop-back canceller is defined as the improvement of the received signal quality under loop-back condition by making use of loop-back canceller.

Following is an example to measure its performances by END(or ENF) measurement. In this method, at first, measure the END(or ENF) with/without loop-back canceller, then calculate the difference of both END.

a) Measurement system

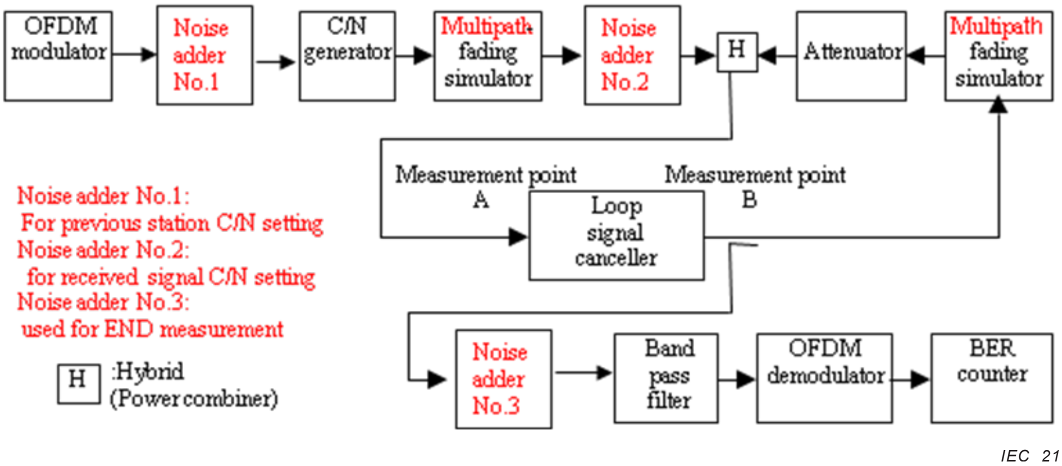


Figure C.1 – Example of measurement block diagram for performances of loop-back canceller

Figure C.1 shows an example of measurement diagram for evaluating the signal quality improvement by making use of a loop back canceller.

Noise adder No.1 is used for setting the C/N of output signal of previous station. Noise adder No.2 is used for setting the C/N of received signal of relay station.

Noise adder No.3 is used for setting the C/N of received signal at receiving point.

b) Measurement points

- A, B

c) Measurement method

1) Set C/N of output signal of previous station by noise adder No.1.
2) Set C/N of received input signal of measured station by noise adder No.2
3) Set D/U ratio of input signal and loop-back interference by D/U setting.
4) The loop-back canceller should be bypassed. Then measure END without loop-back canceller according to the measurement process defined in Clause B.2.

Connect point A and point B directly.

5) Next insert loop-back canceller, and measure END without loop-back canceller according to the measurement process defined in Clause B.2.
6) Calculate the difference of both ENDs which gives the END improvement by loop-back canceller.

C.2 Diversity reception equipment

C.2.1 Outline of equipment

For broadcast-wave relay networks, degradation might be caused by the multi-path and the fading of the propagation in reception signal from previous station.

The diversity reception equipment improves the quality of the transmission signal by receiving the transmitted signal from the previous station with two or more antennas, and combining each received signal appropriately.

As a diversity reception technology for OFDM signal, the maximum ratio combining for each sub carrier technology is the best system to obtain the highest improvement. This technology becomes popular for digital receivers.

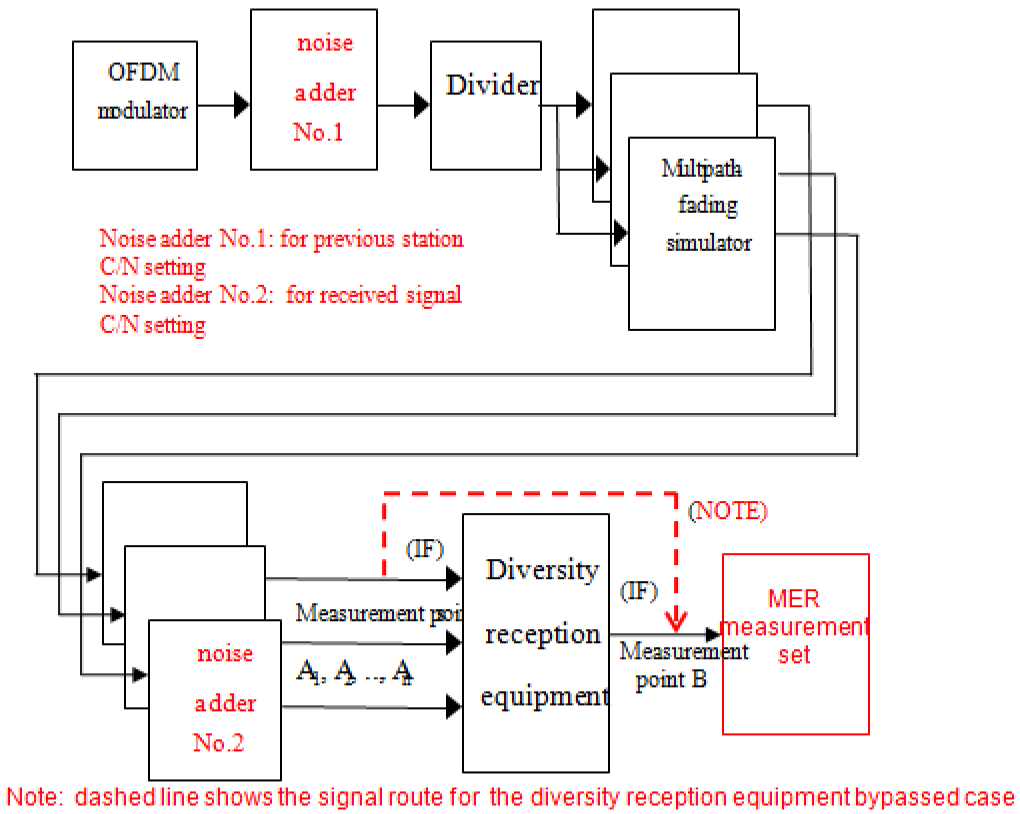
Following is an example of signal process of this technology, named processing in frequency domain.

a) Received OFDM signals of the each branches are transformed (FFT) to the career symbols (frequency domain signal).
b) The career symbols of all branches are combined at each sub-carrier of OFDM signals.
c) The coefficients of each career symbol of the OFDM signal are estimated from the quality of each received OFDM signal, and combined so that C/N of the signal becomes the highest, based on the maximal ratio combining technology.
d) Composite career symbols are processed by decision processing and then transformed (IFFT) to time domain signal. And add guard interval to the output signal of IFFT.

C.2.2 Methods of measurement for performances of diversity reception equipment

For evaluation of the performance of a diversity receiver, several measurement and evaluation methods exist. As an example, a simple method to measure the signal quality improvement by MER is introduced In this method, at first, measure the MER of 2 cases, with diversity reception equipment and without the diversity reception equipment, then calculate the difference of 2 MER measured data.

a) Measurement system



NOTE 3 When the input of diversity reception equipment is plural, an independent noise should be added respectively to each input of the diversity reception equipment.

Figure C.2 – Example of measurement block diagram for performances of diversity reception equipment

b) Measurement points

- A_1, A_2 ... A_n, B

c) Measurement/calculation method

1) Measure the reference MER(M_{in}(dB))
   - Bypass the diversity reception equipment (use dashed line for signal route).
   - Set the multi-path fading simulator for specified parameters.
   - Specified parameters: number of paths, fading pattern, Doppler frequency, delay time and D/U.
   - Measure the reference MER(M_{in}(dB)).
2) Measure the MER(M_{out}) with diversity reception equipment
   - Set the multi-path fading simulator for the same parameters as a).
   - Measure the MER(M_{out}(dB) with diversity reception equipment.
3) Calculate the improvement value by the following formula

   Improvement value(dB) = M_{out}(dB) – M_{in}(dB).

NOTE In this subclause, MER method is introduced as a simple method. If more details should be required, BER method is preferable. In this method, measure the C/N(dB) at which the BER becomes 2×10^{-4} for both without diversity equipment and with diversity equipment. Then calculate the improvement value as the difference of both values. Refer to Clause B.2 for C/N(dB)at which the BER becomes 2×10^{-4}.

C.3 Co-channel interference canceller

C.3.1 Outline of canceller

When some interference may exist at the same frequency band of digital broadcasting RF signal, degradation may be caused by interference.

The co-channel interference canceller improves the quality of the transmission signal by receiving the signal transmitted from the previous station with two or more antennas, and combining each received signal appropriately. As a result, the co-channel interference canceller makes null points to DOA (degree of arrival) of undesired signals.

Following is an example of signal process of this technology, named processing in frequency domain.

a) Received OFDM signals of each branch are transformed (FFT) to the career symbols (frequency domain signal).
b) The career symbols of all branches are combined at every subcarrier of OFDM signals.
c) Composite coefficient for career symbols of each branch is determined, based on MMSE calculation model, to minimize error of composite signal.

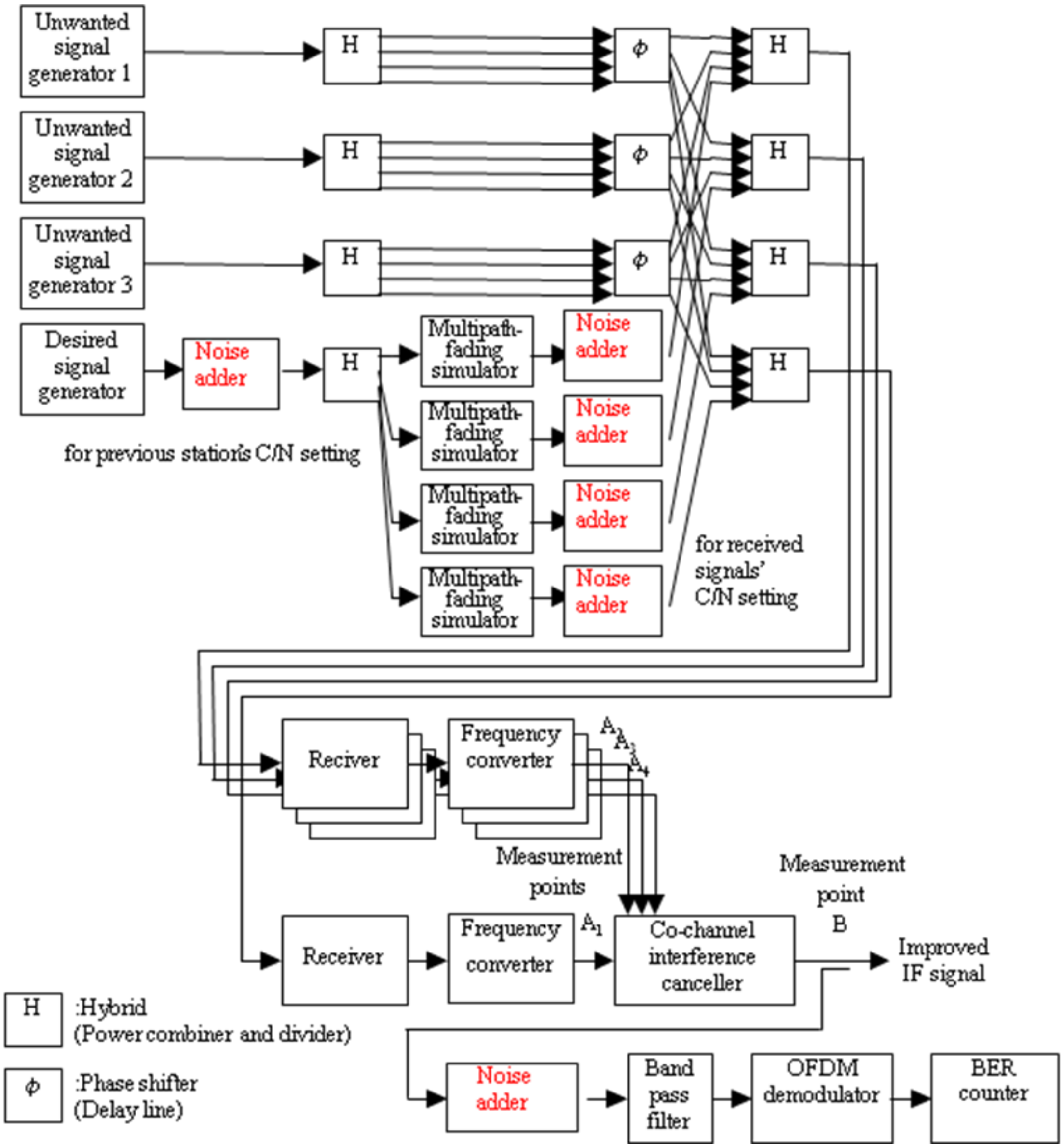
   NOTE MMSE: Minimum Mean Square Error.

d) Composite career symbols are processed decision processing and then transformed (IFFT) to time domain signal.
e) Add guard interval to the output signal of IFFT.

C.3.2 Measurement method for co-channel interference canceller (BER method)

NOTE 1 In this subclause, measuring methods are provided for rejection characteristics of the co-channel interference canceller for the measurement of diversity characteristics and equalizing characteristics of co-channel interference canceller, see Clause C.2s.

Figure C.3 shows the measurement system (example of 4 branch inputs).



IEC 2172/12

NOTE 1 Phase shifters (delay lines), which give one, two and three times of phase differences decided from the arrival direction, arrival of interference waves and antenna array spacing, should be prepared.

Length of delay line for branch 1 : α α: arbitrary cable length.

Length of delay line for branch 2 : α+β β

NOTE 2 Cable length decided by direction of arrival(DOA) and length of array spacing.

Length of delay line for branch 3 : α+2β

Length of delay line for branch 4 : α+3β β= array spacing × sin(DOA) × relative propagation velocity of delay line

NOTE 3 The common local signal should be used for all branches.

Figure C.3 – Example of measurement block diagram for performances of co-channel interference canceller

a) Measurement points

-A_1, A_2, A_3, A_4, B

b) Measurement method

1) The co-channel interference canceller is bypassed.

Measure the equivalent C/N (CN_{in}) without undesired signals (D/U=∞) at which the BER becomes 2×10^{-2}.

(In the case that inner code is operated, the BER above should be 2×10^{-4}.)

2) The co-channel interference canceller is enabled.

Measure the required C/N (CN_{out}) for every D/U and every direction of arrival (DOA) at which the BER becomes 2×10^{-2}.

(In the case that inner code is operated, the BER above should be 2×10^{-4}.)

3) Calculate ENF and/or END according to the calculation process defined in B.2.2.

NOTE 2 As another method, the performance can be measured by MER measurement. In this case, measure the MER instead of BER by MER measuring instrument.

C.4 C/N Reset equipment

C.4.1 Outline of equipment

The C/N Reset equipment is defined as the equipment to improve signal quality in relay station network by the following signal process.

a) Demodulate received signal from previous station.

b) After error correction, re-modulate and transmit re-modulated signal.

This type equipment is effective under certain conditions in which received signal quality is error free. Signal degradation caused at previous station and transmission path can be reset at the process of demodulation/re-modulation.

C.4.2 Measurement method for C/N Reset equipment

As described in C.4.1 above, C/N Reset equipment improves signal quality under error free receiving condition.

Therefore, as for the measurement of the limitation of lowest signal quality against Gaussian noise, the following measurement system may be used (Figure C.4).

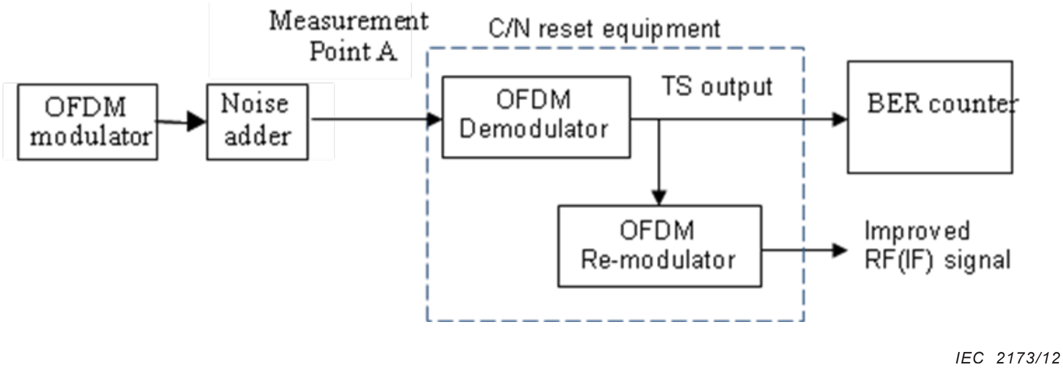


Figure C.4 – Example of measurement block diagram for performances of C/N Reset equipment

Measuring process is as follows:

Measure C/N at which the BER becomes 2×10^{-4} (at Viterbi decoder output).

a) Connect the output of the C/N Reset equipment to the BER counter.

b) Adjust the noise adder to get the BER of 2×10^{-4}.

c) Measure the C/N of the noise adder output.

For the measurement against some signal distortion such as multi-path, interference, etc., replace C/N generator to another equipment such as fading simulator, etc.

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