



ABSTRACT TEST PLAN

ATP-337

G.fast Certification Abstract Test Plan

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Executive Summary

This Broadband Forum Abstract Test Plan, ATP-337 Issue 2, provides a set of functional, stability and basic performance test cases and related pass/fail requirements for G.fast implementations according to ITU-T Recommendations G.9700 [1] and G.9701 [2].

The primary goal of ATP-337 Issue 2 is to provide a set of test cases and framework to verify interoperability between a G.fast Transceiver Unit at the Optical Network Unit (FTU-O) (e.g., a Distribution Point Unit [DPU]) and one or more FTU at the Remote site (FTU-Rs) (e.g., Customer Premise Equipments [CPEs]).

Issue 2 of ATP-337 serves as the test plan, including pass/fail requirements for each test case, for the Broadband Forum G.fast Certification Program. Technical content in this test plan includes test setup information, equipment configuration requirements, test procedures, and pass/fail requirements for each test case, through a reference to the full text within IR-337 Issue 2 [12]. The full IR-337 Issue 2 is available to Broadband Forum members in good standing, and may be downloaded from the [Broadband Forum website](#).

For additional details about the G.fast Certification Program, including requirements for participation in the program or to view the list of currently certified devices, please refer to the [Broadband Forum website](#).

1 Purpose and Scope

1.1 Purpose

ATP-337 Issue 2 provides a set of functional, stability and basic performance test cases and related pass/fail requirements for G.fast implementations according to ITU-T Recommendations G.9700 [1] and G.9701 [2].

The primary goal of ATP-337 Issue 2 is to provide a set of test cases and framework to verify interoperability between an FTU-O (e.g., a DPU) and one or more FTU-Rs (e.g., CPEs). The test cases are defined for a Device Under Test (DUT – either a DPU or CPE), tested against a Link Partner (either a CPE or DPU respectively). The DPU/CPE may be a reference design, however containing the necessary FTU-O/R and system functionality to execute this test plan (see e.g., section 4.2).

Issue 2 of ATP-337 serves as the test plan, including pass/fail requirements for each test case, for the Broadband Forum G.fast Certification Program. Additional documentation is available from the Broadband Forum about the G.fast Certification Program, including program benefits, participation requirements, number and type of equipment to be tested against, and logo usage guidelines. For additional details about the Broadband Forum’s certification programs, please refer to: <https://www.broadband-forum.org/testing-and-certification-programs>.

The reader is directed to the formal certification program documentation, which can be downloaded from the Broadband Forum’s public website, for a full description of the certification requirements and procedures.

Technical content in this test plan includes test setup information, equipment configuration requirements, test procedures, and pass/fail requirements for each test case. Specific manufacturer information for test and measurement equipment has not been included in this document, except in cases where the selection or use of alternate equipment could negatively impact the results of the testing.

1.2 Scope

This Abstract Test Plan is intended to provide a certification test plan for ITU-T Recommendation G.9700 “Fast access to subscriber terminals (G.fast) – Power spectral density specification” and G.9701 “Fast access to subscriber terminals (G.fast) – Physical layer specification”. This Issue 2 is specifically conceived for the basic interoperability objectives of the Broadband Forum G.fast Certification Program.

Issue 2 of ATP-337 is intended to address a common set of basic test scenarios that can apply to different deployments around the world. The test scenarios have been developed based on deployment scenarios in the Fiber to the Distribution Point (FTTdp) architecture as defined by Broadband Forum in TR-301 [5]. Test cases included in ATP-337 Issue 2 are intended to verify the interoperability between an FTU-O and an FTU-R (or multiple FTU-Rs) according to:

- Functionality of mandatory features within the ITU-T Recommendations G.9700 and G.9701,

- Basic performance between two or more transceivers,
- Stability and quality of the connection.

Operator-specific scenarios, including testing with loop types, lengths, or noise scenarios, that may be specific to a deployment, are outside the scope of ATP-337. This Test Plan is applicable to both single-port and multi-port DPUs; test cases applicable only to multi-port DPUs are clearly identified as conditional test cases.

This test plan is also applicable to implementations requiring Reverse Power Feed (RPF) e.g., according to ETSI TS 101 548-1 [11].

This test plan is not intended to replace operator pre-deployment testing, which may include additional tests for a given deployment.

1.3 Compliance Requirements

The tests contained in this document are intended to verify the interoperability between an FTU-R implementation and an FTU-O implementation, while also testing the DUT's compliance to the ITU-T specifications in some key functional areas, such as transmit power, upstream/downstream split ratios, etc. This test plan is not intended to validate completely a DUT's compliance to the ITU-T specifications. Instead these other key aspects of the specification are tested for interoperability with the link partner.

1.4 Test Plan Passing Criteria

The tests contained in this document are each marked with a test status, indicating: "mandatory," "conditional mandatory," or "optional." These terms are defined in section 2.3.

For the purpose of determining a summary result, such as indicating a device "passes ATP-337 Issue 2 testing," the device SHALL pass all "mandatory" tests and all applicable "conditional mandatory" tests. "Optional" tests SHALL NOT impact the summary result. For the purposes of certification, this test plan only defines the requirements for each individual test case, while the certification program might require passing additional tests or testing with multiple link partners to achieve certification. For some tests, parameters are recorded for reporting purposes only. These parameters might be useful for debugging purposes.

For certification of devices supporting multiple ITU-T G.9701 profiles, additional testing requirements may apply.

1.4.1 Test Plan Passing Criteria for Different ITU-T G.9701 Profiles

This clause specifies test pass criteria for devices supporting either a single or multiple ITU-T G.9701 profiles defined in [2]: 106a, 106c, 212a and 212c.

For devices under test, DPU or CPE, the following rules SHALL apply for the required testing and certification listing. These rules guide the general flow of testing, while the individual test status (Mandatory, Conditional Mandatory, and Optional) still apply to each specific test case.

1. Devices supporting a single ITU-T G.9701 profile, either 106a, 212a, 106c, or 212c, **MUST** complete all applicable test cases using that single profile. The profile used for testing **SHALL** be listed as part of the certification record.

2. Devices supporting both ITU-T G.9701 profile 106a and profile 212a **MUST** complete all applicable test cases using profile 212a, and additionally **MUST** complete the following test cases using profile 106a. The certification record **SHALL** list both profiles as certified.
 - a. Tests 6.2.1 through 6.2.6,
 - b. Test 8.1.1,
 - c. Tests 8.2.1 through 8.2.2.

3. Devices supporting both ITU-T G.9701 profile 106c and profile 212c **MUST** complete all applicable test cases using profile 212c, and additionally **MUST** complete the following test cases using profile 106c. The certification record **SHALL** list both profiles as certified.
 - a. Tests 6.2.1 through 6.2.5,
 - b. Test 8.1.2.

Table 1 lists the test cases required per ITU-T G.9701 profile.

Table 1 - Test cases required per ITU-T G.9701 profile

Test Case	Test Cases Required per ITU-T G.9701 Profile	
	106a / 212a	106c / 212c
6.1 Inventory Data Test	M	M
6.2.1 PSD Limit Mask Test	M	M
6.2.2 Sub-carrier Masking Test	M	M
6.2.3 PSD Shaping Test	M	M
6.2.4 RFI Notching Test	M	M
6.2.5 UPBO Test	M	M
6.2.6 TIGA Test	C	N/A
6.3.1 TDD Inter-frame Gap Test	M	M
6.3.2 DS and US ratio configuration (Mds) Test	M	M
6.4 Accelerated MTBE Test	M	M
6.5 Discontinuous Operation Test	O	O
6.6 Bit Swap Test	M	M
6.7 SRA Downshift Test	M	M
6.8 SRA Upshift Test	M	M
6.9 FRA & SRA Upshift Test	M	M

6.10 RPA Test	M	M
6.11 RMC Bit Loading Configuration Test	M	M
6.12.1 Short Disconnect Test	M	M
6.12.2 Long Disconnect Test with LOS Failure	M	M
6.12.3 Long Disconnect Test with LOR Failure	M	M
6.13 Dying Gasp Test	O	O
6.14 Increased Bit Loading Test	M	M
6.15 Test Parameters Test	M	M
7.1 SHINE Stability Test	M	M
7.2 REIN Stability Test	M	M
7.3 Fluctuating Broadband RFI Noise Present at Initialization Test	M	M
7.4 Stationary Broadband RFI Noise Present at Initialization Test	M	M
7.5 Fluctuating Broadband RFI Noise Present at Showtime Test	M	M
7.6 Stationary Broadband RFI Noise Present at Showtime Test	M	M
8.1.1 Single-line Basic Throughput Test over a copper wire pair	M	N/A
8.1.2 Single-line Basic Throughput Test over a coaxial cable	N/A	M
8.2.1 Multi-line Basic Throughput Test over copper wire pairs	C	N/A
8.2.2 Multi-line Disorderly Shutdown Test over copper wire pairs	C	N/A
<ul style="list-style-type: none"> • M: Mandatory Test Case • C: Conditional Mandatory Test Case, refer to test case for specific condition/requirement. • O: Optional Test Case • N/A: Not Applicable Test Case 		

1.4.2 Test Plan Passing Criteria for Devices Requiring RPF

Devices requiring RPF SHOULD comply to ETSI TS 101 548-1 [11], and in such case the DUT and its Link Partner SHALL support the same power class (SR1, SR2, or SR3) according to section 7.2 of [11]. Other RPF technologies might exist, but are not considered in the context of this document.

Due to the nature of RPF, some test cases might be impacted when testing some reversely powered DPU devices, as detailed below.

If the DPU requires RPF for operation, all test cases SHALL apply, except 6.12.1, 6.12.2, 6.12.3, and 6.13, according to the requirements of section 1.4.1. The test report SHALL explicitly indicate the tests were not run and state the applicable reason.

If the DPU supports a local power supply, in addition to RPF, and that supply can be utilized during testing, all test cases SHALL apply according to section 1.4.1. The test report SHALL explicitly state the local power source that was used to complete the testing.

2 References and Terminology

2.1 Conventions

In this Abstract Test Plan, several words are used to signify the requirements of the specification. These words are always capitalized. More information can be found in RFC 2119 [3].

SHALL	This word, or the term “REQUIRED”, means that the definition is an absolute requirement of the specification.
SHALL NOT	This phrase means that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the adjective “RECOMMENDED”, means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications need to be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase “NOT RECOMMENDED” means that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
MAY	This word, or the adjective “OPTIONAL”, means that this item is one of an allowed set of alternatives. An implementation that does not include this option SHALL be prepared to inter-operate with another implementation that does include the option.

2.2 References

The following references are of relevance to this Abstract Test Plan. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Abstract Test Plan are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

Document	Title	Source	Year
[1] G.9700	<i>Fast Access to Subscriber Terminals (G.fast) – Power spectrum density specification</i>	ITU-T	2017

[2]	G.9701	<i>Fast Access to Subscriber Terminals (G.fast) – Physical layer specification</i>	ITU-T	2017
[3]	RFC 2119	<i>Key words for use in RFCs to Indicate Requirement Levels</i>	IETF	1997
[4]	TR-114 Issue 3 Amendment 4	<i>VDSL2 Performance Test Plan – Issue 2</i>	Broadband Forum	2018
[5]	TR-301 Issue 2 Corrigendum 1	<i>Fiber To The Distribution Point</i>	Broadband Forum	2019
[6]	G.227	<i>Conventional Telephone Signal</i>	ITU-T	1998
[7]	RFC 791	<i>Internet Protocol</i>	IETF	1981
[8]	TR-285 Corrigendum 2	<i>Broadband Copper Cable Models</i>	Broadband Forum	2019
[9]	G.997.2	<i>Physical Layer OAM for G.fast</i>	ITU-T	2015
[10]	TS 101 388	<i>Asymmetric Digital Subscriber Line (ADSL) - European specific requirements - [ITU-T Recommendation G.992.1 modified]</i>	ETSI TC ATT M	2007
[11]	TS 101 548-1	<i>European Requirements for Reverse Powering of Remote Access Equipment; Part 1: Twisted pair networks, V2.2.1</i>	ETSI TC ATT M	2018
[12]	IR-337 Issue 2	<i>G.fast Certification Test Plan Issue 2</i>	Broadband Forum	2019
[13]	TR-124 Issue 5	<i>Functional Requirements for Broadband Residential Gateway Devices</i>	Broadband Forum	2019

2.3 Definitions

The following terminology is used throughout this Abstract Test Plan.

Conditional mandatory	Tests marked as “conditional mandatory” also include a conditional statement; which if met, indicates the test SHALL be considered as “mandatory.” If the conditional statement is not met, the test SHALL be considered as “optional” or “not applicable.”
Link Partner	Applicable device to connect to the test setup opposite the device under test (DUT). For example, if the DUT is a CPE device, the Link Partner is a DPU device.
Mandatory	Tests marked as “mandatory” SHALL be performed when completing testing according to this test plan.
Optional	Tests marked as “optional” MAY be completed at the request of the tester or equipment manufacturer.

2.4 Abbreviations

This Abstract Test Plan uses the following abbreviations:

AC	Alternating Current
AM	Amplitude Modulation
AGN	Additive Gaussian Noise
AWGN	Additive White Gaussian Noise
CPE	Customer Premises Equipment
DMT	Discrete Multi-Tone
DPU	Distribution Point Unit
DSL	Digital Subscriber Line
DTU	Data Transfer Unit
DUT	Device Under Test
ETR	Expected Throughput
FLR	Frame Loss Ratio
FM	Frequency Modulation
FRA	Fast Rate Adaptation
FTU	G.fast Transceiver Unit
FTU-O	FTU at the Optical Network Unit (i.e., operator end of the loop)
FTU-R	FTU at the Remote site (i.e., subscriber end of the loop)
GDR	Gamma Data Rate
G.fast	Fast access to subscriber terminals
HON	Higher Order Node
IL	Insertion Loss
LAN	Local Area Network
LOM	Loss of margin

LOR	Loss of RMC
LOS	Loss of signal
LPM	Limit PSD Mask
MAC	Media Access Control
MAE	Mean Absolute Error
MAXATP	Maximum Aggregate Transmit Power
MBW	Measurement Bandwidth
ME	Mean Error
MIB	Management Information Base
MTBE	Mean Time Between Error
NDR	Net Data Rate
NTP	Network Termination Point
OLR	On-line Reconfiguration
PSD	Power Spectral Density
psds/us	per sub-carrier downstream/upstream
REIN	Repetitive Impulse Noise
RF	Radio Frequency
RFI	Radio Frequency Interference
RMC	Robust Management Channel
RPA	RMC Parameter Adjustment
RPF	Reverse Power Feeding
SES	Severely Errored Second
SHINE	Single High Impulse Noise Event
SNRM	Signal to Noise Ratio Margin
SRA	Seamless Rate Adaptation
SSB-SC	Single-Sideband Suppressed-Carrier Modulation
TDD	Time Division Duplexing
TIGA	Transmitter Initiated Gain Adjustment
TXPSD	Transmitter Power Spectral Density
UAS	Unavailable Second
UDP	User Datagram Protocol
UPBO	Upstream Power Back-Off
VLAN	Virtual LAN
VTF	Voltage Transfer Function
WAN	Wide Area Network

3 Abstract Test Plan Impact

3.1 Energy Efficiency

ATP-337 Issue 2 has no impact on Energy Efficiency.

3.2 IPv6

ATP-337 Issue 2 has no impact on IPv6.

3.3 Security

ATP-337 Issue 2 has no impact on Security.

3.4 Privacy

Any issues regarding privacy are not affected by ATP-337 Issue 2.

4 Equipment Features

4.1 Device Under Test (DUT) and Link Partner information

Table 2 and Table 3 are intended to provide test engineers and readers of the test report with sufficient information about the DUT and the Link Partner in order to assure repeatability of results and to allow for accurate comparisons of reported test results. Table 4 and Table 5 provide additional information about the powering of the DPU. Powering of the DPU is not within the scope of certification, and the details are provided for informational purposes only and can be omitted from the test report if the DPU is locally powered.

The information defined in the tables SHALL be provided to the test engineer prior to the start of the testing and SHALL be included as part of the test report. All fields SHALL be populated; if an item is not applicable to the DUT or Link Partner, the item MAY be marked as “Not Applicable.”

Table 2 - DPU Information

FTU-O ITU-T G.994.1 vendor ID (FTUO_GHS_VENDOR)	8 binary octets. See section 7.13.1.1/G.997.2.
FTU-O version number (FTUO_VERSION)	Up to 16 binary octets. See section 7.13.1.3/G.997.2.
DPU system vendor ID (DPU_SYSTEM_VENDOR)	8 binary octets. See section 7.13.2.1/G.997.2.
DPU system serial number (DPU_SYSTEM_SERIALNR)	Up to 32 ASCII characters. See section 7.13.2.3/G.997.2.
DPU uplink interface speed	e.g., 1 Gbit/s for 1000BASE-TX

Table 3 - CPE Information

FTU-R ITU-T G.994.1 vendor ID (FTUR_GHS_VENDOR)	8 binary octets. See section 7.13.1.2/G.997.2.
FTU-R version number (FTUR_VERSION)	Up to 16 binary octets. See section 7.13.1.4/G.997.2.
NT system vendor ID (NT_SYSTEM_VENDOR)	8 binary octets. See section 7.13.2.2/G.997.2.
NT system serial number (NT_SYSTEM_SERIALNR)	Up to 32 ASCII characters as: <NT serial number><space> <NT model><space> <NT firmware version> See section 7.13.2.4/G.997.2.
CPE LAN port interface speed	e.g., 1 Gbit/s for 1000BASE-TX

Table 4 - DPU Powering Information

DPU primary power source (local/RPF/remote)	
DPU RPF specification	
DPU RPF power class (SR1, SR2 or SR3) (see section 7.2 of ETSI TS 101 548-1 [11])	

Table 5 - PSE Information (for RPF)

PSE formfactor (1-box or 2-box solution)	
PSE Product Name & Model (2-box solution)	
PSE power class (SR1, SR2 or SR3) (see section 7.2 of ETSI TS 101 548-1 [11])	

4.2 Management of the DUT and Link Partner

If the DUT is a DPU, the DUT SHALL support a DPU Northbound management protocol that allows the ability to configure and retrieve the G.997.2 managed objects used in this test plan. The management protocol is DUT vendor discretionary.

If the DUT is a CPE, the DUT is managed through the Distribution Point Unit Management Information Base (DPU-MIB) and the ITU-T G.9701 initialization/eoc/RMC. No Local Area Network (LAN)-side management protocol is required for the execution of this test plan, except as required to configure the CPE to pass Ethernet traffic between the G.fast and LAN interface(s).

5 Test Environments

This section contains all the specifications and information required for building the basic testing environment (e.g., test configurations, test setup characteristics, configuration settings of the Device Under Test (DUT) and the Link Partner, and setup of the simulated network environment) for G.fast test cases defined in this test plan. Test case-specific configuration settings are defined in their related section.

5.1 Test Configurations

5.1.1 Ethernet/IP Traffic Setup

The CPE and DPU SHALL support means to pass Ethernet/IP traffic through the G.fast link.

The DPU and CPE each SHOULD support the following requirements to enable these tests. Figure 1 shows the basic setup for passing Ethernet/IP traffic through the DPU and CPE device in a single line test. Figure 2 shows the basic setup for passing Ethernet/IP traffic through the DPU and CPE devices in a multi-line test.

Note: The Physical Layer Test Setup shown in Figure 1 and Figure 2 contains any specific test setup(s) or equipment that may be required within the G.fast link, such as a wireline loop simulator, noise generator, spectrum analyzer, etc. (see section 5.1.3)

The DPU SHOULD support:

1. Forwarding of Ethernet traffic between the G.fast interface(s) and the northbound Ethernet interface, based on Media Access Control (MAC) learning or Virtual LAN (VLAN) markings.

The CPE SHOULD support at least one of the following configurations:

1. IPv4 Bridging between the Wide Area Network (WAN) and LAN ports, as defined in TR-124 Issue 5 [13], WAN.BRIDGE.1.
2. IPv4 Port Forwarding between the WAN and LAN ports, as defined in TR-124 Issue 5 [13], LAN.PFWD.1. The CPE SHALL be configured for forward IPv4 traffic for UDP Port 1024 between the WAN and LAN.

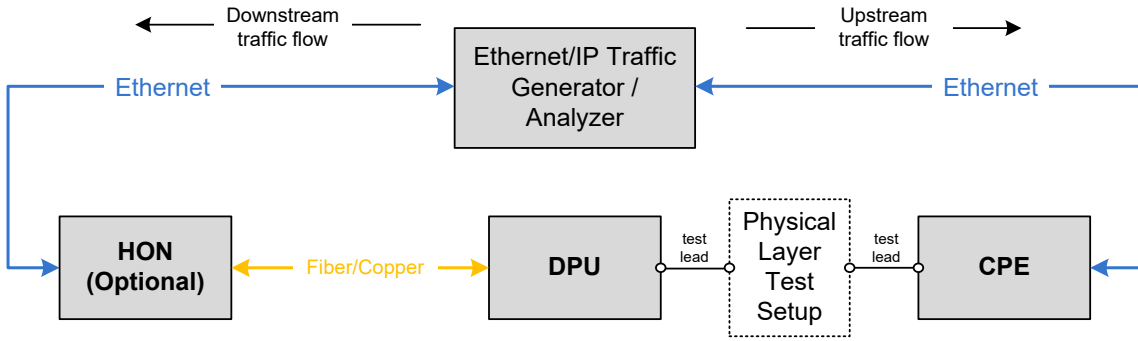


Figure 1 - Test setup for Ethernet/IP traffic with single line test

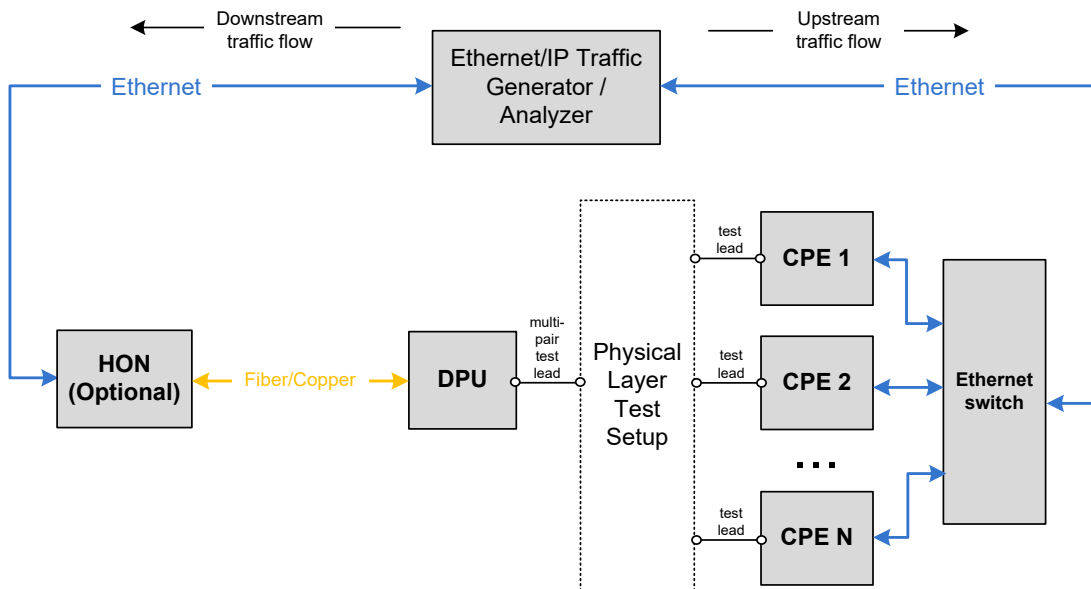


Figure 2 - Test setup for Ethernet/IP traffic with multi-line test

The test leads shown in Figure 1 and Figure 2 to connect the Physical Layer Test Setup to the DPU and CPE(s) SHALL be of 1 meter ± 2.5 cm length. For a multi-pair cable test setup, test leads SHALL be of type CAT5e or better. For a coaxial cable test setup, test leads SHALL be of type RG6 or better.

The Ethernet/IP Traffic Generator/Analyzer shown in Figure 1 and Figure 2 is not able to distinguish whether Ethernet frames are dropped in the DPU, the CPE, the High Order Node (HON), or the Ethernet switch. Hence, when verifying that no Ethernet frames are dropped in the DUT (e.g., in section 8.1.1), a background Frame Loss Ratio (FLR) of 4e-7, with a minimum of 5 dropped frames, is allowed as to not fail the DUT for frames dropped outside its control.

Note: An FLR of 4e-7 corresponds with about 10 dropped downstream frames and 3 dropped upstream frames when running Ethernet traffic at a 1 Gbit/s aggregate net data rate at the default 4:1 downstream:upstream split ratio for 5 minutes, with a frame size distribution as defined in section

5.1.2. This FLR of 4e-7 accomodates the cascading of up to 4 Ethernet interfaces (as shown in Figure 2), each at an FLR of 1e-7. A minimum of 5 dropped frames is allowed for the test to be statistically relevant given the measurement time.

For the test setup for Ethernet/IP traffic with multi-line test shown in Figure 2,

1. The purpose of the Ethernet Switch is to allow a single port to be used on the Ethernet traffic generator/analyzer for the CPE side testing. If multiple ports are used on the Ethernet traffic generator/analyzer, this switch may be eliminated.
2. If used, the Ethernet switch SHALL support a backplane switching speed so as not to limit the performance of the G.fast system, i.e., greater than the summation over all lines of the upstream and downstream G.fast net data rates.
3. The Ethernet connection between the switch and Ethernet traffic generator/analyzer link speed SHALL be 10 Gigabit Ethernet or better.

Test traffic SHALL be defined as Ethernet frames containing the headers shown in Table 6.

Table 6 - Ethernet/IP test frame definition

Ethernet Frame Header	VLAN Tag	IPv4 Header	UDP Header	Data Payload
MAC Destination/Source Addresses, etc.	Optional, downstream flow only	IPv4 Source/Destination Addresses, etc.	UDP Port, etc.	Pseudo-random bit pattern

The information listed in Table 7 SHALL be used to construct the Ethernet/IP frames used for testing. Fields not defined SHALL be calculated according to the appropriate standard (e.g., RFC791 [7] on IPv4) or SHOULD use well known and/or industry-default values. Frames received by the CPE LAN interface, for transmission in the upstream direction, SHALL NOT include a VLAN tag. Frames transmitted in the downstream direction MAY include a VLAN tag, if required by the HON and/or DPU.

Table 7 - Ethernet/IP frame parameter values

	Downstream Flow	Upstream Flow	Description
Ethernet Frame Header			
MAC Destination Address (Note 1)	MAC1	MAC2	Unicast MAC address, static for the duration of testing.
MAC Source Address	MAC2	MAC1	
VLAN Tag (Optional)			
TPID	0x8100	N/A	
VID	Based on equipment configuration.	N/A	
PCP	7	N/A	

DEI	0	N/A	
IPv4 Header			
IP Source	IP1	IP3 (Note 2)	Unicast IPv4 address. IP1 & IP2 SHOULD be globally routable, public IP addresses. IP3 MAY be a private IP address if the CPE is implementing port forwarding.
IP Destination	IP2 (Note 2)	IP1	
UDP Header			
UDP Source Port	1024	1024	
UDP Destination Port	1024	1024	
Payload			
Datagram Payload	PRBS	PRBS	Pseudo-random bit pattern filling remainder of frame bytes.
Note 1: The destination MAC address might be dependent on the configuration of the CPE.			
Note 2: For CPE devices supporting Bridge Mode, IP2 SHALL equal IP3.			

5.1.2 Ethernet Traffic Frame Sizes

The following describes the Ethernet traffic and frames sizes which SHALL be used within each test case described in this document, unless specified otherwise within the specific test case (e.g., where a single, fixed frame size is required).

A mix of Ethernet frame sizes SHALL be used during testing, with the mix of frames being evenly distributed according to the probabilities listed in Table 8.

Table 8 - Frame Size Distribution within Ethernet Traffic

Frame Size (bytes)	Probability
1566	0.050
1500	0.673
1024	0.088
256	0.014
70	0.175
Note: All Ethernet frame sizes being on the first byte of the Destination MAC Address and end on the last byte of the Frame Check Sequence (FCS).	

To calculate the total number of frames per second to transmit through a connection of a given bit-rate, the following calculations SHALL be used.

$$\text{Average_Frame_Size_of_Mix} \left(\frac{\text{bytes}}{\text{frame}} \right) = \left[\sum_{i=1}^M \text{frame_probability}(i) \times \text{frame_size}(i) \right]$$

For the Frame Size Distribution in Table 8, the Average_Frame_Size_of_Mix is 1194 bytes.

$$\text{Required_Frame_Rate} \left(\frac{\text{frames}}{\text{sec}} \right) = \left\lceil \frac{\text{Required_Throughput} \times \frac{1}{8}}{\text{Average_Frame_Size_of_Mix}} \right\rceil,$$

where Required_Throughput is in units of bits per second, and specified in each specific test case for a specific direction, upstream or downstream.

5.1.3 Physical Layer Test Setup

This section contains the specifications and information required for building the basic physical layer testing environment for G.fast test cases defined in this test plan. Different configurations and settings needed for specific test cases are defined in the related section.

One instance of a physical layer test setup is shown in Figure 3, i.e., the instance for the test loop topology (defined in section 5.4.1) with noise injection. Where the noise is injected (at the DPU-side or at the CPE-side or at each side of the loop) is specified in each specific test case where noise injection is part of the test setup. If noise injection is not part of the test setup in a specific test case, then the High Z injection MAY still be connected to the test loop, but the noise source SHALL be switched off.

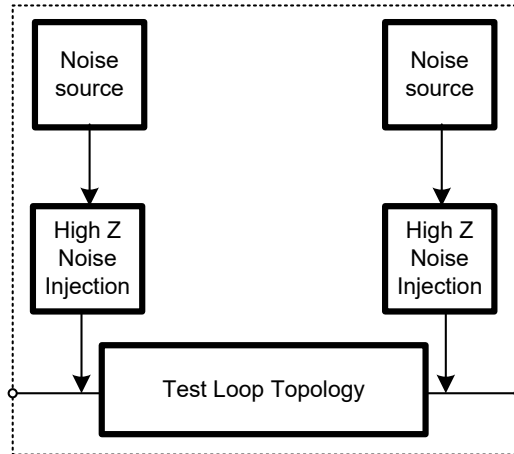


Figure 3 - One instance of a Physical Layer Test Setup (test loop topology and noise injection)

The requirements for High Impedance (Z) noise injector are specified in section 5.4.3. The requirements for the cable plant or line simulator are specified in section 5.4.1. The intended physical layer tests require one noise injection active per direction as there could be a different noise characteristic for DPU and for CPE.

Another instance of a physical layer test setup is shown in Figure 4, i.e., the instance for the PSD Test Jig (defined in section 5.4.2) or the TIGA Test Jig (defined in section 5.4.3) or the Test Loop

Topology (defined in section 5.4.1) with a measurement system. The measurement point should be as close as possible to the G.fast interface at the DUT. The measurement system and where it is connected (at the DPU or at the CPE) is specified in each specific test case where a measurement system is part of the test setup.

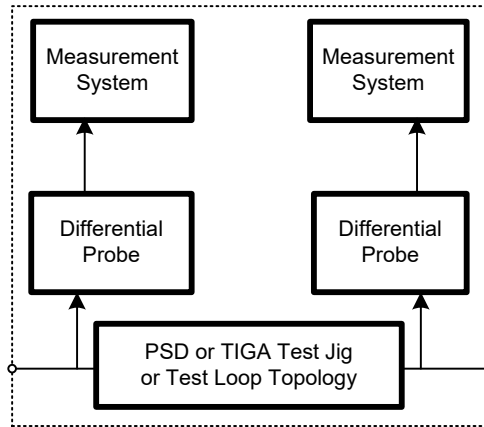


Figure 4 - One instance of a Physical Layer Test Setup (PSD or TIGA Test Jig or Test Loop Topology and measurement system)

5.2 Test Setup Characteristics

Test results obtained as a result of testing performed in accordance with ATP-337 Issue 2 SHALL contain the information described in sections 5.2.1 and 5.2.2.

5.2.1 Temperature and Humidity

The ranges of temperature and humidity of the test facility, over the entire time tests are conducted, SHALL be recorded in a manner similar to that shown in Table 9 and SHALL be included as part of the test report. The temperature SHOULD be within 21±5 °C. The humidity SHOULD be between 5% and 85%.

Table 9 - Temperature and Humidity Range of Test Facility

Parameter	High	Low
Temperature		
Humidity		

5.2.2 Loops Environment Characteristics

The test loops SHALL be recorded in a manner similar to that shown in Table 10 and SHALL be included as part of the test report.

Table 10 - Loops used for Testing

Loop	Cable type, wire gauge and length Cable or Crosstalk Emulator manufacturer and model number

A (coaxial or multi-pair) cable or multi-pair crosstalk emulator description SHALL be included as part of the test report. For a multi-pair cable, this description SHALL indicate the total number of pairs, the number and size of binders, and how each binder is structured. For a multi-pair crosstalk emulator, this description SHALL indicate the total number of pairs and any other information relevant to describe it.

5.3 Device Under Test (DUT) and Link Partner Settings

This section defines the values for all configuration parameters defined in G.997.2 with one default value per configuration parameter. Unless specified otherwise for an individual test case, the G.fast configuration parameter values defined in this section SHALL be used.

For a given service deployment, other configuration parameter values than these default values may be more appropriate.

5.3.1 Profile Settings

The profile SHALL be configured as defined in Table 11. The ITU-T G.9701 profiles are defined in Table 6-1 of ITU-T G.9701.

Table 11 - ITU-T G.9701 profile configuration

Configuration Parameter	G.997.2 reference	Default value
ITU-T G.9701 profiles enabling (PROFILES)	7.1.0.1	Only one profile allowed (see section 1.4)

5.3.2 Time Division Duplexing (TDD) Settings

The TDD SHALL be configured as defined in Table 12.

Table 12 - TDD configuration

Configuration Parameter	G.997.2 reference	Default value
Symbol periods per TDD frame (MF)	7.1.1.1	36
Symbol periods per TDD frame dedicated for downstream transmission (Mds)	7.1.1.2	28
Cyclic Extension (CE)	7.1.1.3	10

5.3.3 Power and Spectrum Usage Settings

The power spectrum usage SHALL be configured as defined in Table 13.

Table 13 - Power spectrum usage configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream maximum aggregate transmit power (MAXATPds)	7.1.2.1	4 dBm (106a, 212a) 2 dBm (106c, 212c)
Upstream maximum aggregate transmit power (MAXATPus)	7.1.2.2	4 dBm (106a, 212a) 2 dBm (106c, 212c)
Downstream sub-carrier masking (CARMASKds)	7.1.2.3	No masked sub-carriers
Upstream sub-carrier masking (CARMASKus)	7.1.2.4	No masked sub-carriers
Downstream PSD mask (MIBPSDMASKds)	7.1.2.5	Limit PSD mask defined in ITU-T G.9700
Upstream PSD mask (MIBPSDMASKus)	7.1.2.6	Limit PSD mask defined in ITU-T G.9700
RFI bands (RFIBANDS)	7.1.2.7	No RFI bands (no PSD reduction)
International Amateur Radio bands (IARBANDS)	7.1.2.8	All IAR bands disabled (no PSD reduction)
Upstream power back-off reference PSD (UPBOPSDA)	7.1.2.9	40 dBm/Hz (1)
Upstream power back-off reference PSD (UPBOPSDB)	7.1.2.10	0 dBm/Hz (1)
Upstream electrical length (UPBOKL)	7.1.2.11	0 dB
Force electrical length (UPBOKLF)	7.1.2.12	false (not forced)
UPBO reference electrical length per band (UPBOKLREF)	7.1.2.13	0 (special value)
Note: These values imply that UPBO is disabled.		

5.3.4 Noise Margin (SNRM) Settings

The noise margins SHALL be configured as defined in Table 14.

Table 14 - Noise margin configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream target noise margin (TARSNRMds)	7.1.3.1	6 dB
Upstream target noise margin (TARSNRMus)	7.1.3.2	6 dB
Upstream maximum noise margin (MAXSNRMus)	7.1.3.3	511 (special value)
Downstream minimum noise margin (MINSNRMds)	7.1.3.4	0 dB
Upstream minimum noise margin (MINSNRMus)	7.1.3.5	0 dB

5.3.5 Seamless Rate Adaptation (SRA) Settings

The SRA SHALL be configured as defined in Table 15.

Table 15 - SRA configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream upshift noise margin (SRA-USNRMds)	7.1.4.1	7 dB
Upstream upshift noise margin (SRA-USNRMus)	7.1.4.2	7 dB
Downstream minimum time interval for upshift SRA (SRA-UTIMEds)	7.1.4.3	8 seconds
Upstream minimum time interval for upshift SRA (SRA-UTIMEus)	7.1.4.4	8 seconds
Downstream downshift noise margin (SRA-DSNRMds)	7.1.4.5	5 dB
Upstream downshift noise margin (SRA-DSNRMus)	7.1.4.6	5 dB
Downstream minimum time interval for downshift SRA (SRA-DTIMEds)	7.1.4.7	2 seconds
Upstream minimum time interval for downshift SRA (SRA-DTIMEus)	7.1.4.8	2 seconds

5.3.6 Fast Rate Adaptation (FRA) Settings

The FRA SHALL be configured as defined in Table 16.

Table 16 - FRA configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream FRA time window (FRA-TIMEds)	7.1.5.1	8 logical frames
Upstream FRA time window (FRA-TIMEus)	7.1.5.2	8 logical frames
Downstream FRA minimum percentage of degraded tones (FRA-NTONESds)	7.1.5.3	50 %

Upstream FRA minimum percentage of degraded tones (FRA-NTONESus)	7.1.5.4	50 %
Downstream FRA number of uncorrectable DTU (FRA-RTXUCds)	7.1.5.5	150
Upstream FRA number of uncorrectable DTU (FRA-RTXUCus)	7.1.5.6	150
Downstream vendor discretionary FRA triggering criteria (FRA-VENDISCds)	7.1.5.7	false (disabled)
Upstream vendor discretionary FRA triggering criteria (FRA-VENDISCus)	7.1.5.8	false (disabled)

5.3.7 Robust Management Channel (RMC) Settings

The RMC SHALL be configured as defined in Table 17.

Table 17 - RMC configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream target noise margin for RMC (TARSNRM-RMCds)	7.1.6.1	9 dB
Upstream target noise margin (TARSNRM-RMCus)	7.1.6.2	9 dB
Downstream minimum noise margin for RMC (MINSNRM-RMCds)	7.1.6.3	3 dB
Upstream minimum noise margin for RMC (MINSNRM-RMCus)	7.1.6.4	3 dB
Downstream maximum bit loading for RMC (MAXBL-RMCds)	7.1.6.5	6 bits
Upstream maximum bit loading for RMC (MAXBL-RMCus)	7.1.6.6	6 bits

5.3.8 Vectoring Settings

If the DUT or Link Partner is a multi-port DPU supporting operation over a copper wire pair, then the vectoring SHALL be configured as defined in Table 18.

Table 18 - Vectoring configuration for multi-port DPU

Configuration Parameter	G.997.2 reference	Default value
FEXT cancellation enabling/disabling downstream (FEXT_TO_CANCEL_ENABLEds)	7.1.7.1	true (enabled)
FEXT cancellation enabling/disabling upstream (FEXT_TO_CANCEL_ENABLEus)	7.1.7.2	true (enabled)

5.3.9 Re-initialization Policy Settings

The re-initialization policy SHALL be configured as defined in Table 19.

Table 19 - Re-initialization policy configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream <i>los</i> defect persistency (LOS_PERSISTENCYds)	7.1.8.1	0.2 seconds
Upstream <i>los</i> defect persistency (LOS_PERSISTENCYus)	7.1.8.2	0.2 seconds
Downstream <i>lom</i> defect persistency (LOM_PERSISTENCYds)	7.1.8.3	2 seconds
Upstream <i>lom</i> defect persistency (LOM_PERSISTENCYus)	7.1.8.4	2 seconds
Downstream <i>lor</i> defect persistency (LOR_PERSISTENCYds)	7.1.8.5	0.2 seconds
Upstream <i>lor</i> defect persistency (LOR_PERSISTENCYus)	7.1.8.6	0.2 seconds
Downstream re-initialization time threshold (REINIT_TIME_THRESHOLDds)	7.1.8.7	10 seconds
Upstream re-initialization time threshold (REINIT_TIME_THRESHOLDus)	7.1.8.8	10 seconds
Downstream low ETR threshold (LOW_ETR_THRESHOLDds)	7.1.8.9	20 seconds
Upstream low ETR threshold (LOW_ETR_THRESHOLDus)	7.1.8.10	20 seconds

5.3.10 Update of Test Parameters Settings

The update of test parameters settings SHALL be configured as defined in Table 20.

Table 20 - Update of test parameters configuration

Configuration Parameter	G.997.2 reference	Default value
Update request flag for near-end test parameters (UPDATE-NE-TEST)	7.1.9.1	false (no update forced)
Update request flag for far-end test parameters (UPDATE-FE-TEST)	7.1.9.2	false (no update forced)

5.3.11 Data Rates Settings

The data rates settings for the downstream channel and the data rates settings for the upstream channel SHALL be configured as defined in Table 21.

Table 21 - Downstream and upstream channel data rates configuration

Configuration Parameter	G.997.2 reference	Default value
Maximum Net Data Rate (MAXNDR)	7.2.1.1	1 500 000 kbit/s
Minimum Expected Throughput (MINETR)	7.2.1.2	518 kbit/s
Maximum Gamma Data Rate (MAXGDR)	7.2.1.3	1 500 000 kbit/s
Minimum Gamma Data Rate (MINGDR)	7.2.1.4	518 kbit/s

5.3.12 Retransmission Settings

The downstream retransmission settings and the upstream retransmission settings SHALL be configured as defined in Table 22.

Table 22 - Downstream and upstream retransmission configuration

Configuration Parameter	G.997.2 reference	Default value
Maximum delay (DELAYMAX)	7.2.2.1	10 msec
Minimum impulse noise protection against SHINE (INPMIN_SHINE)	7.2.2.2	0 symbol periods
SHINE ratio (SHINERATIO)	7.2.2.3	0 %
Minimum impulse noise protection against REIN (INPMIN_REIN)	7.2.2.4	0 symbol periods
REIN Inter-arrival time (IAT_REIN)	7.2.2.5	100 Hz
Minimum Reed-Solomon RFEC/NFEC ratio (RNRATIO)	7.2.2.6	0
RTX-TC testmode (RTX_TESTMODE)	7.2.2.7	false (disabled)

5.3.13 Data path settings

The data path settings SHALL be configured as defined in Table 23.

Table 23 - Data path configuration

Configuration Parameter	G.997.2 reference	Default value
TPS-TC testmode (TPS_TESTMODE)	7.3.1	false (disabled)
DRA testmode (DRA_TESTMODE)	7.3.2	false (disabled)

5.4 Test Setup

For testing of DUT and Link Partner using RPF, the test setup SHALL support operation with power supplied towards the DPU by the PSE.

5.4.1 Test Loop Topologies

The end-to-end network extends from the DPU to the CPE.

An end-to-end network based on multi-pair cable includes the following segments: 1) Patch, 2) Multi-Pair Cable, 3) Isolated Drop Wire, 4) Network Termination Point (NTP), and 5) In Premises Wiring. For the convenience of test setups, this end-to-end network SHALL be partitioned into 2 separate topologies: the Multi-Pair Cable Test Loop Topology (defined in section 5.4.1.1) and the Home Network Bridged Tap Test Loop Topology (defined in section 5.4.1.2).

An end-to-end network based on coaxial cable includes the following segments: 1) Network-side diplexer, 2) Patch, 3) Coaxial Cable, and 4) Premises-side diplexer. For the convenience of test setups, this end-to-end network SHALL be partitioned into 2 separate topologies: coax configuration without diplexers (defined in section 5.4.1.3) and coax configuration with diplexers (defined in section 5.4.1.4).

5.4.1.1 Multi-Pair Cable Test Loop Topology

The Multi-Pair Cable Test Loop Topology is shown in Figure 5. This topology is partitioned into two parts, i.e., the Patch and the Multi-Pair Cable. The Patch is the wiring of the loop that physically resides at the DP. For the purpose of this test plan, the Patch SHALL be a direct pass through (i.e., the Patch length SHALL be set to 0 meter). The Multi-Pair Cable SHALL be real cable or simulated cable.

The test setup of any Multi-Line test case is accommodated by this topology with an appropriate choice of Multi-Pair cable length(s).

Single-Line test cases SHALL use a single pair from the Multi-Pair Cable. All unused pairs SHALL be terminated at both sides of the loop with an 100 Ohm reference load.

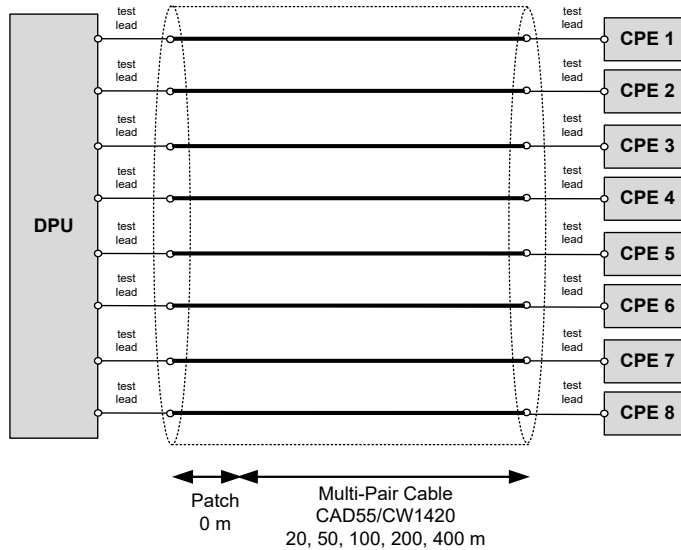


Figure 5 - Multi-Pair Cable Test Loop Topology

Test leads to connect the Multi-Pair Cable to the DUT and link partner (see also Figure 1 and Figure 2) SHALL be 1 meter ± 2.5 cm in length and SHALL be of type CAT5e or better. At DPU side, the test leads MAY share the same cable, with crosstalk between the test leads. At CPE side, isolation between the test leads SHALL be as defined in section 5.4.5.6.

The “Multi-Pair Cable” is a path which is part of the general distribution network. For the purpose of this test plan, the “Multi-Pair Cable” SHALL be realized through the following cable type and cable lengths.

Multi-Pair Cable type:

- CAD55/CW1420

Multi-Pair Cable lengths (not including the test leads):

- 20 meters,
- 50 meters,
- 100 meters,
- 200 meters,
- 400 meters (Note).

The cable type CAD55 is a 4-pair cable of 0.5mm wire and 100 Ohm impedance, defined in TR-285 [8] Annex A. The Multi-Pair Cable (real cable or simulated cable) SHOULD have a similar characteristic as the cable model specified in TR-285 [8] Annex A. The equivalent real cable type is CW1420. For testing with up to 8 pairs with real cable, the Multi-Pair Cable SHALL consist of two 4-pair cables run in parallel adjacent to each other. The test report shall include access to the per pair attenuation and pair-to-pair crosstalk coupling of the multi-pair test loop used.

Note: The ITU-T G.9701 Recommendation is optimized to operate over wire-pairs up to approximately 250 m of 0.5 mm diameter. However, it is capable of operation over copper wire pairs up to at least 400 meters of 0.5 mm diameter, subject to some performance limitations. Therefore,

performance pass/fail criteria defined in this test plan are more relaxed at 400m than at the other loop lengths.

5.4.1.1.1 Cable Accuracy

The CW1420 cable used for testing SHALL meet the following accuracy requirements. For tests requiring 8 wire pairs, both CW1420 cables SHALL meet the following accuracy requirements.

At least one pair SHALL achieve an $MAE \leq 1\text{dB}$ for each of the loop lengths defined in section 5.4.1.1, where the MAE is defined in Equation (1) below. This pair SHALL be selected as the pair with an attenuation measurement falling closest to the arithmetic average (at all frequencies where the theoretical loop attenuation is less than A_{MAX}) of the attenuation measurements of all 4 pairs within the CW1420 cable. The attenuation measurement SHALL be carried out in the in-band Limit PSD Mask (LPM) frequency range (f_{r1} , f_{r2}) defined in clause 7.2.1.1 of ITU-T G.9700 [1] (Note). It SHALL include everything (also connectors, e.g., RJ45) between the points where the test leads are connected to the physical layer test setup described in Figure 2.

Note: In-band LPM for 106 MHz profiles is defined for frequencies between 2 and 106 MHz and between 2 and 212 MHz for 212 MHz profiles.

$$MAE_{LoopX} = \frac{1}{N_i} \sum_{i \in \{A_{Ti} \leq A_{MAX}\}} |A_{Ri} - A_{Ti}|, \quad (1)$$

where

A_{Ri} = Attenuation sample, in dB, of the measured loop X,
 A_{Ti} = Attenuation sample, in dB, of the theoretical loop X, and
 A_{MAX} SHALL be equal to 70dB.

The A_{Ti} values SHALL be calculated according to the models defined in TR-285.

The index “i” belongs to a set defined by the points necessary to measure the attenuation in steps of 50kHz or less and taking into account only those measurement points for which $A_T \leq A_{MAX}$ dB.

N_i is the number of elements in the above set.

Due to the construction of the CW1420, it is expected the other pairs SHOULD have MAEs satisfying the following requirements for each of the loop lengths defined in section 5.4.1.1:

- 1) At least 2 of the 3 remaining pairs will have an $MAE \leq 5$ dB.
- 2) The final remaining pair will have an $MAE \leq 10$ dB.

All single pair testing defined within this test plan SHALL use the pair identified with an $MAE \leq 1$ dB within the CW1420 cable, which SHALL meet the above accuracy requirements. Additionally, care SHOULD be taken in the construction of any physical cable plant to minimize the impacts of cross-talk between cables or loop lengths, which might negatively impact the operation of G.fast systems under test.

5.4.1.2 Home Network Bridged Tap Test Loop Topology

The Home Network Bridged Tap (HNBT) Test Loop Topology is shown in Figure 6. This topology is partitioned into two parts, i.e., the Isolated Drop Wire and the In Premises Wiring, separated by the Network Termination Point (NTP reference point). The In Premises Wiring topology SHALL be a star configuration consisting of 4 bridged taps and one branch to the CPE, all connected at the NTP.

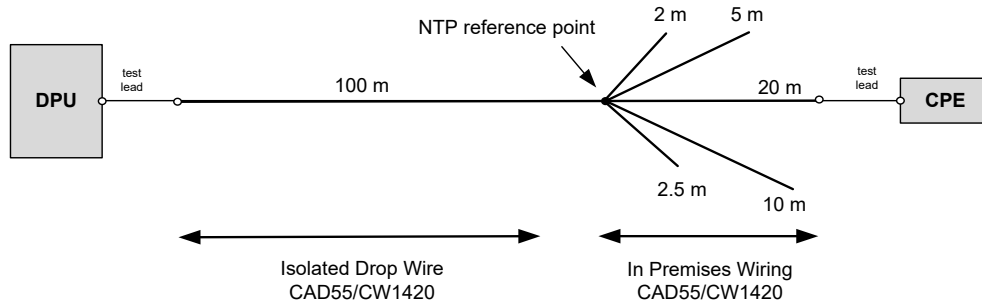


Figure 6 - Home Network Bridged Tap Test Loop Topology

Test leads to connect the test loop to the DUT and link partner (see also Figure 1 and Figure 2) SHALL be 1 meter \pm 2.5 cm in length and SHALL be of type CAT5e or better.

The “Isolated Drop Wire” (see Figure 6) represents the individual subscriber drop wires. For the purpose of this test plan, the “Isolated Drop Wire” SHALL be realized by using a single pair within the following cable type and cable lengths.

Isolated Drop Wire Cable Type:

- CAD55/CW1420

Isolated Drop Wire Cable length (not including the test lead):

- 100 meters

Any unused pairs within the cable SHALL be terminated with 100 Ohm reference impedances.

For the purpose of this test plan, the “In Premises Wiring” SHALL be realized using a single pair within the following cable type and cable lengths.

In Premises Wiring Cable Type:

- CAD55/CW1420

Bridged Tap Lengths from the NTP:

- 2 meters
- 2.5 meters
- 5 meters
- 10 meters

CPE Branch Length from the NTP (not including the test lead):

- 20 meters

Any unused pairs within the cable SHALL be terminated with 100 Ohm reference impedances.

Each bridged tap SHALL be unterminated. The crosstalk isolation between any of bridged taps and between any bridged tap and the branch to the CPE SHALL be as defined in section 5.4.5.6.

5.4.1.3 Coax Configuration Without Diplexers

The coax configuration without diplexers is shown in Figure 7. This topology is partitioned into two parts, i.e., the Patch and the Coaxial Cable. The Patch is the wiring of the loop that physically resides at the DP. For the purpose of this test plan, the Patch SHALL be a direct pass through (i.e., the Patch length SHALL be set to 0 meter). The Cable Cable SHALL be real cable or simulated cable.

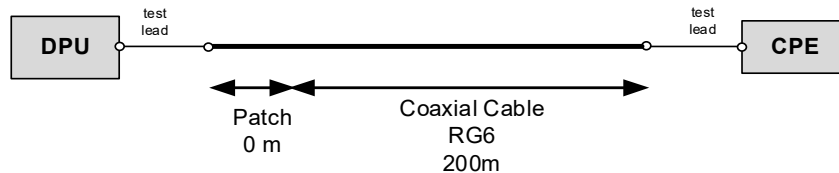


Figure 7 - Coax configuration without diplexers.

Test leads to connect the Coaxial Cable to the DUT and link partner (see also Figure 1 and Figure 2) SHALL be 1 meter \pm 2.5 cm in length and SHALL be of type RG6 or better.

The “Coaxial Cable” is a path which is part of the general distribution network. For the purpose of this test plan, the “Coaxial Cable” SHALL be realized through the following cable type and cable lengths.

Coaxial Cable type:

- RG6

Coaxial Cable lengths (not including the test leads):

- 100 meters,
- 200 meters.

The RG6 type coax SHALL BE as defined in TR-285 Annex D. All connectors SHALL be F-type. Polyethylene foam SHALL be used for coax insulation; the center conductor may be copper-clad steel. The test report shall include access to the cable attenuation of the coaxial cable test loop used.

5.4.1.3.1 Coax Cable Accuracy

The RG6 coaxial cable used for testing SHALL meet the following accuracy requirements.

The typical Insertion Loss (IL) is defined in TR-285 Amendment 1 [8] Annex D for the RG-6 Cable. The required range of accuracy is +/- 1 dB from the typical IL for frequency range below 100MHz and linearly interpolate to a bound of +/- 3dB from the typical IL for frequency at and above 200MHz as shown in Table 1 and Table 2. The measured IL (dB) of the RG6 cable used in the certification SHALL fall within the MIN IL (dB) and MAX IL (dB) range for each of the key frequency points listed in the tables below.

Table 24 - Accuracy Requirements for 100m RG-6

100m RG-6	MIN IL (dB)	TYP IL (dB)	MAX IL (dB)
1 MHz	0	0.66	1.66
10 MHz	0.97	1.97	2.97
50 MHz	3.59	4.59	5.59
100 MHz	5.56	6.56	7.56
200 MHz	6.18	9.18	12.18
400 MHz	11.10	14.10	17.10

Table 25 - Accuracy Requirements for 200m RG-6

200m RG-6	MIN IL (dB)	TYP IL (dB)	MAX IL (dB)
1 MHz	0.32	1.32	2.32
10 MHz	2.94	3.94	4.94
50 MHz	8.18	9.18	10.18
100 MHz	12.12	13.12	14.12
200 MHz	15.36	18.36	21.36
400 MHz	25.2	28.2	31.2

5.4.1.4 Coax Configuration With Diplexers

The coax configuration with diplexers is shown in Figure 8. This topology is partitioned into two parts, i.e., the Patch and the Coaxial Cable. The Patch is the wiring of the loop that physically resides at the DP. For the purpose of this test plan, the Patch SHALL be a direct pass through (i.e., the Patch length SHALL be set to 0 meter). The Cable Cable SHALL be real cable or simulated cable.

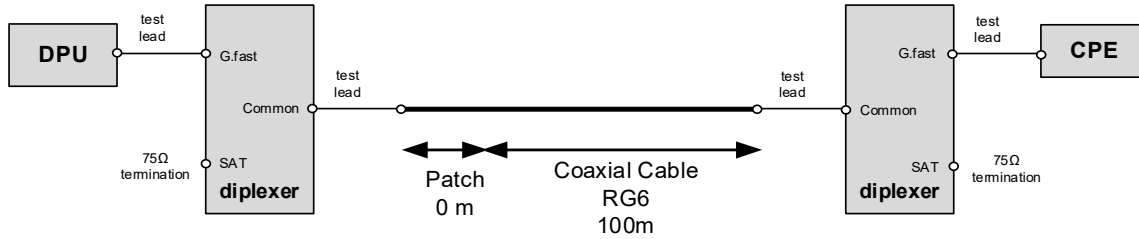


Figure 8 - Coax configuration with diplexers.

Test leads to connect the diplexers to the DUT and link partner (see also Figure 1 and Figure 2) and to connect the Coaxial Cable to the diplexers SHALL be 1 meter ± 2.5 cm in length and SHALL be of type RG6 or better.

The “Coaxial Cable” is a path which is part of the general distribution network. For the purpose of this test plan, the “Coaxial Cable” SHALL be realized through the following cable type and cable lengths.

Coaxial Cable type:

- RG6

Coaxial Cable lengths (not including the test leads):

- 100 meters,

The RG6 type coax SHALL be as defined in TR-285 Annex D. Both diplexers SHALL have identical characteristics as defined in TR-285 Annex D. All connectors SHALL be F-type. Polyethylene foam SHALL be used for coax insulation; the center conductor may be copper-clad steel. The test report shall include access to the cable attenuation of the coaxial cable test loop used and to the attenuation of the diplexers used.

5.4.1.4.1 Diplexer Accuracy

The diplexers used for testing SHALL meet the following accuracy requirements.

Insertion Loss (IL in dB) between Common Port and G.fast Port:

- IL < 5 dB for 30 kHz < f < 430 kHz;
 - IL > 40 dB for 2.1 MHz < f < 2.5 MHz;
 - IL < 4 dB for 5 MHz < f < 6 MHz;
 - IL < 2 dB for 6 MHz < f < 212 MHz;
 - IL < 2.5 dB for 212 MHz < f < 806 MHz;
 - IL > 40 dB for f > 950 MHz;
- where IL is undefined for other frequencies.

Return Loss (RL in dB), with all unused ports terminated with 75 Ohms:

- Common Port: RL > 10 dB for 2.1 MHz < f < 2.5 MHz;

$RL > 10 \text{ dB}$ for $5 \text{ MHz} < f < 212 \text{ MHz}$;
 $RL > 10 \text{ dB}$ for $950 \text{ MHz} < f < 2150 \text{ MHz}$;
 where RL is undefined for other frequencies.

G.fast Port: $RL > 8.5 \text{ dB}$ for $5 \text{ MHz} > f > 20 \text{ MHz}$;
 $RL > 10 \text{ dB}$ for $20 \text{ MHz} > f > 212 \text{ MHz}$.
 where RL is undefined for other frequencies.

If Reverse Power Feed is used in a test, the diplexer SHALL pass DC current with a voltage drop of less than 0.5 Vdc and a maximum of 500 mA current between Common Port and G.fast Port. The diplexer SHALL block DC current between other ports.

5.4.2 PSD Test Jig

The PSD Test Jig is shown in Figure 9. The PSD Test Jig is a flat attenuator that allows the DUT to transmit at its full power (no power back off) and has the advantage of being very well matched to the design impedance R_v , which limits the reflection of power into the measurement.

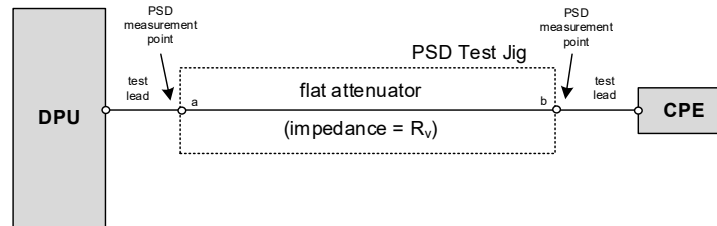


Figure 9 - PSD Test Jig

With a multi-pair cable Physical Layer Test Setup, $R_v = 100 \text{ Ohms}$.

With a coaxial cable Physical Layer Test Setup, $R_v = 75 \text{ Ohms}$.

Test leads to connect the PSD Test Jig to the DUT and link partner (see also Figure 1 and Figure 2) SHALL be 1 meter \pm 2.5 cm in length. Multi-pair test leads SHALL be of type CAT5e or better. Coaxial cable test leads SHALL be of type RG6 or better.

The PSD Test Jig SHALL have the following characteristics at the terminals a and b (see Figure 9). The test report shall include access to the attenuation of the PSD Test Jig used.

5.4.2.1 Input Return Loss

The input return loss of the PSD Test Jig SHALL meet the following requirements:

- For $f \leq 50 \text{ MHz}$: Return Loss $\geq 30 \text{ dB}$;
- For $50 \text{ MHz} < f \leq 250 \text{ MHz}$: Return Loss $\geq 24 - 20 \log_{10}(f / 100 \text{ MHz})$.

The input return loss at a given terminal SHALL be measured with an R_v reference load impedance at the other terminal. This requirement SHALL apply to both twisted pair (100 Ohm reference) and coax (75 Ohm reference) systems.

Note: The above requirement provides a maximum impedance mismatch within the measurement band (DC to 212MHz) of approximately ± 5 Ohms for a 100 Ohm reference impedance / system. This return loss requirement is based on a CAT6 RJ45 style connectors being used within the PSD Test Jig.

5.4.2.2 Voltage Transfer Function

For each direction $a \rightarrow b$ and $b \rightarrow a$, the voltage transfer function (VTF) SHALL be between $VTF_MIN = -20dB$ and $VTF_MAX = -17dB$ for all frequencies from 138 kHz to 240 MHz.

The VTF SHALL be measured with an R_v reference source impedance at the transmit terminal and an R_v reference load impedance at the other terminal.

5.4.3 TIGA Test Jig

The TIGA Test Jig is shown in Figure 10 for the downstream direction. The TIGA Test Jig and measurement point are reversed for the upstream direction. The TIGA Test Jig allows the DUT to transmit at its full power (no power back off) and has the advantage of being well matched to the design impedance, which limits the reflection of power into the measurement. The TIGA Test Jig also allows insertion of FEXT at a level that triggers the Transmitter Initiated Gain Adjustment (TIGA) functionality (see section 6.2.5).

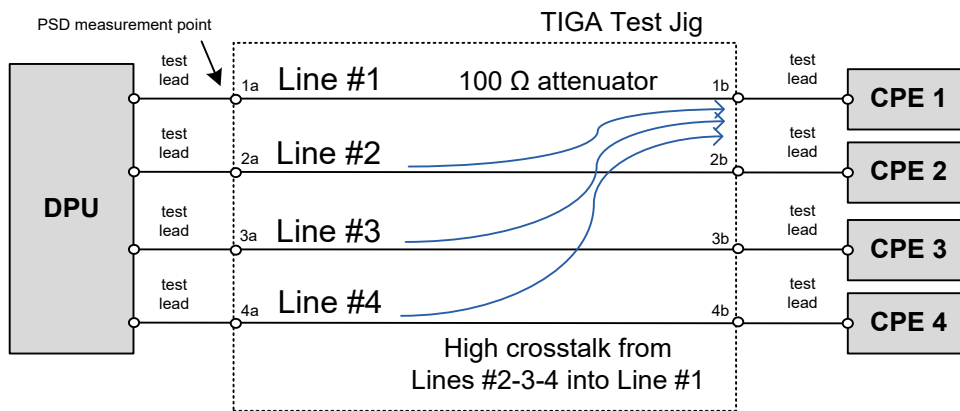


Figure 10 - TIGA Test Jig for the downstream direction

Test leads to connect the TIGA Test Jig to the DUT and link partner (see also Figure 1 and Figure 2) SHALL be 1 meter \pm 2.5 cm in length and SHALL be of type CAT5e or better. At DPU side, the test leads MAY share the same cable, with crosstalk between the test leads. At CPE side, isolation between the test leads SHALL be as defined in section 5.4.5.6.

The TIGA Test Jig characteristics SHALL have the following characteristics amongst the 8 terminals 1a/2a/3a/4a and 1b/2b/3b/4b (see Figure 10). The test report shall include access to the attenuation and pair-to-pair crosstalk coupling of the TIGA Test Jig used.

5.4.3.1 Input Return Loss

At each terminal [n]a and [n]b (with [n]=1 to 4), the input return loss (with the other terminals terminated with an 100 Ohm reference load) SHALL meet the following requirements:

- For $f \leq 50$ MHz: Return Loss ≥ 24 dB;
- For $50 \text{ MHz} < f \leq 250$ MHz: Return Loss $\geq 18 - 20 \log_{10}(f / 100 \text{ MHz})$.

The input impedance at a given terminal SHALL be measured with an 100 Ohm reference load impedance at all other terminals.

Note 1: The input impedance tolerance of the TIGA Test Jig is taken into account for ITU-T G.9700 PSD Limit Mask verification by allowing for a tolerance of 1 dB above the PSD Limit Mask specified in ITU-T G.9700 (see section 6.2.6.7).

Note 2: The TIGA Test Jig cannot be used for the Transmit PSD verification tests defined in sections 6.2.1 to 6.2.5. A PSD Test Jig is defined for that purpose in section 5.4.2.

5.4.3.2 Direct Path VTF

For each direction [n]a→[n]b and [n]b→[n]a (with [n]=1 to 4), the direct path voltage transfer function (VTF) SHALL be higher than the VTF_MIN and lower than the VTF_MAX defined in Table 26.

The direct path VTF SHALL be measured with an 100 Ohm reference source impedance at the transmit terminal and an 100 Ohm reference load impedance at all other terminals.

Table 26 - MIN and MAX limits for direct path VTF

f [kHz]	VTF_MIN [dB]	VTF_MAX [dB]
138	-20	-17
1000	-20	-17
10000	-23	-17
30000	-36	-17
60000	-36	-23
120000	-36	-23
240000	-39	-26
Note: Values between the breakpoints SHALL be interpolated on a linear VTF/ $\log_{10}(f)$ scale.		

5.4.3.3 ELFEXT

For each direction $[n]a \rightarrow [1]b$ and $[n]b \rightarrow [1]a$ (with $[n]=2$ to 4), the Equal Length Far-end Crosstalk (ELFEXT) SHALL be higher than the ELFEXT_MIN and lower than the ELFEXT_MAX defined in Table 27. The ELFEXT $a \rightarrow b$ is defined as the $[n]a \rightarrow [1]b$ FEXT VTF divided by the $[1]a \rightarrow [1]b$ direct path VTF. The ELFEXT $b \rightarrow a$ is defined as the $[n]b \rightarrow [1]a$ FEXT VTF divided by the $[1]b \rightarrow [1]a$ direct path VTF.

The FEXT VTF SHALL be measured with an 100 Ohm reference source impedance at the transmit terminal and an 100 Ohm reference load impedance at all other terminals.

Table 27 - MIN and MAX limits for ELFEXT

f [kHz]	ELFEXT_MIN [dB] Line#2 -> Line#1	ELFEXT_MAX [dB] Line#2 -> Line#1	ELFEXT_MIN [dB] Line#3 -> Line#1 Line#4 -> Line#1	ELFEXT_MAX [dB] Line#3 -> Line#1 Line#4 -> Line#1
138	N/A	-49	N/A	-49
1000	N/A	-32	N/A	-35
10000	-38	-12	-41	-15
30000	-9	-3	-12	-6
60000	-3	0	-6	-3
120000	0	3	-3	0
240000	3	6	0	3
Note: Values between the breakpoints SHALL be interpolated on an linear ELFEXT/ $\log_{10}(f)$ scale.				

5.4.3.4 NEXT VTF

For each terminal pair $[n]a \rightarrow [1]a$ (with $[n]=2$ to 4), the NEXT VTF SHALL be lower than -30dB.

The NEXT VTF SHALL be measured with an 100 Ohm reference source impedance at the transmit terminal and an 100 Ohm reference load impedance at all other terminals.

5.4.4 Noise Models

The following noise definitions are used for testing within this document, with a single noise definition applying to testing both 106 MHz and 212 MHz profiles.

5.4.4.1 Stationary Noise

5.4.4.1.1 Flat Noise

Flat Noise is defined as Additive White Gaussian Noise (AWGN) that extends from 138 kHz to 240 MHz.

Note: The AWGN extends to 240 MHz so that it is not discontinuous at the 212 MHz boundary of the ITU-T G.9700/G.9701 signal spectrum.

The Flat Noise PSD levels are defined in the test setup section of the specific tests using Flat Noise.

Over the 138 kHz to 120 MHz frequency range, the Mean Absolute Error (MAE, see section 5.4.6.1) of the Flat Noise SHALL be less than or equal to 0.5 dB. Over the 120 MHz to 240 MHz frequency range, the MAE of the Flat Noise SHALL be less than or equal to 1 dB.

5.4.4.1.2 Band-limited Noise

Band-limited Noise is defined as Additive Gaussian Noise (AGN) that extends from 2 MHz to 240 MHz with a PSD as defined in this section.

NOTE 1 – The AGN extends to 240 MHz so that it is not discontinuous at the 212 MHz boundary of the ITU-T G.9700/G.9701 signal spectrum.

NOTE 2 – The noise bands are only defined between 2 MHz and 106 MHz, due to the noises use within specific test cases with longer loops (i.e., 100m), where the noise bands combined with the loop attenuation would cause zero bits to be loaded within those bands thereby preventing the desired operation of the test cases. In the case of the BLN_RPA noise files, it is extremely unlikely, given a 100m loop, a system would allocation RMC bits to tones above 106 MHz.

Six Band-limited Noises are defined (referred to as BLN-Type1 to BLN-Type6, see Figure 11 and Figure 12).

For Band-limited Noise of Type 1, the PSD (referred to as PSD_{BLN1}) is defined as follows:

$$\begin{aligned}
 PSD_{BLN1} = & \quad -140 \text{ dBm/Hz for } 2 \text{ MHz} \leq f \leq 50 \text{ MHz} \\
 & \quad -119 \text{ dBm/Hz for } 50 \text{ MHz} < f \leq 60 \text{ MHz} && \text{(noise band 1)} \\
 & \quad -140 \text{ dBm/Hz for } 60 \text{ MHz} < f \leq 70 \text{ MHz} \\
 & \quad -119 \text{ dBm/Hz for } 70 \text{ MHz} < f \leq 80 \text{ MHz} && \text{(noise band 2)} \\
 & \quad -140 \text{ dBm/Hz for } 80 \text{ MHz} < f \leq 240 \text{ MHz}
 \end{aligned}$$

For Band-limited Noise of Type 2, the PSD (referred to as PSD_{BLN2}) is defined as follows:

$$\begin{aligned}
 PSD_{BLN2} = & \quad -140 \text{ dBm/Hz for } 2 \text{ MHz} \leq f \leq 50 \text{ MHz} \\
 & \quad -139 \text{ dBm/Hz for } 50 \text{ MHz} < f \leq 60 \text{ MHz} && \text{(noise band 1)} \\
 & \quad -140 \text{ dBm/Hz for } 60 \text{ MHz} < f \leq 70 \text{ MHz} \\
 & \quad -99 \text{ dBm/Hz for } 70 \text{ MHz} < f \leq 80 \text{ MHz} && \text{(noise band 2)} \\
 & \quad -140 \text{ dBm/Hz for } 80 \text{ MHz} < f \leq 240 \text{ MHz}
 \end{aligned}$$

For Band-limited Noise of Type 3, the PSD (referred to as $PSD_{BLN_RPA_1}$) is defined as follows:

$$\begin{aligned}
 PSD_{BLN_RPA_1} = & \quad -115 \text{ dBm/Hz for } 2 \text{ MHz} \leq f \leq 28 \text{ MHz} \\
 & \quad -140 \text{ dBm/Hz for } 28 \text{ MHz} < f \leq 240 \text{ MHz} && \text{(RPA noise band 1)}
 \end{aligned}$$

For Band-limited Noise of Type 4, the PSD (referred to as $PSD_{BLN_RPA_2}$) is defined as follows:

$$PSD_{BLN_RPA_2} = \begin{cases} -140 \text{ dBm/Hz} & \text{for } 2 \text{ MHz} \leq f \leq 28 \text{ MHz} \\ -115 \text{ dBm/Hz} & \text{for } 28 \text{ MHz} < f \leq 54 \text{ MHz} \\ -140 \text{ dBm/Hz} & \text{for } 54 \text{ MHz} \leq f \leq 240 \text{ MHz} \end{cases} \quad (\text{RPA noise band 2})$$

For Band-limited Noise of Type 5, the PSD (referred to as $PSD_{BLN_RPA_3}$) is defined as follows:

$$PSD_{BLN_RPA_3} = \begin{cases} -140 \text{ dBm/Hz} & \text{for } 2 \text{ MHz} \leq f \leq 54 \text{ MHz} \\ -115 \text{ dBm/Hz} & \text{for } 54 \text{ MHz} < f \leq 80 \text{ MHz} \\ -140 \text{ dBm/Hz} & \text{for } 80 \text{ MHz} \leq f \leq 240 \text{ MHz} \end{cases} \quad (\text{RPA noise band 3})$$

For Band-limited Noise of Type 6, the PSD (referred to as $PSD_{BLN_RPA_4}$) is defined as follows:

$$PSD_{BLN_RPA_4} = \begin{cases} -140 \text{ dBm/Hz} & \text{for } 2 \text{ MHz} \leq f \leq 80 \text{ MHz} \\ -115 \text{ dBm/Hz} & \text{for } 80 \text{ MHz} < f \leq 120 \text{ MHz} \\ -140 \text{ dBm/Hz} & \text{for } 120 \text{ MHz} < f \leq 240 \text{ MHz} \end{cases} \quad (\text{RPA noise band 4})$$

Over the 2 MHz to 120 MHz frequency range (excluding a 500 kHz guard band centered around the noise step frequencies), the Mean Absolute Error (MAE, see section 5.4.6.1) of the Band-limited Noise SHALL be less than or equal to 0.5 dB. Over the 120 MHz to 240 MHz frequency range, the MAE of the Band-limited Noise SHALL be less than or equal to 1 dB.

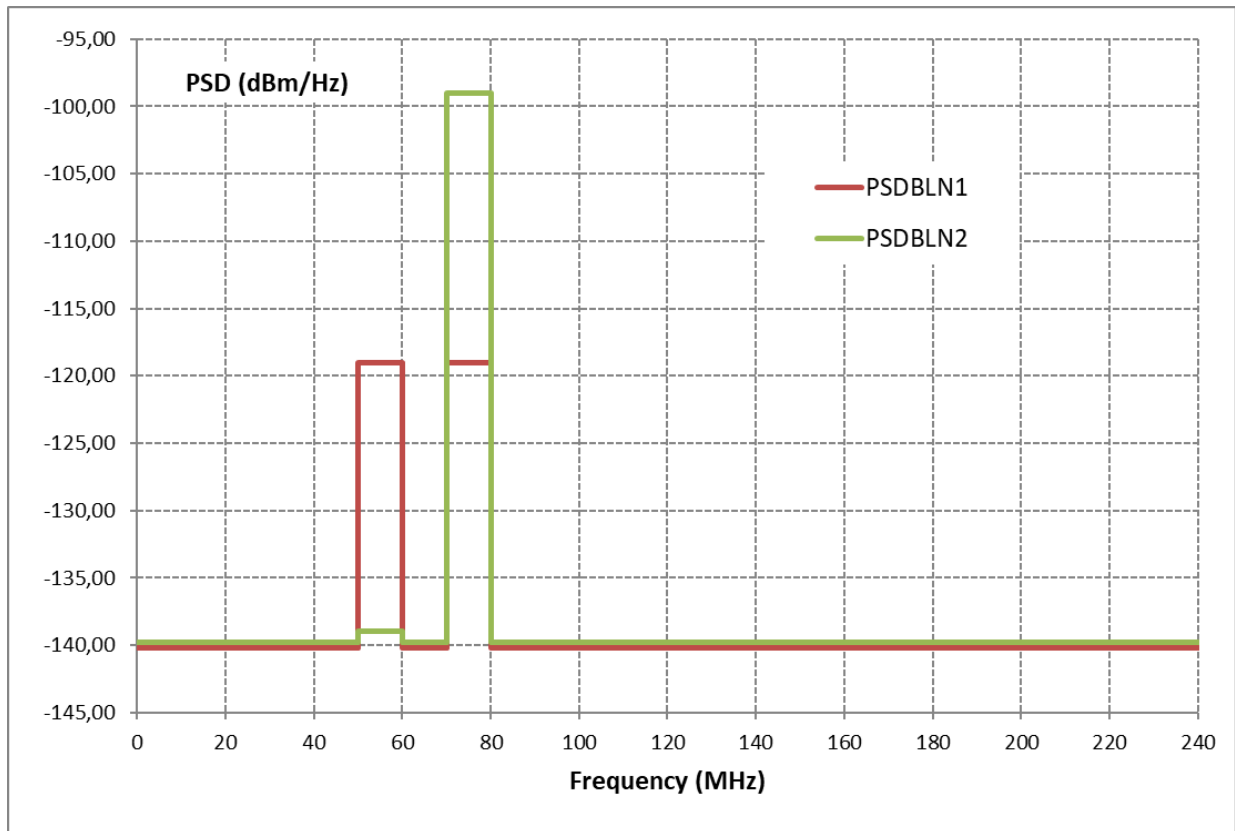


Figure 11 - PSD of the Band-limited Noise of Type 1 and 2.

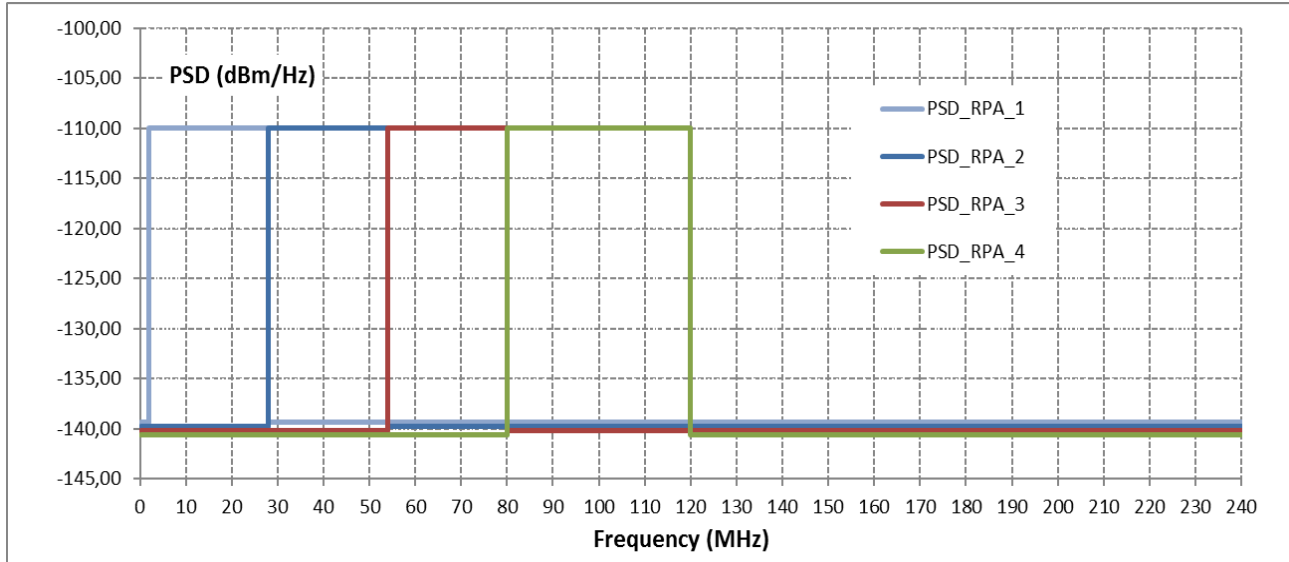


Figure 12 - PSD of the Band-limited Noise of Type 3 to 6.

5.4.4.2 RFI Noise

Two RFI Noise signals are defined:

- Fluctuating Broadband RFI Noise (RFI below 30 MHz - defined in section 5.4.4.2.1);
- Stationary Broadband RFI Noise, defined as the composite of two signals:
 - RFI above 30 MHz – FM Broadcast (defined in section 5.4.4.2.2);
 - RFI above 30 MHz – TV Stations (defined in section 5.4.4.2.3).

The RFI noise is injected on top of Flat Noise. The Flat Noise PSD level is defined in the test setup section of the specific RFI test (see sections 7.3 and 7.4).

5.4.4.2.1 RFI below 30 MHz - Fluctuating Broadband RFI

5.4.4.2.1.1 Signal Specification

The set of RFI signals is referred to as:

$$\{\text{“RFI-CPE}_i(t)\}_{AM}, \text{ with } i = 1 \dots n,$$

where ‘i’ indicates the number of the loop on which the noise is injected and the subscript “AM” indicates the type of RFI.

For a given signal number *i*, the total RFI signal SHALL be defined as follows:

$$\text{RFI-CPE}_i(t) = \text{RFI}(t)$$

The signal set $\{\text{“RFI-CPE}_i(t)\}_{AM}$ SHALL be injected in differential mode. When injected on more than one loop, the signal set $\{\text{“RFI-CPE}_i(t)\}_{AM}$ SHALL be correlated (see section 5.4.5.5).

The Baseline Total RFI Signal, RFI(t), SHALL be composed of the 50 modulated RFI tones defined in Table 28. Of these 50 tones, exactly 45 tones SHALL correspond to RFI interferers which are AM broadcast interferers. Of these 50 tones, exactly 5 tones SHALL correspond to RFI interferers which are Amateur Radio interferers.

Note: The modulation on these tones is consistent with the Fluctuating Broadband RFI Model defined in section D.4.6 of TR-114 Issue 2 [4].

The tones representing the AM broadcast interferers SHALL each consist of double side band modulation. The tones representing the Amateur Radio interferers SHALL each consist of single-sideband suppressed-carrier modulation (SSB-SC).

Each tone SHALL be independently modulated with speech weighted noise, and is limited to 4.2 kHz, each noise source being independently modulated at the syllabic rate. Speech weighted noise SHALL be as defined in ITU-T G.227 [6], which is limited to 4.2 kHz. The target modulation index for each tone is 50%. Syllabic modulation SHALL be performed by periodically interrupting a continuous speech weighted noise source for a period of 150 ms every 200 ms. In the case of amateur band SSB signals, the carrier power column data SHOULD be interpreted as the power of the SSB signal during the on period of the syllabic rated modulation.

The modulating noise SHALL be fluctuating at the syllabic rate and SHALL be subject to fading at a rate and with a time profile representative of night time reception conditions. The fading between different carriers in the set SHALL be independent. In order to achieve the appropriate fading, the dual Arbitrary Waveform Generator (AWG) method specified in section D.4.6 of TR-114 Issue 2 [4] SHALL be used.

Note: This AWG method specifies that to achieve a fade of approximately 1000 seconds duration for carriers in the region of 1 MHz, one of the generators needs to produce a carrier at 1.000000001 MHz. This can be achieved using reference clocks of 10 MHz and 10.00000001 MHz to 2 AWGs, or by using one AWG with a pattern length of $256 \times M$ samples (where $M = 2^{20}$) and one with a pattern length of $256 \times M - 8$ samples.

5.4.4.2.1.2 Specifications of Carrier Power

Table 28 defines for each of the 50 RF tones, the frequency, the differential mode carrier power (into a 50 Ohm reference load), and whether the tone is an Amateur Radio Interferer.

**Table 28 - Differential Mode Carrier Powers for Total RFI Signal,
RFI (t) - Fluctuating Broadband RFI Case**

RF Tone Number	Carrier Frequency (f _c) (kHz)	Differential Mode Carrier Power (dBm)	Amateur Radio Interferer
1	99	-58	
2	270	-93	
3	333	-50	
4	531	-59	
5	630	-82	
6	711	-57	

7	801	-62	
8	855	-80	
9	909	-52	
10	999	-63	
11	1269	-83	
12	3250	-56	
13	3330	-71	
14	3365	-59	
15	3695	-75	Yes
16	3770	-90	Yes
17	4845	-80	
18	5035	-93	
19	5980	-56	
20	6005	-85	
21	6050	-85	
22	6095	-78	
23	6160	-89	
24	6180	-63	
25	7130	-71	Yes
26	7145	-90	Yes
27	7350	-92	
28	9495	-58	
29	9620	-74	
30	9685	-91	
31	9705	-93	
32	9820	-82	
33	11610	-92	
34	11720	-85	
35	11810	-82	
36	11915	-90	
37	12050	-90	
38	12185	-59	
39	13790	-70	
40	14115	-60	Yes
41	15140	-87	
42	15385	-87	
43	15735	-68	
44	17585	-65	
45	17625	-77	
46	17780	-78	
47	21670	-68	
48	21690	-92	
49	21755	-75	
50	23960	-86	

For each AM Broadcast Interferer, the peak power measured over the modulation band SHALL be within 0.5 dB of the carrier power defined in Table 28. The modulation band is defined as $[f_c - 4.2 \text{ kHz}, f_c + 4.2 \text{ kHz}]$.

For each Amateur Radio Interferer, the peak power measured over the modulation band SHALL be within 0.5 dB of the carrier power defined in Table 28. The modulation band is defined as $[f_c, f_c + 4.2 \text{ kHz}]$.

5.4.4.2.2 RFI Above 30 MHz - FM Broadcast

The FM Broadcast RFI is to be considered as a set of RFI noises injected simultaneously on each loop. These are to represent multiple broadcast FM carriers.

5.4.4.2.2.1 Signal Specification

The set of RFI signals is referred to as:

$$\{\text{“RFI-CPE}_i(t)\text{”}\}_{\text{FM}}, \text{ with } i = 1 \dots n,$$

where ‘i’ indicates the number of the loop on which the noise is injected and the subscript “FM” indicates the type of RFI.

For a given signal number i , the total RFI signal SHALL be defined as follows:

$$\text{RFI-CPE}_i(t) = \text{RFI}(t).$$

The signal set $\{\text{“RFI-CPE}_i(t)\text{”}\}_{\text{FM}}$ SHALL be injected in differential mode. When injected on more than one loop, the signal set $\{\text{“RFI-CPE}_i(t)\text{”}\}_{\text{FM}}$ SHALL be correlated (see section 5.4.5.5).

The Baseline Total RFI Signal, $\text{RFI}(t)$, SHALL be composed of the 11 broadcast FM signals defined in Table 29. Ten (10) of these signals are centered below 100 MHz. The 11th broadcast FM signal is placed between 100 MHz and 120 MHz. Its purpose is to provide a strong interferer which is out of band relative to ITU-T G.9701 operating below 106 MHz.

Each of the FM broadcast interferers in the set SHALL be independently modulated by a cosinusoidal signal of frequency f_m of the form $\beta \times \cos(2\pi \times f_m \times t)$. The parameter β is the modulation index. The total FM broadcast interferer is then of the following form where f_c is the interferer center frequency:

$$\cos(2\pi \times f_c \times t + \beta \times \cos(2\pi \times f_m \times t)).$$

The bandwidth of the FM broadcast interferer is consistent with a 0.2 MHz spacing between adjacent FM broadcast carrier frequencies. The modulation band is defined as:

$$[f_c - \beta \times f_m, f_c + \beta \times f_m].$$

5.4.4.2.2.2 Specification of Carrier Power and Signal Structure

Table 29 defines for each of the 11 broadcast FM signals, the signal structure (frequency, modulation frequency, and modulation index), and the differential mode carrier power (into a 50 Ohm reference load). The modulation frequency and modulation index are chosen so that the modulation bandwidth is less than 0.2 MHz. For each broadcast FM signal, the average power over the modulation bandwidth shall be within 0.5 dB of the carrier power defined in Table 29.

Table 29 - Differential Mode Carrier Powers and Signal Structure for RFI Signal- FM Broadcast

Description	Carrier Frequency (f _c) (MHz)	Modulation Frequency (f _m) (kHz)	Modulation Index (β)	Differential Mode Carrier Power (dBm)
1	88.3	15	5	-63
2	89.1	15	5	-68
3	89.9	15	5	-62
4	90.5	15	5	-66
5	91.3	15	5	-65
6	91.9	15	5	-65
7	92.7	15	5	-67
8	93.5	15	5	-64
9	95.3	15	5	-62
10	99.1	15	5	-60
11	107.9	15	5	-70

5.4.4.2.3 RFI Above 30 MHz - TV Stations

This is to be considered as a set of RFI noises injected simultaneously on each loop. These are to represent digital TV signals.

5.4.4.2.3.1 Signal Specification

The set of RFI signals is referred to as:

$$\{\text{“RFI-CPE}_i(t)\}_{\text{TV}}, \text{ with } i = 1 \dots n,$$

where ‘i’ indicates the number of the loop on which the noise is injected and the subscript “TV” indicates the type of RFI.

For a given signal number i , the total RFI signal SHALL be defined as follows:

$$\text{RFI-CPE}_i(t) = \text{RFI}(t).$$

The signal set $\{\text{“RFI-CPE}_i(t)\}_{\text{TV}}$ SHALL be injected in differential mode. When injected on more than one loop, the signal set $\{\text{“RFI-CPE}_i(t)\}_{\text{TV}}$ SHALL be totally correlated, distributed from the same source.

The Baseline Total RFI Signal, RFI(t), SHALL be composed of the 4 digital TV signals defined in Table 30.

Each of the TV signal interferers in the set SHALL be independently modulated with Gaussian Noise which SHALL be flat and SHALL begin 0.31 MHz from the start the modulation band and

SHALL end 0.31 MHz from the end of the modulation band. This allows for a guard band between adjacent TV channels.

5.4.4.2.3.2 Specification of Carrier Power and Signal Structure

Table 30 defines for each of the 4 digital TV signals, the modulation band and the differential mode interferer power (into a 50 Ohm reference load). These values take into account common mode to differential mode conversion.

Table 30 - Differential Mode Carrier Powers and Signal Structure for RFI Signal- TV

Description	Modulation Band (MHz)	Diferential Mode Interferer Power (dBm)
TV Channel 2	54 - 60	-50.0
TV Channel 3	60 - 66	-52.2
TV Channel 4	66 - 72	-52.2
TV Channel 5	76 - 82	-54.0

For each digital TV signal, the average power measured over the modulation band SHALL be within 0.5 dB of the interferer power defined in Table 30.

5.4.4.3 Impulse Noise

5.4.4.3.1 REIN

REIN is defined as a repetition of an AWGN burst, with the time domain and frequency domain characteristics defined in following sub-sections.

5.4.4.3.1.1 REIN Time Domain Characteristics

Two types of REIN are defined, with characteristics listed in Table 31.

Table 31 - REIN time domain characteristics

Parameter	Type 1	Type 2
burst duration	100 μ s	1 ms
burst repetition	10ms (100Hz)	10ms (100Hz)

5.4.4.3.1.2 REIN Frequency Domain Characteristics

During each REIN burst, the REIN PSD is defined as follows (see Figure 13):

$$PSD_{REIN}(f) = \begin{cases} -90 \text{ dBm/Hz}, & 138 \text{ kHz} \leq f < f_c \\ \max(-90 - 40 \times \log_{10}(f / f_c), -150) \text{ dBm/Hz}, & f_c \leq f < 240 \text{ MHz} \end{cases}$$

with f in Hz and $f_c = 2.2 \times 10^6$ Hz.

Over the 138 kHz to 40 MHz frequency range, the MAE (see section 5.4.6.1) of the REIN PSD SHALL be less than or equal to 0.5 dB.

Note: An MAE up to 40 MHz corresponds with an MAE down to a noise level of about -140 dBm/Hz.

Outside the REIN burst, no REIN noise is generated.

The REIN noise is injected on top of Flat Noise as defined in section 5.4.4.1.1. The Flat Noise PSD level is defined in the test setup section of the specific REIN test (see section 7.2).

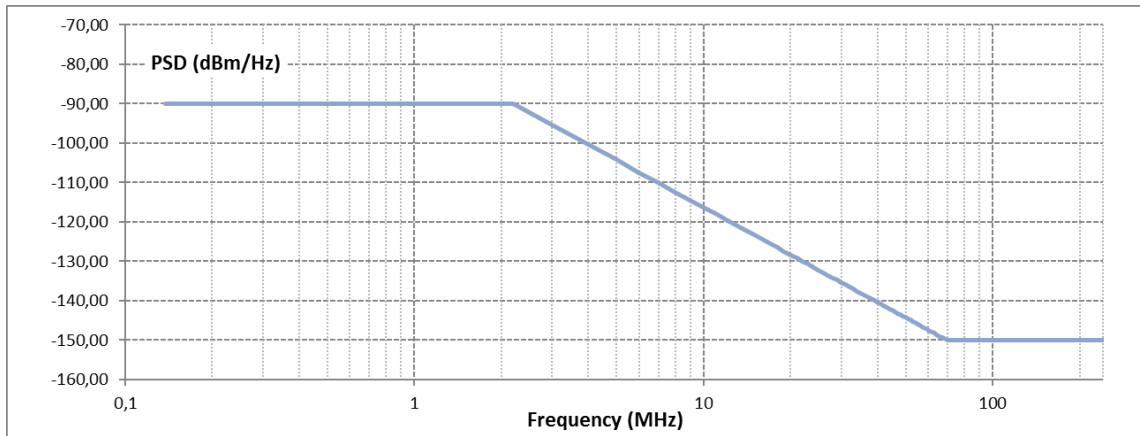


Figure 13 - The PSD of a single REIN burst

5.4.4.3.2 SHINE

SHINE is defined as a repetition of an AGN burst, with the time domain and frequency domain characteristics defined in following sub-sections.

5.4.4.3.2.1 SHINE Time Domain Characteristics

Three types of SHINE are defined (referred to as Type 1, Type 2, and Type 3), with characteristics listed in Table 32.

Table 32 - SHINE time domain characteristics

Parameter	Type 1	Type 2	Type 3
burst duration	4ms	100ms	800ms
burst repetition	1s	10s	20s

5.4.4.3.2.2 SHINE Frequency Domain Characteristics

During each SHINE burst, the SHINE PSD SHALL be as Flat Gaussian Noise at a PSD level of -95 dBm/Hz over the 138 kHz to 240 MHz frequency range.

Over the 138 kHz to 120 MHz frequency range, the MAE (see section 5.4.6.1) of the SHINE PSD SHALL be less than or equal to 0.5 dB. Over the 120 MHz to 240 MHz frequency range, the MAE of the SHINE PSD SHALL be less than or equal to 1 dB.

Outside the SHINE burst, no SHINE noise is generated.

The SHINE noise is injected on top of Flat Noise as defined in section 5.4.4.1.1. The Flat Noise PSD level is defined in the test setup section of the specific SHINE test (see section 7.1).

5.4.5 Noise injection

5.4.5.1 Bandwidth

The noise injector SHALL be capable of injecting Noise/Interference profiles with PSDs included in the spectral range extending from 138 kHz to 240 MHz.

5.4.5.2 Simultaneous Noise/Interference Multi-line Injection

The noise injector SHALL allow simultaneous injection on N lines, where $1 \leq N \leq 8$, depending upon the specific test case.

5.4.5.3 Modes of Injection

Noise injection on each line SHALL be by Differential Mode.

5.4.5.4 Impedance

With the noise/interference considered as a current source, the Norton impedance of the noise-coupling circuit connected to the line (Z_{inj}) SHALL be greater than 4000 Ohms at the point of injection, over the frequency range from 138 kHz to 240 MHz. This Norton impedance is illustrated in Figure 14 as Z_{inj} . The current source I_x is controlled by the noise source and by the parasitic shunt impedance Z_{inj} (see also ETSI TS 101 388 [10]).

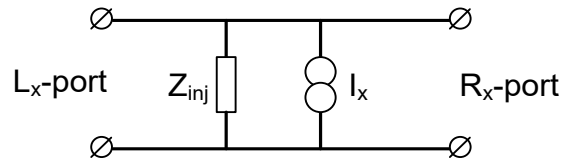


Figure 14 - Norton Equivalent Circuit Diagram

5.4.5.5 Noise/Interference on Different Lines

The noise injector SHALL allow G.fast tests to be carried out with the simultaneous injection of correlated noise/interference types on several lines. The term “correlated” means that all injected noise/interference signals are derived from the same single source, and all are within the PSD/power accuracy as specified for each individual noise/interference type.

The noise injector SHALL allow G.fast tests to be carried out with the simultaneous injection of groups of Independent Noise/Interference types and groups of Correlated Noise/Interference types on several lines.

5.4.5.6 Isolation of Noise/Interference on Different Lines

Consider a port of the injector which is assigned to a specific line. For each pair of such ports the isolation between the two ports of the pair SHALL be at least 70 dB up to 240 MHz. Such isolation SHALL be defined in the following way. If a swept sine wave from a network analyzer is injected into the first port - with its voltage considered as a 0 dB reference - then the resulting measured output at the second port SHALL be at least 70 dB below the 0 dB reference, up to 240 MHz.

5.4.5.7 Noise Floor

With noise/interference generator, the source of a noise/interference, in an idle state - no noise/interference being generated - the noise floor measured at the output of the injector SHALL be equal to or lower than -145 dBm/Hz and low enough to meet the MAE requirement for each individual noise/interference type. The test report shall include access to the noise floor over frequency of the noise injector used.

5.4.6 Test Equipment Requirements

5.4.6.1 Accuracy of Noise Sources

Each noise SHALL be measured independently at the point of injection. This SHALL be done for one noise source at a time, using a NULL loop, with test leads present and terminated by a reference load impedance R_v. The measured noise will be impacted by the noise generator tolerance, the coupling circuit tolerance, cabling tolerance and noise pickup.

With a multi-pair cable Physical Layer Test Setup, R_v = 100 Ohms.

With a coaxial cable Physical Layer Test Setup, $R_v = 75$ Ohms.

At least one measurement SHALL be made per 10 kHz interval. The Mean Error (ME) and Mean Absolute Error (MAE) of the measured simulated noise level values (in dBm/Hz), relative to the theoretical noise level values (in dBm/Hz), SHALL be calculated. The noise calibration frequency ranges f_1 and f_2 SHALL be as specified in section 5.4.4 for the specific noise source.

The Mean Absolute Error (MAE) for noise X is defined as:

$$MAE = \frac{1}{N} \sum_{i=0}^{N-1} |P_{Ri} - P_{Ti}|$$

The Mean Error (ME) for noise X is defined as:

$$ME = \frac{1}{N} \sum_{i=0}^{N-1} (P_{Ri} - P_{Ti})$$

Note: Positive error indicates excessive noise power.

where:

P_{Ri} = power sample, in dBm/Hz, of the generated noise X,

P_{Ti} = power sample, in dBm/Hz, of the theoretical noise X, and

N is the number of power samples for a 10 kHz noise measurement resolution bandwidth.

The noise generator SHALL be compensated such that the absolute value of ME is minimized while maintaining an MAE as specified in section 5.4.4 for the specific noise source.

Note: For noise calibration, there is measurement uncertainty that can not be compensated, consisting of the following contributions:

1. absolute amplitude accuracy
2. vertical linearity
3. frequency response of the measurement equipment used
4. tolerance of the calibration impedance.

5.4.7 Management of the DUT and Link Partner

All configuration/management/status reporting of the FTU-O and FTU-R G.fast interface(s) SHALL be performed through the operation of the FTU-O interface, using the standard control parameters listed above in section 5.3. No configuration of the FTU-R interface shall be performed during this testing (the FTU-R interface(s) is considered a slave to the FTU-O configuration). The configuration of these parameters MAY be operated through the HON, DPU, CRAFT, or other appropriate interface. If a configuration parameter or status parameter is not available and is required for a specific test, that test SHALL be considered as failed.

5.4.8 Minimum Port Interface Speed of the DUT and Link Partner

If the DUT is a DPU, then the DUT SHALL support an uplink interface speed of 1 Gbit/s or better. The link partner is expected to have a LAN port interface speed of at least 1 Gbit/s.

If the DUT is a CPE, then the DUT SHALL support a LAN port interface speed of 1 Gbit/s or better. The link partner is expected to have an uplink interface speed of at least 1 Gbit/s.

6 Functional Tests

For each test in this section, reported items/measurements are verified in the expected results as applicable to the DUT. The Table 33 lists parameters (i.e., configuration parameters and reported items/measurements) referred to as “NE/FE” or “ds/us” in the expected results, and how these are applicable to a DPU and a CPE.

Table 33 - Parameters as applicable to the DUT

Parameter	If DUT is a DPU	If DUT is a CPE
MAXATPds/us	MAXATPds	MAXATPus
MREFPSDMASKds/us	MREFPSDMASKds	MREFPSDMASKus
MAXBL-RMCds/us	MAXBL-RMCus	MAXBL-RMCds
TARSNRM-RMCds/us	TARSNRM-RMCus	TARSNRM-RMCds
SRA-USNRMds/us	SRA-USNRMus	SRA-USNRMds
SRA-DSNRMds/us	SRA-DSNRMus	SRA-DSNRMds
NDRds/us	NDRus	NDRds
GDRds/us	GDRus	GDRds
FLRds/us	FLRus	FLRds
SNRMds/us	SNRMus	SNRMds
SNRM-RMCds/us	SNRM-RMCus	SNRM-RMCds
BITSpds/us	BITSpus	BITSpds
BITSRMCpsds/us	BITSRMCpsus	BITSRMCpsds
BITSDs/us	BITSus	BITSDs
Lds/us	Lus	Lds
T_DTU_in_DMTds/us	T_DTU_in_DMTus	T_DTU_in_DMTds
EFBds/us	EFBus	EFBds
MTBEds/us	MTBEus	MTBEds
Tds/us_measured	Tds_measured	Tus_measured
CURR_24_NE/FE_[x]	CURR_24_NE_[x]	CURR_24_FE_[x]

The measurement systems documented in this section SHALL be calibrated with traceable and verifiable steps dependent on the specific measurement setup and test equipment. The test equipment calibration documentation SHALL be provided upon request.

6.1 Inventory Data Test

6.1.1 Purpose

The purpose of this test is to verify that the DUT inventory information retrieved from the DPU-MIB corresponds with the DUT vendor declared inventory information.

6.1.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.1.3 References

- ITU-T G.9701, clause 11.2.2.10.

6.1.4 Test Setup

See IR-337 Issue 2.

6.1.5 Method of Procedure

See IR-337 Issue 2.

6.1.6 Report

See IR-337 Issue 2.

6.1.7 Expected Results

See IR-337 Issue 2.

6.1.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.2 PSD Mask Tests

The following tests verify the signals transmitted by the DUT conform to the requirements defined in ITU-T G.9700 [1].

Figure 4 shows the specific setup required for the measurement of the G.fast signal. The measurement system for the purpose of PSD mask testing SHALL be connected at the DUT. Examples of measurement systems are given in Appendix I.

The measurement system output SHALL be the verifiable transmit PSD defined in Appendix III of ITU-T G.9700 (referred to as $TXPSD(bw, f)$), with measurement bandwidth bw equal to the MBW defined in Table 8-1 of ITU-T G.9700. This Appendix provides a formal definition for Transmitter Power Spectral Density (TXPSD) for signals comprising a stream of symbols including quiet periods, such as those produced by time division duplexing DMT systems, e.g., G.fast. The TXPSD SHALL be measured over transmitted symbols only. Gap time, quiet symbols and idle symbols SHALL be excluded from the measurement.

The PSD Mask tests verify the PSD for the frequency bands using the measurement bandwidths as specified in Table 8-1 of ITU-T G.9700 over the frequency range defined in Table 34.

Table 34 - PSD Frequency Range

ITU-T G.9701 Profile	Start Frequency	Stop Frequency
106 MHz profile	500 kHz	212 MHz
212 MHz profile	500 kHz	300 MHz (Note 1,2)
<p>Note 1: The value of 300 MHz is the maximum frequency in the measurement bandwidth settings for transmit PSD verification defined in clause 8 of ITU-T G.9700 [1].</p> <p>Note 2: Measurement up to 250MHz is allowed for a measurement system per Appendix I Figure I-1, where the available digital storage oscilloscope is limited to 500 Msamples per second.</p>		

With the the Physical Layer Test Setup (see Figure 4) terminated with impedance R_v at both the DPU-end and the CPE-end, and with the measurement system (see Figure 4) configured as during the measurement of the G.fast signal, the measurement system output (measuring the combination of the background noise present at the DUT side and the measurement system's internal noise floor) SHALL be less than -130 dBm/Hz over the frequency bands defined in Table 34. The noise floor SHALL be measured with both the DPU and CPE replaced with a reference load impedance R_v .

With a multi-pair cable Physical Layer Test Setup, $R_v = 100$ Ohms.

With a coaxial cable Physical Layer Test Setup, $R_v = 75$ Ohms.

6.2.1 PSD Limit Mask Test

6.2.1.1 Purpose

The purpose of this test is to verify that the signals transmitted by the DUT do not exceed the limit PSD mask (LPM) and maximum aggregate transmit power (MAXATP), when no additional spectral controls or restrictions have been configured.

6.2.1.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.2.1.3 References

- ITU-T G.9700, clause 7.2.1.
- ITU-T G.9701, clause 7.3.1.

6.2.1.4 Test Setup

See IR-337 Issue 2.

6.2.1.5 Method of Procedure

See IR-337 Issue 2.

6.2.1.6 Report

See IR-337 Issue 2.

6.2.1.7 Expected Results

See IR-337 Issue 2.

6.2.1.8 Estimated Test Time

The estimated test time for this test case is 30 minutes.

6.2.2 Sub-carrier Masking Test**6.2.2.1 Purpose**

The purpose of this test is to verify that the DUT is able to apply an arbitrary masking of sub-carriers to force no bit loading and reduced transmitted power over the masked carriers.

6.2.2.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.2.2.3 References

- ITU-T G.9700, clauses 6.3 and 7.2.1.
- ITU-T G.9701, clause 7.3.1.3.

6.2.2.4 Test Setup

See IR-337 Issue 2.

6.2.2.5 Method of Procedure

See IR-337 Issue 2.

6.2.2.6 Report

See IR-337 Issue 2.

6.2.2.7 Expected Results

See IR-337 Issue 2.

6.2.2.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.2.3 PSD Shaping Test

6.2.3.1 Purpose

The purpose of this test is to verify that the DUT is able to apply an arbitrary PSD shaping. Within this test, this feature is also used to verify the configuration excluding the VDSL2 17MHz band, through the specific configuration values used for the PSD mask.

6.2.3.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.2.3.3 References

- ITU-T G.9700, clauses 6.4 and 7.2.1.
- ITU-T G.9701, clause 7.3.1.1.

6.2.3.4 Test Setup

See IR-337 Issue 2.

6.2.3.5 Method of Procedure

See IR-337 Issue 2.

6.2.3.6 Report

See IR-337 Issue 2.

6.2.3.7 Expected Results

See IR-337 Issue 2.

6.2.3.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.2.4 RFI Notching Test

6.2.4.1 Purpose

The purpose of this test is to verify that the DUT is able to apply a set of RFI notches for specific frequency bands in order to protect radio services; for example, amateur radio bands or broadcast radio bands.

6.2.4.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.2.4.3 References

- ITU-T G.9700, clauses 6.5 and 7.2.1.
- ITU-T G.9701, clause 7.3.1.2.

6.2.4.4 Test Setup

See IR-337 Issue 2.

6.2.4.5 Method of Procedure

See IR-337 Issue 2.

6.2.4.6 Report

See IR-337 Issue 2.

6.2.4.7 Expected Results

See IR-337 Issue 2.

6.2.4.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.2.5 UPBO Test

6.2.5.1 Purpose

The purpose of this test is to verify that the signals transmitted by the DUT do not exceed the calculated upstream Transmit PSD Mask (PSDMASK), which includes the transmit PSD reductions due to UPBO. The UPBO configuration parameters are communicated to the FTU-R by the FTU-O during initialization and are required for the correct calculation of the Transmit PSD Mask. Additionally, the FTU-R needs to accurately estimate the electrical length (kl0) of the channel to calculate the appropriate Transmit PSD Mask.

6.2.5.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.2.5.3 References

- ITU-T G.9701, clause 7.3.1.4.
- ITU-T G.9701, clause 7.3.1.

6.2.5.4 Test Setup

See IR-337 Issue 2.

6.2.5.5 Method of Procedure

See IR-337 Issue 2.

6.2.5.6 Report

See IR-337 Issue 2.

6.2.5.7 Expected Results

See IR-337 Issue 2.

6.2.5.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.2.6 TIGA Test**6.2.6.1 Purpose**

The purpose of this test is to verify that the signals transmitted by the DUT do not exceed the limit PSD mask (LPM), when high-crosstalk lines join the pre-coded group. This test applies only if the DPU supports operation over a copper wire pair and supports multiple ports.

6.2.6.2 Certification Requirement

- FTU-O: Conditional mandatory, with the condition that the DPU supports operation over a copper wire pair and supports more than 1 port.
- FTU-R: Conditionally mandatory, with the condition that the CPE supports operation over a copper wire pair.

6.2.6.3 References

- ITU-T G.9701, clause 13.2.2.1.

6.2.6.4 Test Setup

See IR-337 Issue 2.

6.2.6.5 Method of Procedure

See IR-337 Issue 2.

6.2.6.6 Report

See IR-337 Issue 2.

6.2.6.7 Expected Results

See IR-337 Issue 2.

6.2.6.8 Estimated Test Time

The estimated test time for this test case is 30 minutes.

6.3 TDD Operations

6.3.1 TDD Inter-frame Gap Test

6.3.1.1 Purpose

The purpose of this test is to verify that the DUT maintains a proper gap time between the start and stop of each TDD transmission, as observed at its interface. The test performed over a number of different loop lengths to assure the introduced delay does not negatively impact the gap time. The loop may be simulated/modeled or may be real cable, but it SHALL introduce a propagation delay related to its length.

6.3.1.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.3.1.3 References

- ITU-T G.9701, clause 10.5.

6.3.1.4 Test Setup

See IR-337 Issue 2.

6.3.1.5 Method of Procedure

See IR-337 Issue 2.

6.3.1.6 Report

See IR-337 Issue 2.

6.3.1.7 Expected Results

See IR-337 Issue 2.

6.3.1.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.3.2 DS and US Ratio Configuration (Mds) Test

6.3.2.1 Purpose

The purpose of this test is to verify that the DUT adheres to the split of downstream/upstream transmission time/rate as configured in the DPU-MIB.

The number of symbols per TDD frame dedicated for downstream transmission (M_{ds}) determines the downstream transmission time ratio ($DS_{ratio} = M_{ds} / (M_{ds} + M_{us})$) and the upstream transmission time ratio ($US_{ratio} = M_{us} / (M_{ds} + M_{us})$). There are M_F symbol periods per TDD frame period, with $M_{ds} + M_{us} = M_F - 1$, since one symbol period per TDD frame is used as a gap time. With configuration according to the section 5.3, the TDD frame period is $750 \mu s$ and the symbol period is $750/36 = 20.83 \mu s$.

This verification is done by comparing:

- the measured downstream and upstream transmission times;
- the configured downstream and upstream transmission times.

6.3.2.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.3.2.3 References

- ITU-T G.9701, clause 10.5.

6.3.2.4 Test Setup

See IR-337 Issue 2.

6.3.2.5 Method of Procedure

See IR-337 Issue 2.

6.3.2.6 Report

See IR-337 Issue 2.

6.3.2.7 Expected Results

See IR-337 Issue 2.

6.3.2.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.4 Accelerated MTBE Test

6.4.1 Purpose

The purpose of this test is to verify through the accelerated MTBE test whether the DUT is able to sustain the minimum MTBE defined in ITU-T G.9701. The RTX_TESTMODE (no retransmission), TPS_TESTMODE (maximum (dummy) data rate), and DRA_TESTMODE (TTRds=Mds; TTRus=Mus) defined in ITU-T G.9701 are used for accelerating the test time.

6.4.2 Certification Requirement

- FTU-O: Mandatory
- FTU-R: Mandatory

6.4.3 References

- ITU-T G.9701, clause 9.8.3.1.

6.4.4 Test Setup

See IR-337 Issue 2.

6.4.5 Method of Procedure

See IR-337 Issue 2.

6.4.6 Report

See IR-337 Issue 2.

6.4.7 Expected Results

See IR-337 Issue 2.

6.4.8 Estimated Test Time

The estimated test time for this test case is 15 minutes.

6.5 Discontinuous Operation Test

6.5.1 Purpose

The purpose of this test is to verify that the DUT can correctly enter and exit discontinuous operation according to the volume of traffic applied on a single line. The transient transmission signals are captured at the interface of DUT. Signal levels equal to the line noise level are expected during the interval(s) of quiet symbols.

6.5.2 Certification Requirement

- FTU-O: Optional
- FTU-R: Optional

6.5.3 References

- ITU-T G.9701, clause 10.7 and Appendix VI.

6.5.4 Test Setup

See IR-337 Issue 2.

6.5.5 Method of Procedure

See IR-337 Issue 2.

6.5.6 Report

See IR-337 Issue 2.

6.5.7 Expected Results

See IR-337 Issue 2.

6.5.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.6 Bit swap or SRA Test

6.6.1 Purpose

The purpose of this test is to verify that the DUT supports the reallocation of data capacity under varying noise, using monitored tones and bit swap or SRA OLR types.

6.6.2 Certification Requirement

- FTU-O: Mandatory.

- FTU-R: Mandatory.

6.6.3 References

ITU-T G.9701, clause 10.2.1.4, 13.2.1.1 and 13.2.1.2.

6.6.4 Test Setup

See IR-337 Issue 2.

6.6.5 Method of Procedure

See IR-337 Issue 2.

6.6.6 Report

See IR-337 Issue 2.

6.6.7 Expected Results

See IR-337 Issue 2.

6.6.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.7 SRA Downshift Test

6.7.1 Purpose

The purpose of this test is to verify that the DUT is able to decrease the net data rate (NDR), based on the external noise on the line increasing slowly over time. The NDR downshift is triggered with an increase of the noise present on the line.

6.7.2 Certification Requirement

- FTU-O: Mandatory
- FTU-R: Mandatory

6.7.3 References

- ITU-T G.9701, clause 13.2.1.1.

6.7.4 Test Setup

See IR-337 Issue 2.

6.7.5 Method of Procedure

See IR-337 Issue 2.

6.7.6 Report

See IR-337 Issue 2.

6.7.7 Expected Results

See IR-337 Issue 2.

6.7.8 Estimated Test Time

The estimated test time for this test case is 15 minutes.

6.8 SRA Upshift Test**6.8.1 Purpose**

The purpose of this test is to verify that the DUT is able to increase the net data rate (NDR), based on the external noise on the line decreasing slowly over time. The NDR upshift is triggered with a decrease of the noise present on the line.

6.8.2 Certification Requirement

- FTU-O: Mandatory
- FTU-R: Mandatory

6.8.3 References

- ITU-T G.9701, clause 13.2.1.1.

6.8.4 Test Setup

See IR-337 Issue 2.

6.8.5 Method of Procedure

See IR-337 Issue 2.

6.8.6 Report

See IR-337 Issue 2.

6.8.7 Expected Results

See IR-337 Issue 2.

6.8.8 Estimated Test Time

The estimated test time for this test case is 15 minutes.

6.9 FRA & SRA Upshift Test

6.9.1 Purpose

The purpose of this test is to verify that the DUT is capable of rapidly performing bit loading reduction in a specified portion of frequency spectrum in both the upstream and downstream directions, based on sudden noise increase.

The noise changes and the related DUT actions are illustrated in Figure 15. In stage 1, a high noise is applied. In stage 2, a low noise is applied, leading to the DUT initiating an SRA to increase the net data rate. In stage 3, the high noise level is applied again, leading to the DUT initiating an FRA to significantly reduce the net data rate, followed by the DUT initiating an SRA to restore a net data rate that should be about the same net data rate as in stage 1.

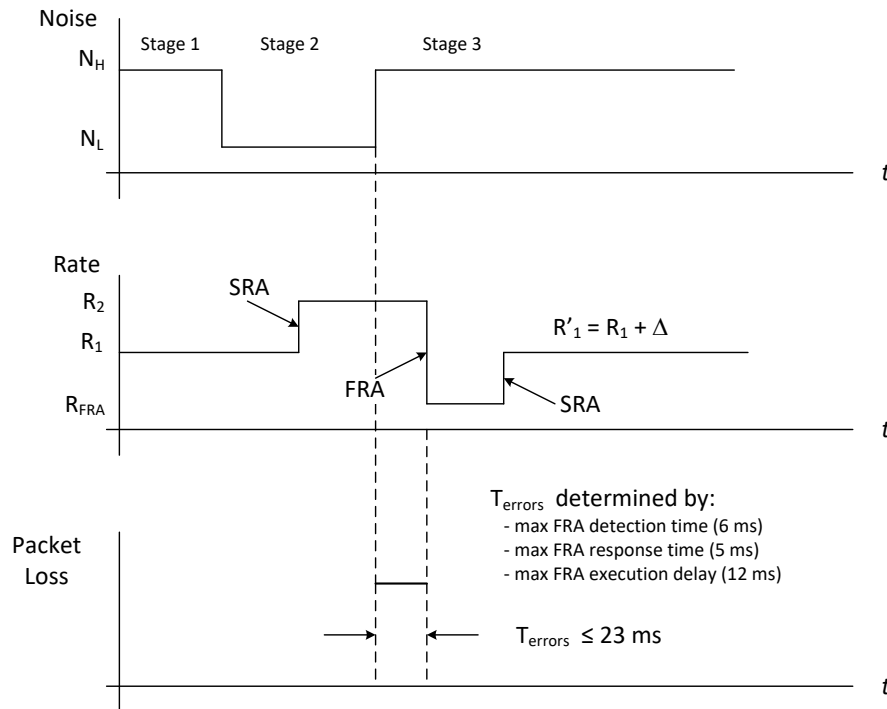


Figure 15 - Illustration of the noise changes and related transceiver actions.

6.9.2 Certification Requirement

- FTU-O: Mandatory.

- FTU-R: Mandatory.

6.9.3 References

- ITU-T G.9701, clauses 13.2.1.1 and 13.3.1.1.

6.9.4 Test Setup

See IR-337 Issue 2.

6.9.5 Method of Procedure

See IR-337 Issue 2.

6.9.6 Report

See IR-337 Issue 2.

6.9.7 Expected Results

See IR-337 Issue 2.

6.9.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.10 RPA Test

6.10.1 Purpose

The purpose of this test is to verify that the DUT is capable of adjusting RMC parameters if the external noise changes over time. The RMC parameter adjustment (RPA) is triggered when the SNR margin of the RMC (either SNRM-RMCds or SNRM-RMCus) is lower than the minimum SNR margin of the RMC (MINSNRM-RMCds or MINSNRM-RMCus).

6.10.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.10.3 References

- ITU-T G.9701, clause 13.2.1.3.

6.10.4 Test Setup

See IR-337 Issue 2.

6.10.5 Method of Procedure

See IR-337 Issue 2.

6.10.6 Report

See IR-337 Issue 2.

6.10.7 Expected Results

See IR-337 Issue 2.

6.10.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.11 RMC Bit Loading Configuration Test

6.11.1 Purpose

The purpose of this test is to verify that the DUT is capable to perform accurately the RMC bit loading configuration.

6.11.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.11.3 References

- ITU-T G.9701, clause 10.2.

6.11.4 Test Setup

See IR-337 Issue 2.

6.11.5 Method of Procedure

See IR-337 Issue 2.

6.11.6 Report

See IR-337 Issue 2.

6.11.7 Expected Results

See IR-337 Issue 2.

6.11.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.12 Re-initialization Policy Test**6.12.1 Short Disconnect Test****6.12.1.1 Purpose**

The purpose of this test is to verify that the DUT supports the re-initialization policy for a loop disconnect that is shorter than the *los* and *lor* defect persistency and hence does not cause a re-initialization.

6.12.1.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.12.1.3 References

ITU-T G.9701, clauses 12.1.4.2 and 12.1.4.3.

6.12.1.4 Test Setup

See IR-337 Issue 2.

6.12.1.5 Method of Procedure

See IR-337 Issue 2.

6.12.1.6 Report

See IR-337 Issue 2.

6.12.1.7 Expected Results

See IR-337 Issue 2.

6.12.1.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.12.2 Long disconnect Test with LOS failure

6.12.2.1 Purpose

The purpose of this test is to verify that the DUT supports the re-initialization policy for a loop disconnect that is longer than the *los* defect persistency and shorter than the *lor* defect persistency, and hence causes a re-initialization triggered by a LOS failure.

6.12.2.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.12.2.3 References

ITU-T G.9701, clauses 12.1.4.2 and 12.1.4.3.

6.12.2.4 Test Setup

See IR-337 Issue 2.

6.12.2.5 Method of Procedure

See IR-337 Issue 2.

6.12.2.6 Report

See IR-337 Issue 2.

6.12.2.7 Expected Results

See IR-337 Issue 2.

6.12.2.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.12.3 Long disconnect Test with LOR failure

6.12.3.1 Purpose

The purpose of this test is to verify that the DUT supports the re-initialization policy for a loop disconnect that is shorter than the *los* defect persistency and longer than the *lor* defect persistency, and hence causes a re-initialization triggered by a LOR failure.

6.12.3.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.12.3.3 References

ITU-T G.9701, clauses 12.1.4.2 and 12.1.4.3.

6.12.3.4 Test Setup

See IR-337 Issue 2.

6.12.3.5 Method of Procedure

See IR-337 Issue 2.

6.12.3.6 Report

See IR-337 Issue 2.

6.12.3.7 Expected Results

See IR-337 Issue 2.

6.12.3.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.13 Dying gasp Test

6.13.1 Purpose

If the DUT is a CPE, then the purpose of this test is to verify that the DUT supports sending the dying gasp to the DPU.

If the DUT is a DPU, then the purpose of this test is to verify that the DUT supports receiving the dying gasp from the CPE and supports conveying the dying gasp over the DPU Northbound management protocol.

6.13.2 Certification Requirement

- FTU-O: Optional.
- FTU-R: Optional.

Purpose of the test is for DUT=FTU-R to verify dying gasp is sent to the DPU.

Purpose of test is for DUT=FTU-O to verify dying gasp is received and conveyed onto the management system.

6.13.3 References

ITU-T G.9701, clause 11.3.3.2

6.13.4 Test Setup

See IR-337 Issue 2.

6.13.5 Method of Procedure

See IR-337 Issue 2.

6.13.6 Report

See IR-337 Issue 2.

6.13.7 Expected Results

See IR-337 Issue 2.

6.13.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.14 Increased Bit Loading Test

6.14.1 Purpose

The purpose of this test is to verify that the DUT is capable to allocate an increased bit loading of up to 14 bits to a subcarrier.

6.14.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.14.3 References

- ITU-T G.9701, clause 10.2.1.4.2.

6.14.4 Test Setup

See IR-337 Issue 2.

6.14.5 Method of Procedure

See IR-337 Issue 2.

6.14.6 Report

See IR-337 Issue 2.

6.14.7 Expected Results

See IR-337 Issue 2.

6.14.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

6.15 Test Parameters Test**6.15.1 Purpose**

The purpose of this test is to verify that the DUT supports measurement and reporting of the test parameters quiet line noise (QLN), active line noise (ALN), insertion loss (HLOG), and signal attenuation (SATN).

6.15.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

6.15.3 References

- ITU-T G.9701, clause 11.4.1.2.
- ITU-T G.997.2, clause 7.10.

6.15.4 Test Setup

See IR-337 Issue 2.

6.15.5 Method of Procedure

See IR-337 Issue 2.

6.15.6 Report

See IR-337 Issue 2.

6.15.7 Expected Results

See IR-337 Issue 2.

6.15.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

7 Stability Tests

7.1 SHINE stability Test

7.1.1 Purpose

The purpose of this test is to verify that the DUT is able to maintain physical layer and traffic stability under noise burst conditions.

The characteristics of SHINE noise Type 1, SHINE noise Type 2, and SHINE noise Type 3 are defined in section 5.4.4.3.2. The SHINE noise Type 1, Type 2, and Type 3 SHALL be injected for $T_{meas} = 60, 120, \text{ and } 240$ sec respectively. The SHINE type 1 is expected to be corrected completely, the SHINE type 2 and SHINE type 3 are expected to have frame loss for the duration of the SHINE impulse.

7.1.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.1.3 References

- ITU-T G.9701, clauses 9.8.3.3, 11.4.2.4, and 11.4.2.5.

7.1.4 Test Setup

See IR-337 Issue 2.

7.1.5 Method of Procedure

See IR-337 Issue 2.

7.1.6 Report

See IR-337 Issue 2.

7.1.7 Expected Results

See IR-337 Issue 2.

7.1.8 Estimated Test Time

The estimated test time for this test case is 15 minutes.

7.2 REIN Stability Test

7.2.1 Purpose

This test assesses DUT physical layer and traffic stability under repetitive noise burst conditions (REIN). Because retransmission is a mandatory capability for a G.fast transceiver, this impulse noise protection mechanism is tested. The REIN noise is injected after the link has trained. After a stabilization period the error metrics SHALL be recorded for the measurement period.

The characteristics of REIN noise type1 and REIN noise type 2 are defined in section 5.4.4.3.1. The REIN noise Type 1 and Type 2 SHALL be injected for $T_{\text{meas}} = 60$ sec.

7.2.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.2.3 References

- ITU-T G.9701, clauses 9.8.3.3, 11.4.2.6, and 11.4.2.7.

7.2.4 Test Setup

See IR-337 Issue 2.

7.2.5 Method of Procedure

See IR-337 Issue 2.

7.2.6 Report

See IR-337 Issue 2.

7.2.7 Expected Results

See IR-337 Issue 2.

7.2.8 Estimated Test Time

The estimated test time for this test case is 10 minutes.

7.3 Fluctuating Broadband RFI Noise Present at Initialization Test

7.3.1 Purpose

This test verifies the stability of the G.fast link in the downstream and upstream direction, when RFI noise is injected at the CPE while the FTU-O and FTU-R initialize and after they reach the Showtime state.

7.3.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.3.3 References

- ITU-T G.9701, clause 11.4.2.8.

7.3.4 Test Setup

See IR-337 Issue 2.

7.3.5 Method of Procedure

See IR-337 Issue 2.

7.3.6 Report

See IR-337 Issue 2.

7.3.7 Expected Results

See IR-337 Issue 2.

7.3.8 Estimated Test Time

The estimated test time for this test case is 5 minutes.

7.4 Stationary Broadband RFI Noise Present at Initialization Test

7.4.1 Purpose

This test verifies the stability of the G.fast link in the downstream and upstream direction, when RFI noise is injected at the CPE while the FTU-O and FTU-R initialize and after they reach the Showtime state.

7.4.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.4.3 References

- ITU-T G.9701, clause 11.4.2.8.

7.4.4 Test Setup

See IR-337 Issue 2.

7.4.5 Method of Procedure

See IR-337 Issue 2.

7.4.6 Report

See IR-337 Issue 2.

7.4.7 Expected Results

See IR-337 Issue 2.

7.4.8 Estimated Test Time

The estimated test time for this test case is 5 minutes.

7.5 Fluctuating Broadband RFI Noise Present at Showtime Test

7.5.1 Purpose

This test verifies the stability of the G.fast link in the downstream and upstream direction, when RFI noise is injected at the CPE after the FTU-O and FTU-R reach the Showtime state.

7.5.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.5.3 References

- ITU-T G.9701, clause 11.4.2.8.

7.5.4 Test Setup

See IR-337 Issue 2.

7.5.5 Method of Procedure

See IR-337 Issue 2.

7.5.6 Report

See IR-337 Issue 2.

7.5.7 Expected Results

See IR-337 Issue 2.

7.5.8 Estimated Test Time

The estimated test time for this test case is 5 minutes.

7.6 Stationary Broadband RFI Noise Present at Showtime Test

7.6.1 Purpose

This test verifies the stability of the G.fast link in the downstream and upstream direction, when RFI noise is injected at the CPE after the FTU-O and FTU-R reach the Showtime state.

7.6.2 Certification Requirement

- FTU-O: Mandatory.
- FTU-R: Mandatory.

7.6.3 References

- ITU-T G.9701, clause 11.4.2.8.

7.6.4 Test Setup

See IR-337 Issue 2.

7.6.5 Method of Procedure

See IR-337 Issue 2.

7.6.6 Report

See IR-337 Issue 2.

7.6.7 Expected Results

See IR-337 Issue 2.

7.6.8 Estimated Test Time

The estimated test time for this test case is 5 minutes.

8 Performance Tests

8.1 Single-line Performance Tests

8.1.1 Single-line Basic Throughput Test Over a Copper Wire Pair

8.1.1.1 Purpose

The purpose of this test is to verify that the DUT can establish a stable link of sufficient performance and stability to pass data traffic over a copper wire pair at the required data rates with the Link Partner.

8.1.1.2 Certification Requirement

- FTU-O: Conditionally mandatory, with the condition that the DPU supports operation over a copper wire pair.
- FTU-R: Conditionally mandatory, with the condition that the CPE supports operation over a copper wire pair.

8.1.1.3 References

- ITU-T G.9701, clause 1.

8.1.1.4 Test Setup

See IR-337 Issue 2.

8.1.1.5 Method of Procedure

See IR-337 Issue 2.

8.1.1.6 Report

See IR-337 Issue 2.

8.1.1.7 Expected Results

See IR-337 Issue 2.

8.1.1.8 Estimated Test Time

The estimated test time for this test case is 45 minutes.

8.1.2 Single-line Basic Throughput Test Over a Coaxial Cable

8.1.2.1 Purpose

The purpose of this test is to verify that the DUT can establish a stable link of sufficient performance and stability to pass data traffic over a coaxial cable at the required data rates with the Link Partner.

8.1.2.2 Certification Requirement

- FTU-O: Conditionally mandatory, with the condition that the DPU supports operation over a coaxial cable.
- FTU-R: Conditionally mandatory, with the condition that the CPE supports operation over a coaxial cable.

8.1.2.3 References

- ITU-T G.9701, clause 1.

8.1.2.4 Test Setup

See IR-337 Issue 2.

8.1.2.5 Method of Procedure

See IR-337 Issue 2.

8.1.2.6 Report

See IR-337 Issue 2.

8.1.2.7 Expected Results

See IR-337 Issue 2.

8.1.2.8 Estimated Test Time

The estimated test time for this test case is 45 minutes.

8.2 Multi-line Performance Tests Over Copper Wire Pairs

These tests apply only if the DPU supports operation over a copper wire pair and supports multiple ports. The number of ports/pairs used for multi-line testing (represented by N) SHALL require the DPU be fully loaded, up to a maximum of 8 ports (4 port DPU is tested with 4 CPE, 8 port DPU is tested with 8 CPE, 16 port DPU is tested with 8 CPE). The DPU ports (for DPU with more than 8 ports) used for testing SHALL be randomly selected by the test lab, at the start of a certification test run (not changed in between link partners).

Note: For DPU certification, a mix of CPEs, selected by the test lab within the G.fast Certification Program guidelines (OD-362), connected to all lines of the DPU, is used for multi-line testing.

NOTE 2 - For multi-line testing for CPE certification, all lines of the DPU involved in the test have the same type of CPE connected.

8.2.1 Multi-line Basic Throughput Test Over Copper Wire Pairs

8.2.1.1 Purpose

The purpose of this test is to verify that the DUT can establish N stable links of sufficient performance and stability to pass data traffic at the required data rates with the Link Partner. The required net data rates within the expected results for this test require the devices to implement vectoring. This test is performed with all devices connecting over a mix of loop lengths, also known as non co-located CPE devices.

8.2.1.2 Certification Requirement

- FTU-O: Conditional mandatory, with the condition that the DPU supports operation over a copper wire pair and supports more than 1 port.
- FTU-R: Conditionally mandatory, with the condition that the CPE supports operation over a copper wire pair.

8.2.1.3 References

- ITU-T G.9701, clause 1.

8.2.1.4 Test Setup

See IR-337 Issue 2.

8.2.1.5 Method of Procedure

See IR-337 Issue 2.

8.2.1.6 Report

See IR-337 Issue 2.

8.2.1.7 Expected Results

See IR-337 Issue 2.

8.2.1.8 Estimated Test Time

The estimated test time for this test case is 60 minutes.

8.2.2 Multi-line Disorderly Shutdown Test Over Copper Wire Pairs

8.2.2.1 Purpose

The purpose of this test is to verify that the DUT is able to sustain with the Link Partner *N-1* stable links when a disorderly shutdown occurs on one line. This test is performed with all devices connecting over a mix of loop lengths, also known as non co-located CPE devices.

8.2.2.2 Certification Requirement

- FTU-O: Conditional mandatory, with the condition that the DPU supports operation over a copper wire pair and supports more than 1 port.
- FTU-R: Conditionally mandatory, with the condition that the CPE supports operation over a copper wire pair.

8.2.2.3 References

- None.

8.2.2.4 Test Setup

See IR-337 Issue 2.

8.2.2.5 Method of Procedure

See IR-337 Issue 2.

8.2.2.6 Report

See IR-337 Issue 2.

8.2.2.7 Expected Results

See IR-337 Issue 2.

8.2.2.8 Estimated Test Time

The estimated test time for this test case is 5 minutes.

Appendix I Example Measurement Systems for PSD Mask Testing

This Appendix provides some examples of measurement systems for the purpose of PSD mask testing (see section 6.2).

Example measurement systems for the purpose of PSD mask testing are a time-gated spectrum analyzer or a digital storage oscilloscope with post-processing, as shown in Figure I-1.

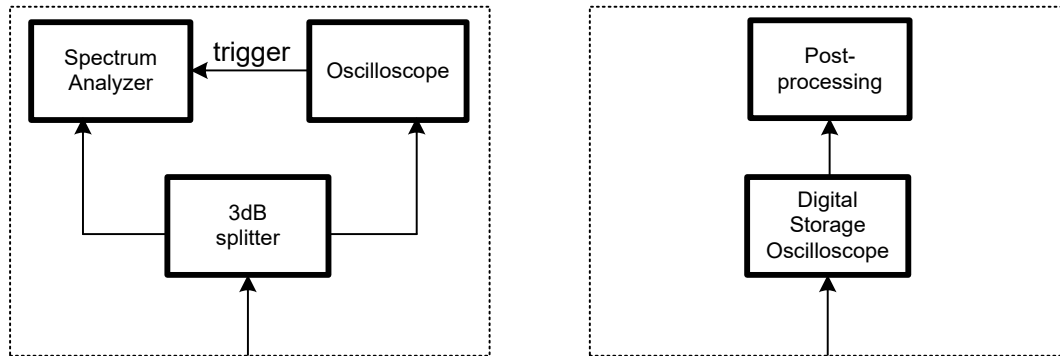


Figure I-1 - Example measurement systems for PSD mask testing.

If the measurement system uses a time gated spectrum analyzer, the spectrum analyzer is set to continuous sweep mode, due to the absence of trigger signal, when measuring the noise floor of the test setup.

Appendix II Summary of the Tests and the Estimated Test Times

This Appendix provides a summary of the tests and the estimated test times.

The summary of the tests and the estimated test times are listed in Table II-1. The tests are each marked with a test status, indicating: “M” for “mandatory,” “CM” for “conditional mandatory,” or “O” for “optional.” These terms are defined in section 2.3.

Table II-1 – Summary of the tests and the estimated test times

Reference	Test name	FTU-O	FTU-R	Estimated test time (minutes)
6.1	Inventory data Test	M	M	10
6.2.1	PSD Limit Mask Test	M	M	30
6.2.2	Sub-carrier Masking Test	M	M	10
6.2.3	PSD Shaping Test	M	M	10
6.2.4	RFI Notching Test	M	M	10
6.2.5	UPBO Test	M	M	10
6.2.6	TIGA Test	CM	CM	30
6.3.1	TDD Inter-frame Gap Test	M	M	10
6.3.2	DS and US ratio configuration (Mds) Test	M	M	10
6.4	Accelerated MTBE Test	M	M	15
6.5	Discontinuous operation Test	O	O	10
6.6	Bit swap or SRA Test	M	M	10
6.7	SRA Downshift Test	M	M	15
6.8	SRA Upshift Test	M	M	15
6.9	FRA & SRA Upshift Test	M	M	10
6.10	RPA Test	M	M	10
6.11	RMC bit loading configuration Test	M	M	10
6.12.1	Short disconnect Test	M	M	10
6.12.2	Long disconnect Test with LOS failure	M	M	10
6.12.3	Long disconnect Test with LOR failure	M	M	10
6.13	Dying gasp Test	O	O	10
6.14	Increased Bit Loading Test	M	M	10
6.15	Test Parameters Test	M	M	10
7.1	SHINE stability Test	M	M	15
7.2	REIN stability Test	M	M	10
7.3	Fluctuating Broadband RFI Noise Present at	M	M	5

	Initialization Test			
7.4	Stationary Broadband RFI Noise Present at Initialization Test	M	M	5
7.5	Fluctuating Broadband RFI Noise Present at Showtime Test	M	M	5
7.6	Stationary Broadband RFI Noise Present at Showtime Test	M	M	5
8.1.1	Single-line Basic Throughput Test over a copper wire pair	CM	CM	45
8.1.2	Single-line Basic Throughput Test over a coaxial cable	CM	CM	45
8.2.1	Multi-line Basic Throughput Test over copper wire pairs	CM	CM	60
8.2.2	Multi-line Disorderly Shutdown Test over copper wire pairs	CM	CM	5
	Estimated total test time for ATP-337 Issue 2			485

End of Broadband Forum Abstract Test Plan ATP-337 Issue 2