TECHNICAL REPORT

TR-380
G.fast Performance Test Plan

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Issue History

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Comments or questions about this Broadband Forum Technical Report should be directed to info@broadband-forum.org.

Editor	Herman Verbueken	Nokia
Physical Layer Transmission Work Area Director	Herman Verbueken	Nokia
G.fast & RPF Certification Testing Project Stream Leader	Frank Van der Putten	Nokia

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Executive Summary

This Broadband Forum Technical Report, TR-380, provides a set of performance test cases and related pass/fail requirements for G.fast implementations according to ITU-T Recommendations G.9700 and G.9701.

The performance tests defined in TR-380 complement the testing requirements defined within the Broadband Forum's Gfast certification program and its associated ATP-337[7] test plan.

The goal of TR-380 is to provide a set of test cases to measure the performance between a DPU and one or more CPEs.

The test plan includes test setup information, equipment configuration requirements, test procedures, and pass/fail requirements for each test case.

1 Purpose and Scope

1.1 Purpose

TR-380 provides a set of 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 performance tests defined in WT-380 complement the testing requirements defined within the Broadband Forum's Gfast certification program and its associated ATP-337[7] test plan.

The goal of TR-380 is to provide performance requirements between a DPU and one or more CPEs. The test cases are defined for a DPU and CPE combination.

Technical content in this test plan includes test setup information, equipment configuration requirements, test procedures, and pass/fail requirements for each test case.

1.2 Scope

This Technical Report is intended to provide a performance test plan for ITU-T Recommendation G.9700 “Fast access to subscriber terminals (G.fast) – Power spectral density specification”[1] and G.9701 “Fast access to subscriber terminals (G.fast) – Physical layer specification” [2].

G.fast provides significant flexibility in transceiver functionality through configuration and therefore it is not practical to include tests for all possible combinations. Since network architectures and deployment practices vary greatly amongst service providers, the network conditions (loop models, noise models, loop lengths, etc.) were selected to represent nominal conditions under which (interoperability) performance is tested. This test plan is focused on ensuring laboratory repeatability such that equipment from different vendors can be validated and compared.

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

Performance testing in the presence of reverse power feeding is out of scope of this issue of TR-380.

1.3 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 system “passes TR-380 testing,” the system SHALL pass all “mandatory” tests and all applicable “conditional mandatory” tests. “Optional” tests SHALL not impact the summary result.
A system is a combination of a DPU and one or more CPEs and is referred to as ‘System Under Test’ or ‘SUT’ in the remainder of the testplan.

Different sets of tests may apply depending on the media type supported (e.g., twisted pair, coax).

The testplan only defines the requirements for each individual test case. For some tests, parameters are recorded for reporting purposes only. These parameters might be useful for debugging purposes.

2 References and Terminology

2.1 Conventions

In this Technical Report, 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 Technical Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Technical Report 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	*Fast Access to Subscriber Terminals (G.fast) - Power spectrum density specification*	ITU-T	07/2019
[2]	G.9701	*Fast Access to Subscriber Terminals (G.fast) - Physical layer specification*	ITU-T	03/2019
[3]	RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[4]	RFC 791	*Internet Protocol*	IETF	1981

[5]	G.997.2	*Physical Layer OAM for G.fast*	ITU-T	03/2019
[6]	TR-285 issue 2	*Broadband Copper Cable Models issue 2*	Broadband Forum	09/2019
[7]	ATP-337 issue 2	*G.fast Certification Abstract Test Plan*	Broadband Forum	08/2019

2.3 Definitions

The following terminology is used throughout this Technical Report.

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."
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 Technical Report uses the following abbreviations:

AGN	Additive Gaussian Noise
CPE	Customer Premises Equipment
DPU	Distribution Point Unit
DTU	Data Transfer Unit
ETR	Expected Throughput
FLR	Frame Loss Ratio
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
LAN	Local Area Network
LOM	Loss of margin
LOR	Loss of RMC
LOS	Loss of signal
MAC	Media Access Control
MAE	Mean Absolute Error
MBW	Measurement Bandwidth

ME	Mean Error
MIB	Management Information Base
MTBE	Mean Time Between Error
NDR	Net Data Rate
NT	Network Termination
NTP	Network Termination Point
PSD	Power Spectral Density
psds/us	per sub-carrier downstream/upstream
REIN	Repetitive Electrical Impulse Noise
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
SUT	System Under Test
TDD	Time Division Duplexing
UAS	Unavailable Second
UDP	User Datagram Protocol
UPBO	Upstream Power Back-Off
VLAN	Virtual LAN
WAN	Wide Area Network

3 Technical Report Impact

3.1 Energy Efficiency

TR-380 has no impact on Energy Efficiency.

3.2 Security

TR-380 has no impact on Security.

3.3 Privacy

Any issues regarding privacy are not affected by TR-380.

4 Equipment Features

4.1 System Under Test Information

Table 1 and Table 2 are intended to provide test engineers and readers of the test report with sufficient information about the SUT in order to assure repeatability of results and to allow for comparisons of reported test results. 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 DPU or CPE, the item MAY be marked as "Not Applicable."

Table 1 - 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.
FTU-O Annex X support (ANNEX_X_SUPPORT_FTU_O)	See section T.4.1/G.997.2.
DPU Broadband Forum Certified?	Yes/No
DPU link interface speed	Gbit/s

Table 2 - 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.
FTU-R Annex X support (ANNEX_X_SUPPORT_FTU_O)	See section T.4.2/G.997.2.
CPE Broadband Forum Certified?	Yes/No
CPE LAN port interface speed	Gbit/s

4.2 Management of the DPU and CPE

The DPU 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 CPE is managed through the DPU-MIB and the G.9701 initialization/eoc/RMC. No 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 System Under Test, and setup of the simulated network environment) for the 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.

The DPU SHOULD support:

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

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

1. IPv4 Bridging between the WAN and LAN ports, as defined in TR-124 Issue 3, WAN.BRIDGE.1.
2. IPv4 Port Forwarding between the WAN and LAN ports, as defined in TR-124 Issue 3, LAN.PFWD.1. The CPE SHALL be configured for forward IPv4 traffic for UDP Port 1024 between the WAN and LAN.

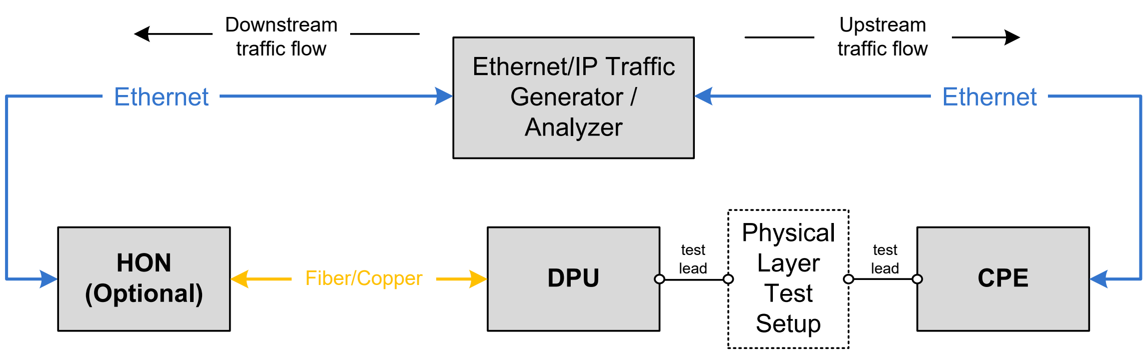


Figure 1 - Test setup for Ethernet/IP traffic with single line test

The test leads, shown in Figure 1, used to connect the Physical Layer Test Setup to the DPU and CPE(s) SHALL be of 1 meter ± 2.5 cm length and SHALL be of type CAT6 or better.

The Ethernet/IP Traffic Generator/Analyzer shown in Figure 1 is not able to distinguish whether Ethernet frames are dropped in the DPU, the CPE, the HON, or the Ethernet switch. Hence, when verifying that no Ethernet frames are dropped in the SUT, a background frame loss ratio (FLR) of 4e-7 is allowed as to not fail the SUT 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 1), 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 single line test shown in Figure 1,

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 3.

Table 3 - 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 4 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 [4] 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 4 - 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

IP Destination	IP2 (Note 2)	IP1	SHOULD be globally routable, public IP addresses. IP3 MAY be a private IP address if the CPE is implementing port forwarding.
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 5.

Table 5 - 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.

$$\text{Average\_Frame\_Size\_of\_Mix}\left(\frac{bytes}{frame}\right) = \left\lceil \sum_{i=1}^{M} \text{frame\_probability}(i) \times \text{frame\_size}(i) \right\rceil .$$

For the Frame Size Distribution in Table 5, the Average_Frame_Size_of_Mix is 1193 bytes.

$$\text{Required\_Frame\_Rate}\left(\frac{frames}{\text{sec}}\right) = \left\lfloor \frac{\text{Required\_Throughput} \times \frac{1}{8}}{\text{Average\_Frame\_Size\_of\_Mix}} \right\rfloor ,$$

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 2, 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.

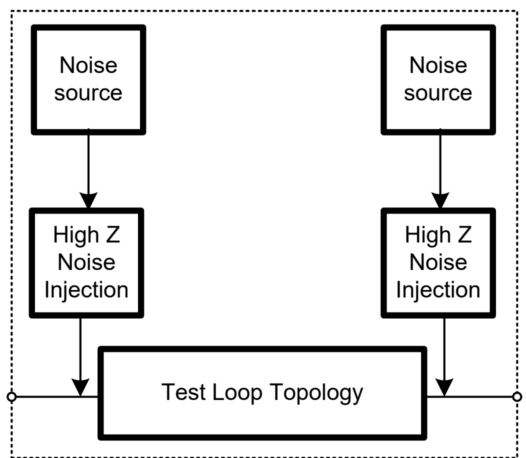


Figure 2 - One instance of a Physical Layer Test Setup

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.

5.2 Test Setup Characteristics

Test results obtained as a result of testing performed in accordance with TR-380 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 6 and SHALL be included as part of the test report. The range of temperature SHOULD be between 15 °C (59 °F) and 35 °C (95 °F). The range of humidity SHOULD be between 5% and 85%.

Table 6 - Temperature and Humidity Range of Test Facility

Parameter	High	Low
Temperature		
Humidity		

5.2.2 Test Equipment Calibration

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 included as part of a written test report.

5.2.3 Loops Environment Characteristics

The test loops SHALL be recorded in a manner similar to that shown in Table 7 and SHALL be included as part of the test report.

Table 7 - Loops used for Testing

Loop	wire type, wire gauge and length Emulator manufacturer, serial number and model number

A wire or emulator description SHALL be included as part of the test report.

5.3 System Under Test settings

This section defines the values for all configuration parameters defined in G.997.2[5] 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.

5.3.1 Profile Settings

The profile SHALL be configured as defined in Table 8.

Table 8 - G.fast profile configuration

Configuration Parameter	G.997.2 reference	Default value
G.9701 profiles enabling (PROFILES)	7.1.0.1	Only one profile allowed

5.3.2 Time division duplexing (TDD) settings

The TDD SHALL be configured as defined in Table 9.

Table 9 - 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 for twisted pair profiles SHALL be configured as defined in Table 10.

Table 10 - Power spectrum usage configuration for twisted pair profiles

Configuration Parameter	G.997.2 reference	Default value
Downstream maximum aggregate transmit power (MAXATPds)	7.1.2.1	8 dBm (106b) 4 dBm (106a, 212a)
Upstream maximum aggregate transmit power (MAXATPus)	7.1.2.2	8 dBm (106b) 4 dBm (106a, 212a)
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 G.9700
Upstream PSD mask (MIBPSDMASKus)	7.1.2.6	Limit PSD mask defined in 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 (Note 1)
Upstream power back-off reference PSD (UPBOPSDB)	7.1.2.10	0 dBm/Hz (Note 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)
Class of downstream limit masks (CLASSMASKds)	7.1.2.14	Classmask_1 (Note 2)
Class of upstream limit masks (CLASSMASKus)	7.1.2.15	Classmask_1 (Note 2)
Note 1: These values imply that UPBO is disabled. **Note 2**: If the DPU supports configuration of CLASSMASK, it MUST be configured at its default		

value (Classmask_1). If the DPU does not support configuration of CLASSMASK, then, G.9701 requires it operates according to Classmask_1.

5.3.4 Noise margin (SNRM) settings

The noise margins SHALL be configured as defined in Table 11.

Table 11 - 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 12.

Table 12 - 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 13.

Table 13 - 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 14.

Table 14 - 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 SUT contains a multi-port DPU, then the vectoring SHALL be configured as defined in Table 15.

Table 15 - 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 16.

Table 16 - Re-initialization policy configuration

Configuration Parameter	G.997.2 reference	Default value
Downstream *los* defect persistency (LOS_PERSISTENCYds)	7.1.8.1	0.2 seconds
Upstream *los* defect persistency (LOS_PERSISTENCYus)	7.1.8.2	0.2 seconds
Downstream *lom* defect persistency (LOM_PERSISTENCYds)	7.1.8.3	2 seconds
Upstream *lom* defect persistency (LOM_PERSISTENCYus)	7.1.8.4	2 seconds
Downstream *lor* defect persistency (LOR_PERSISTENCYds)	7.1.8.5	0.2 seconds
Upstream *lor* 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 17.

Table 17 - 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 18.

Table 18 - Downstream and upstream channel data rates configuration

Configuration Parameter	G.997.2 reference	Default value
Maximum Net Data Rate (MAXNDR)	7.2.1.1	3 000 000 kbit/s
Minimum Expected Throughput (MINETR)	7.2.1.2	518 kbit/s
Maximum Gamma Data Rate (MAXGDR)	7.2.1.3	3 000 000 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 19.

Table 19 - 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 20.

Table 20 - Data path configuration

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

5.4 Test Setup

5.4.1 Test Loop Topologies

Single line tests (non-vectored) are performed on one loop type:

- TP-100 twisted pair

5.4.1.1 Single-Pair Cable Test Loop Topology

The twisted single-pair SHALL be of type TP-100.

The twisted single-pair lengths (not including the test leads) SHALL be as defined in Table 21:

Table 21 - Twisted single pair loop length

Loop Length for TP-100 (m)
35
50
100
150
200
250
300
350
400

Mean Absolute Error (MAE) and Mean Error (ME) for loop X are given by Equation 1 and Equation 2:

Equation 1: MAE

$$MAE_{LoopX} = \frac{1}{N_i} \sum_{i \in \{A_{Ti} \leq A_{max}\}} |A_{Ri} - A_{Ti}|$$

Equation 2: ME

$$ME_{LoopX} = \frac{1}{N_i} \sum_{i \in \{A_{Ti} \leq A_{max}\}} (A_{Ri} - A_{Ti})$$

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 70 dB.

The A_{Ti} values SHALL be calculated according to the TP-100 model defined in TR-285[6] Annex E.

The index “i” belongs to a set defined by the points necessary to measure the attenuation in steps of 50kHz or less from 2 MHz to 212 MHz 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.

The loop SHALL be compensated by adjusting the loop length such that the absolute value of ME is minimized while maintaining an MAE less than or equal to 1 dB. The compensation procedure for all loop lengths SHALL be performed with the noise injector connected as shown in Figure 2.

This accuracy requirement SHALL apply for all test loops.

5.4.2 Noise Models

5.4.2.1 Background Noise

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

> **Note:** The AGN extends to 240 MHz so that it is not discontinuous at the 212 MHz boundary of the G.9700/G.9701 signal spectrum.

The Background Noise PSD (referred to as PSD_{BG}) is defined as follows (see):

PSD_{BG} = -140 dBm/Hz for 2 MHz ≤ f ≤ 30 MHz (low frequency region);
-140 dBm/Hz to -150 dBm/Hz for 30 MHz ≤ f ≤ 40.656 MHz (interpolated dB/f region);
-150 dBm/Hz for 40.656 MHz < f ≤ 240 MHz (high frequency region).

> **Note:** This Noise PSD definition recognizes that at the higher frequencies above 30 MHz, the background noise, while having a flat spectrum, is lower than at the lower frequencies below 30 MHz.

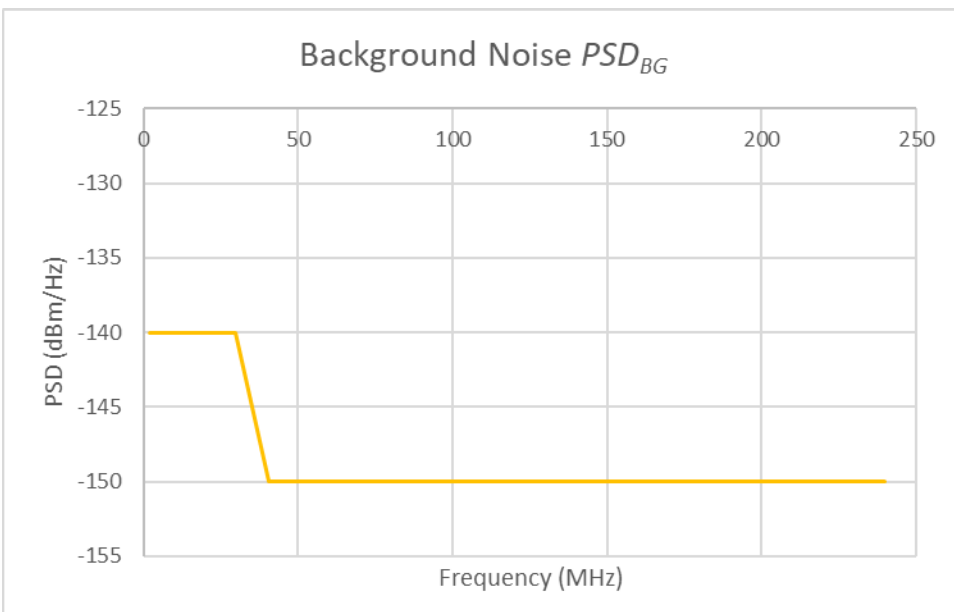


Figure 3 - PSD of the Background Noise PSD_{BG}.

5.4.3 Noise injection

5.4.3.1 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, with the test leads and loop removed, and terminated by the reference impedance Rv. The measured noise will be impacted by the noise generator tolerance and the coupling circuit tolerance.

An example setup is shown in Figure 4:

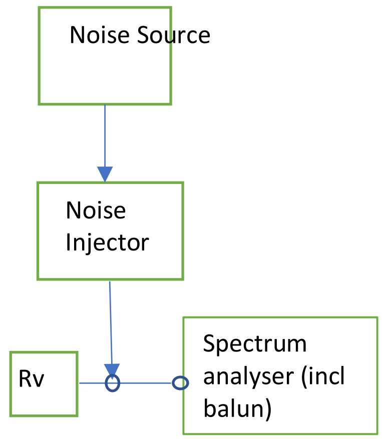


Figure 4 - Example Noise calibration setup

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

At least one measurement SHALL be made per 100 kHz interval with a 100 kHz resolution bandwidth. 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 Mean Absolute Error (MAE) for noise X is defined as:

Formula 1: Noise MAE calculation

$$MAEnoise\ X = \frac{1}{M} \sum_{i \in \{P_{Ti} \geq -150\ dBm/Hz\}} |P_{Ri} - P_{Ti}|$$

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

Formula 2: Noise ME calculation

$$MEnoise\ X = \frac{1}{M} \sum_{i \in \{P_{Ti} \geq -150\ dBm/Hz\}} (P_{Ri} - P_{Ti})$$

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
M is the number of power samples.

The index "i" belongs to a set defined by the points necessary to measure the noise power in steps of 100kHz or less and taking into account only those points for which $P_{Ti} \geq -150$ dBm/Hz.

The noise generator SHALL be compensated such that the absolute value of ME is minimized while maintaining a MAE accuracy of 0.5 dB from 2MHz to 120 MHz and 1 dB from 120 MHz to 240 MHz.

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

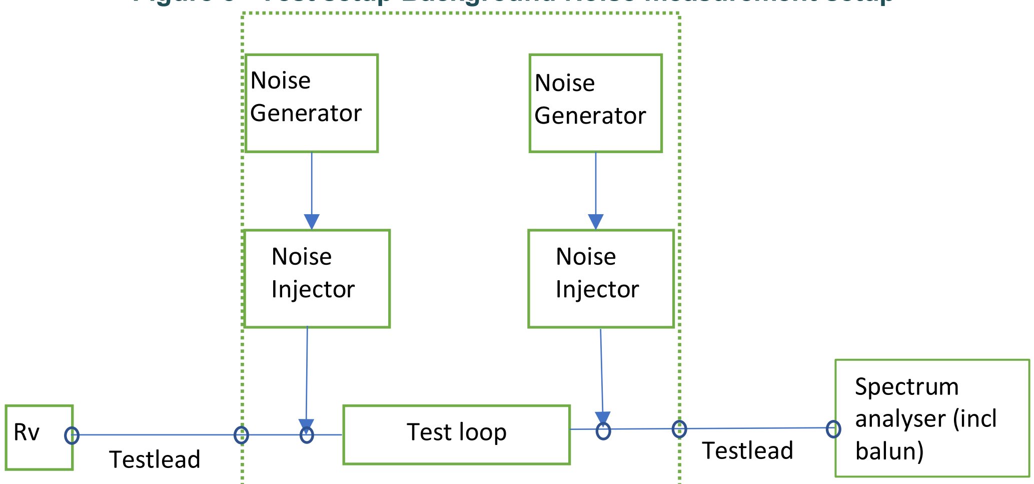
1. absolute amplitude accuracy
2. vertical linearity
3. frequency response of the measurement equipment used
4. tolerance of the calibration impedance.

5.4.3.2 Test setup Background Noise Requirement

A measurement of the test setup background noise SHALL be made, where that noise SHALL be at least 10 dB lower than the lowest defined noise within this test plan. The measurement of the laboratory test setup background noise floor MAY exclude up to 23 narrow band noise "spikes," where a narrow band noise "spike" bandwidth of less than 1 MHz is defined in G.9700[1].

The measurement SHALL be made with a 1 MHz resolution bandwidth.
All equipment in the test setup including loop simulator (if applicable), noise generator, and noise injector SHALL be connected and powered on without generating noise. Figure 5 shows the measurement setup. The measurement SHALL be performed for each test loop in Table 21.

Figure 5 - Test setup Background Noise measurement setup



5.4.4 Minimum Interface Speed of the SUT

In the SUT the DPU 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.

5.4.5 Management of the SUT

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 any 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.

6 Performance Tests

For each test in this section, reported items/measurements are verified in the expected results as applicable to the SUT. The Table 22 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 22 - Parameters as applicable to the SUT

Parameter	**DPU related**	CPE **related**
MAXATPds/us	MAXATPds	MAXATPus
MAXBL-RMCds/us	MAXBL-RMCds	MAXBL-RMCus
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
CURR_24_NE/FE_[x]	CURR_24_NE_[x]	CURR_24_FE_[x]

Performance categories used in this Working Text are defined in Table 23. Each performance category relates to the type of test setup and the corresponding G.fast profile. The performance categories are each marked with a test status, indicating “mandatory (M)”, “conditional mandatory (CM)”, or “optional (O)” test cases.

Table 23 - Performance categories and test case requirements

<table>
<tr><td rowspan="2"></td><td colspan="3">Performance categories</td></tr>
<tr><td colspan="2">CatA</td><td>CatB</td></tr>
<tr><td>G.fast Profile</td><td>106a</td><td>212a</td><td>106b</td></tr>
<tr><td colspan="4">Test case</td></tr>
<tr><td>Single-line TP100 twisted pair</td><td>M</td><td>M</td><td>M</td></tr>
</table>

Performance test cases are defined in Section 6.1, for the following performance categories:

- Section 6.1.1: Single-line TP100 twisted pair: CatA_106, CatA_212 and CatB_106;

6.1 Single-line PerformanceTest

6.1.1 Single Twisted Pair Net Data Rate Performance Test

6.1.1.1 Purpose

The purpose of this test is to measure the single line rate reach performance on twisted pair of the SUT.

6.1.1.2 Test Setup

1. The SUT SHALL be connected to the test setup shown in Figure 1
2. The SUT SHALL be configured 106a, 212a, or 106b G.fast profile per section 5.3.
3. The loops with lengths listed in Table 21 and defined in section 5.4.1.1 SHALL used for testing.
4. Inject the background noise $PSD_{BG,}$ as defined in section 5.4.2.1, at both ends of the loop.

6.1.1.3 Method of Procedure

1. Allow the SUT to establish a G.fast connection through the first loop listed in Table 21.
2. Wait 30 seconds to allow the SUT to perform any adjustments to the link.
3. Record the downstream and upstream net data rate (NDRds and NDRus), downstream and upstream gamma data rate (GDRds and GDRus), downstream and upstream signal to noise ratio margin (SNRMds and SNRMus).
4. Repeat steps 1 through 3 for each of the other loops listed in Table 21.

6.1.1.4 Report

The following items/measurements SHALL be included in the report:

1. The NDRds, NDRus, GDRds, GDRus, SNRMds, SNRMus recorded in step 3 for each loop length.

6.1.1.5 Expected Results

For each loop length in Table 21:

1. For the loop lengths larger or equal 100m, the SNRMds/us SHALL be within the bounds of the configured SRA downshift margin (SRA-DSNRMds/us) and SRA upshift margin (SRA-USNRMds/us), inclusively.
2. For the loop lengths 35 and 50m, the SNRMds/us SHALL be larger than the configured SRA downshift margin (SRA-DSNRMds/us).
3. The aggregate net data rate (i.e., NDRds+NDRus) SHALL be equal to or higher than the required aggregate net data rate indicated in Table 24 for the specific loop length.

Table 24 - Single line performance loop requirements

Loop Length for TP-100 (m)	Aggregate net data rate (Mbit/s for operation according to profile			
	106a Gen 1 (Note)	106a Gen 2 (Note)	106b	212a
35	875	1000	1000	1600
50	850	1000	1000	1600
100	800	969	948	1444
150	530	835	820	994
200	370	650	620	678
250	280	480	445	480
300	280	339	340	339
350	200	252	260	252
400	75	181	200	181

Note:
Gen 1 refers to Gfast systems implementing the feature set and requirements as defined in the Gfast Certification test plan issue 1 (ATP-337 Issue 1).

Gen 2 refers to Gfast systems implementing the feature set and requirements as defined in the Gfast Certification test plan issue 2, including amendments (ATP-337 Issue 2).

6.2 Attainable Net Data Rate Test

6.2.1 Purpose

The purpose of this test is to verify the reliability of the Attainable net data rate (ATTNDR) parameter.

6.2.2 Test Setup

1. The SUT SHALL be connected to the test setup shown in Figure 1.
2. The SUT SHALL be configured according to section 5.3.
3. The loops of 50m, 100m, 200m, as defined in section 5.4.1 SHALL be used for the testing.

6.2.3 Method of Procedure

1. Configure the MAXNDRds and MAXGDRds to 100 000 kbit/s, and MAXNDRus and MAXGDRus to 20 000 kbit/s.
2. Allow the SUT establish a G.fast connection through the loop.
3. Wait 60 seconds to allow the SUT to perform any adjustments to the link.
4. Record the downstream and upstream Attainable net data rate (ATTNDR).

5. Reconfigure the MAXNDR and MAXGDR to default values specified in Table 18 and allow the system to retrain.
6. Wait 60 seconds to allow the SUT to perform any adjustments to the link.
7. Record the downstream and upstream net data rate (NDR).
8. Repeat Steps 1-7 for each of the test loops.
9. Repeat Steps 1-8 for a different randomly selected valid value of Mds.

6.2.4 Expected Results

For each of the measurements:

- For 50m: 0.975 * ATTNDRds/us - 1 Mbit/s < NDRds/us < 1.025 * ATTNDRds/us + 1 Mbit/s,
- For 100m: 0.97 * ATTNDRds/us - 1 Mbit/s < NDRds/us < 1.03 * ATTNDRds/us + 1 Mbit/s,
- For 200m: 0.96 * ATTNDRds/us - 1 Mbit/s < NDRds/us < 1.04 * ATTNDRds/us + 1 Mbit/s.

End of Broadband Forum Technical Report TR-380