2.5, 5, 10G ETHERNET TESTING SERVICE

Clause 128

2.5GBASE-KX PMD Test Plan

Version 1.0

Technical Document

2.5, 5, 10G Ethernet Testing Service

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MODIFICATION RECORD

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Hayden Haynes: Initial draft of test plan.

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Hayden Haynes: Updated to 802.3cb-D3.

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Hayden Haynes	UNH InterOperability Laboratory
Mike Klempa	UNH InterOperability Laboratory

INTRODUCTION

The University of New Hampshire's InterOperability Laboratory (IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This test plan has been developed to help implementers evaluate the functionality of the Physical Medium Dependent (PMD) sublayer of their 2.5GBASE-KX products.

These tests are designed to determine if a product conforms to specifications defined in Clause 128 of the IEEE 802.3 Standard. Successful completion of all tests contained in this plan does not guarantee that the tested device will operate with other devices. However, combined with satisfactory operation in the IOL's interoperability test bed, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function properly in many 2.5GBASE-KX environments.

The tests contained in this document are organized in such a manner as to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are organized into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality. A three-part numbering system is used to organize the tests, where the first number indicates the clause of the IEEE 802.3 standard on which the test plan is based. The second and third numbers indicate the test's group number and test number within that group, respectively. This format allows for the addition of future tests to the appropriate groups without requiring the renumbering of the subsequent tests.

The test definitions themselves are intended to provide a high-level description of the motivation, resources, procedures, and methodologies pertinent to each test. Specifically, each test description consists of the following sections:

Purpose

The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level.

References

This section specifies source material *external* to the test plan, including specific subclauses pertinent to the test definition, or any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by number when mentioned in the test description. Any other references not specified by number are stated with respect to the test plan document itself.

Resource Requirements

The requirements section specifies the test hardware and/or software needed to perform the test. This is generally expressed in terms of minimum requirements, however in some cases specific equipment manufacturer/model information may be provided.

Last Modification

This specifies the date of the last modification to this test.

Discussion

The discussion covers the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here.

Test Setup

The setup section describes the initial configuration of the test environment. Small changes in the configuration should not be included here, and are generally covered in the test procedure section, below.

Test Procedure

The procedure section of the test description contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with observable results.

Observable Results

This section lists the specific observables that can be examined by the tester in order to verify that the DUT is operating properly. When multiple values for an observable are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is generally based on the successful (or unsuccessful) detection of a specific observable.

Possible Problems

This section contains a description of known issues with the test procedure, which may affect test results in certain situations. It may also refer the reader to test plan appendices and/or whitepapers that may provide more detail regarding these issues.

GROUP 1: ELECTRICAL SIGNALING REQUIREMENTS

Overview:

The tests defined in this section verify the electrical signaling characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 128 of IEEE 802.3.

Test 128.1.1 – Signaling Speed

Purpose: To verify that the baud rate of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter Electrical Characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.3 – Signaling Speed
[3] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test fixtures
[4] IEEE Std. 802.3-2018, Annex 48A.1 – High frequency test pattern

Resource Requirements: See Appendix 128.A.

Last Modification: January 8, 2019

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the signaling speed, which is specified in [2].

Reference [2] states that the 2.5GBASE-KX signaling speed shall be 3.125 Gbaud +/- 100 ppm. This translates to 3.125 Gbaud +/- 0.3125 Mbaud, with a nominal Unit Interval (UI) of 320 ps.

In this test, the signaling speed is measured while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT may be any valid 2.5GBASE-KX signal, however the high frequency test pattern defined in reference [4] will be used, due to convenience.

Test Setup: See Appendix 128.A.

Test Procedure:

1. Configure the DUT to send a high frequency test pattern.
2. Connect the DUT's transmitter to the test fixture.
3. Measure the average TX signaling speed.

Observable Results:

a. The signaling speed shall be within 3.125 Gbaud +/- 0.3125 Mbaud

Possible Problems: None.

Test 128.1.2 – Common Mode Output Voltage

Purpose: To verify that the DC common mode output voltage of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.4 – Output amplitude
[3] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test fixtures
[4] IEEE Std. 802.3-2018, Annex 48A.1 – High frequency test pattern

Resource Requirements: See Appendix 128.A.

Last Modification: January 8, 2019

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the common mode output voltage defined in [2].

In this test, the DC common mode output voltage is measured at the V_{com} test point while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT may be any valid 2.5GBASE-KX signal, however the high frequency test pattern defined in reference [4] will be used due to convenience.

Test Setup: See Appendix 128.A.

Test Procedure:

1. Configure the DUT to transmit a valid test pattern.
2. Connect the DUT's transmitter to the test fixture.
3. Measure the common mode output voltage of SL<p> and SL<n> at the V_{com} test point.

Observable Results:

a. The common mode output voltage shall be between 0 V and 1.9 V with respect to the signal shield.

Possible Problems: None.

Test 128.1.3 – Differential Output Amplitude

Purpose: To verify that the differential output amplitude of the DUT transmitter is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.4 – Output amplitude
[3] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test fixtures
[4] IEEE Std. 802.3-2018, subclause 52.9.1.2 –Square wave pattern definition
[5] IEEE Std. 802.3cb, subclause 128.6.5 – PMD transmit disable function

Resource Requirements: See Appendix 128.A.

Last Modification: January 8, 2019

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the differential output amplitude defined in [2].

In this test, the maximum and minimum differential peak-to-peak output voltage are measured while the DUT is connected to the test fixture defined in [3], or its functional equivalent. The signal being transmitted by the DUT shall be the square wave test pattern defined in [4] consisting of a run of at least eight consecutive ones and eight consecutive zeros. For TX disable, the transmitter shall abide by the disable function defined in [5].

Test Setup: See Appendix 128.A.

Test Procedure:

1. Connect the DUT's transmitter to the test fixture.
2. Configure the DUT to send the square wave test pattern defined in [4].
3. Measure the maximum peak-to-peak differential output voltage.
4. Measure the minimum peak-to-peak differential output voltage.
5. Disable the transmitter according to [5] and measure the peak-to-peak output voltage.

Observable Results:

a. The minimum and maximum differential peak-to-peak output voltage shall be no less than 800 mV and no greater than 1,200 mV respectively, regardless of equalization setting.
b. The transmitter output voltage shall be less than 30 mV peak-to-peak when disabled.

Possible Problems: None.

Test 128.1.4 – Transition Time

Purpose: To verify that the rising and falling edge transition times are within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.7 – Transition time
[3] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test fixtures
[4] IEEE Std. 802.3-2018, Annex 48A.1 – High frequency test pattern

Resource Requirements: See Appendix 128.A.

Last Modification: March 15, 2018

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the rising and falling edge transition times defined in [2].

In this test, the transition time is measured while the DUT is connected to the test fixture defined in [3] or its functional equivalent. The transition times are to be measured at the 20% and 80% levels as defined in Table 128-4 of reference [1] using the high frequency test pattern defined in reference [4].

Test Setup: See Appendix 128.A.

Test Procedure:

1. Configure the DUT so that it is sourcing the high frequency test pattern defined in [4].
2. Connect the DUT’s transmitter to the test fixture.
3. Measure the rising and falling edge transition times at the 20% and 80% levels.

Observable Results:

a. The rising and falling edge transition times shall be between 30 ps and 100 ps.

Possible Problems: None.

Test 128.1.5 – Transmit Jitter

Purpose: To verify that the peak-to-peak transmit jitter of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.8 – Transmit jitter test requirements
[3] IEEE Std. 802.3cb, subclause 128.7.1.9 – Transmit jitter
[4] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test fixtures
[5] IEEE Std. 802.3-2018, Annex 48A.1 – High frequency test pattern

Resource Requirements: See Appendix 128.A.

Last Modification: January 8, 2019

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the peak-to-peak transmit jitter defined in [2] and [3].

In this test, the peak-to-peak transmit jitter is measured while the DUT is connected to the test fixture defined in [4] or its functional equivalent. Reference [2] specifies that the DUT must transmit the high frequency test pattern defined in reference [5]. For this test, Duty Cycle Distortion is considered part of Deterministic Jitter and jitter is defined with a BER of 10^{-12}.

Test Setup: See Appendix 128.A.

Test Procedure:

1. Connect the DUT's transmitter to the test fixture.
2. Configure the DUT so that it is sourcing the high frequency test pattern defined in [5].
3. Measure the random jitter, deterministic jitter, duty cycle distortion and total transmit jitter.

Observable Results:

a. The Random Jitter value shall not exceed 0.2 UI.
b. The Deterministic Jitter value shall not exceed 0.12 UI.
c. The Duty Cycle Distortion value shall not exceed 0.035 UI.
d. The Total Jitter value shall not exceed 0.32 UI.

Possible Problems: None.

GROUP 2: IMPEDANCE REQUIREMENTS

Overview:

The tests defined in this section verify the impedance characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 128 of IEEE 802.3.

Test 128.2.1 – Differential Output Return Loss

Purpose: To verify that the differential output return loss of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.5 – Differential output return loss

Resource Requirements: See Appendix 128.A.

Last Modification: January 8, 2019

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the differential output return loss, which is specified in [2].

For the purpose of this test, the differential output return loss is defined as the magnitude of the reflection coefficient expressed in decibels. The reflection coefficient is the ratio of the voltage in the reflected wave to the voltage in the incident wave. For frequencies from 100 MHz to 2 GHz, the differential return loss of the driver shall abide by Equation 128-3. The reference impedance for differential return loss measurements is 100 Ω.

$$Returnloss \quad \geq \left\{ \begin{matrix} 10 & 100 \leq f < 625 \\ 10 - 10\log10\left(\frac{\mathrm{f}}{625}\right) & 625 \leq f \leq 2000 \end{matrix} \right\} (dB) \qquad (EQ. 128 - 3)$$

Test Setup: See Appendix 128.A.

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT’s transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 100 MHz to 2000 MHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:

a. The differential output return loss shall abide by the limits described in Equation 128-3.

Possible Problems: None.

Test 128.2.2 – Common-Mode Output Return Loss

Purpose: To verify that the common-mode output return loss of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.1 – Transmitter characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.1.6 – Common-mode output return loss

Resource Requirements: See Appendix 128.A.

Last Modification: March 15, 2018

Discussion:

Reference [1] specifies the transmitter characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the common-mode output return loss defined in [2].

For the purpose of this test, the common-mode output return loss is defined as the magnitude of the reflection coefficient expressed in decibels. The reflection coefficient is the ratio of the voltage in the reflected wave to the voltage in the incident wave. For frequencies from 100 MHz to 2 GHz, the common-mode return loss of the driver shall abide by Equation 128-4. The reference impedance for common-mode return loss measurements is 25 Ω.

$$Returnloss \geq \left\{ \begin{matrix} 7 & 100 \leq f < 625 \\ 7 - 13.275\log10\left(\frac{\mathrm{f}}{1250}\right) & 625 \leq f \leq 2000 \end{matrix} \right\} (dB) \qquad (EQ.128-4)$$

Test Setup: See Appendix 128.A

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing normal IDLE signaling.
3. Connect the DUT’s transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 100 MHz to 2 GHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:

a. The common-mode output return loss shall abide by the limits described in Equation 128-4.

Possible Problems: None.

Test 128.2.3 – Differential Input Return Loss

Purpose: To verify that the differential input return loss of the DUT is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.2 – Receiver characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.2.5 – Differential input return loss

Resource Requirements: See Appendix 128.A.

Last Modification: March 15, 2018

Discussion:

Reference [1] specifies the receiver characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the differential input return loss defined in [2].

For the purpose of this test, the differential input return loss is defined as the magnitude of the reflection coefficient expressed in decibels. The reflection coefficient is the ratio of the voltage in the reflected wave to the voltage in the incident wave. For frequencies from 100 MHz to 2 GHz, the differential input return loss of the driver shall abide by the margins defined in Equation 128-3. The reference impedance for differential input return loss measurements is 100 Ω.

$$Returnloss \geq \left\{\begin{matrix} 10 & 100 \leq f < 625 \\ 10 - 10\log10\left(\frac{\mathrm{f}}{625}\right) & 625 \leq f \leq 2000 \end{matrix}\right\} (dB) \qquad (EQ.128-3)$$

Test Setup: See Appendix 128.A.

Test Procedure:

1. Calibrate the VNA to remove the effects of the coaxial cables.
2. Configure the DUT so that it is sourcing PRBS9.
3. Connect the DUT’s transmitter to the VNA.
4. Measure the reflection coefficient at the DUT transmitter from 100 MHz to 2 GHz.
5. Compute the return loss from the reflection coefficient values.

Observable Results:

a. The differential input return loss shall abide by the limits described in Equation 128-3.

Possible Problems: None.

GROUP 3: ELECTRICAL RECEIVER REQUIREMENTS

Overview:

The tests defined in this section verify the electrical signaling receiver characteristics of the Physical Medium Dependent (PMD) layer defined in Clause 128 of IEEE 802.3cb.

Test 128.3.1 – Bit Error Ratio

Purpose: To verify that the bit error ratio (BER) of the DUT receiver is within the conformance limits.

References:

[1] IEEE Std. 802.3cb, subclause 128.7.2 – Receiver characteristics
[2] IEEE Std. 802.3cb, subclause 128.7.2.1 – Receiver interference tolerance
[3] IEEE Std. 802.3cb, Annex 69A – Interference tolerance testing
[4] IEEE Std. 802.3-2015, Figure 69A-1 – Interference tolerance test setup
[5] UNH-IOL 100Base-Tx TP-PMD Test Suite, Appendix 25.D

Resource Requirements: See Appendix 128.A.

Last Modification: March 15, 2018

Discussion:

In this test, the receiver is tested to ensure it can extract data from a lossy channel while simultaneously being affected by interference.

Reference [1] specifies the receiver characteristics for 2.5GBASE-KX devices. This specification includes conformance requirements for the interference tolerance defined in reference [2].

Reference [3] outlines a procedure to inject interference onto the channel by coupling with the receive pair of the DUT. This is done while using a lossy channel in order to create a low signal-to-noise environment. An informative description of the test channel is provided in reference [4].

Note: For 2.5G, the transmitter control block in the test setup diagram of reference [4] is omitted.

Reference [1] states that the target BER of a 2.5GBASE-KX device is 10^{-12}. Based on the analysis in reference [5], if more than 7 errors are observed out of $3x10^{12}$ bits, it can be concluded that the bit error rate of the device is greater than 10^{-12} with less than a 5% chance of error.

Test Setup: See Appendix 128.A.

Test Procedure:

1. Connect the DUT to the interference tolerance test setup shown in reference [4].
2. Turn on the interference source.
3. Turn on the pattern generator, configured for a sequence of alternating ones and zeros.
4. Send $3x10^{12}$ bits to the DUT receiver.
5. Complete all tests with signaling speeds of 3.125 Gbaud and 3.125 Gbaud +/- 0.3125 Mbaud.

Observable Results:

a. There shall be no more than 7 errors observed for any iteration.

Possible Problems: None.

APPENDICES

Overview:

Test plan appendices are intended to provide additional low-level technical detail pertinent to specific tests contained in this test plan. These appendices often cover topics that are outside of the scope of the standard, and are specific to the methodologies used for performing the measurements in this test plan. Appendix topics may also include discussion regarding a specific interpretation of the standard (for the purposes of this test plan), for cases where a particular specification may appear unclear or otherwise open to multiple interpretations.

Scope:

Test plan appendices are considered informative supplements, and pertain solely to the test definitions and procedures contained in this test plan.

Appendix 128.A - Test Fixtures and Setups

Purpose: To specify the measurement hardware, test fixtures, and setups used in this test plan.

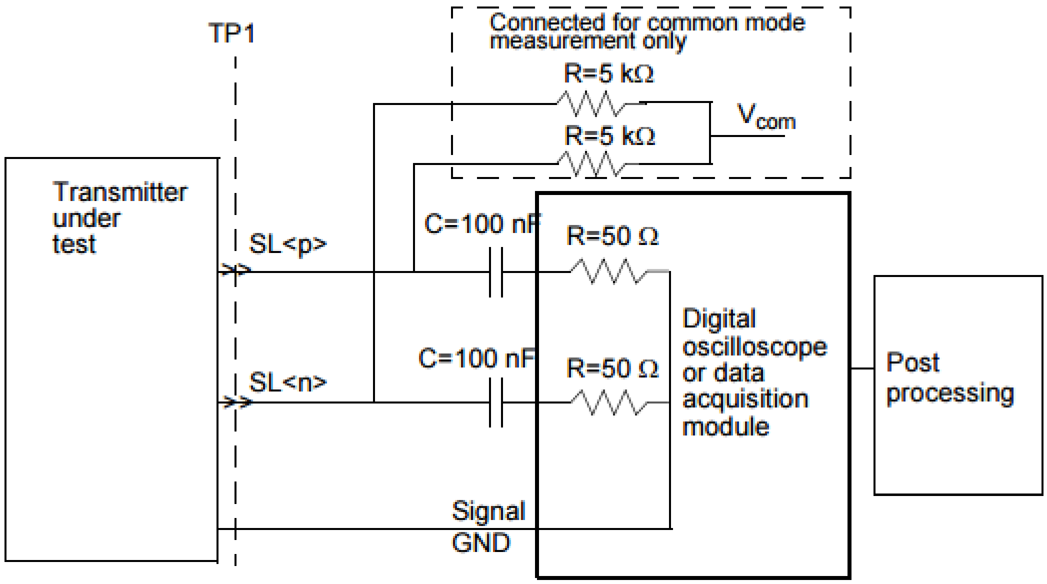
References:
[1] IEEE Std. 802.3cb, subclause 128.7.1.1 – Test Fixtures

Last Modification: March 15, 2018

Discussion:

The tester will need the following in order to perform tests in Group 1.

1. Digital Storage Oscilloscope, 20 GHz bandwidth (minimum).
2. Transmitter Test Fixture.
3. Post Processing.
4. Digital Multi-meter.
5. SMA cables.

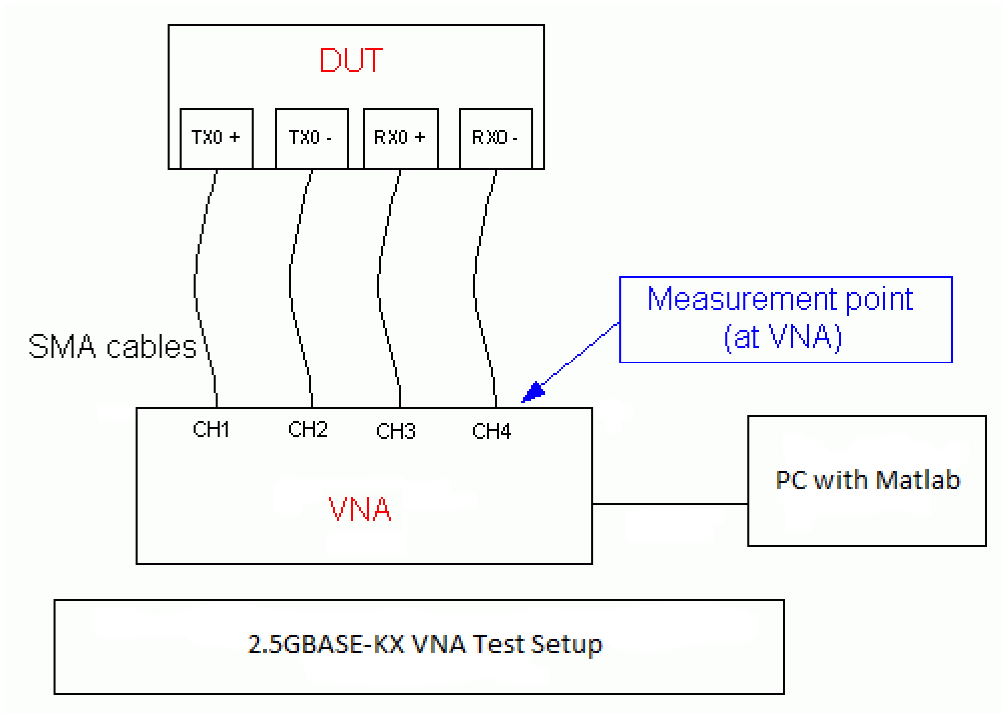


128.A-1: example test setup for tests 128.1.1 through 128.1.7

Explanation of 128.A-1:
For test, 128.1.2(Common Mode Output Voltage), the DSO is not used to perform the test. For 128.1.2 the portion of the diagram above outlined with dotted lines will be used. Vcom in this diagram will be a DMM, set to measure voltage.
For the other six tests (128.1.1-128.1.6, excluding 128.1.2), the DSO will be used. The DUT should be connected to the DSO as depicted in the above diagram through the channel slots on the DSO with SMA cables. The DSO is connected to a computer for post processing.

The tester will need the following to perform tests in Group 2.

1. Vector Network Analyzer.
2. SMA cables.
3. Post Processing.



128.A-2: example test setup for tests 128.2.1 through 128.2.3

Explanation of 128.A-2:

For tests, 128.2.1 through 128.2.3, connect the DUT to the VNA with SMA cables according to the 128.A-2 setup diagram. For post processing, connect the VNA to the PC.