

Anritsu and Tektronix Automotive Ethernet Test Solution

Introduction

As advanced automotive systems such as ADAS (Advanced Driver Assistance Systems) and in-vehicle infotainment become more sophisticated, the demand for higher data speeds in automotive networks continues to grow. To support these bandwidth requirements, the automotive industry is increasingly adopting Ethernet-based in-vehicle networks. Ensuring compliance of Ethernet components—transmitters, receivers, cables, and connectors—is critical for reliable operation within these networks.

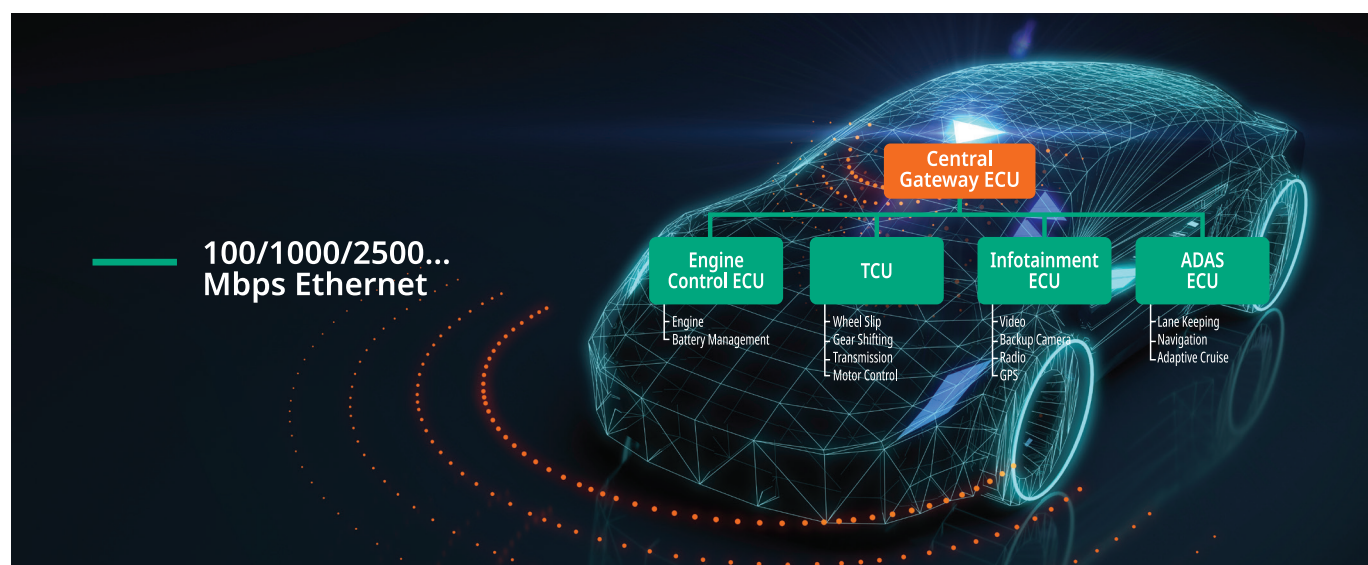


Figure 1. ECUs in a Car

The IEEE 802.3bw (100BASE-T1) and IEEE 802.3bp (1000BASE-T1) standards, along with the IEEE 802.3ch multigigabit Ethernet specification, define compliance tests to ensure interoperability among automotive Ethernet equipment.

Two critical tests in these standards are:

- Media Dependent Interface (MDI) Return Loss (RL)
- Mode Conversion measurements.

MDI refers to the physical and electrical interface between the Ethernet transceiver (PHY) and the transmission medium (like a twisted-pair cable). In automotive Ethernet standards like 100BASE-T1, 1000BASE-T1, and MultiGBASE-T1 (IEEE 802.3ch), the MDI typically connects to single-pair twisted cable, designed for automotive environments.

MDI is important because it defines how the PHY connects to the media and sets the electrical requirements to ensure proper signal integrity and interoperability between devices from different vendors.

MDI Return Loss (RL)

- Return Loss measures how much of the signal is reflected back toward the transmitter due to impedance mismatches at the MDI.
- The goal is to ensure the impedance of the transmitter output matches the characteristic impedance of the cable (usually 100 Ω differential), minimizing reflections.

Mode Conversion (Mode Conversion Loss)

- Automotive Ethernet uses differential signaling, where the signal is transmitted over two conductors with opposite polarities.
 - Mode Conversion refers to unwanted transformation between Differential Mode (the desired signal) and Common Mode (undesirable signal).
- This test checks how well the MDI maintains differential integrity that is minimizes leakage into common mode.

These tests evaluate the interface under test to confirm that the differential paths are compliant with the standards over specific frequency ranges.

The IEEE 802.3 standard, specifically the **Open Alliance PMA TC8 test suite**, is a set of specifications and test procedures used to ensure the physical layer (PMA) of Automotive Ethernet devices, such as ECUs, conform to the standard. These tests are crucial for interoperability and reliable operation in demanding automotive environments.

Tektronix Series 6 Oscilloscope provides a comprehensive Open Alliance PMA TC8 Test Suite that focus on validating the physical layer (PMA) of Automotive Ethernet implementations, including 10Base-T1S, 100Base-T1, 1000Base-T1 and MultiGBase-T1 configurations. The example screenshot below shows a list of test cases for 1000Base-T1.

Note: The Test Suite can validate the Return Loss results; however, the actual measurements must be performed using a VNA. The highlighted “Return Loss” section specifically requires a VNA, and for this application note, we are using the Anritsu MS46524B. The S-parameter data captured by the MS46524B can then be uploaded to the Tektronix Series 6 Oscilloscope for validation. If the data meets the specified requirements, the result will be marked as a pass by software.

This brief outlines a comprehensive test solution using Anritsu’s ShockLine™ VNA (**MS46524B**) in conjunction with Tektronix support tools and third-party fixtures for precise MDI RL and Mode Conversion measurements

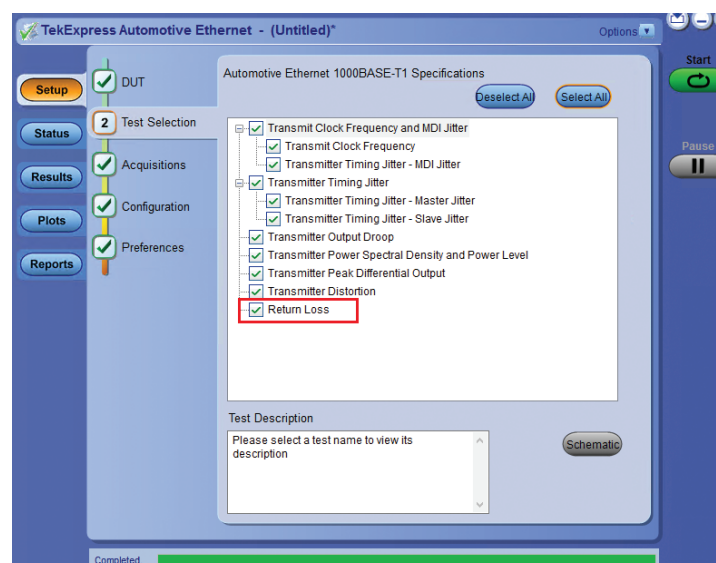


Figure 2. 1000BASE-T1 Test Suite on Tektronix Series 6 Oscilloscope

IEEE Compliance Targets:

The IEEE 802.3bw (100BASE-T1) and IEEE 802.3bp (1000BASE-T1) standards, define compliance tests to ensure interoperability among automotive Ethernet equipment.

Below are the compliance targets for 100BASE-T1 and 1000BASE-T1:

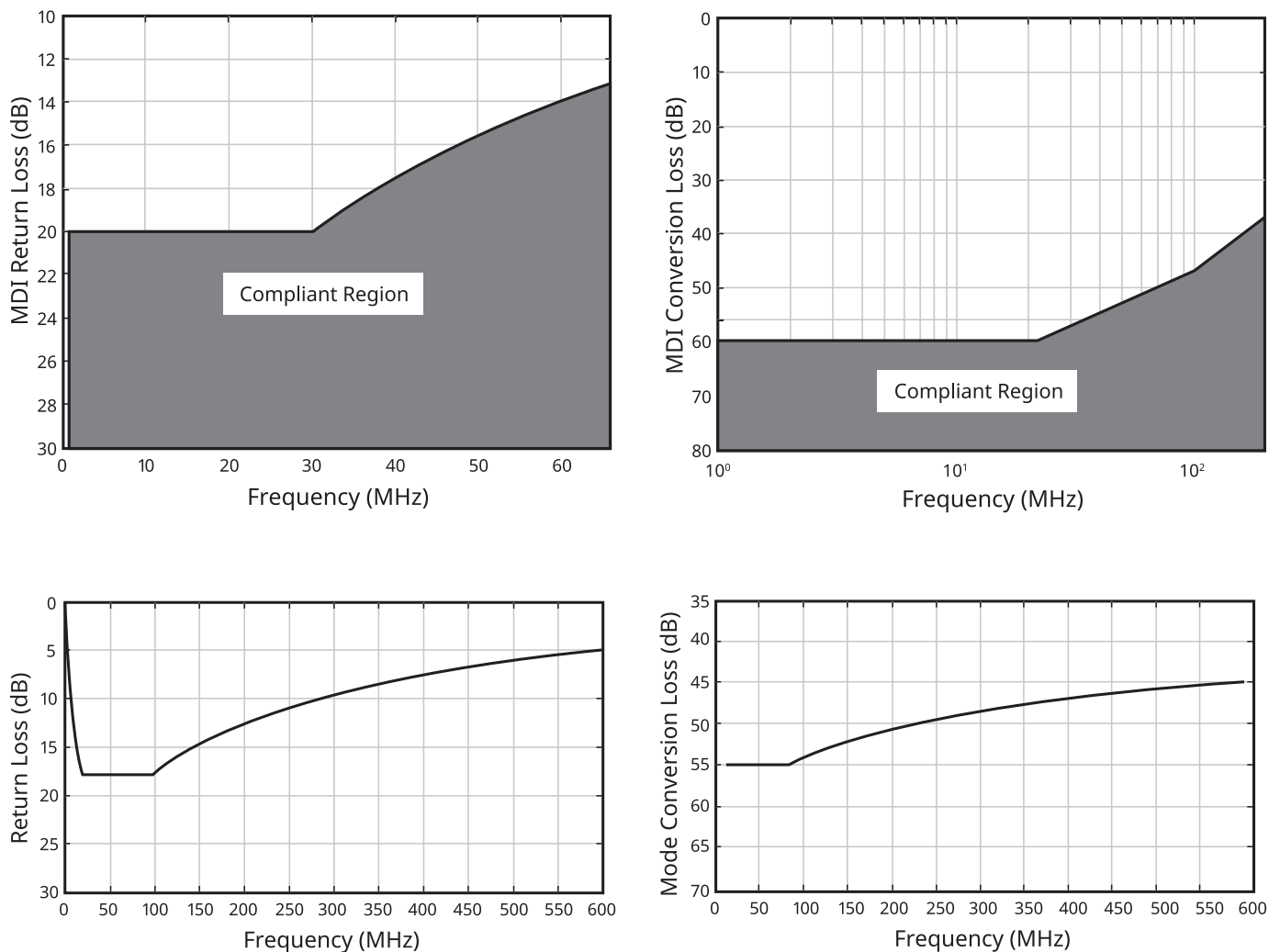


Figure 4. 1000BASE-T1 Return Loss & Mode Conversion Compliance Limits

Recommended Test Setup

- The MDI RL and Mode Conversion Loss tests are typically performed using a Vector Network Analyzer (VNA) and suitable test fixtures.
- Since automotive Ethernet operates on differential signaling, MDI RL and mode conversion tests must be differential as well.
- Anritsu's ShockLine MS46522B (2-port) and MS46524B (4-port) VNAs offer high-performance differential measurements up to 8.5 GHz frequency option —ideal for evaluating MDI and RL performance.
- Anritsu's ShockLine VNAs support SCPI-based remote programming, allowing for integration into automated test environments.



Figure 5. ShockLine MS46522B and MS46524B VNAs

VNA Configuration Setup

Frequency Range	300 kHz to 1 GHz
Disable IF Gain Ranging	ON
Power	13 dBm
Averaging During Calibration	10
IFBW	100 Hz
Points	1600

Table 1. VNA Configuration Used in Testing

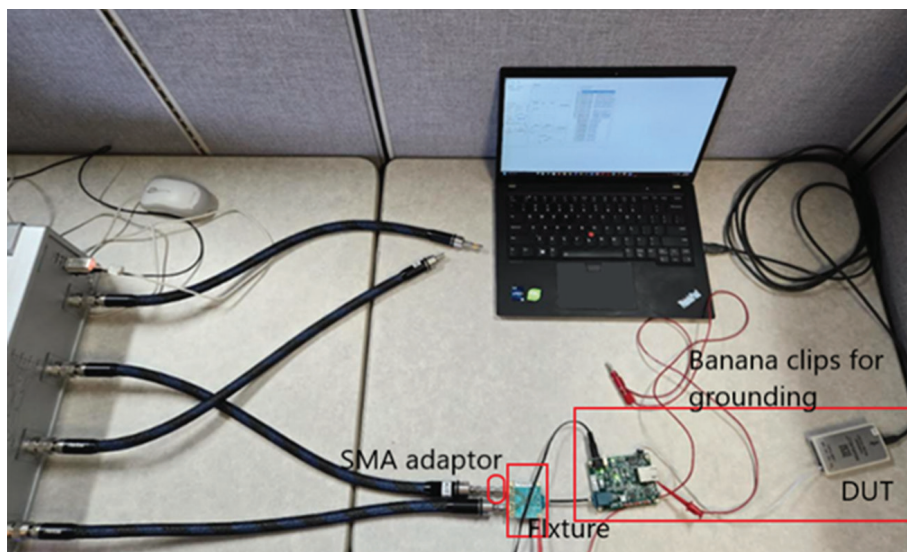
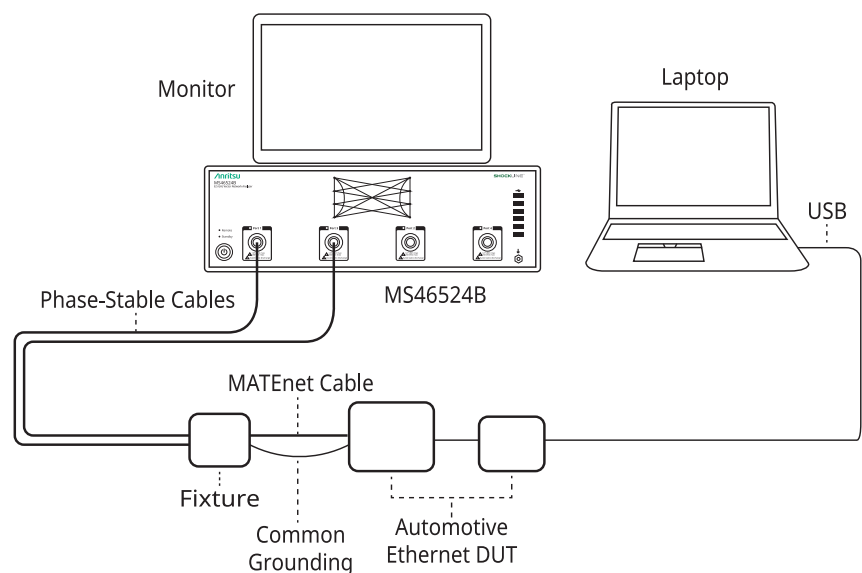


Figure 6. Test Setup Overview

Test Equipment Configuration

Qty	Description
1	MS46524B 4-port 8.5 GHz VNA
2	SMA(f) to SMA(m) Phase-Stable Cables (Anritsu 3671KFK50-60)
1	Wilder Technologies Fixture (ETH-TPA-AW-MN)
1	Infineon Automotive Ethernet DUT (DB-88Q2112-A2-MC-KIT-1)
1	TOSLK50A-20 Calibration Kit
1	MATenet(f) to MATenet(f) Short Cable
1	Grounding Clip or Banana Cable
1	SMA(f) to (m) Adapter

Table 2. Test Equipment Configuration

Test Setup Overview

As illustrated in Figure 6 on the previous page.

- The VNA **phase-stable cables** connect to the Wilder Technologies fixture, which in turn connects to the Automotive Ethernet DUT using a **MATenet(f) to MATenet(f)** cable.
- The DUT is linked to the PC via USB.
- Ensuring that the DUT and fixture share a common ground plane is critical; to achieve this, banana clips are used as shown.
- Additionally, an SMA(f) to (m) adapter is employed on one of the coaxial cables to provide a low-friction connection to the fixture during testing.

Since automotive Ethernet lacks a universal connector like RJ45, users must select fixtures compatible with their DUT's connector type.

To ensure accurate RL and mode conversion measurements, the VNA must be precisely calibrated (VNA configuration details in Table 1). Anritsu's TOSLKF50A-20 calibration kit is used to move the calibration plane to the fixture interface, eliminating cable and component effects.

Pre-Test Requirements – Fixture Qualification per OPEN Alliance

Prior to Return Loss and Mode Conversion Loss measurements on the DUT (for 100BASE-T1 and 1000BASE-T1), certain conditions must be met.

The OPEN Alliance Automotive Ethernet ECU Test Specification Layer 1 mandates that:

- The **test fixture** used to connect to the DUT's MDI pins must meet the specified limit for fixture mode-conversion.

This ensures reliable and accurate measurement results.

Below is the Mode Conversion Loss specification that the fixture must satisfy.

To verify compliance:

1. Calibrate the VNA with Table 1 setup configuration using phase-stable cables and the TOSLKF50A-20 kit.
2. Connect the fixture—with a MATenet cable attached—directly to the VNA ports, leaving the DUT side of the fixture open (unterminated).
3. Measure SDC11.

4. The results should meet or fall below the specified limits shown below.

MDI Mode Conversion / OA BroadReach

Item: Requirement for ECU Test Fixture
 S_{dc11} / Transvers Conversion Loss (TCL)

— Limit TCL ECU Test Fixture

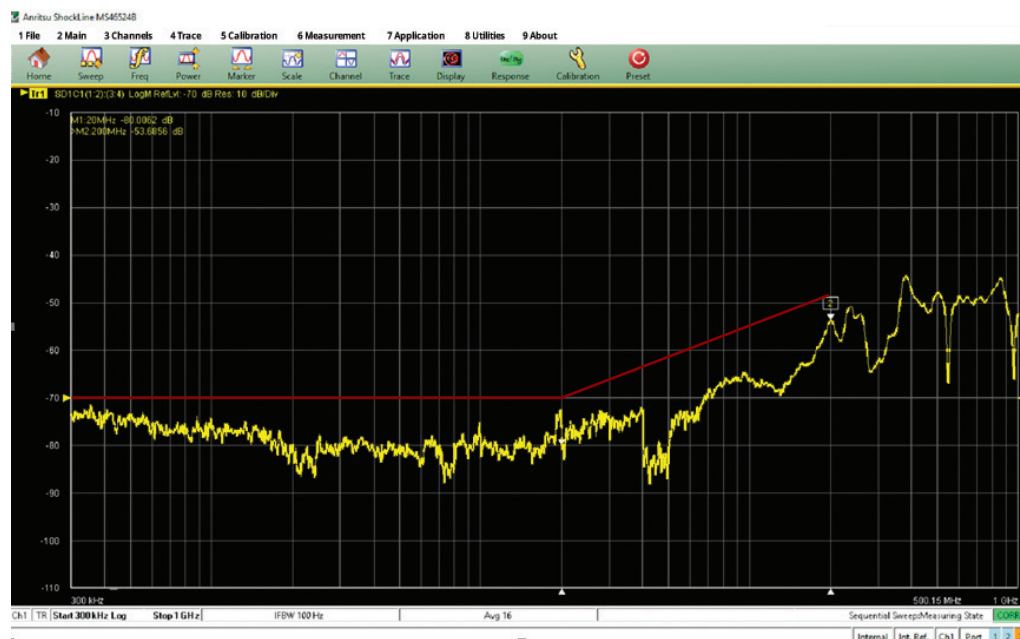
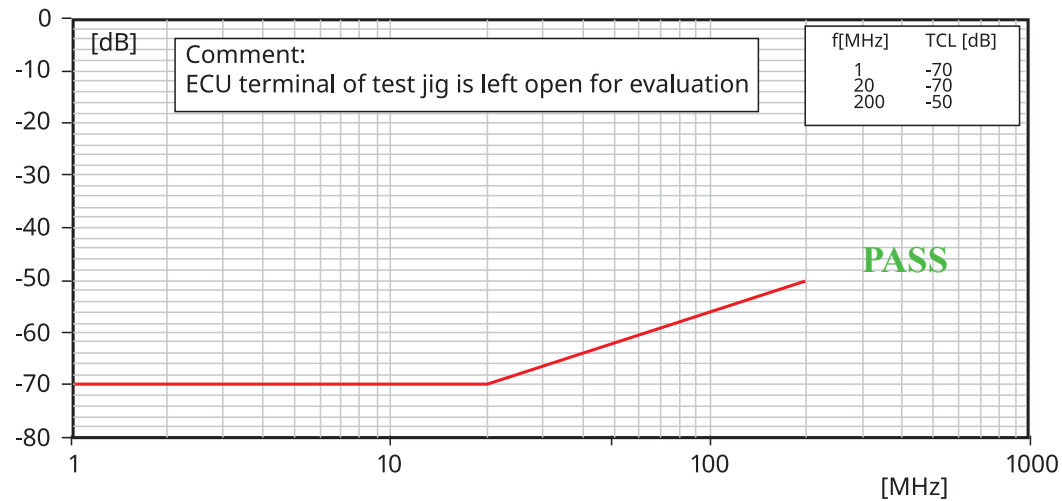


Figure 7. Fixture Mode-Conversion Loss Measurement Using Anritsu MS46524B VNA vs Spec

Test Procedure for MDI RL and Mode Conversion Loss

1. Use the previously calibrated setup.
2. Connect the phase-stable cables to the fixture, and the fixture to the DUT using the MATenet cable.
3. Ground the fixture and DUT using a crocodile or banana clip for a shared ground plane.
4. Use Infineon's SMI Automotive Register Access Tool to configure the DUT for 100BASE-T1 or 1000BASE-T1 test modes.
5. Launch the SMI_AutomotiveGUI and select the options highlighted by the red box in the image below, and click "Refresh".

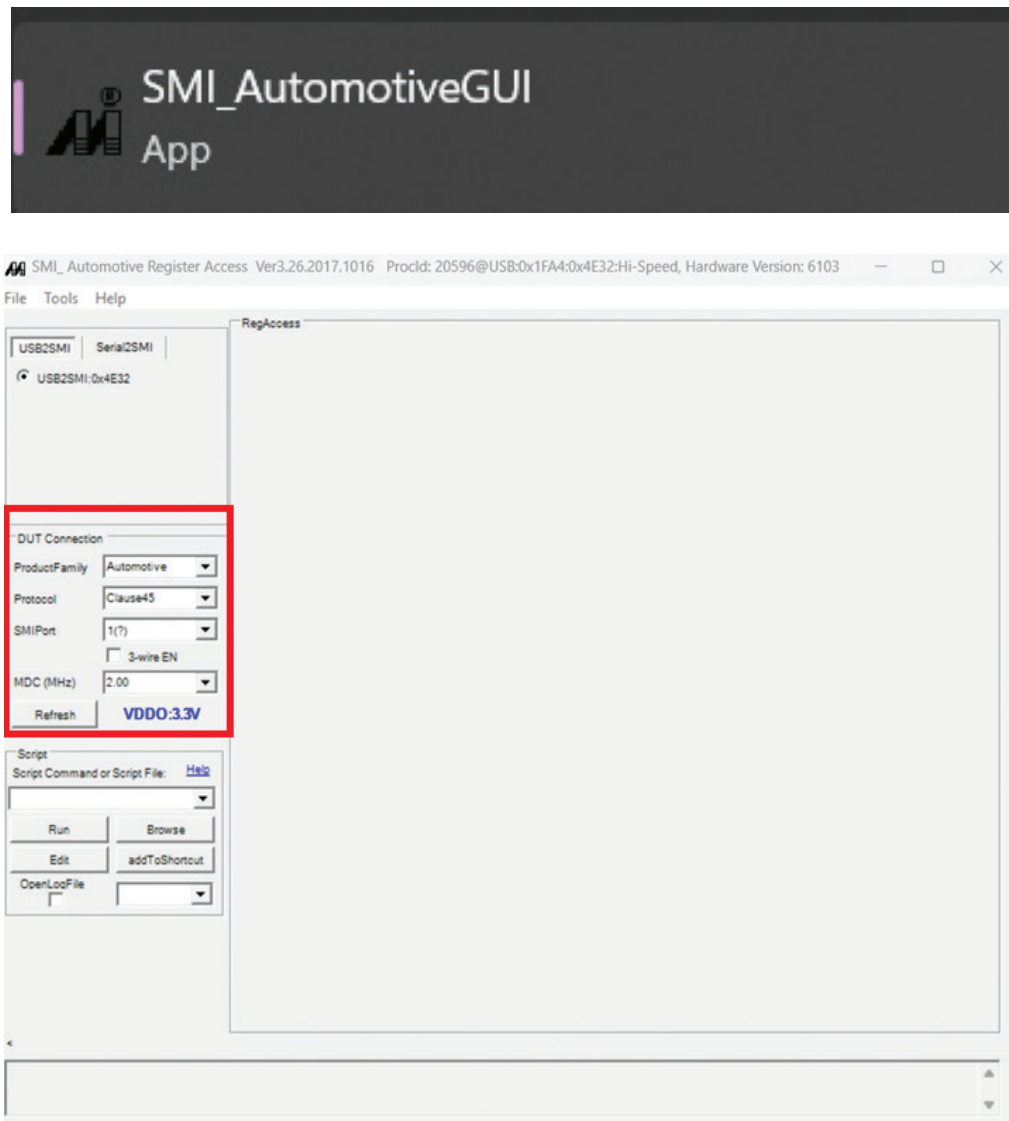


Figure 8. SMI_AutomotiveGUI UI

6. After clicking “Refresh”, the following UI will appear.

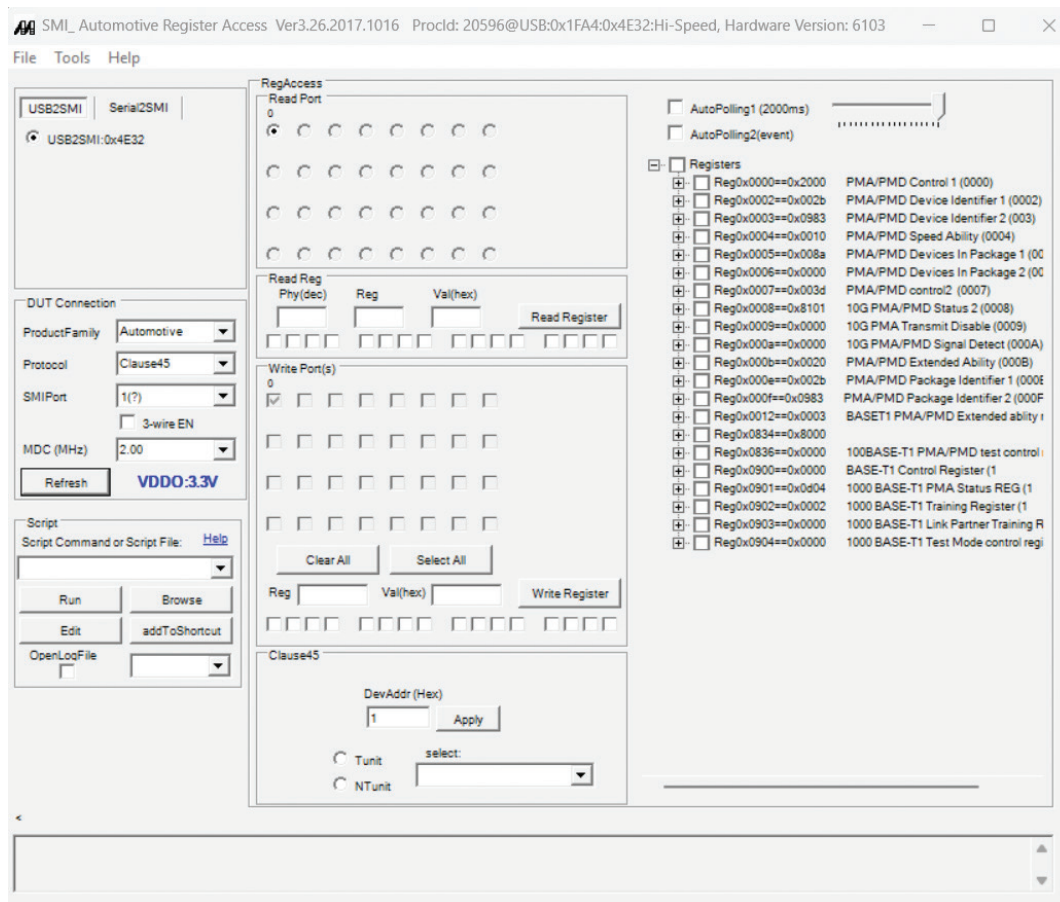


Figure 9. SMI_AutomotiveGUI UI with Test Mode Configurations

100BASE-T1 Configuration

- To configure the DUT for 100BASE-T1 test mode.
 - Set the hardware switches to “100” test mode, “Slave” mode, and select “SGMII” for register access, as shown in the image below.
 - Then, using the SMI Automotive Register Access tool, write “011” to the 100BASE-T1 PMA/PMD test control register.

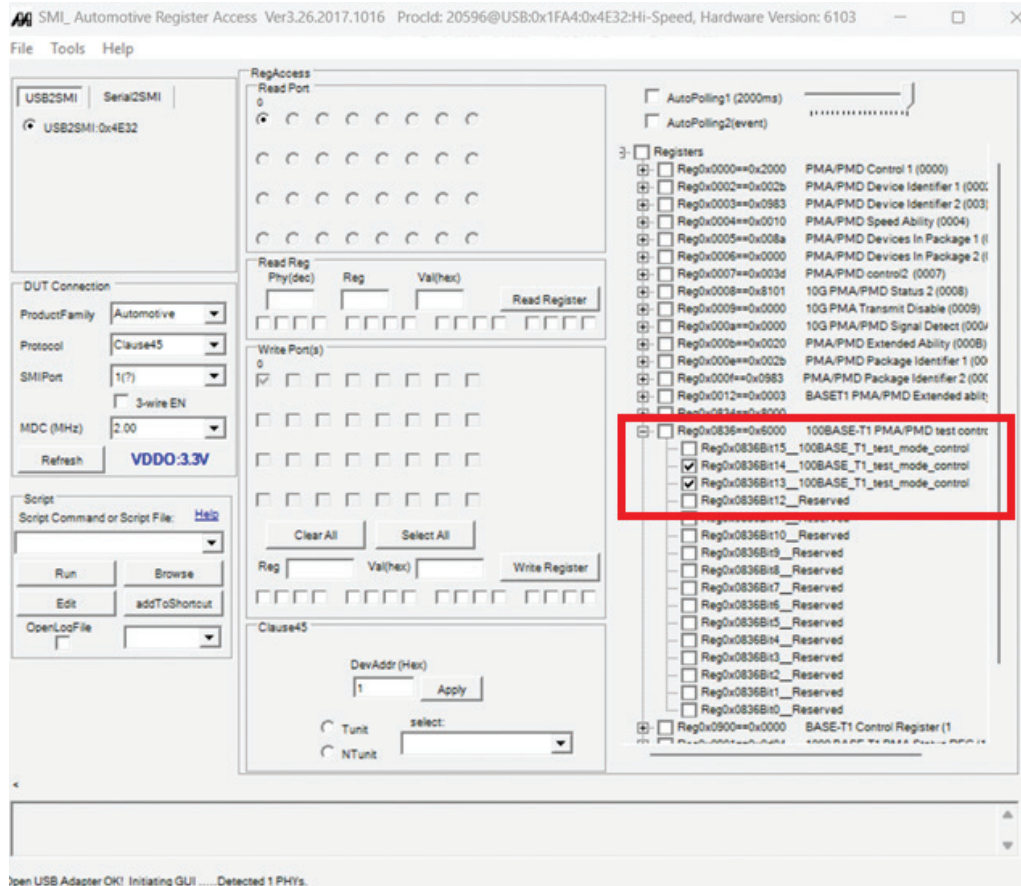
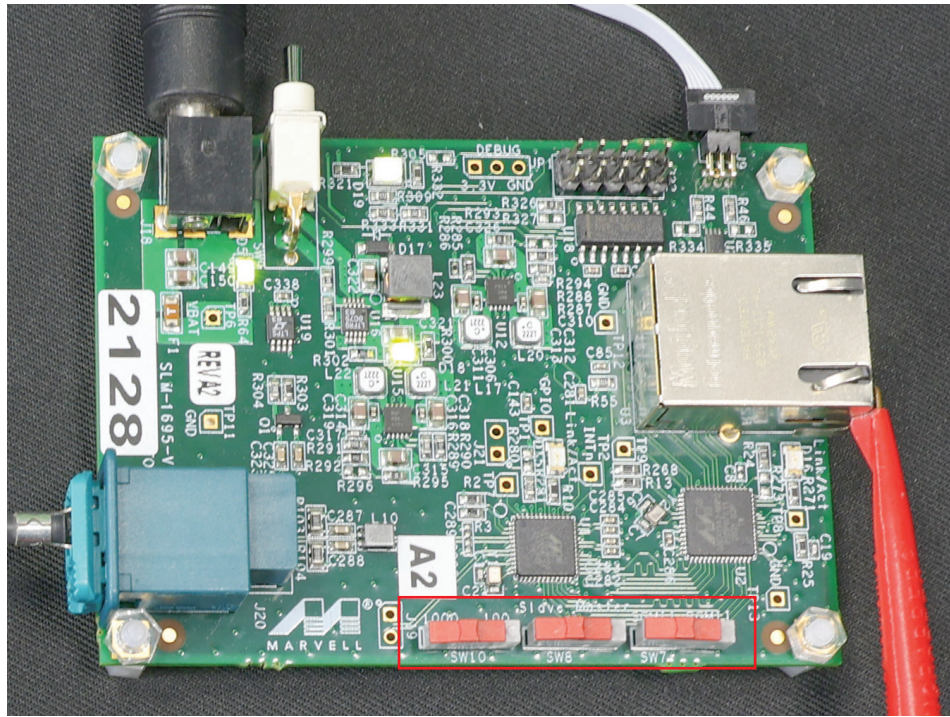


Figure 10. SMI_AutomotiveGUI UI – 100BASE-T1 Test Mode Configuration

100BASE-T1 Test Data

Return Loss:

- The measured Return Loss for 100BASE-T1 is shown below alongside the specification. The results meet the required limits.

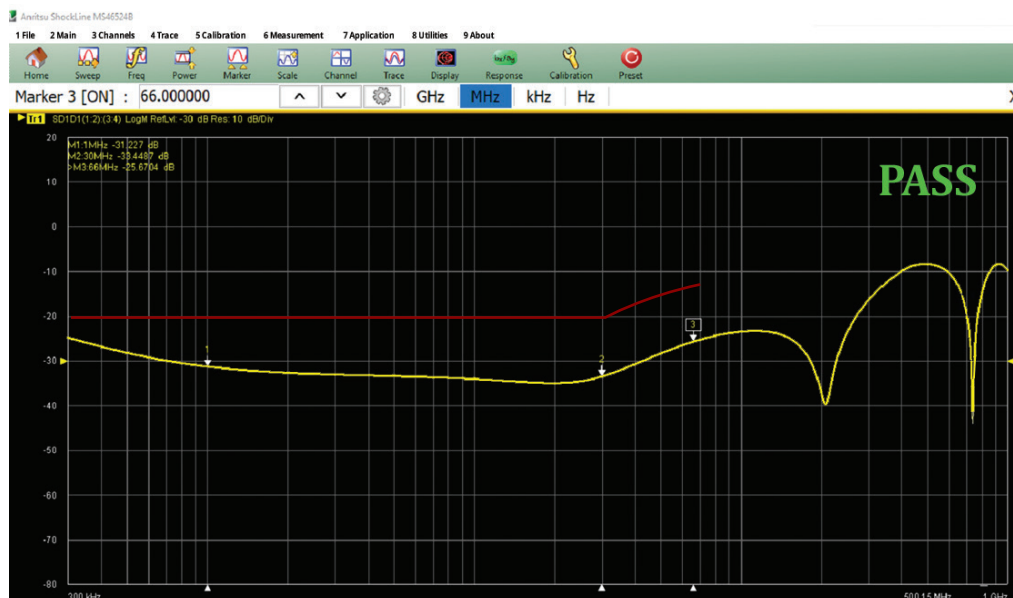
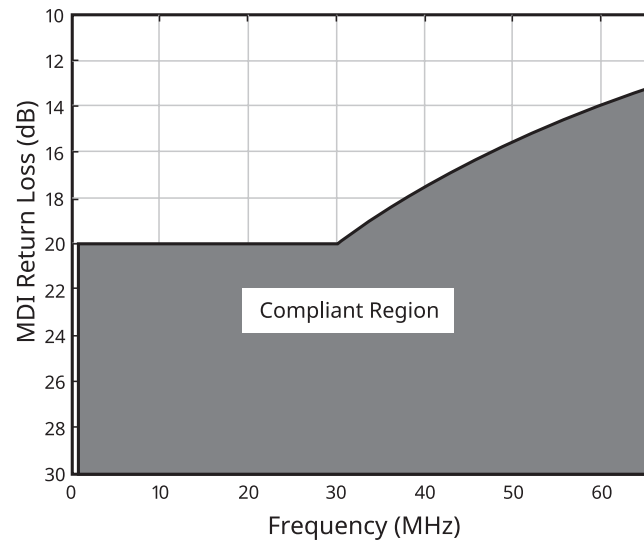


Figure 11. Return Loss Result vs Spec

Mode Conversion Loss:

- The measured Mode Conversion Loss for 100BASE-T1 is shown below alongside the specification. The results are within the acceptable range.

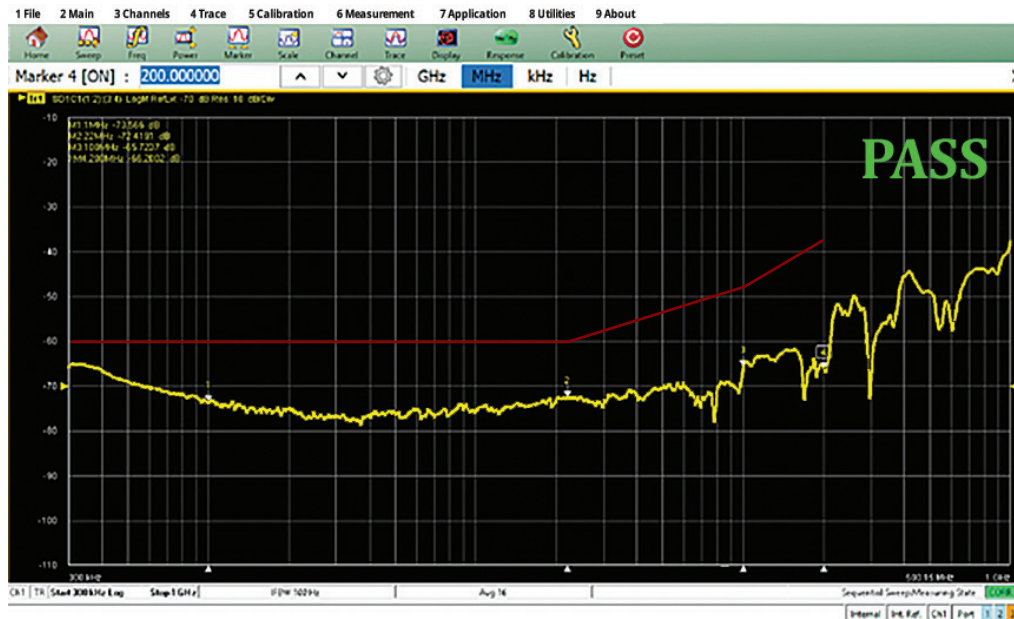
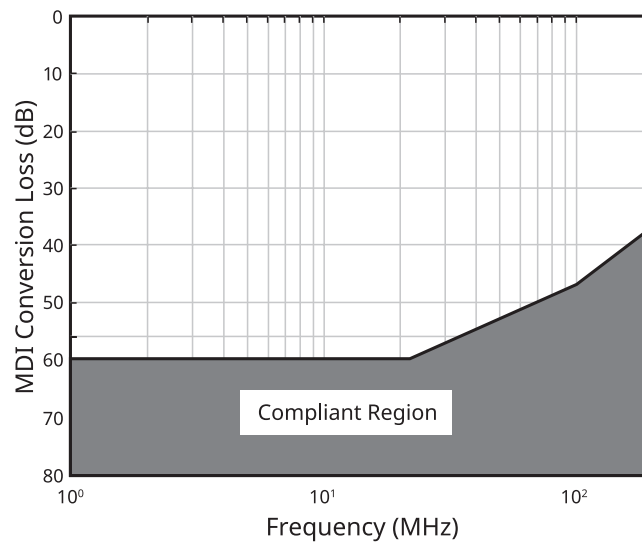


Figure 12. Mode Conversion Loss Result vs Spec

1000BASE-T1 Configuration

- To configure the DUT for 1000BASE-T1 test mode:
 - Set the hardware switches to “1000” test mode, “Slave” mode, and select “SGMII” for register access, as highlighted in the image below.
 - Then, using the SMI Automotive Register Access tool, write “111” to the 1000BASE-T1 Test Mode control register.

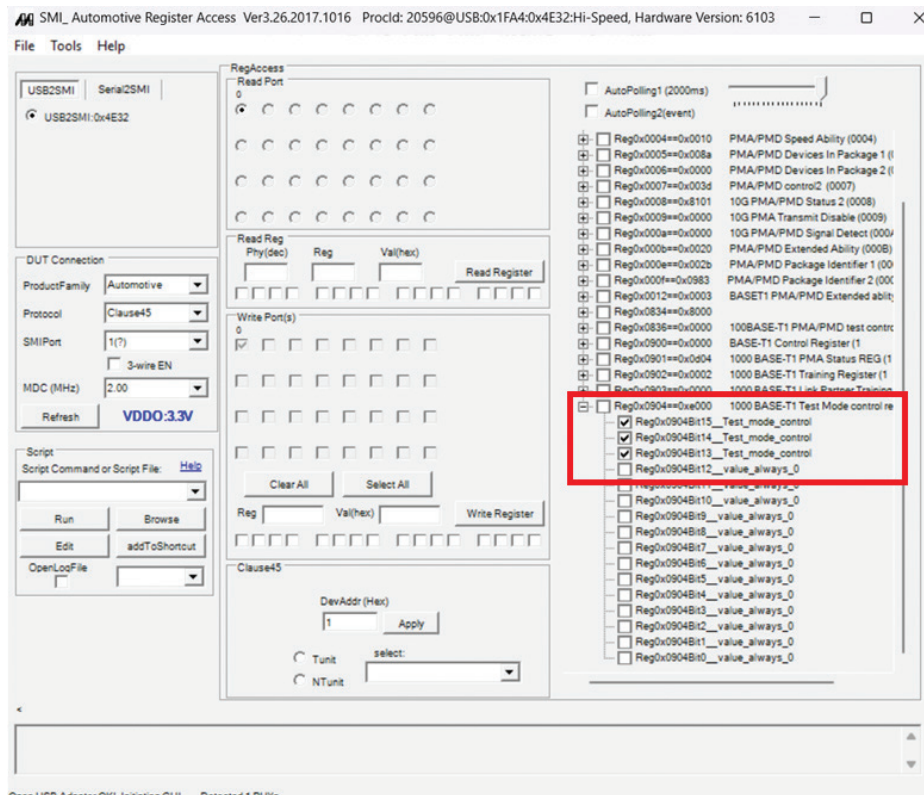
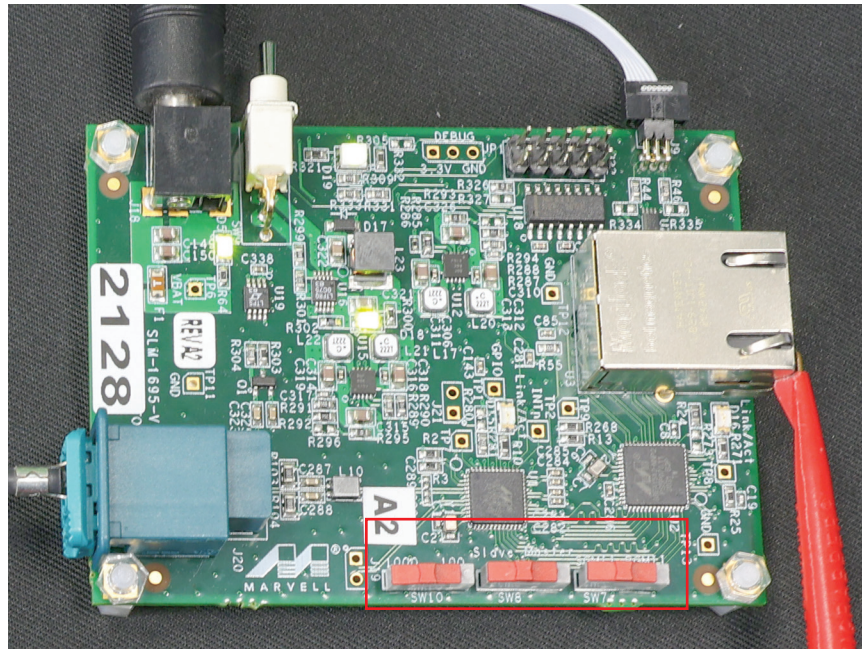


Figure 13. SMI_AutomotiveGUI UI – 100BASE-T1 Test Mode Configuration

1000BASE-T1 Test Results

Return Loss:

- The measured Return Loss for 1000BASE-T1 is presented below along with the specification. The DUT passes the compliance criteria.

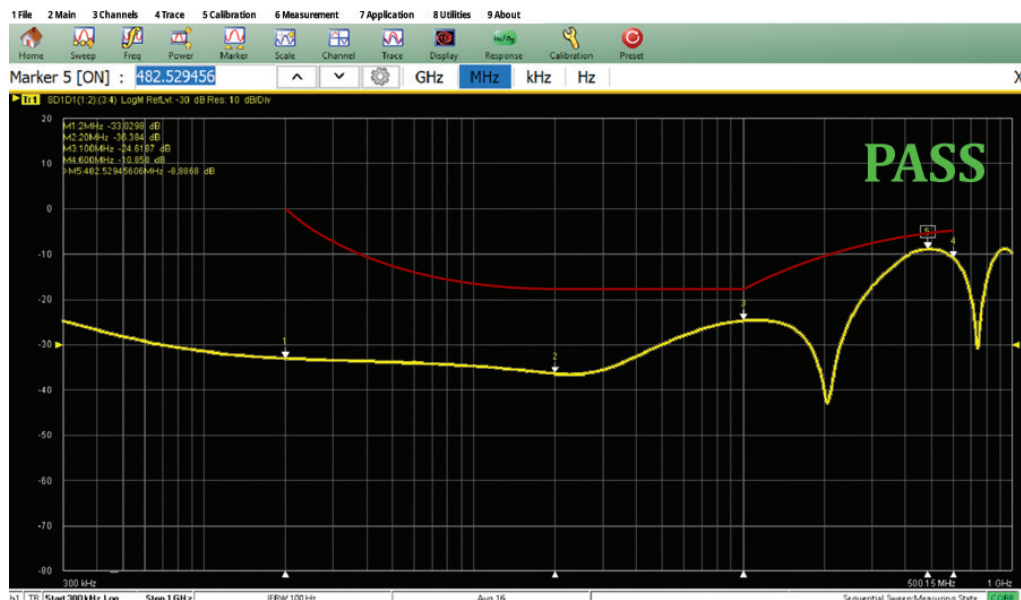
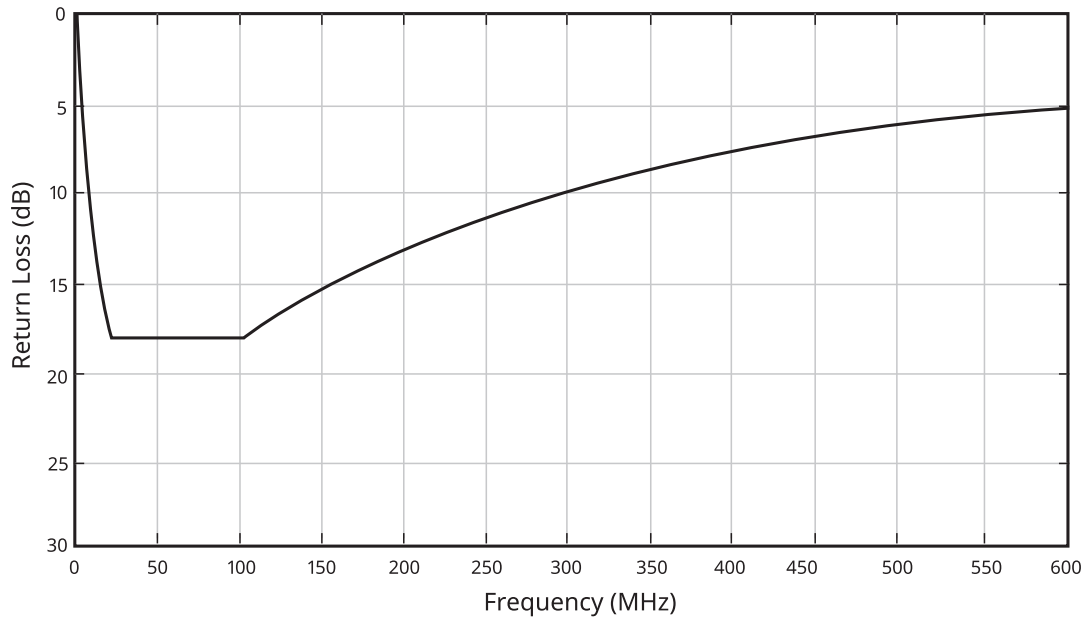


Figure 14. Return Loss Result vs Spec

Mode Conversion Loss:

- The measured Mode Conversion Loss for 1000BASE-T1 is shown below with the corresponding specification. The results conform to the required limits.

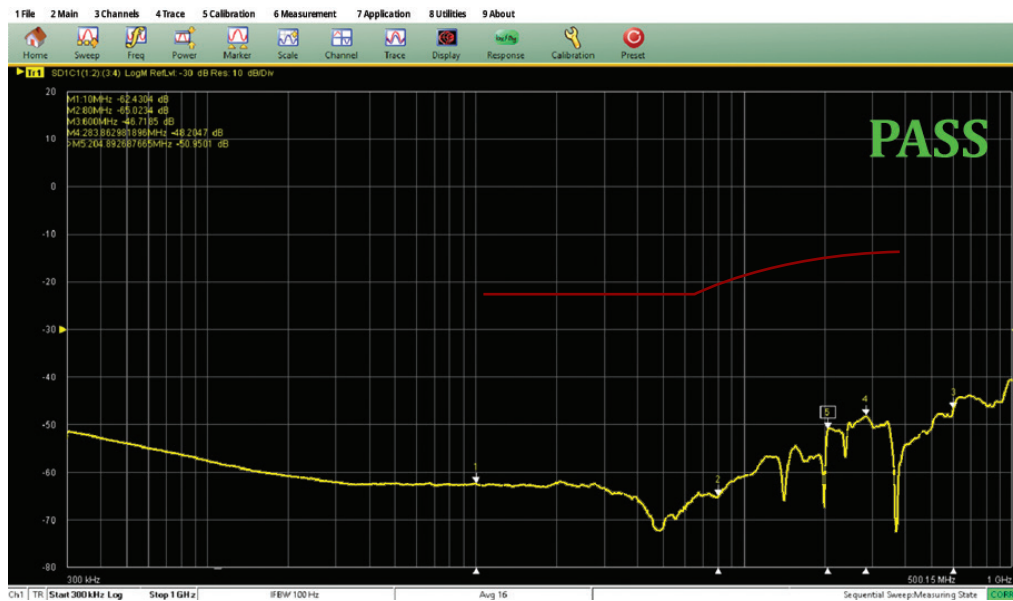
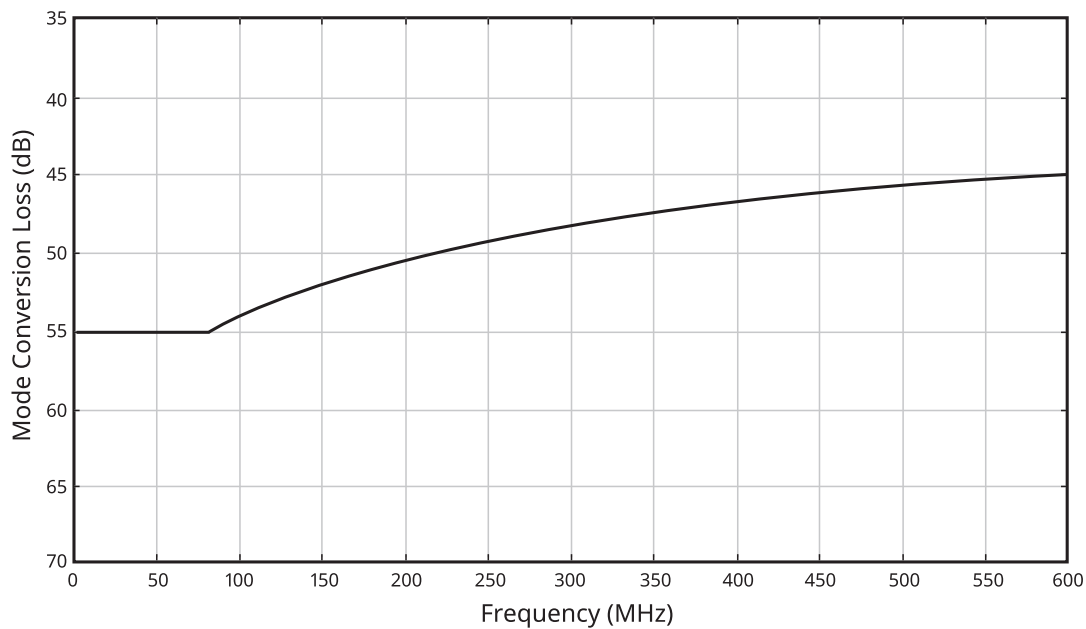


Figure 15. Mode Conversion Loss Result vs Spec

Conclusion

This technical brief introduced the Anritsu/Tektronix automotive Ethernet MDI RL and mode conversion measurement solution using the ShockLine MS46524B 4-port VNA with third-party fixtures. The solution offers a robust, VNA-based methodology for conducting accurate and reliable measurements. Together, the Anritsu and Tektronix instrument suite provides a complete and flexible platform for validating 100BASE-T1 and 1000BASE-T1 Ethernet components in automotive applications.



Specifications are subject to change without notice.

• **United States**

Anritsu Americas Sales Company

490 Jarvis Drive, Morgan Hill, CA 95037-2809, U.S.A.
Phone: (408)-778-2000

• **Canada**

**Anritsu Electronics Ltd.
Americas Sales and Support**

490 Jarvis Drive, Morgan Hill, CA 95037-2809, U.S.A.
Phone: +1-800-Anritsu (1-800-267-4878)

• **Brazil**

Anritsu Eletrônica Ltda.

Praça Amadeu Amaral, 27 - 1 Andar
01327-010 - Bela Vista - São Paulo - SP, Brazil
Phone: +55-11-3283-2511

• **Mexico**

Anritsu Company, S.A. de C.V.

Blvd Miguel de Cervantes Saavedra #169 Piso 1, Col. Granada
Mexico, Ciudad de Mexico, 11520, MEXICO
Phone: +52-55-4169-7104

• **United Kingdom**

Anritsu EMEA Limited

900 Capability Green, Luton, Bedfordshire, LU1 3LU, U.K.
Phone: +44-1582-433200

• **France**

Anritsu SA

12 avenue du Québec, Immeuble Goyave,
91140 VILLEBON SUR YVETTE, France
Phone: +33-1-60-92-15-50

• **Germany**

Anritsu GmbH

Nemetschek Haus, Konrad-Zuse-Platz 1,
81829 München, Germany
Phone: +49-89-442308-0

• **Italy**

Anritsu S.R.L.

Spaces Eur Arte, Viale dell'Arte 25, 00144 Roma, Italy
Phone: +39-6-509-9711

• **Sweden**

Anritsu AB

Kistagången 20 B, 2 tr, 164 40 Kista, Sweden
Phone: +46-8-534-707-00

• **Finland**

Anritsu AB

Technopolis Aviapolis, Teknobulevardi 3-5 (D208.5.),
FI-01530 Vantaa, Finland
Phone: +358-20-741-8100

• **Denmark**

Anritsu A/S

c/o Regus Winghouse, Ørestads Boulevard 73, 4th floor,
2300 Copenhagen S, Denmark
Phone: +45-7211-2200

• **Spain**

Anritsu EMEA GmbH

Representation Office in Spain

Calle Manzanares 4, Primera planta, 28005 Madrid, Spain
Phone: +34-91-572-6761

• **Austria**

Anritsu EMEA GmbH

Am Belvedere 10, A-1100 Vienna, Austria
Phone: +43-(0)1-717-28-710

• **United Arab Emirates**

Anritsu A/S

Office No. 164, Building 17, Dubai Internet City
P. O. Box – 501901, Dubai, United Arab Emirates
Phone: +971 (0) 4-2424919

• **India**

ANRITSU INDIA PRIVATE LIMITED

6th Floor, Indique ETA, No.38/4, Adjacent to EMC2,
Doddanekundi, Outer Ring Road, Bengaluru – 560048, India
Phone: +91-80-6728-1300
Fax: +91-80-6728-1301

• **Singapore**

ANRITSU PTE LTD

1 Jalan Kilang Timor, #07-04/06 Pacific Tech Centre
Singapore 159303
Phone: +65-6282-2400

• **Vietnam**

ANRITSU COMPANY LIMITED

16th Floor, Peakview Tower, 36 Hoang Cau Street, O Cho Dua Ward,
Hanoi, Vietnam
Phone: +84-24-3201-2730
Fax: +84-24-3201-2740

• **P.R. China (Shanghai)**

Anritsu (China) Co., Ltd.

Room 2301-2303, Tower A, New Caohejing International Business
Center No. 391 Gui Ping Road, Shanghai, 200233, P.R. China
Phone: +86-21-6237-0898

• **P.R. China (Hong Kong)**

ANRITSU COMPANY LIMITED

Unit 1302, 13th Floor, New East Ocean Center,
No.9 Science Museum Road, TsimShaTsui East,
Kowloon, Hong Kong
Phone: +852-2301-4980

• **Japan**

ANRITSU CORPORATION

8-5, Tamura-cho, Atsugi-shi, Kanagawa, 243-0016 Japan
Phone: +81-46-296-1244
Fax: +81-46-296-1239

• **Korea**

Anritsu Corporation Limited

8F, A TOWER, 20, Gwacheondaero 7-gil, Gwacheon-si,
Gyeonggi-do, 13840, Republic of Korea
Phone: +82-2-6259-7300

• **Australia**

Anritsu Pty Ltd

Unit 20, 21-35 Ricketts Road, Mount Waverley, Victoria 3149, Australia
Phone: +61-3-9558-8177

• **Taiwan**

ANRITSU COMPANY, INC.

7F, No. 316, Sec. 1, NeiHu Rd., Taipei 114, Taiwan
Phone: +886-2-8751-1816

List Revision Date: 20251202



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11410-02995, Rev. A Printed in United States 2025-12
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