KTA1550: How to Test AC Response of Active EMI & ESD Suppressor for Ethernet Applications

Introduction

The purpose of this document is to outline the instrumentation and test procedure to measure Common Mode Rejection, Return Loss, and Insertion Loss for the KTA1550 dual channel EMI and ESD suppressor IC intended for ethernet applications.

The KTA1550 evaluation board is capable of being configured to control the device in any operation mode and accommodates common mode rejection, return loss, and insertion loss measurements. Specific evaluation board components must be placed or removed to configure the board for each AC response measurement. The evaluation board top layer assembly drawing in Figure 1 shows component locations. Refer to the specific measurement instructions for component placement requirements.

Required Equipment

The following equipment is required to perform measurements outlined in this document:

1. Vector Network Analyzer (VNA), minimum range of 0.1MHz to 300MHz required. For measurements outlined in this document, an HP8753E 30kHz to 6GHz VNA was used.
2. Instrument grade 1.5ft. SMA to SMA, 50Ω coaxial test cables, 2 required.
3. 6-inch or shorter SMA to SMA 50Ω coaxial cables, 4 required.
4. VNA calibration kit, HP85033D 3.5mm calibration kit or equivalent calibration kit VNA in use.
5. Lab Bench Power Supply, Agilent/Keysight E3631A or equivalent DC power supply.
6. KTA1550 Evaluation Board, Revision 1-170915.
7. KTA1550/52 Balun Fixture, 2 required.
    a. An unbalanced to balanced line transformer is required to connect the single ended VNA ports to the differential ethernet line I/O of the KTA1550 EVB. The transformer should have a 1:2 impedance ratio to match the 50Ω VNA source/termination impedance to the 100Ω ethernet line termination impedance.
    b. The KTA1550/52 balun test fixture utilizes a North Hills 0319NA 1:2 unbalanced to balanced line transformer. This transformer has a maximumly flat response from 100kHz to 100MHz with than 0.1dB of insertion loss. The KTA1550/52 balun test fixture uses SMA type connector.
    c. Other unbalanced to balanced line RF transformers may be used, but must demonstrate equal or better electrical characteristics.

Initial Test Set-Up

1. The Vector Network Analyzer should be set for the desired frequency span and source amplitude:
    a. Set the VNA source amplitude to -10dBm
    b. Set the VNA frequency span (start/stop frequency) for 0.1MHz to 100MHz. Wider frequency spans up to 300MHz may be measured if desired. 10/100/1000Base-T system operating bandwidth is 100MHz; system bandwidth is limited to 300MHz by the KTA1550 balun test fixture transformer.
    c. Using the VNA calibration kit, perform a full 2-Port calibration, making sure to place the calibration terminations at the ends of the VNA port cables.
2. Power Supply Setting:
    a. The KTA1550 is capable of 5 different operating modes that provide various levels of performance based on system needs. MODE 1 sets normal default device operation. Refer to Table 1 for KTA1550 EVB SW1 switch settings based on the applied VDD level for default operation. If other operating modes are to be tested, refer to application note AN93 for device set-up.

VDD Level	SW1 - 1	SW1-2	SW1-3	SW1-4	SW1-5
2.5V	OFF	OFF	OFF	ON	OFF
3.3V	OFF	OFF	OFF	OFF	ON

Table 1: EVB SW1 setting for default MODE 1 operation

    b. Adjust the lab bench DC power supply to 2.5V or 3.3V according to the desired SW1 switch setting and connect the positive supply lead to J15 (VDD) and J17 (VCT). Connect the supply ground lead to the EVB GND at J16 or J18.

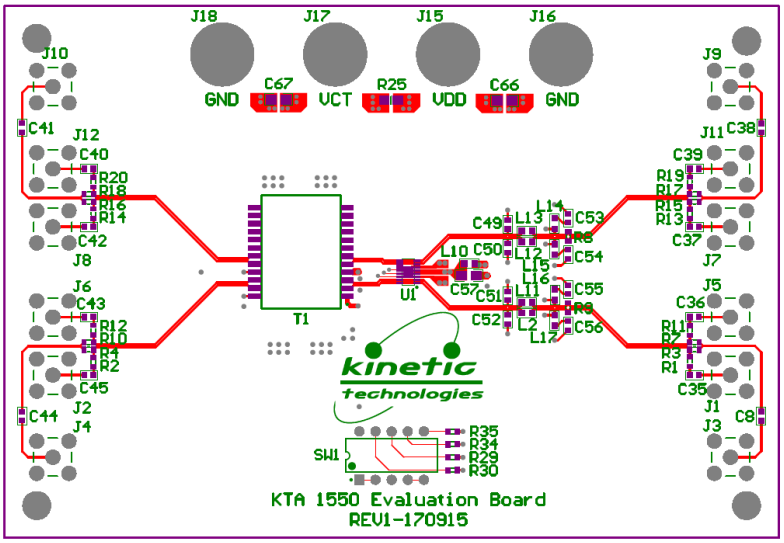

Figure 1: KTA1550 Evaluation Board Top Layer Assembly Drawing

AC Response Measurements

The following procedures outline the KTA1550 AC response tests.

Common Mode Rejection

The KTA1550 typically improves system common mode rejection (CMR) by more than 10dB over a stand-alone PoE PHY-Side Choke transformer. To quantify the benefit of the KTA1550, the evaluation board CMR should be measured without the KTA1550 mounted on the PCB to obtain the baseline CMR provided by the PoE coupling transformer. The CMR measurement is then repeated with the KTA1550 mounted on the PCB. The CMR contribution by the KTA1550 is then quantified by subtracting the amplitude data values of the baseline measurement from the KTA1550 measurement.

CMR Measurement Evaluation Board Set-Up

To measure system common mode rejection, the KTA1550 evaluation board must be configured with the following component placements. Refer to Figures 1 and 2 for component locations.

1. Place a zero-ohm jumper resistor for R3, R4, R7, R10, R15, R16, R17, R18, L2, L11, L12, L13.
2. Remove or leave open (not placed) R1, R2, R8, R9, R11, R12, R13, R14, R19, R20, L14, L15, L16, L17.
3. For Vector Network Analyzer connections and settings, refer to Figures 3 and 4 for EVB connections:
    a. Connect port 1 to J9 to measure TRD0 from the transformer PHY side and J10 to port 2 at the transformer Media side.
    b. Connect port 1 to J3 to measure TRD1 from the transformer PHY side and J9 to port 2 at the transformer Media side.
    c. Set the VNA for an S21 measurement and plot the real or magnitude data.
        i. The CMR measurement amplitude is very low at frequencies below 1MHz. VNA averaging and smoothing may be enabled to achieve a smooth response plot. A good starting point would be to set VNA averaging at 16 with a smoothing aperture of 5% to 6%.
4. DC Power Supply
    a. Connect the DC power supply as outlined in the EVB initial set-up instructions

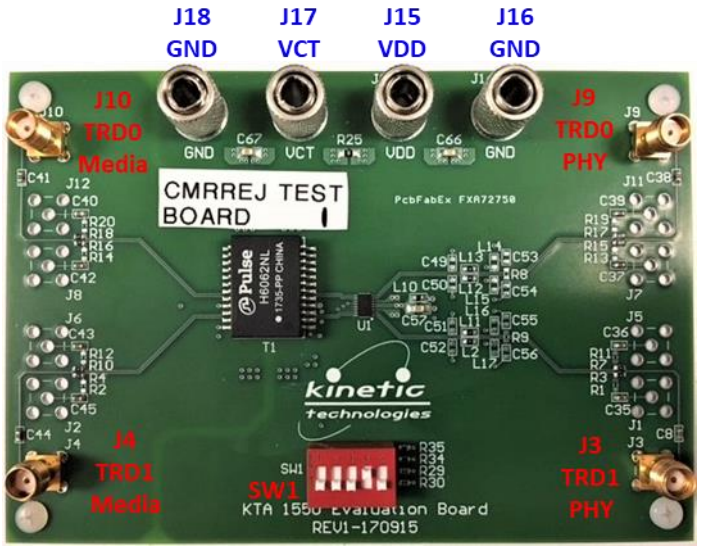

Figure 2: KTA1550 EVB configured for Common Mode Rejection test

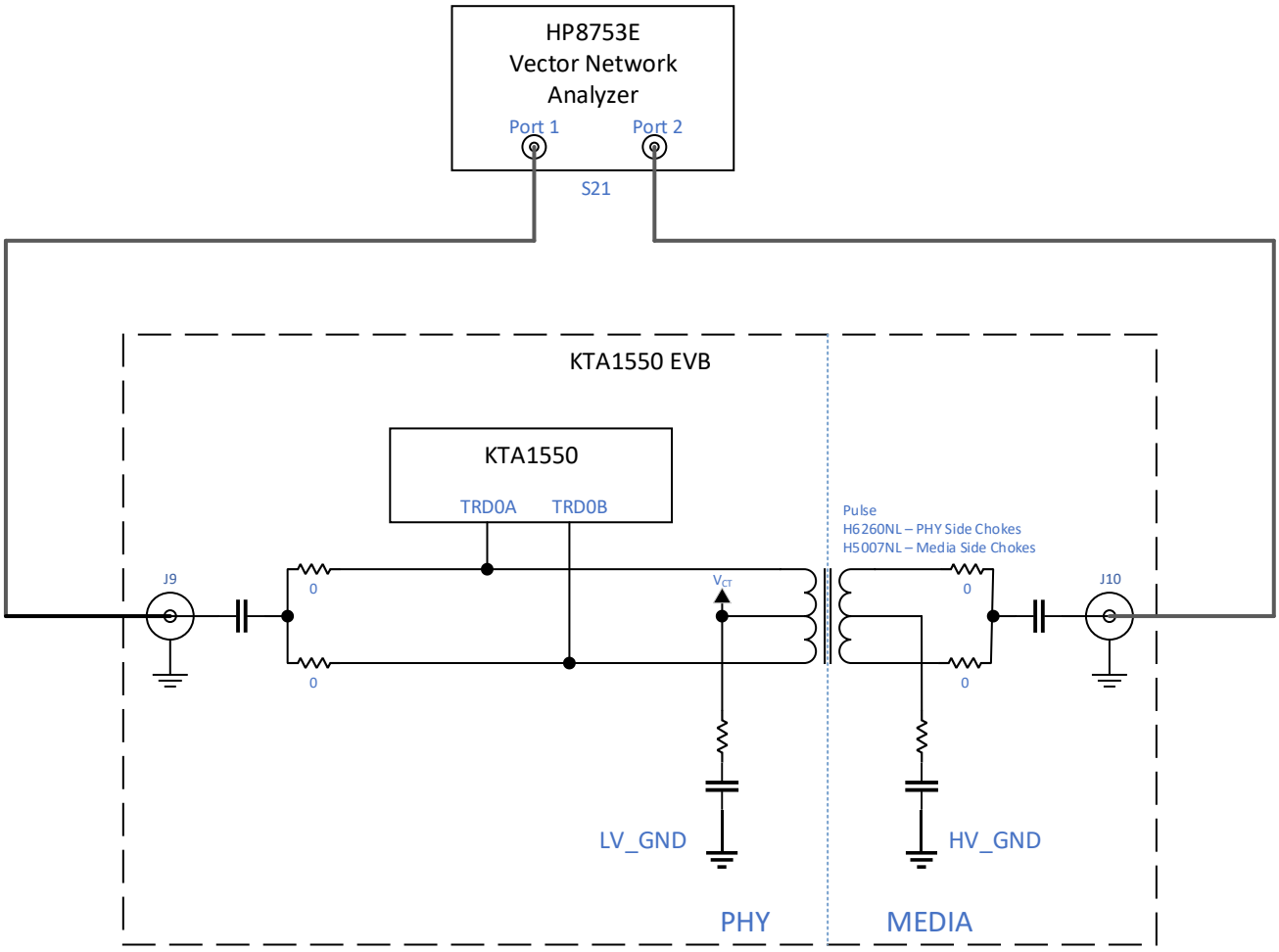

Figure 3: Vector Network Analyzer connection diagram for TRD0 common mode rejection measurements

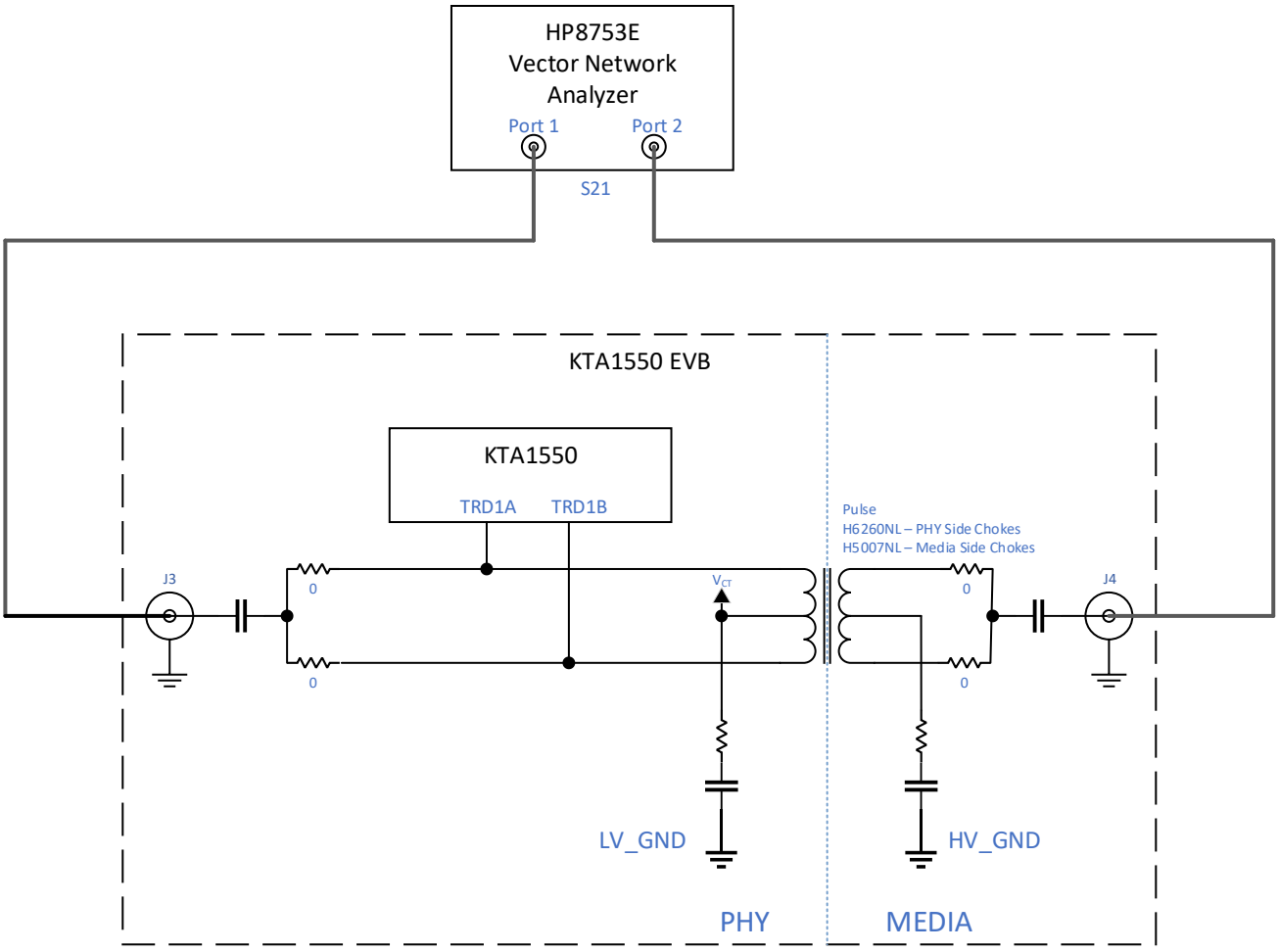

Figure 4: Vector Network Analyzer connection diagram for TRD1 common mode rejection measurements

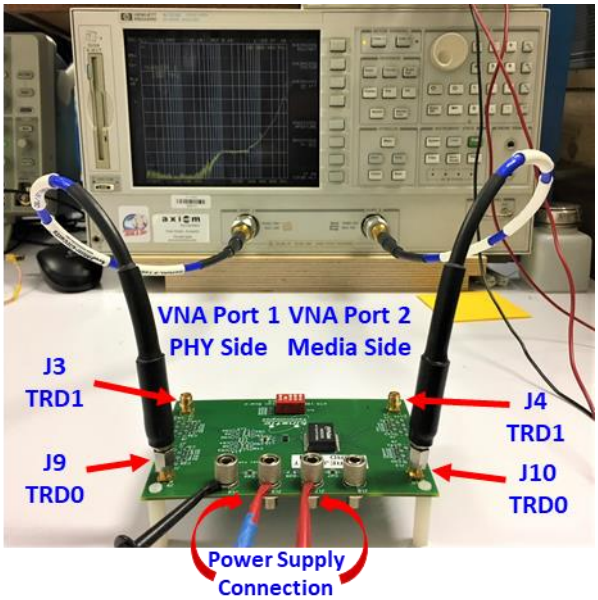

Figure 5: EVB connection to VNA for Common Mode Rejection test

Return Loss

The KTA1550 EMI/ESD suppressor along with the PoE transformer will exert a measurable level of power loss to a reflected or returned signal back to the MEDIA side of the system. A KTA1550 balun fixture is required for this measurement to match the unbalanced VNA port to the balanced differential signal path on the EVB.

Return Loss Measurement Evaluation Board Set-Up

To measure KTA1550 return loss, the KTA1550 evaluation board must be configured with the following component placements. Refer to Figures 1 and 6 for component locations.

1. Place a zero-ohm jumper resistor in positions R1, R2, R11, R12, R13, R14, R19, R20, L2, L11, L12, L13.
2. Place a 100.1Ω, 1% tolerance resistor in positions R8 and R9. These resistors terminate the PHY side of the transmission line for the return loss measurement.
3. Remove or leave open (not placed) R3, R4, R7, R10, R15, R16, R17, R18, L14, L15, L16, L17.
4. For Vector Network Analyzer connections and settings, refer to Figures 7, 8 and 9 for EVB connections:
    a. Connect VNA port 1 to J1 of the KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J8 and J12 respectively with a short SMA to SMA coax cable to measure TRD0 return loss.
    b. Connect VNA port 1 to J1 of the KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J2 and J6 respectively with a short SMA to SMA coax cable to measure TRD1 return loss.
    c. Set the VNA for an S11 measurement and plot the real or magnitude data.
5. DC Power Supply
    a. Connect the DC power supply as outlined in the EVB initial set-up instructions

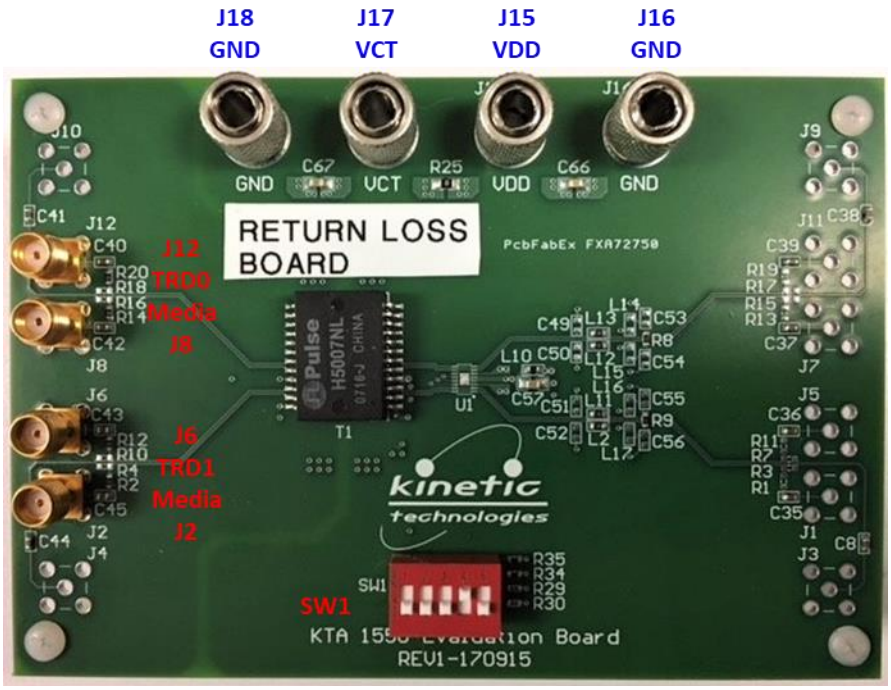

Figure 6: KTA1550 EVB configured for Return Loss test

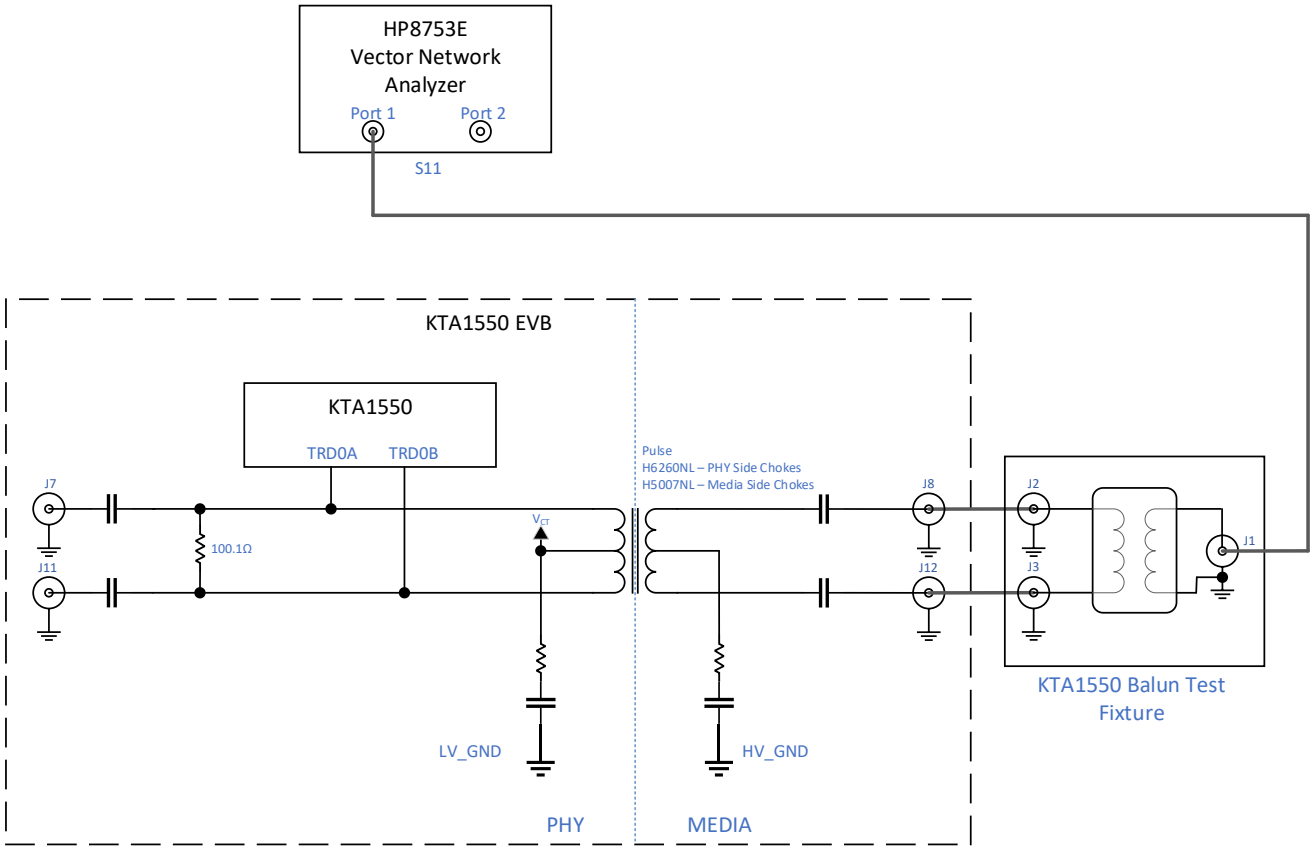

Figure 7: Vector Network Analyzer connection diagram for TRD0 return loss measurement

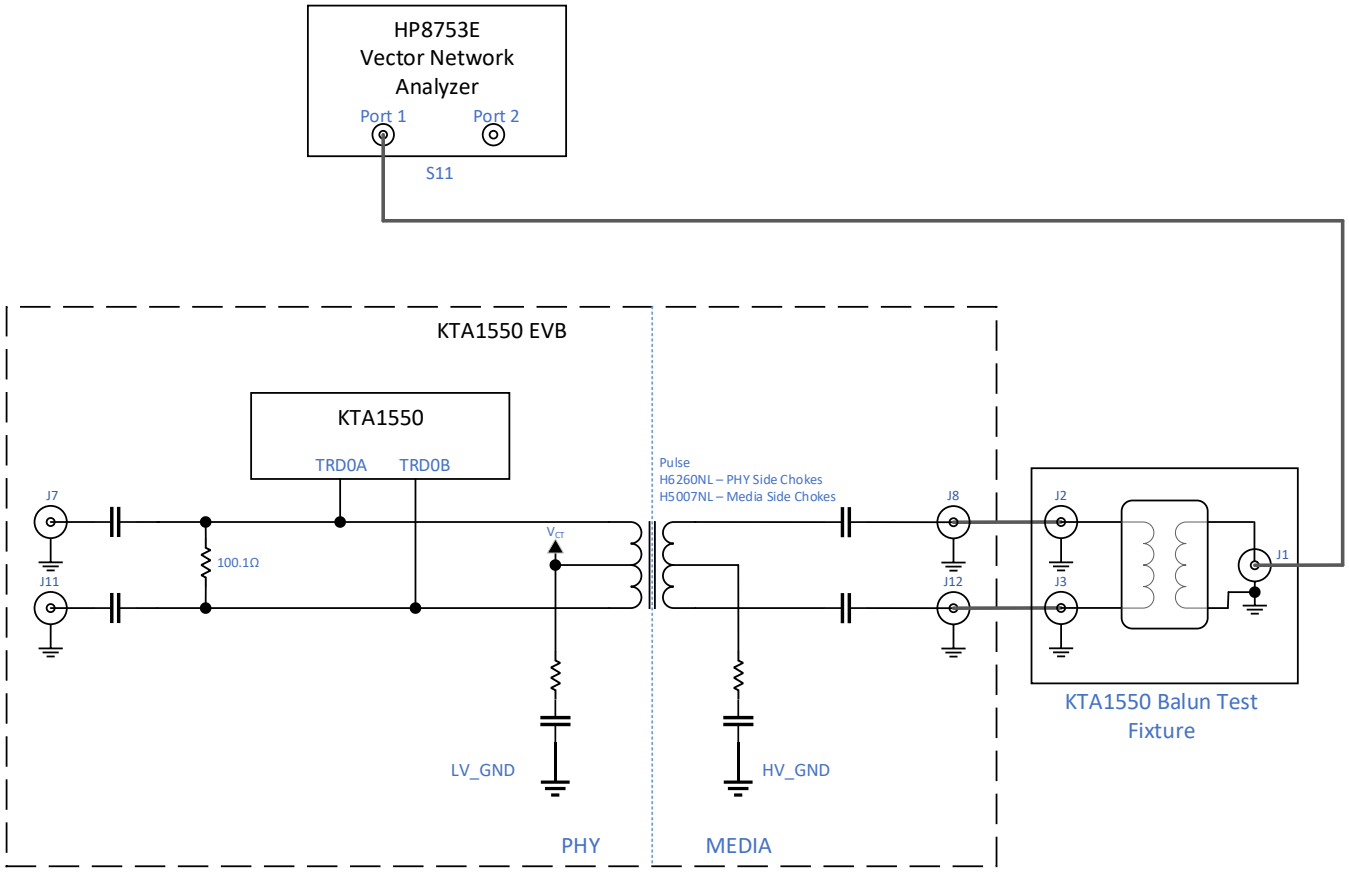

Figure 7: Vector Network Analyzer connection diagram for TRD0 return loss measurement

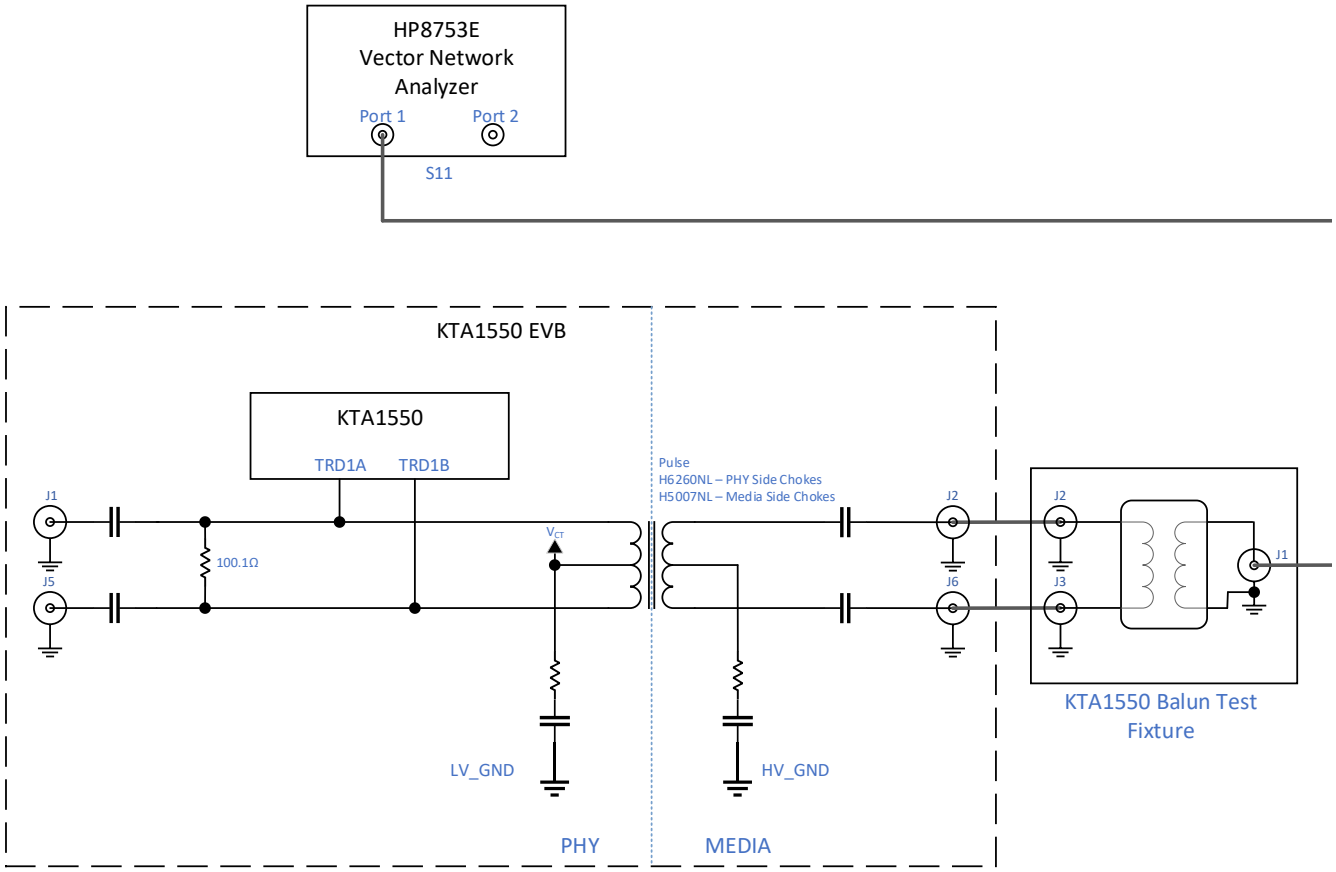

Figure 8: Vector Network Analyzer connection diagram for TRD1 return loss measurement

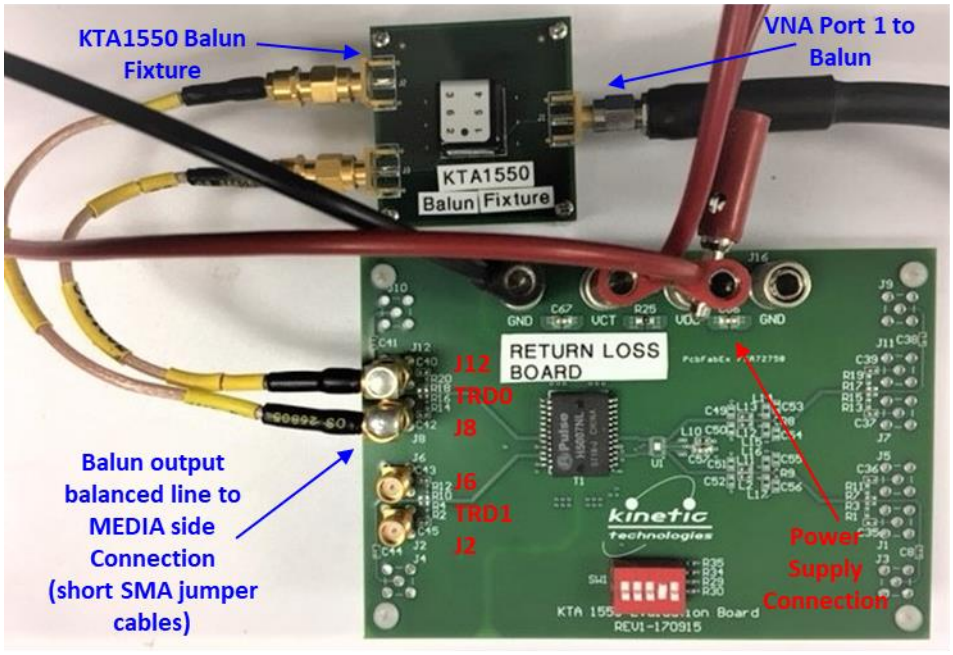

Figure 9: Return Loss EVB and balun test fixture with VNA Port 1 and power supply connections

Insertion Loss

The KTA1550 EMI/ESD suppressor along with the PoE transformer and PCB will exert very low level of power loss due to signal path impedance. To assess the insertion loss contribution of the KTA1550, the signal path loss of the EVB and PoE transformer should first be measured without the KTA1550 mounted on the board. Next, mount the KTA1550 on to the EVB and remeasure the signal path loss. The insertion loss induced by the KTA1550 is determined by subtracting the path loss with the device from the path loss without the device.

Insertion Loss Measurement Evaluation Board Set-Up

To measure KTA1550 insertion loss, the KTA1550 evaluation board must be configured with the following component placements (Refer to Figures 1 and 10 for component locations):

1. Place a zero-ohm jumper resistor in positions R1, R2, R11, R12, R13, R14, R19, R20, L2, L11, L12, L13.
2. Remove or leave open (not placed) R3, R4, R7, R8, R9, R10, R15, R16, R17, R18, L14, L15, L16, L17.
3. For Vector Network Analyzer connections and settings, refer to Figures 11, 12 and 13 for EVB connections:
    a. TRD0 Insertion Loss Measurement
        i. Connect VNA port 1 to J1 of a KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J7 and J11 respectively with a short SMA to SMA coax cable.
        ii. Connect VNA port 2 to J1 of a KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J8 and J12 respectively with a short SMA to SMA coax cable.
    b. TRD1 Insertion Loss Measurement
        i. Connect VNA port 1 to J1 of a KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J1 and J5 respectively with a short SMA to SMA coax cable.
        ii. Connect VNA port 2 to J1 of a KTA1550 1:2 balun test fixture. Connect J2 and J3 on the balun test fixture J2 and J6 respectively with a short SMA to SMA coax cable.
    c. Set the VNA for an S21 measurement and plot the real or magnitude data.
4. DC Power Supply
    a. Connect the DC power supply as outlined in the EVB initial set-up instructions

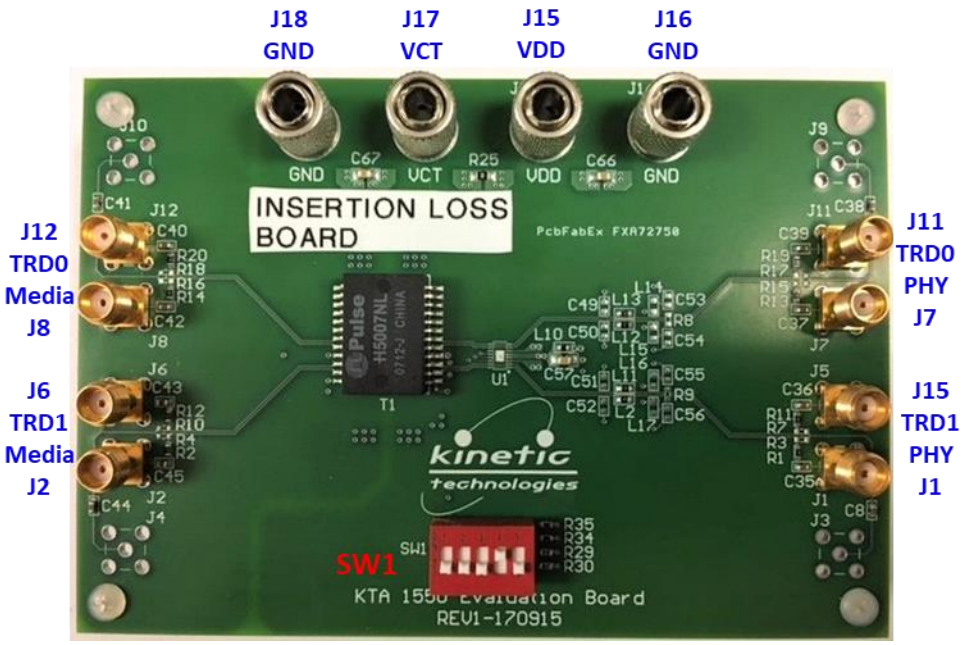

Figure 10: KTA1550 EVB configured for Return Loss test

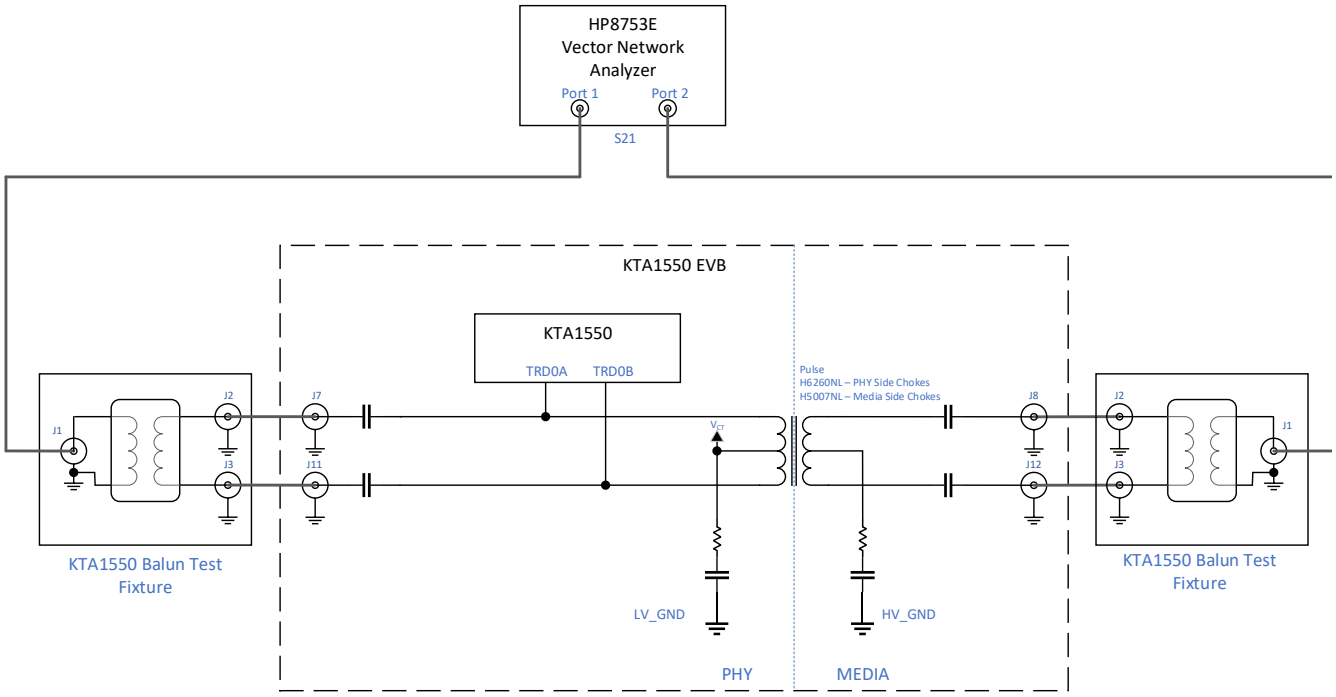

Figure 11: Vector Network Analyzer connection diagram for TRD0 insertion loss measurements

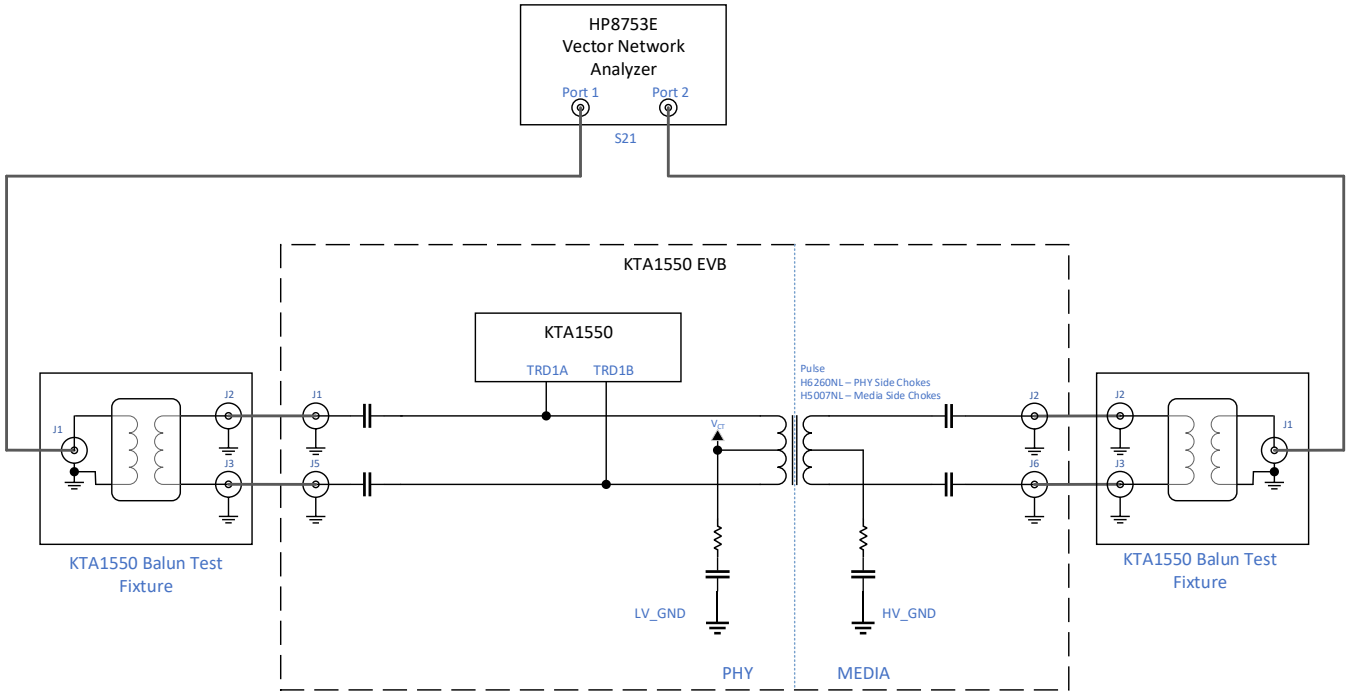

Figure 12: Vector Network Analyzer connection diagram for TRD1 insertion loss measurements

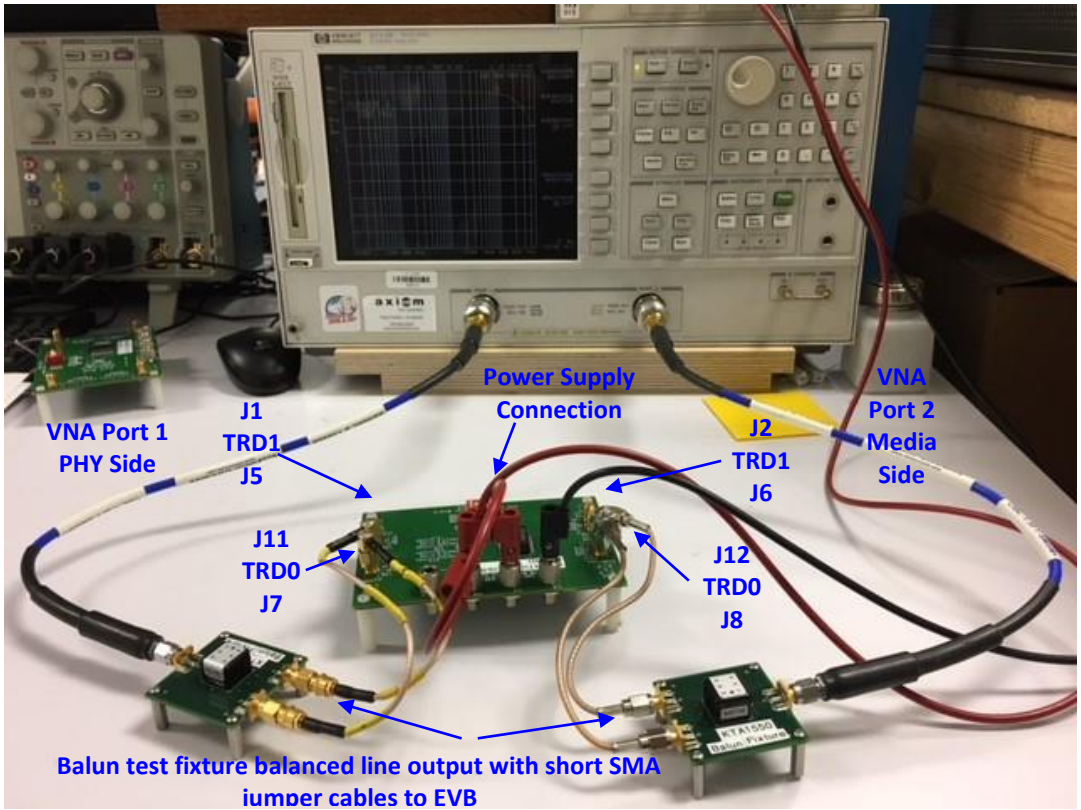

Figure 13: Insertion Loss EVB and balun fixtures with VNA Port 1, Port 2 and power supply connections

References

1. KTA1550 device datasheet
2. KTA1550-EVB, KTA1550 EVB schematic diagram and bill of materials
3. Application Note AN93: KTA1550 Design Guide