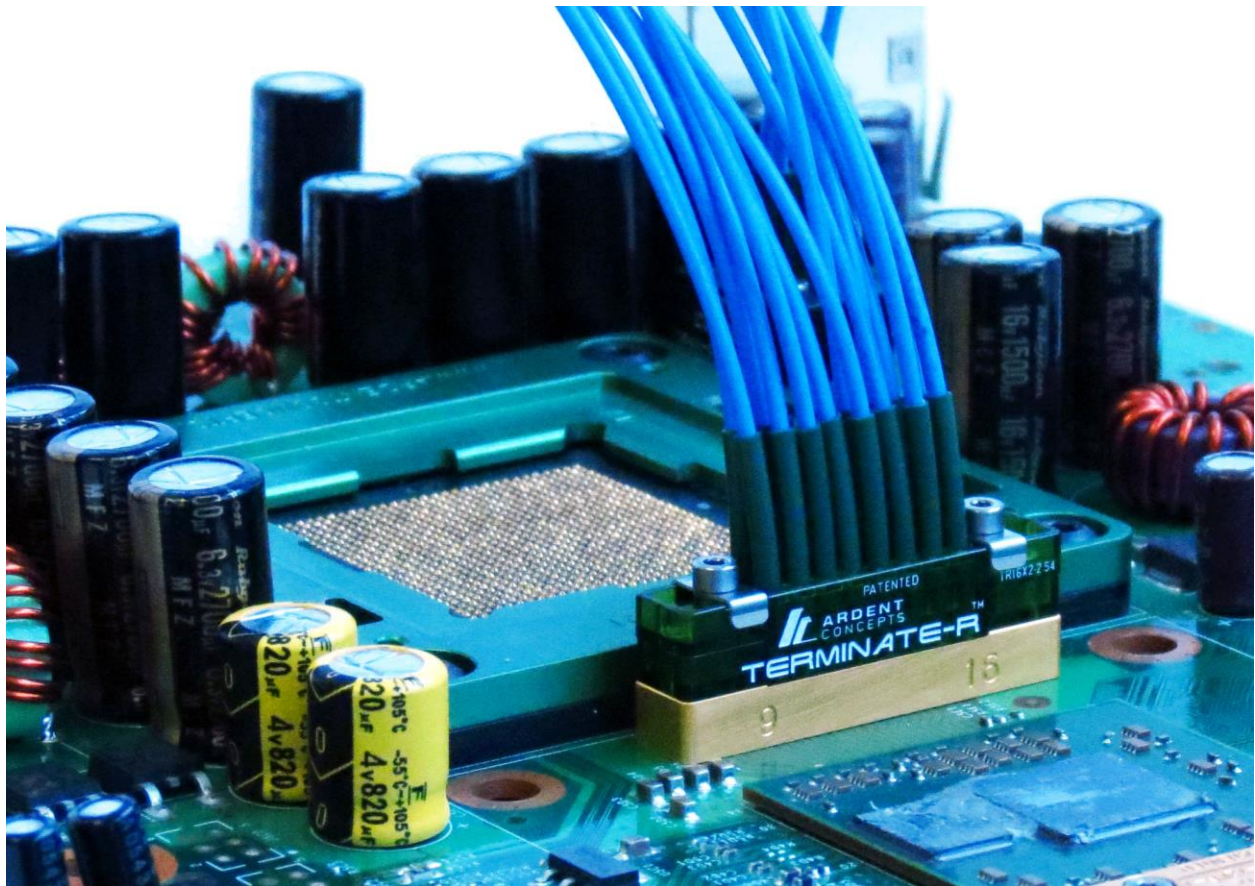




## AM-031

TR: High Density 70 GHz Multi-Coax Cable Termination Connector

Application Note



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## INTRODUCTION

Provided is the user application note for TR, a high frequency multi-coax PCB signal launch system with a solderless compression mount interface for use from DC to 70 GHz.

## TR ASSEMBLY ISOMETRIC VIEW and DETAIL

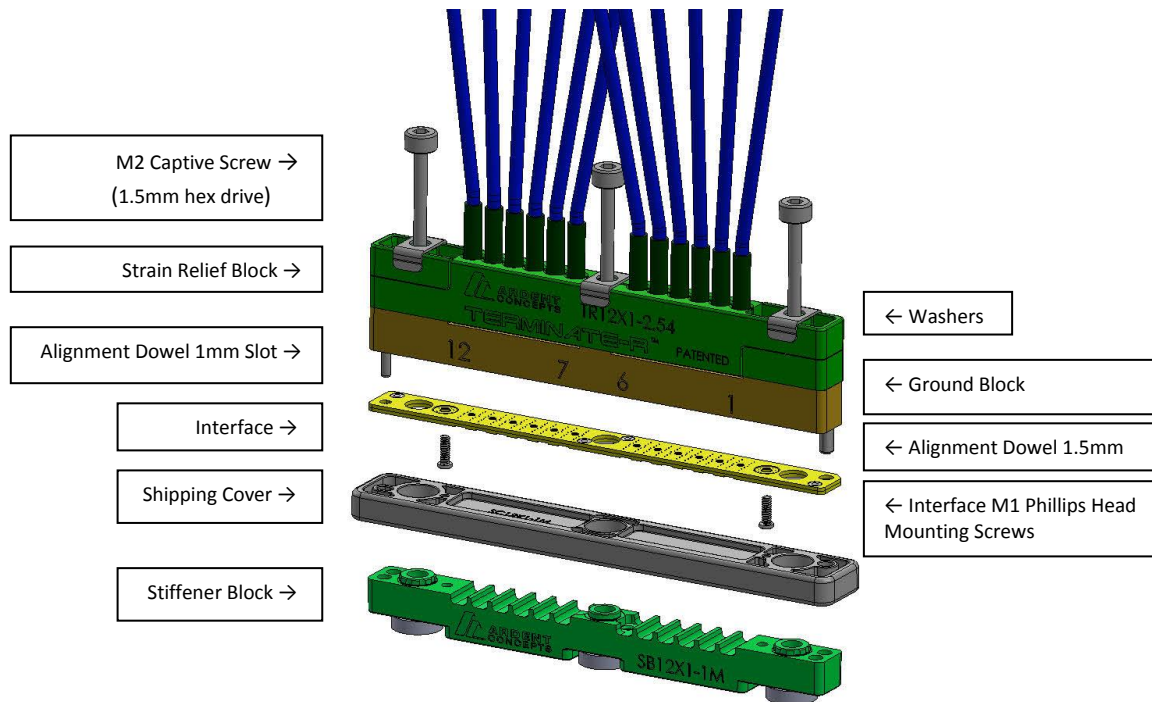


Diagram 1: Exploded CAD image of TR12X1 assembly

## VERIFY CONTENTS

Carefully remove the TR package in a clean stable area.

Verify all TR package parts are present:

- TR Assembly
- Hardware Tool (M2 hex driver)
- Manual (this document)

Review the manual and note advisories before use.

## INSTALLATION

### BOARD PREPARATION

- Inspect the TR board mounting surface for contamination and any obvious surface obstructions, bumps, or imperfections.
- Inspect the surface for solder and solder flux contaminants, surface should be solder free.
- Use lint free cleaning cloth to wipe the board mounting surface clean of dust and contaminants.
- Apply a few drops of uncontaminated isopropyl  $\geq 70\%$  alcohol to a cleaning cloth to remove particles that are not easily removed.
- Ensure most alcohol is removed from the PCB surface by wiping the surface with a dry lint free cleaning cloth.
- After the board footprint surface has been inspected and cleaned, avoid contact with the board surface with fingers or other contaminating objects.
- **CAUTION: The TR must rest evenly on the board surface to work correctly.**
- **NOTE:** An alternative solution to remove dust is to use a filtered compressed dust can.
- **CAUTION: Do not apply large bursts of air pressure to avoid static shock to circuit components.**

## INSTALLING the STIFFENER BLOCK

For boards thinner than 60 mils (1.5 mm) it is recommended to use a PCB Stiffener Block (Example Part number SB12X1-2.54-1M) under the PCB to aid in PCB planarity.

- Carefully remove the shipping cover and Stiffener Block from the TR Assembly by loosening the M2 Captive Screws at the top of the Strain Relief Block until they are easy to slide out of the stiffener and PCB (See Figures 1 and 2).
- NOTE: These screws will not completely remove from the TR Assembly in normal use. If the screws are damaged and need to be replaced, see section Care and Maintenance.

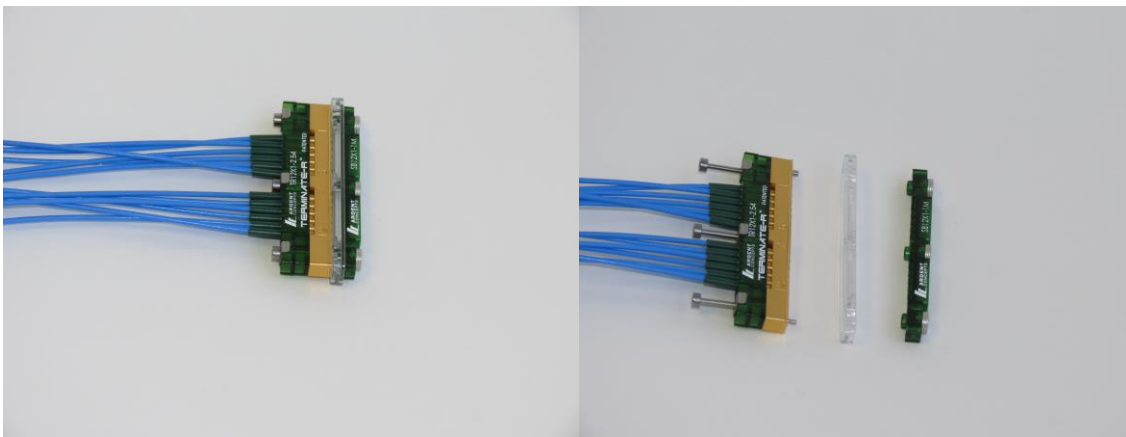


Figure 1: TR Assembly

Figure 2: Protective Bottom Cover and Stiffener Block Removed from the TR Assembly

- Once all the M2 mounting screws are removed from the Stiffener Block, the protective Shipping Cover and the Stiffener Block will fall away from the assembly (See Figure 2).
- Carefully locate the TR board footprint and align the press bosses of the Stiffener Block to the back of the TR footprint on the PCB (See Figures 3 and 4).
- NOTE: The Stiffener Block is symmetrical in design so attention to left/right orientation is not required. The press bosses will hold the Stiffener Block to the PCB backside. At this point, an arbor press MAY be used if necessary to fully seat the bosses on the Stiffener Block.
- With the press bosses aligned and holding the Stiffener Block in place, carefully apply hand pressure to press the bosses into the PCB.

- NOTE: It is not necessary to fully compress the Stiffener Block to the PCB at this stage. During further installation of the the TR Assembly, the M2 Captive Screws will fully seat the stiffener before being fully torqued.

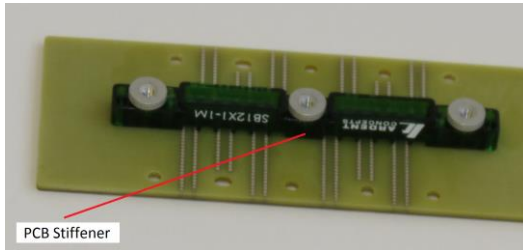


Figure 3: Mounting the Stiffener Block

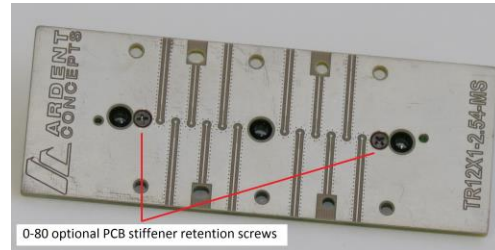
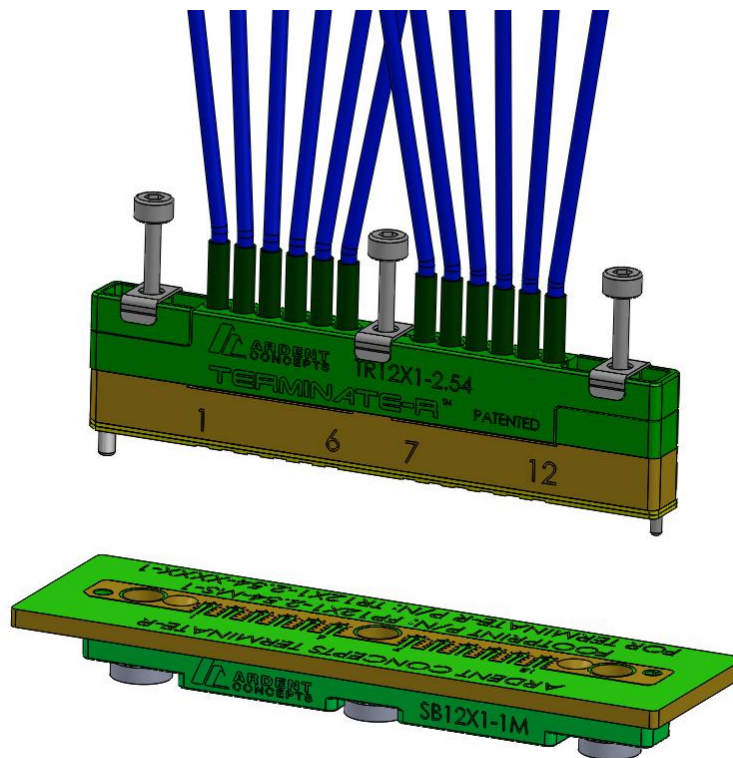


Figure 4: Mounting the Stiffener Block with Retention

- NOTE: At this stage, optional 0-80 screws may be used to secure the stiffener to the PCB. If these screws are used, it is vitally important that the screw heads be recessed or below the top metal mounting plane (See Figure 4).
- NOTE: For boards greater than 60 mils (1.5 mm) M2 pem nuts may be used in place of the Stiffener Block.
- NOTE: For Boards less than 25 mils thick (flex circuits) consult Ardent.



## MOUNTING TR



**Diagram 2: Exploded CAD image of TR12X1 assembly mounting on a PCB**

- Locate the alignment dowels on the bottom of the TR Assembly and reference them for alignment (See Figure 5).
- **CAUTION: Avoid contact with the interface springs to prevent damage.**
- Carefully align the two dowel pins with their corresponding holes being sure to align the 1.5mm dowel pin with the 1.5mm hole and the 1mm dowel slot pin with the 1mm slot hole (See Figure 6).
- **NOTE:** The 1.5mm dowel will always align near Channel 1.

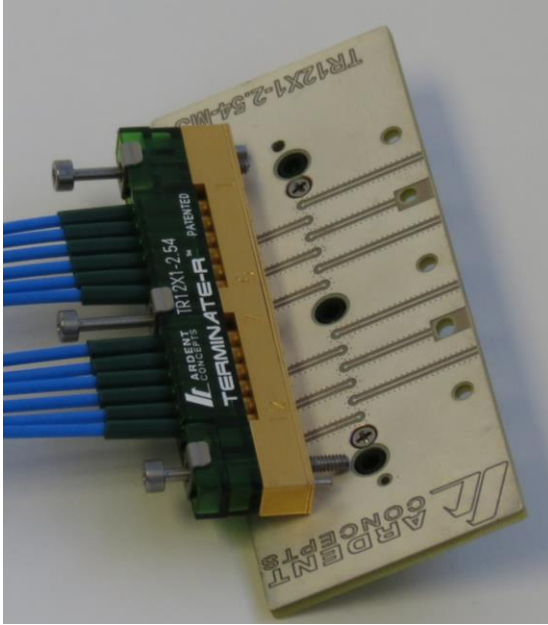


Figure 5: Aligning the TR Assembly

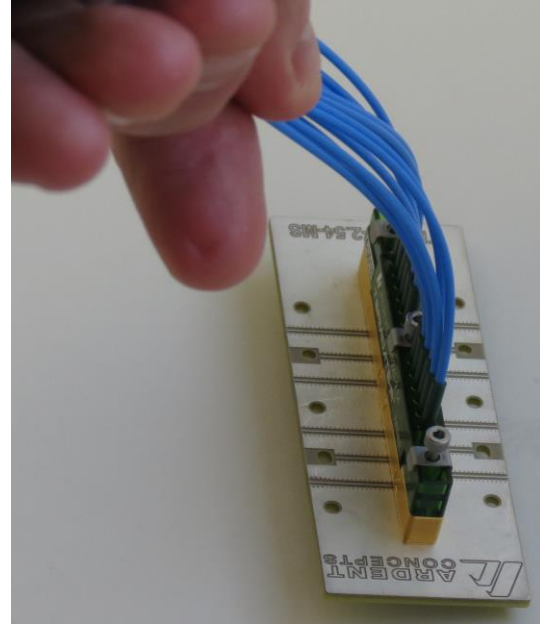


Figure 6: Holding the TR Assembly in Place

- Carefully push down on the block and hold it in place (See Figure 6).
- To ensure that the Stiffener Block is aligned with the TR Assembly, push the hex screws in and rotate to verify contact.
- If the TR assembly has 3 M2 screws as in a X12 or X24 assemblies, tighten the middle screw before tightening the side screws (See Figure 7).
- While holding the TR Assembly in place, tighten the M2 hex screws located on top of the Strain Relief Block until a torquing resistance is observed (See Figure 8).

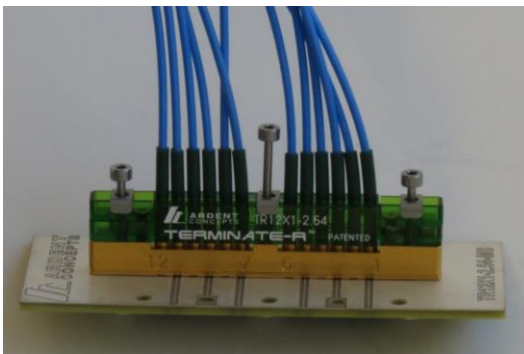


Figure 7: Verifying M2 Screw Contact

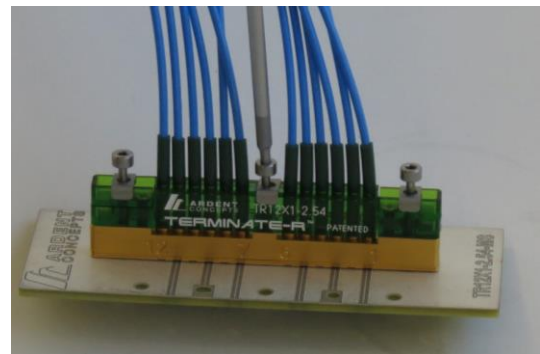


Figure 8: Tightening the Middle M2 Screw

- After all the screws have been tightened snugly into place, go back over the M2 screws with the driver to be sure they are all torqued evenly to 1.5 in-lbs (0.169Nm).
- NOTE: There will be a noticeably large resistance to turning the screws when they are fully tightened (See Figure 9).

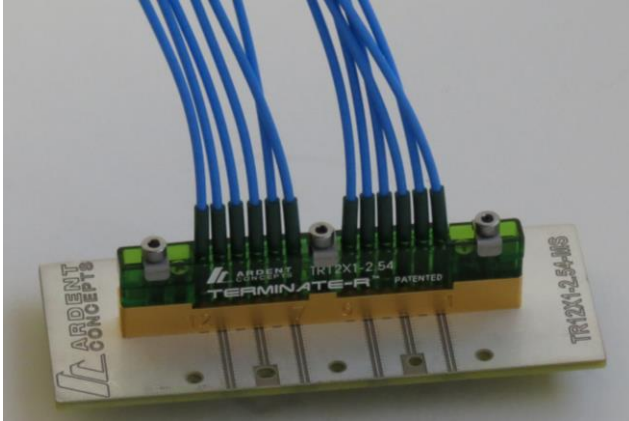


Figure 9: Mounted TR Assembly Complete

- **CAUTION: Do not overtighten the M2 hex screws**
- NOTE: The Stiffener Block is fully compressed into the board at this stage.

## INTEGRATING TR to INSTRUMENTATION

### PERMISSIBLE COAX CONNECTION HARDWARE INSTRUMENTS

Prepare Torque Wrench Instruments

- 5/16" 8 in-lb. (0.90 Nm) Open Ended Torque Wrench

Prepare Open Ended Wrench Instruments and Ardent Tools

- Ardent Hardware Tools
- 5/32" Open Ended Wrench
- 5/16" Open Ended Wrench
- 7 mm Open Ended Wrench

**CAUTION:** Do not use other tools like pliers and Vise-Grips as they can damage the high precision connectors.



Figure 10: Recommended Permissible Hardware Instruments

## PROCEDURE for CONNECTING the TR COAX CONNECTOR to INSTRUMENTATION

**CAUTION:** Care must be considered when assembling connections. Misalignment will significantly damage the fingers or plug of the coax connector. Time must be taken for proper alignment to ensure correct measurements. It is best to tighten the connectors as far as possible by hand before using tools.

- Minimize the variable parameters of the cable geometry assembly by supporting and handling it with care. Do not pull, rotate, or place the cable assembly under tension.
- Verify that calibration ports are gauged, concentric, and set to the right pin depth.
- Carefully align the coax connector to the calibration reference port.
- While holding the cable assembly and adapter port stationary, rotate the coupling nut by hand.
- Hand tighten the connection first.
- Do not force the connection if the coupling nut is not threading smoothly.
- To couple the connection to a repeatable pin depth, grip the base of the female coax connector by hand or with an open ended wrench.
- Insert the Torque Wrench onto the coupling nut such that it forms an angle less than 90° with the hand grip or the stationary wrench.
- While holding the coax cables and connectors stationary, apply a moment force with the torque wrench at the coupling nut into the decreasing angle direction. Hold the torque wrench from the end (See Figure 11).
- Keep the coax cables and connectors stationary while gently applying the moment force at the coupling nut just until the torque wrench begins to yield slightly.
- **CAUTION:** Ensure the coax cables and connectors remain stationary at all times during the connection to prevent connector wear and measurement error.
- **CAUTION:** Do not exceed a moment force of 8 in-lb (0.90 Nm) at the coupling nut to avoid damage and measurement error.
- **CAUTION:** Inspect the connector coax metal surface for scratches that may contain metal particles due to open ended wrench wear. Clean to prevent measurement error contamination.

- NOTE: The applied moment force is only at the coupling nut.
- NOTE: The function of the coupling nut is to bring and hold the center conductors to a repeatable depth.

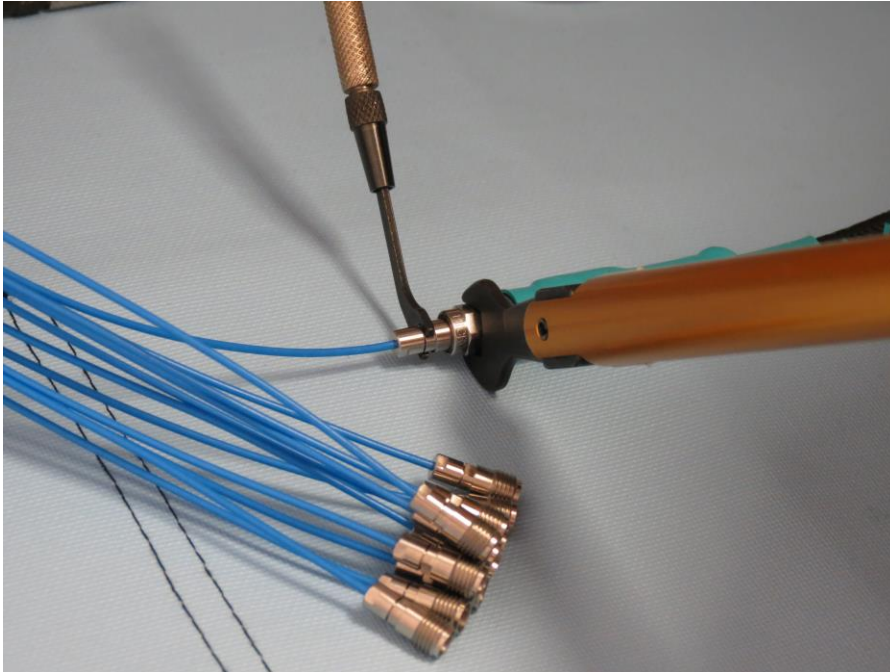


Figure 11: Connection Torque Procedure

## DISCONNECTING TR FROM INSTRUMENTATION

- Carefully hold the device under test and instrument cables stationary by hand or with the corresponding permissible open ended wrenches: 5/32", 5/16", or 7mm.
- Repeat the connection procedure with an opposite moment force for disconnection.
- Place the torque wrench on the coupling nut and apply a steady moment force to loosen the connection with the torque wrench.
- When the moment force resistance feels released, continue to uncouple the connection by hand.

## EXPECTED RESULTS

### EVALUATION KIT

The scattering parameter performance of the TR Assembly can be observed by an Evaluation Kit offered. The Evaluation Kit contains a TR Assembly, PCB mounting board with microstrip traces, and two movable end launch connectors.

#### EVALUATION KIT BOARD

There is an 8 channel evaluation kit available with 2.92 mm (K- Connector) 6" cables.

The board is 62 mils thick with Rogers 3003 (10 mils thick) substrate ENIG laminated onto FR4.

Each metal layer is 1.7 mils thick with ENIG plating.

The board has two line standards to de-embed board loss.

The L2 / M line standard is 0.50" long and can also be used as an open to move the reference plane just before the narrow microstrip transition.

The L1 / M line standard is 0.75" long.

A load adapter may be connected to one end of the line standards.

With the L2 / M line open standard, the reference plane extension determines a characterized attenuation with the end launch and microstrip. The loss characterization is determined by the PNA when measuring the open standard.

PLEASE NOTE: The loss of the microstrip trace under the interface still remains and therefore further characterization would be implemented to completely remove the microstrip trace up to the signal landing pads.

PLEASE NOTE: To ensure a correct de-embedded return loss measurement, ideally part of the microstrip trace would be included just before entering under the interface.

#### END LAUNCH CONNECTOR

Each Evaluation Kit contains two Signal Microwave Edge Launch Connectors: 2.92 mm Female.



## VECTOR NETWORK ANALYZER CALIBRATION PARAMETER SETTINGS

The round trip time for a TR Evaluation Kit with 6" cables is less than 2 ns.

Rise Time Period of Vector Network Analyzer =  $1 / \text{Frequency Span} \rightarrow 1 / 40 \text{ GHz} = 25 \text{ ps}$ .

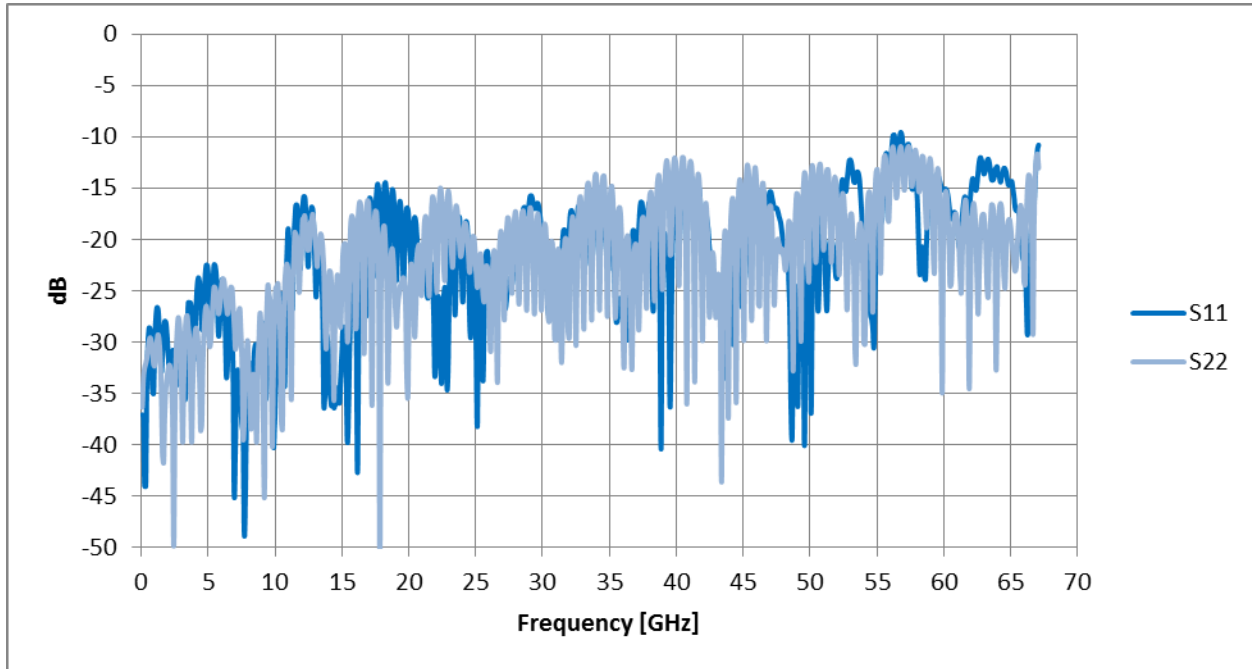
The scattering parameter performance for an 8 channel TR 06KF Evaluation Kit was measured ideally with the following equipment settings:

- ❖ Vector Network Analyzer Agilent E8361A PNA
- ❖ Sweep Type: Step
- ❖ Number of Points: 1601
- ❖ Intermediate Frequency Bandwidth: 100 Hz
- ❖ Rise Time:  $\approx 14 \text{ ps}$
- ❖ Stimulus Time: 0 ns to 2 ns
- ❖ Stimulus: 0.041875 GHz to 67.041875 GHz

## DETERMINING PHASE LENGTH

- To determine the phase length of each cable:
- Remove the interface from the TR Assembly.
- Note: Phase length measurements will not be accurate with the interface on the TR assembly because the contacts are not compressed.
- In the time domain, select a step response in real format mode.
- Connect a TR coax channel to the calibrated port.
- Allow time for a steady state response.
- Determine and mark the middle of the step response rise and record the time value.
- This chosen middle value will be used as a reference.
- Average for what time the chosen middle rise value would fall on.
- Disconnect the channel and connect a new channel.
- Allow time for a steady state step response.
- Determine and mark the middle of the step response rise and record the time value.
- Average for what time the chosen middle rise value would fall on.
- Repeat this process and when completed, the different time values for when the chosen middle value of the step response rise occurred can be compared.

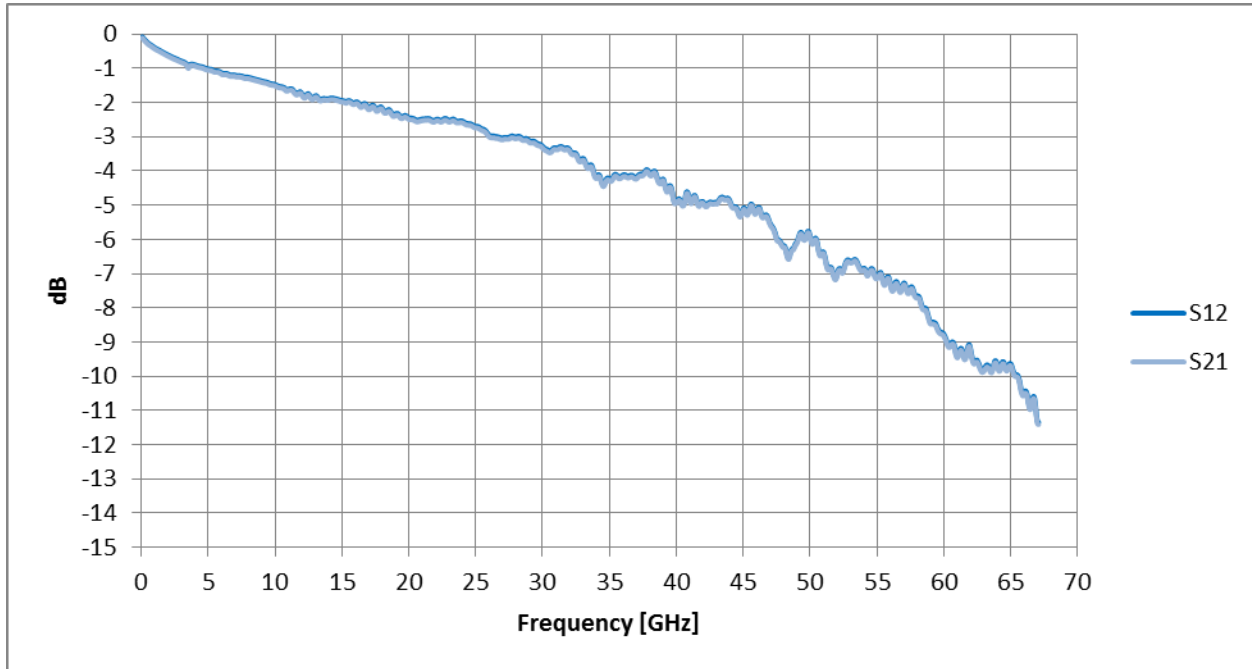
## RETURN LOSS



### Interpolation 1: Return Loss for a 06KF Evaluation Kit

NOTE: The 2.92 mm End launch connector and 0.5" microstrip (Rogers 3003 10 mil thick ENIG substrate laminated onto FR4) is included in measurement.

## INSERTION LOSS



### Interpolation 2: Insertion Loss for a 06KF Evaluation Kit

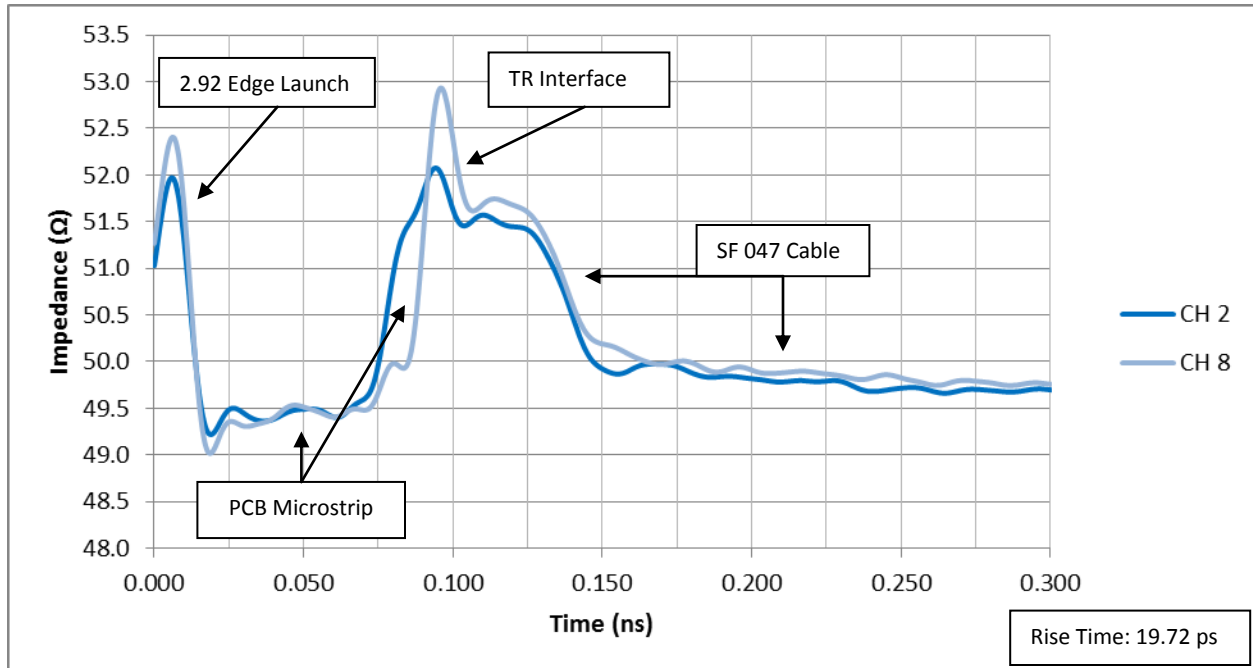
NOTE: The 2.92 mm End launch connector and 0.5" microstrip (Rogers 3003 10 mil thick ENIG substrate laminated onto FR4) is included in loss.

NOTE: The attenuation of the 06K assembly and interface is -2.5 dB at 40 GHz.

NOTE: The attenuation of the 06V assembly and interface is -1.9 dB at 40 GHz.

TR 12" Cable Assembly Insertion Loss	TR 6" Cable Assembly Insertion Loss
≤ 22 GHz: -2.39 dB	≤ 22 GHz: -1.30 dB
≤ 40 GHz: -3.46 dB	≤ 40 GHz: -1.92 dB
Loss Due to Cable 22 GHz: -2.18 dB	Loss Due to Cable 22 GHz: -1.09 dB
Loss Due to Cable 40 GHz: -3.08 dB	Loss Due to Cable 40 GHz: -1.54 dB
Loss Due to Interface 40 GHz: -0.38 dB	Loss Due to Interface 40 GHz: -0.38 dB

## TIME DOMAIN REFLECTION



### Interpolation 3: Time Domain Reflection for a 06KF Evaluation Kit

NOTE: The measurement includes a 2.92 mm End launch connector and 0.5" microstrip (Rogers 3003 10 mil thick ENIG substrate laminated onto FR4).

NOTE: The interface reactance is controlled.

## CARE and MAINTENANCE

### STORING TR

The Shipping Cover should be placed on the TR Assembly for storage just like the TR Assembly was received. The Shipping Cover will protect the contacts and should be mounted between the interface and the Stiffener Block (Please see Figures 2 and 3).

## INTERFACE REMOVAL and REPLACEMENT

- **CAUTION:** Handle the interface carefully. Avoid contact with the fragile interface springs.
- To remove the interface, carefully remove the two M1, 3mm screws. Carefully set in a controlled area with the milled channel side facing down (See Figures 12-15).

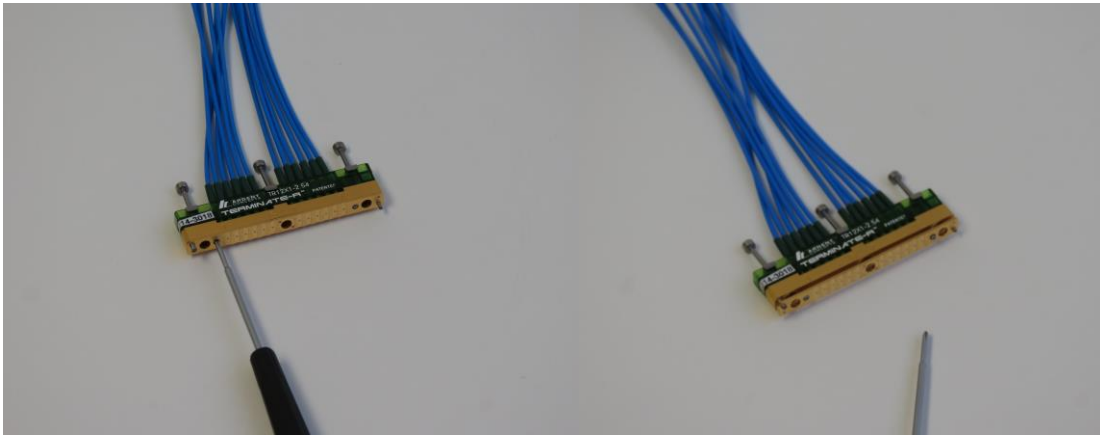


Figure 12: Removing the M1 Screws

Figure 13: Sliding the Interface Off

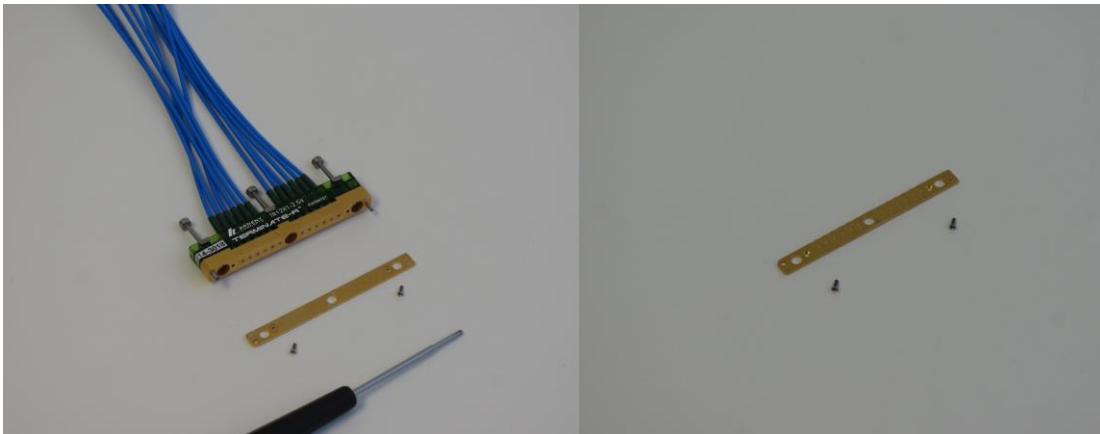


Figure 14: The Interface Removed

Figure 15: The Interface Resting with the Milled Channel Facing the Surface

- To install the interface, align the interface with the dowels and insert it onto the dowels carefully with the channeled surface contacts facing outward.

## REPLACING M2 CAPTIVE HEX SCREWS

- To replace the M2 Captive Screws from the TR Assembly verify that the screws are not engaged by unscrewing them until they are free to slide.
- Fully extend an M2 screw by applying an outward pull force.
- While applying the outward pull force rotate the M2 screw by hand counter clockwise to engage the threaded part of the screw with the captivating threads in the strain relief.
- Once the M2 screw thread is engaged with the strain relief, it can be backed out completely and replaced by turning it counter clockwise further.
- Once the M2 is removed, screw a replacement into the strain relief.



## COAX CABLE CONNECTOR INSPECTION

Carefully inspect the center of the coax connector and discontinue use immediately if the following is noted:

Bent or Non-Concentric Coax Center Conductor Fingers

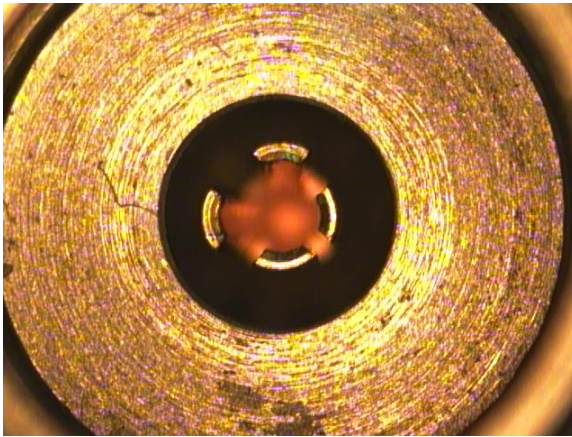


Figure 16: Magnified View of a Damaged Coax Connector

Bent or Non-Concentric Center Conductor Plug

Scratches on the Center Conductor

Inspect the center conductor for contamination and perform a precision cleaning procedure if the following is noted:

Dust, Substances, and Metal Particles On and Surrounding and the Center Conductor

## PRECISION CLEANING PROCEDURE

SENSITIVE CAUTION: If necessary carefully use uncontaminated thin electronic foam tipped cleaning swabs to wipe the center conductor. Do not mix cleaning contact with the center conductor and the outer coupling nut/ threads.

CAUTION: An alternative solution to remove dust is to use a filtered compressed air can.

CAUTION: Do not apply large bursts of air pressure to avoid a static charge build up on the center conductor.

## USE EXPECTANCY DURATION

The TR interface is rated for 1000 (mate and de-mate) cycles to the PCB.

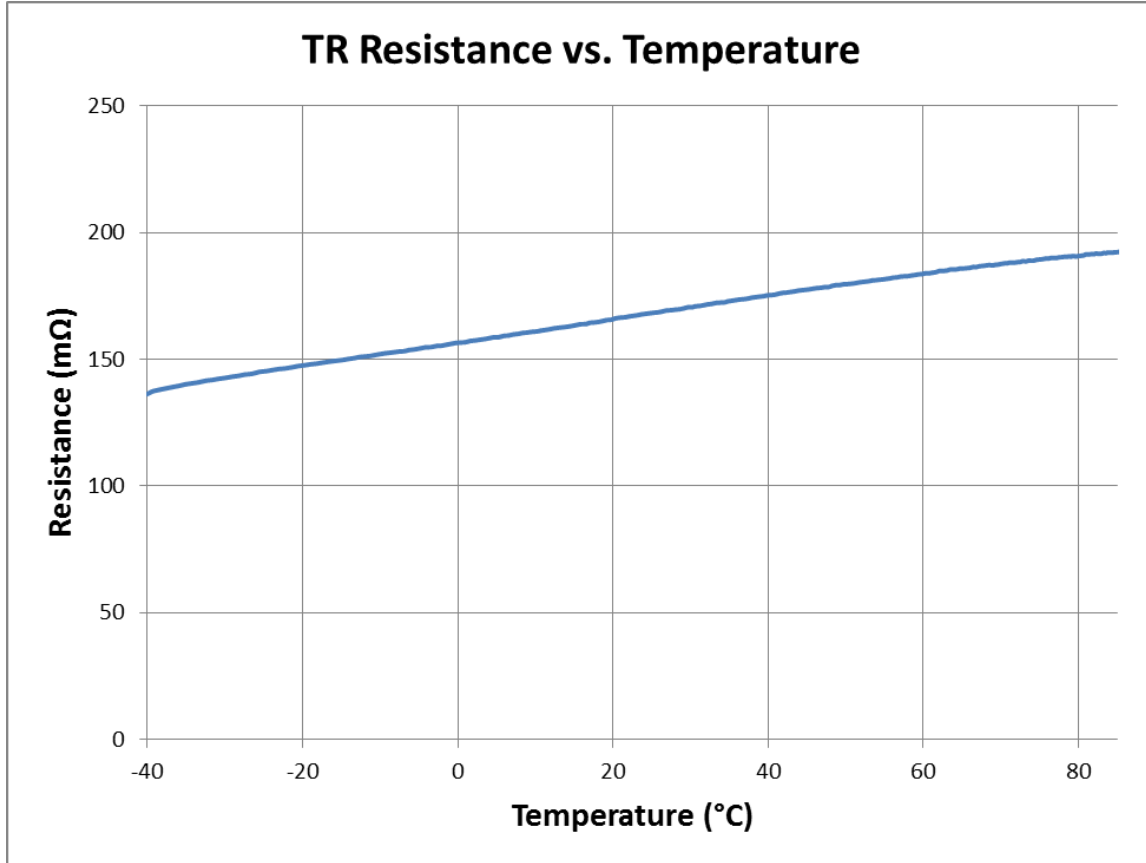
NOTE: The TR interface is field replaceable.

# ENVIROMENTAL PERFORMANCE

## TEMPERATURE RATING

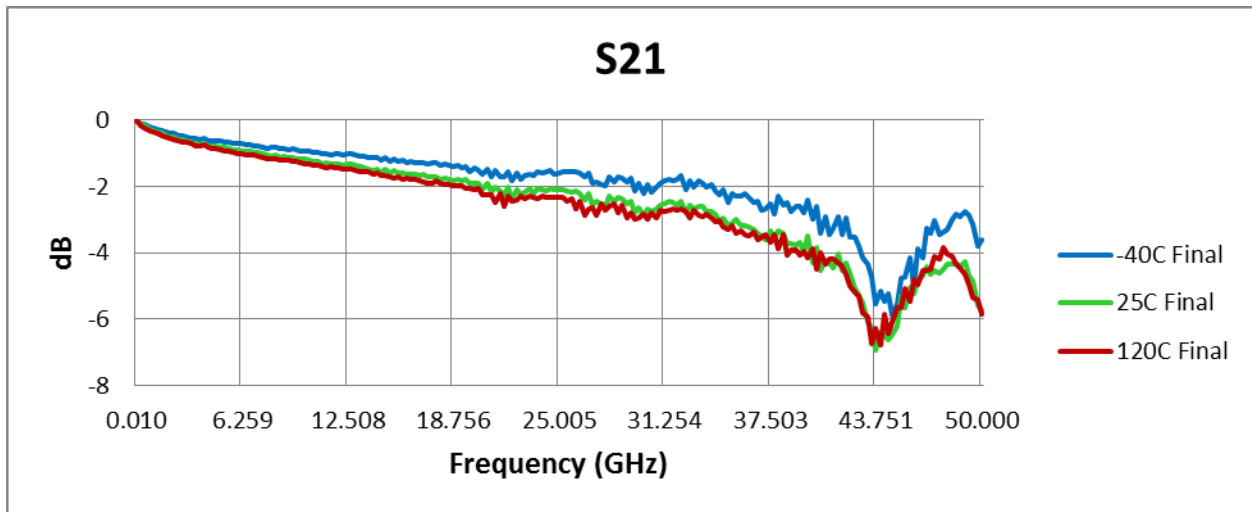
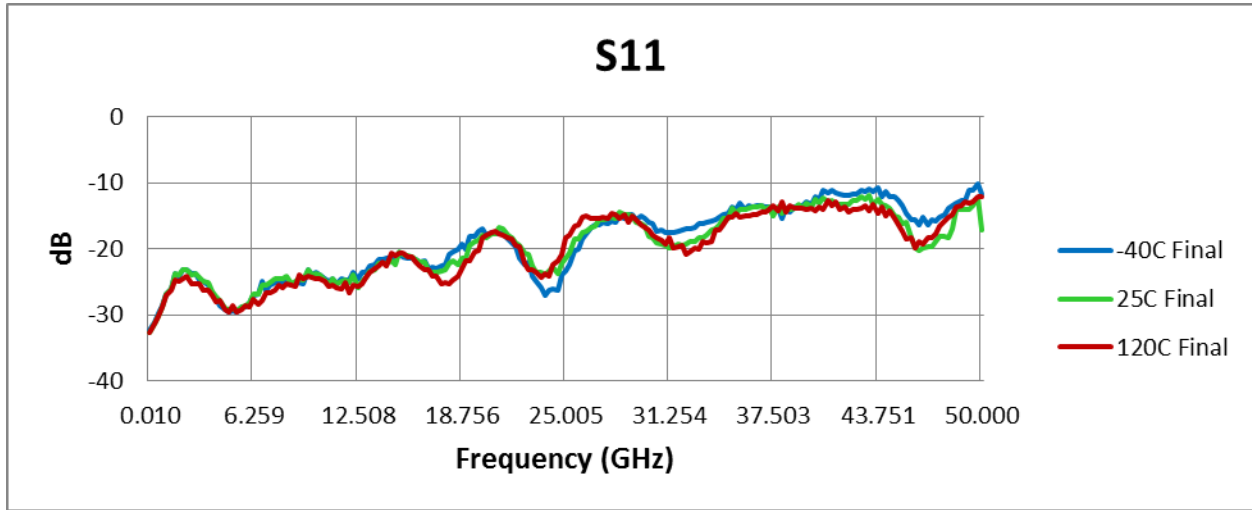
MIL-STD 810G

Maximum Temperature before Material Deformation: 135°C



Resistance Tolerance:  $\pm 17$  m $\Omega$  at (21.1 °C)

## EVALUATION KIT TEMPERATURE PERFORMANCE



## HUMIDITY and FROST RATING

MIL-STD 810G

## TENSION PERFORMANCE

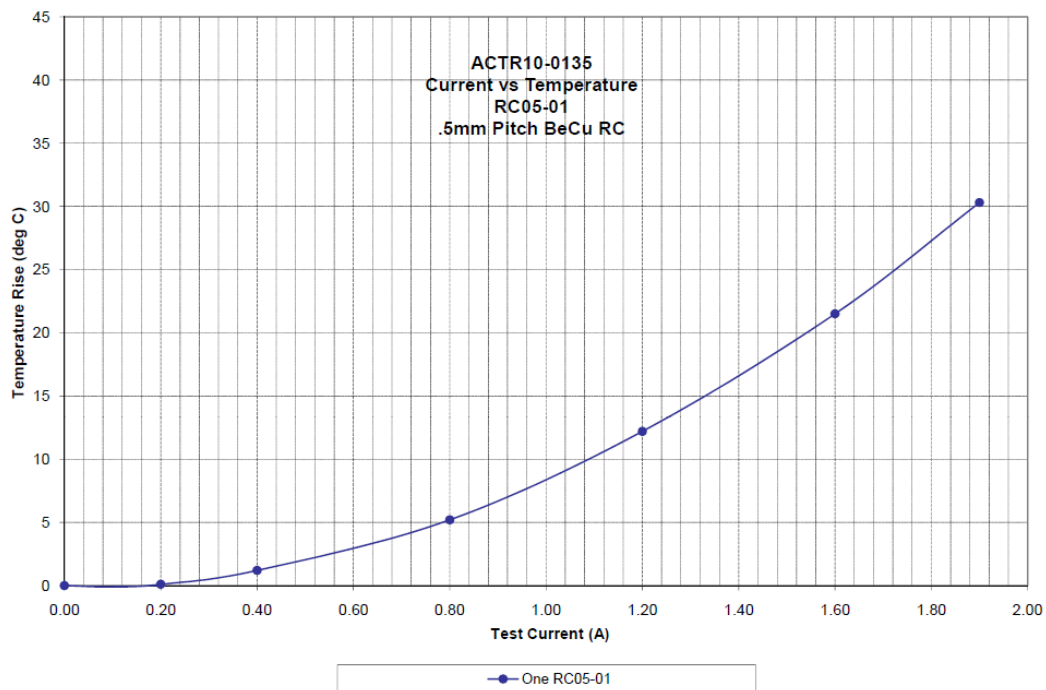
As tension is applied to the cable of a TR Assembly the geometry of the cable will change. As the cable stretches the coax center conductor will contract.

The maximum pull strength the TR Assembly can handle before at risk of failing electrically is 2.5 lbs of tension static load.

NOTE: The minimum pull force required for an open varies, the average value is 5.5 lbs.

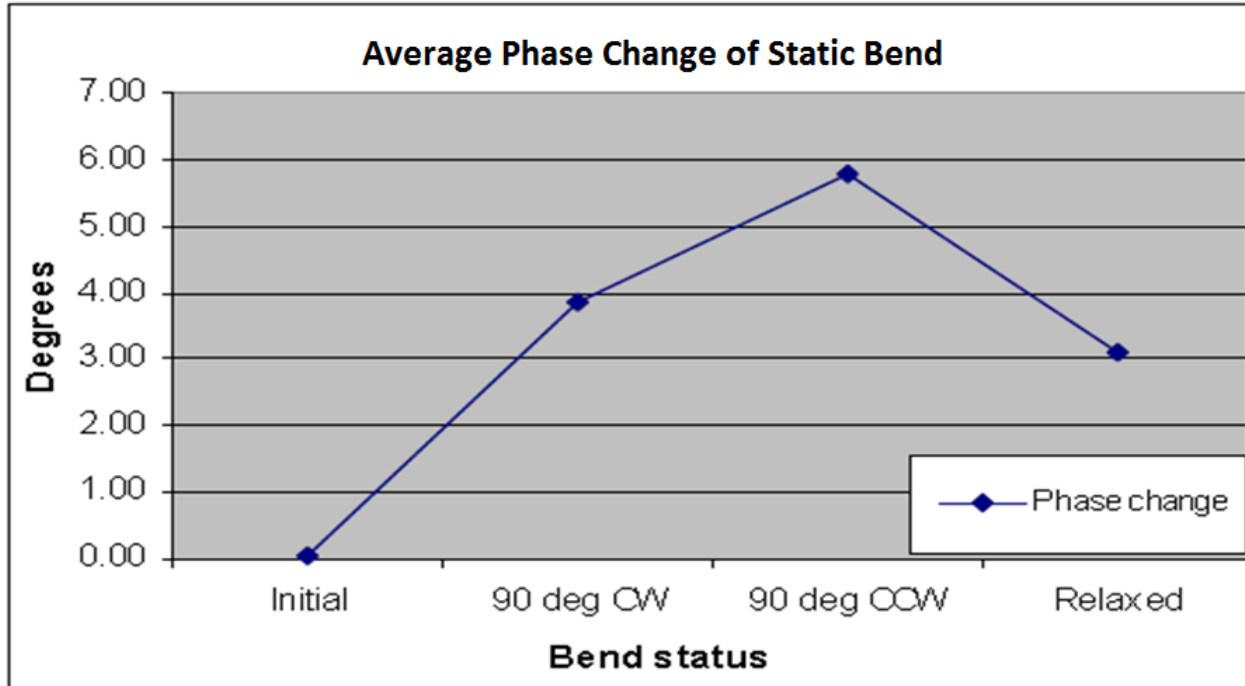
NOTE: A static load is defined as not having rotational moment pull forces or variable pull force loads.

## CURRENT CAPACITY



## BEND RADIUS

Minimum Centerline Bend Radius: .100" /2.54mm



## COAXIAL CABLE SPECIFICATION

The cable used in the TR assemblies is made by Teledyne Storm Microwave and the cable's trade name is Storm Flex 047. Below is a link to the Teledyne website and more information:

[http://www.teledynestorm.com/microwave/mw\\_cablefxgp.asp?div=mw&cg=422-0017](http://www.teledynestorm.com/microwave/mw_cablefxgp.asp?div=mw&cg=422-0017)

## TR BOARD OPTIMIZATION

### OPTIMIZATION PROCEDURE

- The optimization checklist provides the input parameters for simulating the unique information stack up of every board. This must be filled out prior to beginning any optimization work.
- For the TR assembly there is an optional optimization report that determines footprint specification parameters for improved impedance matching.
- The default optimization return loss performance for the TR assembly at the connector is -20 dB for up to 20 GHz and -12 dB from 20 GHz to 40 GHz.
- The current footprint for the connector has tolerance limitations for modifications.

### HFSS SIMULATION

The simulation determines the optimal board footprint parameters for TR. The simulation models the performance of a signal as it transitions under the connector, thru the interface, and up to a few inches of coax cable.

- A complete model of the connector is simulated with the corresponding board stack up, optimization goals, references, and desired performance specifications requested.
- Simulations are available for a microstrip and a stripline.

The parameters kept constant for simulation optimizations are the following:

- Gap width under the connector.
- Anti-pad ground diameter and microstrip top metal return channel width (guard channel).
- Via diameter
- Return via bolt circle diameter
- Return via location on the bolt circle

The parameters frequently adjusted during the optimization phase are the following:

- Signal capture pad diameter
- First return layer anti-pad diameter
- Trace width under connector

See Figure 17 for the tuned footprint simulation parameters.

## Microstrip Board Interface Model

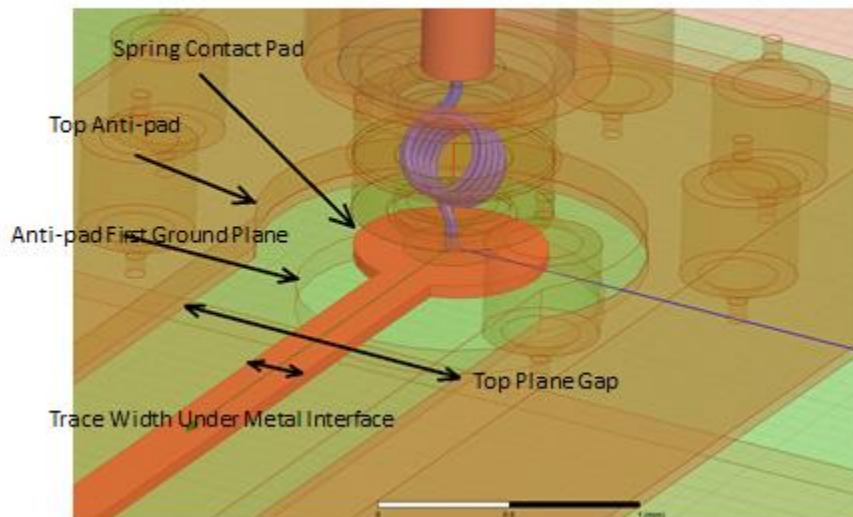


Figure 17: Tuned Simulation Parameters



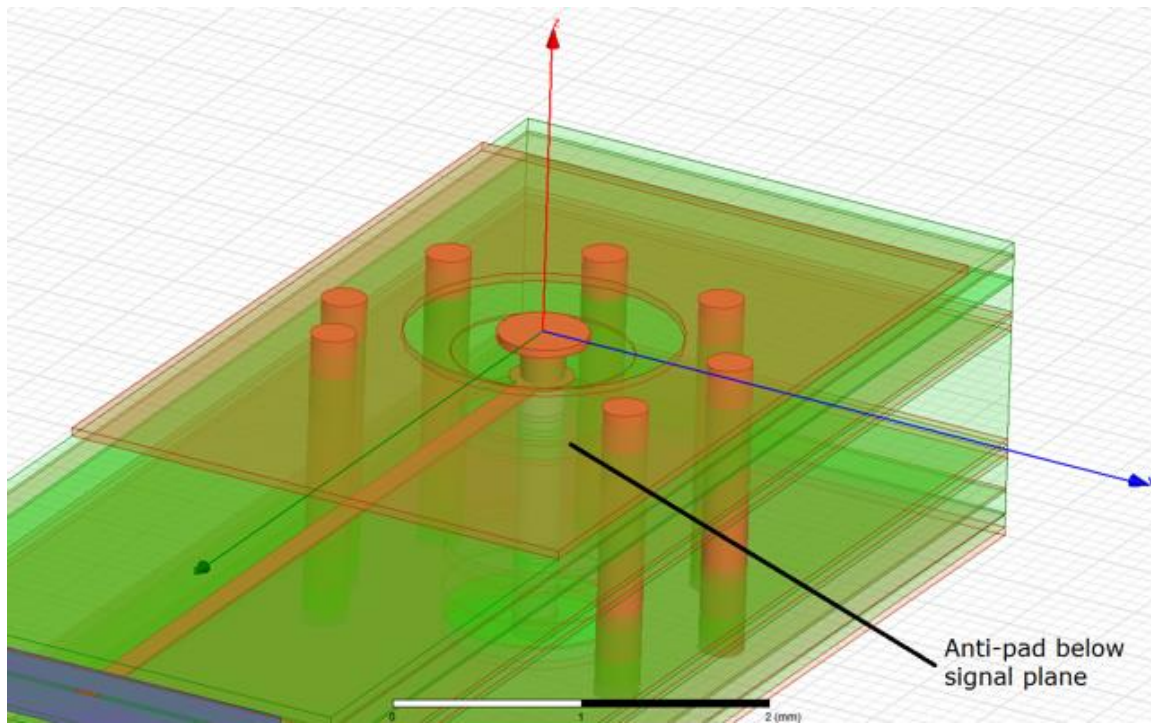


Figure 18: Stripline Model Showing the Through 83 mil Diameter Ground Via Bolt Circle Coax Structure

## OPTIMIZATION REVIEW

After the variable parameters have been quantified, a report is compiled that provides the new connector footprint parameters.

Thru Scattering parameter graphs are provided to quantify the reflected power with the new footprint optimization parameters.

The following simulated S-Parameter graphs are provided:

Return Loss, Insertion Loss, Step Response Time Domain Reflection (TDR)

NOTE: The current footprint for the connector has tolerance limitations for modifications. The Time Domain Reflection graph provides a high resolution image of impedance values with a rise time of 25 ps for a frequency span bandwidth of 40 GHz.

NOTE: The graphs provide a forward and reverse pathway thru the connector (legend indicated by coax and microstrip), (See Figures 19-21).

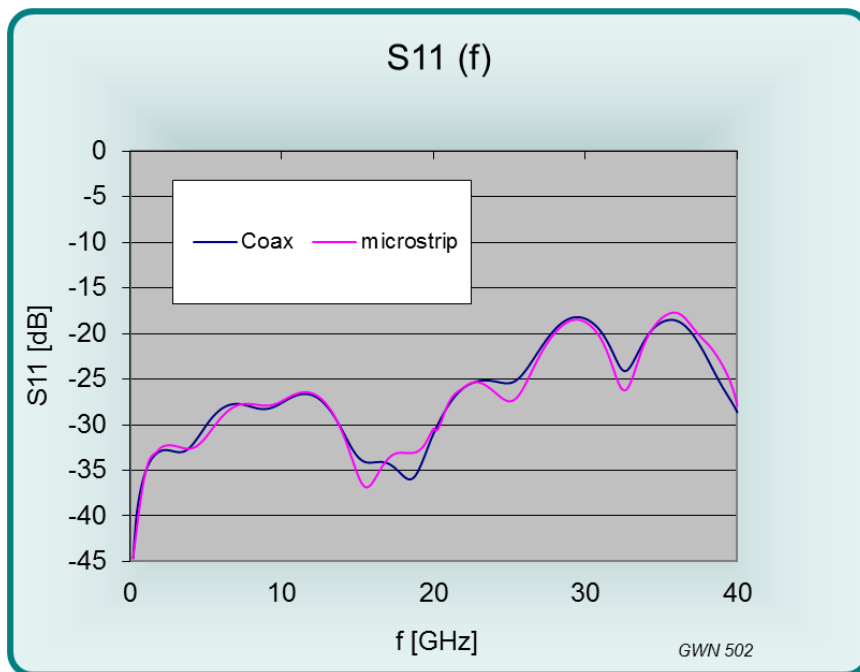


Figure 19: Optimized Return Loss Simulation

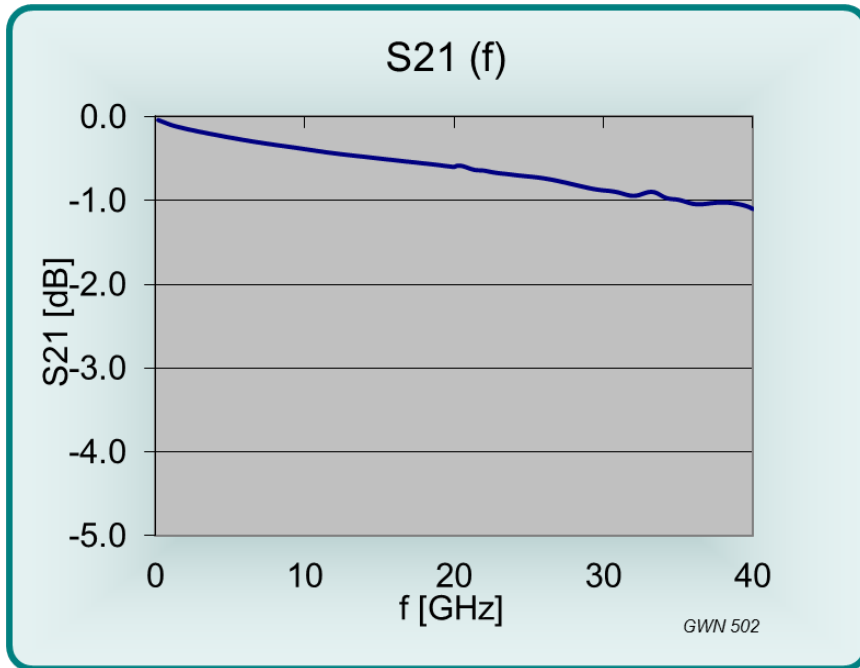


Figure 20: Optimized Insertion Loss Simulation

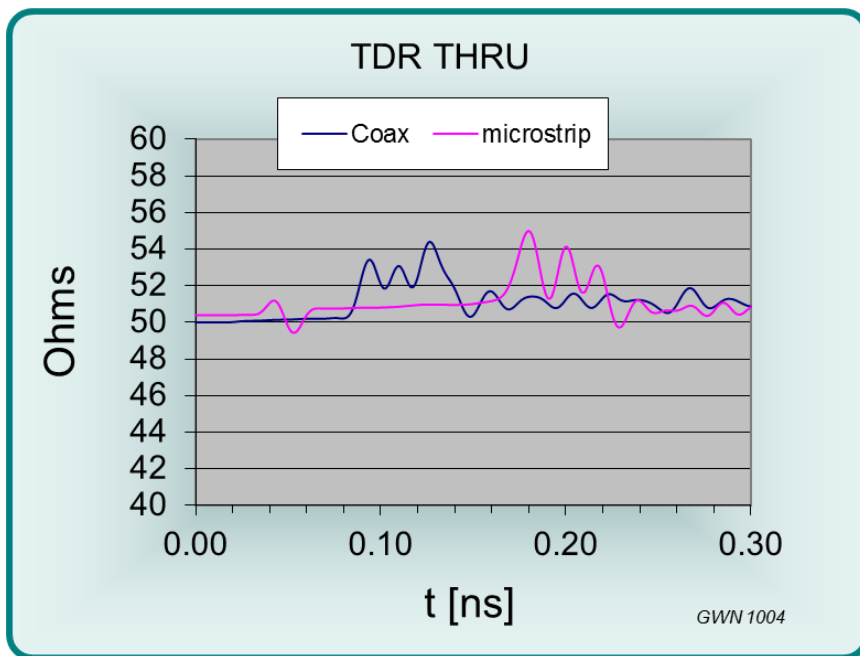


Figure 21: Optimized Time Domain Reflection Simulation (Step Response Rise Time: 10 ps)

## NARROW TRACE TRANSITION UNDER TR ASSEMBLY

Since there is a grounded metal air gap channel under the connector, a capacitive reaction will occur and a narrower inductive trace is required under the connector.

A model of the interface is included in the simulation and the channel height is 4.5 mils.

The HFSS simulation models the narrow trace transition with approximately 0.5 inches of the incident board trace.

## FINAL BOARD REVIEW

After the board optimization parameters have been verified and implemented, a new board file is sent to Ardent Engineering to verify that TR will be compatible with your board.

Procedure Includes:

Verification of Footprint Specification Tolerances with Cadence Board File Viewer

NOTE: The final board review does not contain HFSS model, only simulation results. A model may be attainable. Please consult factory here.

After the board file has been reviewed, specifications or configurations measured out of tolerance are noted and corrections are recommended.

Approval of a board footprint is awarded when specifications are determined within tolerance.

The final board review will also communicate reminders of important parameters to consider.

### IMPORTANT NOTE

Verify Board Integration:

- Filled Contact Vias
- No Soldermask Area under Connector
- No Narrow Trace Width Tapers

## REFERENCE MATERIALS

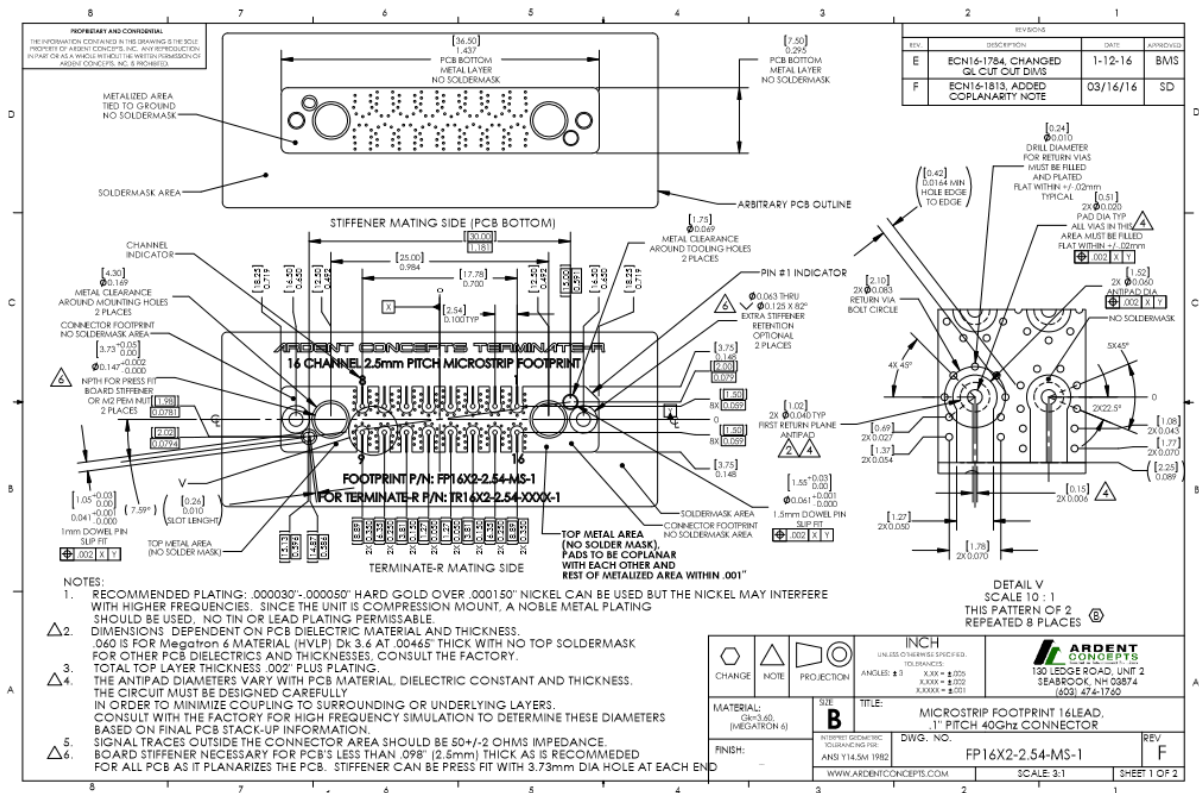
### OPTIMIZATION COMPARISON CHART

The Optimization Chart compares results of optimization simulations and corresponding parameter changes.

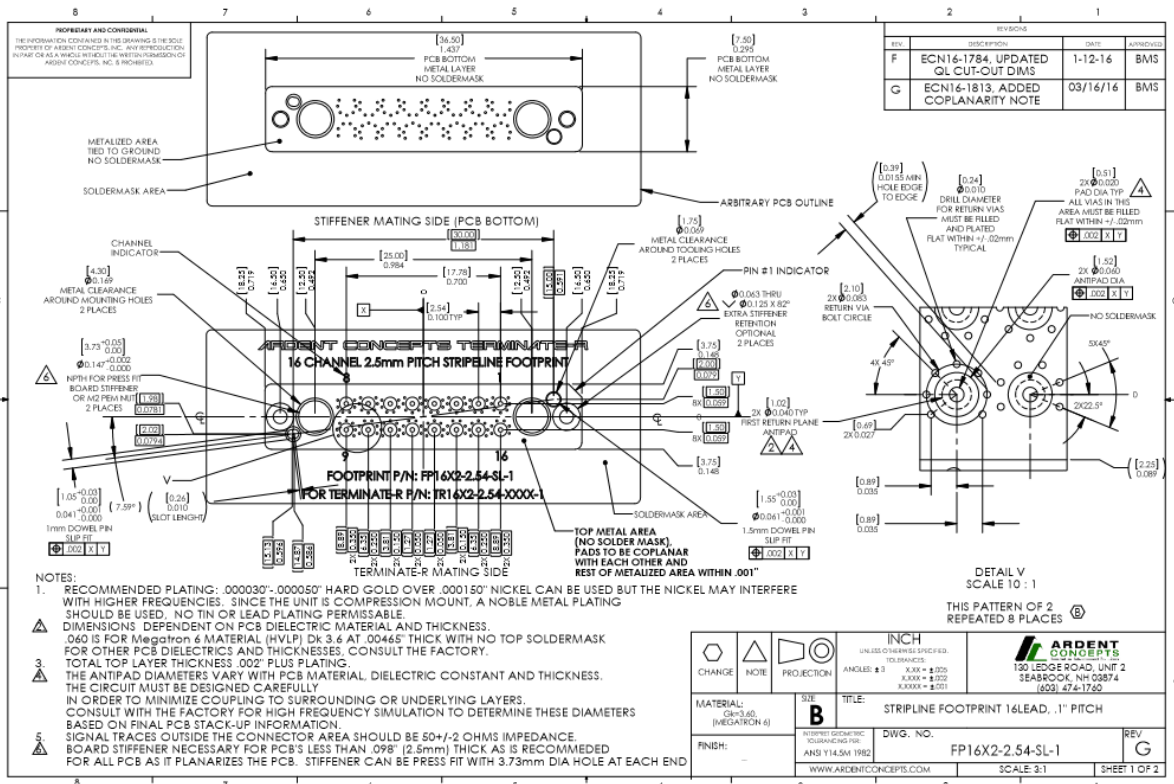
Microstrip Parameter	Example 1 (mils)	Example 2 (mils)	Example 3 (mils)	Example 4 (mils)	Evaluation Board (mils)	Footprint (mils)
Connector Contact Pad Diameter	17.8	17.8	17.8	17.8	17.8	20
Top Trace Width Underneath Connector Body	10.6	9.1	8.5	10.2	10.6	6.0
Gap Width on Top Plane	50	50	50	50	50	50
Anti-pad Diameter on Top Plane	60.3	60.3	60.3	60.3	60.3	60
Anti-pad Diameter in GND Plane Below Trace	55.9	56.7	43.3	51.2	51.2	40.2
Extension of Narrow Trace Outside connector body	0	0	0	0	0	0
Dielectric Thickness	10.0	8.7	5.0	5.5	10.0	4.7
Dielectric Type First Layer	Rogers 4350	Rogers 4003	Rogers 3003	Nelco SI	Rogers 3003 (ENIG)	Megtron 6 (HVLP)
Dielectric Constant	3.48	3.38	3.1	3.4	3.1	3.6

# WEBSITE FOOTPRINTS/BOARD/ALLEGRO FILES

## TR FOOTPRINT



Footprint 1: Microstrip TR16X2-2.54



Footprint 2: Stripline TR16X2-2.54

# ASSEMBLY DRAWINGS

