

## **Wiring Ringing Effects When Interfacing with RI8535B Digital Test Instrument Module and RI74315C Fixture Digital Scan Module (RIK0127A)**

### **or How to Avoid Failure**

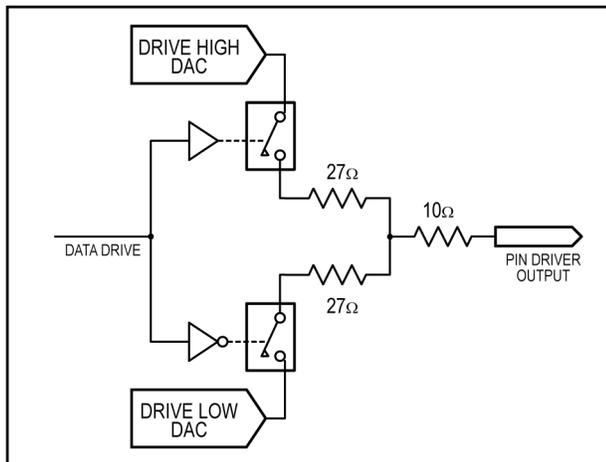
#### **Application Note**

November 12, 2010  
Author: Richard Doporto  
Revision: D

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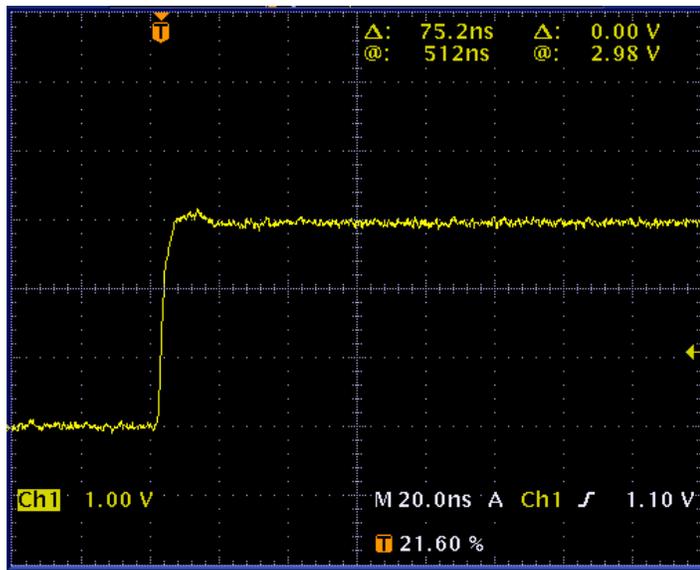
## Overview

This application note explores how various interconnection techniques effect signal quality and hopefully serves to help the user avoid digital disasters when using the RI8535B Digital Test Instrument Module (TIM) and RI74315C Fixture Digital Module (RIK0127A). In this document we will examine various digital signal propagation techniques and how they directly effect the integrity of the signal. Both the RI8535B and RI74315C use the same driver circuitry. This driver is capable of data transmission rates beyond 100MHz and logic high levels settable from any range up to 4.0 volts. A simplified block diagram of the Roos Instrument Pin Driver is shown below in *Figure 1*.



*Figure 1.*

Roos Instrument Pin Driver Simplified Block Diagram.



*Figure 3.*

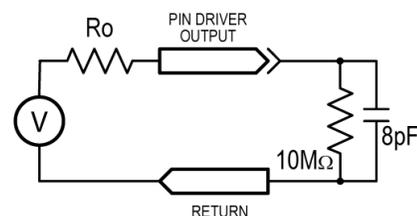
Connection directly at the pin driver output.

## Reflections and Waves

Because of the ever increasing need for speed, the RI pin drivers output rise and fall times are approximately 2nS (10 to 90% with 4V @100%). The progression from ideal pin drive to a real world transmission line with its attendant losses, parasitics, ringing, and reflections can cause the user serious headache if careful attention is not paid in how digital interconnections to a device under test (DUT) are made. In extreme cases of poor connection techniques, excessive overshoot or undershoot can damage protection clamp diodes on device inputs. Even worse, for cases of latch up the device can be destroyed.

## In A Perfect World

Figures 2 and 3 illustrate a direct and ideal connection from the RI8535B Digital TIM pin driver output directly to an oscilloscope with no wiring between.



*Figure 2.*

Simplified diagram of connection at the pin driver output.

In the real world, this type of connection is simply not possible because of fixturing, DIB and DUT configurations, and the ever increasing mixed signal interface connections to a device under test.

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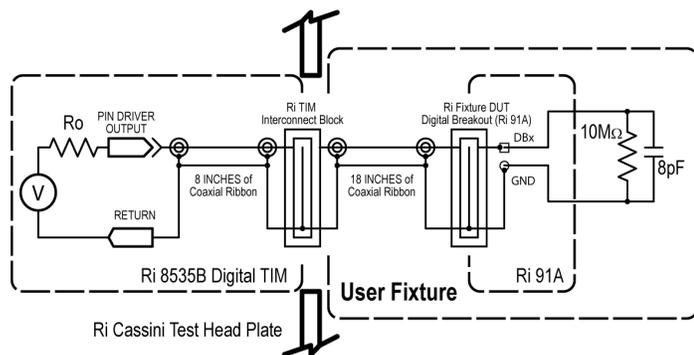
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## In The Real World

Because devices to be tested typically sit in sockets fed by robotic handlers, and these sockets sit on DUT boards within fixtures several inches to several feet from the instruments providing stimulus and measurement, a reliable method of transporting high speed digital signals is needed to insure signal integrity and error free operation. A single RI8535B Digital TIM provides the ability to interconnect up to 120 pins of digital control in a 1.4 inch square fixture interface block. This block mates to the fixture and allows the user to directly connect to a DUT board or breakout individual digital lines by connecting to an RIK0091A Digital Breakout Module. (RI 91A)



## Keep It Short

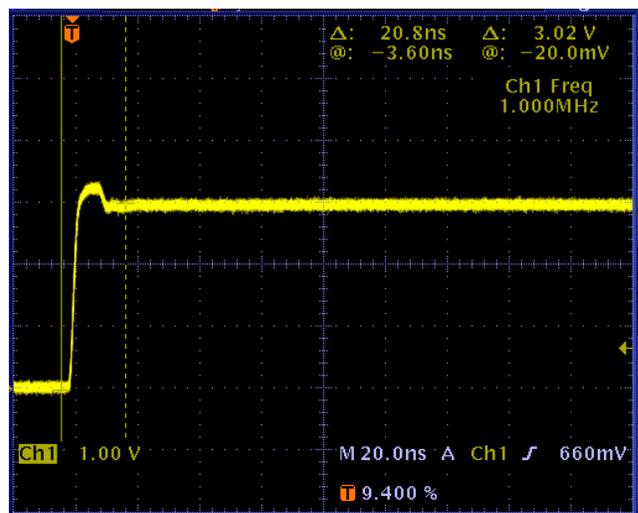
**Figure 4** illustrates a recommended connection configuration with the ability to break out individual digital lines within the fixture for connections to the DIB or DUT board. Additionally, the user can forgo the use of the RI 91A Digital Breakout Module and connect the coaxial ribbon cable directly to the DUT board or through an RI Digital Interface Block and then onto the DUT board.

**Figure 4.**

Simplified diagram of coaxial ribbon connection to RI 91A Digital Breakout Module within DUT Fixture.

## Keep It Fast

**Figure 5** shows the rising edge of a test waveform at the DB pin on the RI 91A Digital Breakout Module connected to an oscilloscope. The signal shows no ringing or overshoot. The reflection impulse after the initial 2nS rising edge is caused by the 26 inches of coaxial ribbon cable being unterminated. If one was to connect short wires from the DB pins of the RI 91A to a DUT this would function very well up to 100Mhz.



**Figure 5.**

Waveform at the RI 91A Digital Breakout Module DB pins.

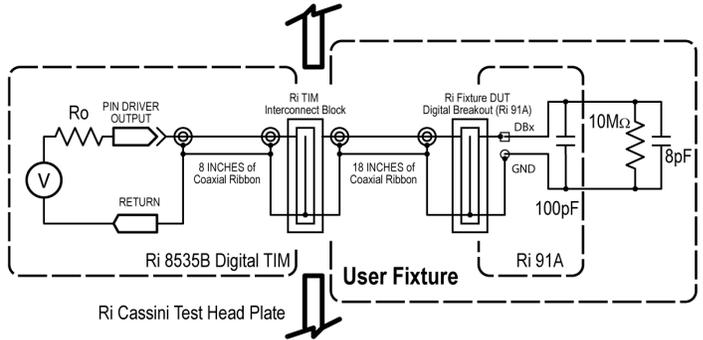
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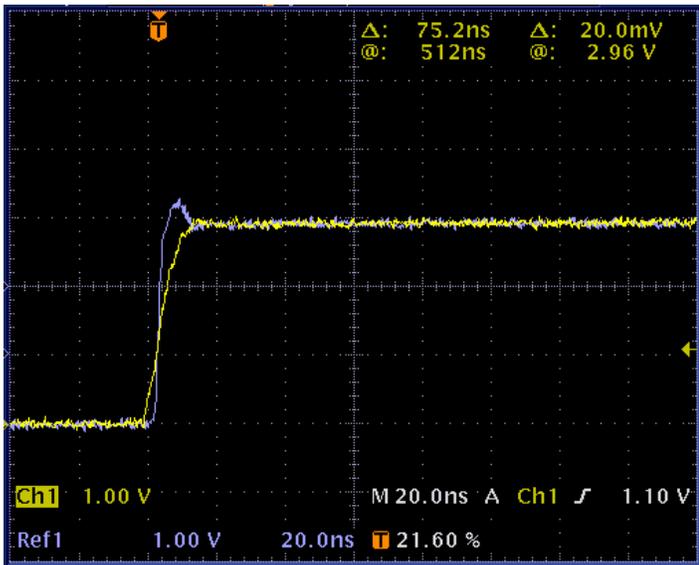
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## Aesthetics

Figures 4 and 5 presented an example of the RI8535B Digital TIM's pin drivers high speed performance and stability when driving 26 inches of coaxial ribbon into what is in effect a high impedance. If the aesthetics of an impulse reflection bothers the user, or the device to be tested, it is not unreasonable to add additional capacitance or a small series resistance at the end of the transmission line to remove edge reflections. **Figure 7** shows the effect of an additional 100pF.



**Figure 6.**  
Additional 100pF at the RI 91A Digital Breakout Module DB pins.



**Figure 7.**  
Additional 100pF at the RI 91A Digital Breakout Module DB pin (Yellow Trace)

## Compromise

The yellow trace shown in Figure 7 shows the reflection completely absorbed and no ringing on the line. The rise and fall times in this test case will increase from 2nS to 5nS. This is not an unreasonable compromise and should still allow operation approaching 100Mhz. The blue trace is the test case from Figures 4 and 5 shown for comparison. Users device types change from application to application and thus different device types will present different impedance's and parasitic capacitance looking back at the pin driver. The selection of series resistance and capacitance needs to be selected and confirmed to prevent transmission errors on a pin to pin basis. The confirmation of signal integrity is especially important for clock and reset signals as ringing or glitches caused by poor signal quality during test could cause the DUT to enter or exit a mode the user did not intend during test. This would result in a failed device when the device otherwise would of tested good.

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## Real World Failure

Figures 8 and 9 illustrate the least preferred method of interconnection to a DUT. 3 feet of 26AWG hook up wire.

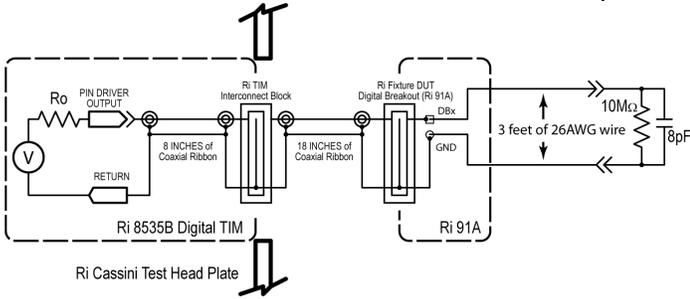


Figure 8.

As can be seen in Figure 9, this type of connection will produce large over/undershoot and ringing. If one was to move data at higher speeds the DUT input logic would most likely mis-trigger or glitch because of the ringing impulse. This would present itself as random failures due to data errors.

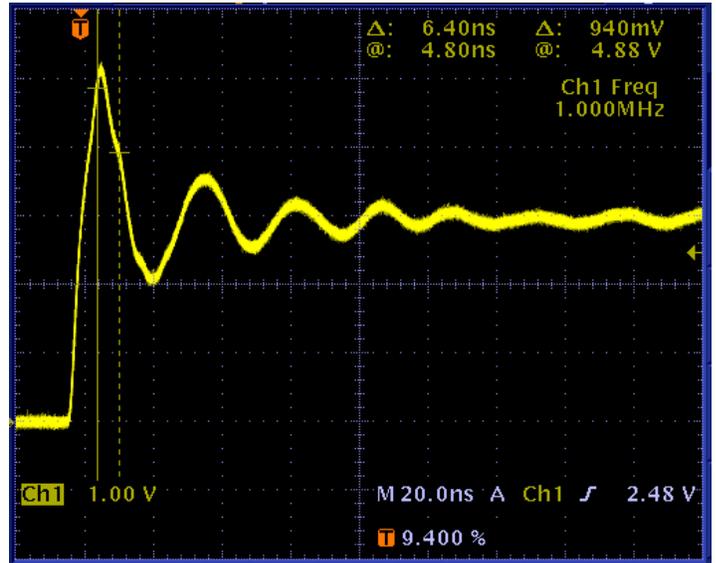


Figure 9.

Excess ringing and overshoot (and undershoot not shown.)

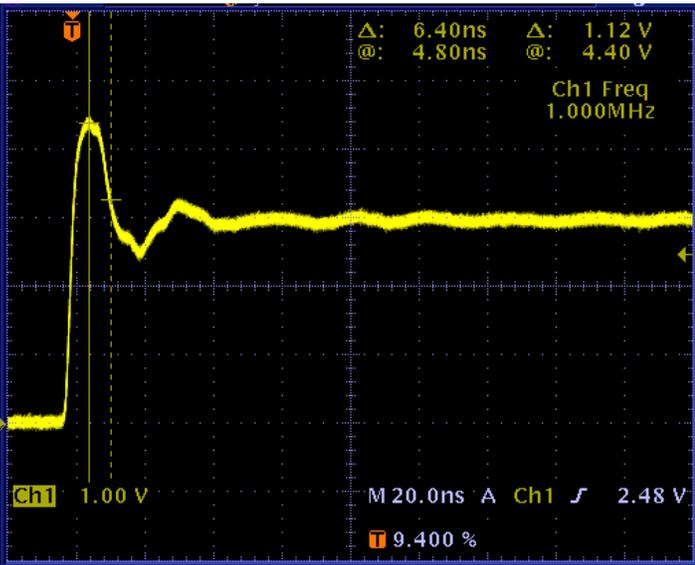


Figure 10.

Ringing is reduced but overshoot (and undershoot not shown) is still a concern.

## Twister Failure

Figures 10 and 11 illustrate the effect of twisting the drive and return line into a twisted pair interconnection to a DUT. The same 3 feet of 26AWG hook up wire as used in Figure 4, but now as a tightly wound twisted pair.

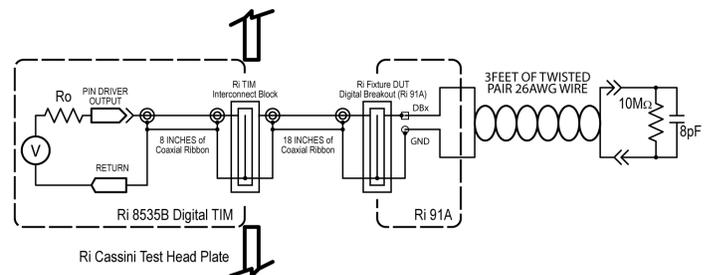


Figure 11.

This technique will reduce the line ringing but over/undershoot is still several volts.

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## Twister With A Cap

Using the same setup from Figure 10 and 11, the user can dampen the over/undershoot and ringing by adding additional capacitance at the end of the line at the DUT. In this example a 270pF capacitor is added at the end of the twisted pair.

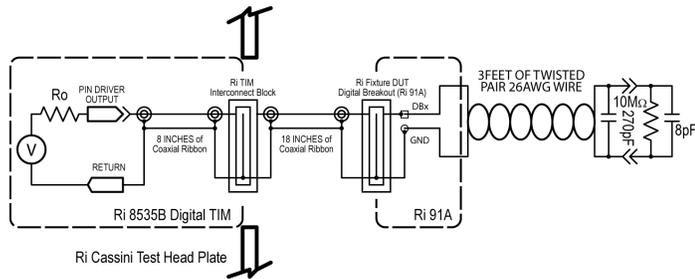


Figure 12.

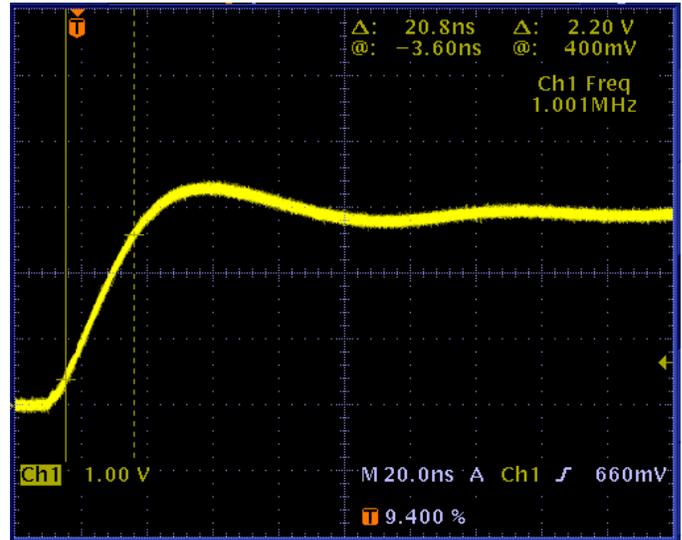


Figure 13.

Large added capacitance to the end of the line at the DUT.

The disadvantage of this technique is that it reduces the data transfer speed. Note that the rise/fall time is now 25nS+.

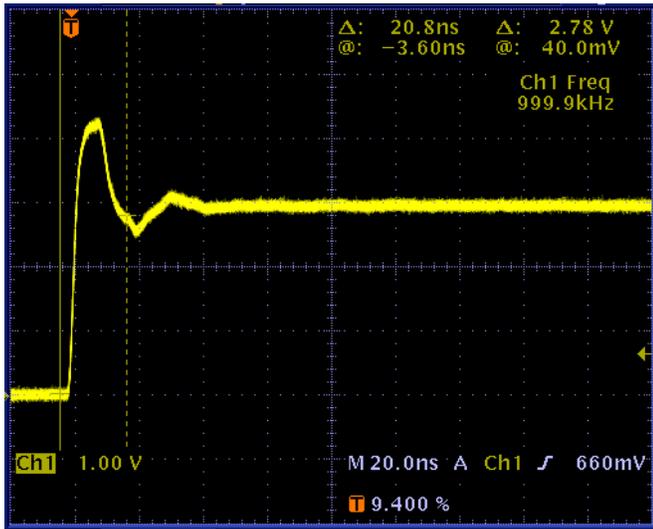


Figure 14.

Signal at the end of 3 feet of ribbon cable.

## Ribbon Cable Failure

This setup shows the effects of a 3 foot long ribbon cable (Figure 10). The signal line has 2 ground returns on either side.

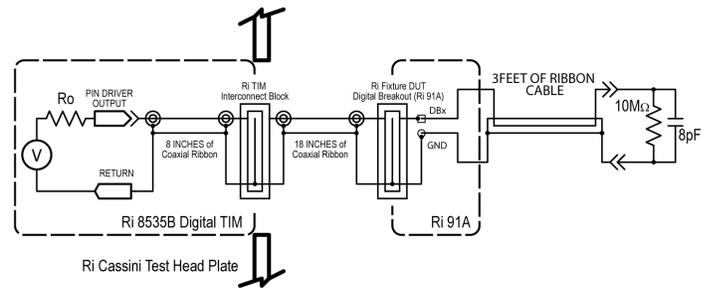


Figure 15.

3 feet of ribbon cable.

This connection performs marginally better than twisted pair but still suffers from over/undershoot.

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## Coaxial Cable

This setup shows the effects of a 3 foot long RG178 coaxial cable. (Figure 17). It is the most ideal connection to the DUT because it does not ring and closely replicates the direct connection from Figures 5 and 6.

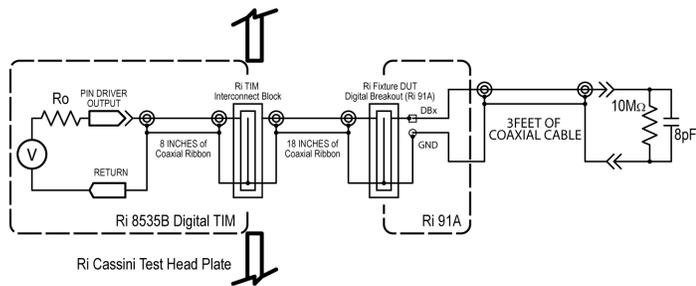


Figure 16. Coaxial connection.

As can be seen in Figure 17, over/undershoot and line ringing is eliminated. The 2 small steps are reflections due to no line termination. The user could easily add a small series resistance and small capacitance to the return and eliminate this reflection as well.

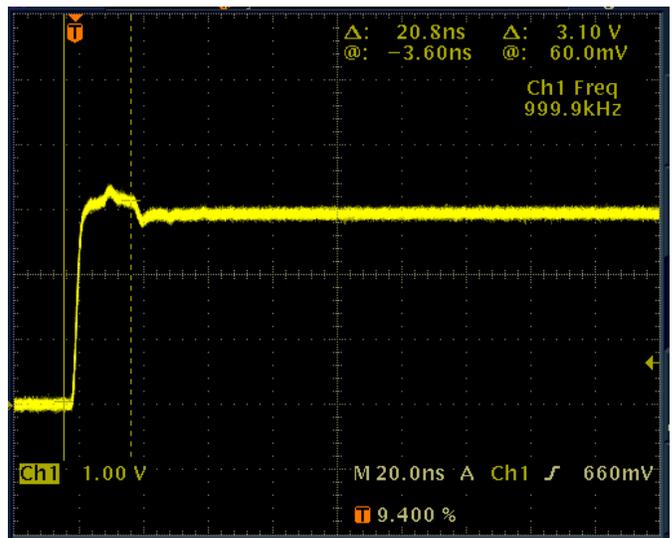


Figure 17.

Near ideal signal at the end of 3 feet of RG178 coaxial cable.

## Every user's connection needs are different

Many 100's of papers have been written over the years describing the effects of transmission lines and signal integrity regarding high speed transfer of data to receiving devices. For most practical purposes, where fast rise and fall time digital signals are concerned, the characteristic impedance of the transmission line actually behaves as a pure resistance. (See Figure 18.)

$$R = \sqrt{\frac{L}{C}}$$

Figure 18.

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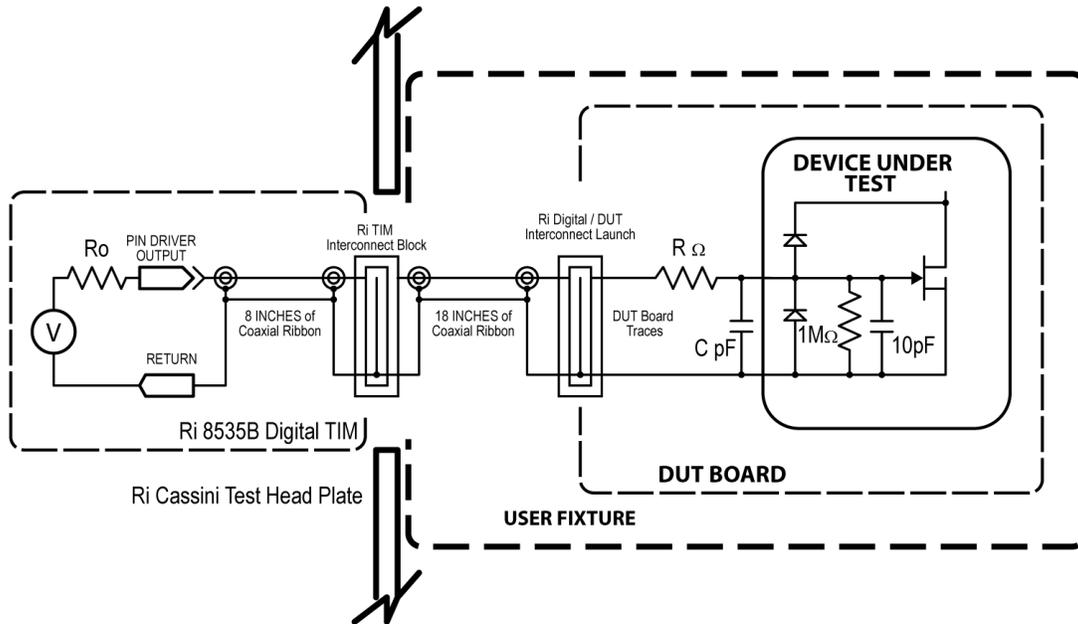
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## High Speed Digital Connections

If the connection to the device requires the highest speed then signal integrity becomes an important concern. With the addition of a series resistor and capacitor to ground the user can optimize the waveform step function for maximum error free throughput. The series  $R\Omega$  in Figure 19 is typically less than 100 ohms and depending on the DUT a small capacitor ( $C\text{ pF} < 100\text{pF}$ ) may or may not be needed.



*Figure 19.*

A typical highest speed application.

## Conclusion

Digital interconnection techniques that are not somewhat impedance matched will degrade the integrity of the signal. Making connections using several connection mediums will cause additional reflections. Making the interconnection several feet long will prevent one from running at the highest speeds. Not having a direct return path (ground) parallel with the transmission signal is a recipe for disaster.

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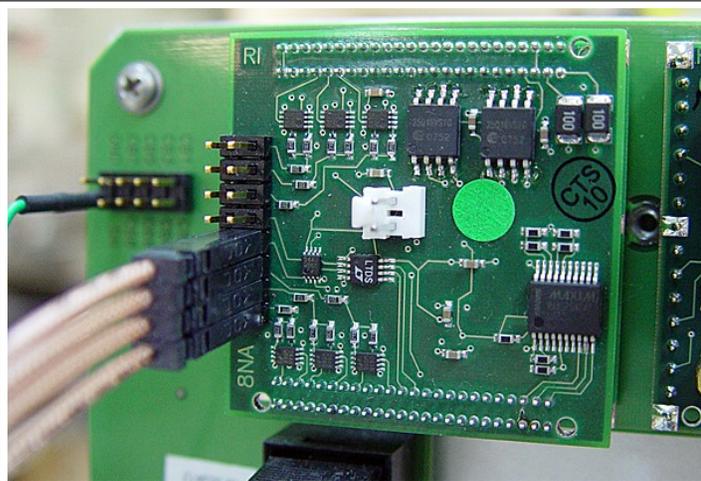
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## Digital Fixture Interface Needs

Roos Instrument's provides its customers a complete digital interface solution. Below is an abbreviated list of Instrument to Device Under Test components to assist in your applications success.

- ◆ [RI8535A/B/C](#) 40/80/120 Pin Digital Test Instrument Module
- ◆ [RIK0017A](#) High Speed Serial Fixture Digital Module Kit
- ◆ [RIK0127A](#) Fixture Digital Module RI74315C
- ◆ [RIK0137A](#) Matrix Fixture Insert Digital Pogo Block 20 pins
- ◆ [RIK0141A](#) Digital TIM Block 80pins
- ◆ [RIK0142A](#) Digital TIM Block 120pins
- ◆ [RIK0146A](#) Digital TIM Block 40pins
- ◆ [RIK0147A](#) Digital Breakout Module 20pins
- ◆ [RIK0148A](#) 1x2 Coax Cable Assy 16" RG178 (Set of 5)



### Digital Fixture Scan Module Interface

RIK0127A Fixture Digital Scan Module. Provides the user with 8 - 80MHz digital I/O from within the fixture. Shown here with 4 I/O driving coax connected directly to DUT board.



### Digital Breakout Module

Y00091A1 provides the ability to breakout signals from the RI8535B Digital Test Instrument on an individual pin for pin basis. Shown here connected to 5 individual coax.

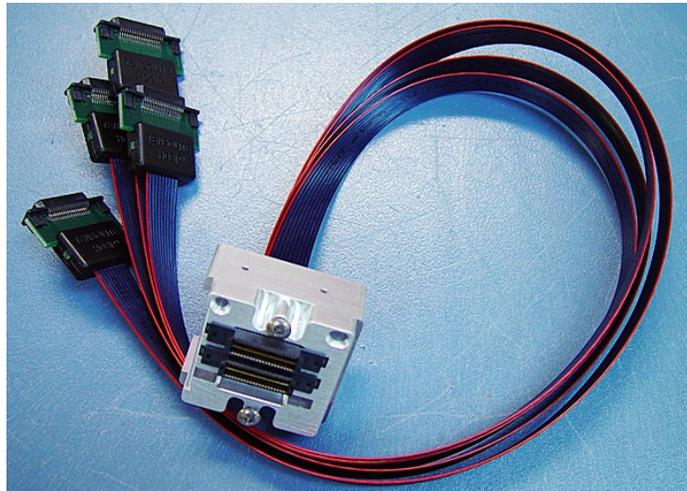
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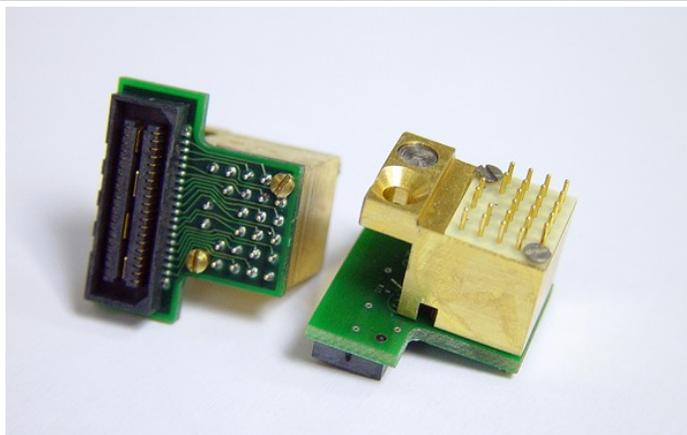
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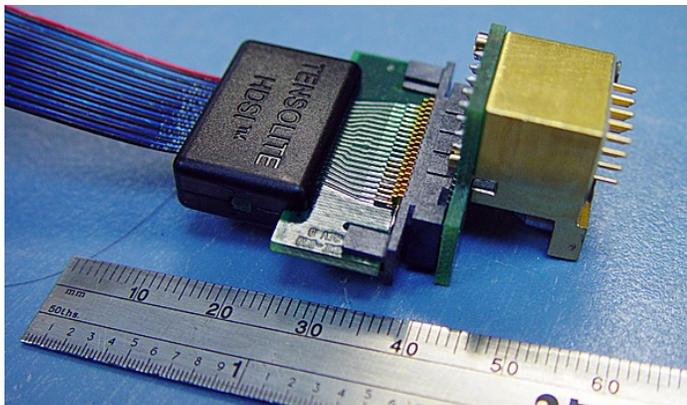
## Impedance Controlled High Speed Connections

RIK0141A Digital TIM Block – 40, 80 or 120 pins. Allows fixture to mate directly to the RI8535B Digital TIM. 20 pin digital I/O pigtailed provides flexibility in locating launch locations on the DUT board when using the RIK0137A Digital Pogo Block.



## Impedance Controlled Pogo DUT Launch

RIK0137A 20Pin Digital Pogo Block.



## Impedance Controlled Pogo DUT Launch

RIK0137A 20Pin Digital Pogo Block mated with the RIK0141A Digital TIM Block. The pogo block allows the user to remove the DUT board from the fixture without the need to remove connectors from sockets. The pogo connection uses less than 0.5 square inches of DUT board area.

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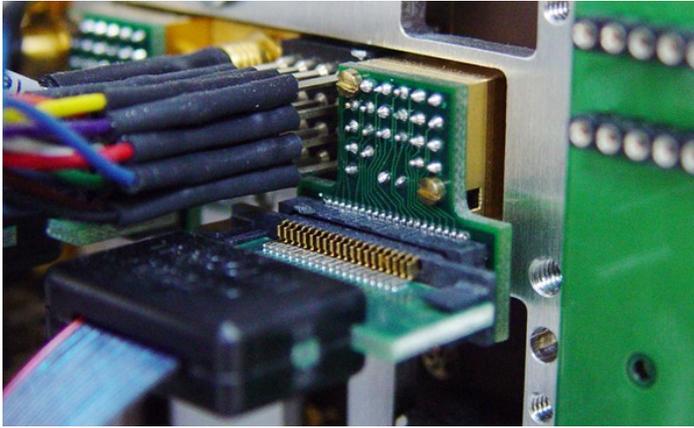
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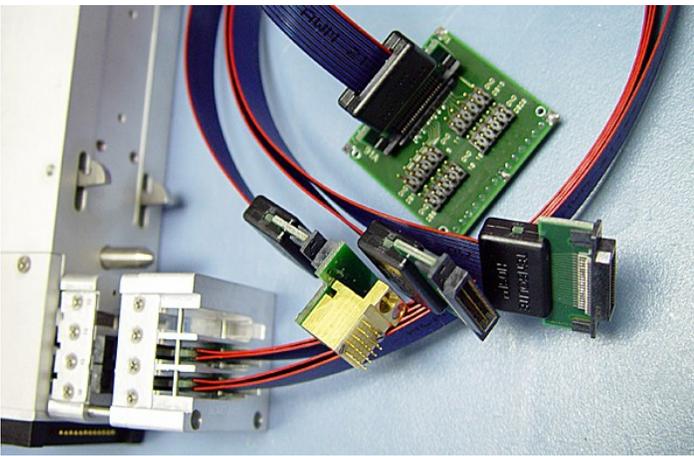
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## **Pogo DUT Launch**

RIK0137A 20Pin Digital Pogo Block mated with the RIK0141A Digital TIM Block installed in a typical quad site fixture.



## **Everything One Needs To Not Fail**

All the high speed digital accessories one needs to connect the RI8535B Digital Test Instrument Modules 120 digital pins to a DUT board quickly and without failure the first time.

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