

# **MIL-STD-1553 Bus Connections for Test Configurations**

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## 1 INTRODUCTION

There are several important factors to consider when configuring a test bus for the development and testing of MIL-STD-1553 systems. It is possible to use either fully compliant MIL-STD-1553 buses or alternatively a "simulated bus" can be developed as a resistor network. It is important to properly terminate the test bus regardless of which configuration is used. Proper termination is necessary to minimize transmission line reflections, overshoots, ringing, and oscillations that can result in data errors. This application note provides methods to minimize data errors and avoid violating any 1553 component specifications.

## 2 PROPER BUS TERMINATION

In order to prevent data errors or possible over-voltages, it is advisable that all test setups and embedded environments ensure proper terminations are used on the MIL-STD-1553 buses. It is important that proper bus terminations be used in both development and test environments as well as on deployable platforms.

Unless the 1553 transmitters within the test equipment are very low impedance voltage sources, they will provide higher voltages to un-terminated buses than to properly terminated buses. Moreover, operation on un-terminated 1553 buses can result in transmission line reflections, leading to overshoots, oscillations, and ringing. The use of properly terminated buses will prevent these anomalies, thus eliminating the possibility of over-voltages or data errors due to improper bus configuration.

Figures 2 through 9 show various configurations that may be used including both fully compliant MIL-STD-1553 buses, along with resistive "simulated bus" networks. These include the various combinations of transformer and direct coupling for the 1553 interface components and the test equipment.

For the simulated bus resistor networks shown, the load impedance on both the 1553 interface components' and the test equipment's transmitters will be the same as if they were driving a fully compliant 1553 bus. These impedances will be approximately 78 ohms for transformer-coupled connections and approximately 39 ohms for direct coupled connections.

The simulated bus networks will deliver approximately the same stub voltages that will be received on a compliant 1553 bus, assuming a short bus with relatively low cable attenuation. That is, about 7 volts peak-to-peak to the stubs for direct coupled receiving terminals, and about 5 volts peak-to-peak to the stubs for transformer-coupled receiving terminals.

Holt's recommendation is to use the configuration shown in Figures 1 and 2. This diagram shows a fully compliant MIL-STD-1553 bus with bus couplers. Transformer coupling is used for both the 1553 interface component and the test equipment. Transformer coupling provides the following advantages over direct coupling and the simulated bus configurations:

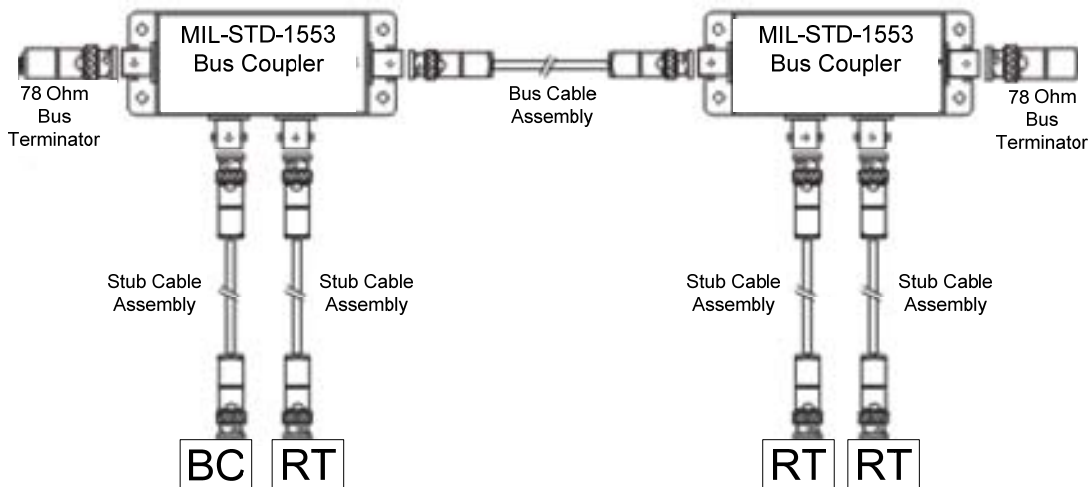
1. The coupling transformer's 1.4:1.0 turns ratio doubles the impedance of the 1553 interface component's or test equipment's stub presented to the 1553 bus. This reduces the peak voltages resulting from transmission line reflections (and therefore data errors) and allows the use of longer stub

lengths.

2. Transformer coupling provides a matched impedance (70 to 85 ohms) to the 1553 interface component's and test equipment's transmitters, further reducing reflections.
3. The resistors in the bus couplers, in conjunction with the capacitance of the coupling and isolation transformers, stub cables, and transceivers, provide filtering and attenuation of any reflections that occur.
4. The use of transformer coupling provides a reduction in any common mode noise from the main bus.

When connecting to a compliant MIL-STD-1553 bus, the recommendations for maximum stub lengths in MIL-STD-1553B should be met. The maximum stub length for direct coupled terminals is 1ft. The maximum stub length for transformer coupled terminals is 20 ft.

If one of the simulated bus configurations is used, then the cable lengths between the "simulated bus" resistor(s) and the 1553 interface component, and the "simulated bus" resistor(s) and the test equipment should also be minimized.



**Figure 1 - Typical MIL-STD-1553 Bus with Transformer Coupled Stubs**

## MIL-STD-1553 Bus

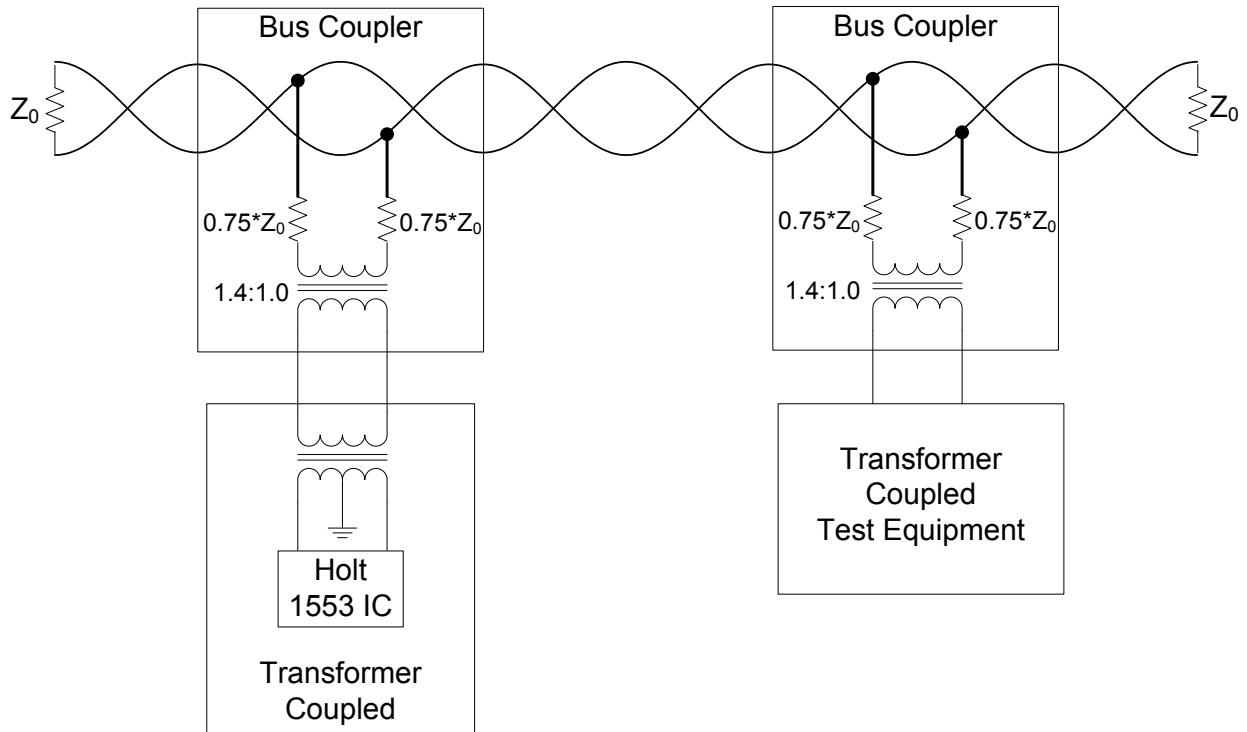


Figure 2 - Transformer-Coupled 1553 interface component and transformer-coupled test equipment using a fully compliant MIL-STD-1553 bus and bus couplers.

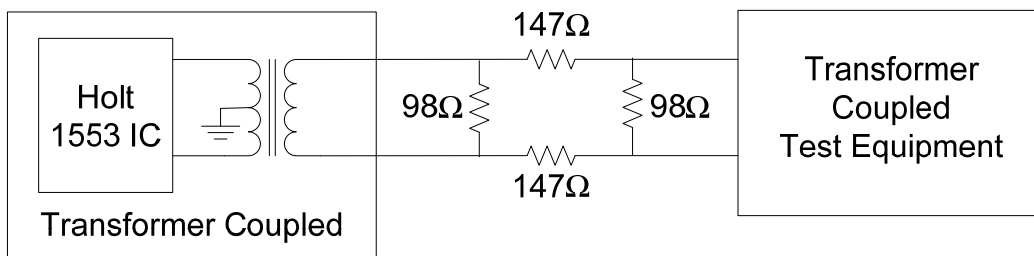
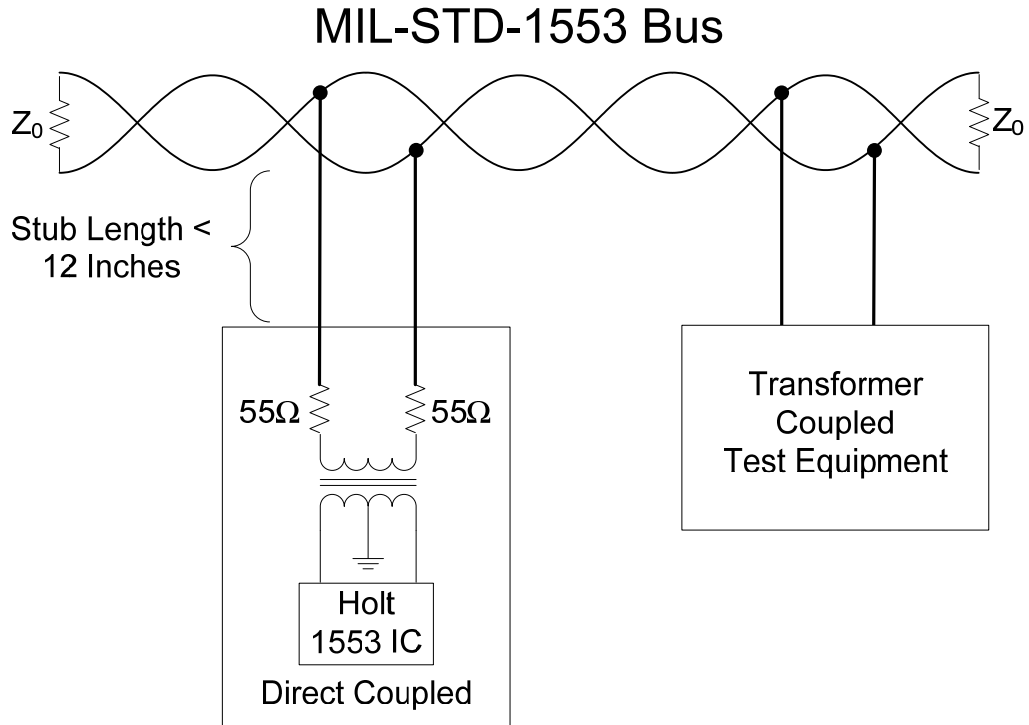
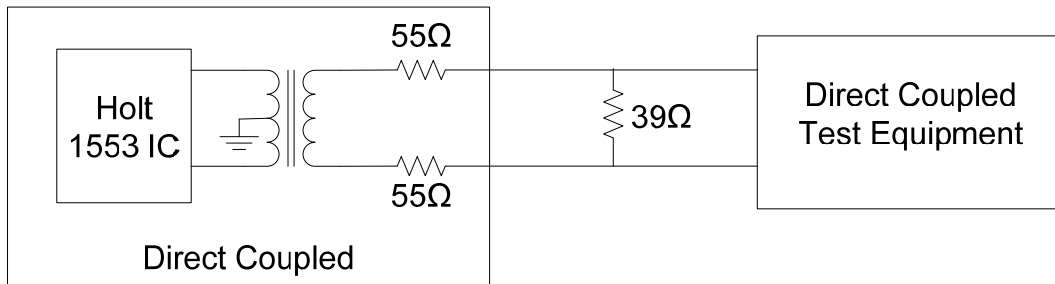


Figure 3 - Transformer-Coupled 1553 interface component and transformer-coupled test equipment using a resistive simulated bus configuration.



**Figure 4 - Direct Coupled 1553 Interface Component and direct coupled test equipment using a fully compliant MIL-STD-1553 bus.**



**Figure 5 - Direct Coupled 1553 Interface component and direct coupled test equipment using a resistive simulated bus configuration.**

## MIL-STD-1553 Bus

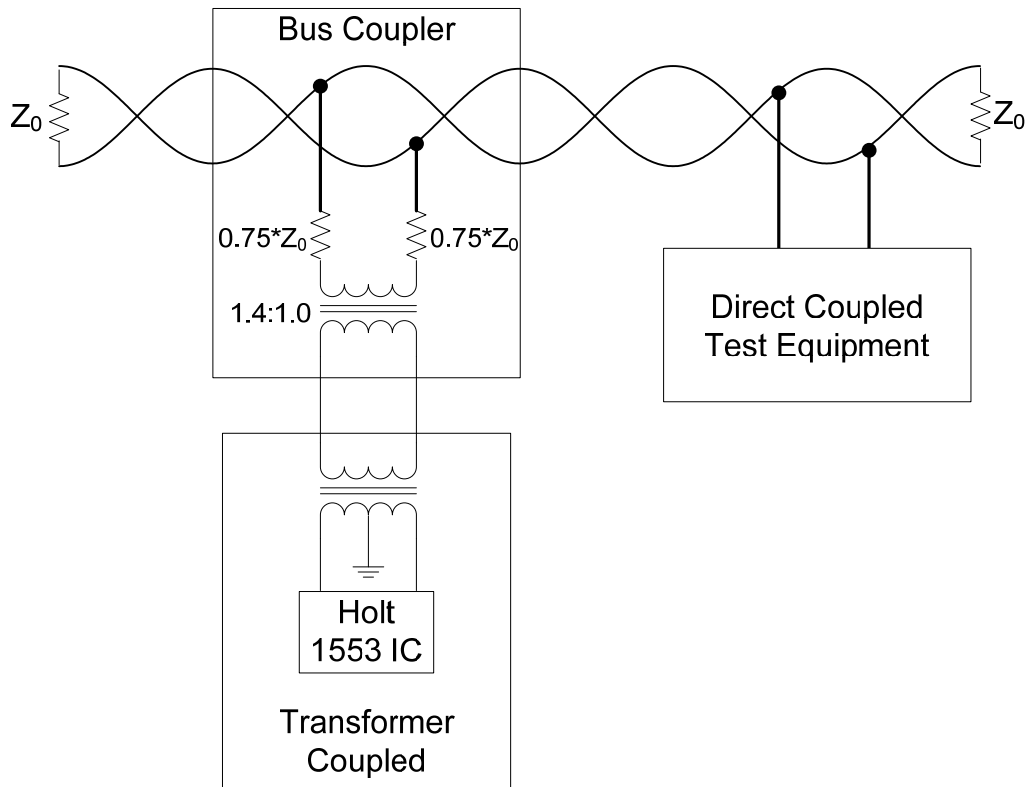


Figure 6 - Transformer coupled 1553 interface component and direct coupled test equipment using a fully compliant MIL-STD-1553 bus with bus coupler.

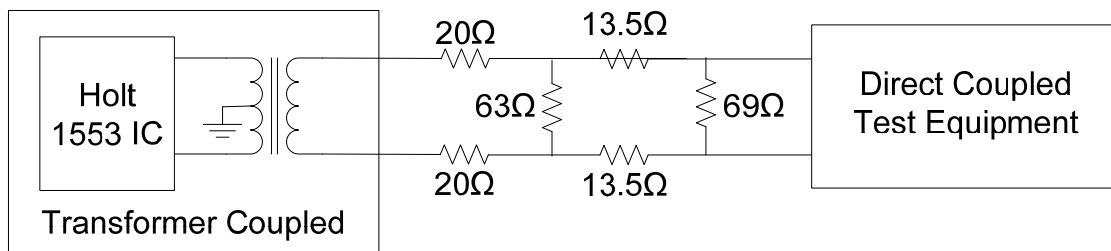
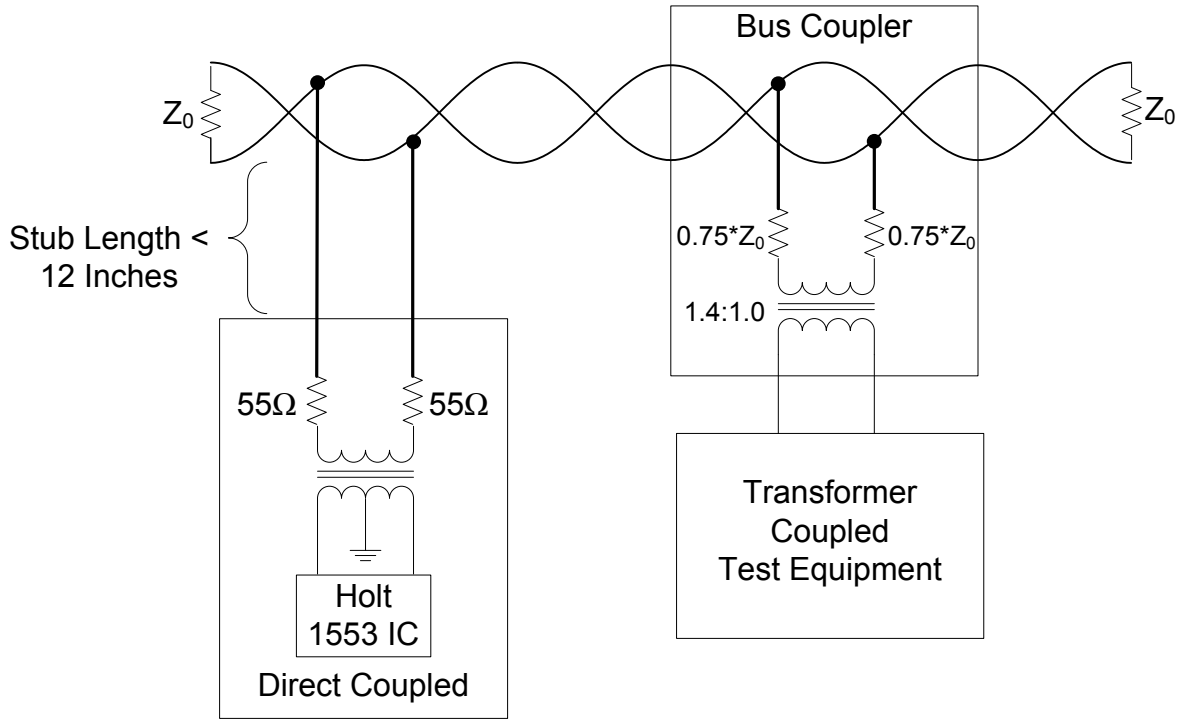
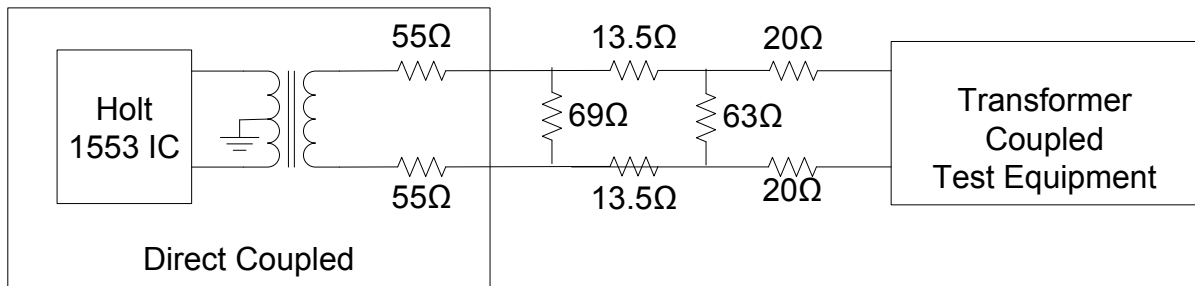


Figure 7 - Transformer coupled 1553 interface component and direct coupled test equipment using a resistive simulated bus configuration.

# MIL-STD-1553 Bus



**Figure 8 - Direct coupled 1553 interface component and transformer coupled test equipment using a fully compliant MIL-STD-1553 bus.**

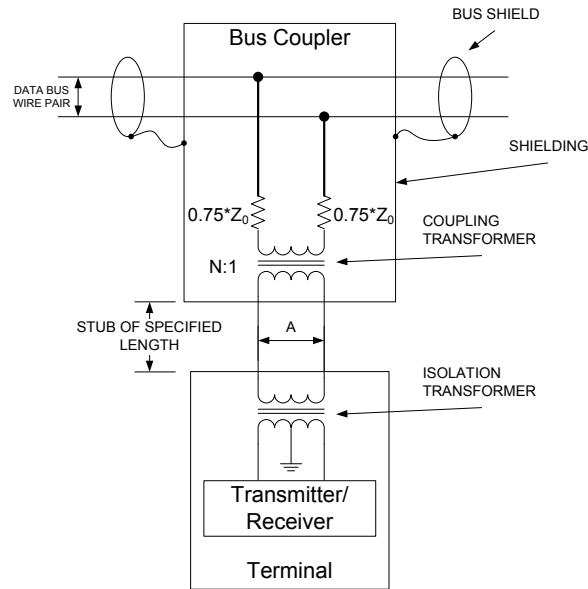


**Figure 9 - Direct coupled 1553 interface component and transformer coupled test equipment using a resistive simulated bus configuration.**

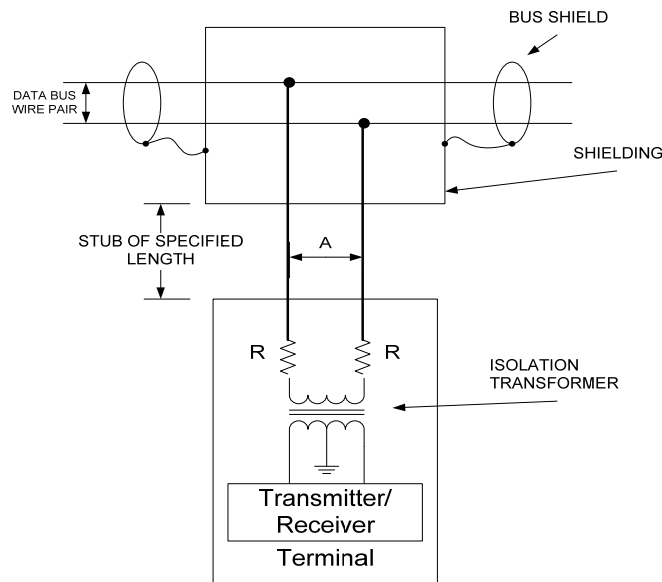


### 3 MIL-STD-1553 TEST CIRCUITS

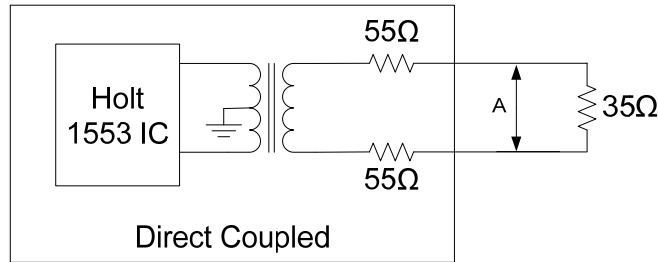
MIL-STD-1553B and the RT Validation Test Plan define the test circuits to be used for measuring various terminal characteristics. Figures 10 and 11 below show the data bus connections as defined in MIL-STD-1553. The coupling transformer shown in Figure 10 is required and the transformer shall have a turns ratio of  $1:1.41 \pm 3.0\%$  with the higher turns on the isolation resistor side of the stub. The series isolation resistors in Figure 11 shall have a value of  $55.0\Omega \pm 2.0\%$ .



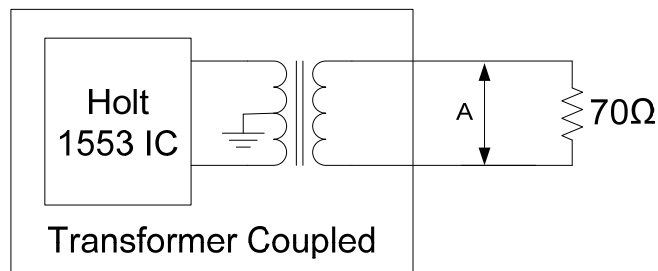
**Figure 10 - Data Bus Interface Using Transformer Coupling IAW MIL-STD-1553B**



**Figure 11 - Data Bus Interface Using Direct Coupling IAW MIL-STD-1553**



**Figure 12 - Direct coupled 1553 interface component test circuit used for RT validation and MIL-STD-1553 electrical validation tests.**



**Figure 13 - Transformer coupled 1553 Interface component test circuit used for RT validation and MIL-STD-1553 electrical validation tests.**

### 3.1 Databus Transmission Methods

The following parameters are measured at point A in Figure 10 or Figure 11:

1. BC Inter-message Gap Time
2. RT Response Time
3. Minimum no-response time-out

### 3.2 Cable Stub Measurements

Every data bus shall be designed such that all stubs at point A of Figure 10 shall have a peak-to-peak amplitude, line-to-line within the range of 1.0 and 14.0 V for a transmission by any terminal on the bus. Similarly, every data bus shall be designed such that all stubs at point A of Figure 11 shall have a peak-to-peak amplitude, line-to-line within the range of 1.4 and 20.0 V for a transmission by any terminal on the bus.

### 3.3 Terminal Input Characteristics

The following parameters are measured at point A in Figure 10 or 11 for transformer or direct coupled connections respectively:

1. Input Waveform Compatibility
  - a. Zero Crossing Deviation
  - b. Receive Threshold
2. Common mode rejections
3. Input impedance
4. Noise Rejections

### **3.4 Terminal Output Characteristic Measurements:**

Direct coupled terminals are to be measured at point A in the test circuit shown in Figure 12. The following measurements are taken with  $35\ \text{Ohm} \pm 2.0\%$  resistive load:

1. Output Voltage Amplitude
2. Output Waveform
  - a. Zero Crossing Deviation
  - b. Rise/Fall Times
  - c. Distortion (Overshoot/Ringing)
3. Output Noise
4. Output Symmetry

Similarly, for transformer coupled terminals, the terminal I/O characteristics are to be measured using a test circuit as shown in Figure 13 with a  $70\ \text{Ohm} \pm 2.0\%$  resistive load.

### **3.5 Other Measurements**

#### **3.5.1 Power on/off noise**

A terminal shall limit any spurious output during a power-up or power-down sequence. The maximum allowable output noise amplitude shall be  $\pm 250\ \text{mV}$  peak, line-to-line for transformer coupled stubs and  $\pm 90\ \text{mV}$  peak, line-to-line for direct coupled stubs, measured at point A of Figures 12 or 13.

#### **3.5.2 Electrical Isolation**

All terminals shall have a minimum of 45 dB isolation between data buses. Isolation here means the ratio in dB between the output voltage on the active data bus and the output voltage on the inactive data bus. Each data bus shall be alternately activated with all measurements being taken at point A on Figure 12 or 13 for each data bus.

## 4 ADDITIONAL RESOURCES

- Holt Evaluation Kits are available for most devices that include complete and easy to use demonstration software, documentation, schematics, and Bills of Materials. Versions are available with low level sample software and API level software.
- HI-6130 / HI-6131 / HI-6132 MIL-STD-1553 / MIL-STD-1760 3.3V BC / MT / RT Multi-Terminal Device Datasheet
- MAMBA™: HI-6135 3.3V MIL-STD-1553 / MIL-STD-1760 Compact Remote Terminal with SPI Host Interface Datasheet
- MIL-STD-1553B Notice 4
- MIL-HDBK-1553A
- SAE AS4111 - Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals

## 5 Revision History

Revision	Date	Description of Change
AN-551, Rev. New	04/20/16	Initial Release