DRAFT

White Paper

Test Methodology for DVI Twisted Pair Characterization

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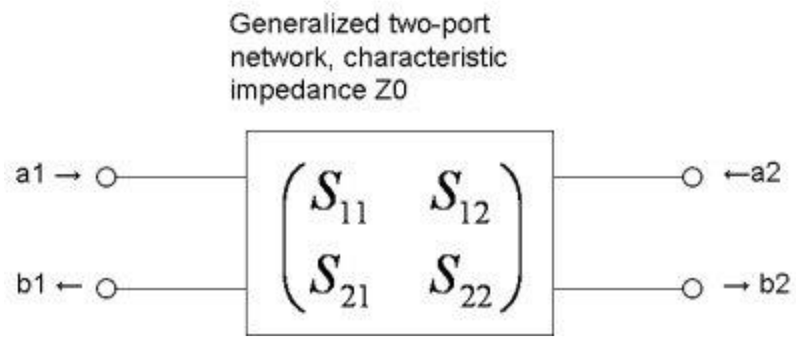
February 2014

Introduction – This white paper describes a modern test approach to defining the complete electrical characteristics of a DVI Cable as found in certain aircraft avionics and sensor systems. These systems are found in multiple AF platforms; i.e. B1, C17, C130H. All information and concepts described herein are considered proprietary to Dragoon ITCN.

Requirement- DVI Twisted Pair cables play an important part in the realization of modern airborne sysyems. In addition to avionics, sensors increasingly employ 2 to 3 channels of flat panel displays that require DVI cables. In the process of flight testing and fielding these platforms, it has been the experience of DragoonITCN that detailed characterization of the complex impedance for an aircraft-installed DVI cable is highly useful and can result in significant system cost reduction if properly executed. A test fixture that can measure and record very precise complex impedance (attenuation and phase group delay over a video-centric frequency range) with a graphical representation of VSWR (Smith chart) that can be imprinted on a cable tag with date – would be a highly desirable entry to a Table of Allocation or Standard Test Equipment list that is used to maintain the Prime Mission Equipment.

Methodology and Technical Approach – This type of complex measurement is typically conducted through the acquisition of vector-error corrected data. In a laboratory, a vector network analyzer would be utilized to collect sets of complex, frequency-dependent parameters commonly called S-Parameters. In the laboratory, there are four sets of Scatter Parameters that can be collected based on the two connection ports of the instrument. In terms of S-Parameters we notate S_{11} representing the reflection of forward energy on Port 1 ($S_{1\_}$) and the measurement of reflected energy on Port 1 ($S_{\_1}$). In the same vein forward energy transmission is notated as S_{12} where energy is transmitted on Port 1 ($S_{1\_}$) and measured on Port 2 ($S_{\_2}$). Typically, cables are measured using the insertion technique whereby the two cable ends are "inserted" between the two ports and an S_{12} measurement performed. This will provide a measurement of power loss over the cable as well as phase shift.

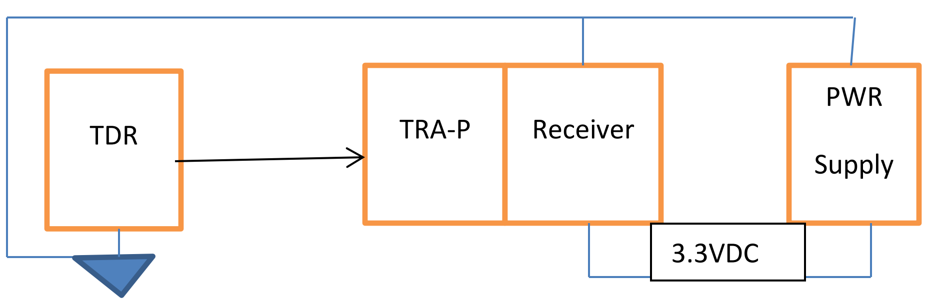


While easily performed in a lab environment, this technique is difficult to perform "at-platform" on the aircraft. The reason for this difficulty is that both ends of the cable under test need to be connected to the same test instrument. With the cables installed on the aircraft it is almost physically impossible to connect both ends to a common instrument. Therefore we propose that instead of using the insertion technique, a more viable approach for obtaining the same information is the reflection technique. The reflection technique uses the S11 measurement to fully characterize the RF cable.

The S_{11} measurement "at-platform" has its own unique set of challenges. Since only one end of the cable is connected to the instrument, the other end must be deliberately mismatched during a series of measurements to provide complex, multi-term equations which can be solved for the measurement parameters of interest. For this S_{11} measurement, the opposite end of the cable under test will be deliberately mismatched by shorting the cable or leaving it as an open circuit. These two mismatches provide two different phase relationships of the reflected signal on the cable. In addition, a measurement with a "perfect" load is performed where no energy is reflected back to the instrument. So to perform the phase measurement on the cables embedded on the aircraft a maintainer would be required to connect one end of the cable to the diagnostic instrument and when prompted, connect an adapter representing an open, then one representing a short and finally one representing a load to the opposite end of the cable under test.

Another challenge in doing "at-platform" diagnostics utilizing S-Parameter measurements is the level of knowledge and training required by the maintainer. As outlined above, the measurement required for each cable is a multi-step process of which careful metrological technique is required to obtain reliable, repeatable results. For this reason, a cable analyzer that automates the process and provides prompts to the maintainer is proposed. In addition, the open, short, load components can be encapsulated into a common module, controlled by the instrument which negates the need for the maintainer to connect multiple test adapters to the cable, reduces chances for operator error during the measurement and finally removes a potential FOD (Foreign Object Debris) source from the flight line.

Receiver Impedance is a critical measurement of the DVI cable best accomplished by the DragoonITCN TDR technique, well established with the BCIT product.



The differential time-domain reflectometer (TDR) set up measures the reflected waveform returned from a load when driven with a unit step input. It is obtained by driving the load under test with a step pulse using a driver with a specified source impedance and rise time. The reflected waveform is the difference between the observed waveform at the device under test when driven by the the specific test signal and the waveform that results when driving a standard test set load with the same test signal. From this measurement via a high-speed digitizer, the impedance of the cable can be accurately determined.*

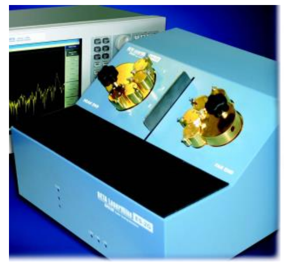
Finally, the complexity of modern ISR sensors means that the “at-platform” problem encapsulates more than just the cables of interests. These cables are typically connected to displays which form part of the circuit path of the DVI system. Providing complex measurements of just the cables may not provide a complete or desirable picture of system performance. If it is desirable to leave the displays or terminals connected to the cables during testing, the problem of mis-matching the end of the cable becomes more challenging. In this manner the instrument would be measuring the power and phase attributes of both the cables and displays as a subsystem.

As a result an “at-platform” test set could be used to measure multiple DVI cables on an aircraft. In addition to the phase information, VSWR/return loss and cable loss would also be derived that indicates the performance health of the cable as well as noise suseptibility. This test set will be fully automated to minimize the effort and knowledge required for the maintainer. It will also store measurement results for use in calibration of the ISR platform and maintenance history for the platform and components.

It is the assertion of this paper that by combining the aforementioned functional modules in a novel configuration, the resulting test tool can not only fault isolate DVI cables to an extremely accurate degree, but also provide key complex impedance data for *non-faulty* cables that will serve well the multiple AF platforms that employ DVI coaxial networks within their systems.

Wideband RF Module (VNA)	1. Generates stimulus signal and measure response
	2. Creates S-Bridge signal path (couplers/isolators)
Controller Card	1. Automates the test with user interface SW
	2. Calibration SW and Firmware to normalize test fixture effects

Concept - DragoonITCN is proposing a Second Phase II SBIR sponsored by AFRL that leverages the TDR and bus interface monitoring capability to address the DVI cable noise/integrity issue. Combining our digital and software GUI expertise with Beta LaserMike’s direct twisted pair cable test element, a comprehensive test tool is realized for minimal investment.

The concept is to integrate a Vector Network Analyzer in VXI format with DragoonITCN's controller and TDR card with Beta LaserMike's balun twisted-pair fixture with a DVI connector adaptor pig-tail and display the GUI DVI cable test result on a Tablet computer. Interfacing the Twisted Pair fixture with the VNA and TDR with operator SW will constitute the basis of this effort, but the overall risk is moderate since the technique of characterizing the DVI cable is understood.

Summary – DragoonITCN is uniquely qualified to fabricate and manufacture the test equipment described herein. Our BCIT product (developed on an AF SBIR) is found worldwide and has an NSN. In cooperation with the cable test experts at Beta LaserMike, we believe that a practical DVI Test Set can be realized in prototype form before the B1 Milestone. This white paper describes the methodology proposed and attempts to convey the comfort level we have with the technology.

*Ref: DVI Test and Measurement Guide Rev 1.0 DDWG Electrical Test Working Group 2/25/2001