MIL-STD-1553 AS4111-AS4114 Testing Methods

For almost the last half century MIL-STD-1553 has been widely used as the defense industry's standard for data communications for various applications within aerospace and defense. Commercial avionics for the flight actuators on the Airbus A-350 have also adopted this robust databus. Core systems deploying it typically have to operate over the lifetime of the program, and are updated and enhanced as new technology becomes available and is adopted. This drives the test systems to also be retrofitted with updated equipment to support these new designs. Many new programs still use MIL-STD-1553 as the primary deterministic databus and the new equipment must support this standard. Due to natural progression of the test equipment, equipment manufacturers also need to keep pace with the latest technologies to support efficient and effective testing of the MIL-STD-1553 equipment. Testing is typically executed in accordance with the MIL-STD-1553 test plans such as the industry standard SAE AS4111 to AS4114 for remote terminals and bus controller equipment. These standards define all of the testing that must be performed for MIL-STD-1553 devices both during design verification and production testing.

The test documents define exactly what tests are to be performed, but allow for multiple methods of implementation. This gives the manufacturer many options of how to design and implement their test station. In this article, we will discuss three basic methods of implementing the test systems to perform this testing, and explain the pros and cons of each. These methods are manual testing, automated testing and fully integrated testing. Since Remote Terminals (RT's) are a significant volume item that most companies will produce, we will use the RT Production Test Plan as our example.

AS4112 defines the electrical and protocol testing for production remote terminal devices that operate on a MIL-STD-1553 bus. The standard defines the test setup, and the expected measurement values and limits, but does not specifically dictate what equipment to be used for the testing, or how to create the conditions necessary to produce the results. This allows the test engineer wide latitude in the design of test systems. Test environments can range from totally manual with individual instruments to a fully automated, or integrated approach. The advantages of an automated system are accuracy, repeatability and speed. As an example we will describe three scenarios. The first being a manual test setup with separate instruments, the second being an automated version of the manual setup, and the last being an integrated "off-the-shelf" system running automated scripts to perform all testing.

Manual Test Method

The basic equipment necessary to perform the electrical testing is a Bus Controller (BC) or simulator, a digitizing oscilloscope and a computer, along with the properly connected Remote Terminal Unit Under Test (UUT). (The system configuration is shown in Figure 1.) By invoking commands from the BC that produce the proper responses by the UUT, the user can then measure the electrical characteristics of the signals by adjusting the oscilloscope settings. Then the measurement would be recorded and compared to the limits called out in the AS4112 document. This same process would be repeated for each section in the document until all electrical tests are completed.

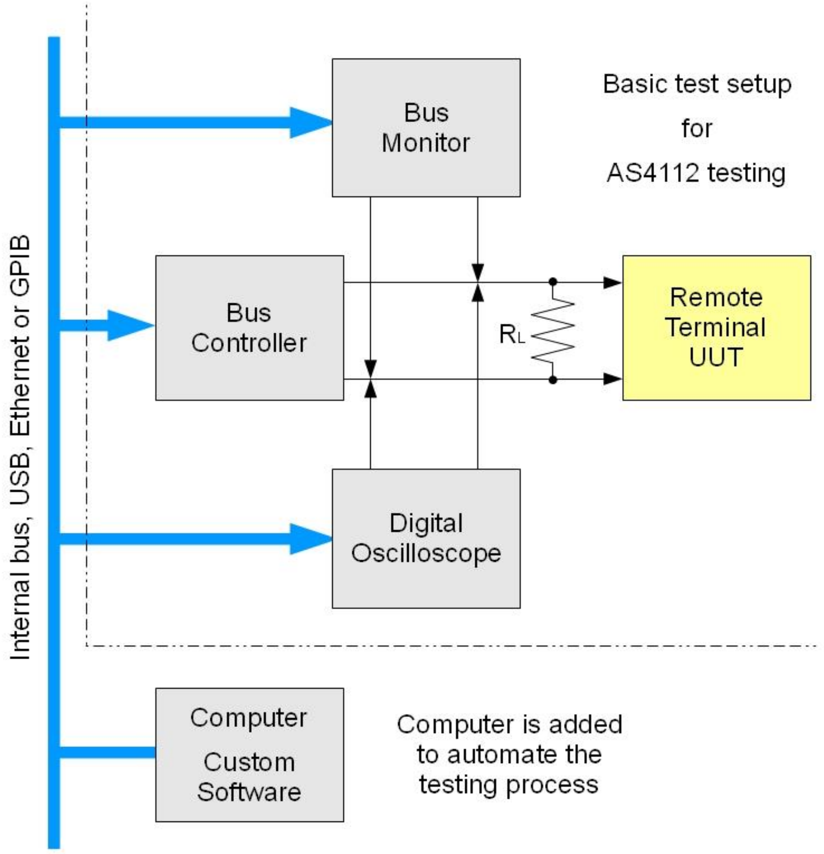

Figure 1

One critical detail that demands careful attention is that the method of connecting the UUT to the bus differs dramatically than when using the Remote Terminal attached to an actual MIL-STD-1553 data bus. No bus couplers are used in this testing, making short lead lengths and grounding an important consideration in the design of the test system. The goal is to capture, as accurately as possible, the signal levels at the bus terminals of the RT. This also applies to any of the test configurations mentioned in this article.

To perform the protocol tests, the same setup is used except the oscilloscope is replaced by a 1553 bus monitor. For this set of tests, a series of commands are initiated and sent to the UUT and then the bus is monitored for the proper response from the UUT (or no response in some instances). Again, the process is repeated for each of the protocol tests and the results recorded.

With the number of tests to be performed, it becomes obvious that this method requires little engineering effort up front but is very time consuming to perform the tests, record and analyze the results, and produce the final report.

Automated Test Approach

The second scenario includes all of the same hardware components as above, but adds a computer (as shown in Figure 1) with the capability of controlling the other instruments, either on the same backplane or through PCIe, USB, Ethernet, etc. By learning the command sets of the different instruments and following the guidelines of the AS4112 test plan, software can be written to automatically send the commands, receive and interpret responses and produce test reports.

The second approach can reduce the test time dramatically from the manual method, but requires a substantial engineering effort to implement. The capabilities and instruction sets for multiple instruments from different vendors must be learned and code must be written to communicate with them, the AS4112 test plan reviewed and understood and the software written and debugged. The effort to implement this type of system is generally proportional to the amount of flexibility desired to add or change RT’s with different addresses, capabilities, etc. A more flexible approach will demand more engineering time to design user interfaces and design software that can be used on multiple devices. Due to real world budgeting constraints, it is common for these types of systems to become more or less “hardcoded”, and dedicated to one particular RT type.

Integrated Test Solution

The last option is to purchase an integrated solution from a company that specializes in MIL-STD-1553 hardware, software and systems. By taking advantage of the advanced simulation and analysis software products available, coupled with the latest hardware that includes built-in “digital scope” capability, a system can be configured that automatically performs most all aspects of the test with no engineering development effort[1]. Through the use of Python scripts for automation, these systems are essentially turnkey solutions (shown in Figure 2). The user only needs to enter the basic information such as model number, serial number, date of test, etc. along with some basic setup info and the test is ready to run at the push of a button. At the conclusion of the test, a report can be automatically generated that shows the full results of the test including the limits, measured values and pass/fail information (Figure 3). This type of approach gives the user the best of both worlds, very little up-front engineering effort coupled with minimal test time.

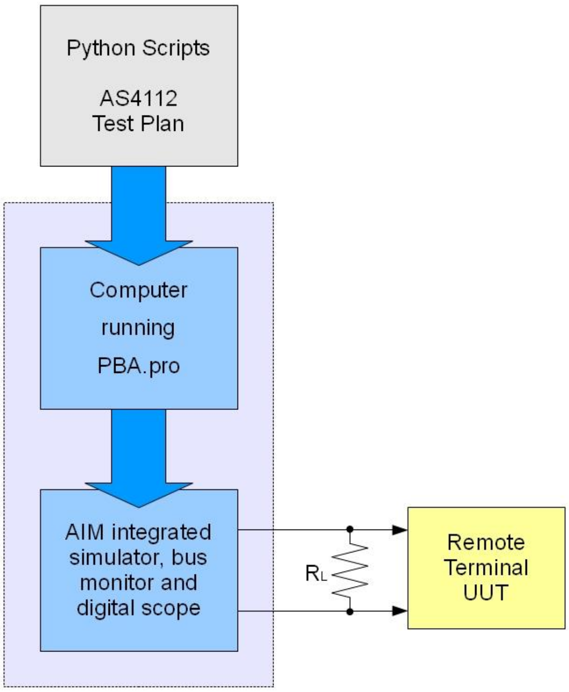

Figure 2

An added benefit to selecting this integrated solution from an established supplier is that the user has the benefit of the accumulated experience of the system supplier and their existing customer base. Most of the issues that can be encountered when designing and debugging a system have already been addressed through the testing and validation of similar systems. This means that the test engineer can eliminate many of the common errors of first time implementer, thus saving time and money.

[1] It should be noted that even with integrated approaches, such as including a 'digital scope functionality', there are limits when it comes to some specific tests such as the Common Mode Rejection' and 'Input Impedance' tests that require an additional 'function generator' device and impedance measurement

AIM offers MIL-STD-1553 modules with the Digital Scope option, and PBA.pro advanced simulation and analysis software. The AS4112 (and AS4111) test plans are available as Python Scripts. AIM has supplied many integrated systems including the before mentioned components, either integrated directly by AIM or by the by the end user.

In conclusion, AS4111 through AS 4114 provide a standard set of tests to assure proper operation of equipment in a MIL-STD-1553 system. They allow the designer to determine the necessary tools (test equipment, software, cabling) to accomplish the tests. This is an advantage in that a designer has maximum flexibility in system architecture and components. At the same time, it presents the challenge of understanding the tradeoffs to achieving the end goal, within the program constraints of time and budget (both recurring and non-recurring costs). Today there are solutions available to fulfill virtually any program need.

Test Report

The reports are always written to the reports sub directory. The Filename may be changed via the Global Settings. See (3) for more details.

```
*****************************************************************************************************************
*                                              T E S T R E P O R T                                              *
*****************************************************************************************************************
*                                                                                                               *
* Operator: John Doe                                                               Monday, 2020/03/02 14:32:15 *
* Comment:                                                                                                      *
*---------------------------------------------------------------------------------------------------------------*
* Report filename:                                                                                              *
* D:/PBA.pro_Script_Projects/PBA.pro-SCR-PTP-E/scripts/reports/PBA.pro Internal                                 *
* RTs_123_2020_03_02_14_32_15_Report_Electrical Tests.txt                                                       *
*                                                                                                               *
* PBA.pro Project filename:                                                                                     *
* D:/PBA.pro_Script_Projects/PBA.pro-SCR-PTP-E/scripts/Analogue_Tests.ppref                                     *
*---------------------------------------------------------------------------------------------------------------*
*                                                  T E S T E R                                                  *
*                                                 -------------                                                 *
*                                                                                                               *
* objectName                                                            Tester                                  *
* Name                                                                  PBA.pro with MILScope                   *
* Partnumber                                                            N/A                                     *
* Serialnumber                                                          59                                      *
* ModificationState                                                                                             *
* CalibrationDate                                                                                               *
* Comment                                                                                                       *
*---------------------------------------------------------------------------------------------------------------*
*                                                     U U T                                                     *
*                                                    -------                                                    *
*                                                                                                               *
* objectName                                                            UUT                                     *
* Name                                                                  PBA.pro Internal RTs                    *
* Partnumber                                                            1234                                    *
* Serialnumber                                                          123                                     *
* ModificationState                                                     N/A                                     *
* CalibrationDate                                                       N/A                                     *
* Comment                                                                                                       *
*---------------------------------------------------------------------------------------------------------------*
*                                                  R E S U L T                                                  *
*                                                 -------------                                                 *
*                                                                                                               *
* Test Manager Version:                                                 V02.77.0                                *
* PBA.pro Version:                                                      V02.77                                  *
* Special Test Scope:                                                   None                                    *
* Name of test application:                                             Electrical Tests                        *
* Result evaluation:                                                    automatic                               *
* Test result:                                                          PASSED                                  *
* Total number of scripts:                                              7                                       *
* Scripts N/A:                                                          0                                       *
* Scripts Skipped:                                                      0                                       *
* Scripts disabled:                                                     0                                       *
* Scripts passed:                                                       7                                       *
* Scripts failed:                                                       0                                       *
*****************************************************************************************************************

-----------------------------------------------------------------------------------------------------------------
| Application:                                                                                        14:32:15 |
| Electrical Tests                                                                                              |
-----------------------------------------------------------------------------------------------------------------

-----------------------------------------------------------------------------------------------------------------
| Test Group:                                                                                         14:32:15 |
| 5_1_1_1_Amplitude                                                                                             |
-----------------------------------------------------------------------------------------------------------------
|                                                                                                               |
-----------------------------------------------------------------------------------------------------------------
| Test Script:                                                                                        14:32:15 |
| 5_1_1_1_Amplitude.py                                                                                          |
|---------------------------------------------------------------------------------------------------------------|
| INFORMATION                                                          |MinValue |Value     |MaxValue |Unit|Status |
|---------------------------------------------------------------------------------------------------------------|
| Amplitude (Pri)                                                      |18       |21.63     |27       |    |PASSED |
| Amplitude (Pri) (Min)                                                |18       |21.47     |27       |    |PASSED |
| Amplitude (Pri) (Max)                                                |18       |22.12     |27       |    |PASSED |
-----------------------------------------------------------------------------------------------------------------
*                                                                                                               *
*****************************************************************************************************************
* Group Result:                                                                                        |Status  *
* 5_1_1_1_Amplitude                                                                                    |PASSED  *
*****************************************************************************************************************

*****************************************************************************************************************
* Test Group:                                                                                         14:32:15 *
* 5_1_1_2_Rise_and_Fall_Times                                                                                   *
*****************************************************************************************************************
```

Figure 3