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M9-Series to Di-Series Conversion – Lessons Learned

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Abstract

Consolidated Automated Support System (CASS) Test Program Set (TPS) migration to eCASS is a one-time event, taking an existing CASS TPS and all the corresponding TPS supporting elements and making them compatible with all of the CASS family of testers. This paper focuses on the lessons learned as a result of converting the digital portions of the TPSs for the MH-60R/S from the M9-Series CASS digital test unit to the Di-Series digital test instrument.

Introduction

The M9-Series Digital Test Units (DTU) has served in CASS stations since the early 1990's. With the release of the new electronic CASS (eCASS) program in 2010, a new and updated digital tester was needed. [1] The Di-Series Digital Test Instrument (DTI) was selected for use in the eCASS series of testers. The Di-Series uses VXI-compliant hardware and software for easy integration, like the M9-Series. The Di-Series promises powerful performance, flexibility, and reliability, while reducing the number of instruments needed by a test system. A translator was needed to convert from M9-Series to Di-Series for eCASS Test Program Sets (TPS's). This was achieved by Teradyne's TPS Converter Studio™. The converter generates C-language code from the L-Series digital source files. The C-language code controls the Di-Series instruments through the Teradyne CShell™ Applications Programming Interface (API). This interface has function calls similar to the M9-Series DTU. [2] This paper will discuss the lessons learned during the migration process between M9 and Di-Series for MH-60R/S TPS's. Figure 1 shows the CASS Family of Testers that uses the M9 and Di-Series DTI.
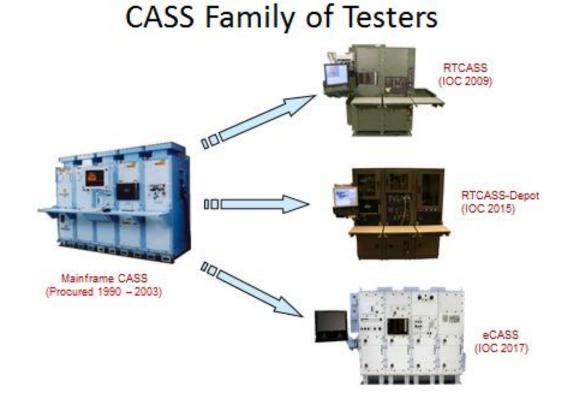

Figure 1: CASS TPS Migration

LASAR

The migration from M9 to Di-Series has encountered issues with LASAR jobs. These issues include: monitor statements, L2_Diagnose Functional External Program (FEP), corrupt cds file along with missing system library, LASAR simulation, and variable declaration in the FPPLIST.SYM file.

Monitor Statements

Monitor statements are used to verify that the stimulus from the DTU was applied. Monitor statements apply stimulus and read it simultaneously. The Di-Series DTI is failing monitor low statements. While testing the H-60 Multiplexer/Demultiplexer (MUXDEMUX) air signal conditioner Shop Replaceable Assembly (SRA), monitor low statements were causing inputs to fail because they were not being read accurately. The inputs were checked with an oscilloscope with and without the Unit Under Test (UUT) to determine if the UUT was causing issues. Figures 1 and 2 show the two waveforms.
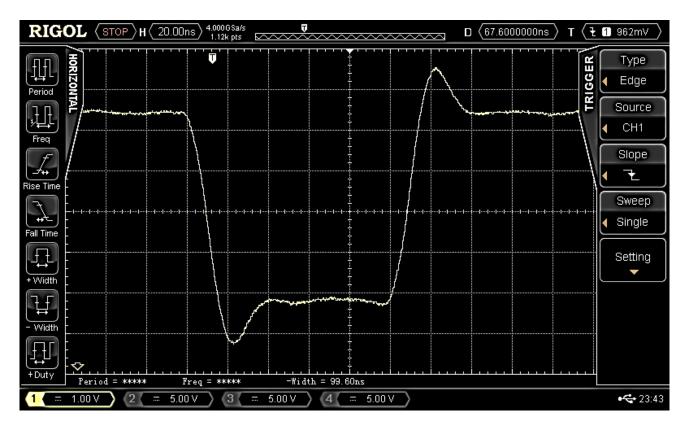

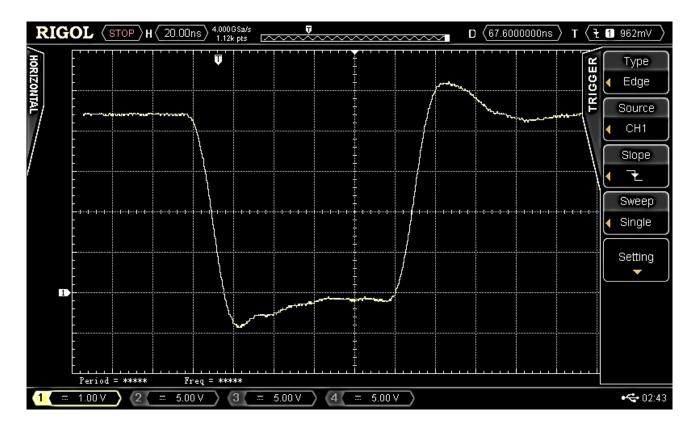**Figure 2: Signal with UUT Attached**

Figure 3: Signal without UUT Attached

Figures 1 and 2 show that the UUT has very little effect on the stimulus applied from the DTI. This test uses a clock of 2000 ns, is asserted at 175 ns, and returns at 275 ns. The window used to monitor this stimulus is in between 210 ns and 250 ns. The stimulus also follows a return to one format. The VOL level was set to 1V, so anything below this value will be read as LO. Both waveforms are well below this limit and should not be failing. Investigation is being done to determine the cause of these monitor statements failing.

L2_Diagnose FEP

L2_Diagnose is a FEP that calls the LASAR routine and runs it. This FEP catches faults accurately as long as there is a valid cds and fault dictionary. However, if there is no fault inserted and the test passes, the L2_Diagnose FEP sends a fail flag back to ATLAS, causing the test to always fail. Figure 3 shows the runtime window error message when the LASAR test passes, but returns the fail flag back to ATLAS. Error code 3019 is a catch-all failure that does not isolate what the error is. As of March 2016, L2_Diagnose FEP has been updated and no longer sends a fail flag for a passed test. A five-second delay is now needed after performing the L2_Diagnose. Teradyne has commented that this five-second delay will be encoded in the FEP to eliminate it having to be an ATLAS command.
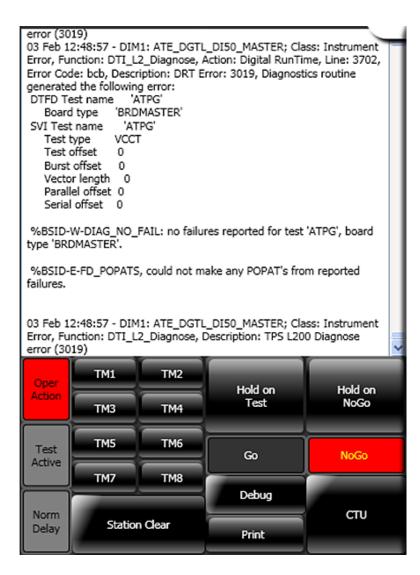
Figure 4: Error Message for a Passing LASAR Job

Missing System Library/Corrupt .CDS File

One of the main issues encountered is the lack of the Teradyne system library: $SYS_CHAR_LIB (TERALIB). When the L200 was installed, the system library was not installed correctly. This library should be located at:

$SYS_CHAR_LIB = [L200.11V00.L20LIB.TERALIB.TERALIB]TERALIB.SCL

The TERALIB is a system library that houses char models. When the system library does not have a required char model, a local library should be created. This is created by manually creating the missing char models and compiling them into a library. The build process is normally automated via a command file. When running the command file for the char models, there must be no warning or errors. If warning or errors exist, the local char library built from the command file will not be valid. Without a valid char library, a valid .cds cannot be generated.

Once the char models are accurate and this library builds correctly, a .cds can be generated by this command:
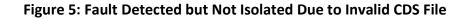
EDIT $CIRCUIT.SOURCE

LIST ALL NO PSET_SELECT
EXIT

This generated .cds is what eCASS needs for the L2_Diagnose FEP to detect and isolate faults, along with the fault dictionary (.fsd). The .cds file contains guided probe information, such as, the char models and net list information. The fault dictionary contains tables X, Y, and Z. Table X contains the PO PAT, Table Y contains the fault callouts, and Table Z contains the fault signatures.

Fault detection cannot be achieved without the .cds file. Figure 4 shows the runtime window of the error that occurs when no cds is present, but a fault was detected. Error code 3019 is printed here as well as a catch-all failure.

Figure 5: Fault Detected but Not Isolated Due to Invalid CDS File

LASAR Simulation

The H-60 MUXDEMUX air signal conditioner circuit card misisolated a stuck at zero fault. The INTERJUJ command is used to turn possible detects into hard detects. For the H-60 MUXDEMUX air signal conditioner SRA, INTERJUJ caused faults to be misisolated. Faults were able to be isolated after running the LASAR simulation without INTERJUJ.

The PROBGEN /MATRIX command was removed from the simulation because guided probe was not being used. Since guided probe was not being used, the following command was modified from having "TRACE" to "NOTRACE".

SET DEFAULT POST L200/DIAGNOSE=TRACE,FAULT_DICTIONARY/CIRCUIT

FPPLIST.SYM File

If more than 16 output bits are being used, the FPPLIST.SYM file must be altered from its standard state. In the standard state, the variable XDATA only allows up to 16 output bits. For the H-60 MUXDEMUX air signal conditioner SRA, there are 19 output bits being tested. With the original code, the system would hang after the LASAR completed and get a memory error.

The variable can be corrected by changing the variable type from an INT$2 to INT$4 and is shown below.

Updated Code
```
VAR XDATA    : ARRAY[6500] OF INT$4 ; ! array of pattern and pin data from
                    ! Xtable
```
Standard Code
```
!VAR XDATA    : ARRAY[8225] OF INT$2 ; ! array of pattern and pin data from
                    ! Xtable
```

RTCASS LASAR Jobs

After uncovering issues with eCASS's LASAR fault detection, it has recently been discovered that the migration from CASS to RTCASS LASAR jobs was not successful. The TPS's were verified only to pass. No fault was inserted to determine if the LASAR accurately detected the fault. Most, if not all, of the F-18 TPS's that use LASAR do not accurately call out a fault. This issue is most likely due to an invalid or corrupt .cds file and will be investigated.

Low-Z Setting

Turning the low impedance (Low-Z) option ON sets the output impedance to 12 Ω, while leaving it OFF sets the output impedance to 50 Ω. Given that many terminations are 50 Ω, Low-Z should only be used conditionally. It was found in one TPS that Low-Z was turned on for all stimulus channels. This was causing ringing on a clock signal which resulted in test failures. The ringing caused unintended "double clocking." Once Low Z was turned off, the ringing disappeared and the test passed every time. The faster slew rate on eCASS probably exacerbated the ringing effect, while the older CASS system had less ringing and passed (perhaps marginally). Figures 5 and 6 show the differences in the clock signal on eCASS with and without the Low-Z option.
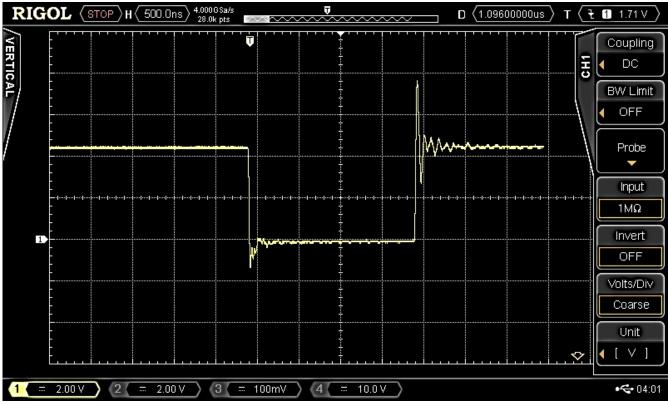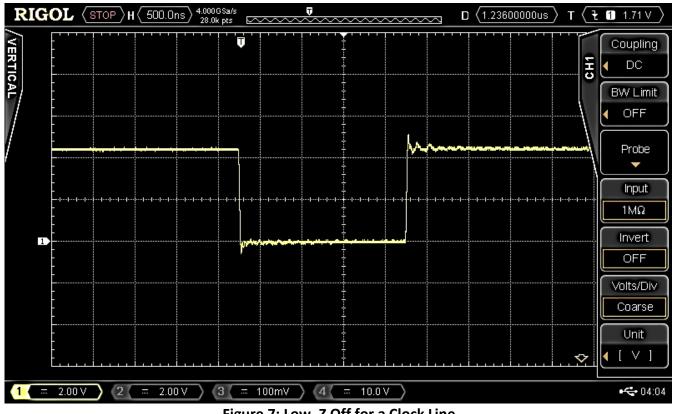
Figure 6: Low_Z On for a Clock Line

Figure 7: Low_Z Off for a Clock Line

IOX Voltage Fluxuation

The Di-Series DTI used in eCASS behaves differently when holding pins in the high impedance state. This was discovered during a migration test, which was using the DTU to test a relay. The test path is shown in Figure 7.

Figure 8: Relay Test Path

The test first performs an IOXALL to tri-state the pins. With the pin to the relay coil IOXed (relay open), the signal path through the relay is driven high while it looks for an output-low (< 1.3 V) on the relay output. This test failed, and an oscilloscope trace showed that the output signal was floating at 1.3 +/- 0.5 V (behavior for the same test on CASS has not been confirmed to see if this test originally passed only marginally). The code for this test is shown below.

```
ENTRY RELAY;
! Test relay K1 using wraparound. First test open, then closed.
LOAD;
        IOXALL;
        IH RELAY_INPUT OL RELAY_OUTPUT FTEST;
        IOX RELAY_OUTPUT;
        IH RELAY_ENABLE PATC WAIT 65000;
        OH RELAY OUTPUT FTEST;
        IOXALL;
```

```
        NOSTEP;
PATC STOP;
BURST;
RETURN;
```

As a work-around to this problem, the test was performed with LOAD = $ON in order to stabilize the IOX'ed pin on the relay output. By pulling the voltage level up to VCOM, set to be 2.0 V, the tri-state level maintains a tighter signal voltage. With a higher voltage on the tri-stated pins, an input-low was driven on the relay enable line to prevent closing of the relay during a "relay open" test.

This change in tri-state voltage required a change in the ftest from output-low to output-between. VOL and VOH levels of 1.0 V and 3.0 V were chosen, respectively. With the above changes, the test successfully detects the open relay.

DTI Alignment

The Di-Series DTI has experienced calibration failures more rapidly than expected. The DTI calibration program failed verification less than a week after passing an adjustment. The DTI failed to initialize (TN 800) four times in a row during a weekly CAL-verification test. The Primary Cause of Failure (PCOF) provided was "DTI Alignment failed," which did not describe the cause of the failure. Many maintenance hours were expended to correct this DTI failure. The DTI has to be monitored to ensure no drift will impact any TPS's. The DTI may need calibration adjustments more frequently than its current 12-month cycle.

Asynchronous Routines

The CASS DTU behaves differently than eCASS when running in asynchronous mode. CASS asynchronous routines are not dependent on the value of $MAX_BURST_TIME. This max burst time limits how long the L200 will run in synchronous mode before returning back to ATLAS. On eCASS, the max burst time appears to limit L200 running time for both synchronous and asynchronous modes.

For one TPS, the L200 was set to loop in asynchronous mode until an operator intervention. On eCASS, the test would only loop for a couple of seconds and then return a fail flag because the L200 was not completing. It was discovered that eCASS is dependent on $MAX_BURST_TIME while running in asynchronous mode. A previous synchronous routine had set $MAX_BURST_TIME to 5 seconds and eCASS was using this as a timeout. As a solution, $MAX_BURST_TIME was set to -1 seconds, which allows an infinite amount of time for the L200 to loop.

IOX Placement

CASS allows IOX command of a dynamic pin outside of the burst. It was discovered that eCASS does not share this behavior. During tests in which IOX was attempted outside of the burst, subsequent tests failed to trigger properly. Moving the IOX command inside of the burst (and inside of the PATC STOP statement) fixes this problem for eCASS. The L200 code for the original and updated patterns is shown below.

```
        CASS Code                        eCASS Code
ENTRY u2_11khz;                  ENTRY u2_11khz;
 load;                            load;
    USE TSET 5 CPP = 1               USE TSET 5 CPP = 1
    PATC LOOP 32000                  PATC LOOP 32000
      IH xa1_102 IL xa1_105;           IH xa1_102 IL xa1_105;
      IL xa1_102 IH xa1_105            IL xa1_102 IH xa1_105
    PATC ENDLOOP;                    PATC ENDLOOP;
    PATC STOP $ALWAYS;               IOX xa1_102 xa1_105;
 burst;                              PATC STOP $ALWAYS;
 IOX xa1_102 xa1_105;              burst;
RETURN;                          RETURN;
```

Citations

[1] Teradyne, Inc. (2016). *Defense & Aerospace Customers and Programs.* [Online]. Available:
http://www.teradyne.com/products/defense-aerospace/defense-aerospace-customers-and-programs

[2] Teradyne, Inc. (2015). *Di-Series Digital Test Instruments.* [Online]. Available:
http://www.teradyne.com/File%20Library/Defense-Aero/Instruments/Di-Series-Datasheet.pdf