Department of Defense Electronic Equipment Intermittent Fault Characterization

Research Conducted and Compiled by:

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04 December 2014

Introduction:

Intermittency, even down in the nanosecond range, negatively affects reliable electrical equipment functionality and is a leading contributor to No Fault Found (NFF). Significant limitations exist in current Department of Defense (DoD) conventional Automatic Test Equipment (ATE) which masks short duration intermittency. This results in faulty equipment items "passing" conventional ATE scanning, sampling, averaging and multiplexing test methodologies and techniques. To compensate for these ATE testing shortfalls, the DoD needs a means of detecting, isolating and repairing short duration intermittency in electronic pathways in Line Replaceable Unit (LRU) chassis.

The purpose of this study is to capture the duration and ohmic characteristics of actual DoD electrical intermittency that cause electronic equipment malfunctions. This study was requested by the Joint Intermittent Testing (JIT) WIPT.

Statement of the Issue:

Electronic equipment aging, contamination and wear results in a degradation of the circuitry interconnectivity over time. This is aggravated and accelerated by extreme physical forces in severe military operational environments consisting primarily of vibrational stress, temperature and humidity extremes, and a high-operational tempo.

These factors induce intermittent ohmic events that deviate from the circuitry's designed parameters. The duration of these intermittent events can range down to nanoseconds, may occur repeatedly, or may just be one-shot in nature. The reseating of a connector or circuit board adjacent to a degraded connection, solder joint, etc., can temporarily cause the intermittent connection to appear repaired. Invariably the intermittent will re-manifest itself in an operational environment, usually in a relatively short period of time.

Figure 1 illustrates how an intermittent migrates through different stages of severity as it worsens. These events usually occur when environmental stress is present.

- Stage 1: Short duration (under 50 nanosecond) and/or low ohmic (under 10 ohm) intermittent events can cause problems in high frequency (10 MHz or higher) or other sensitive or critically balanced circuits.
- Stage 2: Longer duration (50 nanosecond to 1 millisecond) and/or higher ohmic (10 to 500 ohm) interment events cause problems in many different circuit designs.
- Stage 3: Long duration (1 millisecond or longer) high ohmic (500 ohm to open) intermittent events cause frequent circuit problems. Because the source of the problem (cracked solder joint, loose wire wrap, sprung connector, etc.) has become so severe, the intermittent tends to repeatedly occur in the presence of environmental stress, possibly enabling conventional ATE to detect the problem. These severe problems typically occur at all temperatures in the presence of vibration, whereas the Stage 1 and Stage 2 intermittent events frequently only occur at specific temperatures.

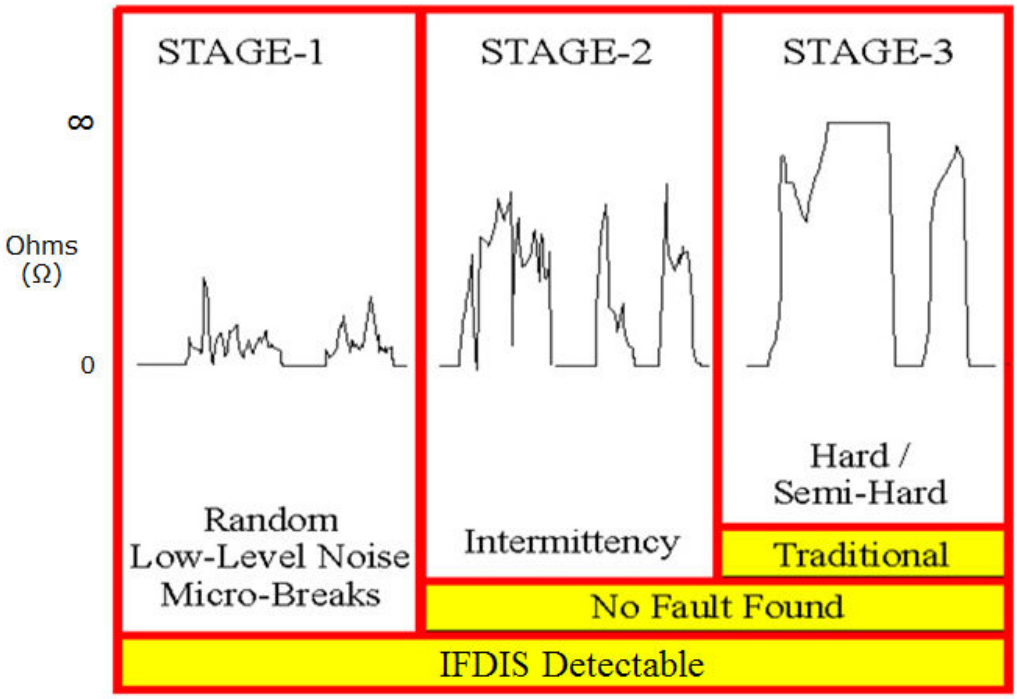


Figure 1. Intermittent Stages

Approach:

The first step was to find intermittent circuits so that the intermittent events in those circuits could be characterized. Due to the random nature of intermittency, the Intermittent Fault Detection and Isolation System (IFDIS) was employed to test F-16 AN/APG-68 Radar System Programmable Signal Processor (PSP) chassis to determine if there were intermittent circuit paths in the units, and if so, precisely which paths were intermittent. This was easily accomplished because the IFDIS monitors all of the circuits individually, concurrently and continuously during testing. The IFDIS also provided the needed vibration and temperature environment. Once intermittent circuits were identified by the IFDIS, an Agilent Technologies Model DSO9254A Digital Storage Oscilloscope with a 2 GHz Radio Frequency Probe (Model N2796A), capable of operation down into the picosecond range, was employed to identify and capture screen shots of actual intermittent events as they occurred.

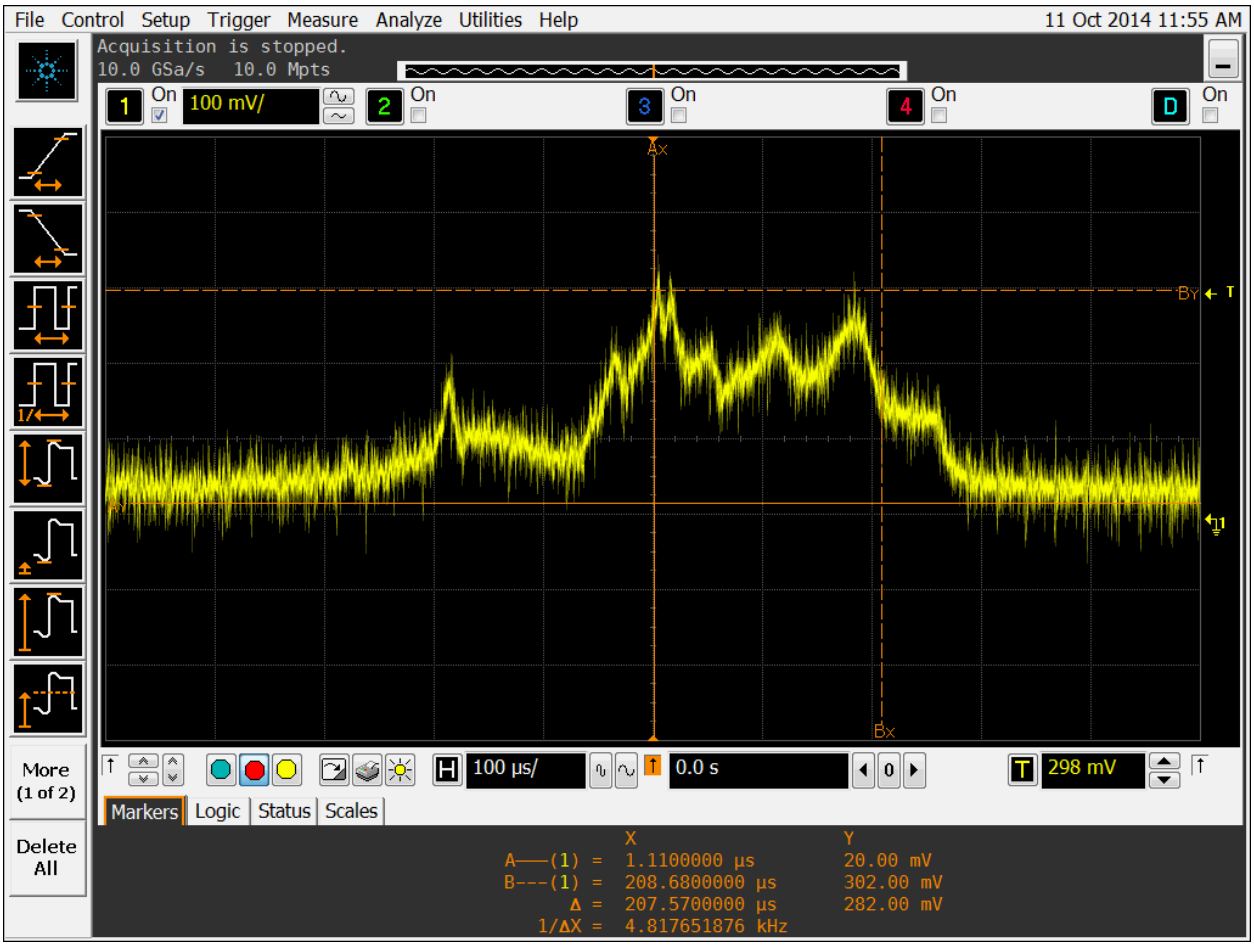
Once the IFDIS identified the exact circuits that were intermittent, it was then possible to test independently of the Intermittent Fault Detector (IFD). This was accomplished by using a battery, resistor and the oscilloscope set-up to capture the circuit's intermittent event characterization. This battery technique, used in some cases, minimized environmental noise and displayed a cleaner screen capture of actual intermittent events.

Intermittent durations in this report were captured by the oscilloscope in the microsecond range. The primary point of interest of this report was whether or not intermittent fault durations repeat at the same duration. Although all the intermittence captured did occur in the microsecond range, no two durations or wave forms were the same, hence no distinct failure pattern or duration pattern exists. Intermittence occurs at irregular intervals, is not continuous or steady and does not follow a specific failure pattern.

Test Results:

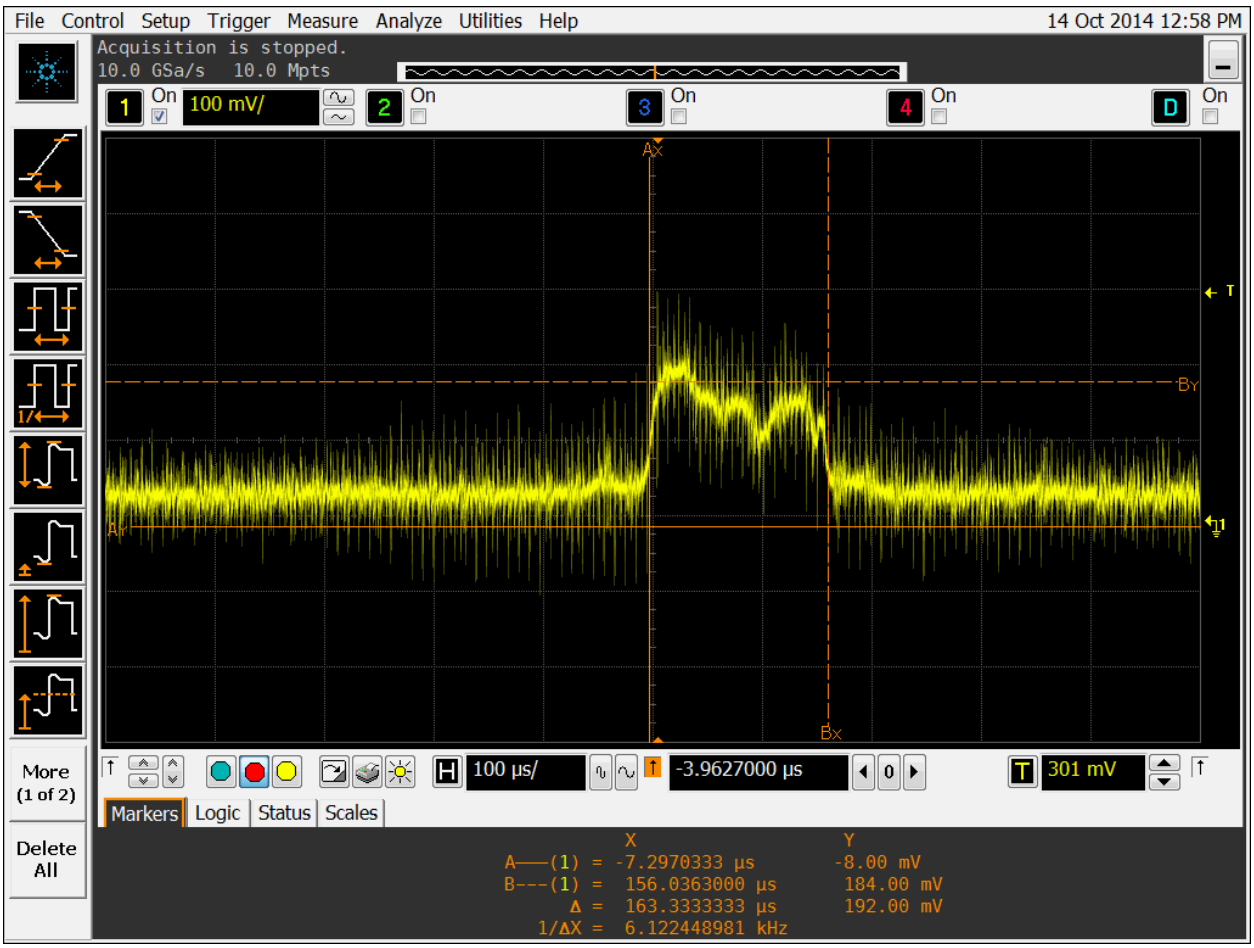
Test Case #1

PSP S/N 11357, intermittent Pin A09-469, five separate oscilloscope captures demonstrate the same intermittent event at different durations. In order to capture this information IFDIS was first required to detect and isolate the intermittent event on Pin A09-469.



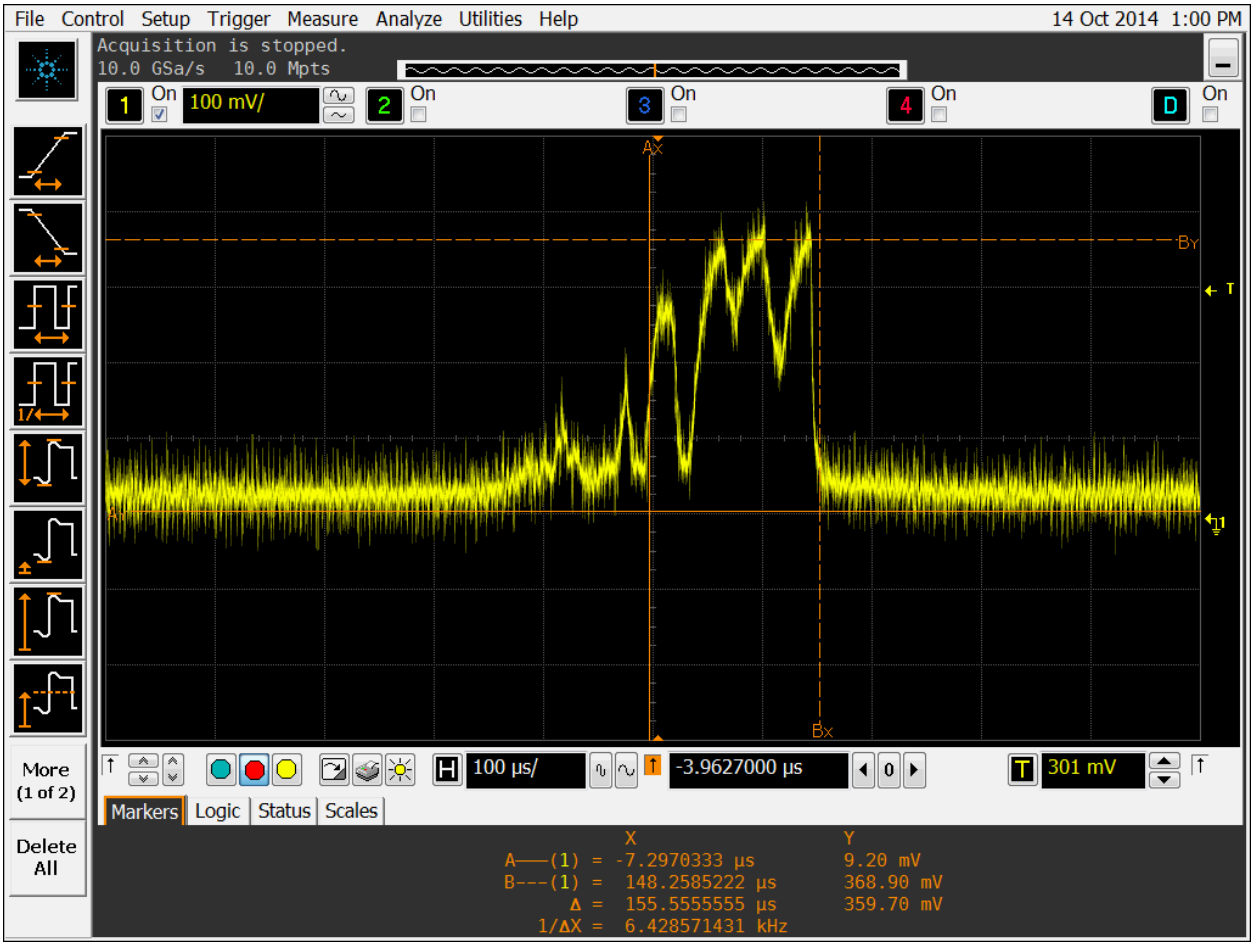
Test Date: 11 October 2014, 11:55am

PSP S/N 11357, Intermittent Pin A09-469 - Intermittent duration approximately 207 microseconds, scope reading taken after IFDIS detected and isolated Pin A09-469



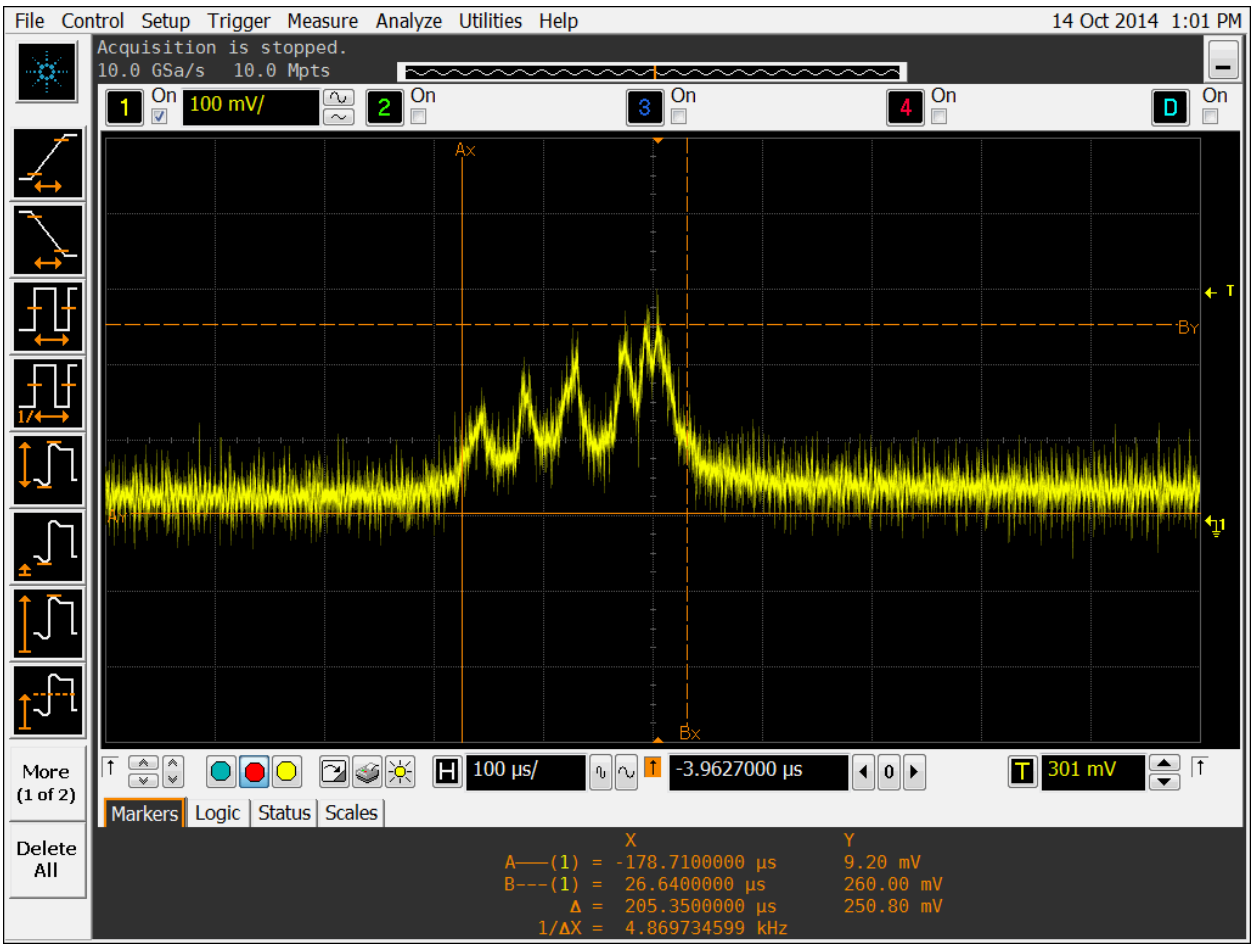
Test Date: 14 October 2014, 12:58pm

PSP S/N 11357, Intermittent Pin A09-469 - Intermittent duration approximately 163 microseconds, scope reading taken after IFDIS detected and isolated Pin A09-469 on second IFDIS test run.



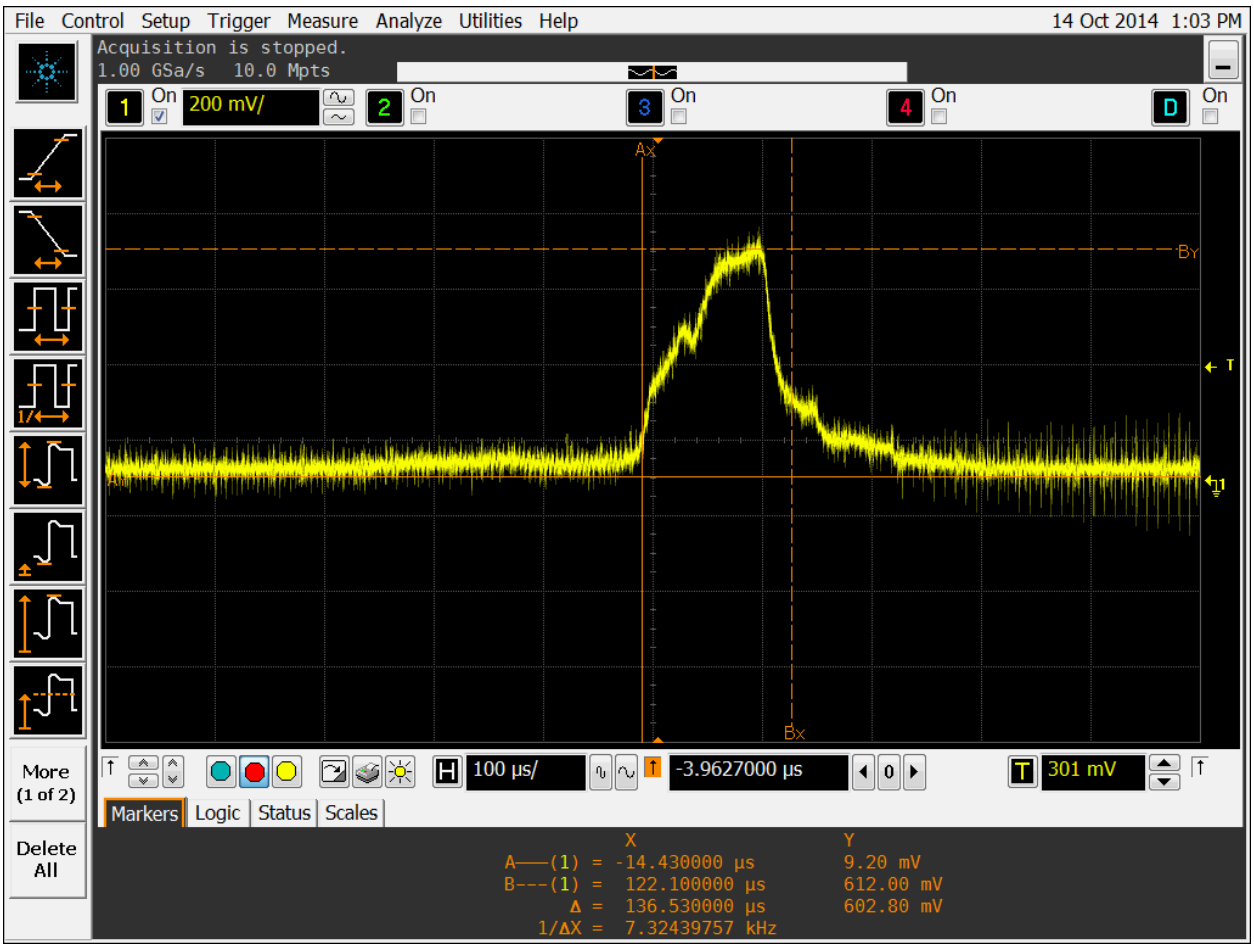
Test Date: 14 October 2014, 1:00pm

PSP S/N 11357, Intermittent Pin A09-469 - Intermittent duration approximately 155 microseconds, scope reading taken after IFDIS detected and isolated Pin A09-469 on second IFDIS test run.



Test Date: 14 October 2014, 1:01pm

PSP S/N 11357, Intermittent Pin A09-469 - Intermittent duration approximately 205 microseconds, scope reading taken after IFDIS detected and isolated Pin A09-469 on second IFDIS test run.



Test Date: 14 October 2014, 1:03pm

PSP S/N 11357, Intermittent Pin A09-469 - Intermittent duration approximately 136 microseconds, scope reading taken after IFDIS detected and isolated Pin A09-469 on second IFDIS test run.