Intermittent Fault Detection & Isolation System (IFDIS)

Mr. Ken Anderson
Vice President
Universal Synaptics Corp.
Problem

- Approximately 50% of the malfunctioning LRUs/WRAs inducted into the depot for repair are not actually repaired
  - Test No Fault Found (NFF)
  - Disassembled, Cleaned & Reassembled (DCR)
  - Circuit cards are reseated
  - SRUs/SRAs are replaced which subsequently test NFF
- NFF activity costs DoD $2B to $10B annually
Problem

• Conventional test equipment is incapable of detecting intermittent circuits in LRU/WRA chassis
  – Cracked solder joints
  – Loose wire wraps
  – Loose crimp connections

• These electromechanical devices fail intermittently long before they fail permanently
Problem

• Consistent discontinuity (hard failure) can be detected using conventional equipment
• Intermittent discontinuity is very short in duration
• Often only seen during stress situations
  – High G loading
  – Thermal extremes
  – Vibration
  – Combination of stresses
• Conventional testers are not designed to detect intermittent faults
  – Test one circuit or function at a time (sequential testing)
  – Scans, samples or averages intermittent faults out
  – Lack of test coverage and sensitivity to detect random intermittent faults that cause NFF
Solution

• Build a tester specifically designed to detect and isolate intermittent circuits
  – Must monitor *ALL* circuits (parallel testing) in a unit under test (UUT) *ALL* the time to prevent missing any random intermittent event
  – Must be sensitive enough to detect nanosecond range intermittent events
  – Must simulate operational environment

• The Intermittent Fault Detection & Isolation System (IFDIS) is such a tester
IFDIS Major Components

• Intermittent Fault Detector developed and patented by Universal Synaptics
  – Hardware neural network analog instrument
  – *Individually, simultaneously* and *continuously* monitors thousands of circuit paths
  – Detects and records all momentary discontinuities as short as **20 nanoseconds**

• Shake table

• Environmental chamber

• Interface Test Adaptor (ITA)
IFDIS

Intermittent Fault Detection and Isolation System - IFDIS
Conventional Tester Probability of Detecting a Random Intermittent Event

.03% detection probability
IFDIS Probability of Detecting a Random Intermittent Event

100% detection probability
Intermittent Fault Detection & Isolation System (IFDIS)

Mr. Sami Mansour
Director
523rd EMXS, USAF
Air Force Problem

- Conventional testers are unable to detect the problem in F-16 Modular Low Power Radio Frequency (MLPRF) LRUs 51% of the time.
- Discovered chassis intermittent circuits in 1999:
  - Using a microscope, found ribbon cable had cracked solder joints.
  - MLPRF SRUs had 90% NFF rate.
  - Initiated massive ribbon cable re-soldering program.
- No depot tester could detect intermittent circuits.
Air Force Solution

- Discovered IFDIS capability in 2006
- Stood up two systems in 2009 through SBIR Phase III vehicle
  - One in F-16 MLPRF repair shop
  - One in “Bad Actor” laboratory
- IFDIS Tested over 400 MLPRFs
- Over 25 times ($56M) return on investment
MLPRF Chassis
MLPRF With ITA Installed

Built Right...Ready to Fight
MLPRF Ribbon Cable & Wiring

Built Right...Ready to Fight
MLPRF Results

- Intermittent faults detected and isolated in over 58% of the units IFDIS tested (over 400 MLPRFs)
- Increased Mean Operating Hours Between Depot Repair from 290 to 926 hours (more than Tripled)
- Near the top of the MICAP list for over a decade, now not even on the MICAP list
- Troubleshooting time reduced by over 50%
- Over 25 times ($56M) return on investment
Future

- Recently started IFDIS testing F-16 Radar Antenna

- Plan to stand up 8000+ channel system in 2013
  - Capable of testing F-16 Programmable Signal Processor (PSP) – Unreliable & costly to sustain
  - Plan to expand IFDIS testing to many LRUs
  - Will be capable of testing virtually any LRU in the USAF inventory, as well as Joint Service LRUs
F-16 Radar Antenna with ITA
F-16 PSP

Built Right...Ready to Fight
Air Force Summary

- IFDIS was great investment – amazing ROI
- Solving our intermittent / NFF circuit problem
- Reliability improvement greater than expected
- Reducing Air Force maintenance costs
- Expanding to other LRUs as rapidly as possible
- Next year should have large enough IFDIS to test any LRU in the USAF inventory, as well as Joint Service LRUs
Intermittent Fault Detection & Isolation System (IFDIS)

Mr. Brett Gardner
Avionics Advanced Aircraft Technologies (AAT)
Team Lead, FRC SW

Department of Defense Maintenance Symposium and Exhibition
November 13-16, 2012
Navy Intermittent Fault Issues

• Intermittent / No fault found (NFF / A799) circuit problem with all Navy WRAs chassis
• F/A-18 Generator Convertor Unit (GCU) consistently appears on the F/A-18 top degrader list
  – GCU chassis currently tested with conventional continuity tester
  – Intermittent circuit detection extremely limited using conventional tester
• IFDIS technology was investigated by AAT 2010
• NAVSUP/F18 PMA funded GCU/IFDIS test demonstration
GCU Chassis
GCU Tied to IFDIS
IFDIS precisely detected and isolated one or more intermittent circuits in 80% of the GCUs tested.
Navy Results

- Selected (5) Ready for use (RFU) F18-C GCU chassis for IFDIS testing
- IFDIS detected and isolated intermittent circuits in 80% of the RFU GCU Chassis
- IFDIS stand up 2014 at FRCSW as part of Capital Improvement Program (CIP)
- Several other FRCSW NAE top degrader chassis are in the pipeline for IFDIS testing at FRCSW Depot, APG-73/65, E2 MC, F18 E/F/G GCU
Navy Results Cont.

- IFDIS is self learning – requires limited engineering oversight and $$ to program
- Repeatable results – Operator can repeat testing as required to verify vibration and temperature related faults
- Verification – Once repaired, chassis is re-run on IFDIS to verify repair
- Cable assemblies and hold down fixtures manufactured locally at low $$ using standard parts readily available in supply
- Interface compatible with Automated Wire Test Set (AWTS)
  - Leverage off of I-level AWTS interface
  - Systems deployed with AWTS IDs compatible with IFDIS
Questions?
Back up slides
Intermittent Fault Causes

Pin not soldered
Intermittent Fault Causes

Cracked Solder Joint
# Test Coverage 101

## Conventional Automatic Test Equipment (ATE)

<table>
<thead>
<tr>
<th>TP1</th>
<th>TP2</th>
<th>TP3</th>
<th>TP4</th>
</tr>
</thead>
<tbody>
<tr>
<td>60ms of testing</td>
<td>1360ms missed</td>
<td>4% Test Coverage</td>
<td></td>
</tr>
</tbody>
</table>

*Note – Conventional ATE scanning measurement window must perfectly synchronize with fault at the precise moment the fault occurs or the fault is missed completely, the result is No Fault Found.

## IFDIS

<table>
<thead>
<tr>
<th>TP1</th>
<th>TP2</th>
<th>TP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1340ms of testing</td>
<td>100ms missed</td>
<td>93% Test Coverage</td>
</tr>
</tbody>
</table>

*Note – All lines All the time test coverage equals no missed defects!