

An aerial photograph of Salt Lake City, Utah, showing a dense urban area with various buildings and green spaces. In the background, the Wasatch-Catchewasatch Mountains are visible, with some peaks covered in snow under a clear blue sky.

# **State of the Art – Live Wire Testing**

**Dr. Paul Smith, Dr. Cynthia Furse  
LiveWire Test Labs, Inc.  
Salt Lake City, Utah**

# Paul Smith, Cynthia Furse, “State of the Art in LiveWire Testing,” Joint FAA/DoD/NASA Conference on Aging Aircraft, Jan 31-Feb 3, 2005, Palm Springs, CA

## ■ State of the Art Live Wire Testing

- Paul Smith (LiveWire Test Labs, Inc.), Cynthia Furse (University of Utah and LiveWire Test Labs, Inc.)

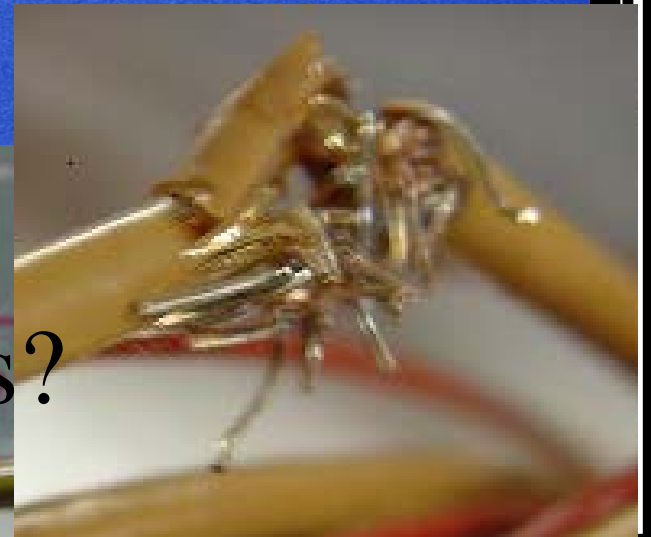
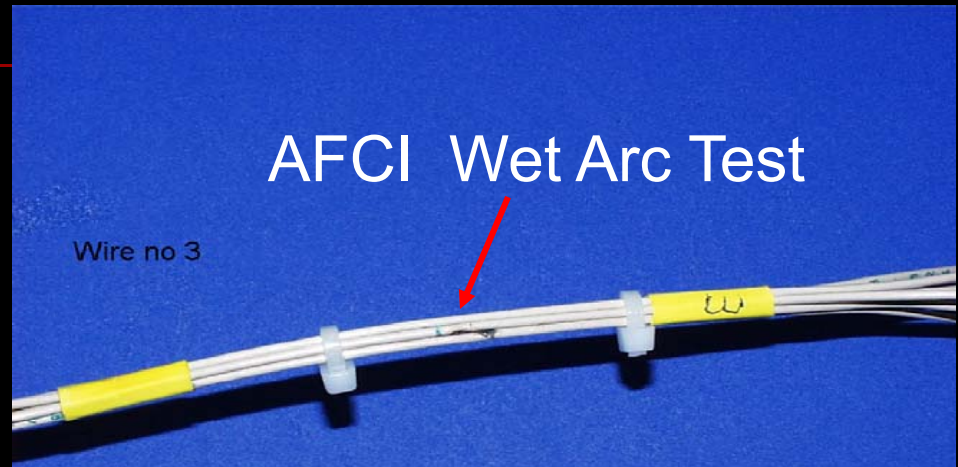
A lot of effort has gone into testing wires on the ground. While this is important, certain problems remain undetectable in an unpowered system. Tests and theoretical analysis show that problems such as wet and dry arcs, loose pins, chafing, etc. can only be detected while an aircraft is powered and/or in flight. This leads to high maintenance costs for a large percentage of aircraft wiring system anomalies.

There is significant hesitancy to use arc fault circuit interrupters (AFCI's) on aircraft even though they will make the aircraft safer. Part of the problem is that if an AFCI trips on an arc event, the damage is so small that it is virtually undetectable on the ground even through close visual inspection. With the expectation of false trips, it will be difficult to know if a trip event represents a real problem or a ghost.

Advances in spread spectrum wire testing continue to improve the ability to detect and to pinpoint the location of wet arcs, dry arcs, exposed conductors in condensation, and other intermittent and hard fault events. By continuously monitoring system wiring using smart connectors and smart circuit breakers, much of the time and effort spent finding intermittent faults on the ground can be eliminated. Tests have been performed on wires carrying DC, AC power, and data bus communication signals with real aircraft loads without mutual interference. Accurate distance to fault information has been reported even with faults on branched wiring

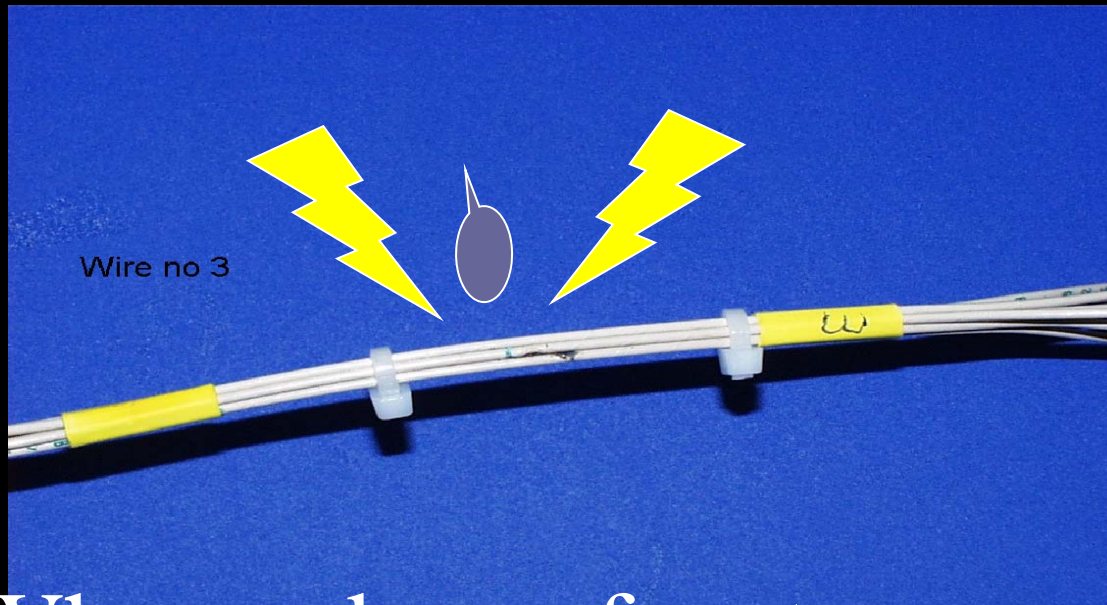
networks and short circuits to airframe ■

# Traditional Methods Work Well IF Wire is OPEN or SHORT



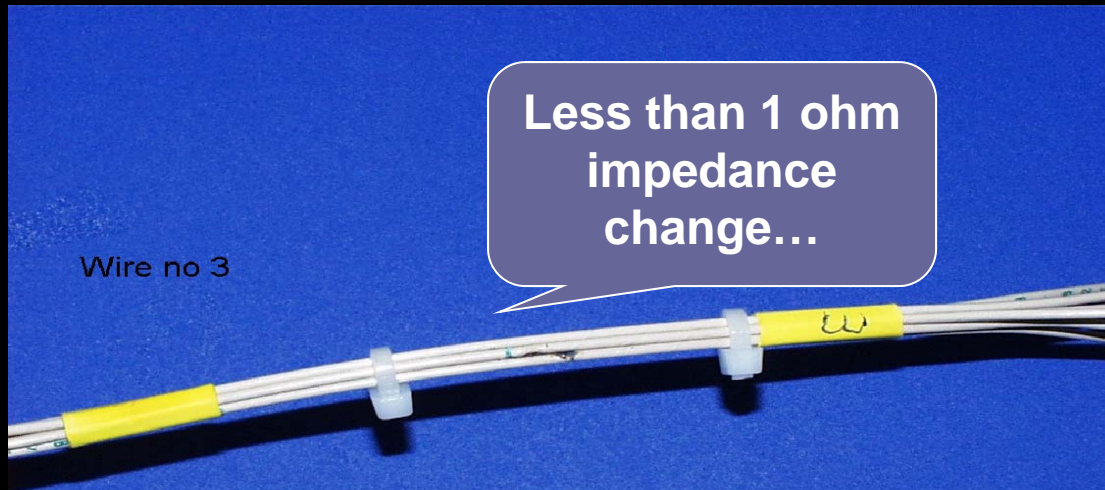
What About Frays and Arcs?

# LiveWire Locates Faults while the Wire and Fault are LIVE



When a drop of water creates a wet arc, it is a **SHORT CIRCUIT** for a few milliseconds.

# LiveWire Locates Faults while the Wire and Fault are LIVE



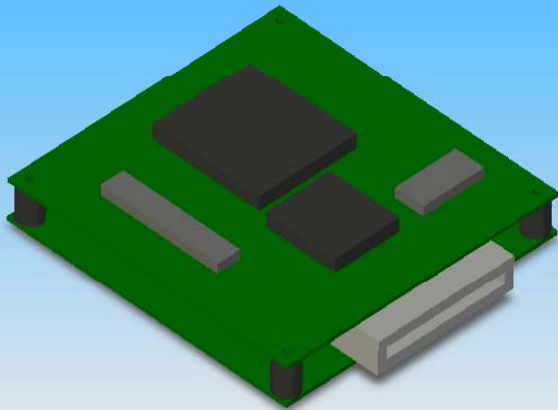
Less than 1 ohm  
impedance  
change...

When the water is gone, the fault is too small to detect. We must locate it in the few ms it is a SHORT.

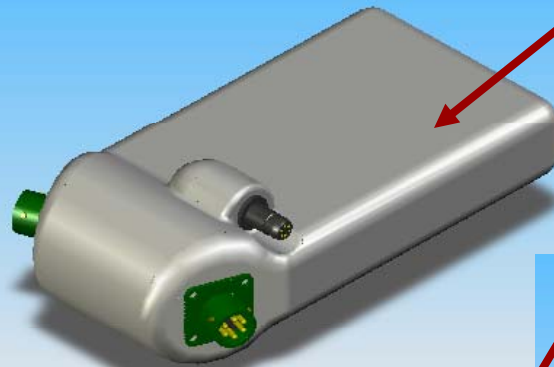
# To Run LIVE:

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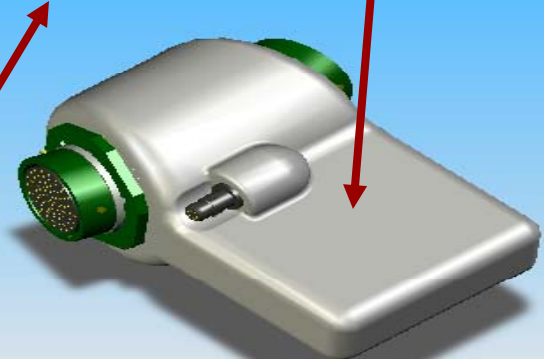
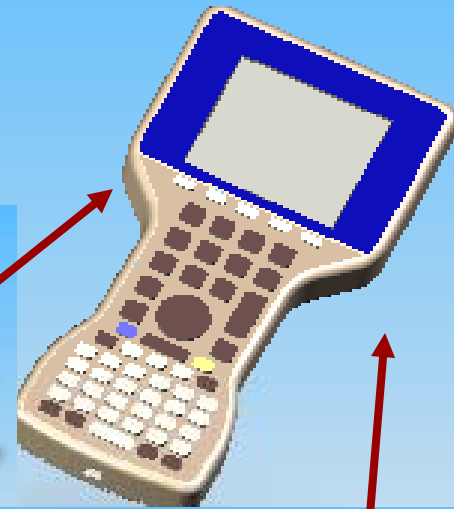
- **Electronic Hardware Form Factor**
- **NonInterference with Aircraft Signals**
- **Realistic Wire Environment**
  - Realistic aircraft loads
  - Controlled / Uncontrolled Impedance Cables
  - Branched Wires
- **Data Collection and Interpretation**



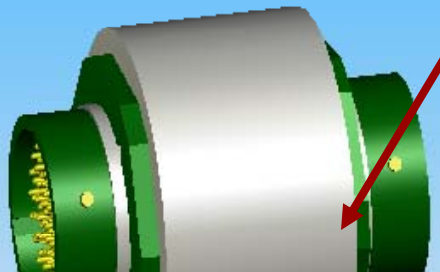
2003



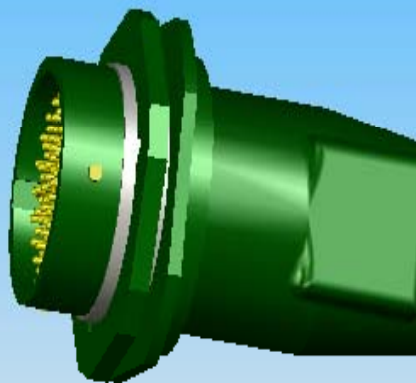
2004-5



2005



2006



2007

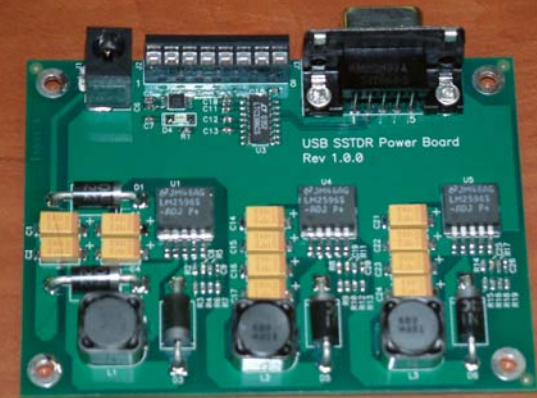
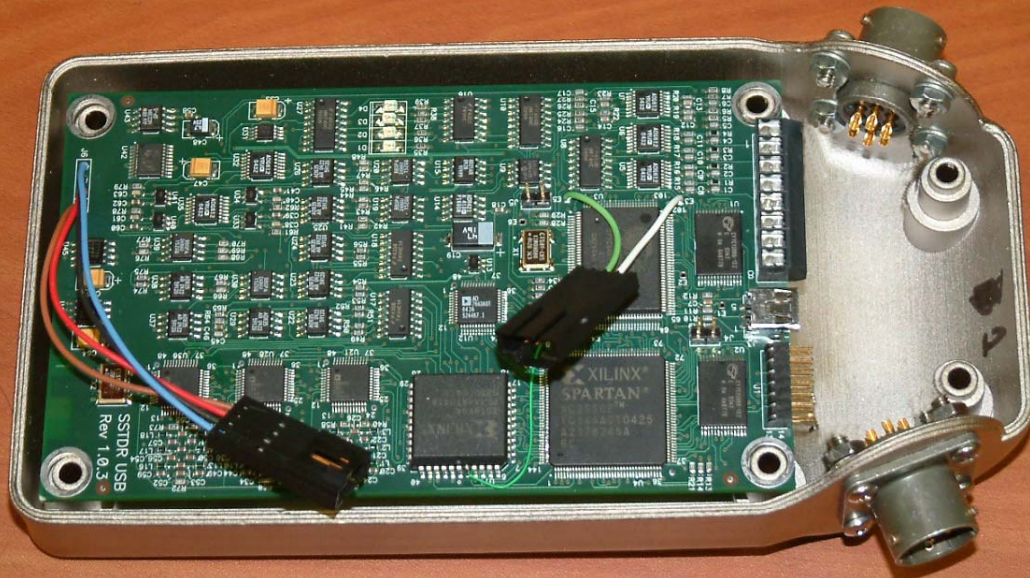


Livewire & Minnesota  
Defense

**LiveWire**  
Test Labs, Inc.

# New Board Development

- Preliminary Specs from USAF SBIR Phase I
- First pass hardware from FAA BAA
- Packaging by Minnesota Defense





# Arc Fault Circuit Interrupter Reduces Size of Fault But How can you LOCATE it?



10 A Thermal Breaker Tripped



AFCI Tripped on "Wet Arc"

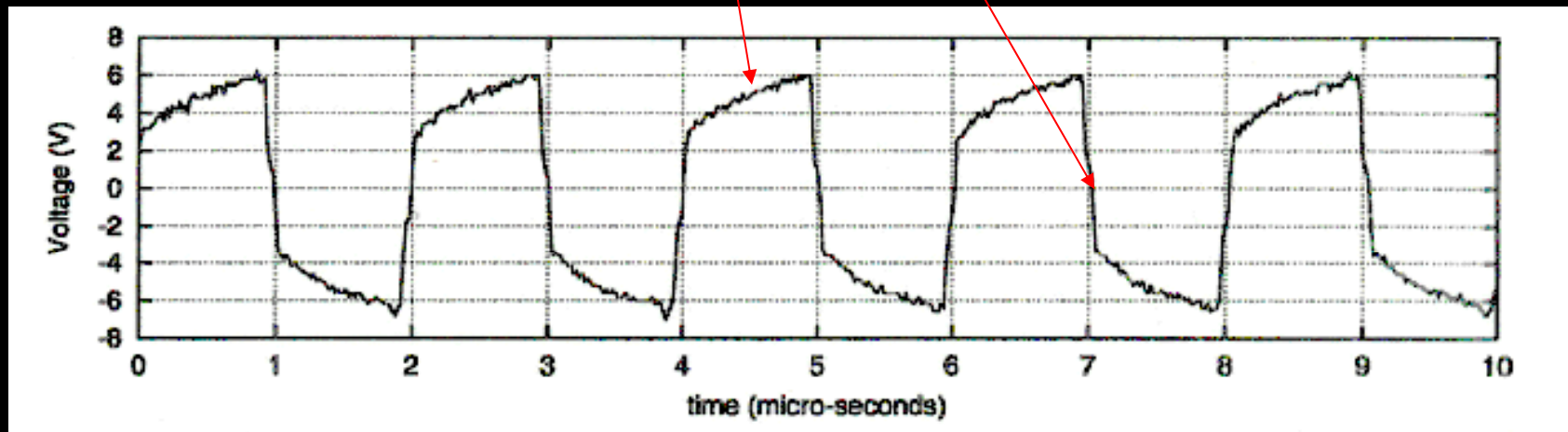
# To Run LIVE:

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- Electronic Hardware Form Factor
- NonInterference with Aircraft Signals
- Realistic Wire Environment
  - Realistic aircraft loads
  - Controlled / Uncontrolled Impedance Cables
  - Branched Wires
- Data Collection and Interpretation

# To Run Live: NonInterference with Aircraft Signals LiveWire S/SSTDR Technology

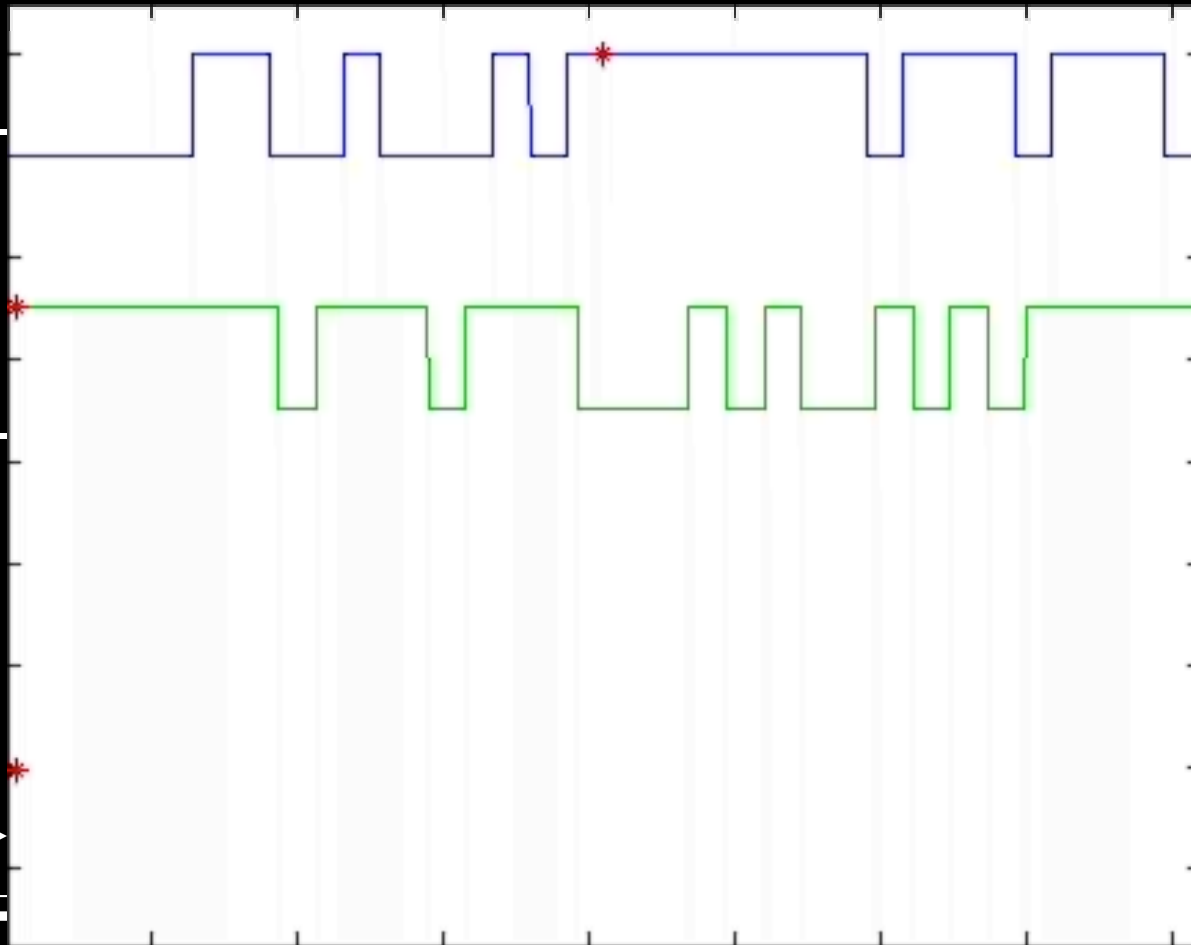
- Superimpose a tiny PN code signal that looks like noise on the existing signal.
- Test LIVE to catch intermittent faults while they are near open or short circuits.



# STDR: Sequence TDR

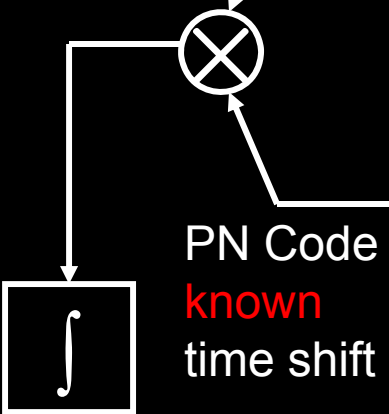
PN Code  
unknown  
time shift

PN Code  
known  
time shift

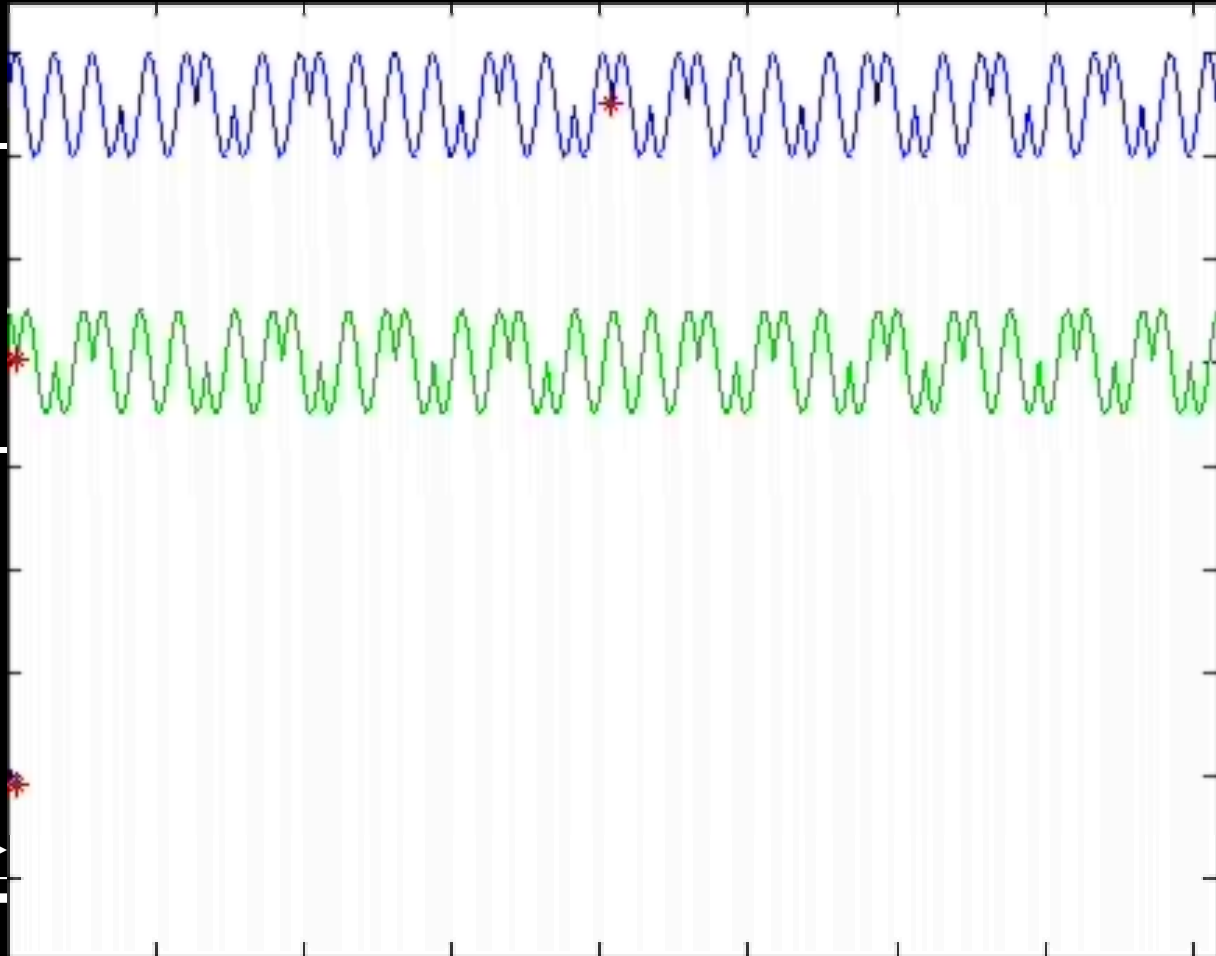


# SSTDR: "Super Stealthy TDR"

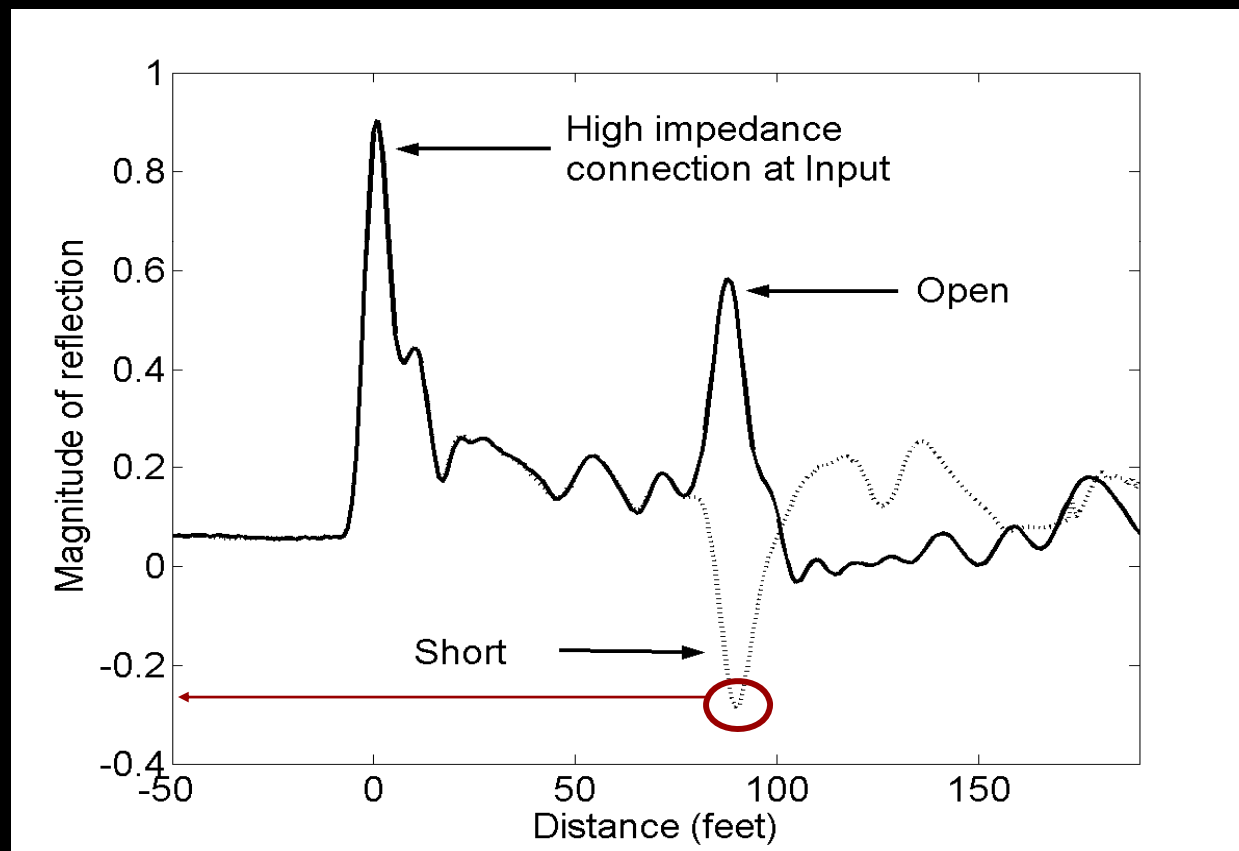
PN Code  
unknown  
time shift



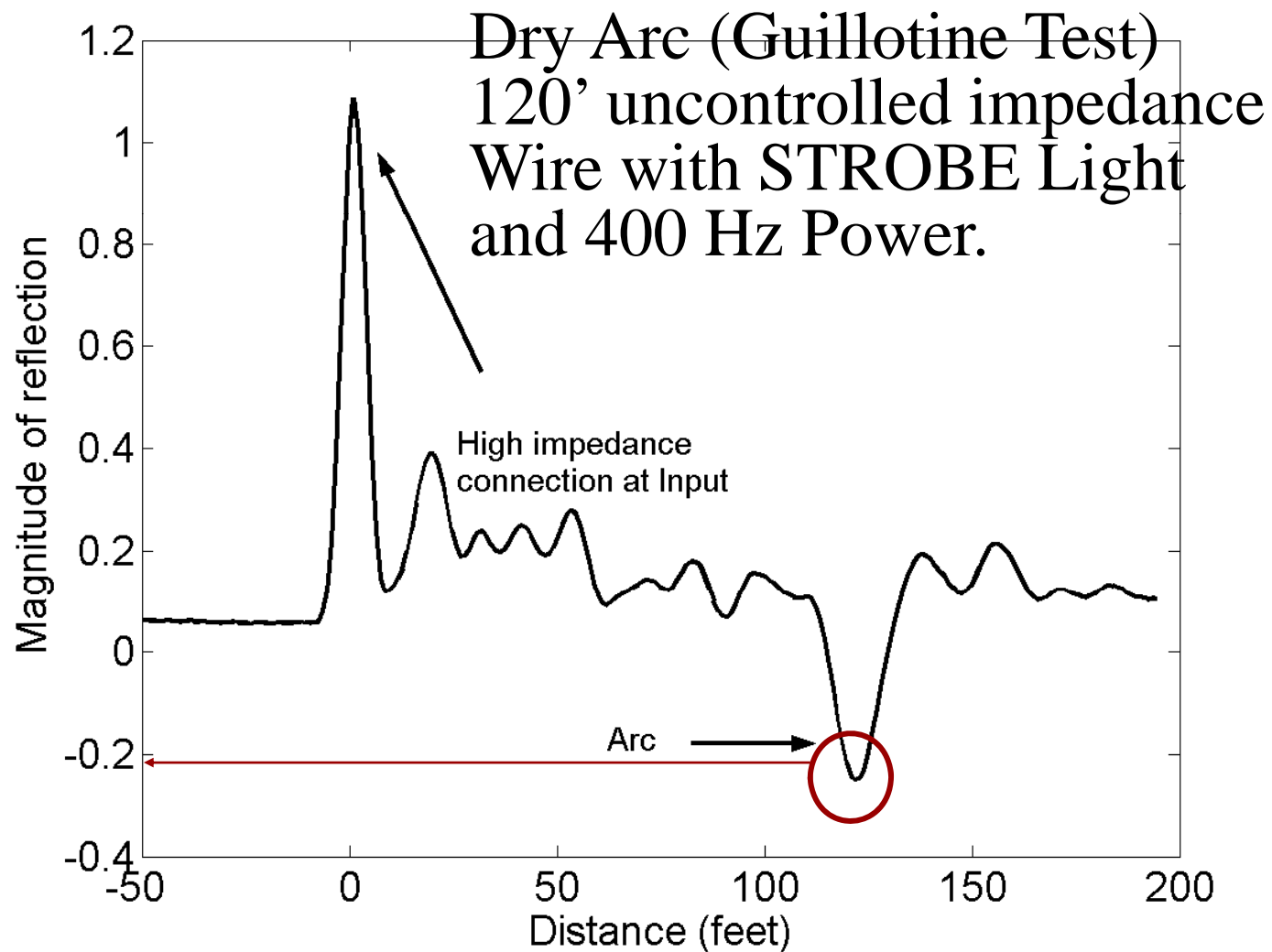
PN Code  
known  
time shift



# STDR



# To Run LIVE: Realistic Aircraft Loads



# To Run LIVE:

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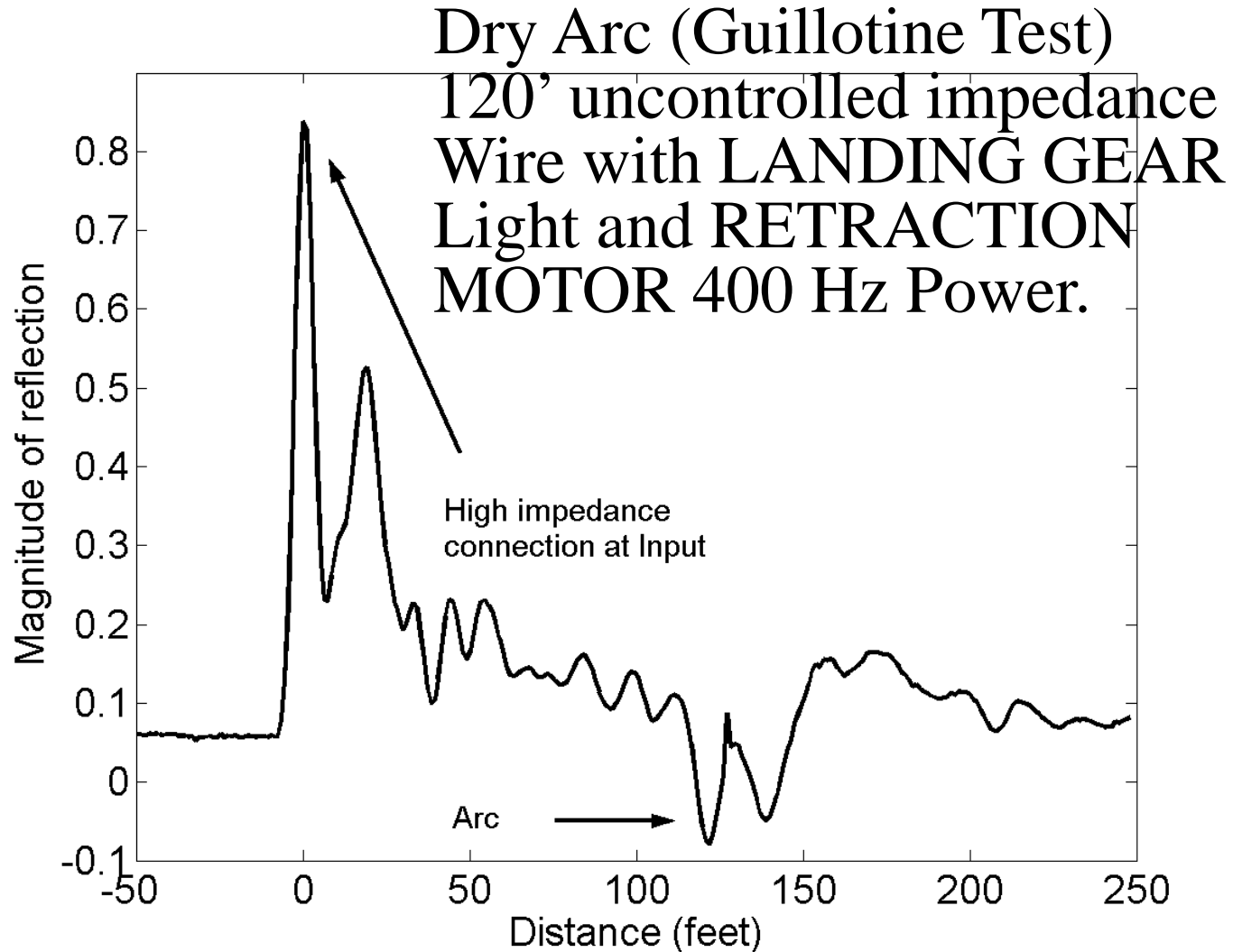
- Electronic Hardware Form Factor
- NonInterference with Aircraft Signals
- **Realistic Wire Environment**
  - Controlled / Uncontrolled Impedance Cables
  - Realistic aircraft loads
  - Branched Wires
- Data Collection and Interpretation



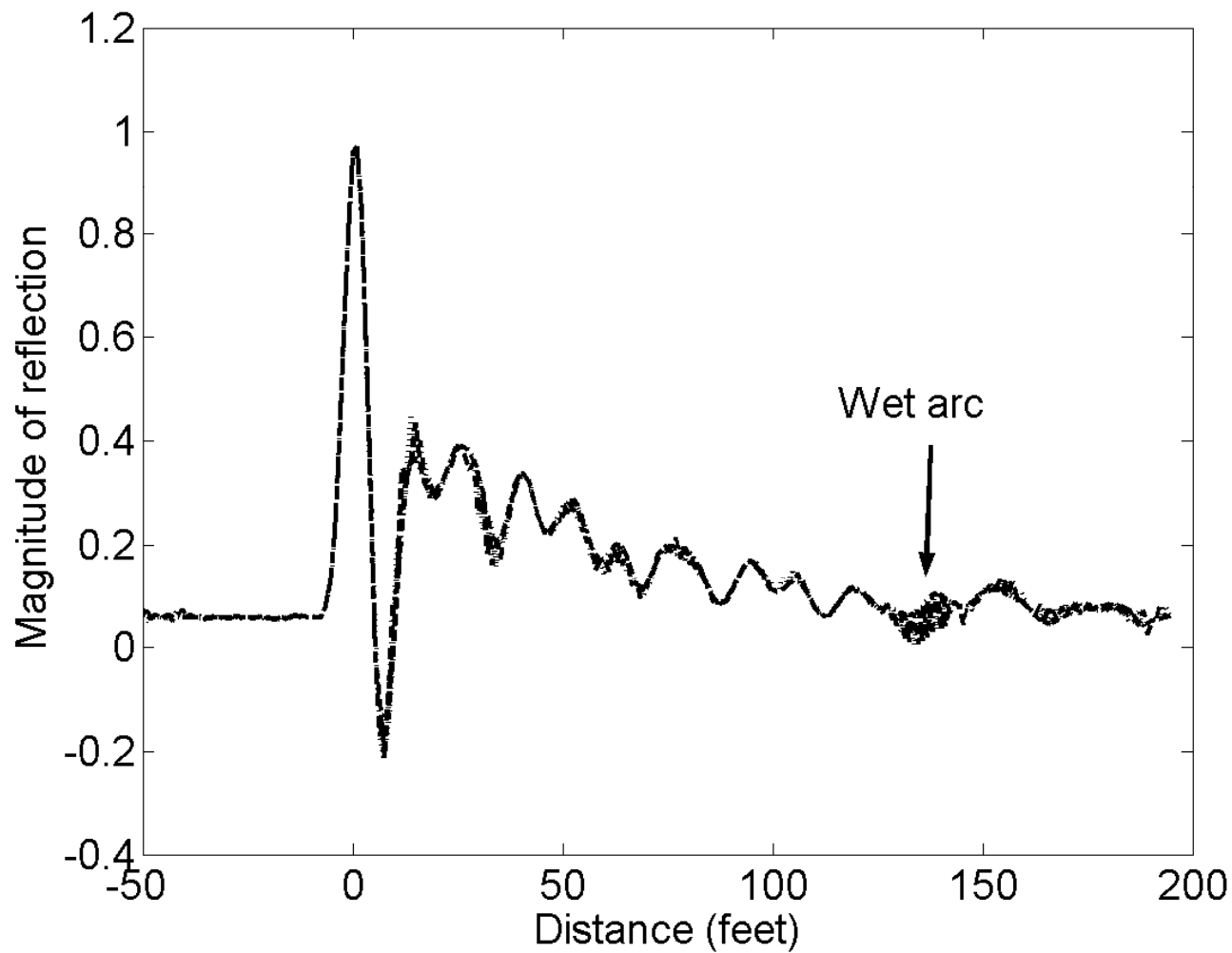
# Uncontrolled Impedance Cable



# To Run LIVE: Realistic Aircraft Loads

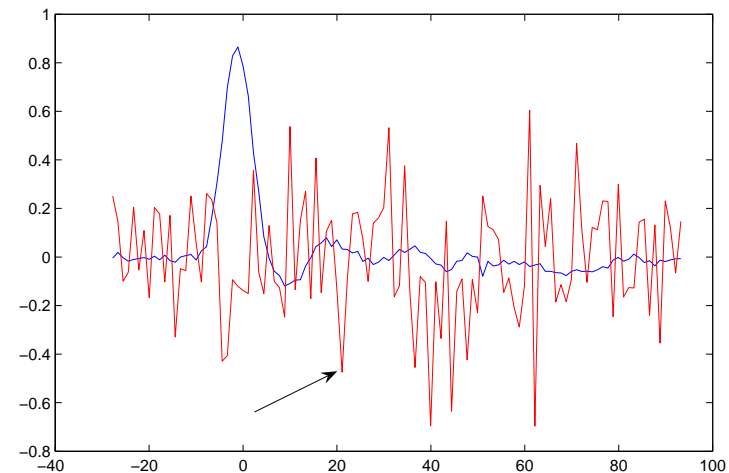


# To Run LIVE: Wet Arc

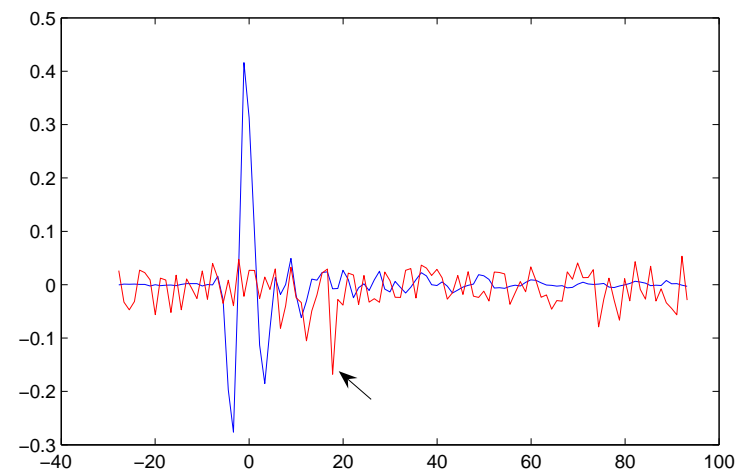


# Tests in Presence of Noise

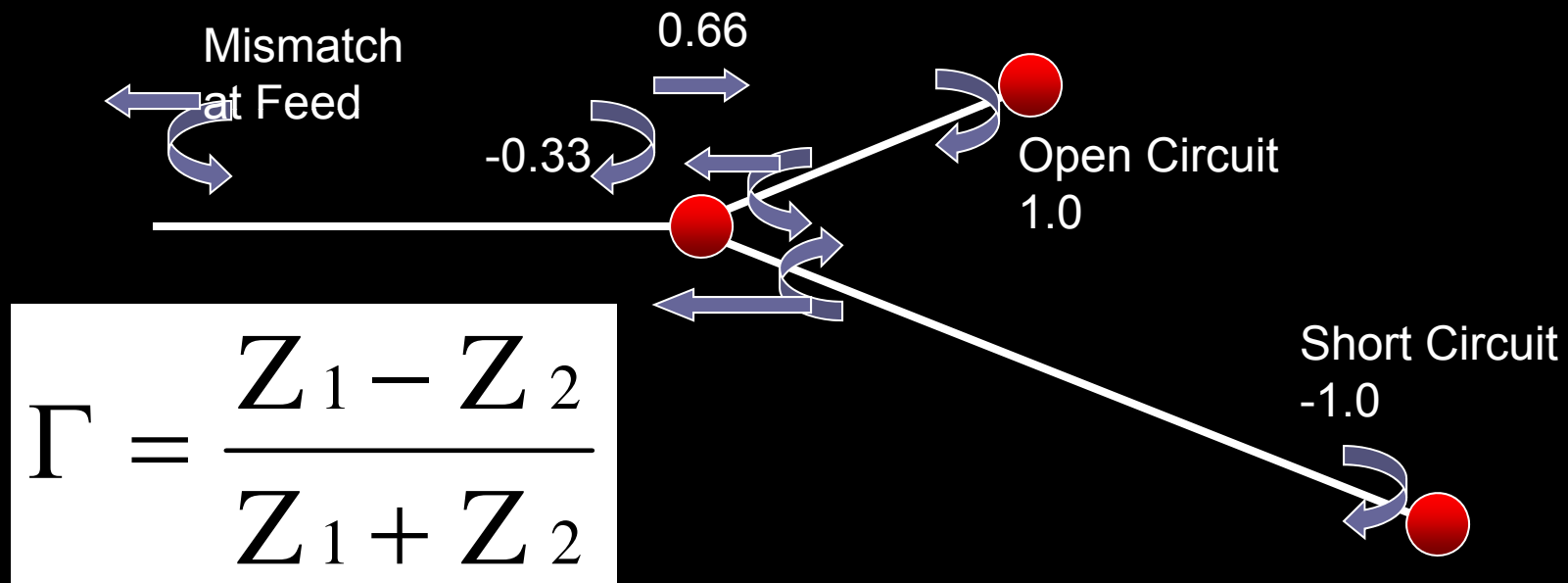
STDR test with fluorescent lamp at 60 Hz, arc test with branched network, arc at end of 12 ft branch. Test with slow hardware catches part of arc.



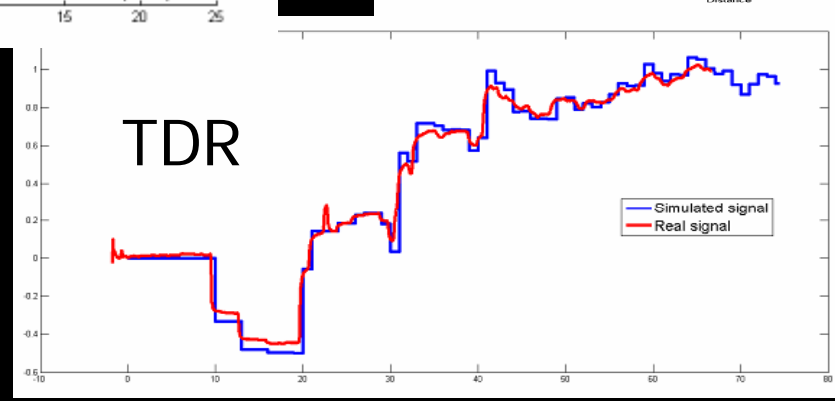
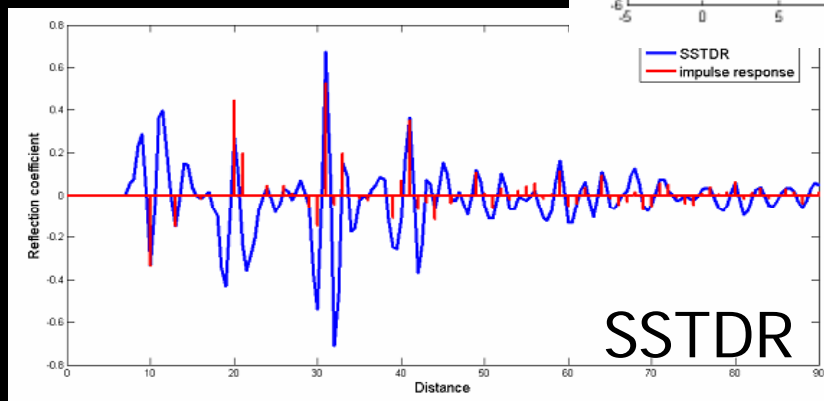
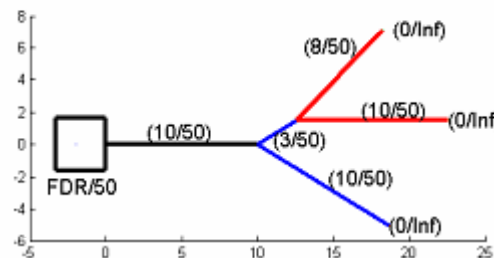
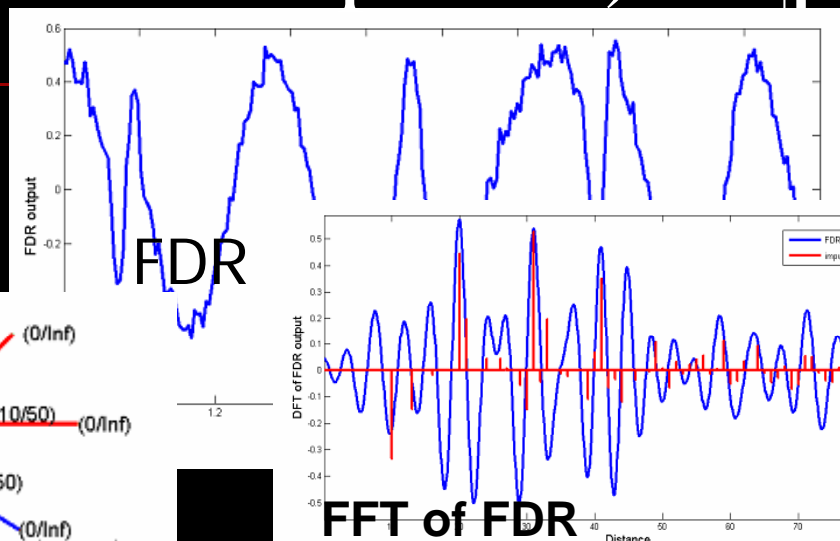
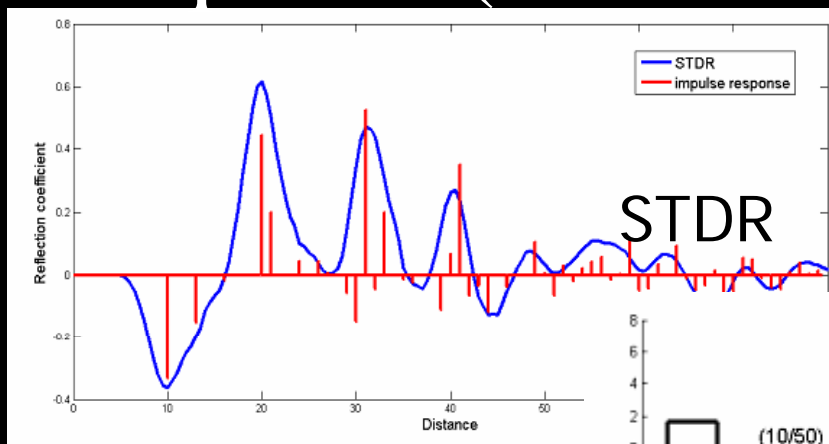
SSTDR test with fluorescent lamp at 60 Hz, arc test with branched network, arc at end of 8 ft branch. Test with slow hardware catches part of arc.



# To Run LIVE: Must be able to handle BRANCHED Circuits



# Branched Wire Mapping Network Required (under UofU development)

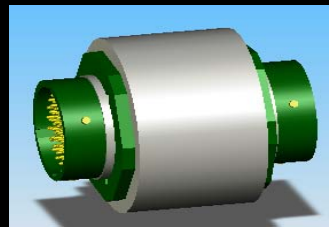


# LiveWire System 2007 Data Acquisition Options

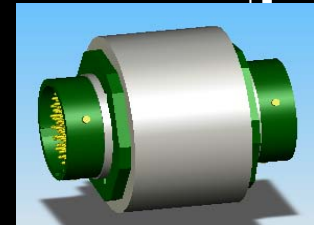
Smart Breakers



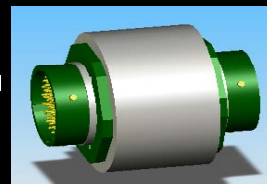
Sensor Placement



Lightning Protection



Comm Link



Connectors

Branched Networks



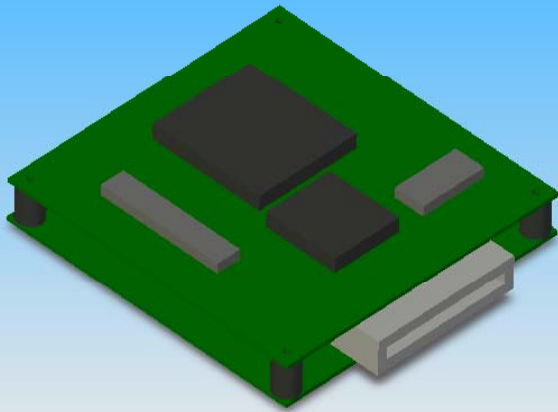
Handheld / GUI

# To Run LIVE:

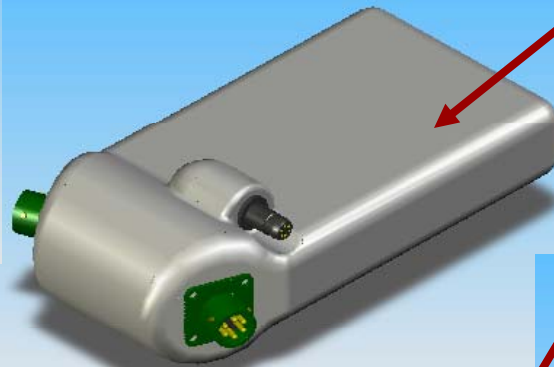
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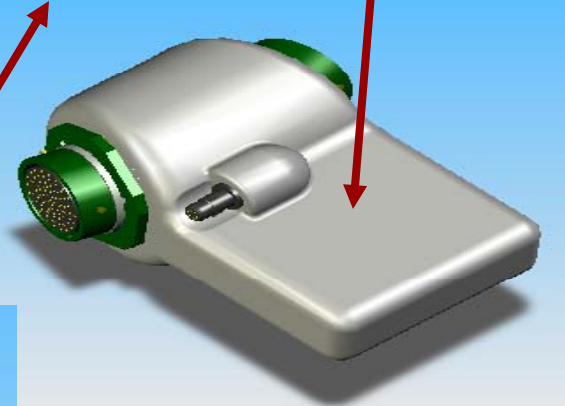
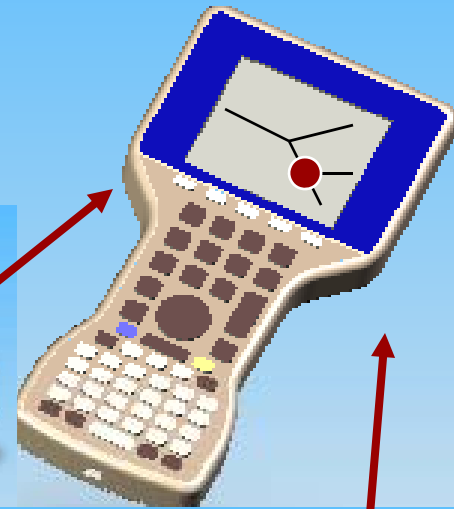




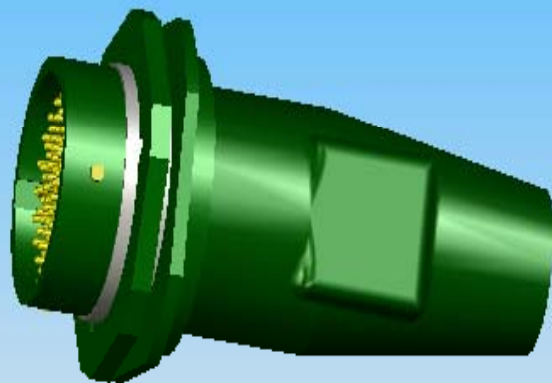
2003



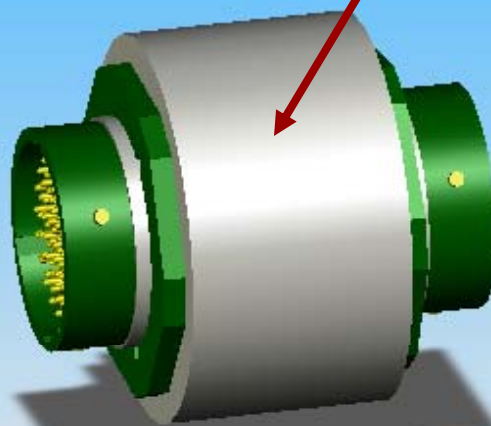
2004-5



2005



2007



2006

LiveWire

**LiveWire**  
Test Labs, Inc.

# We would like to Thank our Partners



Minnesota Wire & Cable Co.



TEXAS INSTRUMENTS



Juniper Systems, Inc.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TEST LABS, INC.

**Dr. Paul Smith**  
**LiveWire Test Labs, Inc.**  
**PSmith@LiveWireTest.com**



Questions ?

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