Performance Testing of the RJ-45 Connector

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Requirements for a Strain Gauge Connector

- Reliable, rugged construction
- Stable performance in a wide variety of environmental conditions. In particular, contact resistance must remain low and stable, and thermoelectric effects must be minimized.
- Latching
- Easy to terminate
- Low cost of purchase, installation, and maintenance

Key Question - **Does it stay connected**?

- Most important parameter is connector **resistance**, particularly for 1/4 bridge measurements.
- Stability over various environmental conditions:
  - Temperature
  - Humidity
  - Vibration

Test Goals

- Goal was **NOT:**
  - To thoroughly characterize all electrical aspects of the RJ-45 connector.
- Goal **WAS:**
  - Determine if connector maintains its integrity through a wide variety of environmental conditions.
  - Characterize actual performance in a typical “real-world” situation; 350 ohm 1/4 bridge configuration.

RJ-45 connector specifications - AMP performance criteria (1)

- AMP document 108-1163 (spec) and 501-91 (test report)
  - Available on AMP web site (www.connect.amp.com)
- General criteria for all tests:
  - 40 connectors
  - Resistance change < 30 mOhms

RJ-45 connector specifications - AMP performance criteria (2)

- Temperature
  - 25 cycles of -40 degC to +60 degC;
  - 1 minute transition, 30 minute dwell at temperature
  - 1 day total test time
- Humidity
  - 10 cycles of +4 to +60 degC, 95% RH.
  - 24 hours/cycle (10 days total time)

RJ-45 connector specifications - AMP performance criteria (3)

- Vibration
  - 10 Hz to 50 Hz, sinusoid, .06 inch.
    - .62g@10Hz, 15g@50Hz
  - 15 minutes in each of three axes. (45 minutes total)
  - No discontinuities > 1 uSecond
- Durability
  - 750 cycles, mating and un-mating
  - 500 cycles/hour (1.5 hours total time)

RJ-45 connector specifications - AMP performance criteria (4)

- Pull
  - Cables, w/ plugs attached, loaded with 17 lbf, mated to jacks
  - Jacks rotated 45 deg in each direction.

AMP published qualification **results**: (501-91)

- No visible damage to any connectors after all tests.
- Resistance measurement after all tests.
  - All connectors met +/- 30 mOhm spec
  - Average resistance change was 1-3 mohms
  - Max-min changes were typically +/-15 mohms; up to 29 mOhms (largest change after thermal shock)

Hewlett-Packard's Testing (1)

- R&D lab temperature test
  - +25 degC to + 85 degC; 8 hours at +85 degC
- Standard Class B environmental test regime
  - Temperature
    - -5 degC to +60 degC over 2 day period
  - Humidity
    - 40 degC/95% R.H. for 5 days.

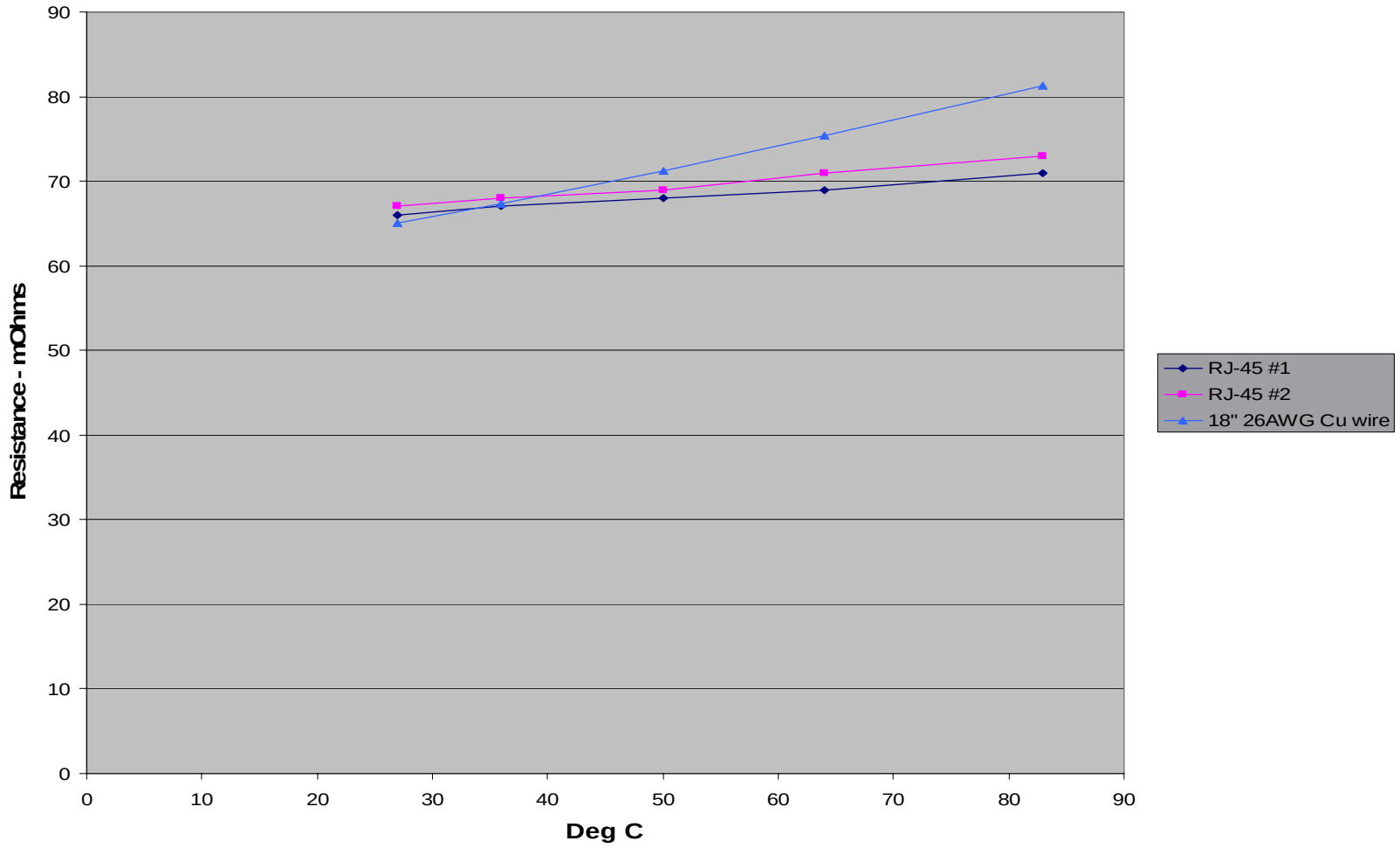
Hewlett-Packard's Testing (2)

- Standard Class B environmental test regime (cont)
  - Vibration
    - 1 hour lo-level random (.2g RMS)
    - 30 minutes swept sine (5-500 Hz, .5g RMS), 5 minute dwell at resonances.
    - 15 minutes hi-level random (2g RMS)
    - Cables unsupported during test to maximize connector vibration and stress.

Test Results - R&D lab temperature test

- +25 to +85 deg C
  - 5.7 mohm change over 25-85 deg C range
  - 65 mohm nominal resistance – includes ~ 6 inches of #26 AWG lead wire. (lead wire accounts for 20 of the 65 mOhms)
  - .15%/deg C resistance change – about 40% of the tempco of copper wire.

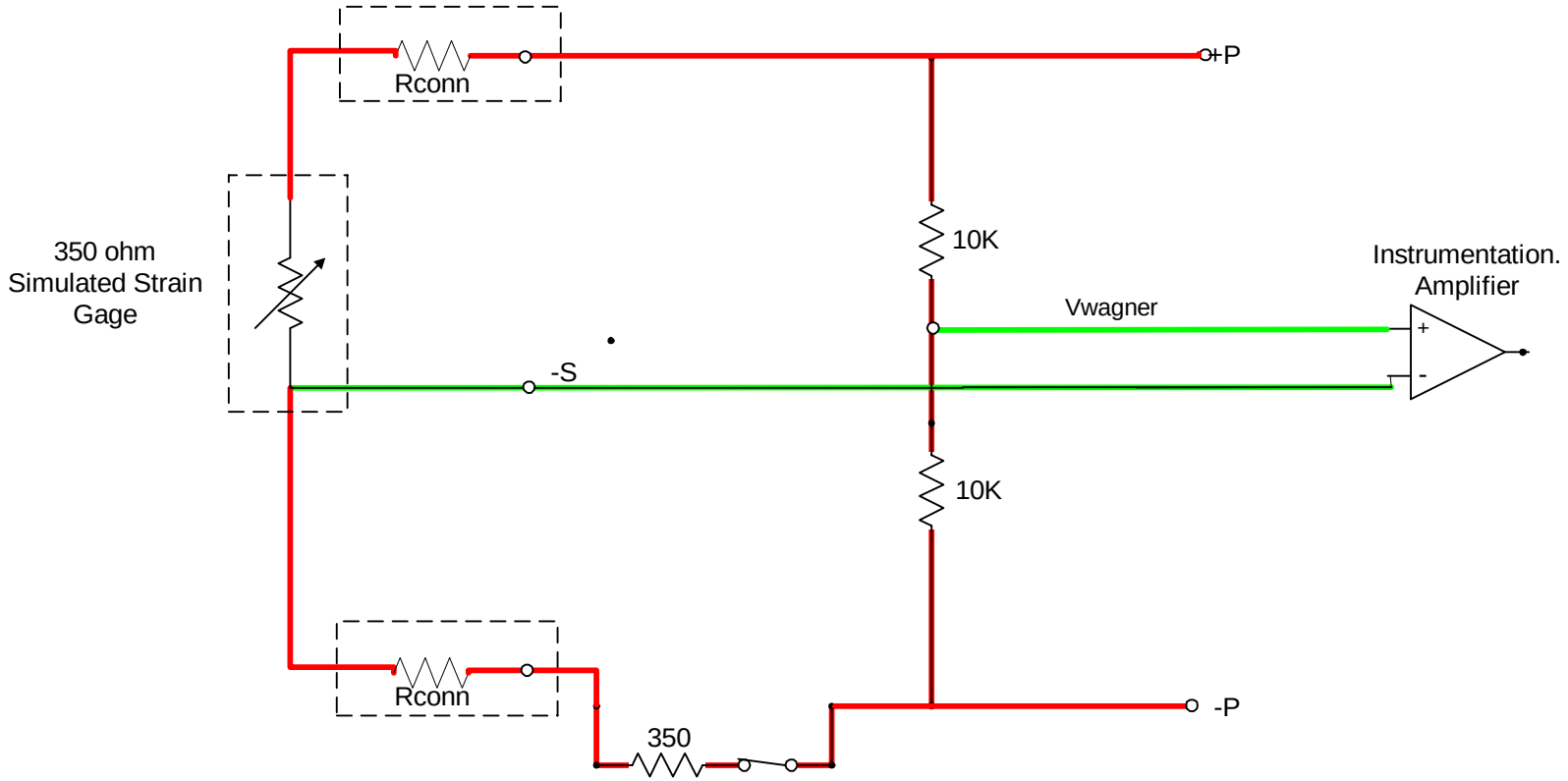
RJ-45 Resistance vs Temperature



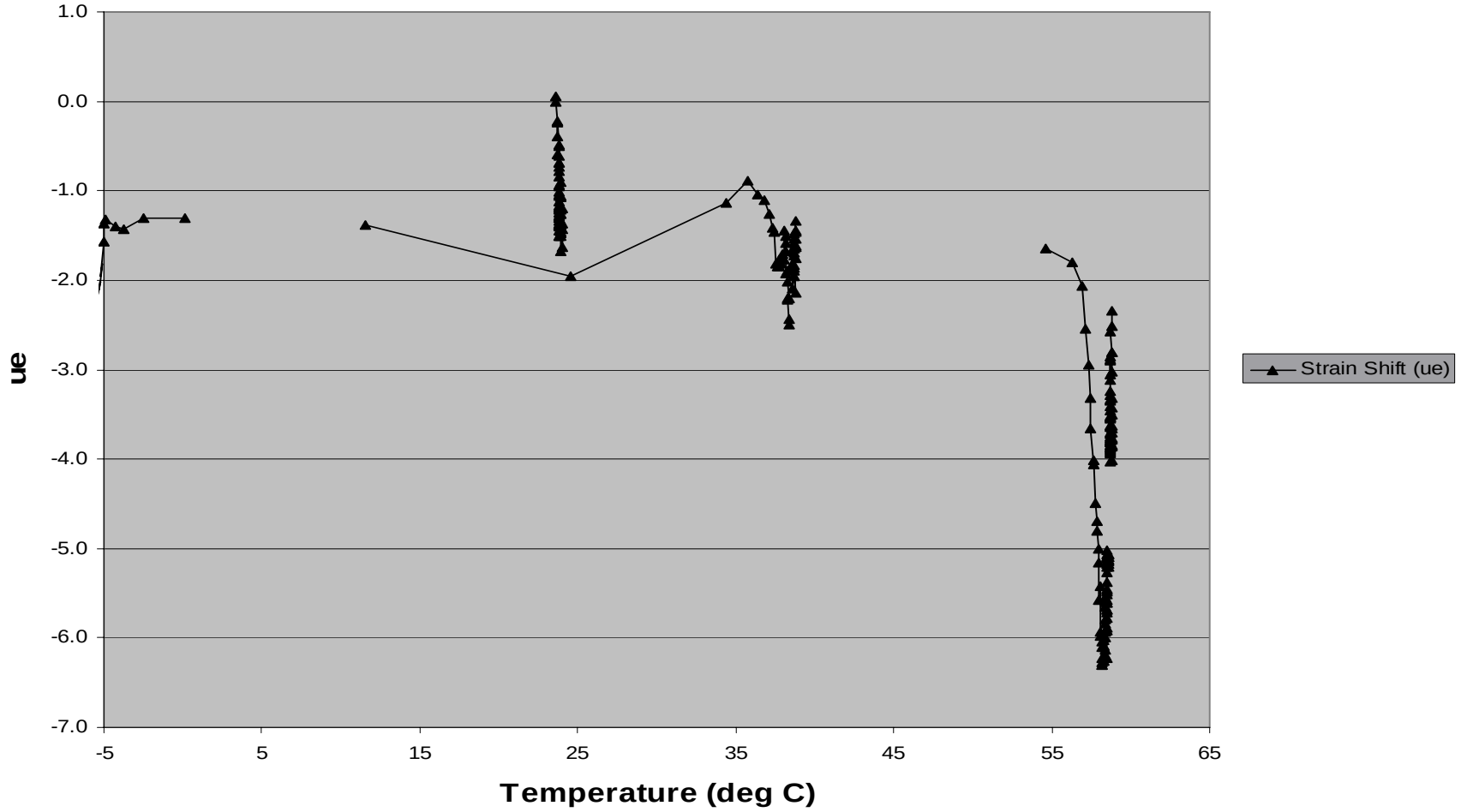
Test Results - Environment lab temperature test

- -5 to +65 deg C
- Connector configured as a 350 ohm 1/4 bridge
  - < 6 ue apparent strain shift over temperature range
  - Equivalent delta resistance change < 4.2 mOhms

Test Configuration - Simulated 350 ohm 1/4 bridge



Apparent Strain Shift vs Temperature



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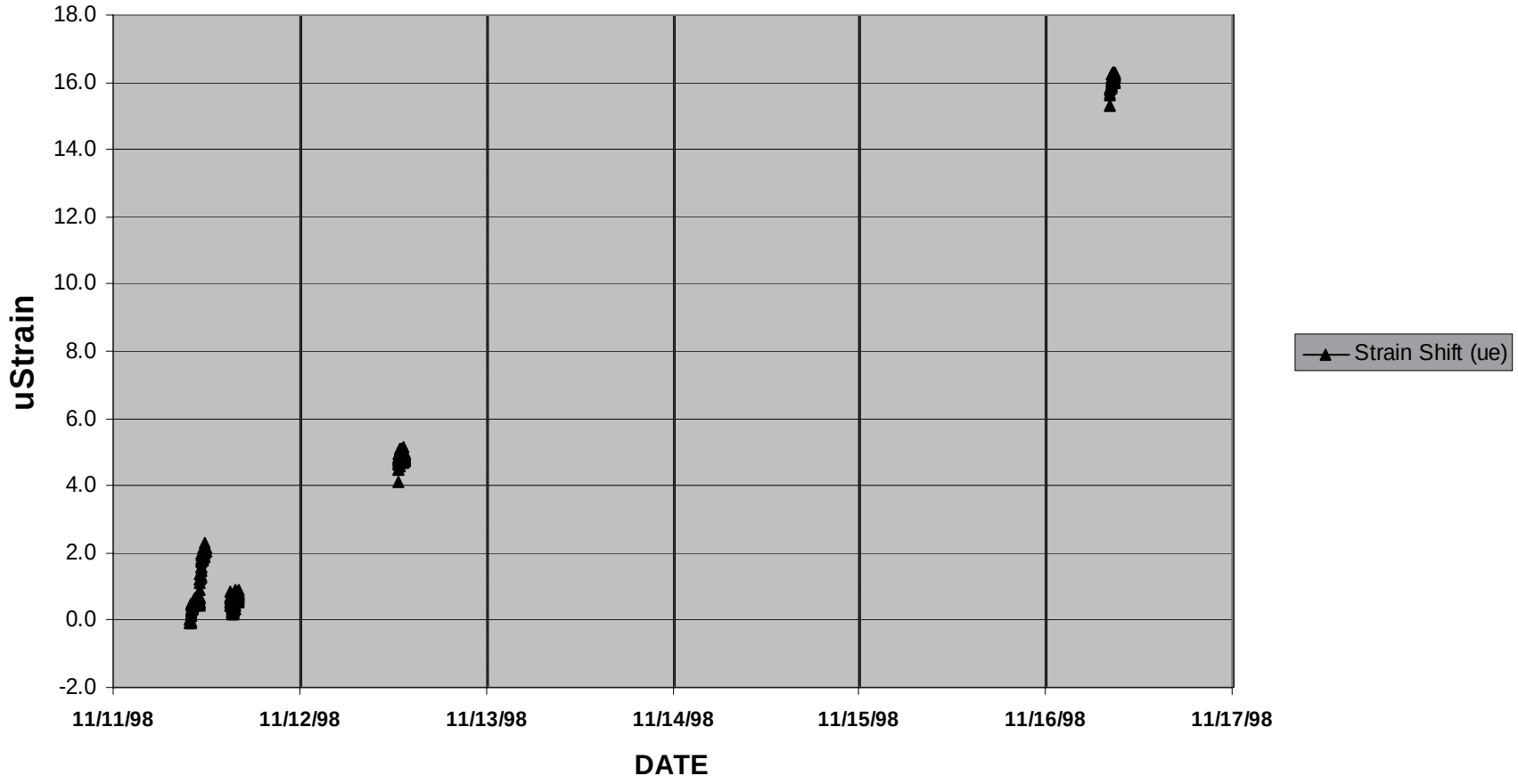
Test Results - Humidity

- 5 days, 40degC/95% R.H.
- Connector configured as a 350 ohm 1/4 bridge
  - ~ 16 ue shift over 5 days; equivalent to ~ 10 mhom resistance change.
  - Believed to be caused by Wagner voltage shift

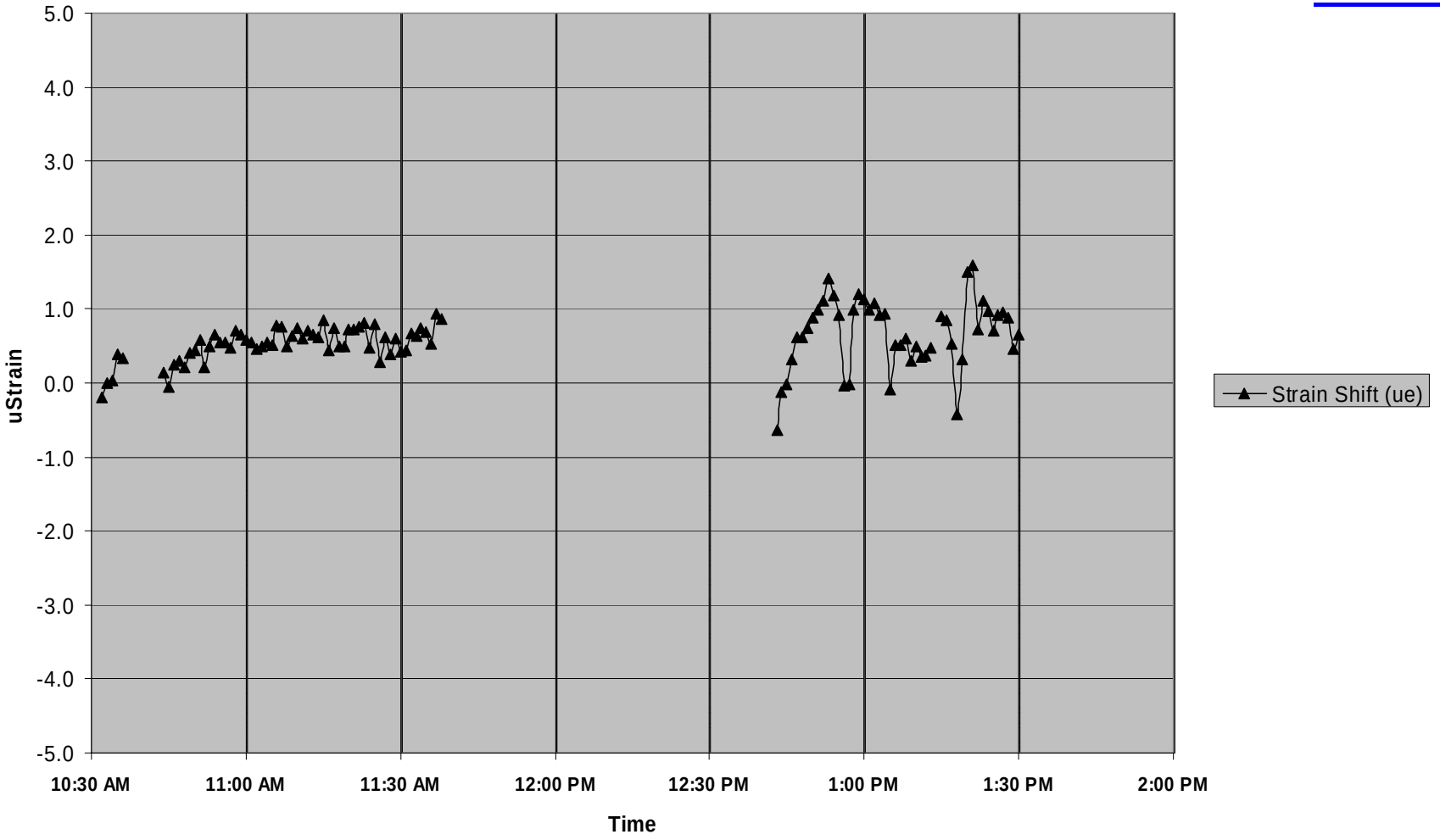
Apparent Strain Shift vs. Humidity



Test Results - Vibration

- Tests done AFTER 5 days in humidity
  - Opportunity for corrosion
- Connector configured as a 350 ohm 1/4 bridge
  - Lo level vibration - readings varied < 1 ue
  - Hi level vibration - readings varied -.5/+1.5 ue (2ue P-P)
  - Equivalent resistance change .35-1.2 mOhm

Apparent Strain Shift vs Vibration



Test Results - the “Wiggle Factor”

- RJ-45 connectors allow some motion between the mating parts, even when fully seated and locked.
  - Tested 4 different connectors, connected as 350 ohm 1/4 bridge.
  - Typical strain reading changed 2-3 ue as connector is moved; maximum was 5 ue, tends to return to original value after several seconds.
  - Equivalent resistance change 1.4-3.5 mOhms.

Conclusions:

- Based on our tests, the RJ-45 demonstrates:
  - Stable and predictable contact resistance over temperature
  - Stable contact resistance even in moderate to severe vibration
  - Lo sensitivity to the effects of humidity

Recommendations for use:

- Buy good quality connectors; gold-plated. They're not expensive, so don't cut corners here.
- Minimize strain and vibration of the connector by properly securing the cables. Cable management hardware is available from the telecom industry; see your local IT telecom closet.
- Get a good tool for attaching the plugs to the cables.
- Use the long strain-relief boots with the latch protector.
- Don't step on the plugs; you can damage the plastic "fins" between the connector fingers, and cause connection problems. The good news: a damaged connector is cheap and easy to replace.