# EB2014-SP-002 NEW PERFORMANCE IN CAPACITIVE SENSOR ELECTRONICS FOR HIGH TEMPERATURE DISC BRAKE WEAR TESTING

Manning, Bryan + Foster, Robert L. + Capacitec + Eurosales@capacitec.com + Shanglei Li, Link Engineering + Linkeurosales@linkeng.com

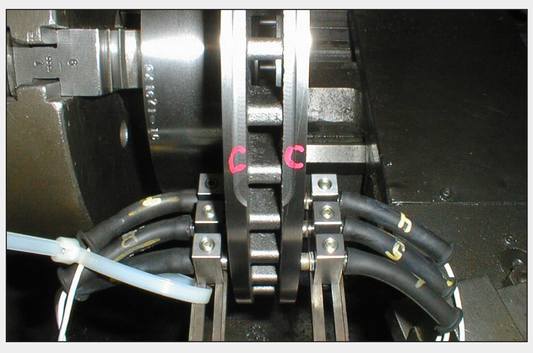
## Abstract/Objective

### OVERVIEW

Testing was performed at Capacitec, Link Engineering and CE test labs to determine the differences between the legacy 4100 non contact displacement measurement system and the new Capteura® 220 and 520 series systems.

Testing was performed at the Capacitec testing laboratory using NIST traceable methods to determine changes in the following performance criteria:

- Signal-to-noise ratio
- % Linearity (accuracy) improvement
- Frequency response improvement
- Amplifier drift
- Resolution
- Static discharge of pre-amp
- Linear range



Three Capacitec non contact HPC-150 probes positioned on both sides of a disc brake dynamometer test fixture

Groove width 7.62 mm
Radius at 10mm off edge: 120 mm

| rpm | rev/sec | Circumference mm | Velocity mm/s | Velocity m/s | Groove Time s | Frequency Hz |
|---|---|---|---|---|---|---|
| 63 | 1.05 | 753.6 | 791 | 0.79 | 0.0096 | 103.8 |
| 100 | 1.67 | 753.6 | 1256 | 1.26 | 0.0061 | 164.8 |
| 160 | 2.67 | 753.6 | 2010 | 2.01 | 0.0038 | 263.7 |
| 250 | 4.17 | 753.6 | 3140 | 3.14 | 0.0024 | 412.1 |
| 400 | 6.67 | 753.6 | 5024 | 5.02 | 0.0015 | 659.3 |
| 630 | 10.50 | 753.6 | 7913 | 7.91 | 0.0010 | 1038.4 |
| 1000 | 16.67 | 753.6 | 12560 | 12.56 | 0.0006 | 1648.3 |
| 1600 | 26.67 | 753.6 | 20096 | 20.10 | 0.0004 | 2637.3 |

Bandwidth testing was performed at Link Engineering with the following details on the live rotational rotor speed

### OBJECTIVE

Disc Brake systems suppliers and OEMs continue to seek improved performance of non-contact sensors used in the dynamic measurement (up to 870°C) of disc brake wear on dynamometers. Improvements sought:

- Reduced noise
- Improved linearity
- Small diameter sensors with large range
- Increased bandwidth
- Less thermal drift
- Compact electronics

Performance data will show typical legacy electronics in comparison to the new family of Capteura® Model 220 and 520 electronic amplifiers.

Results highlighted in this poster will show significant improvement in:

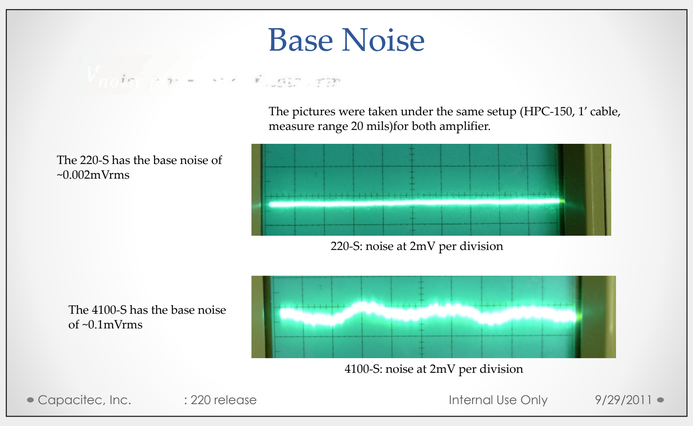
- Signal to noise
- Linearity
- Bandwidth

Capteura® 208 Series modular 8-channel design versus legacy 4008 8-channel system

## Methodology/Results

### SIGNAL TO NOISE

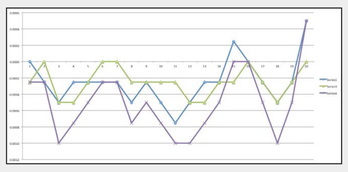
A signal to noise comparison test was performed at Capacitec to show improvements between the 4100-S and new 220-S amplifiers with HPC-150 probes, 1 foot cable and a 0.508mm range.



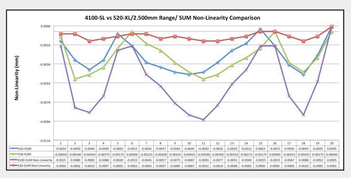

**RESULTS:** These scope plots show a voltage peak-to-peak broadband noise improvement of the Model 220-S compared to a 4100-S with a filtered bandwidth of 200Hz. This improvement ratio will be seen through all bandwidth filter settings.

### LINEARITY

A rigid body rotor motion test was performed at Capacitec to show the affects of standard linearity specifications creating a perceived Thickness Variation under large range conditions. Linearity improvements of the new 520-XL amplifiers versus the standard 4100-SL with HPC-150 probes, 1 foot cable and a 0.508mm range will be compared.



520-XL result




Comparison of 4100-SL & 520-XL

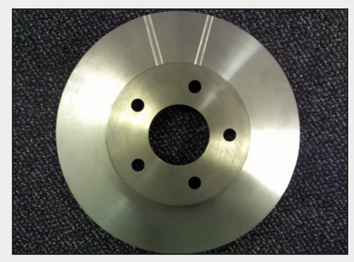
**RESULTS:** The super linearity of the 520-XL amplifier with the a large range of 2.5mm and its small 9.5mm OD sensor eliminates the perceived Apparent Dynamic Thickness Variation (ADTV) due to a +/- 1 mm, Left to Right, Rotor motion.

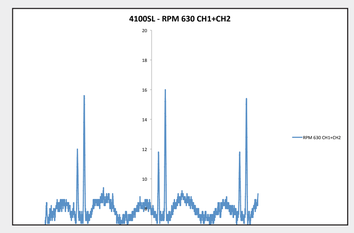
For On-Vehicle applications Model 520 higher linearity improves the ADTV error from large caliper induced rotor movement toward one probe.

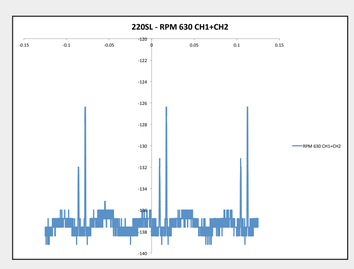
### BANDWIDTH

Model 4100-SL and 220-SL Capacitec amplifiers were tested on a dynamometer station at Link Engineering to observe the effect of frequency bandwidth response on the output attenuation from two discrete steps 0.050mm to 0.100mm deep. Investigation will show the results of a brake rotor at 630 RPM.

Notch Width - 7.82 mm
Notch1 Depth - 0.10mm
Notch2 Depth - 0.05mm






**RESULTS:** Increased amplifier frequency response
Significantly limits output attenuation for Real Time or On-Vehicle testing.

## Conclusions

**Improved amplifier signal to noise ratios allow the User to either increase frequency response or increase the probes safety standoff range without loss of robust RTV or DTV results.**