LVR, a new linear sensor for use in extremes of temperature, radiation, chemical and other harsh environments, better performance than an LVDT and it's output is stable to <3 ppm/degree C.

Sensors Converge

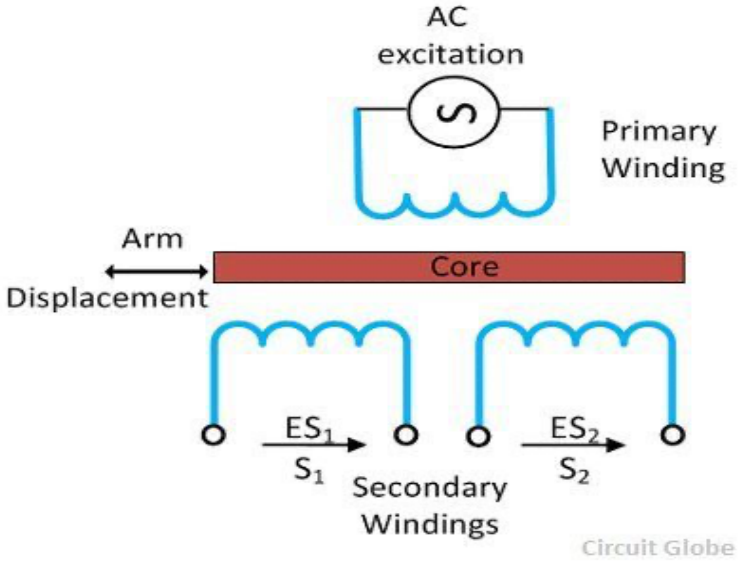
LVR, a Temperature Independent Alternative to LVDT's in Harsh Environments

June 20–22, 2022 | Santa Clara, CA

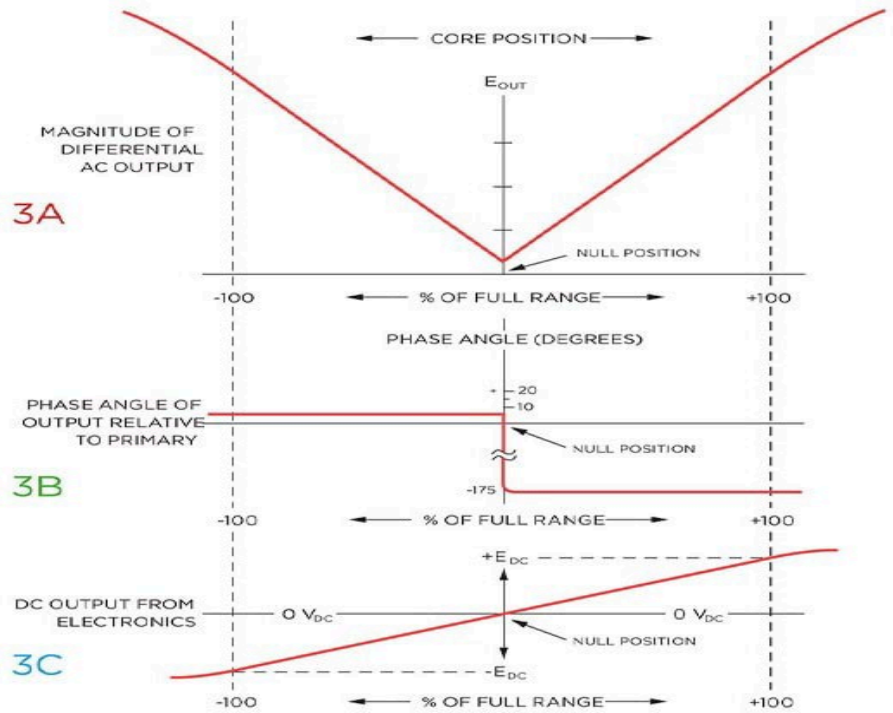
#SensorsConverge

Current method for measurements in Harsh Environment

LVDT (Linear Variable Differential Transformer History of 200 years and Michael Faraday



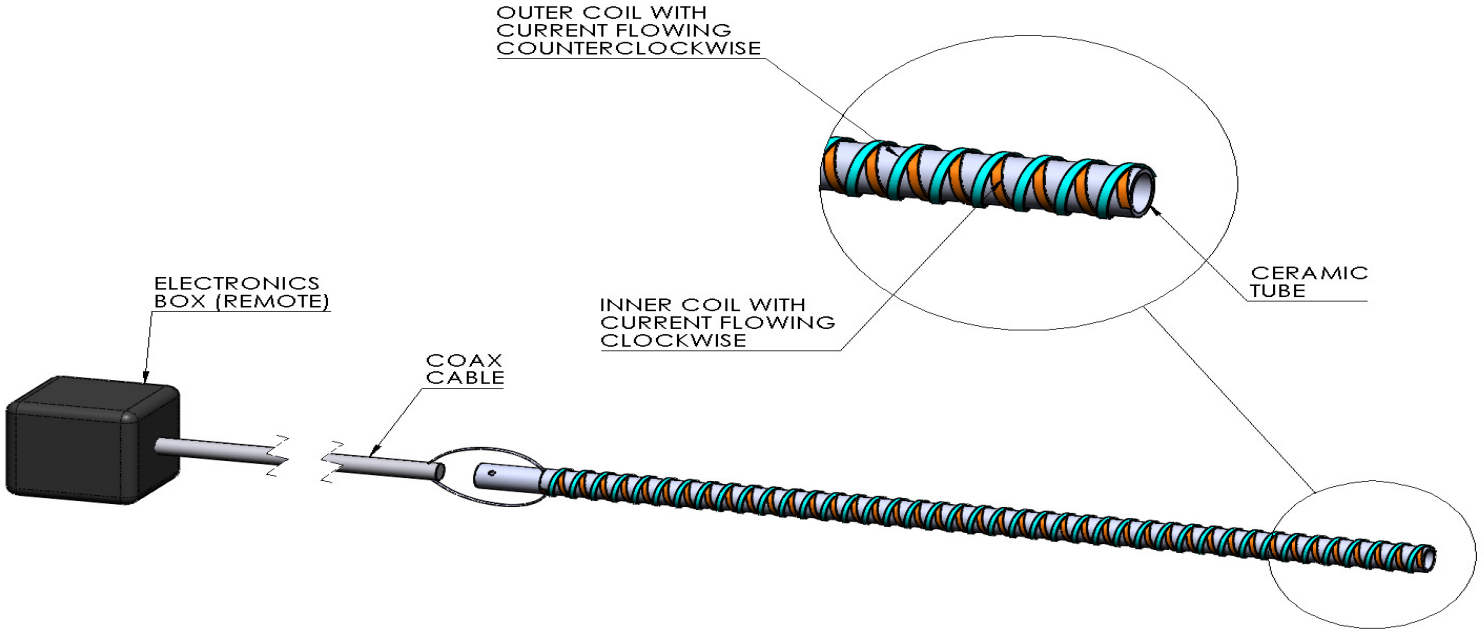
Electronics is located away from Harsh Environment Requires 6 wires, 2 for each coil



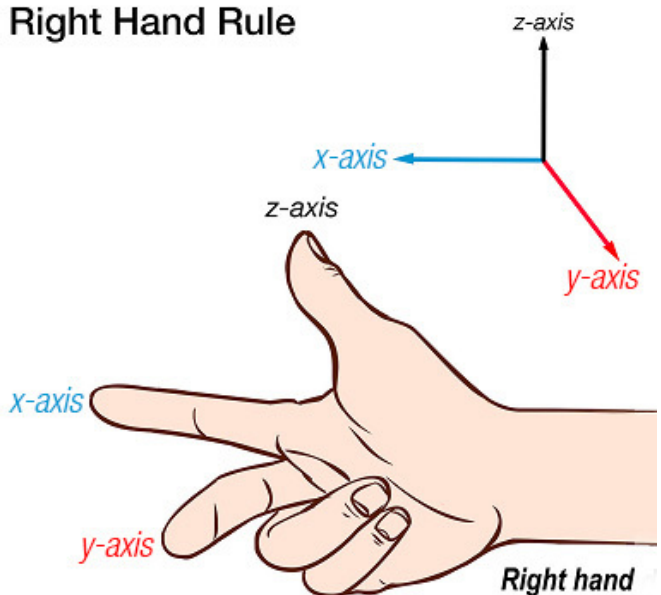
Performance Specs for LVDT

- Accuracy at Null Point: 0.25% Full Scale
- Resolution at Null Point : 0.1% Full Scale
- Temperature stability at Null Point : 50ppm/Degree C
- Operational temperature -55 to 200 C

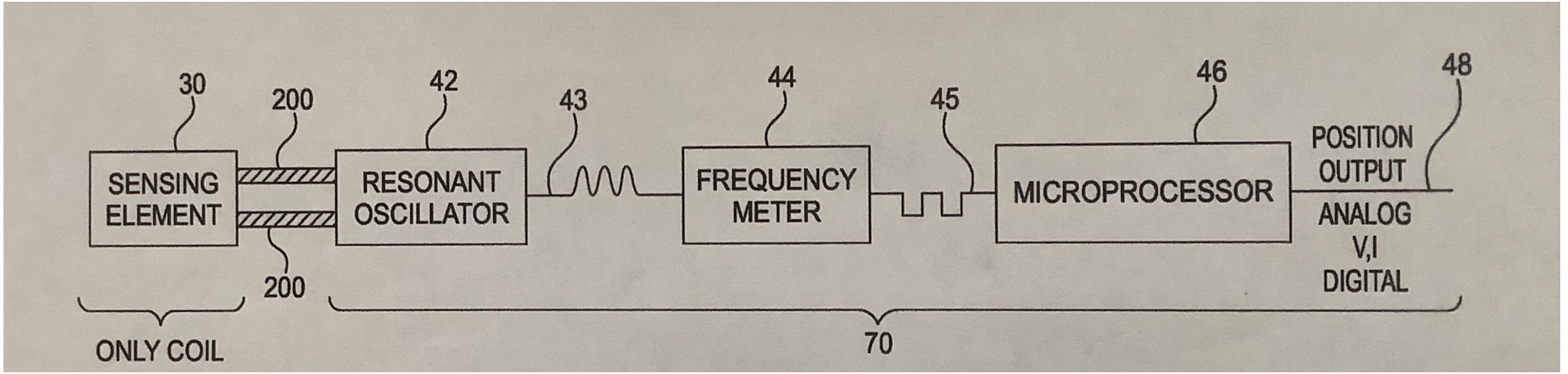
LVR (Linear Variable Resonance) Sensor Electronics located outside Harsh Environment



X axis is magnetic field
Z axis is electric field
Curled fingers are direction of current flow
Magnetic fields of the two coils cancel but Electric fields add



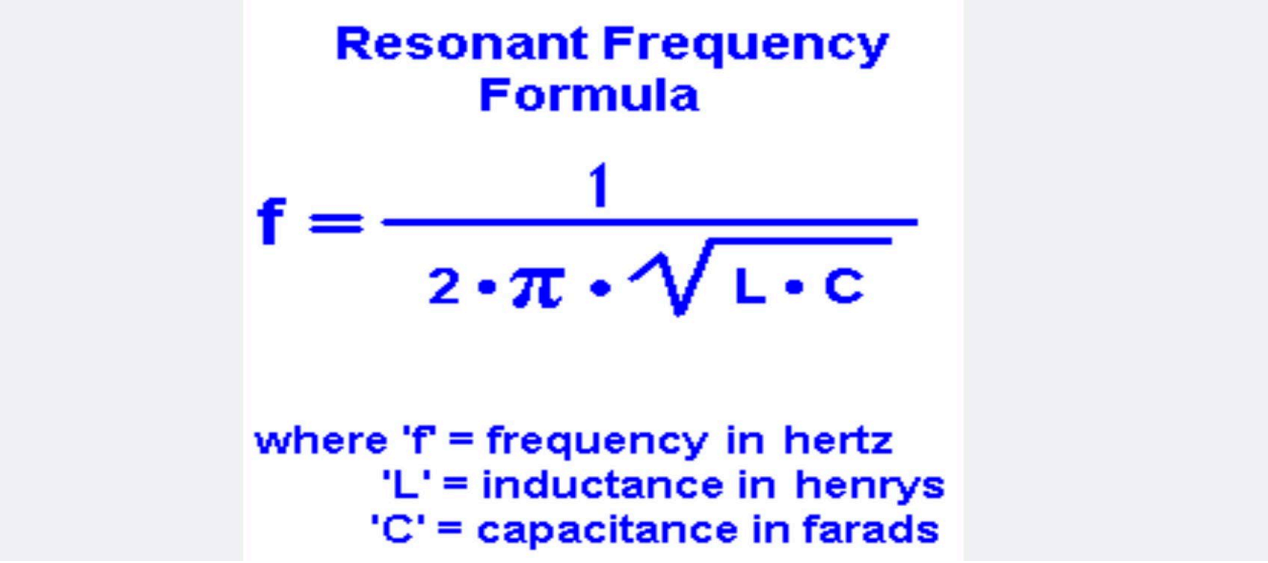
200 refers to the coax cables between the coil and the electronic box



Frequency formula depends on inductance (L) and capacitance (C) but not Resistance

Signal amplitude does change with temperature and could be a rough temperature sensor

Signal output is digital not analog

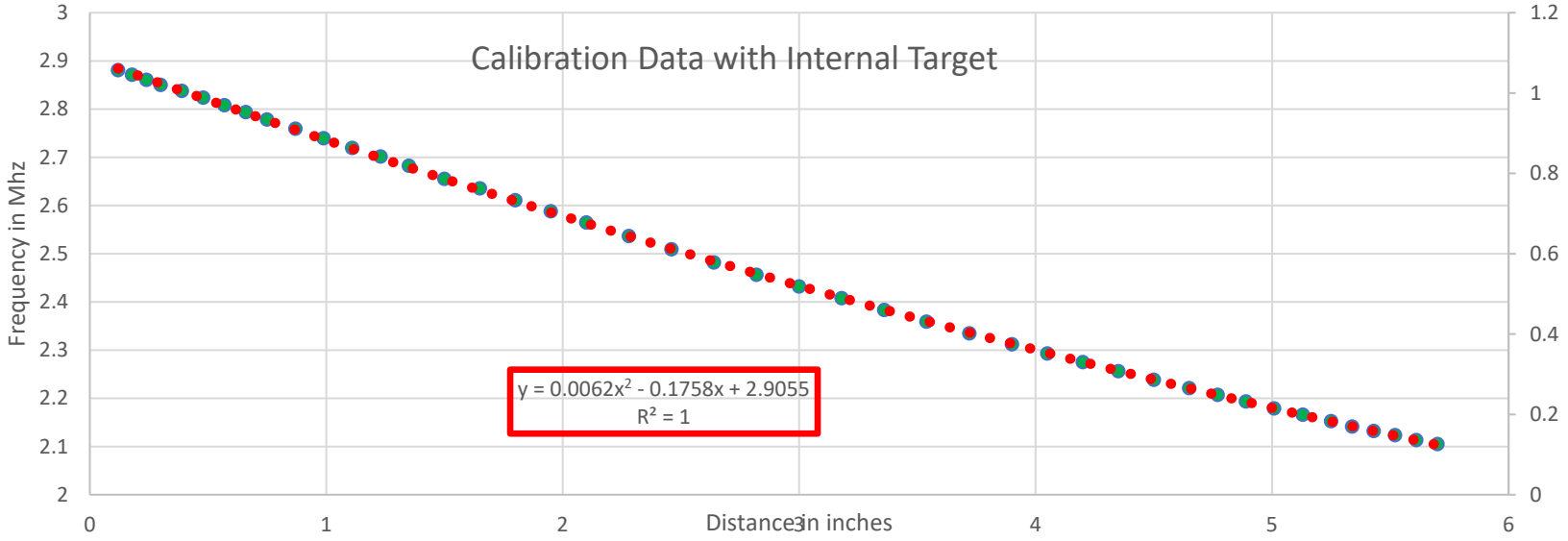


Electric Fields are short range

The long range magnetic fields are cancelled. Only short range remains.

Frequency output is mapped against a calibrated source producing the results below

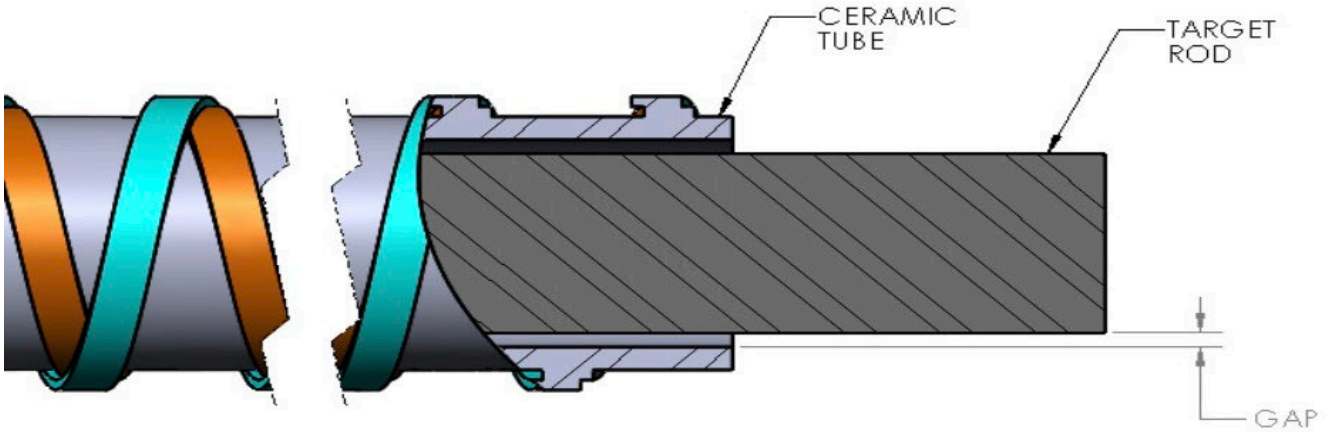
Perfect quadratic fit allows full calibration with only three data points
Note the large change in easily measured frequency



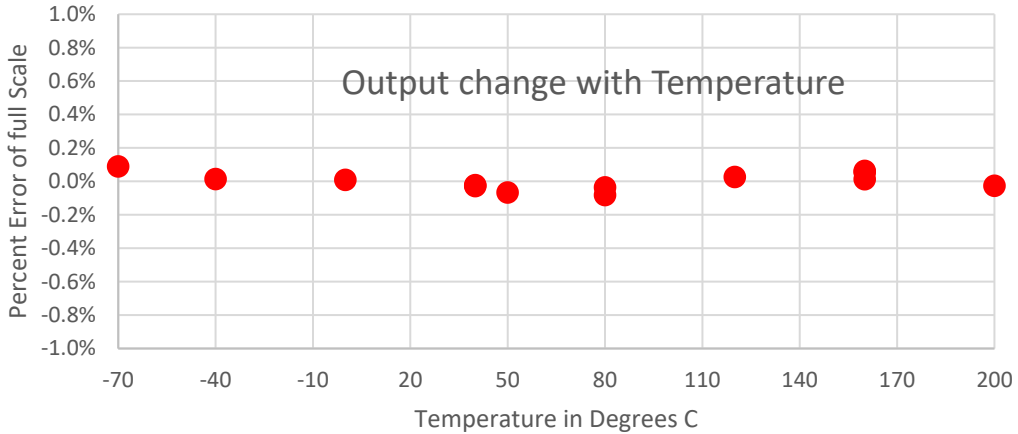
Frequency change is measured by a frequency meter with a 1 hertz resolution out of a minimum change of 500 Khz
Accuracy is currently 0.1% FS will improve to 0.01%
Resolution is 0.01% FS will improve to 0.001%
Temperature range -70 C to 200 C
rated for 450 C but are awaiting new oven to test
Using Refractory metals could raise rating to >1000 C
Remaining small temperature effect is due to mechanical expansion (or contraction) of physical components

Gap change between coil and target rod does change frequency and gives small temperature effect.

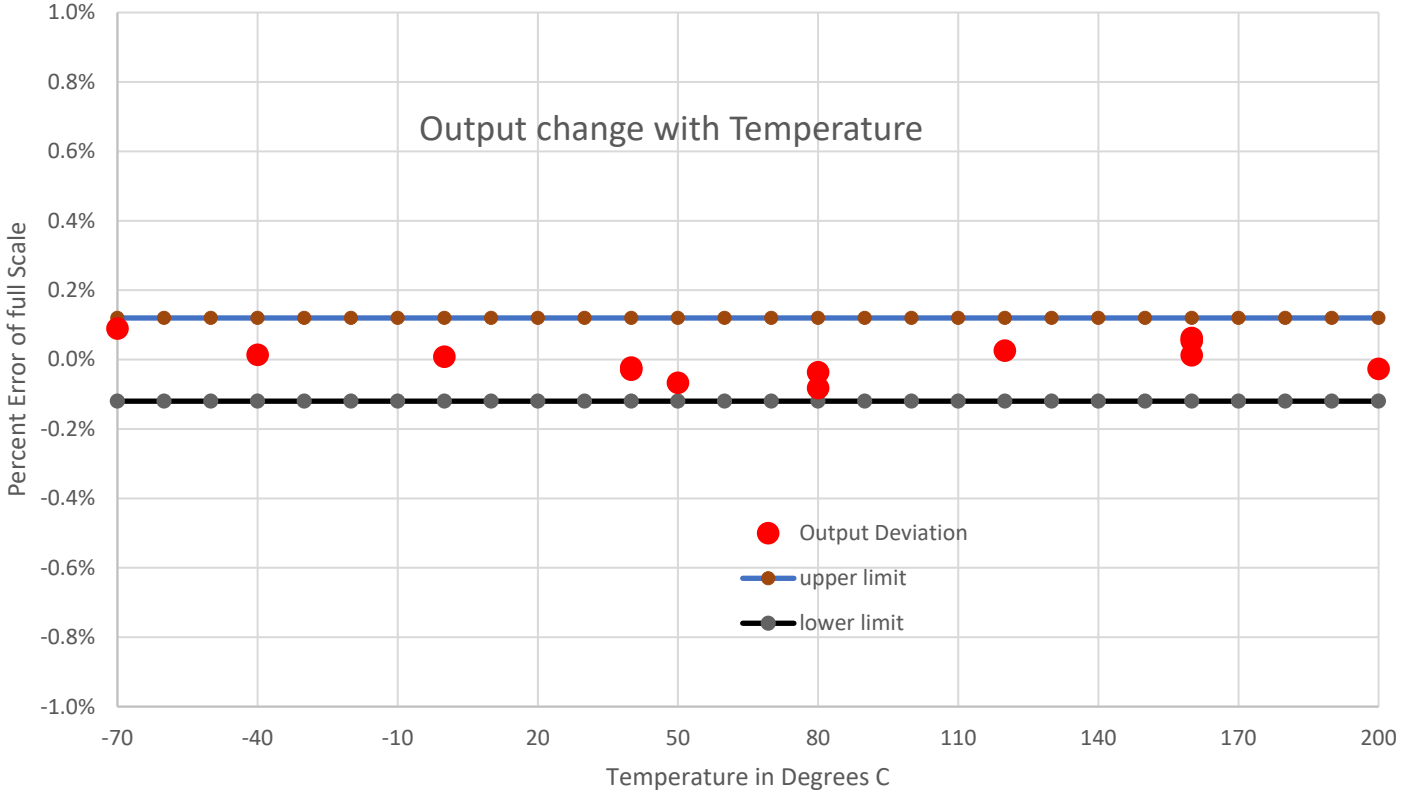
This is basis for use as a gap sensor.
This effect is eliminated with choice of Titanium for the target rod.



- The position measurement changes by les than 0.1% FS over full range.
- This is equivalent to 3 ppm/degree C
- This data taken with a sensor that had only 0.1% FS accuracy



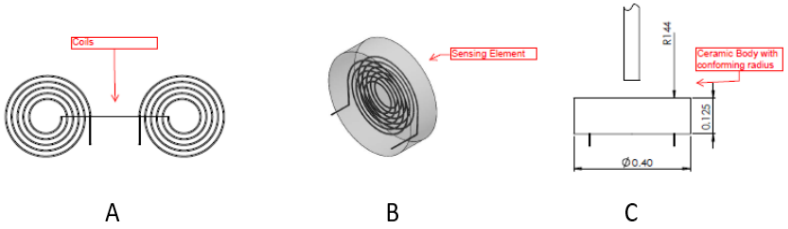
Ti


Output change with Temperature
Percent Error of full Scale
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
-70
-40
-10
20
50
80
110
140
170
200
Temperature in Degrees C
Output Deviation
upper limit
lower limit

Comparison of LVR to LVDT

	LVR	LVDT
Fundamental Output Signal	Digital	Analog
Operating Temperature Range (°C)	-70 to 200 C Optional to 450 C Possible to >1000 C	-55 to 200 C
Stroke to Length **Maximum Length**	2:1 > 8 feet	3:1 1-2 feet
Resolutionand	.001% FS	.1% FS
# of Wires to Electronics	2	6
Accuracy (Full-scale)	0.01% FS	0.25%FS
Temperature Sensitivity	<3ppm C	>50 ppm C
Requires Shielding from External Magnetic Fields	No	Yes

- LVR can also be used as a rotary sensor, a gap sensor and liquid level sensor

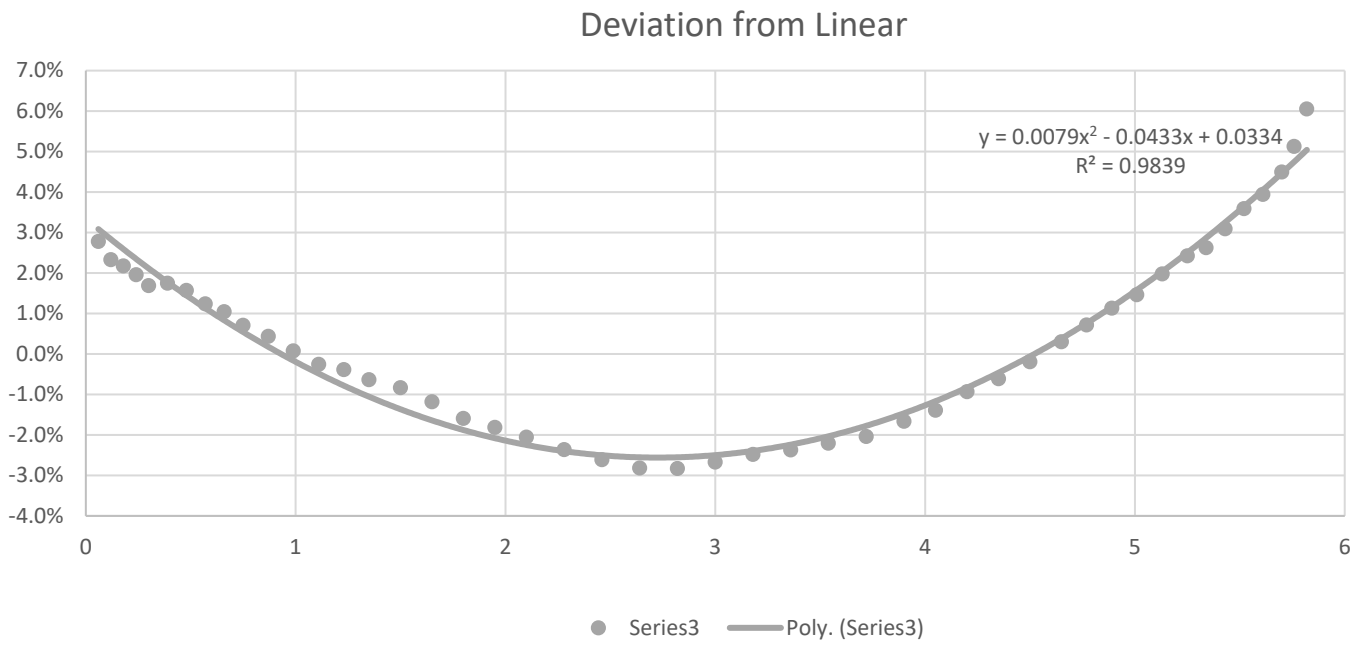


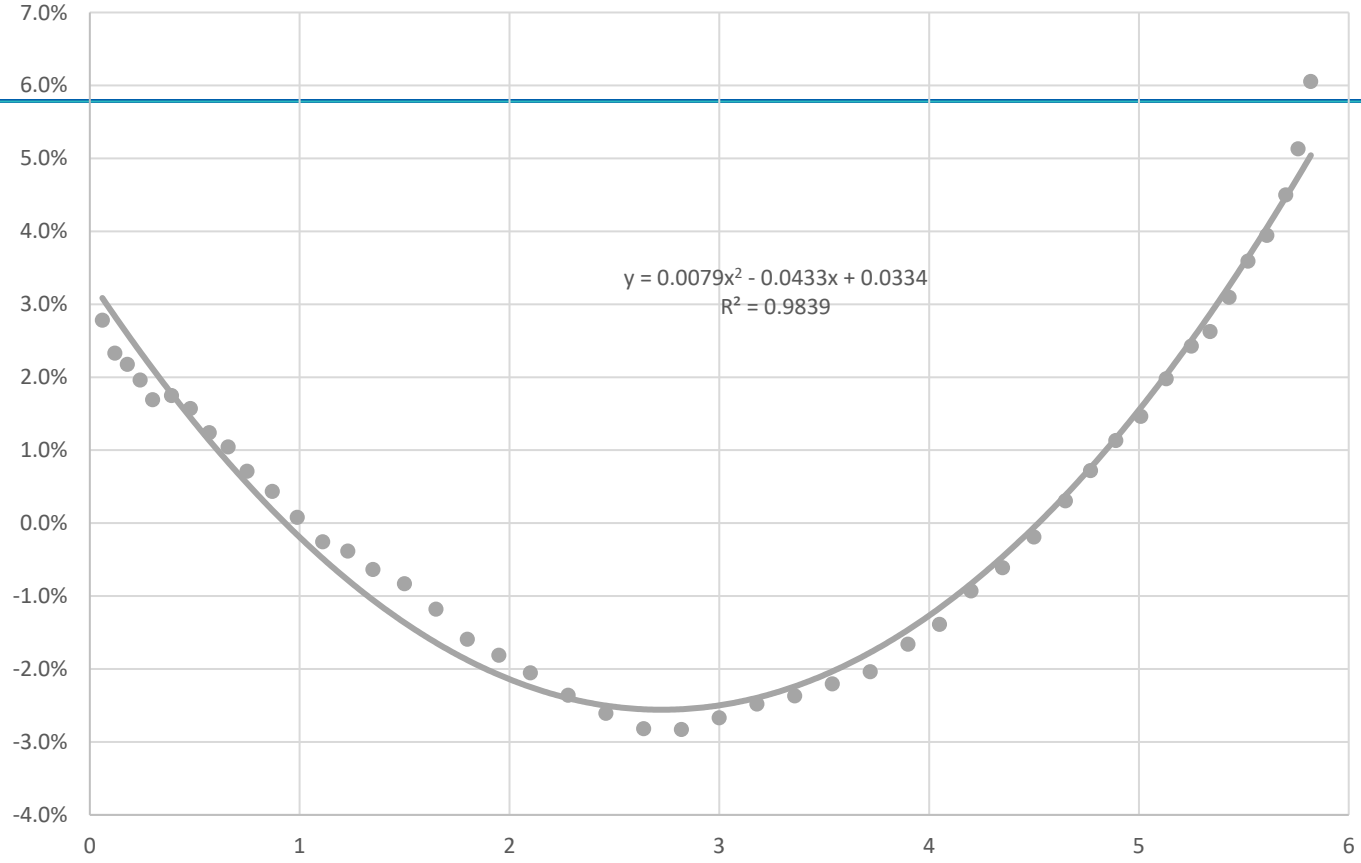
A. Diagram of windings of conductive coils

B. Sensing element of stacked conductive coils encased in ceramic body

C. Sensing element encased in jet engine wall with compressor blade in proximity

Deviation of output from Linear




7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
0
1
2
3
4
5
6
y = 0.0079x² - 0.0433x + 0.0334
R² = 0.9839