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HOW DO TAVIS VARIABLE RELUCTANCE TRANSDUCERS WORK?

The inductance of a coil can be determined by the number of turns of wire and the reluctance of the magnetic circuit. Reluctance is synonymous with resistance in that the greater the reluctance, the fewer the magnetic lines of force for a given magnetomotive force. If the major portion of the reluctance of a given magnetic circuit is due to an air gap, then the reluctance is proportional to that air gap. Every effort is made in Variable Reluctance technology to approach this ideal condition.

The inductance of a circuit is inversely proportional to its magnetic reluctance; inductive reactance (XL) is proportional to inductance. It is apparent then that XL=k/g for a double-active VR sensor design.

Let:
Eo = Output Voltage from coils
EI = Input Voltage to coils
k = Numerical Constant
XL_1 = Inductive Reactance of Sensor L1
XL_2 = Inductive Reactance of Sensor L2
g_0 = Initial air gap of both the sensors
g_1 = Air gap of Sensor L1
g_2 = Air gap of Sensor L2
Δg_0 = Incrementa l change of position of the diaphragm

Then:

(1) $$XL_1 = \frac{k}{g_1}$$

(2) $$XL_2 = \frac{k}{g_2}$$

(3) $$I = \frac{E_I}{XL_1 + XL_2} = \frac{E_I}{\frac{k}{g_1} + \frac{k}{g_2}} = \frac{E_I \cdot g_1 \cdot g_2}{k \cdot (g_1 + g_2)}$$

(4) $$E_0 = \frac{E_I}{2} - I \cdot XL_2 \quad \text{or} \quad \frac{E_0}{E_I} = \frac{g_2 - g_1}{2 \cdot (g_1 + g_2)}$$

If rest conditions are such that:

$g_2 = g_1 = g_{0,}$ then $E_0 = 0$ at Zero Pressure

let $g_2 = g_0 + \Delta g_0$ and $g_1 = g_0 - \Delta g_0$

then $$\frac{E_0}{E_I} = \frac{g_0 + \Delta g_0 - g_0 + \Delta g_0}{2 \cdot (g_0 + \Delta g_0 + g_0 - \Delta g_0)}$$

and $$\frac{E_0}{E_I} = \frac{\Delta g_0}{2 \cdot g_0}$$

As seen from the above result, the output voltage from a double-active sensor design (See Figure 1) is proportional to diaphragm displacement. A diaphragm displacement equal to 20% of the initial air gap is not unusual with VR technology. Output voltages of 0.1 volts per volt of input are possible. This is about twenty-five times the output of a typical strain gage instrument.

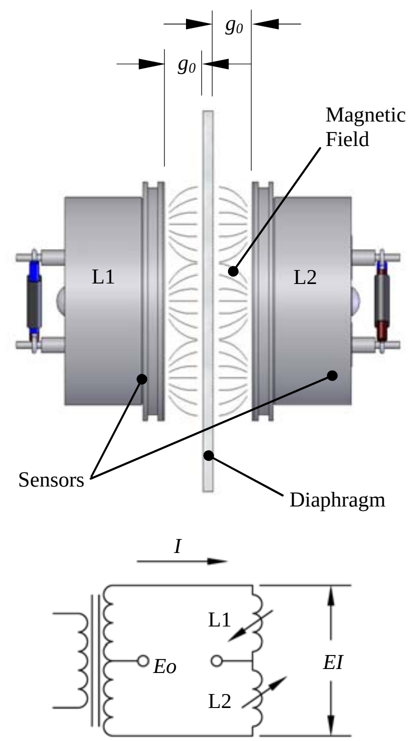

Figure 1
Double-Active Sensor Design

If only one sensor is "active" (i.e. only one sensor is in proximity to the diaphragm, such as with an absolute pressure sensor), then the output voltage is not entirely proportional to the diaphragm displacement. Therefore, Tavis single-active sensor designs employ a unique circuit to linearize the output. Linearities of less than ±0.1% of full scale are readily obtained.

Advantages of VR Sensing:

- Large gage signal output simplifies amplification and reduces drifts, increases tolerance to radiation environments.
- Low power consumption results from high Q inductors that do not absorb energy.
- Sensors are completely isolated from the pressure media even with differential inputs.
- All elements including the magnetic cores are welded in place to assure long term stability.
- The diaphragm is completely free of all restrictions (non-contact) assuring true infinite resolution.
- Output changes due to acceleration and vibration are inherently low in all axes.
- High overpressure is easily incorporated. As much as 1000 times Full Range overpressure is acceptable on some low pressure designs.
- Pressure transducer designs are inherently rugged.
- Simplicity of design enhances reliability.
- Wet-wet sensing capability (media on both sides of diaphragm).

Electronic Circuit:

- DC input voltage is used to create a sine wave of constant amplitude.
- This sine wave is used to excite the transducer coils.
- The output of the gage is then demodulated (detected) to give a proportional DC output voltage.
- In some designs, the AC gage signal is amplified and then detected. In others, it is detected first and then amplified.
- In current (4-20 mA) circuits, this gage voltage is converted to a proportional DC line current.
- Standard voltage circuitry requires less than 200 mW of input power.