The hot and cold of LVDTs

Changes in temperature can cause subtle errors in LVDT readings.

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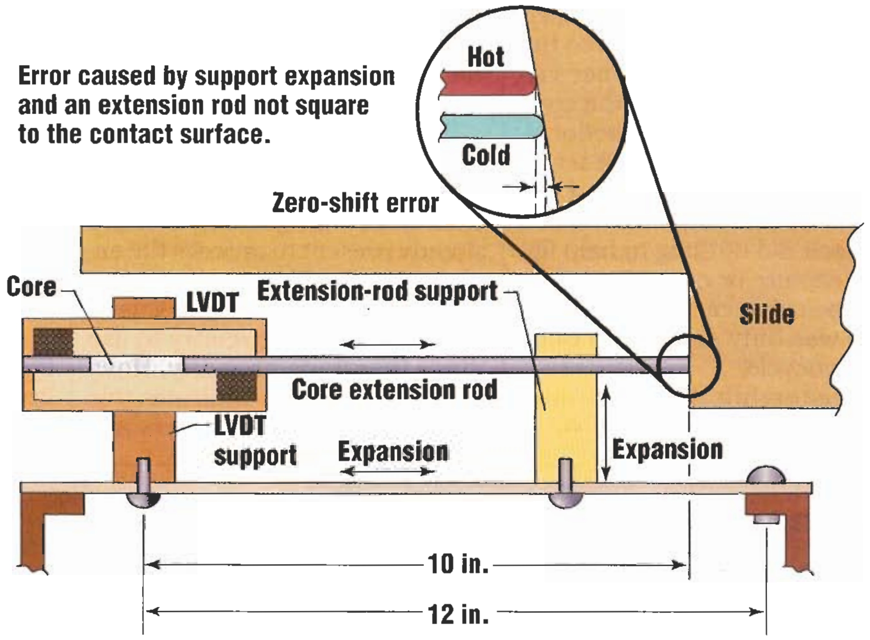
LVDT installation factors



Different expansion coefficients between various metals can affect the accuracy of an LVDT installation, as evident in this layout. A brass-core extension rod 10-in. long is fastened to an LVDT mounted on a steel plate 12 in. from the plate's attachment point on a machine. The difference in expansion coefficients between steel and brass creates an offset error of almost 0.004 in. with a 30°C rise in temperature. Additional errors can creep into the measurement if the LVDT support and extension rod guide are not square to the surface being measured. The null or zero position of the LVDT shifts as the supports expand or contract.

Designers rarely consider how changes in temperature might affect linear-variable differential transformers (LVDTs). Yet a temperature change large enough can skew LVDT readings.

This affect can take the form of a shift in LVDT output level with respect to its core displacement. This creates a scaling error. It's the same as multiplying the calibrated output signal by a scale factor slightly larger or smaller than unity.

Or it can take the form of a change in the null-reference output position, the starting or reference point used for calibrating the LVDT output. This type of error is known as a zero-shift or scale-shift error. The effect is the same as adding or subtracting a small constant value to the calibrated output voltage.

Rising ambient temperatures produce a higher resistance in the copper wire used for the primary and secondary coils of the LVDT. The high primary-coil resistance boosts winding impedance and forces primary current to drop. This affects output and sensitivity levels generating a scaling error.

A change in the winding resistance of the secondary does not have as much impact if the load that has a high impedance is used. But resistance changes in the secondary will factor into the transfer of power to a low-impedance load. For example, if the load impedance is 50× greater than the secondary-winding resistance, a 50% rise in secondary resistance would only reduce output voltage by approximately 1%.

Of course, changes in temperature make materials expand or contract in accordance with their thermal coefficient of expansion.

Edited by Robert Repas

When mounting an LVDT, the use of materials with wide differences in expansion coefficients may cause zero-shift errors.

For example, suppose a 10-in.-long core extension rod is made of brass with a thermal expansion coefficient of 0.000019. The mounting surface is steel with a coefficient of 0.0000105. The LVDT is 12 in. from its mounting point. A 30°C change in temperature lengthens the rod by 0.0057 in. However, the mounting plate expands only 0.00378 in. The result is a null shift of 0.00192 in.

Fortunately, there are several methods that reliably compensate for ambient temperature changes. The first replaces the copper wire in the LVDT windings with manganin. Manganin wires have almost zero temperature coefficient so their resistance does not change with temperature.

The advantage of this method is that it incurs no additional circuitry or space. However, designers must quantify the temperature variation and order a special LVDT. Manganin-wire windings also have higher resistance than copper windings, so they are less sensitive then copper-wound LVDTs.

A constant-current power source holds primary current constant regardless of the change in resistance. The stable primary current helps keep the output and voltage sensitivity constant. If a constant-current power source is not available, an external resistance in series with the primary winding helps stabilize the current. This series resistor should also have a negative temperature coefficient to counteract the positive-temperature coefficient of the winding.

Thermistors inserted in series with the primary or secondary circuit can compensate for sensitivity changes with temperature. As this requires adding a resistance that drops with rising temperatures, the thermistor must have the right negative temperature coefficient to offset the rising resistance of the LVDT winding.

All in all, designers can reduce scale-shift errors by carefully arranging the mechanical layout and by the choice of materials used for mounting the LVDT. **MD**

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