APPLICATION NOTE 2:

USING A PRECISION SINE WAVE REFERENCE WITH LVDT SYSTEMS

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PRECISION LVDT SYSTEMS

LVDT's or Linear Variable Differential Transducers are used for linear position sensing. Applications for these devices include position control servo systems such as aircraft control surfaces, paving equipment and automated laser trim systems.

The LVDT is in essence a transformer with a single input winding and two output windings on a common moveable core. This moveable core is connected to the portion of the system where it is desired to sense position. In the 'centered' position the output of each winding is equal in amplitude and will cancel in the LVDT demodulator for a zero output. As the core deflects, one winding will generate a larger amplitude than the other winding. This difference in amplitude will show direction as the polarity of the demodulated output, and distance as the amplitude.

When the LVDT is used in closed loop control systems where the servo loop will always return to zero, then accurate control of amplitude will not be necessary. An example is a paving machine where the LVDT senses tilt and the servo system returns the machine to the level state.

In position sensing the amplitude output of the LVDT will be a function of position. The accuracy to which this position can be resolved will then be a function of the amplitude accuracy of the LVDT drive signal. One way to express the accuracy required here is to take the case of the demodulated LVDT output being digitized for input to computer. Then accuracies can be expressed in bit levels. A 12-bit system, for instance, will be required to resolve 1 part in 4096, this translates to an accuracy level of 0.01%.

When temperature variations are factored into the system accuracy, the requirements for an LVDT reference become very demanding. For the system to maintain 12 bit accuracy to 1 LSB from -55 to 125°C would require system drift of less than 1.4 ppm/°C, of which reference drift is only one component. This places extreme demands on reference drift requirements, pointing out the need for low reference drift such as that provided by the Thaler SWR200 and SWR300.

The basic LVDT system configuration block diagram is shown in Fig. 1. The reference is a sine wave oscillator, the output of which will usually need to be buffered by a high-current or high-power amplifier. This provides the stimulus to the primary winding of the LVDT. The secondary output of the LVDT can be demodulated in a number of ways. The simplest would be full wave rectifiers on each secondary connected in series opposing to cancel. This is most useful when zero or center sensing is desired. High accuracy applications will require synchronous demodulation using the stimulus signal for synchronization. The output is demodulated and filtered to a DC voltage representing position.

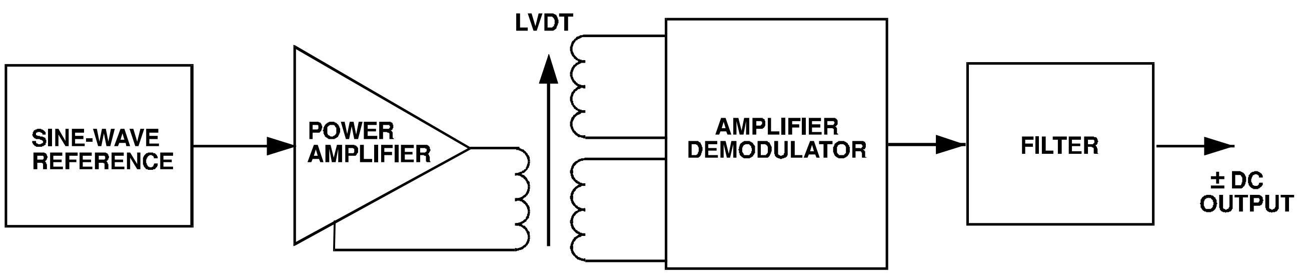

FIGURE 1. POSITION SENSOR BLOCK DIAGRAM.

In an actual application shown in Figure 2, a Thaler Sine Wave Reference is used as a reference for the sine wave drive. The objective in the LVDT driver is to maintain the tightest possible control over drive amplitude. The power amplifier selected to buffer the sine wave should have good AC accuracy specifications; in particular, open loop gain should be as high as possible. Drift of AC voltage vs. temperature is one of the key specifications of the SWR200 and SWR300 making it easy to determine the effect on the error budget of the oscillator. Errors over temperature associated with the op amp are best controlled by using an amplifier with the highest possible open loop gain. But don't just look at the amplifier open loop gain specification. Many high open-loop gain amplifiers are optimized for DC accuracy, and the open loop gain at the frequency at which the LVDT is driven may be very low. So keep an eye on the amplifier gain-bandwidth product and Bode plots as well. Using the amplifier in the inverting configuration will provide maximum linearity and eliminate errors due to common-mode effects.

Frequently offset and input related parameters are used to specify and refer to "high accuracy" op amps, but in this case, DC errors can be ignored by using AC coupling. When using AC coupling, proper capacitor sizing along with the use of a high quality capacitor will help to preserve the high system AC accuracy. High accuracy is insured by including the output coupling capacitor within the AC feedback loop of the amplifier. A separate DC feedback loop insures a minimum of power amplifier offset to insure maximum voltage swing capability.

Some LVDTs may not require nearly as much power to drive as the circuit shown here can provide and there are a number of other amplifier choices at lower power levels. But the circuit shown here is especially useful in multiple LVDT systems using a single precision source. It should be mentioned that in such applications it is possible to have long cable runs to some LVDTs and use of the lowest possible frequency will insure best accuracy.

Figure 2 shows a representative circuit of an LVDT demodulator using a synchronous demodulator. Many components are available to implement this function ranging from analog switches to switched input op amps. The synchronous demodulator requires a timing reference input from the primary of the LVDT. Some phase adjustment of the timing signal should be provided due to phase shifts from cabling and the LVDT itself. The demodulator is followed by a stage of active filtering to provide a position indicating DC output.

Output from the demodulator can be either a positive or negative voltage with the polarity indicating the direction of deflection from center. The voltage value of the signal represents the distance of deflection.

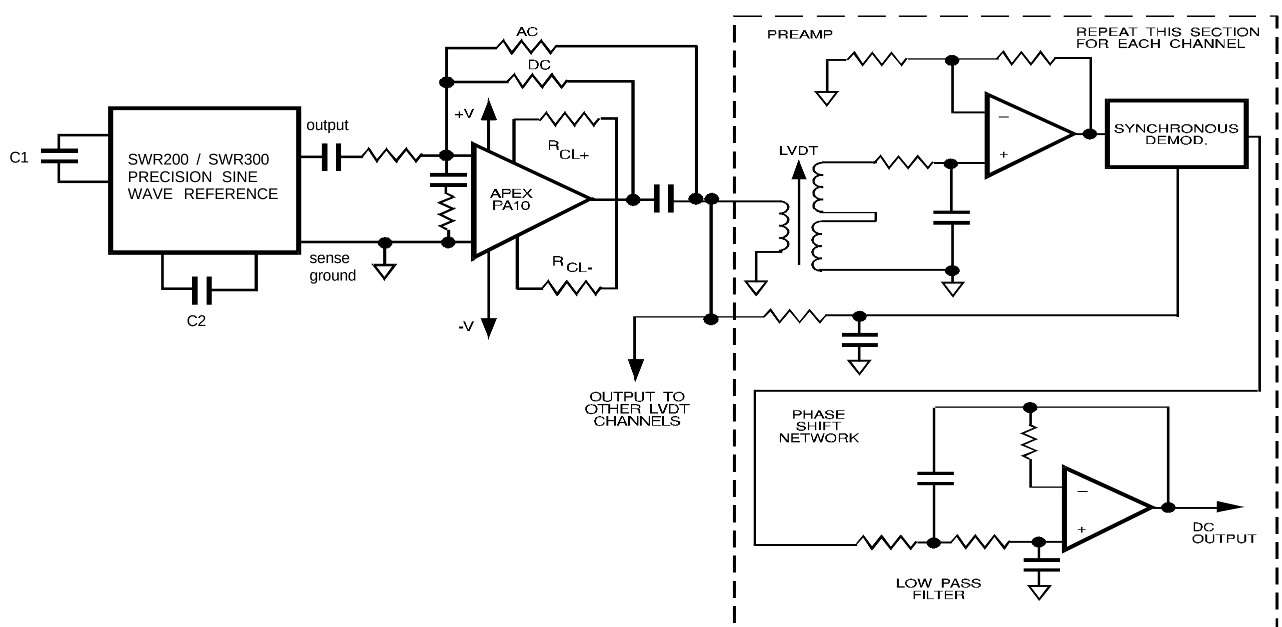

FIGURE 2. SWR200 AND POWER AMP IN MULTIPLE-LVDT SYSTEM.