LVDT's

An LVDT, or a *L*inear *V*oltage *D*ifferential *T*ransformer, is shown in Fig. 3. An LVDT is a transformer which has a movable core, a single winding on the primary, and a pair of secondary windings. The secondary windings are connected in *opposition*, so that the output

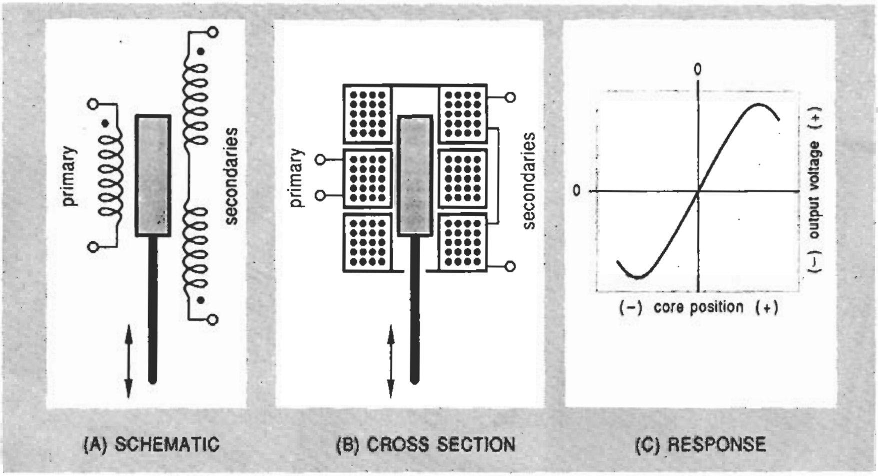

FIG. 3—LINEAR VARIABLE DIFFERENTIAL TRANSFORMERS, or LVDT's for short, can be used for extremely precise position-to-voltage transducers. The output voltage is proportional to the core position. Microweighing is one use.

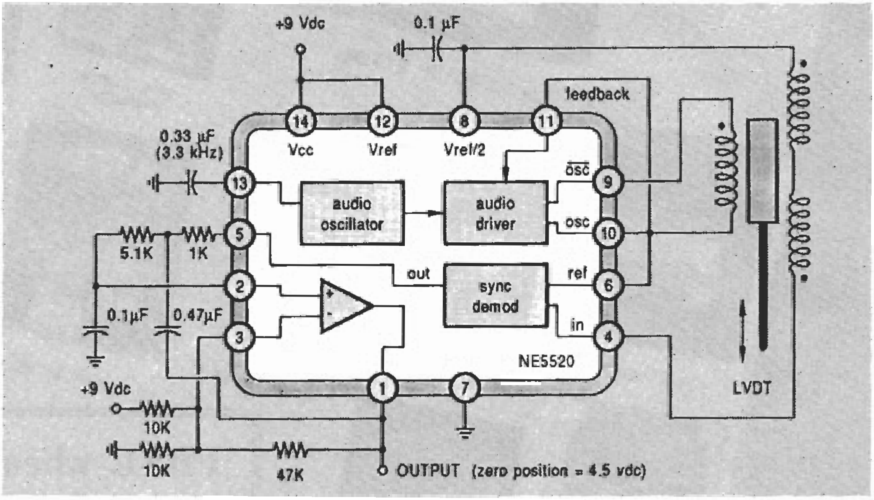

FIG. 4—THE PHILLIPS/SIGNETICS NE5520N has an internal precision sine-wave generator, a sync demod, and an extra op-amp that gets used here as an output filter. This is how to apply it as an LVDT signal conditioner. Since the chip can do so much more, it does seem a shame to waste it on LVDT uses.

voltage will be the *difference* between the two.

When the movable core is in the center, equal and opposite voltages are induced in the secondaries, and the output voltage is zero. As your core moves up, a 0-degree phased sine wave appears in your output. As it moves down, a 180-degree phased sine wave appears instead.

With careful design, you can get a linear sine-wave output voltage whose amplitude changes with position, and whose phase is (0) degrees for positions above center and (180) degrees for positions below center.

In short, an LVDT is a very precise and ultra-sensitive *position-to-voltage transducer.* Some LVDT devices can easily sense any motions or position changes as small as a thousandth of an inch or less. They can also be made large enough to measure distances of several feet or more.

Unfortunately for hackers, LVDT's are rather pricey, since they are both low-volume and precision components. One useful surplus source is *AST Servo,* while others advertise in the *Sensors* and *Measurement and Control* trade journals.

Several LVDT uses? Weigh scales, especially for microweighing; torque sensing; accelerometers; distance measurement; inclinometers; pressure transducers; for seismometry; load cells; micropositioners; and anywhere else where you want to convert a very small motion or distance change into a useful electrical signal.

For precision results, your LVDT must get driven from a pure audio sine wave of a fixed and known amplitude. Distortion could lead to bad harmonics which will in turn create output errors and other difficulties.

To further up the LVDT precision, you can use an LVDT in its *servo mode.* Here, you'd use feedback to move, balance, shove, or otherwise continually coerce the *LVDT* back to its null position. That is known as *null seeking* and, because of the feedback, many nonlinearities can be greatly reduced if not canceled outright.

While LVDT's are usually super-precise, there's no reason you can't throw one together on your own to create a low-cost position sensor. Be sure to let me know what you do come up with on that.

By another of those astounding coincidences that infest this column, it looks like we need a sync demod to extract the position info from an LVDT. But, if we have a simple and cheap circuit that does that, why limit it to LVDT uses, when so much more can be done so much better with it? Which brings us around to...

The misnamed chip

Sometimes a manufacturer might simply put the wrong name on one of their integrated circuit chips. For instance, which of these two has the greater hacker potential: a *Signetics* NE5520N LVDT Signal Conditioner, or a *Phillips* NE5520N Universal Single Chip Treasure Finder?

As you might guess, *Signetics* is *Phillips* and, of course, the NE5520N is the NE5520N. Figure 4 shows details. What we have is a

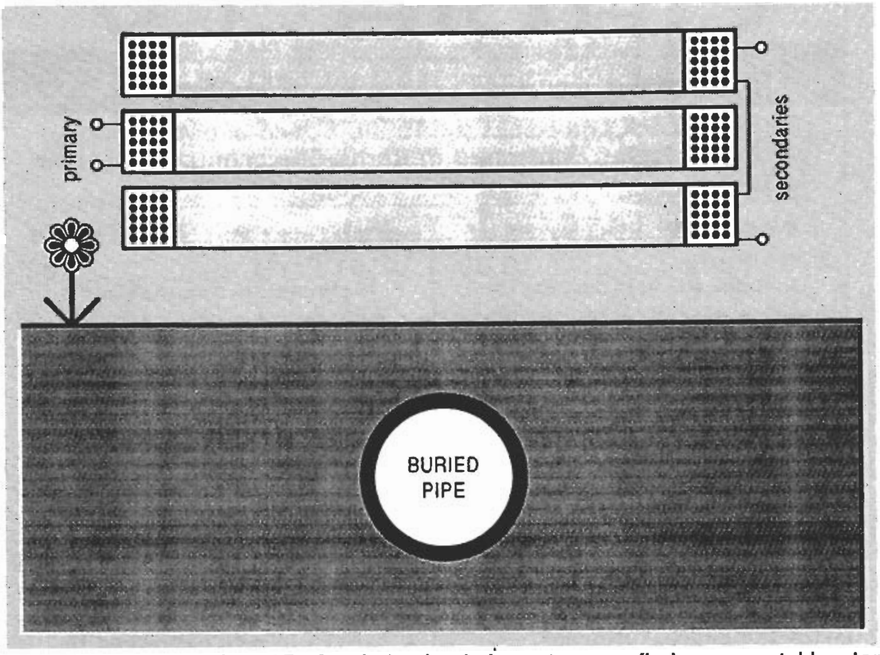

FIG. 5—THE SENSING HEAD of an induction-balance treasure finder or a metal locator can be thought of as an LVDT in disguise. The target acts as a movable core. Synchronous demodulation can separate metal from mineral detection.

precise amplitude and low-distortion audio sine-wave generator, a synchronous demodulator, and one uncommitted op-amp you can use for output filtering, meter driving, or in-phase to quadrature conversions. The circuit shows you how to power and sense the output of an LVDT.

While you actually could use one of those chips with an LVDT, the beast should work well for an extremely wide variety of hacker stuff. Where else could we use an audio source and a sync demod?

One place could include modulated infrared alarms and communicators that can ignore both sunlight and room lighting. A second might be in the fluxgate magnetometer used in solid-state digital compasses.

How about treasure finding? I can think of at least a dozen uses here. Figure 5 shows us how the search head of an induction balance metal locator is really an LVDT in disguise.

In the absence of a buried object, the voltages induced into the output sensing coils are equal and opposite. A buried ore or a metal object will distort the transmitted field, and unbalance the output voltages.

Now for the neat part; any "metal" objects return an in-phase component to the output signal, while "mineral" deposits, such as a well-rusted can, returns us a quadrature signal. Nicely separating the goodies from all the grunge and garbage.

Thus, the NE5520N circuit can be used for in-phase discrimination of metal objects, or for quadrature discrimination of mineral objects.

To do the quadrature synchronous demodulation, just shift the phase of your reference by 90 degrees. Add a second NE5520N, and you can also add such advanced features as automatic ground tracking and the "native" soil background cancellation effects featured on the higher priced locators.

Similarly, over in those receiver-transmitter styles of metal locators often chosen for pipe finding, fiber optics can be used to optically couple from the transmitter to the receiver, minimizing any field distortions an actual cable might create. A sync demod at the receiver could then be used for improved sensitivity and for metal/mineral discrimination.

The NE5520N costs around $7 in smaller quantities. Supply current is around seven milliamperes, easily provided by a 9-volt battery. While you can run the chip at +5 volts, its stability will not be as good.

For additional NE5520N circuit details and bunches of applications info, see the *Industrial Linear Data Manual II* offered by *Phillips*. Check out the NE5521N as well.