16
StudSensor

The StudSensor (Figure 16.1) is another application that demonstrates the utility of capacitive technology. This low cost device (under \$30) is a simple and effective use of capacitive sensors in a consumer product. As developed by Zircon International, Inc., the StudSensor helps locate the position of a wall stud (typically 2 × 4 or 2 × 6" wood) behind wallboard or plaster walls. Stud location is important for carpenters or homeowners attaching shelves to a wall or installing electrical outlets. Previously, wall studs could sometimes be located by banging on the wall with a hammer, but this method is somewhat destructive and not too reliable; happily, wall studs have a dielectric constant which is different from air's, and their location is revealed to a capacitive sensor.

The StudSensor, invented by Robert Franklin and Frank Fuller, was awarded U.S. Patent 4,099,118 on July 4, 1978.

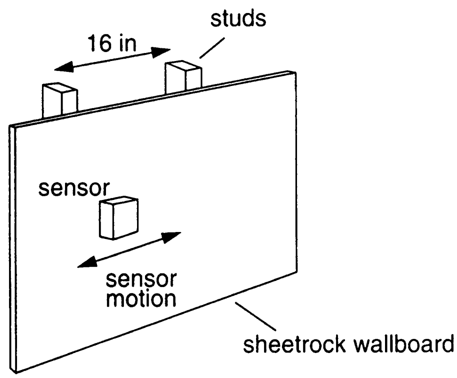

Figure 16.1 StudSensor in use

16.1 BLOCK DIAGRAM

Using the basics described earlier in this book, a relatively straightforward sensing circuit may be designed. The circuit is built with the familiar elements shown in Figure 16.2.

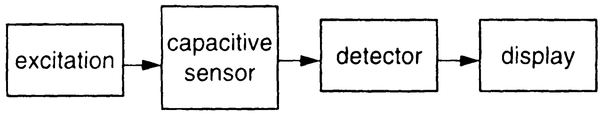

Figure 16.2 StudSensor block diagram

16.2 CIRCUIT DIAGRAM

In this capacitive sensor implementation (Figure 16.3) the electrode excitation is handled by a multivibrator, the integration circuit is a simple "leaky capacitor," and the measurement circuit is a voltage follower driving a display. The display shows the relative dielectric constant in the vicinity of the StudSensor's electrodes, which increases with the presence of a wall stud. The device is placed on a wall and the bias is adjusted so that the magnitude output just begins to register on the meter.

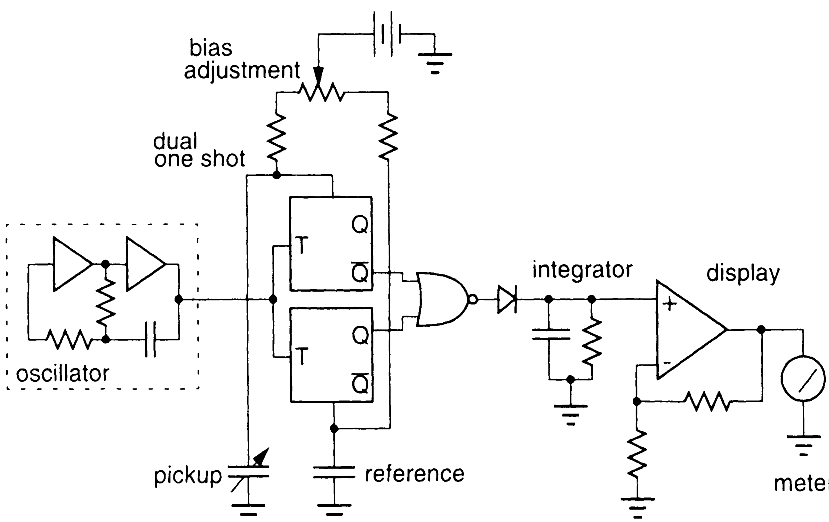

Figure 16.3 StudSensor circuit

Although this basic circuit accomplishes the task of displaying the change in dielectric constant, it can be improved for cost and usability. Three enhancements are included in the production StudSensor:

- Low cost LED display replaces meter
- Stud location sensitivity increased
- Self calibration circuit added

16.2.1 Low cost display

A numeric voltage display could be used for an absolute readout, but for this application only a relative response is needed. A simple magnitude display uses several voltage comparators and LEDs (Figure 16.4).

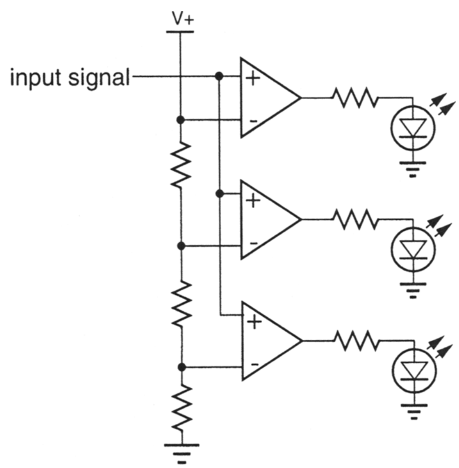

Figure 16.4 Magnitude display

16.2.2 Increased sensitivity

Increased sensitivity may be achieved through the use of two additional plate sensors. The single plate implementation has a relatively broad response and also is dependent on the stability of a reference capacitor. The addition of two additional capacitive sensor plates working in opposition to the primary plate increases the sharpness of the response curve. This connection also improves circuit stability, as two similar-dielectric capacitors are balanced.

The two additional plates are mounted beside the primary sensor (Figure 16.5), which then increases the *x*-axis sensitivity (Figure 16.6).

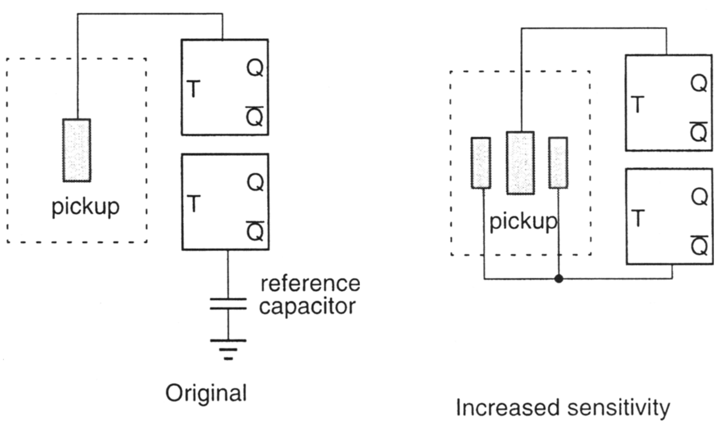

Figure 16.5 Increased sensitivity

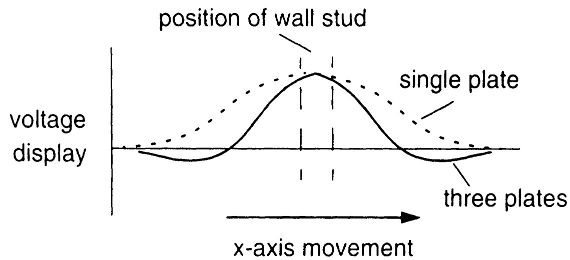

Figure 16.6 Sensitivity curve

16.2.3 Self calibration

One other design problem is the need to calibrate the sensor offset voltage to the wallboard thickness. The circuit above manually calibrates sensor offset with an adjustable bias control. This function can be automated with a FET-driven bias calibration circuit (Figure 16.7).

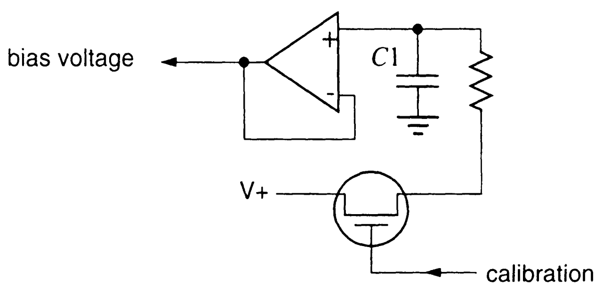

Figure 16.7 Bias calibration circuit

In the original circuit, the device must be placed on the wall away from a stud and manually adjusted so the meter is in range. The new circuit initiates a calibration cycle on powerup which slowly charges $C1$ and increases the bias voltage until the first display LED indicator turns on. At that point, the calibration signal is turned off, the bias voltage stabilizes, and StudSensor is ready for operation.

In the event the device is coincidentally switched on when directly over a stud, the device will give no stud indication as it is moved. Recalibration over a new wall area corrects the problem.

16.3 MODIFIED CIRCUIT DIAGRAM

By making the adjustments described in section 16.2, it is relatively simple to add a low cost display, increased sensitivity, and self calibration to the original circuit. Figure 16.8 shows a diagram of the improved circuit.

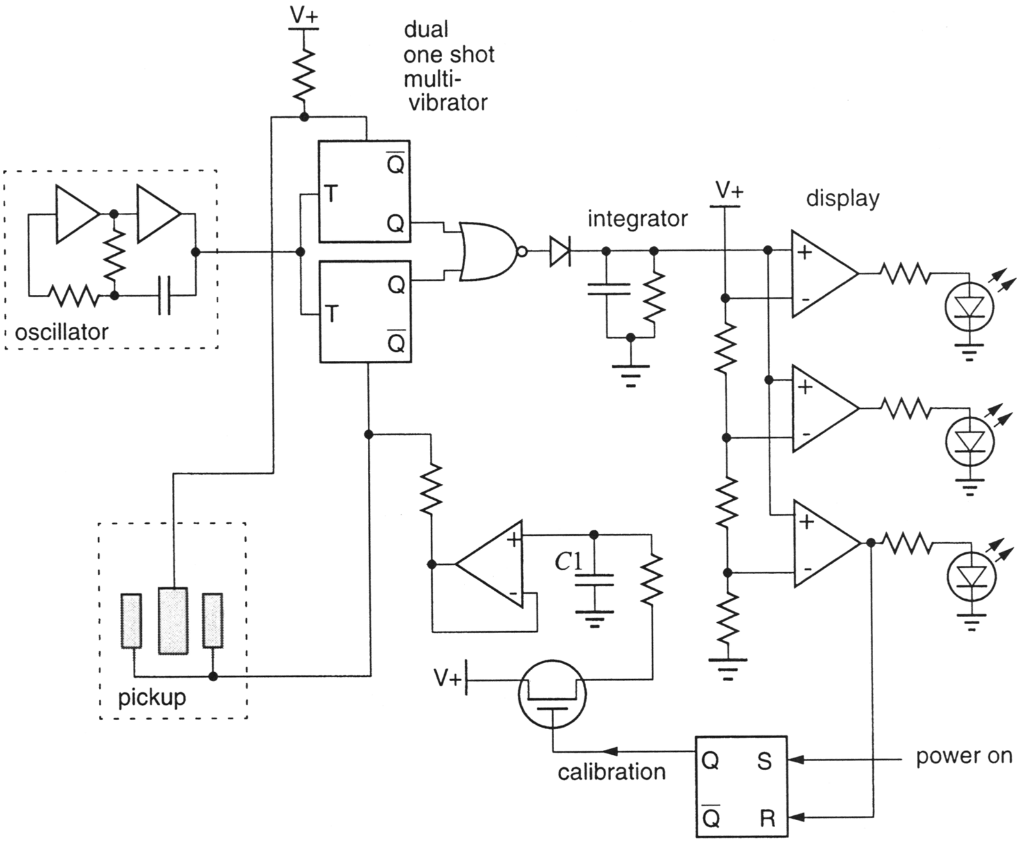

Figure 16.8 Modified circuit