Interfacing Level Transducers

Chapter 14

Level is usually measured to determine the *contents* of a container because of the linear relationship between level and volume (when the sides of the container are vertical). Contents can also be measured as mass (or weight), by weighing the container; and they can be determined by measuring pressure at the bottom of the container, if the density of the contents and the geometry of the container are known. Interfaces to pressure and force measurement are discussed in Chapters 11 and 12.

Level measurement can use extremely simple or very sophisticated techniques. For the latter, the electronic interface is usually part of the measurement package, and is not relevant for discussion here. A few examples of some simple, and quite common, techniques—and interfaces—are mentioned here.

FLOAT AND POTENTIOMETER

A float, linked to a potentiometer or a rheostat, is perhaps the most common form of level measurement. In such applications as vehicle fuel-tank level measurement, the level is read directly on a meter. If communication to a measurement system is desired, the simplest form of handling is via a follower-connected op amp.

In Figure 14-1, the potentiometer is excited by an AD581J 10V reference, and it is buffered by an AD741J op amp. The relationship between output and level can be expressed as 10% (of full height) per volt.

A plain (or fancy) RC filter may be interposed between the pot and the output of the follower to average out the effects of noise

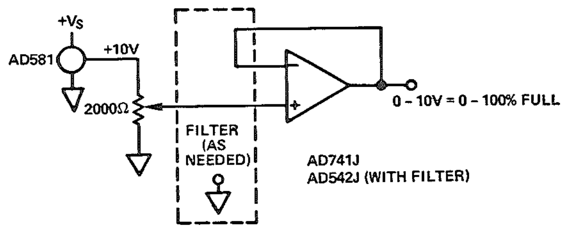

Figure 14-1. Level measurement using float and pot

(ripples, waves, and froth at the surface of the fluid). See Figures 3-7 and 3-8 and associated text for a discussion of some techniques. Generally, a FET-input amplifier, such as the AD542J, would be used if a filter is required.

An instrumentation amplifier, such as the AD521, or perhaps even an isolator, would be used if ground problems are expected (or suspected). For 4-to-20mA current transmission, the pot can be connected directly to the input of the isolated 2B22 V/I translator without loss of linearity; however, in the case of the common-based 2B20, a buffer should be used unless the nonlinearity caused by loading of the 10kΩ input impedance of the 2B20 is tolerable.

If, instead of (or in addition to) a direct analog reading, a pair of decisions must be made to turn a fill circuit on at one level and turn it off at another, the output of the pot (or the buffer) may be applied to one input of each of two comparators. The level-set signals (also derived from the AD581) are applied at the other inputs. The sense of the comparator connections (+ or −) is determined by whether the decision is *fill* or *stop*.

OPTICAL SENSING

A simple optical sensing system consists of a light source, a photodetector, and appropriate circuitry. Figure 14-2 shows these elements. When the liquid level is low, the diode conducts, and the output of the comparator is high; when the liquid level interrupts the optical path, the output of the comparator goes low. If liquid motion causes excessive electrical noise, a filter can be inserted between the diode and the comparator input, as shown. A small amount of positive feedback from the output of the comparator could also be used for hysteresis to avoid frequent reversals due to low-frequency noise.

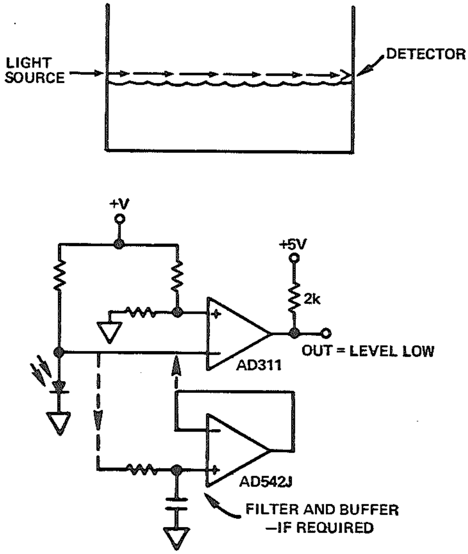

Figure 14-2. Simple optical level sensing

THERMAL SENSING

The self-heating characteristics of thermistors can be used to detect liquid level. In Figure 14-3, the 2kΩ (@ 25°C) thermistor has low resistance when it is hot (i.e., self-heated in air), and the output of an AD311 comparator goes high. When the thermistor is in contact with liquid, its temperature drops, its resistance rises, and the output of the comparator goes low.

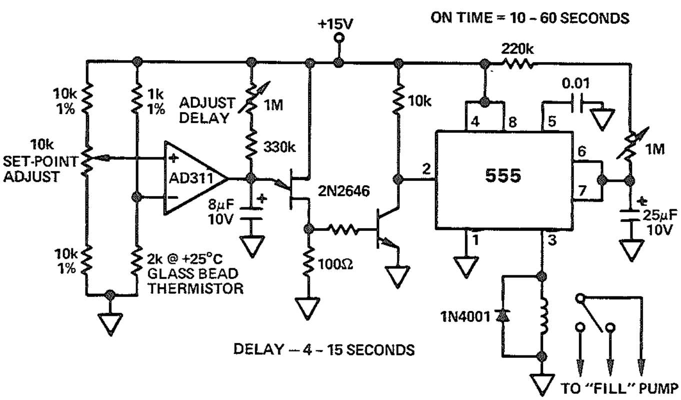

Figure 14-3. Thermistor-sensed level-control system

In a typical fill-control application, such as the one shown in Figure 14-3, when the liquid level drops away from the thermistor, the open-collector output transistor shuts off, and the current through the adjustable pullup resistor charges the 8μF capacitor up. When the 2N2646 unijunction transistor fires, it operates the 555 timer, which cause the *fill* relay to close. The 2N2646 continues to be turned on until the liquid rises to cool the thermistor.

As the liquid is drawn off and the level drops, this circuit will thus act to restore the liquid level to the set point.

The delay time in triggering the 2N2646, caused by the charging of the capacitor, is adjusted so that turbulence and sudsing action at the surface of the liquid do not cause the circuit to fire prematurely. The timer *on-time* is adjusted to provide enough hysteresis so that the circuit does not oscillate at the fill point.