Some Thoughts on Electromech Low Liquid Level Sensors

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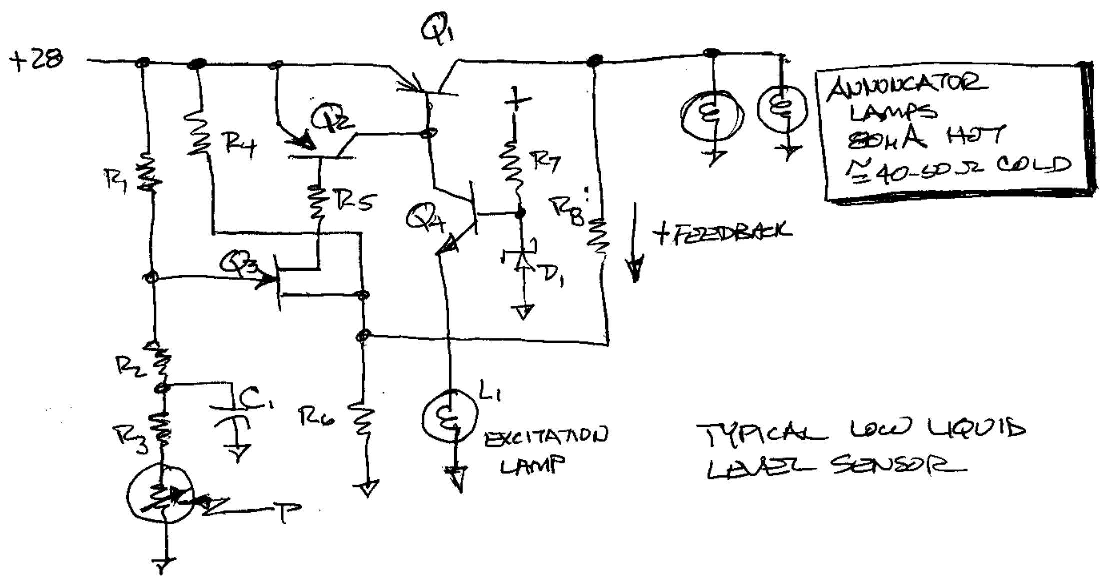
16 August 2004

Rod,

I hear by the grapevine over in customer service that Premier is still dealing with some low liquid level sensor hassles and that you were one of the folk pulling the cart. I've spoken with several teams over the past 6-7 years about the Electromech low liquid level sensors. I'm a bit mystified as to the nature and persistence of the problems with this product. They've been applied in thousands of installations for over 20 years.

It might be helpful if I were to offer some background on the technology upon which this product is based. Dean Matson (formerly of



Missiles Group) and I designed this product while employees of Electromech. Three important design goals were (1) active press to test that exercised as much of the electronics as possible, (2) versatility in offering different lengths of sensor tube with a common electronics package and (3) minimize possibility of latent failures.

The simplified diagram above describes the sensor's operation. Pass transistor Q1 is configured to control up to 100 milliamps of incandescent lighting typical of annunicator panels of the time. Q1 is turned ON by base current pull-down through lamp regulator Q4 and excitation lamp L1. The regulator setpoint for Q4 is controlled by the value of zener D1. Q1 is held OFF by shunting Q4 pull down current through transistor Q2. Q2 is held ON by base pull-down currents flowing through R5, a conducting transistor Q3 and voltage divider R4/R6. Transistor Q3 is turned on by gate pull-up current from +supply through R3. Transistor Q3 is turned OFF by conduction through photocell, R2 and

R3. Capacitor C1 offers a means for inserting some time delay in responding to a low liquid level condition.

When the sensor tip is immersed, the photo transistor is dark. It's resistance is very high allowing gate voltage on Q3 to rise. Q3 turns on, Q2 turns on, Q4 turns off and annunciator lamps are dark. If the sensor tip becomes exposed, light from L1 is conducted around the prism at the tip to the photocell. Phtotocell resistance drops. Gate voltage of Q3 drops below voltage divider allowing Q3 to turn off. Q2 turns off allowing pull-down current through Q4 to turn Q1 ON. The annunciator lamps illuminate.

Resistor R8 provides positive feedback and hysteresis to reduce tentative operation at the low-liquid level setpoint.

Press to test is accomplished by direct illumination of the photocell with a second lamp (not shown).

If lamp L1 burns out. Q1 looses its source of pull-down current and the unit will fail press to test.

I've heard that there are several problems associated with the low liquid level sensors in Premier. Sensitivity to stray light and/or light reflected from opposite surface of tank. Sensitivity to sloshing causing light to flash near the low liquid warning setpoint. Sensitivity to "noise" (turning other accessories on and off cause warning to flash). If there are others, I'd be pleased to know what they are.

Some points to consider about the physics that drive operation of this product:

(1) The product was designed to drive incandescent lamps. The typical pair of annunicator lamps offered about 50 ohms cold resistance and about 350 ohms resistance when illuminated.

- I understand that the sensors are presently driving inputs to a solid state annunicator controller. Do we know the input impedance of the controller?

- Is the input internally predisposed to go to ground (pull down) or bus (pull up)?

(2) Cadmium Sulfide photo cells have a broad manufacturing tolerance on light/dark resistance and sensitivity to light.

- During development we conducted a variety of experiments to gage sensitivity to ambient light and reflection of excitation lamp light from tank surfaces.

- Results using photo cells at that time convinced us that reflection from tank surfaces was too small to be a concern.

- Sunlight shining in though an open fuel filler cap would confuse the sensor. This was deemed not to be an issue at the time.

- On several occasions I recall telling technicians in the field that they could test a sensor in place by shinning a bright flashlight on it assuming they could get a straight shot at it from the fuel filler cap.

- In situations were ambient light –OR- wall reflections are an issue. A porous light-shield could be incorporated to cap off the tip of a sensor in a problem installation.

- It is possible that contemporary cadmium-sulfide have average characteristics from those used earlier in this product's market history. This is a useful point for investigation.

(3) In situations where liquid being monitored has strong changes in local level due to sloshing, some liquid damping can be incorporated with the same "fix" as for ambient light issues. A cover on the tip of the sensor fitted with tiny holes will provide hydraulic damping to the response dynamics.

- I don't recall any situations where customers found it necessary to add a cap on our offerings for either ambient light interference or slosh dynamics although this was discussed as a solution for both situations. We were prepared to offer it as needed.