Build Your Own
Water Tank Level Control System

I was sitting in my field office when the project manager for Braun Electric came in. He spotted a salesman and was inquiring about a replacement switch for a water tank he used to supply his mountain cabin. The switch, which mounted on the side of the tank near the bottom, had a rubber diaphragm which moved when pressure was put upon it. This movement caused a cam to rotate which operated microswitches which…in turn…turned on his pump and chlorinator to control the water level and chlorinate the water which was pumped from a nearby creek. I asked about the price of the switch and Dave told me it would cost between $ 800.00-1,000.00! That's way too much money! I told him it could be done A LOT CHEAPER. What follows is how we designed it and how it operates. And we saved him a bundle of money to boot!

Pressure versus Level

I've been into electronics all of my life. I remember reading about the first microprocessors in the early '70's. They're all made up of switches arranged in various matrixes to form the core logic. All they can really do is sense ON/OFF conditions. I also remember reading a TAB book entitled "Digital Interfacing to a Analog World" by Joseph J. Carr. An excellent book by an excellent author. It covered devices known as 'data converters' which we now know as A/D or D/A (Analog/Digital or Digital/Analog) converters. These devices allow us to read and control various parameters in the 'real world'. The PIC 16C71 microcontroller has a 4-channel 8-bit A/D built in to the chip. We use one of those channels to read the pressure on the tank to control the level.

Here's how it works. Physics has taught us that for every 27.7" of water level above a measurement point…the pressure will increase at a 1 PSI rate. In other words…if you've got a tank 277" tall and the measurement point is at the same elevation with the very bottom of the tank…the pressure will be 10 PSIG. PSIG stands for **P**ounds per **S**quare **I**nch **G**auge. Gauge pressure is corrected to atmospheric (14.69 PSI @ sea level) pressure. PSIA is absolute pressure and is referenced to a vacuum. This is a constant no matter what the diameter of the tank may be. Dave's tank is 16 ft. high (192" high) and when it's full…the pressure is 192/27.7 = ~6.9 PSIG.

We selected a 0-25 PSIG pressure transmitter which produces a 1-5 VDC output. This means that 0 PSIG=1 VDC & 25 PSIG=5 VDC. Since the most pressure were going to see is 6.9 PSIG…we're only using 27.7 % (interesting numerical coincidence…don't you think!) of the range of the transmitter. Because this is an 8-bit analog register in the PIC…we only have a resolution of 256 counts.

The input range of the PIC is 0-5 VDC so an input pressure of 0 PSIG (1 VDC) creates an offset of 51 (20 % of 256). The remaining resolution of 205 (256-51) for full range actually gives us ~ 57 counts (27.7 % x 205) for the 0-16 ft. range of the tank. This calculates out to be about 3.6 " per count. This means that we can resolve or see a change of 1 in the analog register for each 3.54 " of level change. Or looking at it another way…57 counts=100 % of the level so 1 count=1.84 % of the total level. This is enough resolution to accurately control and indicate the level in the water tank.

How it Works

Looking at the schematic diagram…you can see that the pressure transmitter is hooked up to channel 0 of the PIC. As the level in the tank increases…the PIC measures that level via pressure and makes a series of decisions based solely on the analog signal. I'll go through the power up sequence and explain all the features in order. When the unit is initially powered up…ALL outputs come on for 5 seconds to test their operation. If the input level is 1 VDC or above…outputs rb.7 (pump control)…rb.6 (hi/lo alarm)…rb.0 (audible alarm) are energized. If the input level is < 1 VDC…a sensor fail condition exists and rb.0-rb.6 will toggle on and off @ 1 Hz. Rate. For obvious reasons…you don't want the pump control to be on since you can't tell how full the tank is. This was especially important to Dave because he didn't want to dump chlorinated water back into the creek and ruin his fishing!

Hi/lo alarms are on for tank levels of < 4 ft. and > 15.5 ft. The audible alarm (rb.0) times out after 10 minutes in high level only to avoid being a nuisance to the neighbors while the level alarm (rb.6) remains until the condition is corrected. The pump control output is on until you reach the 15 ft. level. It stays off until the level decreases to 12 ft. and turns back on until you reach the 15 ft. level again. The level LED's work in a bargraph fashion so each successive level energizes all the levels beneath it. This also helps you spot a defective LED should it even burn out. Please note that the LED's don't reflect the 4 ft. and 15.5 ft. alarm levels. We kinda' ran out of outputs…

I went up to Dave's cabin in the Sequoia National Forest about 35 miles East of Porterville, CA. It turns out that Dave's water tank was not only 16 feet high but held 30,000 gallons of water and supplied the community of 41 cabins, which are located at a 5,000 foot elevation. They piped water in ¼ mile from a nearby creek with a 2" line. The water gravity feeds down to a sand tank which filters the water from mud and debris.

Then it continues down to the tank which operates a 2" electric solenoid valve and a chlorine injector…to purify the water. Imagine that…a PIC running a water district ! Before installing the system, I not only checked the operation of the control system before we installed it, but I also checked the calibration of the pressure transmitter. It was off about 3" maximum and that was at the very bottom of the tank. Since 1" is .14% error (1/(27.7 x 25))…worst case accuracy was ~ 0.5 %. Not bad for an inexpensive unit.

The water feeds into a 3” line for distribution to the cabins. The tank is so high above some of the cabins, that a pressure regulator had to be installed on the lower cabins. For every 27.7 “ below the tank…the water pressure increased 1 PSIG. Since some of the cabins were located hundreds of feet below the tank…the pressure went up very quickly ! That’s why steeply inclined rivers and creeks flow with such volume and power. There’s a lot of pressure behind that water to move it so quickly.

We not only cover electronics and theory in our articles, but we also like to include the physics that the real world operates on as well. It is these physical properties of temperature, pressure, flow, and other parameters such as the above mentioned pressure/level relationship. Just for your information…you can also measure the flow of a fluid through a pipe by decreasing the diameter with an orifice plate (a metal plate with a small hole in the middle inserted between pipe flanges which are bolted together) and measuring the difference of pressure between the upstream and down stream side. The flow is the square root of the differential pressure. It’s important to understand these relationships because they form the basis of instrumentation which is able to measure things in the real world.

After we got it installed, it took about two days to fill the tank. After we had finished up we ate some barbequed Tri-tip sandwiches. All that walking up and down the hill got us pretty hungry. Dave had some rainbow trout in the refrigerator and invited me back up to spend the weekend some time. It seems that the trout fishing is real good up there ! It’s nice to be able to help out a friend and make some new friends in the process. Now…if I can just figure out how to automate the fishing process.

Once again, we were able to custom design a PIC-based control system with more features than are commercially available. We’re selling the programmed PIC16C71 and ceramic resonator for $ 15.00 postpaid in the continental U.S. You pay the extra postage and we’ll ship anywhere in the world. If you have need of a variation of this product or it’s sparked your imagination for something new…let us know how we can design your next product…for a reasonable price…of course!

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