Day Tank Controller Design Details

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A day tank controller is a pretty simple device. It should sense when the level of fuel in the day tank drops to somewhere around ¼ full and turn the electric fuel pump on. When the fuel level rises back up to around ¾ full, it should turn the pump off. If ever the fuel level gets much below the ¼ full mark, it should turn on an audible and visible 'Low Fuel' alarm. By sounding an alarm, we will get a few minutes warning before the engine dies if the pump fails, the main tank runs dry or the primary fuel filter becomes clogged. If the fuel level rises close to the top of the day tank, a 'Fuel Overflow' alarm should come on.

To sense the level of the fuel in the tank, I used four reed switches. These are tiny glass encased switches that are activated by bringing a magnet in close proximity to them. The plan was to use a float of some sort with a magnet attached that would slide up and down on a PVC pipe. The reed switches would be inside the PVC pipe, and as the magnet attached to the float came near each switch, the contacts of the switch would close. Two of the reed switches would signal the point at which the fuel pump should be turned on and off. The third reed switch would indicate a low fuel level in the tank.

Anytime the day tank was low or empty, there should be a way of turning the pump on manually. To do this, I wanted to control the fuel pump with a switch which, much like a bilge pump switch, had positions for On, Off, and Automatic. Since it would be possible (and, actually, quite likely with my short attention span) to put the switch in the On position and forget to switch it back to Automatic mode when it refilled, the fourth switch would indicate a high fuel level in the tank and sound an alarm.

My next decision was what to use as a float. It needed to be impervious to diesel and light enough to float. I considered carving a doughnut out of foam and encapsulating it in epoxy. Though this would have worked, I discovered that the float from a carburetor rebuild kit for my outboard was the perfect size to slide up and down on a length of 1/2" PVC pipe, and this is what I used. I epoxied two magnets onto opposite sides of the top of the float.

To build the sensor assembly, I started with a length of ½" PVC pipe that was about 1-1/2" longer than the inside height of the tank. I bonded a cap onto the bottom of the pipe. I wanted to permanently attach the pipe to the top of the tank, and to do this, I took two more PVC caps and cut the ends off, leaving two rings that could be slid onto the pipe. I then made two circular gaskets from a diesel impervious gasket material (O-rings would also work) to make a watertight seal. I positioned the pipe so that it would clear the bottom of the tank by about 1/2", then marked the pipe where it exited the top of the tank. Next I slid the float onto the pipe and used PVC adhesive to bond the lower ring in place. I slid one of the gaskets in place, positioned the PVC pipe in the hole, slid the top gasket in place and then glued the top ring into place, making sure to apply enough pressure to slightly compress the gaskets.

The next step in making the sensor assembly was to mount the reed switches. I planned to attach each reed switch to a dowel, and slide the dowel into the PVC pipe. I found a dowel of the correct diameter, cut it the same length as the PVC pipe, and began marking the location that each switch would be positioned. The lowest switch would be the Low Fuel sensor and I marked the dowel even with the magnet when the float was resting on the cap at the bottom of the PVC pipe. The highest switch would be the High Fuel sensor, and I marked the dowel even with the magnet when the float was moved up as high as it would go. The next switch would turn the fuel pump on, and for this sensor I put a mark on the dowel about ¼ of the distance between the Low and High Fuel sensor positions. The last switch would turn the fuel pump off, and I put a mark on the dowel about ¾ of the distance between the Low and High fuel sensors.

Next I soldered the two wires onto each reed switch. Since the current passing through each switch will be small, I used AWG 28 wire, but any size between AWG18 to AWG 28 will work. The wires must be long enough to connect each switch to the controller . I planned to mount the controller onto the day tank, so I allowed about 2 feet of wire to reach from the PVC pipe to the controller. I used masking tape to label each pair of wires as “Lo”, “On”, “Off” and “Hi”, and then used a hot glue gun to attach each switch to the dowel. I secured the wires to the dowel with cable ties and slid the dowel into the PVC pipe. Using an Ohmmeter connected to each pair of wires, I slid the float up and down the PVC pipe to make sure all sensors were working. The completed sensor assembly is shown in Figure 1 below.

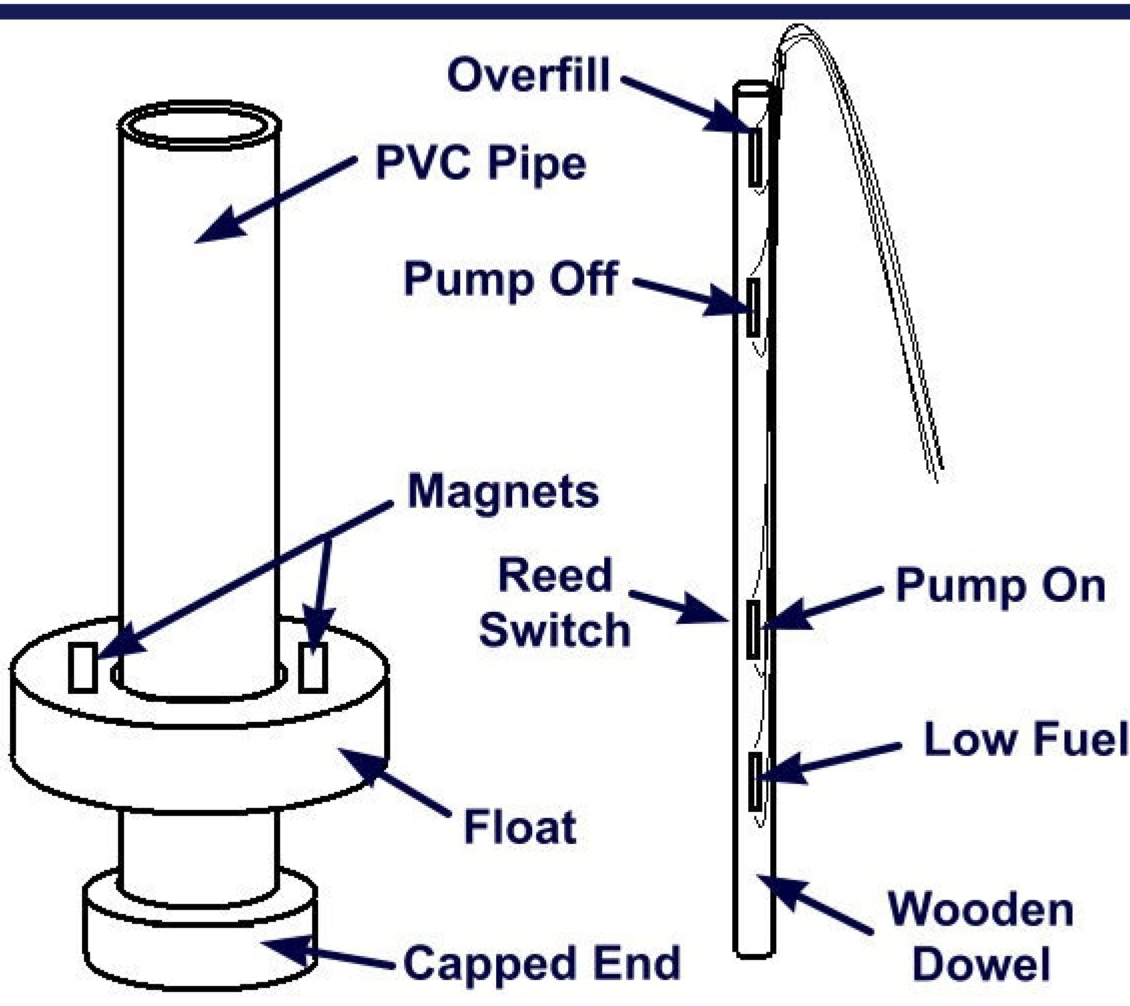

Figure 1. Sensor Assembly

I wanted the controller circuitry to be simple and reliable, and chose to use 4 relays as the basic control elements. The schematic in Figure 2 shows the basics of the controller. It consists of the four reed switches, four relays and an alarm horn. When the magnet passes close to any of the sensor switches, the contacts close – otherwise the switch contacts are open. Three of the relays have one set of contacts. When the relay coil is not energized, the Normally Closed or NC contacts are closed. When the coil is energized, the Normally Open or NO contacts are connected. The fourth relay, labeled “Pump On”, has two sets of contacts that function in the same manner.

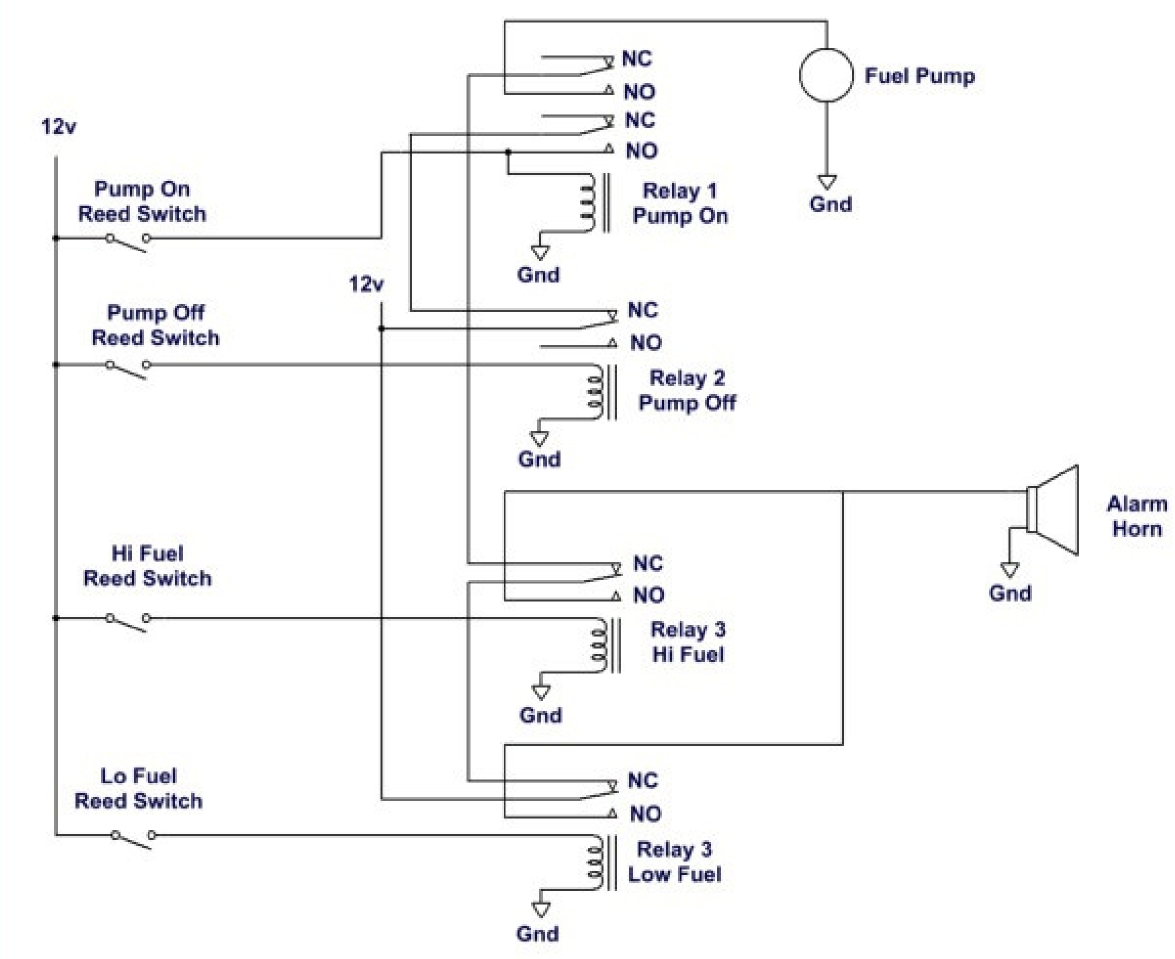

Figure 2. Basic Schematic

To understand how the circuit works, lets assume there is enough fuel in the day tank to position the float somewhere between the “Pump On” and “Pump Off” sensors. Since the magnet is not close to any of the sensor switches, all four of them are in the open position, and all the relays are in the de-energized or NC positions. As the fuel is consumed, the float drops lower until the magnet comes into proximity with the “Pump On” sensor and the switch contacts close. This routes 12 volts to the coil of

Relay 1, energizing it and causing the center contacts to connect with the NO contacts. If you follow the wire from the plus side of the pump, you can see it goes to the upper set of NO contacts of Relay 1, then to the NC contacts of of the “Hi Fuel” relay, to the NC contacts of the “Lo Fuel” relay and then to 12 volts. As long as the “Pump On” relay is energized and neither the “Lo Fuel” or “Hi Fuel” sensors are activated, the pump will run.

As fuel is pumped into the day tank, the float will begin to rise again and the “Pump On” sensor switch contacts will open. Relay 1 remains energized, however, because 12 volts is still routed to the coil through the NC contacts of Relay 2 and the NO contacts of Relay 1. The pump remains on until the float reaches the “Pump Off” sensor, energizing Relay 2, and turning the pump off. As fuel is consumed again, the float begins to drop, Relay 2 is de-energized, and the process starts over.

If, when the float drops down to activate the “Pump On” sensor, something prevents the tank from filling, such as an empty main fuel tank for example, the float will continue to drop lower until the “Lo Fuel” switch contact closes. The “Lo Fuel” relay will be energized, and the pump will be turned off. In addition, 12 volts will be routed to the alarm horn through the NC contacts of the “Lo Fuel” relay. Likewise, if the fuel continues to be pumped into the day tank after the “Pump Off” reed switch is activated, once the float reaches the “Hi Fuel” sensor, the pump will be shut off and the alarm horn will sound.

I wanted a few refinements to complete the circuit. When the horn is sounding, I want some indication of what is causing the alarm. In addition, I want to be able to turn the horn off while I correct the problem. I added two red LEDs to indicate the “Hi Fuel” or “Low Fuel” conditions, and a switch to turn the horn off. I also added a green LED to indicate that the pump is on. Finally, I added connectors so that the controller could be disconnected and removed if desired, and a switch for the pump with On, Off and Automatic positions. The complete schematic is shown in Figure 3.

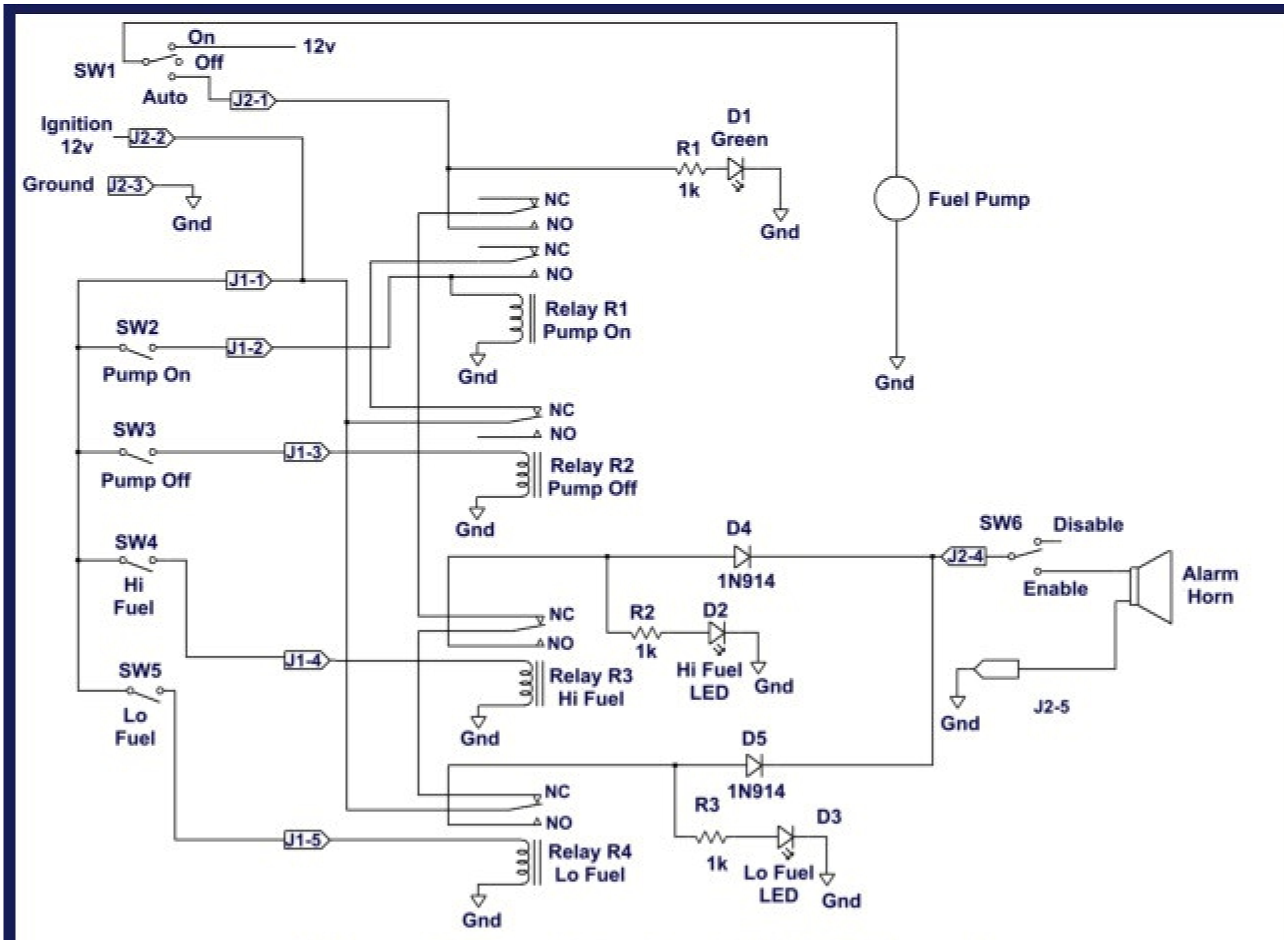

Figure 3. Complete Controller Schematic

Note that there are two minor shortcoming to the controller design that could be corrected at the cost of added complexity. First, if the pump switch is in the "ON" position and the engine ignition is off, there will be no alarm if the tank overflows. Second, if the alarm is sounding, I have to look in the engine room to determine the cause. It would be nice to add external LEDs for the Day Tank status.

For the fuel pump, I went to a local auto parts store and asked for a universal diesel compatible electric fuel pump. For my 90HP Lehman, even the smallest fuel pump at 30 gallons per hour was considerably more than I needed. The least expensive price I found was $38.00, and this included a mounting bracket and hose fittings.

Building the circuit is straightforward if you have done any electrical soldering. If not, the Nine of Cups website[1] given in the appendix has a set of video tutorials on soldering basics. A complete parts list is given in Table 1, and the websites for the parts suppliers are also provided in the appendix.

Ref	Description	Part No.	Source	Unit Cost	Extended Cost
R1-R3	Resistor, 1k Ohm, 5%, ¼ watt	690865	2	$0.01	$1.00*
D1	LED, Green	790111	2	$0.04	$0.42*
D2-D3	LED, Red	697590	2	$0.04	$0.42*
D4-D5	Diode, Small Signal, 1N914	36311	2	$0.02	$0.20*
	LED Panel Mounting Hardware	23077	2	$0.15	$0.45
	LED Interconnects, 4" Stripped Leads	417480	2	$1.10	$3.30
Relay1	Power PC Mount relay, DPDT,12v,5amp	843235	2	$2.19	$2.19
Relay2-4	Power PC Mount relay, SPDT,12v,5amp	172937	2	$1.09	$3.27
J1-J2	Terminal Block, .2" Term Spacing, 2 terms	152347	2	$0.65	$1.30
J1-J2	Terminal Block, .2" Term Spacing, 3 terms	152355	2	$0.47	$0.94
Enclosure	ABS Plastic Enclosure	18893	2	$4.79	$4.79
Horn	Piezo Siren, Panel Mount, 12v,100dB,2500Hz	336225	2	$5.05	$5.05
SW1	Switch, SPDT, Toggle,On-Off-On	318123	2	$3.30	$3.30
Wire	Hook-up wire, stranded,22awg, 100' roll	126077	2	$3.55	$3.55
Wire	Duplex,16AWG,Marine Grade, 25' Roll	200298	3	**	**
Wire	Solid, 28awg				
SW1	SPDT Switch, On-Off-On	621536	2	$3.29	$3.29
SW2-4	Reed Switches	171871	2	$0.79	$3.16
	Dowel, 3/16" x 24" (5mm x 60cm)		4	$2.00	$2.00

Table 1. Parts List and Sources

*   Minimum order quantity is 10 pieces
** Length of wire will vary depending on the installation

I located the switch in the engine room in an accessible position. The photo below shows the completed day tank with controller attached.

Once the controller was completed and tested, the hoses were all attached. The fuel pump was turned on until the day tank was half full, then the switch was set to automatic. It worked flawlessly, and has continued to work without a problem for over two years now. We have been completely happy with it, and it has totally eliminated our air leak problems. The total capacity is about 3 gallons (11 liters), but the amount of fuel that is pumped each cycle is closer to 1.5 gallons (6 liters), enough for 1-2 hours of motoring depending on speed.

References:

1. Video tutorials on soldering basics, http://www.nineofcups.com/boatprojects.html
2. Jameco Electronics, www.jameco.com, (800) 831-4242
3. Defender Industries, www.defender.com, (800) 628-8225
4. Any large hardware or building supply