Ballast System in 2006 Nautique SV211

Overview

There is lots of dialog on Planet Nautique regarding the ballast system in these era Nautiques, so I figured I would document what I have learned. Much of it surrounds the inability to empty the tanks when they are full which I will address below. If you have a ballast system with Jabsco Ballast Puppy pumps, analog ballast gauges, a keypad, and a ballast controller (aka "run dry" module) then read on. If you want none of the detail and simply want a way to reliably empty the ballast tanks go straight to the section **Bypassing the Ballast Controller** towards the end.

First let me provide an overview of how the system works. *Figure 1* shows a simple block diagram of the entire system. The ballast pumps are the heart of the system and are reversible impeller type pumps. I believe that earlier boats may have used aerator type pumps and had separate units for filling and emptying. In my experience the Jabsco Ballast Puppy pumps have been quite reliable and robust. They are self-priming and you would really have to run them dry for a while to cause damage. I replaced the impellers after about 13 years of operation and they were not in bad shape.

Working back from the pumps this is how the entire system works. The pumps will operate in either direction by reversing the polarity on the ~12V supply. So +12V in one polarity will fill the tanks and reversing the polarity will empty them. *I did not trace every wire but I believe this is how the system works. If you know better let me know and I will make corrections.* You can see that there is a relay each for fill and empty. Therefore, if you have 3 ballast tanks you will have a total of 6 ballast relays. There is a circuit breaker for each pump that is not shown. If the pump is shorted out, the circuit breaker will pop and you will need to reset it. The relays and circuit breakers are in the port side hatch where the battery switch is. A signal driven by the PME box, usually located under the dash, energizes the relay coil which flips the appropriate relay. These relays are normally in the ground position. By flipping either relay to the +12V position the pump will operate in either the fill direction or the empty direction. There are separate fill and empty signals coming from the PME box so a total of 6 wires for 3 ballast tanks are required.

The tank sender is an analog "float type" unit that simply forms a variable resistor. The metal rod that projects down into the tank is nominally 240 ohms. With the float all the way at the bottom of the rod the tank will indicate "empty" and will measure about 240 ohms. As the water in the tank rises the float runs up the rod and "shorts out" a portion of the rod. As a result, the resistance will drop to about 65 ohms when the tank is full, ie the float is at the top of the rod. In my opinion these analog sending units are likely the weak point in the entire system. I pulled one out of my boat and ran the float up and down the rod with an ohmmeter attached. Most of the time the resistance changed smoothly but at times would get "stuck" at 240 ohms. I tried this both in a bucket of water and sitting dry on the bench. We will find later that if the sending unit fails, ie reads "empty", you will run into difficulties emptying your tanks.

The PME box drives a constant current source of about 20mA into the sending units. For those electrical engineers out there, we know that Voltage = Current * Resistance (V = IR). If the current is constant at 20mA then the voltage on the sender wire will vary from about 4.8V when empty (0.02A * 240 ohms) to about 1.3V (0.02A * 65 ohms) when full. This will be important as we discuss the ballast controller later. The analog ballast gauges are simply voltage driven gauges that range from about 4.3V empty to about 1.3V full. I verified operation by pulling them out of my boat and running them on a test bench. BTW, if you disconnect the sending unit, introducing an infinite resistance, the gauge will go way below empty.

The ballast controller (aka run dry) module is at the heart of our problems. The unit itself it built by Faria and is quite well designed and robust. I took one apart and found that it had good surge protection, reverse polarity protection, and was built of high quality solid state components. Operation is fairly simple and completely analog. If there is one weakness it might be the mechanical potentiometers, used to adjust the threshold, which could wear out over time. Mine seemed to be fine after about 14 years. There is a whole section below on the ballast controller so I won't go into too much detail here. The idea behind this ballast controller is to make sure there is water in the tank before allowing the pumps to operate in "empty mode", presumably to save the pump bearing and/or the impellers. What it does is compare the analog signal coming from the sender units with a fixed threshold, again adjusted by potentiometers. The threshold is set somewhere around 4.3V which is about where the tank would read empty (see above) or just above empty. I believe Nautique "calibrates" the threshold to match the sender unit which has some variability. In my case I measured the threshold for the 3 tanks to be 4.8V, 5.0V, and 4.6V for the starboard, center, and port ballast tanks respectively. If your sending units work reliably at all you can adjust the threshold easily by turning the appropriate potentiometer (more later).

The output of the ballast controller is simply an "empty enable signal" back to the PME box. If this signal is "low" (close to ground) when you push the "empty" button on the keypad then the pump will operate. HOWEVER, if this signal is "high" (close to 12V), indicating that tank is already empty, the pump will NOT operate. The light will flash on the keypad but the pump will not run. So, you can imagine if your sender is bad/flakey OR you have any issue with the wiring, this ballast controller will prevent you from emptying the tank.

The keypad has a variety of buttons to operate various functions. This keypad is built by DNA Group (www.dnagroup.com) who also produces the PME box. I'm pretty sure the connection between the keypad and the PME box is a 4 wire CAN bus, used heavily in the auto industry. There is a CAN bus controller at both ends to handle the communication. So, when you push one of the ballast buttons, all you are doing is sending a command to the PME box to interpret. There is no direct connection between the buttons on the keypad and any of the functions they operate (e.g. lights, ignition, ballast pumps, etc.). The PME box interprets these commands and drives the appropriate wires. When you push and hold one of the ballast buttons to empty a tank, the PME box interprets the command AND looks at the empty enable from the Ballast Controller to determine whether to turn on the pump.

Ballast Controller Details

As mentioned, this module is built by Faria and is quite robust in my opinion. I believe it is no longer available, at least from Nautique Parts, although there may be other sources. It is a fairly basic design and I even considered developing one of my own and offering it to folks that wanted to purchase one. But the reality is that the weakness in the system is really the analog sending units and the whole concept of "run dry protection". If you are paying attention at all, you can clearly hear a difference in the pitch of the pump when the tank is dry. Anyway, I had to analyze the ballast controller to the point that I understood the entire system so here are the details. *Figures 2 through 4* show the module position under the dash, along with the mating connector, and the printed circuit board inside the controller with the cover removed. You should really NOT have to access the circuit board directly. I did this only to analyze the board and come up the recommendations below. Adjustments are made by removing the plugs as outlined below.

The schematic of one of the 3 channels is shown in *Figure 5*. The unit operates on nominally +12V and has essentially 3 inputs from the sending units and 3 outputs that are the "empty enable" signals. It appears that Faria intended this unit to directly drive the relay coils based on the documentation (*Figure 6*) and wiring labels I found. However, Nautique does not use it this way and instead uses the outputs as enable signals to the PME box. The connector is a Deutsch DT type 12 pin connector that will become important later when we bypass the controller. The +12V power has some reverse polarity protection, decoupling, and a Zener diode regulator circuit. However, it appears that the Zener voltage is so high that it never goes into regulation. Anyway, the "+12 REG" is what powers the LM2903 comparators and a 78L05A +5V linear regulator. The sender signal goes into the – pin of the comparator through a 10K resistor. A voltage divider is developed through a 33.2K, 10K trim POT, and 20k resistor from +12 REG to ground respectively. The wiper of this POT feeds the + pin of the comparator through a 10K resistor and is the threshold reference signal. There is a 1M resistor between the output of the comparator and the + pin which provides hysteresis. If the sender voltage is lower than the fixed threshold the comparator flips high which in turn feeds the gate driver (U4) which drives the gate of the MOSFET Q4. When the gate of the MOSFET is driven high, the drain collapses and the output of the system is driven low. Again this "could" directly drive the coil of a relay, but in the Nautique case this simply becomes an enable to the PME box. Note that the gate driver is logic level +5V so the linear regulator 78L05A is used to provide the +5V required.

Adjusting the Ballast Contoller Threshold

Faria provides access to the threshold adjustment POTs through "plugs" in the bottom of the housing (see *Figure 2*). You can remove the appropriate plug and turn the POT with a small Philips head screwdriver. You do NOT have to remove the controller from the boat. Below is the decoder ring for the SV211. I suspect other boats (210, etc.) are the same but don't count on it.

Label	Ballast Tank	CW	CCW
Ballast #1	Port	Raises Threshold	Lowers Threshold
Ballast #2	Center	Raises Threshold	Lowers Threshold
Ballast #3	Starboard	Raises Threshold	Lowers Threshold

Ballast #1 and #2 are under the larger plug, #1 next to the rectangular blank connector. Ballast #3 is under the smaller plug. **In most cases you will want to RAISE the threshold (CW) to get your pumps to turn on.** In other words, you want the ballast controller to always "think" there is water in the tank. Remember that the nominal "empty" voltage is about 4.8V so we need the threshold to be above this value. Fortunately, there is enough range in the trim POT to get us to about 5.7V. The only case you might want to LOWER the threshold (CCW) is when the pump continues to operate when the tank is completely empty. I personally would just turn the pump off…..

Bypassing the Ballast Controller

There are several ways to bypass the ballast controller and get your tanks to empty. I show 3 possibilities below. I do not recommend #1, but that was my first approach.

#1 – The Jumper Approach - The "brute force" way is to create jumper wires so you can reverse the polarity of the pump directly. The idea is you unplug the ballast pump, plug in the jumpers in reverse polarity, and then turn on the pump in the fill mode. Since the polarity of the pump is reversed the tanks will empty. When finished, remove the jumpers and plug in the pump. I have a post here https://www.planetnautique.com/vb5/forum/nautique-topics/maintenance-technical-discussion/21717-ballast-run-dry-control-module This absolutely works but there is a WAY more elegant way to do it.

#2 – Adjust the Threshold on the Ballast Controller – This is a reasonable approach assuming that your wiring is good and the sender is plugged in. Even if the sender is flakey, reading 240 ohms all the time, there is enough adjustment in the trim POT to get the pump to come on. You can see if this approach will work by observing your ballast gauge. If the needle points to empty or above with the ignition on then this approach should work. If the needle is below empty, indicating the sender is disconnected or really messed up, this approach will NOT work and you need to look at #3. Essentially just rotate the offending trip POT all the way CW and the pump should operate. You might consider rotating ALL 3 trim POTs CW since you're under the dash anyway…..

#3 – The Bypass Plug – This approach works no matter the condition of the sender or if it's even plugged in. A schematic of the dash area wiring harness is shown in *Figure 7*. This is just the part that pertains to the ballast controller and gauges. From our description of how the ballast controller works it becomes clear that if we simply short the "empty enable" signals to ground we will bypass the "run dry" functionality, and the system will ignore the tank level sender inputs and always empty. This works perfectly as I have verified. We can create a "jumper plug" using readily available parts and plug this into the connector that would normally plug into the ballast controller. I recommend that you use a zip tie to stabilize the dangling connector pair. You can leave the ballast controller in place, in case you might want to remove the jumper plug in the future and plug back in the ballast controller. Or, as I did in my case, remove the ballast controller entirely. In my opinion the "run dry" functionality was a bad idea from the git go.

Figure 8 is a schematic of the bypass plug and *Figure 9* is a picture of the completed unit. The parts you need are as follows and available from https://www.mouser.com/ or https://www.digikey.com/:

QTY	TE Connectivity P/N	Mouser P/N	Description	Price (as of 8/17/19)
1	DT04-12PA	571-DT04-12PA	12 pin receptacle	$6.25
1	W12P	571-W12P	Wedgelock	$0.41
4*	1060-14-0122	571-1060-14-0122-LP	Contact pins	$0.27
3	Pieces of 18AWG stranded wire about 5" in length			

* Recommend that you get some extras in case you mess up. 20 of these contacts are $5.

The contacts are "crimp style" so in theory you don't really need to solder them. You could just strip the ends of the wire and crimp the contacts. I'm a fan of soldering them also which is what I did. Create the complete wire assembly using the 3 pieces of wire and the 4 contacts FIRST. THEN insert them into the connector. Then complete the assembly with the wedge lock. There are YouTube videos online that explain how the connectors work and how to assemble them. Simply search on ***Deutsch DT Connector***.

A note about the "keying" – This is WAY too much detail but what the heck. These connectors have 4 different keying options, "A" through "D". Keying is used to make sure that you don't plug the connector in backwards. Almost all the connectors in your boat are "keyed' in some fashion. These DT connectors use "ears" on the corners of the connector to implement the keying. If you look closely at the plug you pulled off your ballast controller or the ballast controller connector you will see these ears/slots. The ballast controller/plug takes an "A" keying, hence the part number above is DT04-12P**A.** The 4 keying options are color coded, the "A" keying is grey in color. Here is why I even bring this up. The plug connector in MY boat is brown in color, indicating a "**D**" keying. Huh? How can that be since the ballast controller was clearly designed for the "A" keying and even the 1 page Faria document says use the "A" keying?? Well I took a close look at the brown plug and 1 of the ears was filed off so it would fit into the "A" keying of the ballast controller. My theory is that when Correct Craft built my boat there was a shortage of "A" keyed connectors so they bought a bunch of "D" keyed connectors and shaved 1 of the ears off. **The moral to this story** – Ignore the color of your connector and order the “A” keying above.

That’s it, hope this is helpful to someone.

2006 SV211 Ballast System Block Diagram

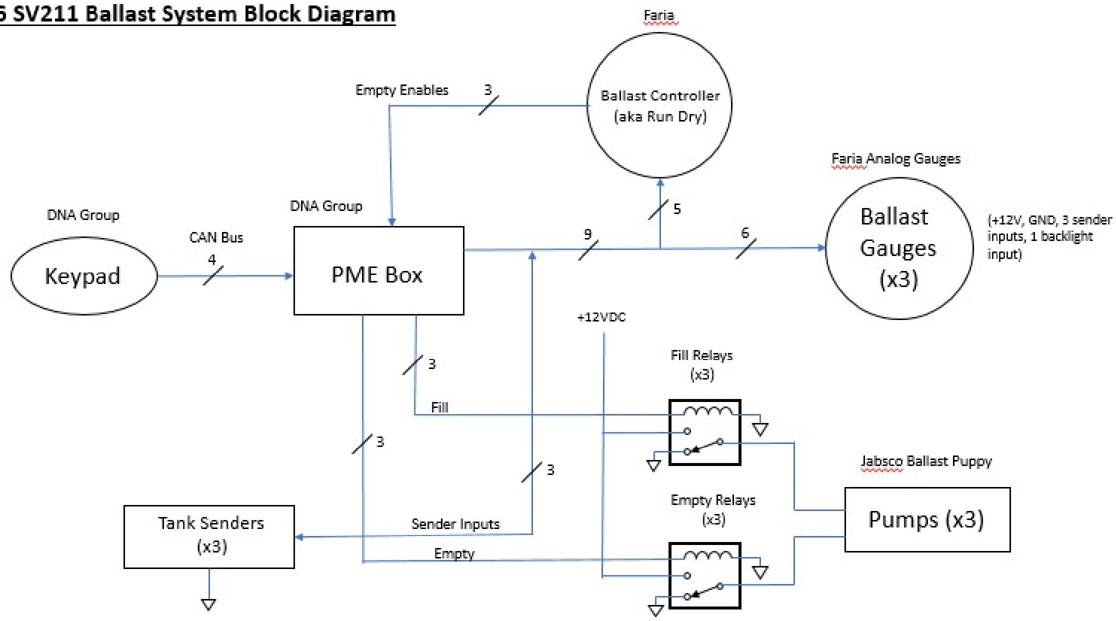


Figure 1

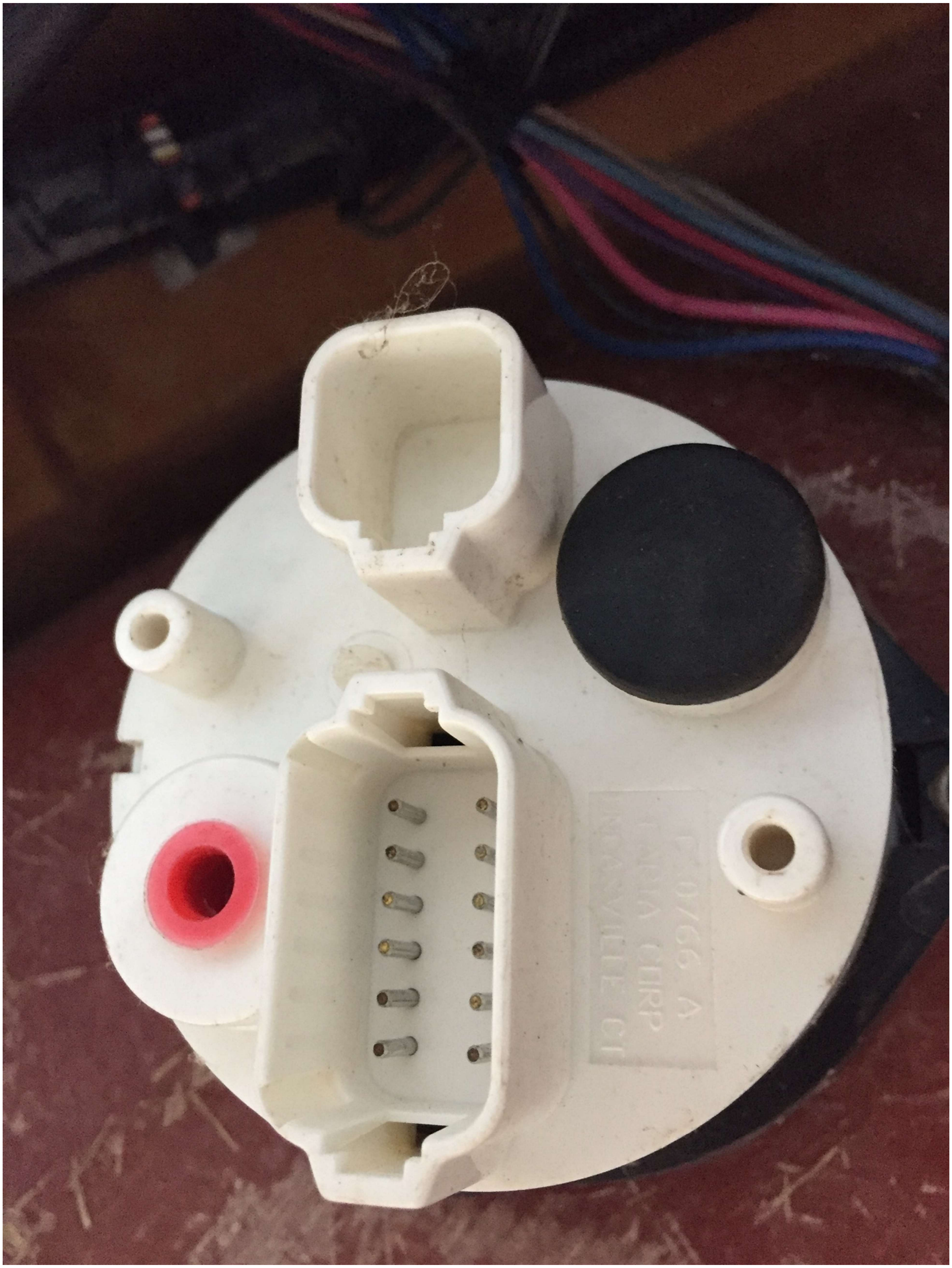


Figure 2 – Ballast Controller under Dashboard

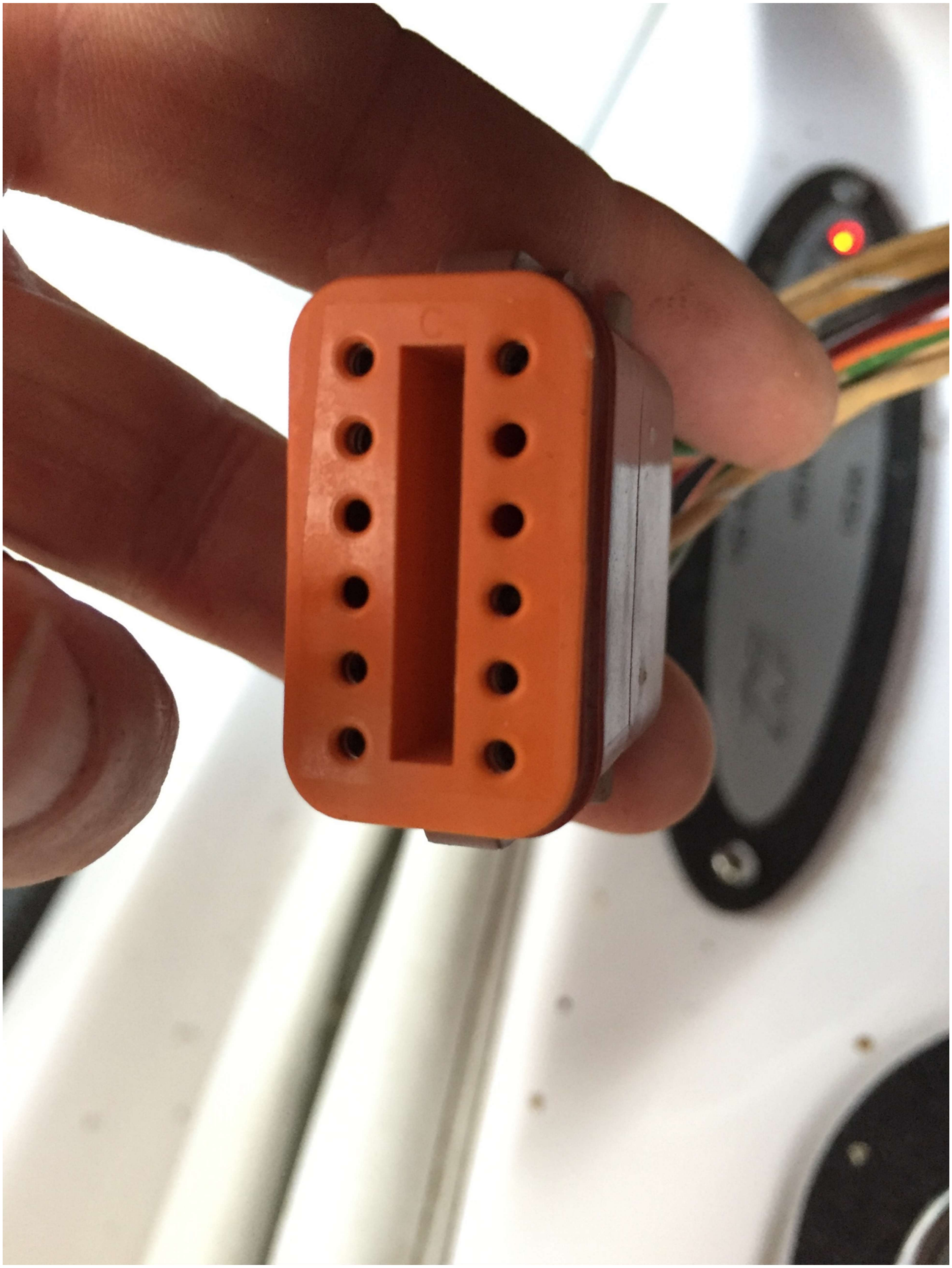


Figure 3 – Ballast Controller Connector

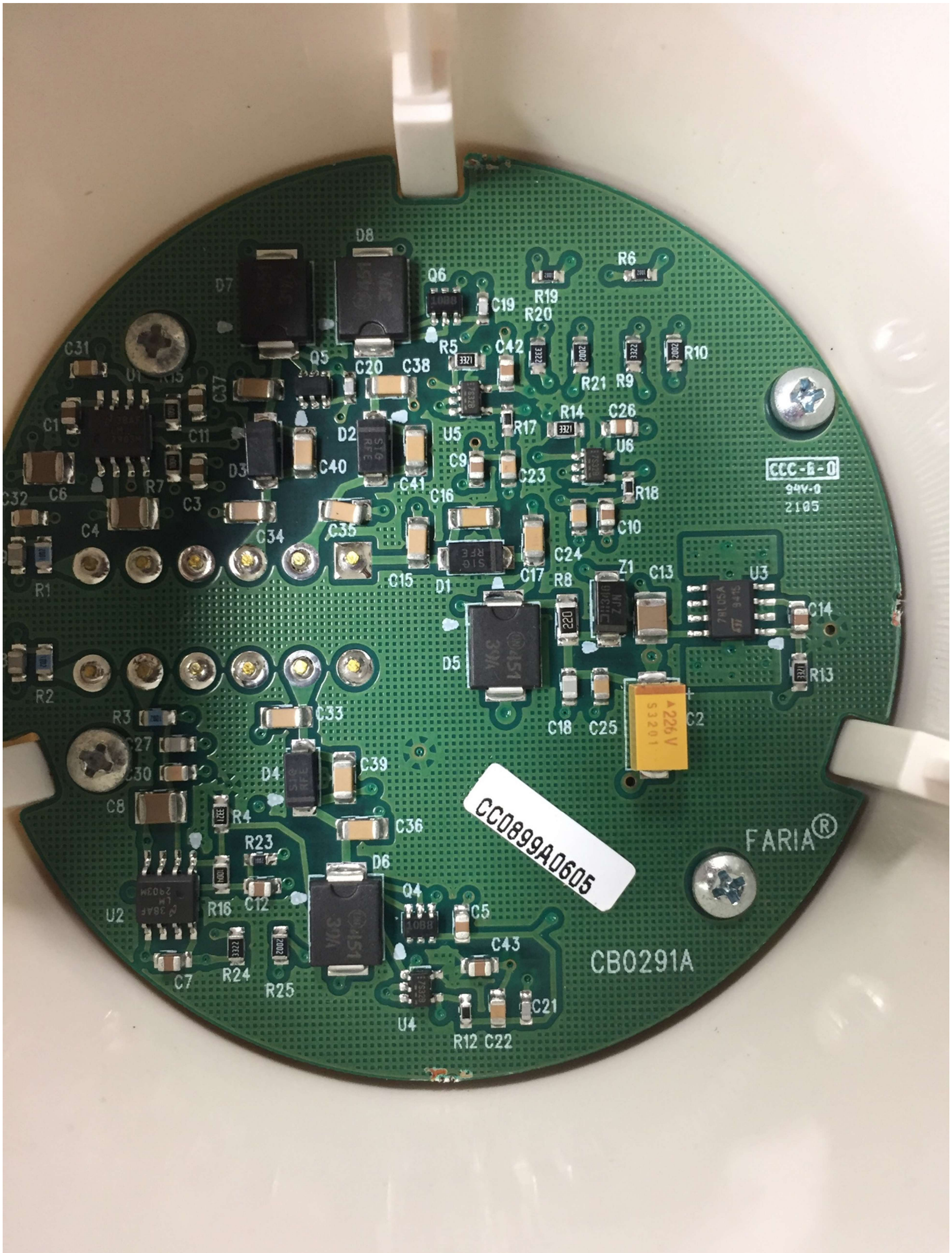


Figure 4 – Ballast Controller Circuit Board with Cover Removed

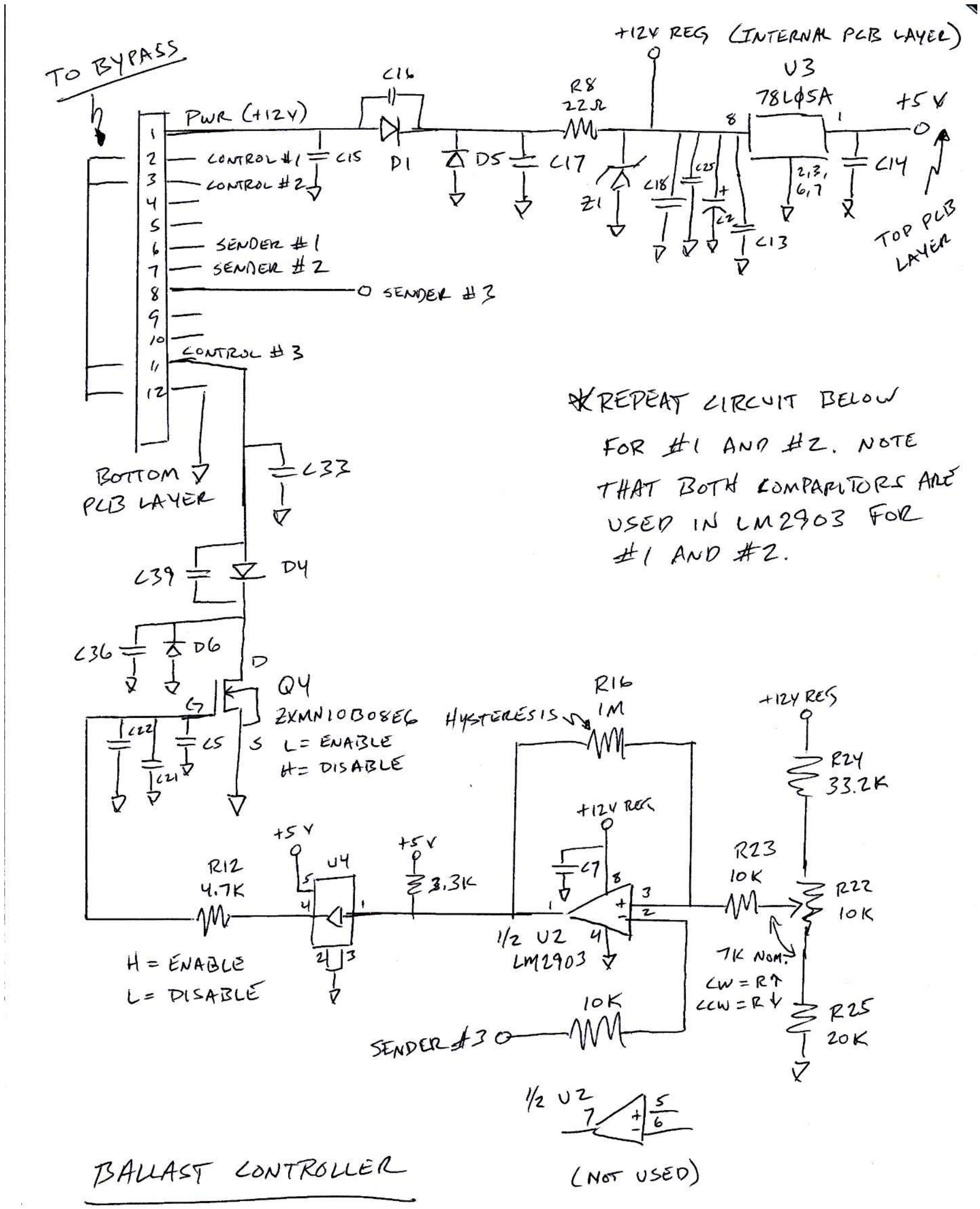


Figure 5 – Schematic of Ballast Controller (one channel of 3)

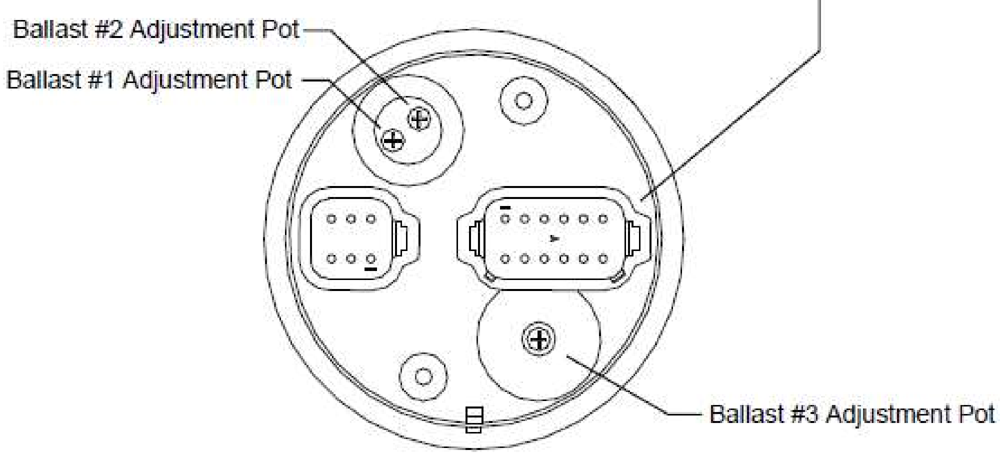
Faria® MARINE INSTRUMENTS

Instructions

Correctcraft Ballast Control

P1 12 Pin Deutsch, A Key

Pin# Function
1) +14 V
2) Control #1 Output-relay Coil, 72 W To +14 Vdc
3) Control #2 Output-relay Coil, 72 W To +14 Vdc
4) N/a
5) N/a
6) Ballast Gauge #1 Sender Input
7) Ballast Gauge #2 Sender Input
8) Ballast Gauge #3 Sender Input
9) N/a
10) N/a
11) Control #3 Output-relay Coil, 72 W To +14 Vdc
12) Ground



Controller Is Pre Set At Factory To Nominal Values
If Adjustment Is Necessary, Remove Plug To Access Corresponding Ballast Tank Adjustment Potentiometer.

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Figure 6 - Ballast Controller from Faria

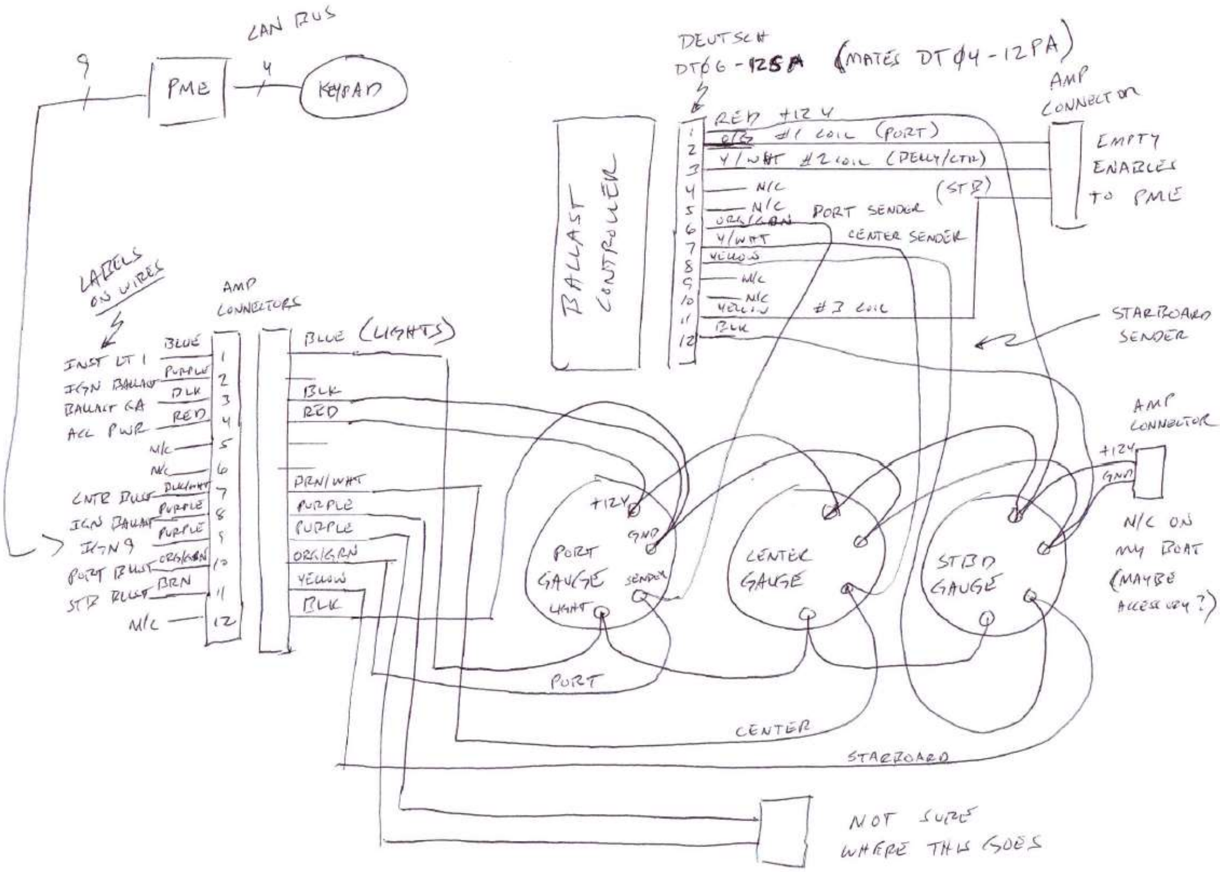

Figure 7 - Dash Area Wiring

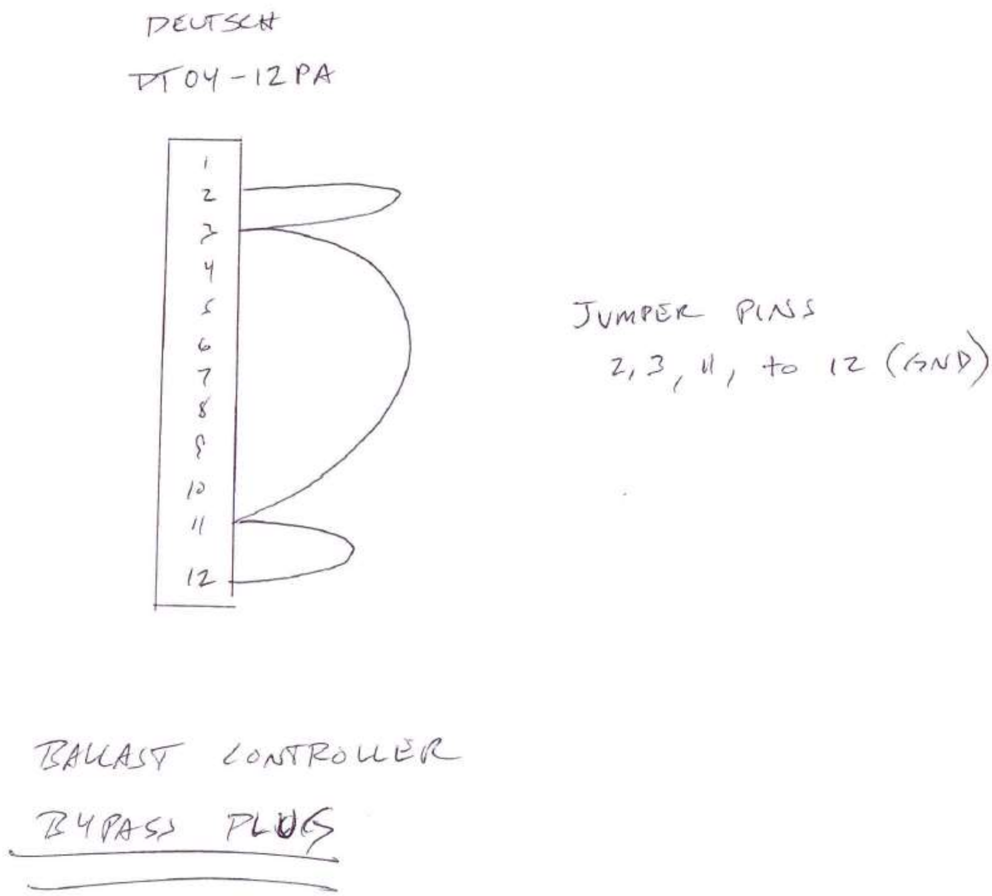

Figure 8 - Bypass Plug Schematic

Figure 9 - Bypass Plug