Discovery Fresh Water System

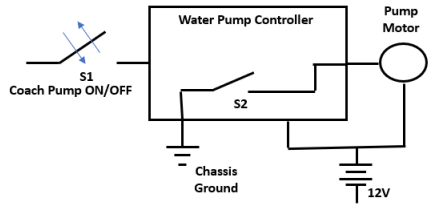
INTRODUCTION

This paper is intended to supplement training provided at Camp Discovery during national rallies. The distinct advantage of the in-person Camp Discovery training is the opportunity see/touch actual components, and to learn more and ask questions about your specific model year coach.

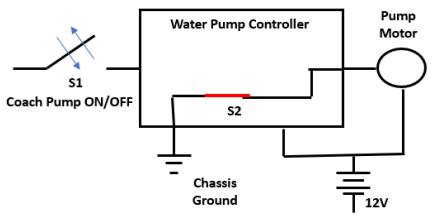
The components in Fleetwood Discovery freshwater systems include a fresh water holding tank, water pump with an internal pressure switch, multiple ON/OFF switches, one fuse, and a pump controller. The holding tank and coach plumbing routing are not covered in this paper. Component descriptions, simplified and detailed system operation, and an electronic diagram are discussed. Appendix 1 is a more detailed discussion about electronic latches and includes a link to a good You Tube video describing their operation . This paper deals primarily with operation and has little trouble-shooting information. A trouble-shooting appendix would be a good future project to improve this document (volunteers?). I am not an expert on this topic, so please email me (rickblaher@gmail.com) if you see anything errant.

Simplified Operation

The following 3 graphics describe what happens when you press a ON/OFF switch in the coach. In these graphics, S1 represents ANY water pump ON/OFF switch in your coach. S2 is only representative of what the **circuit** inside the controller does. The controller circuit has two states: ON or OFF. It will either complete (motor ON) or open (motor OFF) a ground path to the motor. Chassis ground is present at the controller at all times; likewise, 12V is always present at the controller and the water pump motor.

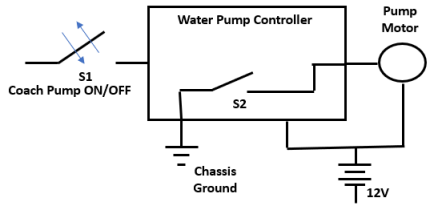


- Assume the pump is initially turned off.
- S1 is OPEN; S2 is OPEN (No ground path to motor)
- Motor OFF - Does NOT Run



Press any S1 Momentarily

- S1 CLOSES, sending a CHANGE STATE command to Water Pump Controller, then RE-OPENs
- S2 CLOSED by Controller completing ground path to motor
- STATE has been changed from OFF to ON
- Motor ON – Runs upon demand for water (faucet turned on)



- Again, press any S1 momentarily
- S1 CLOSES, sending a CHANGE STATE command to Water Pump Controller, then RE-OPENs
- S2 OPENED by Controller, breaking the ground path to motor
- STATE has been changed from ON to OFF
- Motor OFF

SYSTEM COMPONENTS

Water Pump/Pressure Switch

The water pump is powered by 12 Volts DC. Even though it is turned ON, the pump may not be physically running. This is because the pump contains an internal pressure switch that prevents the pump from running unless the pressure switch senses demand (faucet turned on). The water pump then runs until there is no longer demand for water. Then the pump stops running but is still turned ON.

ON/OFF Switches

ON/OFF switches are located in the coach galley, bathroom(s), and water bay. These are momentary switches, meaning their contacts are only closed while you are pressing a switch button. They are called momentary switches because they are designed to provide only a momentary connection (in our case, a path to ground) when pressed and released.

Fuses

Fuses protect both the battery system and components being powered by the batteries. Each fuse is specified for the maximum expected current through the fuse. If the specified current is exceeded, i.e. a short occurs, the fuse will break the path ("blow") between the batteries and components being powered. This prevents battery drain and may preclude component damage. If you are troubleshooting a pump that doesn't run when turned ON, the fuse is the first place to check.

Some of the general literature I researched alluded to a second, inline fuse. I did not find any Discovery water pump applications that use more than a single 10-amp (10A) fuse. A 10A fuse is used to protect the water pump circuit regardless of which brand controller is used. If you upgrade your water pump to one with higher flow rating, be sure to check its continuous current specification, and replace the 10A fuse with a 15A one if necessary. Make sure your controller is specified for higher current as well.

EZ-ID fuses.

EZ=ID fuses light up and are easy to identify when the fuse opens (blows), thus its name. They are more expensive than "regular" fuses but can greatly facilitate troubleshooting electrical problems. I replaced many of my fuses, including the water pump 10A fuse, with the EZ-ID type. The first thing I did when the water pump quit working was check the fuse. It wasn't lit so I errantly assumed the fuse was good. I removed and visually inspected it anyway. It appeared to be ok, so I eliminated it as the source of my problem. I then spent three more days periodically troubleshooting before actually pulling and testing the fuse. The fuse was blown. I replaced the fuse and the pump operated – problem corrected. EZ-ID fuses are supposed to light, but there is no guarantee that they will. **TROUBLESHOOTING LESSON LEARNED: Always test *any* suspect fuse with a meter.**

Al Welch provided this explanation for the EZ-ID fuse not lighting. The reason the fuse did not light up is because the controller switches the ground to the motor. The EZ-ID fuse depends on the circuit being complete to the appliance. It is a light like any other and needs a positive (hot side of the fuse holder) and negative (ground of the equipment) connection to light up. In the case of the water pump the ground connection was missing.

And this from Gary Osburn. That actually explains why the problem was hard to find. EZ- ID fuses are a great time saver when they work - like everything else, I guess. What nobody tells you is that the EZ-ID fuse only lights up when there's a load on the circuit. They get enough ground through the load, whether a light bulb or a motor, to light up the internal LED. A water pump won't act as a load unless a faucet is opened which causes the built-in pressure switch to close.

Figure 1. Above screenshot from Precision Circuits, Inc: https://precisioncircuitsinc.com/product/water-pump-control-10-amp-switch-to-ground/. This is the controller used in my 2016 Discovery 40E.

The following information is available from Precision Circuits, Inc: http://www.precisioncircuitsinc.com/wp-content/uploads/2014/08/00-10027-000-Water-Pump-Control-RevE.pdf

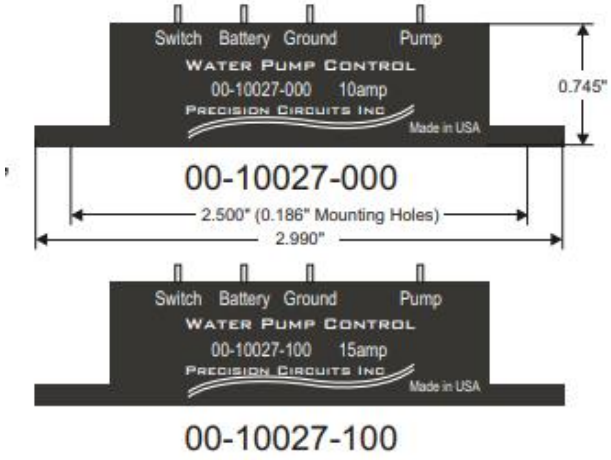


Figure 2. Photos of Precision Circuits, Inc water pump controller models. Note the P/N on the controller.

Figure 3. Intellitec water pump controller image. Note the P/N on the controller. Information about the controller is available from https://www.intellitec.com/wp-content/uploads/2019/07/53-00145-000.pdf

Controller

Because our coaches use multiple interior water pump ON/OFF switches, an electronic controller is needed to manage the pump's operation. The controller is a simple, encapsulated circuit with four external connections: 12V+, Ground, Switch, and Load (sometimes labeled Pump).

Sometime between 2013-2015 Fleetwood changed their water pump controller supplier from Intellitec Monoplex to Precision Circuits, Inc. It is possible that Fleetwood still employs both brands in their various coaches. You should find the controller near the water pump. Figures 1, 2, and 3 above show pictures of controllers. My 2016 40E Precision Circuits Inc. controller is located on the water bay ceiling. The detailed controller circuit designs are probably proprietary for both suppliers and need not be addressed here, as the functional operation of both controllers is essentially the same from an operational standpoint.

The water pump controller, irrespective of supplier, is basically a simple "latch" circuit. The controller "latches" the water pump to either an ON or OFF condition and holds it there until something tells it to switch conditions. Pushing an ON/OFF button toggles the condition of the latch circuit between ON and OFF.

Let's assume the pump is turned OFF to begin with. When you momentarily press **any** ON/OFF button to activate the pump, the controller "latches" the pump condition to ON until **any** ON/OFF button is pressed again. A second press will cause the pump to be "latched" to OFF. So, momentary presses of any ON/OFF button simply toggle the pump operational condition between ON and OFF. The circuit diagrams in Figures 4 and 5 below show what happens electronically each time you press a coach water pump switch. Figure 4 is a simplified diagram (albeit more detailed than the figures in the introduction.

NOTE: Remember, when the pump is latched to ON by the controller, the pump is ready to run but will not pump water from the fresh water tank unless the pressure switch in the pump senses a demand for water.

Refer to Figure 4. The electronic latch circuit used in Discoveries is referred to as a an "active low" latch. This means that a momentary "low" signal (a ground) triggers the latch to either latch the pump ON or OFF. The positive side of the pump and the controller itself are always connected to a 12V+ volt battery source (red lines). The controller provides the ground return path (red jumper in Figure 4) for the pump causing it to operate, or it removes the ground return path to disable the pump, depending on presses of a momentary ON/OFF switch. The red jumper is not an actual wire. It is for visulizing what happens inside the controller.

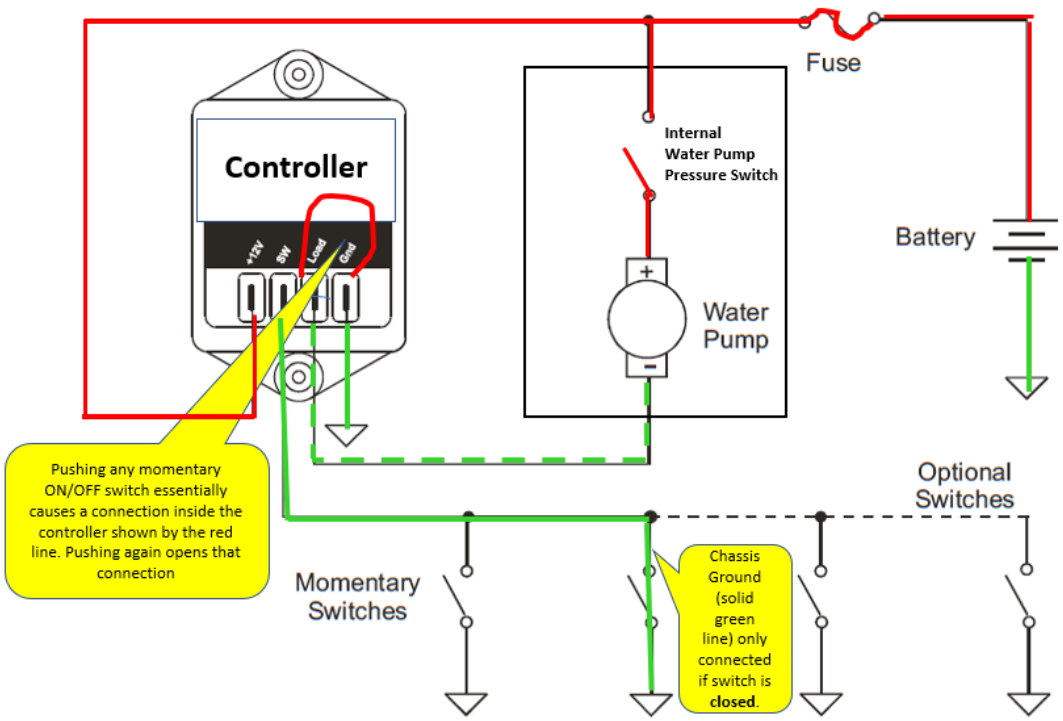


Figure 4. Simplified Water Pump block diagram from Precision Circuits, Inc.

THEORY OF OPERATION

General Coach Water Pump System Operation (Refer to Figure 4 above)

- This section should give you a reasonably good understanding of how the water pump system works. The Figure 5 circuit operation is for those who might wish for more detail. I found that both together are useful.
- A single low current signal wire can be run from all the coach's switches throughout the RV to the SWITCH terminal (labeled SW, 2nd from Left) of the controller.
- A momentary **ground** through *any* switch (4 shown) on this wire *toggles* the water pump On & Off. The Pump can be turned on in one location, and then turned off in another.
- The positive side of the water pump is connected, through an internal (to the pump) pressure switch, directly to the + side of the Coach Battery through a fuse.
- The water pump controller uses solid state switching to connect the negative side of the water pump to chassis ground through the LOAD/PUMP terminal (3rd from left - red jumper) of the controller to run the pump when there is demand for water (faucet turned on).
- When the an ON/OFF switch is pressed again, the ground path to the motor is inside the controller and the pump shuts off.

NOTE: Any time a faucet is initially opened there is a slight decrease in pressure in the coach's water lines, which is sensed by the pressure switch in the water pump and signals the pump to run if it has been latched to ON by the controller. If the pump has been latched OFF by the controller, the pressure switch has no effect on motor operation. The motor will not turn on, and you have no water pressure until the pump state is changed to ON by activating an ON/OFF switch.

Detailed Operation (Refer to Figure 4 above and Figure 5 below)

- Keep in mind that any electrical component needs a difference of potential (e.g., 12 volts and ground (zero volts) for our discussion) to operate. The operation of your water pump is determined by whether and when power (12v) and ground (0v) are applied.
- It's useful to print out a color copy of **Figure 5** as you work through the following steps.
- First, trace the red line from the breaker box (battery) 12 V + source on the diagram to each of these five components: One side each of 3 lights; one side of the motor; 12V+ power input terminal on the controller.
- Notice that the source voltage of 12V+ is present at all those points **at all times.** The rest of the operation is determined by what happens with the ground connections.
- Beginning with the system latched to the OFF and starting at the chassis GROUND connection on the right side of the diagram (this symbol ), trace the SOLID green line to all the components **One side each of 3 momentary switches, plus GROUND terminal at the water pump controller**. These points are always at ground potential. There is **NO** complete, closed electrical ground path through the momentary switches and no direct path between chassis ground and the motor at this point. The **solid and dashed green** lines are prevented form "seeing" each other because the controller is latched to the OFF condition. All of the **dashed green** lines are out of the circuit at this point. The lights are OFF because there is no continuous, closed path for current between 12v+ and ground.
- Also note that, at this point, there is no path between the motor and ground (**dashed green line**), so the motor is **not energized** either.
- Now, let's press any water pump ON/OFF switch. During the moment in which THAT water pump switch is pressed, the water pump switch closes its contact (only for the duration of the moment), **connecting** the **solid green and dashed green lines**. Note that all three switches are connected by the dashed green line and the switch you pressed closed its contacts momentarily. It does not matter which switch is pressed.
- TWO things happen as a result of that momentary press of an on/off switch:

  1) Chassis ground potential is connected through the water pump switch you pressed and down to the SWITCH terminal of the water pump controller. This momentary ground connection from the water pump ON/OFF switch you pressed is telling the controller to do something – specifically change the latch from the current condition to the opposite condition (from OFF to ON in this case) Select any momentary switch on the Figure 5 diagram and trace from chassis ground through the water pump ON/OFF switch and to the controller SWITCH terminal to convince yourself it is a continuous path for that moment. Do not confuse the controller SWITCH terminal with the momentary water pump switches.

  2) This will cause the controller to perform a function. When the controller sees this "low signal" from the ON/OFF switch at the controller SWITCH terminal, it internally changes the latch condition, and closes the path from ground to the water pump and ALL the switch lights. Trace the blue dashed lines from the water pump controller PUMP (sometimes referred as LOAD) terminal to the water pump and three momentary switch bulbs. This causes the pump motor to operate and lights all the momentary switch bulbs.
- Now, you press any water pump momentary switch sometime later. The process to alert the controller to perform an operation is exactly the same as the first time. The momentary press causes the ground path to the SWITCH terminal to be completed for the moment of water pump

ON/OFF switch engagement. The water pump controller senses the “LOW” (0 volts, ground potential) at the SWITCH terminal and the controller ***switches*** states from ON to OFF by removing the internal ground connection between the chassis ground and the motor and lights. The lights extinguish and the pump motor stops operating until a momentary switch is pressed again.

- Even though the momentary water pump switch is held for a short time and then opens, the lights stay on and the pump continues to operate because the controller has “latched” them to the ON condition. When the button was pressed the second time the dashed blue line path was opened by the controller, shutting both the motor and the lights off.

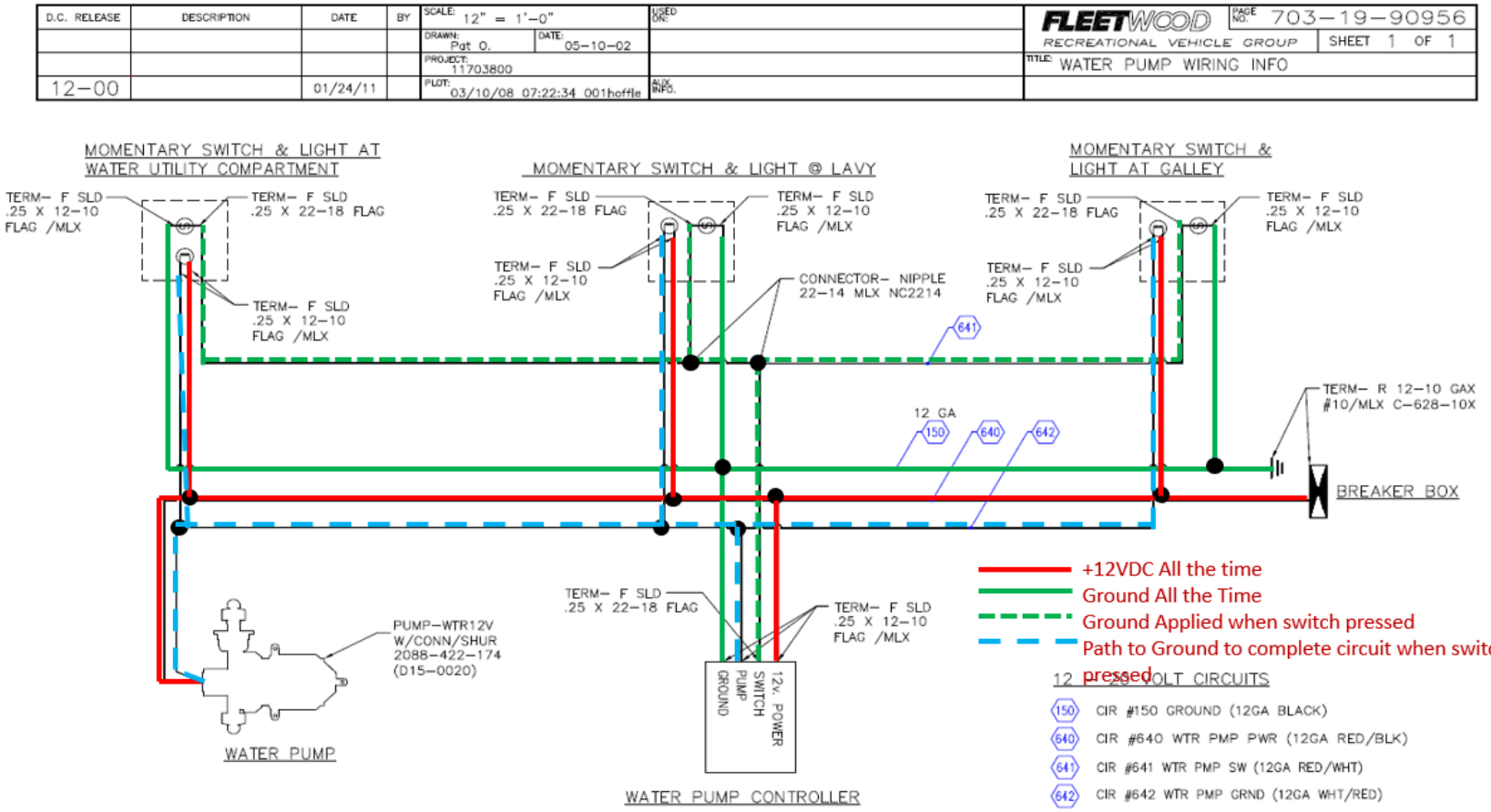
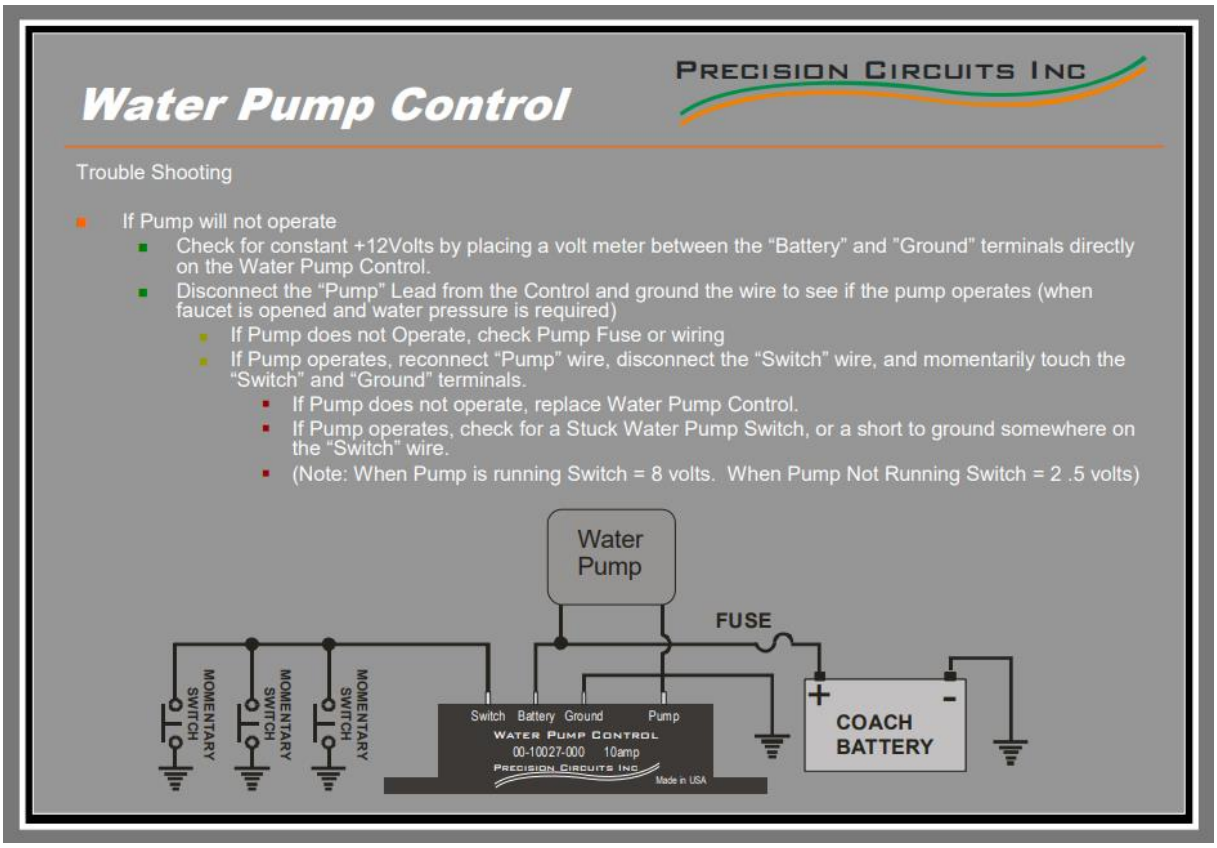


Figure 5. Color-coded representative water pump system wiring diagram

Figure 6. The following chart are provided by Precision Circuits, Inc: http://www.precisioncircuitsinc.com/wp-content/uploads/2014/08/Water-Pump-Trouble-Shooting-5-1912.pdf



Simple block diagram and troubleshooting above

Appendix 1
About Latches

A latch is an electronic logic circuit that has two inputs and one output. This discussion is about what happens functionally INSIDE the device. Within the latch circuit (not the lugs on the outside of the device), one of the inputs is called the **SET** input; the other is called the **RESET** input. When you see HIGH and LOW, the terms are related to the digital condition of the solid-state components (usually 5 volts and ground)

Latch circuits can be either active-high or active-low. The difference is determined by whether the operation of the latch circuit is triggered by HIGH (5v) or LOW (ground)

Both inputs of an **active-high circuit** are normally tied to ground (LOW), and the latch is triggered by a momentary HIGH signal on either of the inputs.

Both inputs of an **active-low circuit are** normally HIGH, and the latch is triggered by a momentary LOW signal on either input. (Discoveries are active LOW)

In an active-low latch, the two logic circuit inputs are normally held at HIGH to start with. When the **SET (1st press of momentary water pump switch)** input momentarily goes LOW (momentary switch closes to complete ground path from chassis), the output of the latch goes HIGH. What happens outside the controller module is that the internal digital HIGH **causes a ground to be applied through the controller LOAD (PUMP) output terminal to the pump** and momentary switch lights. The output then remains unchanged until the **RESET (2nd push of a water pump momentary switch)** input momentarily goes LOW again (3rd press of the momentary water pump switch). This condition remains until a water pump momentary switch is again pressed.

See this You Tube video for a detailed technical explanation of a logic latch circuit.

https://www.youtube.com/watch?v=KM0DdEaY5sY