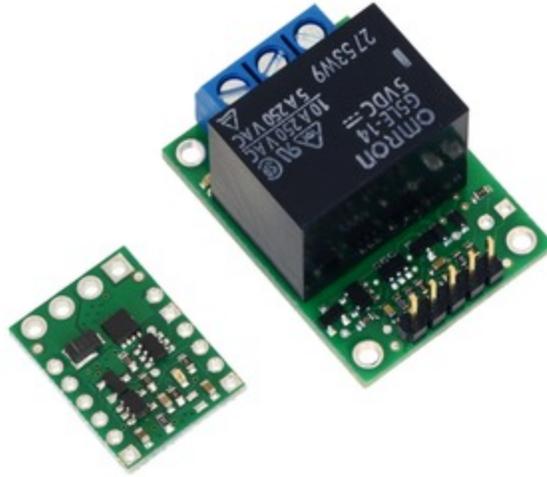


Pololu RC Switch User's Guide



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1. Overview

The Pololu RC switches allow you to turn devices on and off using standard radio control (RC) pulses. We offer a version with an integrated low-side MOSFET and a version with a single-pole, double-throw (SPDT) contact, allowing you to drive large loads directly. Two digital outputs indicate the presence of a valid signal and whether the switch is activated.

These switches can be used with standard hobby RC systems for radio-controlled switch applications. Example applications include using extra channels on an RC receiver or servo controller to turn on lights, motors, or irrigation valves.

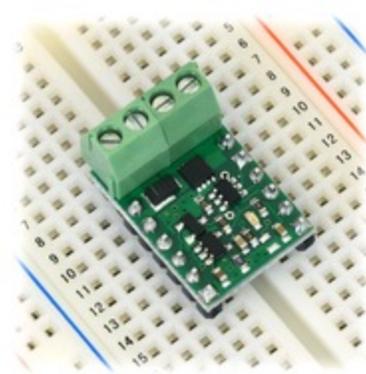
The RC switch measures the width of incoming RC pulses and compares it to a user-configurable threshold (with $\pm 64 \mu\text{s}$ of hysteresis) to decide whether to activate the switch. By default, the threshold is approximately $1700 \mu\text{s}$, with switch activation occurring above the threshold (longer pulses), but the switch has a learning mode that allows you to change the threshold and the activation direction. A safe-start feature reduces the likelihood of unexpected activation.

The **Pololu RC Switch with Medium Low-Side MOSFET** [<http://www.pololu.com/catalog/product/2803>] has an integrated low-side MOSFET that allows it to drive moderate loads (up to around 15 A). It comes as a partial kit.

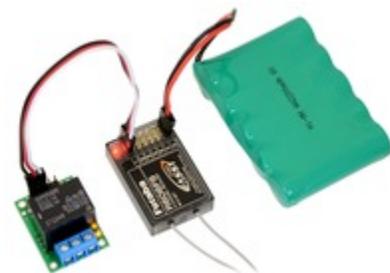
The Pololu RC Switch with Relay comes with a single-pole, double-throw (SPDT) relay so it can drive large, electrically isolated loads. It is available fully assembled or as a partial kit:

- **Pololu RC Switch with Relay (Assembled)**
[<http://www.pololu.com/catalog/product/2804>]
- **Pololu RC Switch with Relay (Partial Kit)**
[<http://www.pololu.com/catalog/product/2805>]

Please note that relays make a clicking sound when they are turned on or off, so the RC Switch with Relay might not be suitable for applications requiring quiet operation.



Pololu RC Switch with Medium Low-Side MOSFET on a breadboard.



The Pololu RC Switch with Relay connected to a typical RC receiver.

Warning: These products are not designed to or certified for any particular high-voltage safety standard. Working with voltages above 30 V can be extremely dangerous and should only be attempted by qualified individuals with appropriate equipment and protective gear.

Note: This guide does not apply to our older RC switches (products #752 [<http://www.pololu.com/catalog/product/752>], #1210 [<http://www.pololu.com/catalog/product/1210>], and #1211 [<http://www.pololu.com/catalog/product/1211>]).

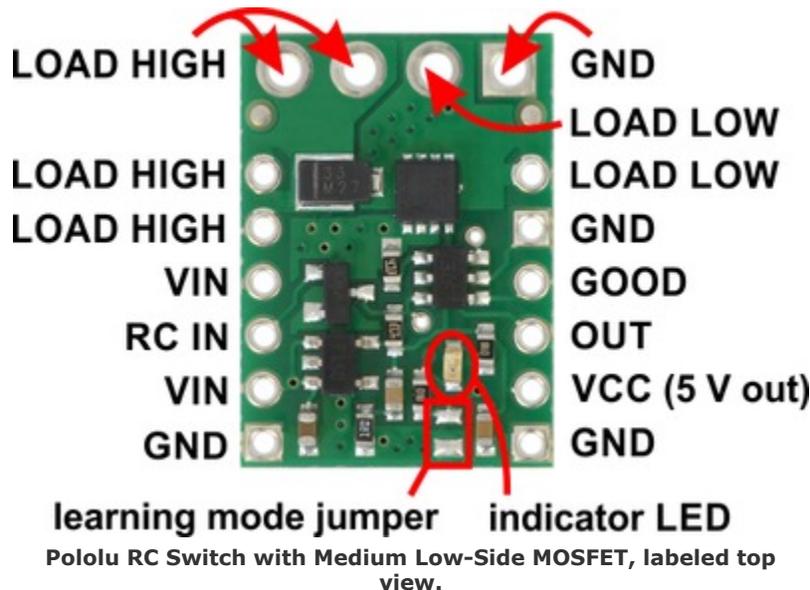
1.1. Contacting Pololu

We would be delighted to hear from you about any of your projects and about your experience with the RC switch. You can **contact us** [<http://www.pololu.com/contact>] directly or post on our **forum** [<http://forum.pololu.com/>]. Tell us what we did well, what we could improve, what you would like to see in the future, or anything else you would like to say!



2. RC Switch with Medium Low-Side MOSFET

2.1. Components of the RC Switch with Medium Low-Side MOSFET



The Pololu RC Switch with Medium Low-Side MOSFET has twelve smaller through holes spaced 0.1" apart that fit 0.1" header pins and four larger holes that fit 3.5mm screw terminals.

The **GND**, **VIN**, and **RC IN** pins make up the switch's RC interface and can be connected directly to an RC receiver or servo controller:

- The **GND** pin is the ground or reference voltage.
- The **VIN** pin is the power input.
- The **RC IN** pin is the RC signal input. The switch measures the width of these pulses and uses that to decide whether to activate or not.

Power for the board can be applied through an RC receiver or separately to the **VIN** pins, and can range from 2.5 V to 16 V. This allows the board to be powered from a 4- or 5-cell NiMH or NiCD battery pack. In that configuration, the battery pack will typically be connected to an RC receiver or **servo controller** [<http://www.pololu.com/catalog/category/102>], which passes the power on to the RC switch.

The **VCC** pin connects to the output of the onboard regulator and is 5 V when the board is powered with a source that is greater than or equal to 5 V and approximately equal to **VIN** when it is below 5 V. **VCC** is also the gate voltage that is used to turn the MOSFET on, so it should be noted that lower **VCC** voltages will lead to higher MOSFET on resistances, which in turn limits the maximum current the device can switch.

Two additional outputs are available:

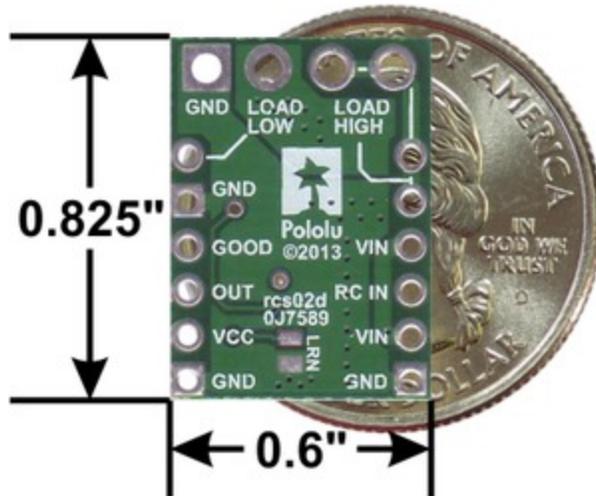
- The **GOOD** pin indicates the presence of a valid RC signal (10–330 Hz pulse rate, 0.5–2.5 ms pulse width).
- The **OUT** pin indicates whether the MOSFET is on.

When these outputs are high they will be at the same voltage levels as **VCC**.

The **LOAD LOW** and **LOAD HIGH** pins are connections for your load and load supply. The **LOAD LOW** pins are normally disconnected from GND, but when the switch activates the MOSFET turns on and connects **LOAD LOW** to GND. More details on connecting your load and load supply to the switch can be found in **Section 2.2**.

The yellow **indicator LED** indicates what state the switch is in. The LED behavior is described in **Section 5**.

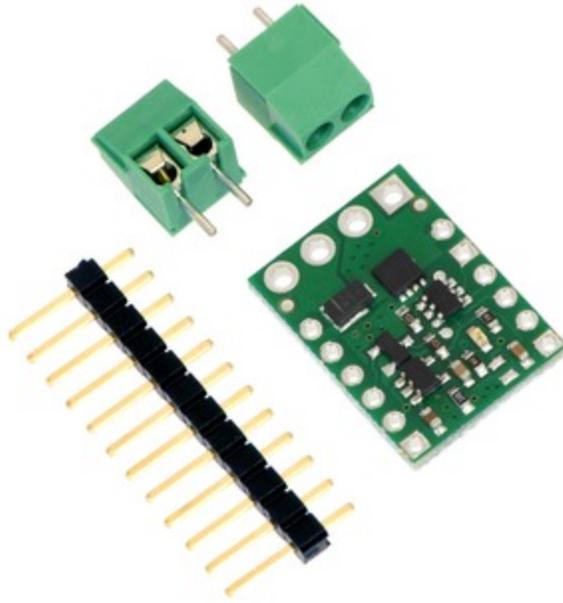
The **learning mode jumper** on both the top and bottom of the board can be used to get the device into learning mode and configure it. The configuration procedure is described in **Section 6**.



Pololu RC Switch with Medium Low-Side MOSFET, bottom view with dimensions.

Included Hardware

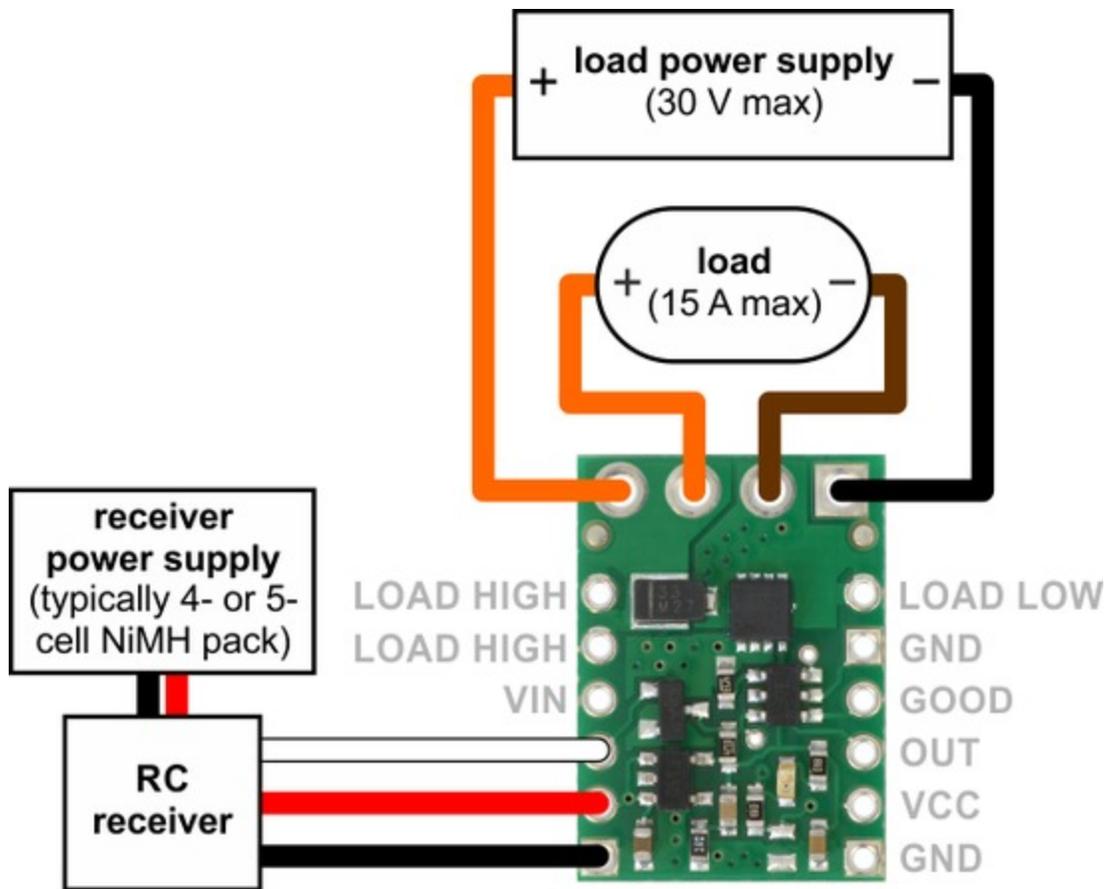
A 12-pin **0.1" straight breakaway male header** [<http://www.pololu.com/catalog/product/965>] and two **3.5mm 2-pin terminal blocks** [<http://www.pololu.com/catalog/product/2446>] are included with the Pololu RC switch with medium low-side MOSFET. The header pins can be soldered in and used to connect the RC switch to perfboards or **breadboards** [<http://www.pololu.com/catalog/category/28>]. Please note that the included terminal blocks are only rated for 10 A; for higher power applications, use thick wires soldered directly to the board.



**Pololu RC Switch with Medium Low-Side MOSFET
with included hardware.**

2.2. Connecting the RC Switch with Medium Low-Side MOSFET

The typical way to connect the Pololu RC Switch with Medium Low-Side MOSFET is shown in the diagram below:



Typical wiring diagram for the Pololu RC Switch with Medium Low-Side MOSFET.

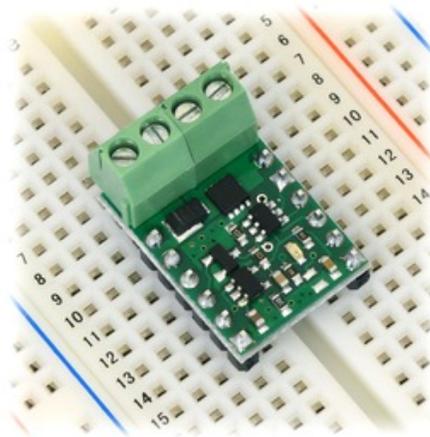
An onboard regulator allows the switch to be powered from voltages between 2.5 V and 16 V. However, for most applications we recommend using a 4- or 5-cell NiMH or NiCD battery pack to power the switch. The battery pack will typically be connected to an RC receiver or **servo controller** [<http://www.pololu.com/catalog/category/102>], which passes the power on to the RC switch. The switch can be plugged directly into the RC receiver using a Female-Female servo extension cable. These can be found in our **Servo Cables** [<http://www.pololu.com/catalog/category/112>] category.

The negative side of your load supply should connect to the GND pad on the top-right side of the board, and the negative side of the load itself should connect to the LOAD LOW pin. The four pins labeled LOAD HIGH are internally connected and intended to give you convenient connection points for both your load and your load power supply. There is a flyback (also known as a “freewheeling”) diode between the MOSFET output and load supply, which allows you to safely connect an inductive load such as a motor or relay. Alternatively, the positive side of the load could be directly connected to the load supply off of the board. The board’s MOSFET can deliver up to 15 A with VCC at 5 V and can handle load supply voltages up to 30 V.

For lower power applications the smaller 0.1”-spaced pins can be used instead of the terminal block to connect the load and load supply.



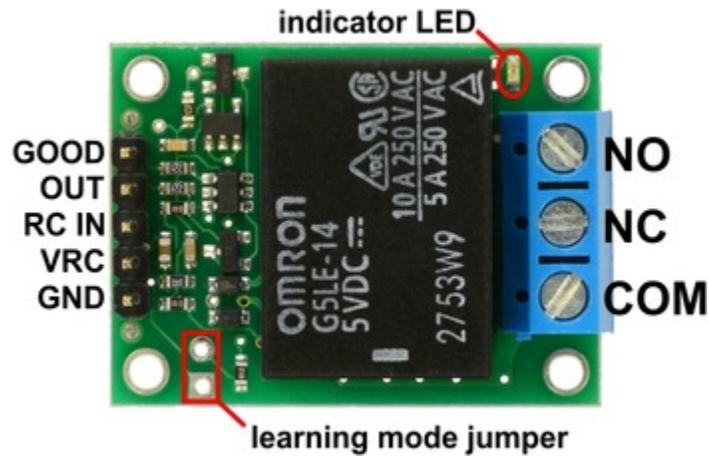
Pololu RC Switch with Medium Low-Side MOSFET with included terminal blocks and headers soldered to the component side.



Pololu RC Switch with Medium Low-Side MOSFET on a breadboard.

3. RC Switch with Relay

3.1. Components of the RC Switch with Relay



Pololu RC Switch with Relay, labeled top view.

The Pololu RC Switch with Relay has five pins spaced 0.1" apart that give access to its logic interface.

The **GND**, **VRC**, and **RC IN** pins make up the switch's RC interface and can be connected directly to an RC receiver or servo controller:

- The **GND** pin is the ground or reference voltage.
- The **VRC** pin is the power input.
- The **RC IN** pin is the RC signal input. The switch measures the width of these pulses and uses that to decide whether to activate or not.

We generally recommend that you supply the **GND** and **VRC** pins with power from a 4- or 5-cell NiMH or NiCD battery pack. Typically, the input voltage range will be limited by the properties of the relay coil. The included Omron G5LE-14-DC5 relay requires an input voltage of at least 3.75 V to operate. At room temperature (23° C), the relay can tolerate voltages up to 8.5 V, but this limit decreases at higher temperatures. At 85° C, the relay can only tolerate voltages up to 6.5 V. You can see the **Omron G5LE-14-DC5 datasheet** [http://www.pololu.com/file/download/G5LE.pdf?file_id=0J619] (1MB pdf) for more information. As a whole, the switch will draw about 100 mA when the relay is on, but that current draw depends on the input voltage. The board itself can operate anywhere in the 2.5 to 16 V range, but the included Omron relay requires a more restrictive range of voltages.

Two additional outputs are available:

- The **GOOD** pin indicates the presence of a valid RC signal (10–330 Hz pulse rate, 0.5–2.5 ms pulse width).
- The **OUT** pin indicates whether the relay is activated (i.e. the relay coil is energized).

When high, the **GOOD** and **OUT** outputs will output a voltage approximately equal to 5 V or **VRC**, whichever is lower. When low, these outputs will be at 0 V (ground). These outputs have 220 Ohm resistors in series with them to protect them from short circuits.

The yellow **indicator LED** indicates what state the switch is in. The LED behavior is described in **Section 5**.

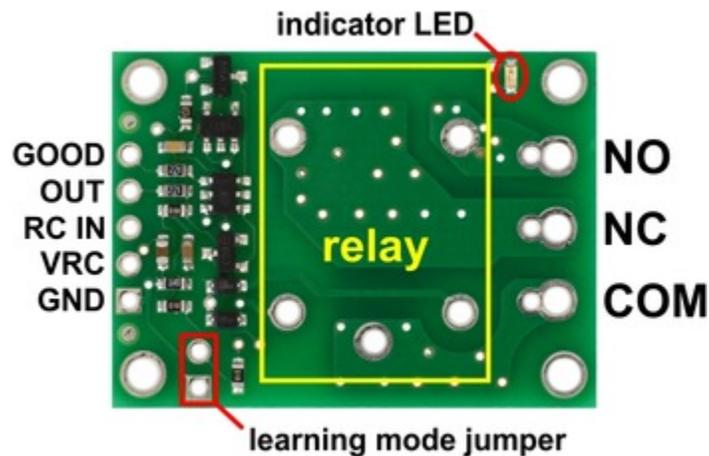
The **learning mode jumper** can be used to get the device into learning mode and configure it. The configuration procedure is described in **Section 6**.

The **NO**, **NC**, and **COM** pins are connected directly to the relay.

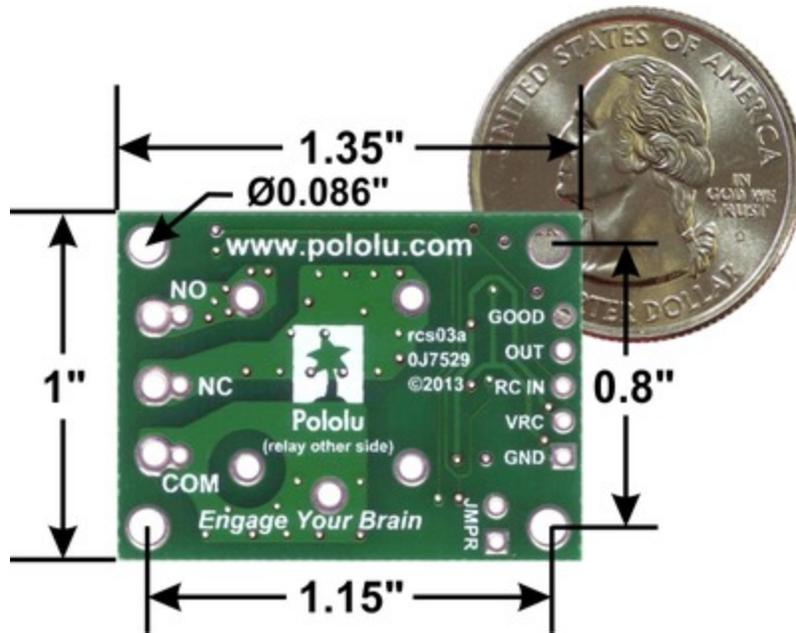
- **NO** stands for “normally open”. This pin is normally disconnected from the COM pin, but they become connected when the relay is active.
- **NC** stands for “normally connected”. The NC pin is normally connected to the COM pin through the relay, but they become disconnected when the relay is active.
- **COM** stands for “common”.

These pins are electrically isolated from the logic side of the board and are routed on the PCB with a minimum clearance of 60 mils (1.5 mm) from other copper and from the board edges, though manufacturing variations in the board edges can make those distances slightly lower.

In most applications, the current and voltage ratings for the module will match the ratings of the relay used. Maximum current, maximum voltage, and life expectancy are interdependent; we therefore recommend careful examination of your relay’s datasheet. If you are using the included relay, please refer to the **Omron G5LE-14-DC5 datasheet** [http://www.pololu.com/file/download/G5LE.pdf?file_id=0J619] (1MB pdf) for information.



Pololu RC Switch with Relay carrier board, labeled top view.



Pololu RC Switch with Relay, bottom view with dimensions.

Included hardware

The Pololu RC Switch with Relay is available in two versions:

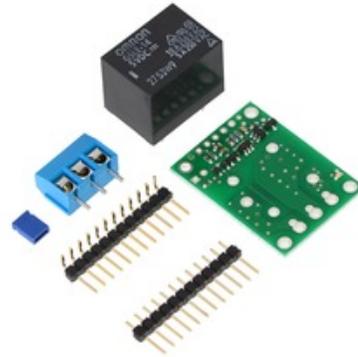
- The **assembled version** [<http://www.pololu.com/catalog/product/2804>] ships with the 5V Omron relay, header pins, and terminal block soldered in. A 1×2-pin male header and a shorting block are also included with the assembled version and can be used together as a tool when configuring the device. The assembled version can be incorporated into an existing RC system without the need for any additional soldering.
- The **partial kit version** [<http://www.pololu.com/catalog/product/2805>] gives you the flexibility to choose different connections. It includes a 5V Omron relay, 0.1" 12-pin male header, a 0.1" 12-pin right-angle male header, a 3-pin terminal block, and a shorting block. The headers can be broken into smaller pieces and optionally soldered to the board, or wires can be soldered directly to the board for the most compact installation.



Warning: When soldering the terminal block into the partial kit version, be sure to use the *larger* set of holes. If you use the smaller holes, which are intended for 0.2" male header pins, there will not be enough space to mount the relay.



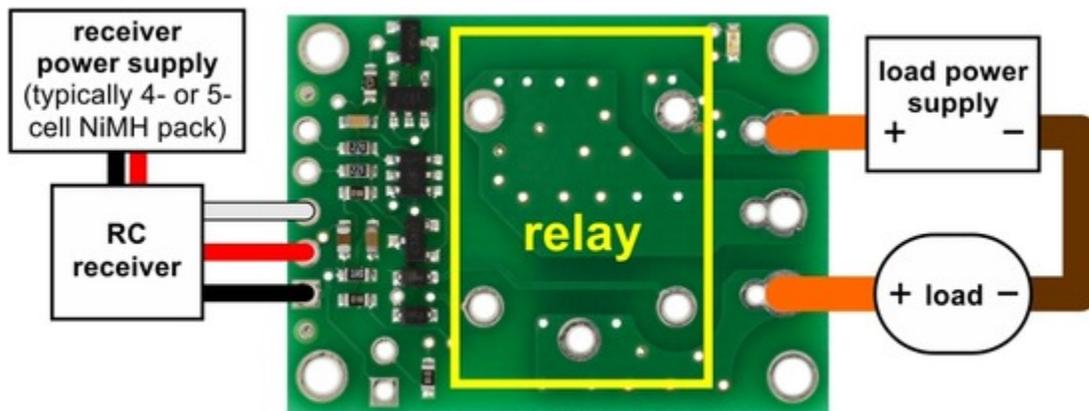
Pololu RC Switch with Relay (Assembled) with included hardware.



Pololu RC Switch with Relay (Partial Kit).

3.2. Connecting the RC Switch with Relay

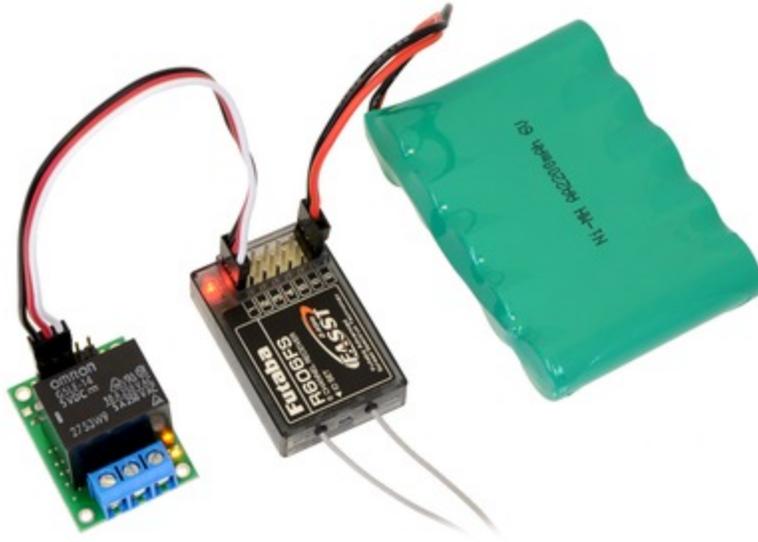
The typical way to connect the Pololu RC Switch with Relay is shown in the diagram below:



Typical wiring diagram for the Pololu RC Switch with Relay.

We generally recommend that you use a 4- or 5-cell NiMH or NiCD battery pack for the logic power supply. The power supply will typically be connected to the RC receiver, which passes the power on to the RC switch. The switch can be plugged directly into the RC receiver using a Female-Female servo extension cable. These can be found in our **Servo Cables** [<http://www.pololu.com/catalog/category/112>] category.

One typical way of connecting the relay is to put it between the load and the positive terminal of the load's power supply. The load is the device that you want to control with the RC switch. The negative terminal of the power supply should connect to the other side of the load. The negative terminal of the power supply does not necessarily need to be connected to the GND pin of the logic side. In the diagram above, the positive terminal of the load power supply is connected to the NO pin and the positive terminal of the load is connected to COM. They will normally be disconnected, but when the switch turns on, the relay will activate and connect the two, allowing the load to be powered.



The Pololu RC Switch with Relay connected to a typical RC receiver.

3.3. Schematic Diagram for the RC Switch with Relay

The schematic diagram of the Pololu RC Switch with Relay is shown below:

4. Functional Description

This section documents the functions and behavior of the RC switch. The information in this section is not needed to use the device, but it might be helpful if you are curious about the details.

Timing accuracy

The timing accuracy of the RC switch is limited by its internal clock, which has an accuracy of $\pm 2\%$. Because of this, the threshold and other timing parameters might vary by a few percent.

Configuration parameters

The device stores two user-settable configuration parameters: *threshold* and *inversion*.

The *threshold* parameter is a pulse width that can range from 900 to 2100 μs and must be a multiple of 16 μs . The default threshold is 1696 μs .

The *inversion* parameter can either be enabled or disabled. When inversion is disabled, the pulses have to be above the threshold in order to activate the switch. When inversion is enabled, the pulses have to be below the threshold in order to activate the switch. By default, inversion is disabled.

Pulse measuring

The device measures standard RC pulses on its RC IN line. It is designed to have strict requirements for the signal and to deactivate itself as soon as possible when those requirements are not met. The device expects the pulses to have a width within 500 to 2500 μs and a frequency within 10 to 333 Hz. These limits cannot be strictly enforced because of the $\pm 2\%$ clock accuracy, but the device is designed to accept any signal that is within these limits. If there has been no activity for 130 ms, the signal is considered to be bad. If there have been too many glitches detected on the RC input, the signal is considered to be bad.

The device requires three good pulses in a row before it will consider the signal to be good. However, as soon as the signal violates any of the rules above, it will consider the signal to be bad and deactivate the switch.

When comparing the measured pulse width to the threshold to determine whether the pulses are above or below the threshold, the device uses a hysteresis of $\pm 64\mu\text{s}$.

Safe-start

The device has a safe-start feature that reduces the likelihood of unexpected activation. Safe-start mode is active at power up, and while the safe-start mode is active, the switch does not activate. The device deactivates safe-start mode when the signal is good and it receives a pulse in the off position. The device will re-activate safe-start mode if the signal is bad continuously for 500 ms.

If the device is receiving a valid RC signal which suddenly stops, it will take 130 ms before the signal is recognized as bad. From there, it will take 500 ms before the safe-start mode becomes active, so there will be a total of 630 ms between the loss of the signal and the re-activation of safe-start mode.

To get out of safe-start mode and activate the switch, you should move the input to the off position and then move it to the on position.

Even with the safe-start feature, unexpected activation of the switch is still possible. With the Pololu RC Switch with Relay, one way this could happen is if the switch is activated but the logic power supply is at 3 V, which is too low to actually turn on the relay. If the logic power rises from 3 V to 5 V then the relay could turn on unexpectedly.

5. Outputs and Indicator LED

The **OUT** pin is an output that indicates whether the switch is active. The OUT pin is high whenever the integrated MOSFET or relay is turned on.

The **GOOD** pin is an output that indicates whether the signal is valid (10–330 Hz pulse rate, 0.5–2.5 ms pulse width). When the **GOOD** pin is low, it means the signal is invalid. In that situation, the **OUT** pin will also be low.

The yellow **indicator LED** shows what state the device is in. There are four states the device can be in during normal operation:

- If there is no input signal, the LED will blink with a 50% duty cycle and a period of 1 s. In this case, the OUT and GOOD pins will be low.
- If the pulses are in the on position but the switch is not active because safe-start mode is active, the LED will do a double-blink with a period of 1 s. In this case, the OUT pin will be low and the GOOD pin will be high.
- If the pulses are in the off position, the output will be off and the LED will do a brief blink once per second. In this case, the OUT pin will be low and the GOOD pin will be high.
- If the pulses are in the on position and the output is on, the LED will be mostly on and blink off briefly once per second. In this case, the OUT and GOOD pins will be high.

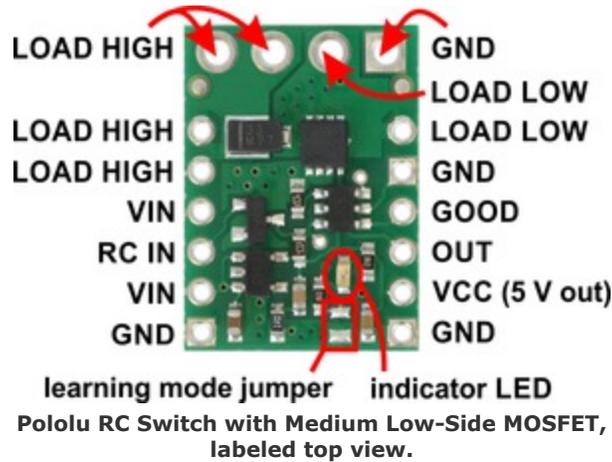
If the power supply voltage drops too low, the device will detect this and stop running. This is called a *brown-out reset*. After the power supply voltage recovers (which could be a few milliseconds later), the device will suspend normal operation briefly and do a special LED blink. The blink consists of a single blink followed by a double blink, with a period of 7/8 s and three repetitions.

During learning mode, the LED exhibits several other types of blinking. These are documented in **Section 6**.

6. Configuring Your RC Switch

The RC switch has two user-settable configuration parameters, *threshold* and *inversion*, which are described in **Section 4**. This section and the following sections explain how to set both parameters.

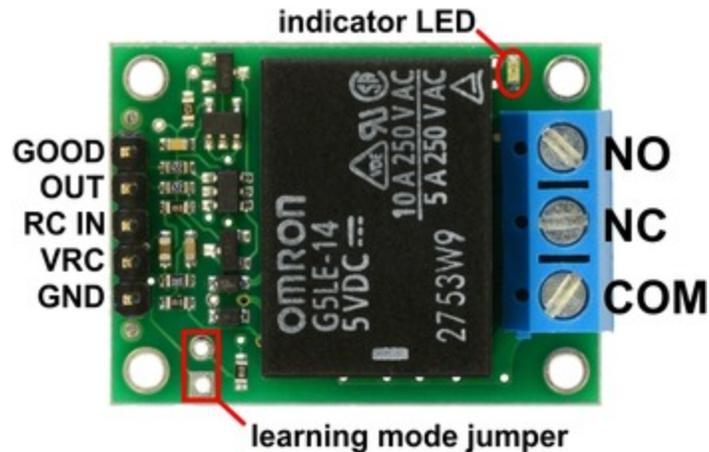
To configure the device, you will need to be able to connect and disconnect the two parts of the learning mode jumper. This will be required at several points by the instructions in the following sections.



For the Pololu RC Switch with Medium Low-Side MOSFET, the learning mode jumper consists of a pair of exposed pads on the top of the component side of the board. An alternate learning mode jumper is available on the other side of the board and is labeled “LRN”; you can use whichever jumper is more convenient. To connect the two pads, you can use a wire, screwdriver, or some other conductive tool.



Connecting a 1×2-pin male header to a blue shorting block makes a tool that can be used to activate the learning mode on the Pololu RC Switch with Relay.



Pololu RC Switch with Relay, labeled top view.

For the Pololu RC Switch with Relay, the learning mode jumper consists of two holes. You could use a wire to connect the two holes, but we recommend inserting a 1×2-pin male header into the included blue shorting block and using that as a tool to connect the two holes. The assembled version of the switch comes with a 1×2-pin male header. If you have the partial kit version, you can break two pins off of the included male header to get a 1×2-pin piece. To make the contact, stick the two exposed pins into the two holes of the learning mode jumper and then tilt the tool towards the side and press on it to ensure a good connection with the inside edge of each hole. It is not sufficient to just rest the tool on the learning mode jumper; you must tilt it and apply some force.

6.1. General Configuration Procedure

This is the general procedure for configuring the device. To follow these instructions, you will need to know how to connect and disconnect the learning mode jumper, as described in [Section 6](#).

1. Get the device into learning mode. In order to do this, power off the device, connect the learning mode jumper, and then power it on. After it is powered on, disconnect the learning mode jumper. At this point, you will see the indicator LED fading in and out with a period of 1 second. Your device is now in learning mode, and will be until you next turn off the power. In learning mode, it will not turn on the relay. If you want to abort learning mode, you can power off the device at this point and none of your settings will change.
2. Tap the learning mode jumper (connect it and then disconnect it). This restores all of the settings in the device to their default values; the threshold will be 1696 μ s and inversion will be disabled. The indicator LED should be blinking a different pattern now. If you want to use the default settings and exit learning mode, you can power off the device at this point and skip the instructions below.
3. Now the device is in the pulse-measuring phase of learning mode. This is where you can choose what threshold to use.
 - If you want to use the default threshold, you should not send RC pulses to the device. The device will indicate that the RC input signal is not recognized by blinking the LED with a 50% duty cycle and a period of 0.5 s.
 - If you want to use a custom threshold, you should send RC pulses to the device. The device will indicate that it recognizes the RC input signal by blinking the LED with a special pattern that consists of a fade in followed by a blink, with a period of 2 s. The device will calculate the minimum and maximum pulse widths seen during this phase of learning mode, and set the threshold equal to the point midway between them (the average). In general, we recommend moving your input to both the off position and the on position during this phase of learning mode, and not moving it anywhere outside of that range. However, if you are using a servo controller to send pulses, you might want to simply send pulses equal to the desired threshold. If you accidentally send incorrect pulses, you will have to power off the device and start over at step 1.

4. Tap the learning mode jumper again to save the chosen threshold. If the threshold you chose was not within the allowed range of 900 to 2100 μs , then the device will indicate an error by blinking the LED rapidly eight times per second. If that error happens, the threshold will not be saved and you should power off the device and try the procedure again with a different threshold. If the threshold you chose was within the allowed range, then it will be saved to non-volatile memory and you will see the LED fade in repeatedly with a period of 1 s.
5. You can now chose whether to enable inversion. If you do not want to enable inversion, simply power off the device now to exit learning mode. If you do want to enable inversion, tap the learning mode jumper again. The LED will start fading out repeatedly with a period of 1 s.
6. Power off the device to exit learning mode. Your learning mode jumper connection should be removed at this point. The settings you chose have been saved in non-volatile memory of the device and you can power it on to use the new settings.

6.2. Restoring the Default Settings

This section gives steps for restoring the switch to its default settings. This is a good thing to try if you have any trouble using the switch. The general configuration procedure is documented in **Section 6.1**, but the instructions here are easier to follow if you just want to restore the device to its default settings. To follow these instructions, you will need to know how to connect and disconnect the learning mode jumper, as described in **Section 6**.

1. Get the device into learning mode. In order to do this, power off the device, connect the learning mode jumper, and then power it on. After it is powered on, you should disconnect the learning mode jumper. At this point, you will see the indicator LED fading in and out with a period of 1 second.
2. Tap the learning mode jumper (connect it and then disconnect it). The indicator LED should be blinking a different pattern now.
3. Power off the device to exit learning mode.

After following these instructions, the threshold should be 1696 μs and inversion should be disabled.

6.3. Enabling inversion

This section gives steps for enabling inversion while still using the default threshold of 1696 μs . The general configuration procedure is documented in **Section 6.1**, but the instructions here are easier to follow if you just want to enable inversion and are happy with the default threshold value. To follow these instructions, you will need to know how to connect and disconnect the learning mode jumper, as described in **Section 6**.

1. Since you don't want to set the threshold, you should stop sending RC pulses to the device. If you are controlling the switch with an RC receiver, you might need to power off the transmitter and power cycle the receiver. If possible, you could just disconnect the wire going to the RC IN pin.
2. Get the device into learning mode. In order to do this, power off the device, connect the learning mode jumper, and then power it on. After it is powered on, you should disconnect the learning mode jumper. At this point, you will see the indicator LED fading in and out with a period of 1 second.
3. Tap the learning mode jumper (connect it and then disconnect it). The indicator LED should be blinking with a 50% duty cycle and a period of 0.5 to indicate that there is no signal being received. If you see it doing a pattern where it fades in and then blinks, then you are still sending pulses to the device. You should figure out how to stop sending pulses, and start over at step 1.
4. Tap the learning mode jumper again. The LED should now be fading in repeatedly with a period of 1 s.
5. Tap the learning mode jumper again. The LED should start fading out repeatedly with a period of 1 s.
6. Power off the device to exit learning mode.