

All you need to know about Relays

Courtesy of Ron Ray

This page is everything you wanted to know about relays. What they are, why and when you want to use them, how to use and wire them, and stuff like that.

What's a "relay"?

It's a electrical device that functions something like a wired remote control switch. Instead of having the switch you push/flip/whatever do the work of supplying power to whatever you wanted it to, you have it control a relay which then does the real on/off switching work. That's it. It's really not very complicated, now is it?

A mechanical relay does this through the use of an electromagnet - a magnet that is only "on" when there's power running through it - that pulls a set of spring loaded contacts to make or break the connection and achieve the on-off effect. This is called the "coil" or trigger wire - the other wire coming out of the coil is connected to ground. Whenever you apply power to the other coil wire (the trigger), the relay is on. As soon as power to this trigger is turned off, the relay turns off. Simple, huh? There are also "solid state" relays that achieve the same effect through transistors. Either one functions the same way, the solid state stuff just has no moving parts to wear out, but they tend to be more expensive and not as readily available since the regular mechanical ones are inexpensively and readily available as very high quality, durable units.

Why is this useful?

For one big reason - some devices use a lot of power and that means large wires and heavy duty contacts inside all of the switches and connectors are needed. And you want to use as little wire (in length/distance) as possible. It's more expensive and heavier than smaller low-power wires and it's harder to work with. If the wire develops a short, it's a much bigger problem - and the longer the wire involved, the more chances you have for something to go wrong.

Additionally, heavy-duty switches are large, cumbersome, and generally have a very poor "feel" to them. By "feel", I mean the tactile sensation you get from using the switch - is it a smooth silky operation with a nice delicate "click" to tell you what's happening, or is it more like Igor straining to flip a massive and cumbersome switch to turn on the power to bring Dr. Frankenstein's creature to life? You get the idea. It's easier and cheaper to make a low power switch in the quality you would expect in a fine automobile. And it will last longer. That's a good thing!

A relay alleviates this by using a single relatively small and low power wire to control the on-off of electrical flow. You mount the relay near the device it controls, and run a simple large power wire to the relay. Then you run a small wire back to the switch. The switch you flip just supplies power to the relay coil and functions as a trigger - if the coil has power, the magnet energizes and the relay contacts move to make (or break - it can work both ways) the high power connection to your device.

Relay Ratings and Configurations

Relays are typically discussed in terms of several things.

- How much power the high power side can handle in Amps
- The voltage and power type (AC or DC) the coil needs to operate
- The number and type of contacts the relay has

The first thing, the power rating, is very simple - a relay is rated for its capacity to handle power. That's what it's for, and that's what you hear most often. It will be described as a 20A, 30A, or whatever relay. This must be as big as or bigger than the maximum rating of the thing you want to control with the relay. It will be rated at some voltage as well, so be sure it all matches.

The second things, the coil voltage and type, is typically omitted when working in a known environment. All automotive relays use a 12V DC coil, so this information is implied if the relay is intended for use in a car. For use in other environments (home, industrial, etc.) there will be a rating on what the relay coil expects. Just match this to what the trigger wire will have in it. Note that the coil does not have to work on the same voltage as the voltage being sent over the high power contacts. There is no need to send high voltage to the small switch - the whole point is to use small wires and switches to control the relay, after all. The common case here is a doorbell in your house. The actual pushbutton outside is typically being fed 24V AC and it hooks up to a relay inside the doorbell chime unit to make the chime happen. The chime will often work on 120V AC (normal household electricity), so the relay controls this.

The third thing, the number and type of contacts, is used to control various things at once and control them by turning them on or by turning them off. This is described in the same way any other switch is described - by the number of poles and the number

of throws. Most automotive are very simple and of the SPST or SPDT variety - read below to learn what that means.

The number of contacts (or poles), is the number of things that the relay can control at once. The relay is just an electromagnetically controlled switch, and you can have the same electromagnet flip a number of switches in unison the same way you could mount a bar across a number of different switch levers to force them to be switched in unison. A good example of this are the circuit breakers in your house. Some of them will be two breakers tied together with a bar so they switch together to make a two pole switch out of two single pole switches. With a relay, this is very useful for making one switch control two different things - like turning on the parking lights and the dash lights in your car with one switch.

The number of throws is the number of distinct contacts you can send power to - the number of places you can "throw" the switch to. (Think of an old fashioned blade switch - like Igor used - to get the mental image here.) Typically, you have one input and one or more outputs. If you can connect the output to one thing, as in a simple on-off switch, you have a single throw. If you have two outputs, like in a power window switch where you have up and down, you have two throws. If it was more like a dial switch where you could select from three or more things, like the fan speed control switch, then you would have three or more throws.

This number of poles and number of throws is designated with a simple abbreviation like "SPST". This stands for Single Pole, Single Throw. Another popular one is "DPDT", which is for Double Pole, Double Throw. Beyond that they are usually designated with numbers, such as "3PDT" (Three Pole, Double Throw) or "SP4T" (Single Pole, Four Throw). By looking at this information, you can tell how the relay can switch things, and find out if it is right for your needs. As noted above, most automotive are very simple and of the SPST or SPDT variety - they can control one thing and switch it on or off, or apply power to one of two different things.

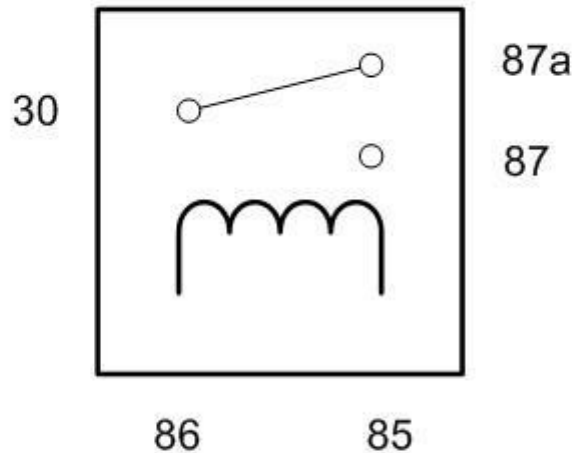
Lastly, the contacts in the switch or relay are described as "normally open" (NO) or "normally closed" (NC). This simply describes what the "at rest" state is. For a relay, that means if no power is applied to the coil/trigger wire. In the typical case where you want to turn something on, you use the "normally open" set of contacts so that when you apply power to the relay, the contacts close, and power is sent to the desired device. This is used for things like turning on your fog lights or things like that. In the case of wanting to turn something off, you use the "normally closed" set of contacts so that when you apply power to the relay, the contacts open and the power is no longer sent to the desired device. This is used for things like an emergency stop switch or other more unusual "control" cases. One example is in certain multiple relay electric fuel pump setups on fuel injected vehicles to control when the pump is on and to ensure it turns off in case of the engine stalling - this is used to reduce the risk of fire (due to the pump still pumping fuel) in case of an accident and a ruptured fuel line.

Typical Automotive Relay

This diagram shows a typical Bosch relay used in the automotive world. It is the closest thing to a universal relay standard in the automotive world, so you will see this type of diagram and/or contact numbering system often if you work on cars enough. This is especially true in the hot-rod or "aftermarket" arena where these style relays are often used to achieve custom or "trick" effects on a vehicle such as anything that opens or closes with a motor, or the "no door handles" look where the door is unlatched electrically instead of mechanically.

This relay is a SPDT relay with a single NO contact (terminal 87) and a single NC contact (terminal 87a). These relays usually have a small wiring diagram molded into the top of the relay and all of the contacts are clearly labeled on the relay so you can trace the wiring with ease. They also use a standard size and configuration for their plug-in terminals so that you can get a standard molded plastic base with the proper wiring hookups in it. This enabled you to unplug all of the connections all at once for ease of servicing - such as if you need to test or replace the relay itself.

Relay Wiring Guide and Terminal Numbers



- 30 - High Power Feed (Must be Fused!)
- 85 - Relay Coil Ground
- 86 - Relay Coil Feed (Trigger Wire)
- 87 - High Power Output - Normally Open Contact
- 87a - High Power Output - Normally Closed Contact

Where to Buy Relays

Relays are readily available in "kit" form from places like [Ron Francis Wire Works](http://www.ronfrancis.com/) <http://www.ronfrancis.com/> - they have a complete relay kit with everything you need under part #RL-40 for around \$24. (Earlier versions of this page listed their kit as part #RL-22, it appears that Ron Francis has since changed their relay kits around to use higher-amperage relays.) Other places like Radio Shack and your local auto parts store sell them too. The trick is finding one that has a way to mount it easily and is easy to wire.

You can also buy all of the pieces for wiring a relay from places like [Waytek Wire](http://order.waytekwire.com/cgi-bin/lansaweb?procfun+wordpr01+webfunc+M37+FUNCPARMS+WEBCMP%28S0020%29:01+WEBID%28S0020%29:01) <http://order.waytekwire.com/cgi-bin/lansaweb?procfun+wordpr01+webfunc+M37+FUNCPARMS+WEBCMP%28S0020%29:01+WEBID%28S0020%29:01> for much less per-relay, but you have to buy all of the individual pieces (relay, plastic connector, wire terminals) in a high enough quantity to meet the minimum order requirements on each piece (currently 100 pieces or \$5 per line item, whichever is less and the total order must be at least \$35 to avoid an extra \$5 handling charge). This works out quite well on larger projects where you will be wiring up 5 or more relays and want to do the work with as few splices as possible.

Below are some part numbers, minimum quantities, and prices I looked up on the Waytek website. These are obviously all subject to change, but it gives you an idea and shows how quantities don't always line up with each other, so you might want to buy a few extra of some things to get an "even number" or items. Also, terminals are something you can always use extra of, and they're cheap, so I always suggest buying more than you strictly need. They come in handy if you screw something up or need to re-wire things later on. :-)

TODO: Link each part name to the Waytek product page on that item.

| Part | Part # | Price Each | # Req Per Relay | Price Per Relay | Min Quantity | Price for Min Qty | Recommended Quantity | Price for Recommended Qty |
|---------------|--------|------------|-----------------|-----------------|--------------|-------------------|----------------------|---------------------------|
| 40A Relay | 75114 | \$3.8247 | 1 | \$3.8247 | 2 | \$7.6494 | 7 | \$26.7729 |
| Connector | 75280 | \$0.7315 | 1 | \$0.7315 | 7 | \$5.1205 | 7 | \$5.1205 |
| Terminal | 30073 | \$0.1800 | 5 | \$0.9000 | 28 | \$5.04 | 50 | \$9.0000 |
| Totals | - | \$ | - | \$5.4562 | - | \$17.8099 | - | \$40.8934 |

By looking at the recommended price column, you can see that for slightly less than the price of two relay kits from Ron Francis, you can get enough stuff from Waytek to wire up seven relays - and have 15 terminals left over for another three full relay rewiring jobs. And you can wire it with no extra splices just like the factory would have done it. I have bought a lot of stuff from Waytek and always been very happy with their service and the quality of their parts. The online ordering from their website is really nice, though they do seem to take it offline for part of each night for reasons unknown to me, so order earlier in the day. :-)