

Relay Actuation Application Note:

This application note discusses topics related to the activation of a relay. Many of the same concepts involved in relay activation are present in DC-DC converter design, stepper motor driver modules, three phase motor controllers, solenoid activation, and car ignition systems. The systems listed all feature a coil in their design. Each design contends with many of the same characteristics such as coil voltage, current, resistance, inductance, and time.

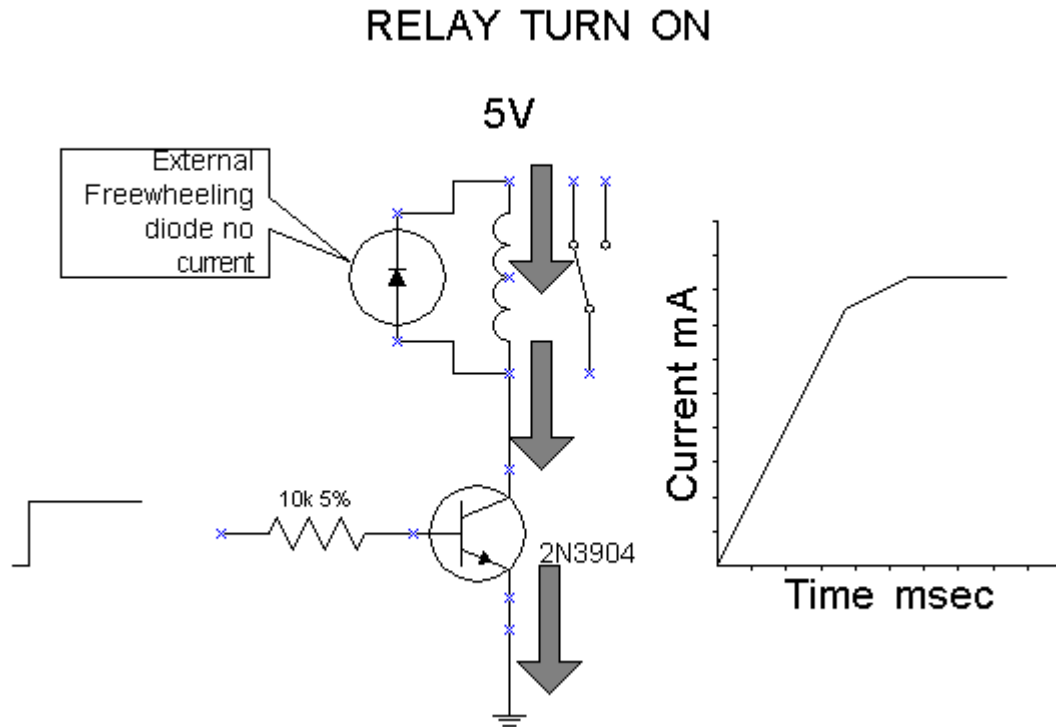
- 1) The higher the voltage, the less time required to meet a desired current.
- 2) A lower inductance coil will take less time to reach a desired current level than a large inductance(with the same voltage drive).
- 3) When voltage is first applied to a coil it will draw no current, the current will then increase approximating a linear ramp.
- 4) The energy stored in a coil is best described in this formula: $\frac{1}{2} * L * I^2$. Note that the energy goes up with the square of the current.
- 5) When de-energizing a coil, it will produce any voltage (100s, 1000s, millions of volts) needed to continue conducting current at its last set level. This is where freewheeling diodes and other suppression devices are introduced.
- 6) Manufacturers do not normally specify inductance in their data sheet specifications. Usually voltage and resistance are listed, sometimes just voltage. The current needed to turn on the relay can then be calculated by dividing the voltage by the resistance.
- 7) Latching relays normally have magnets designed to hold the switch in its last position. The coil only needs to be activated long enough to stick the arm to the desired side.
- 8) Reed relays have contacts that are enclosed in a vacuum tube. Reed relays have operation/release times of 1msec or less. Traditional Telecom contact relays have operation/release times of 10msec or more.

The most widely used method of transient suppression is a switching diode. The diode must be able to conduct the same amount of current used to activate the relay. The diode must be rated at a reverse voltage higher than what is applied across the coil during activation. Also the suppression diode must be fast, so that once the driver circuit is shut off, the diode can then take over conducting the current.

The diode applied across the coil is sometimes referred to as the freewheeling diode. The time required for the current to fade down is related to the inductance of the coil, the current that was last applied, the intrinsic resistance, and the forward diode voltage. The diode forward voltage can be anywhere between (.4v and 1.2v), depending on the diode and temperature. Fast PN switching diodes such as 1n914 or 1n4148 can be used for lower current relays. Higher current schottkey diodes are probably required for high current relays. Some relays can be purchased with the freewheeling diode already installed inside

the package.

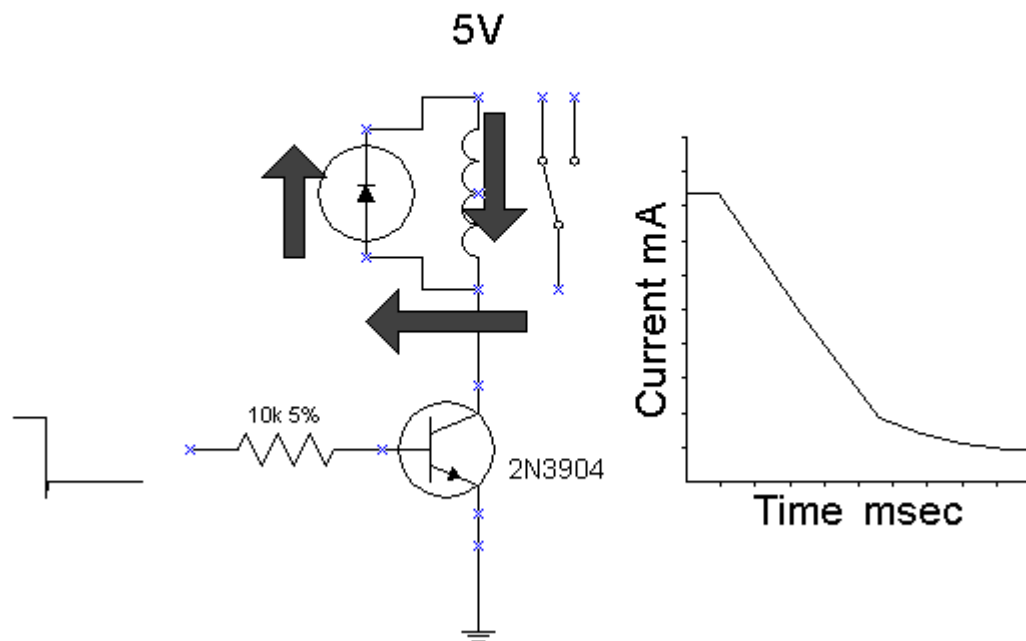
The figures indicate a 2N3904 diode as the switching component, there are countless methods and components that can be used.



The component used to switch the relay must be able to withstand the relay voltage in the off state. If you are driving your relay with a 74 series integrated circuit or a microcontroller directly, try to use a relay rated for 3v or 5v.

Power dissipation is normally not a problem for the driving circuit. When the transistor is off it will draw no current and therefore no power is dissipated. When the transistor is on it will end up drawing the rated current, but low voltage therefore little power.

RELAY TURN OFF

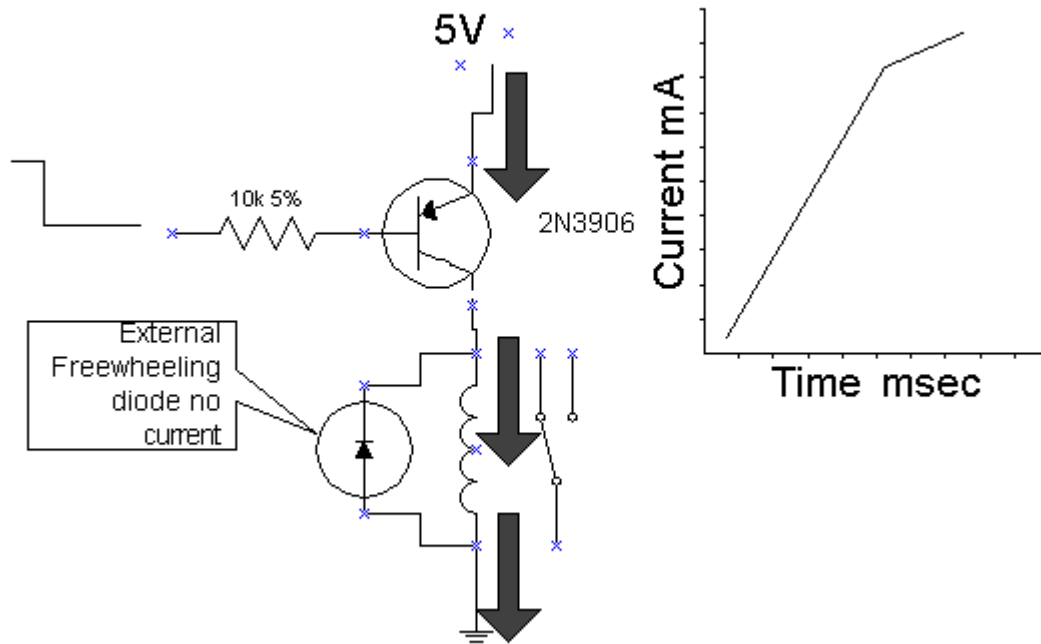


As indicated in the figure above, when the sinking transistor is in the off state the current is directed toward the freewheeling diode. Eventually the current passing around the coil and diode will die down.

Diodes are by far the most common configuration for the suppression of transients, however, many other schemes have been conceived and implemented. TVS, capacitors, zeners, resistors, mosfets, and transistor combinations have been used. Some methods are implemented for recycling energy, quicker reaction times, less supply line spikes, and faster current decay.

The driver circuit can sink and also source the current. The freewheeling suppression diode is orientated in the same direction with the P of the PN connected to the ground terminal. This source configuration may offer some advantage in your design. Advantages include: simplifying the PCB design by utilizing a common ground, driving one relay off of another, spare source drivers are handy from another type of circuit, and PNP transistors are used elsewhere in the design.

PNP RELAY TURN ON



Some ICs may have been designed for driving LEDs, Fiber optic diodes, solenoids, motors, and light bulbs. Some of the ICs may have internal diodes that can be carefully used for the freewheeling diode. The nice feature of having the suppression diode near the corresponding relay is that the transient currents are localized to an area on the PCB; this could reduce EMI problems.