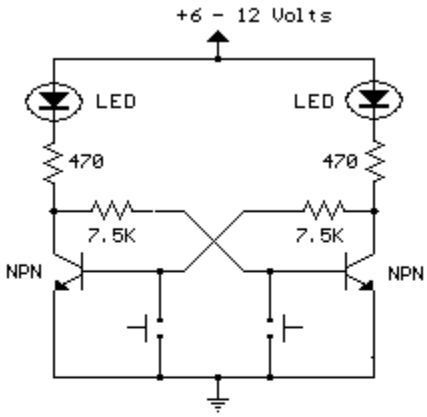
Set/Reset Flip Flop

This is an example of a set/reset flip flop using discrete components. When power is applied, only one of the transistors will conduct causing the other to remain off. The conducting transistor can be turned off by grounding it's base through the push button which causes the collector voltage to rise and turn on the opposite transistor.



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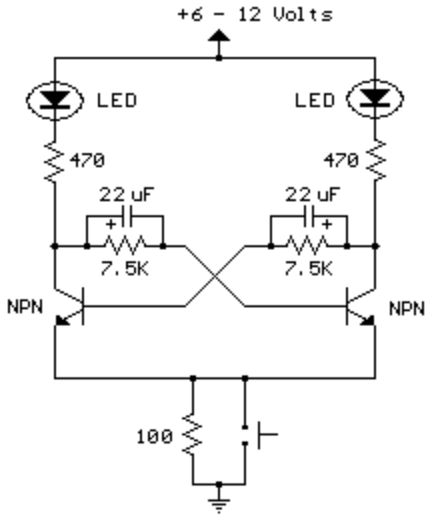
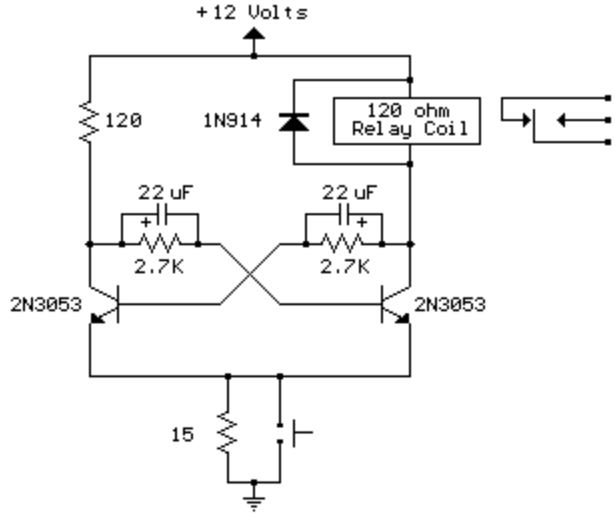
Bistable Flip Flop

Here are two examples of bistable flip flops which can be toggled between states with a single push button. When the button is pressed, the capacitor connected to the base of the conducting transistor will charge to a slightly higher voltage. When the button is released, the same capacitor will discharge back to the previous voltage causing the transistor to turn off. The rising voltage at the collector of the transistor that is turning off causes the opposite transistor to turn on and the circuit remains in a stable state until the next time the button is pressed and released. Note that in the LED circuit, the base current from the conducting transistor flows through the LED that should be off, causing it to illuminate dimly. The base current is around 1 mA and adding a 1K resistor in parallel with the LED will reduce the voltage to about 1 volt which should be low enough to ensure the LED turns completely off.





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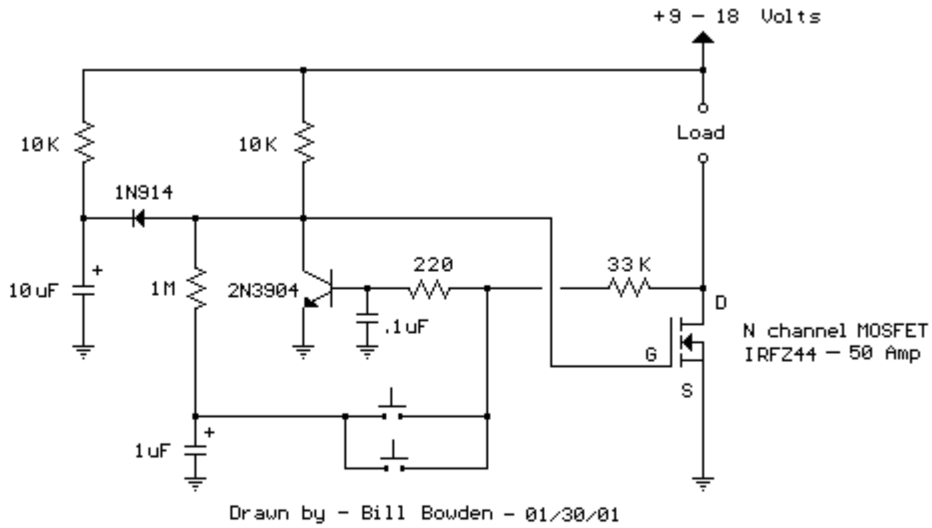
High Current MOSFET Toggle Switch with Debounced Push Button.

This circuit was adapted from the "Toggle Switch Debounced Pushbutton" by John Lundgren. It is useful where the load needs to be switched on from one location and switched off from another. Any number of momentary (N/O) switches or push buttons can be connected in parallel.

The combination (10K, 10uF and diode) on the left side of the schematic insures the circuit powers up with the load turned off and the NPN transistor conducting. These components can be omitted if the initial power-on condition is not an issue.

When a switch is closed, the 1uF cap voltage is connected to the junction of the 220 ohm and 33K resistors causing the circuit to change state. When the switch is opened, the cap charges or discharges to the new level through the 1M resistor, and the circuit is ready to toggle again in about 1 second. It takes a little time for the cap to move to the new level, either +V or ground.

The (0.1uF) capacitor at the transistor base was added to supress noise that might cause false triggering if the switches are located far away from the circuit. The circuit was tested using a 12 volt, 25 watt automotive lamp, and IRFZ44. Other MOSFETs can probably be used.



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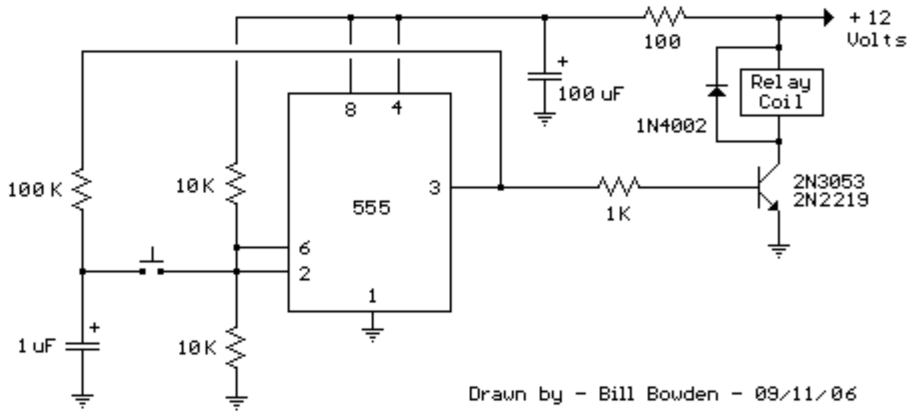
Relay Toggle Circuit Using a 555 Timer

This 555 timer circuit below toggles a relay when a button is pressed. Pins 2 and 6, the threshold and trigger inputs, are held at 1/2 the supply voltage by the two 10K resistors. When the output is high, the capacitor charges through the 100K resistor, and discharges when the output is low. When the button is pressed, the capacitor voltage is applied to pins 2 and 6 which causes the output to change to the opposite state. When the button is released, the capacitor will charge or discharge to the new level at the output (pin 3). The parts are not critical, the resistors can be somewhat higher or lower, but the 2 resistors at pins 2 and 6 should be equal values, and the resistor connected to the cap should be 10 times greater or more.

Advantages of this circuit are the large hystersis range at the input which avoids false triggering, and only a few parts are needed for construction. One disadvantage is the relay may be engaged when power is first applied. To solve this problem, you could tie the reset line (pin 4) to another resistor/capacitor combination with the capacitor at ground and the resistor at the +V point. This will cause pin 4 to be held near ground for a short period which will reset the output when power is applied.

The 100 ohm resistor and 100uF capacitor serve to filter noise on the supply line if the circuit is used in a automotive application. They may not be necessary. The circuit may work well without those parts.



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Relay Toggle Circuit Using a 556 Timer

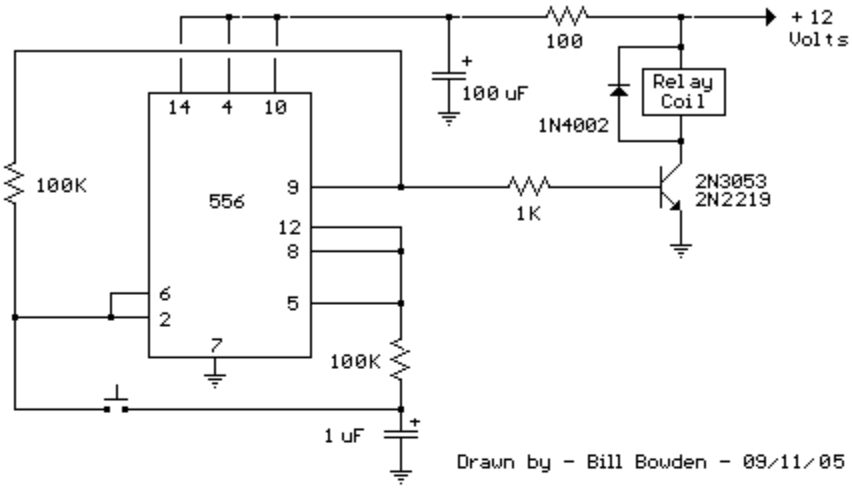
This toggle circuit operates by using a couple 555 timers wired as inverters. Pins 2 and 6 are the threshold and trigger inputs to the first timer and pin 5 is the output. The output at pin 5 will always be the inverse of the input at pins 2 and 6. Likewise, the output at pin 9 of the second timer will always be the inverse of the input at pins 8 and 12. A 100K resistor connects the output of one inverter to the input of the other so the state of one will be the opposite of the other.

In operation, the 1uF capacitor will charge to whatever voltage is present at the output on pin 5. When the button is pressed, the capacitor voltage will be applied to the input of the other timer which will reverse the state of both timers and toggle the relay, either on or off.

To follow it more closely, assume the output at pin 5 is +12 volts and the second output at pin 9 is zero volts. The 1uF cap will be charged to 12 volts. When the button is pressed, the cap will apply +12 to the inputs at pin 2 and 6 which will cause the output at pin 9 to go to zero, turning off the relay. When the button is released, the cap will discharge to zero, since the voltage at pin 5 is now zero. When the button is again pressed, the capacitor will apply zero to pins 2 and 6 causing the output at pin 9 to switch positive and engage the relay, and the cycle repeats.

The advantage of this circuit is the large hystersis range on the inputs. The button can be held closed indefinetly without upsetting the state of the outputs since the input voltage will be 1/2 the supply due to the equal value 100K resistors. The switching points are 1/3 and 2/3 of the supply so that a voltage of 50% has no effect. The circuit will also toggle very fast and needs no switch debouncing. One disadvantage is that it may turn on with the relay either engaged or disengaged. To solve that problem, you could use a resistor in series with one of the reset lines (4 or 10) and add a capacitor from the reset line to ground.

The 100 ohm resistor and 100uF capacitor serve to filter noise on the supply line if the circuit is used in a automotive application. They may not be necessary. The circuit may work well without those parts.



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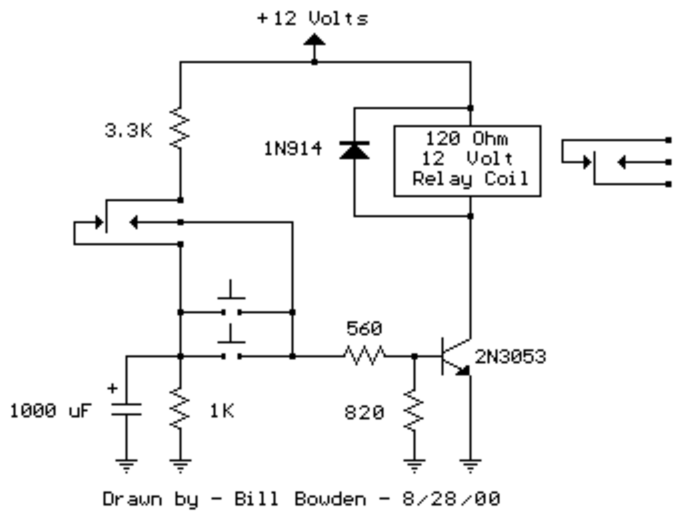
Single Transistor Relay Toggle Circuit

The circuit below requires a double pole, double throw relay in conjunction with a single transistor to allow toggling the relay with a momentary push button. One set of relay contacts is used to control the load, while the other is used to provide feedback to keep the relay activated or deactivated. Several push buttons can be wired in parallel to allow toggling the relay from different locations.

In the deactivated state, the relay contacts are arranged so the 1000 uF capacitor will charge to about 2.7 volts. When the switch is closed, the capacitor voltage is applied to the transistor base through a 560 resistor causing the transistor to turn on and activate the relay. In the activated state, the relay contacts are arranged so the 3.3K resistor and 560 ohm resistor provide a continous current to the transistor base maintaining the activated state. While in the activated state, the capacitor is allowed to discharge to zero through the 1K resistor. When the switch is again closed, the capacitor will cause the transistor base to move toward ground deactivating the relay.

The circuit has three distinct advantages, it requires only a few parts, always comes up with the relay deactivated, and doesn't need any switch debouncing. However since the capacitor will begin charging as soon as the button is depressed, the button cannot remain depressed too long to avoid re-engaging the relay. This problem can be minimized with an additional resistor connected from the transistor base to ground so that the base voltage is close to 0.7 volts with the button depressed and the transistor is biased in the linear region. With the button held down, the relay coil voltage should be somewhere between the pull in and drop out voltages so that the relay will maintain the last toggled state. This worked out to about 820 ohms for the circuit I built using a 12 volt, 120 ohm relay coil and 2N3053 transistor. Temperature changes will effect the situation but the operation is still greatly improved. I heated the transistor with a hair dryer and found that the relay will re-engage with the button held down for approximately 1 second, but this is not much of a problem under normal operation.



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Single MOSFET Relay Toggle Circuit

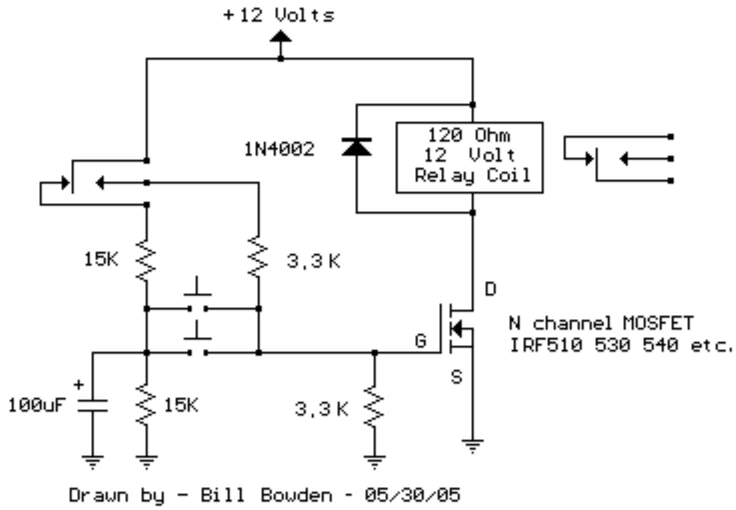
This circuit is similar to the one above, but uses a N channel mosfet such as IRF530, 540, 640, etc. in place of the NPN transistor. Smaller mosfets could be used, but I don't know the part numbers. I tested the circuit with a IRF640, IRFZ44, IRFZ34 and REP50N06.

The circuit has the same three advantages, it requires only a few parts, always comes up with the relay deactivated, and doesn't need any switch debouncing.

In operation, when the relay is deactivated, the 100uF capacitor will charge to 6 volts. When the button is pressed, the capacitor will apply 6 volts to the MOSFET gate turning it on. The capacitor voltage (and gate voltage) will fall from 6 to 3 volts in about 200 mS which should be enough time for the relay contacts to move. For very slow relays, a larger capacitor may be needed.

When the relay energizes, the contacts will apply 12 volts to the 3.3K resistor producing 6 volts at the gate, which will keep the relay energized indefinetly. The capacitor will now discharge to zero since the +12 relay contact is no longer connected to the 15K resistor.

When the button is again pressed, the capacitor will apply zero volts to the gate turning off the relay. There should be no problem holding down the button causing the relay to re-engage since the gate voltage will be only about 1.8 volts when the button is held down and the mosfet requires about 3.5 volts or more to start conducting. But you do need to wait about 1 second or longer between button presses, so the capacitor has time to charge or discharge. Two push buttons are shown, but you could have several more in parallel to control the relay from several different locations.



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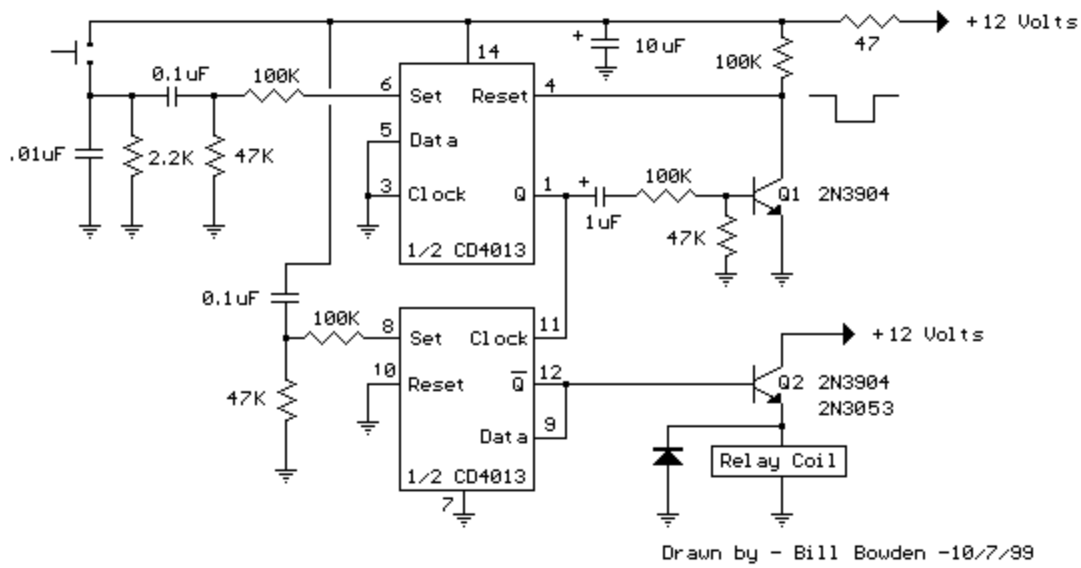
CMOS Toggle Flip Flop Using Push Button

The circuit below uses a CMOS dual D flip flop (CD4013) to toggle a relay or other load with a momentary push button. Several push buttons can be wired in parallel to control the relay from multiple locations.

A high level from the push button is coupled to the set line through a small (0.1uF) capacitor. The high level from the Q output is inverted by the upper transistor and supplies a low reset level to the reset line for about 400 mS, after which time the reset line returns to a high state and resets the flip flop. The lower flip flop section is configured for toggle operation and changes state on the rising edge of the clock line or at the same time as the upper flip flop moves to the set condition. The switch is debounced due to the short duration of the set signal relative to the long duration before the circuit is reset. The Q or Qbar outputs will only supply about 2 mA of current, so a buffer transistor or power MOSFET is needed to drive a relay coil, or lamp, or other load. A 2N3904 or most any small signal NPN transistor can be used for relay coil resistances of 250 ohms or more. A 2N3053 or medium power (500 mA) transistor should be used for coil resistances below 250 ohms. The 47 ohm resistor and 10uF capacitor serve to decouple the circuit from the power supply and filter out any short duration noise signals that may be present. The RC network (.1/47K) at the SET line (pin 8) serves as a power-on reset to ensure the relay is denergized when circuit power is first applied. The reset idea was suggested by Terry

Pinnell who used the circuit to control a shed light from multiple locations.



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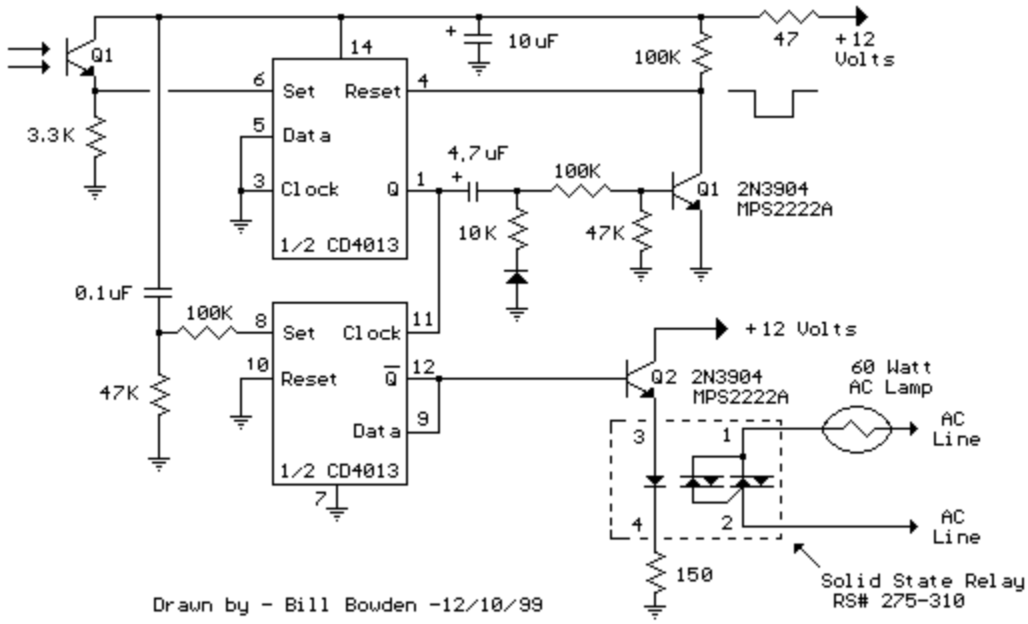
CMOS Toggle Flip Flop Using Laser Pointer

The circuit below is similar to the one above but can be used with a laser pointer to toggle the relay rather than a push button. The IR photo transistor Q1 (Radio Shack 276-145A) or similar is connected to the set input (pin 6). The photo transistor should be shielded from direct light so that the voltage at the set input (pin 6) is less than 1 volt under ambient conditions and moves to more than 10 volts when illuminated by the laser pointer or other light source. The reset time is about a half second using a 4.7uF cap which prevents the circuit from toggling more than once during a half second interval. The 10K resistor and diode provide a faster discharge path for the 4.7uF cap so the circuit can be retoggled in less than 1 second. The 3K resistor in series with the photo transistor may need be adjusted for best performance. The relay shown is a solid state variety to be used with lights or other resistive loads at less than 3 amps. A mechanical relay can also be used as shown in circuit above.



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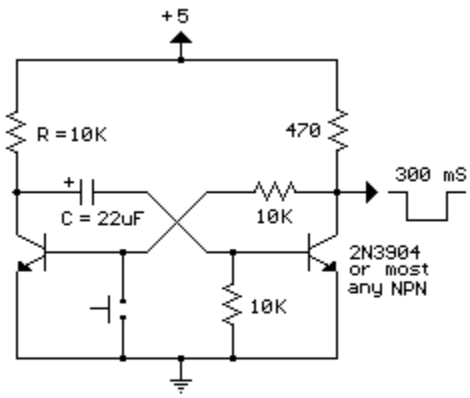
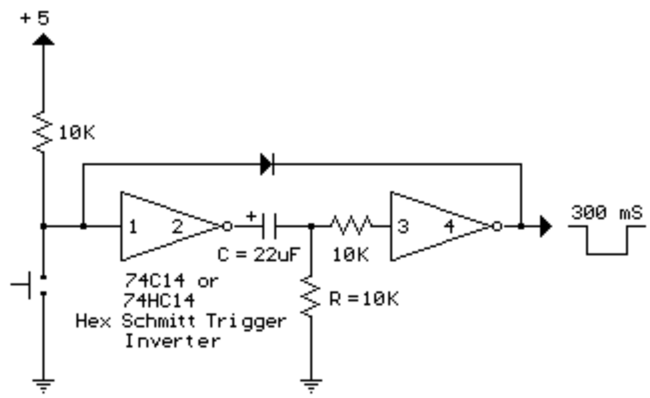
Monostable Flip Flop

The monostable flip flop, sometimes called a 'one shot' is used to produce a single pulse each time it is triggered. It can be used to debounce a mechanical switch so that only one rising and one falling edge occurs for each switch closure, or to produce a delay for timing applications. In the discrete circuit, the left transistor normally conducts while the right side is turned off. Pressing the switch grounds the base of the conducting transistor causing it to turn off which causes the collector voltage to rise. As the collector voltage rises, the capacitor begins to charge through the base of the opposite transistor, causing it to switch on and produce a low state at the output. The low output state holds the left transistor off until the capacitor current falls below what is needed to keep the output stage saturated. When the output side begins to turn off, the rising voltage causes the left transistor to return to it's conducting state which lowers the voltage at it's collector and causes the capacitor to discharge through the 10K resistor (emitter to base). The circuit then remains in a stable state until the next input. The one shot circuit on the right employs two logic inverters which are connected by the timing capacitor. When the switch is closed or the input goes negative, the capacitor will charge through the resistor generating an initial high level at the input to the second inverter which produces a low output state. The low output state is connected back to the input through a diode which maintains a low input after the switch has opened until the voltage falls below 1/2 Vcc at pin 3 at which time the output and input return to a high state. The capacitor then discharges through the resistor (R) and the circuit remains in a stable state until the next input arrives. The 10K resistor in series with the inverter input (pin 3) reduces the discharge current through the input protection diodes. This resistor may not be needed with smaller capacitor values.

Note: These circuits are not re-triggerable and the output duration will be shorter than normal if the circuit is triggered before the timing capacitors have discharged which requires about the same amount of time as the output. For re-triggerable circuits, the 555 timer, or the 74123 (TTL), or the 74HC123 (CMOS) circuits can be used.





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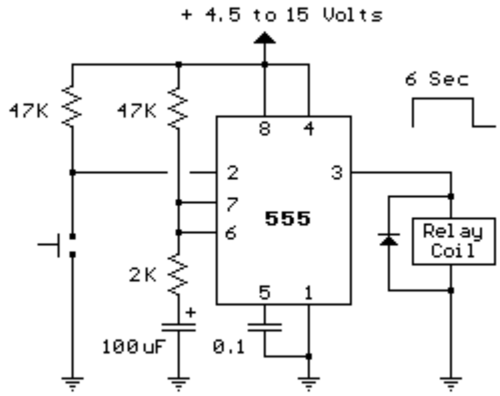
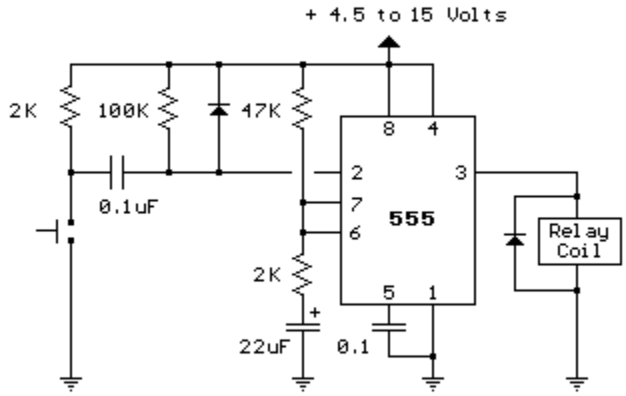
555 timer Mono stable (one shot) circuit

The two circuits below illustrate using the 555 timer to close a relay for a predetermined amount of time by pressing a momentary N/O push button. The circuit on the left can be used for long time periods where the push button can be pressed and released before the end of the timing period. For shorter periods, a capacitor can be used to isolate the switch so that only the initial switch closure is seen by the timer input and the switch can remain closed for an unlimited period without effecting the output.

In the idle state, the output at pin 3 will be at ground and the relay deactivated. The trigger input (pin 2) is held high by the 100K resistor and both capacitors are discharged. When the button is closed, the 0.1uF cap will charge through the button and the 100K resistor which causes the voltage at pin 2 to move low for a few milliseconds. The falling voltage at pin 2 triggers the 555 and starts the timing cycle. The output at pin 3 immediately moves up to near the supply voltage (about 10.4 volts for a 12 volt supply) and remains at that level until the 22 uF timing capacitor charges to about 2/3 of the supply voltage (about 1 second as shown). Most 12 volt relays will operate at 10.4 volts, if not, the supply voltage could be raised to 13.5 or so to compensate. The 555 output will supply up to 200mA of current, so the relay could be replaced with a small lamp, doorbell, or other load that requires less than 200mA. When the button is released, the 0.1uF capacitor discharges through the 100K and 2K resistors. The diode across the 100K resistor prevents the voltage at pin 2 from rising above the supply voltage when the cap discharges. The 2K resistor in series with the 22uF cap limits the discharge current from pin 7 of the timer. This resistor may not be necessary, but it's a good idea to limit current when discharging capacitors across switch contacts or transistors.





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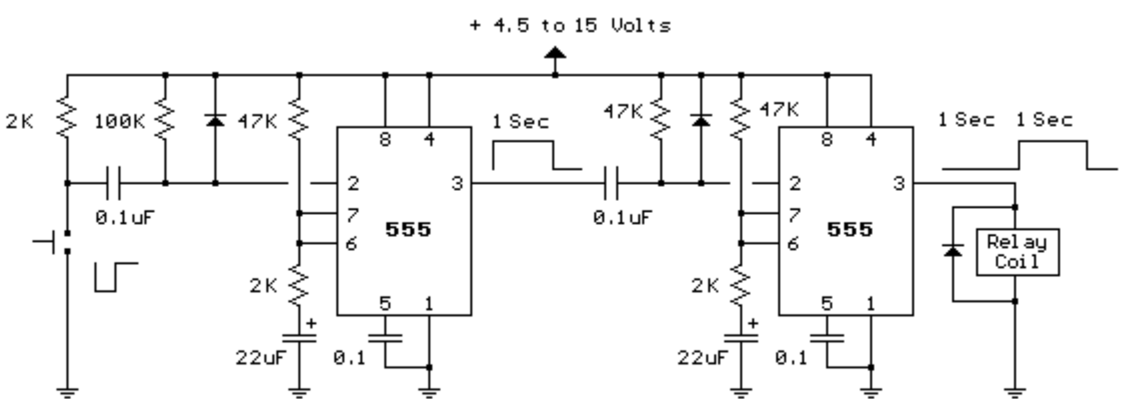
Generating a Delayed Pulse Using The 555 Timer

The circuit below illustrates generating a single positive pulse which is delayed relative to the trigger input time. The circuit is similar to the one above but employs two stages so that both the pulse width and delay can be controlled. When the button is depressed, the output of the first stage will move up and remain near the supply voltage until the delay time has elapsed, which in this case is about 1 second. The second 555 stage will not respond to the rising voltage since it requires a negative, falling voltage at pin 2, and so the second stage output remains low and the relay remains de-energized. At the end of the delay time, the output of the first stage returns to a low level, and the falling voltage causes the second stage to begin it's output cycle which is also about 1 second as shown. This same circuit can be built using the dual 555 timer which is a 556, however the pin numbers will be different.



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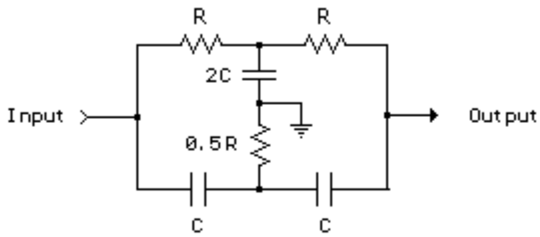
RC Notch Filter (Twin T)

The twin T notch filter can be used block an unwanted frequency or if placed around an op-amp as a bandpass filter. The notch frequency occurs where the capacitive reactance equals the resistance (Xc=R) and if the values are close, the attenuation can be very high and the notch frequency virtually eliminated. The insertion loss of the filter will depend on the load that is connected to the output, so the resistors should be of much lower value than the load for minimal loss. At audio frequencies, the filter could function as a bass and treble boost circuit by attenuating the mid range frequencies. Using 1.5K resistors and 0.1uF capacitors, the band stop at -10dB is about 500 Hz to 2Khz. The depth and width of the response can be adjusted somewhat with the 0.5R value and by adding some resistance across the C values. If the circuit is used around an op-amp as a bandpass filter, the response may need to be dampened to avoid oscillation.



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