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80 CIRCUITS as of 7-3-2011

Talking Electronics

See [TALKING ELECTRONICS WEBSITE](#)

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INTRODUCTION

This is the second half of our Transistor Circuits e-book. It contains a further 100 circuits, with many of them containing one or more Integrated Circuits (ICs).

It's amazing what you can do with transistors but when Integrated Circuits came along, the whole field of electronics exploded.

IC's can handle both analogue as well as digital signals but before their arrival, nearly all circuits were analogue or very simple "digital" switching circuits.

Let's explain what we mean.

The word analogue is a waveform or signal that is changing (increasing and decreasing) at a constant or non constant rate. Examples are voice, music, tones, sounds and frequencies. Equipment such as radios, TV's and amplifiers process analogue signals.

Then digital came along.

Digital is similar to a switch turning something on and off.

The advantage of digital is two-fold.

Firstly it is a very reliable and accurate way to send a signal. The signal is either HIGH or LOW (ON or OFF). It cannot be half-on or one quarter off.

And secondly, a circuit that is ON, consumes the least amount of energy in the controlling device. In other words, a transistor that is fully turned ON and driving a motor, dissipates the least amount of heat. If it is slightly turned ON or nearly fully turned ON, it gets very hot.

And obviously a transistor that is not turned on at all will consume no energy.

A transistor that turns ON fully and OFF fully is called a SWITCH.

When two transistors are cross-coupled in the form of a flip flop, any pulses entering the circuit cause it to flip and flop and the output goes HIGH on every second pulse.

This means the circuit halves the input pulses and is the basis of counting or dividing. Digital circuits also introduce the concept of two inputs creating a HIGH output when both are HIGH and variations of this.

This is called "logic" and introduces terms such as "Boolean algebra" and "gates."

Integrated Circuits started with a few transistors in each "chip" and increased to whole mini or micro computers in a single chip. These chips are called Microcontrollers and a single chip with a few surrounding components can be programmed to play games, monitor heart-rate and do all sorts of amazing things. Because they can process information at high speed, the end result can appear to have intelligence and this is where we are heading: AI (Artificial Intelligence).

But let's crawl before we walk and come to understand how to interface some of these chips to external components.

In this Transistor Circuits ebook, we have presented about 100 interesting circuits using transistors and chips.

In most cases the IC will contain 10 - 100 transistors, cost less than the individual components and take up much less board-space. They also save a lot of circuit designing and quite often consume less current than discrete components.

In all, they are a fantastic way to get something working with the least componentry.

A list of of Integrated Circuits (Chips) is provided at the end of this book to help you identify the pins and show you what is inside the chip.

Some of the circuits are available from Talking Electronics as a kit, but others will have to be purchased as individual components from your local electronics store.

Electronics is such an enormous field that we cannot provide kits for everything. But if you have a query about one of the circuits, you can contact me.

Colin Mitchell
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To save space we have not provided lengthy explanations of how the circuits work. This has already been covered in TALKING ELECTRONICS Basic Electronics Course, and can be obtained on a [CD for \\$10.00](#) (posted to anywhere in the world) See Talking Electronics website for more details: <http://www.talkingelectronics.com>

MORE INTRO

There are two ways to learn electronics.

One is to go to school and study theory for 4 years and come out with all the theoretical knowledge in the world but almost no practical experience.

We know this type of person. We employed them (for a few weeks!). They think everything they design WILL WORK because their university professor said so.

The other way is to build circuit after circuit and get things to work. You may not know the in-depth theory of how it works but trial and error gets you there.

We know. We employed this type of person for up to 12 years.

I am not saying one is better than the other but most electronics enthusiasts are not "book worms" and anyone can succeed in this field by constantly applying themselves with "constructing projects." You actually learn 10 times faster by applying yourself and we have had technicians repairing equipment after only a few weeks on the job. It would be nothing for an enthusiast to build 30 - 40 circuits from our previous Transistor eBook and a similar number from this book. Many of the circuits are completely different to each other and all have a building block or two that you can learn from.

Electronics enthusiasts have an uncanny understanding of how a circuit works and if you have this ability, don't let it go to waste.

Electronics will provide you a comfortable living for the rest of your life and I mean this quite seriously. The market is very narrow but new designs are coming along all the time and new devices are constantly being invented and more are always needed. Once you get past this eBook of "Chips and Transistors" you will want to investigate microcontrollers and this is when your options will explode.

You will be able to carry out tasks you never thought possible, with a chip as small as 8 pins and a few hundred lines of code.

As I say in my speeches. What is the difference between a "transistor man" and a "programmer?" TWO WEEKS!

In two weeks you can start to understand the programming code for a microcontroller and perform simple tasks such as flashing a LED and produce sounds and outputs via the press of a button.

All these things are covered on [Talking Electronics website](#) and you don't have to buy any books or publications. Everything is available on the web and it is instantly accessible. That's the beauty of the web.

Don't think things are greener on the other side of the fence, by buying a text book. They aren't. Everything you need is on the web AT NO COST.

The only thing you have to do is build things. If you have any technical problem at all, simply email [Colin Mitchell](#) and any question will be answered. Nothing could be simpler and this way we guarantee you SUCCESS. Hundreds of readers have already emailed and after 5 or more emails, their circuit works. That's the way we work. One thing at a time and eventually the fault is found.

If you think a circuit will work the first time it is turned on, you are fooling yourself.

All circuits need corrections and improvements and that's what makes a good electronics person. Don't give up. How do you think all the circuits in these eBooks were designed? Some were copied and some were designed from scratch but all had to be built and adjusted slightly to make sure they worked perfectly.

I don't care if you use bread-board, copper strips, matrix board or solder the components in the air as a "bird's nest." You only learn when the circuit gets turned on and WORKS!

In fact the rougher you build something, the more you will guarantee it will work when built on a printed circuit board.

However, high-frequency circuits (such as 100MHz FM Bugs) do not like open layouts and you have to keep the construction as tight as possible to get them to operate reliably.

In most other cases, the layout is not critical.

TRANSISTORS

Most of the transistors used in our circuits are BC 547 and BC 557. These are classified as "universal" or "common" NPN and PNP types with a voltage rating of about 25v, 100mA collector current and a gain of about 100. Some magazines use the term "TUP" (for Transistor Universal PNP) or "TUN" (for Transistor Universal NPN). We simply use Philips types that everyone recognises. You can use almost any type of transistor to replace them and here is a list of the equivalents and pinouts:

NPN



c b e
BC 547
BC 337 / 8

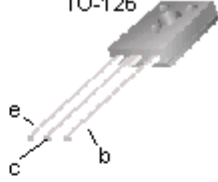
PNP



c b e
BC 557
BC 327 / 8

NPN

TO-126



BD 139
BD 679 (darlington)

NPN



e b c
2N 3904
2N 2222

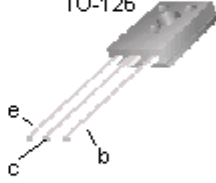
PNP



e b c
2N 3906

PNP

TO-126



BD 140

NPN



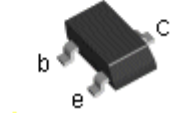
e c b
BC 639

PNP



e c b
BC 640

SOT23



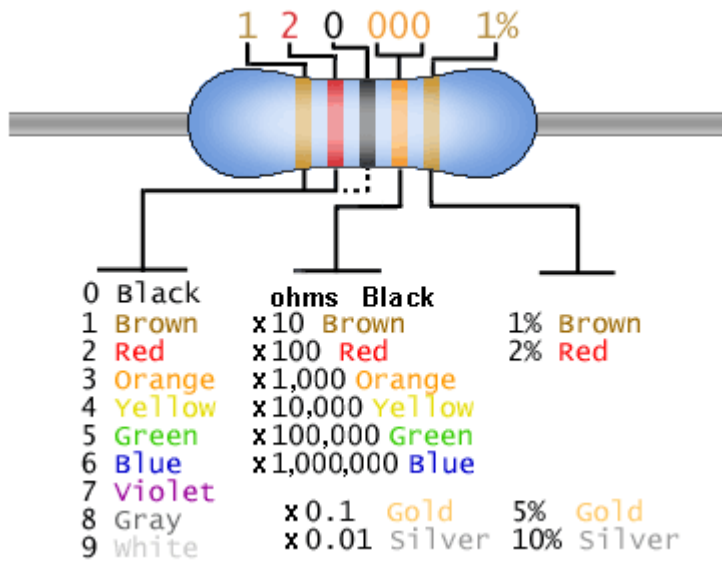
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[Beeper Bug](#)
[Blocking Oscillator](#)
[Book Light](#)
[Buck Regulator](#) 12v to 5v
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[Low Voltage Flasher](#)
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RESISTOR COLOUR CODE



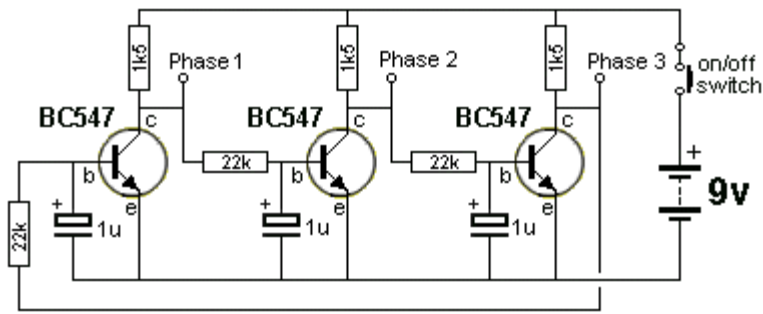
See [resistors from 0.22ohm to 22M](#) in full colour at end of book and another [resistor table](#)

RECTIFYING a Voltage

These circuits show how to change an oscillating voltage (commonly called AC) to DC. The term AC means Alternating Current but it really means Alternating Voltage as the rising and falling voltage produces an increasing and decreasing current.

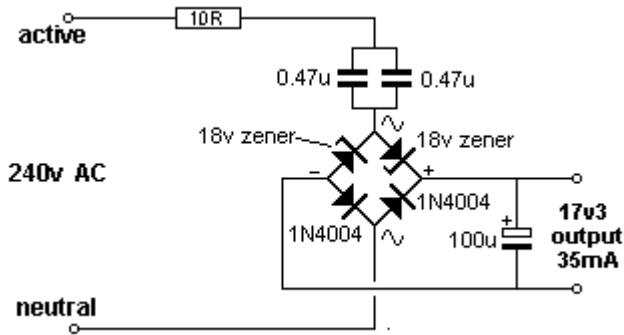
The term DC means Direct Current but it actually means Direct or unchanging Voltage.

The output of the following circuits will not be pure DC (like that from a battery) but will contain ripple. Ripple is reduced by adding a capacitor (electrolytic) to the output.



3-PHASE SINEWAVE GENERATOR

This circuit produces a sine wave and each phase can be tapped at the point shown.



TRANSFORMERLESS POWER SUPPLY

This clever design uses 4 diodes in a bridge to produce a fixed voltage power supply capable of supplying 35mA.

All diodes (every type of diode) are zener diodes. They all break down at a particular voltage. The fact is, a power diode breaks down at 100v or 400v and its zener characteristic is not useful.

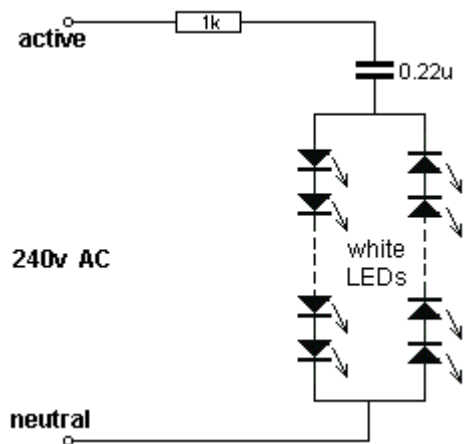
But if we put 2 zener diodes in a bridge with two ordinary power diodes, the bridge will break-down at the voltage of the zener. This is what we have done. If we use 18v zeners, the output will be 17v4.

When the incoming voltage is positive at the top, the left zener provides 18v limit (and the left power-diode produces a drop of

0.6v). This allows the right zener to pass current just like a normal diode but the voltage available to it is just 18v. The output of the right zener is 17v4. The same with the other half-cycle.

The current is limited by the value of the X2 capacitor and this is 7mA for each 100n when in full-wave (as per this circuit). We have $10 \times 100n = 1u$ capacitance. Theoretically the circuit will supply 70mA but we found it will only deliver 35mA before the output drops. The capacitor should comply with X1 or X2 class. The 10R is a safety-fuse resistor.

The problem with this power supply is the "live" nature of the negative rail. When the power supply is connected as shown, the negative rail is 0.7v above neutral. If the mains is reversed, the negative rail is 340v (peak) above neutral and this will kill you as the current will flow through the diode and be lethal. You need to touch the negative rail (or the positive rail) and any earthed device such as a toaster to get killed. The only solution is the project being powered must be totally enclosed in a box with no outputs.



LEDs on 240v

I do not like any circuit connected directly to 240v mains. However Christmas tress lights have been connected directly to the mains for 30 years without any major problems.

Insulation must be provided and the lights (LEDs) must be away from prying fingers.

Read the article above for the type of capacitor and add an equal number of LEDs in each string so the reverse voltage is equal across each LED.

It does not matter how many LEDs you add to each string as the brightness will be the same. As you add each pair, the current will drop a very small amount until eventually, when you have 100 LEDs in each string, the current will be zero.

For the circuit shown, each LED will see 20mA peak during the half-cycle they are illuminated. The 1k resistor will drop 15v - since the RMS current is 15mA ($15mA \times 1,000 \text{ ohms} = 15v$). No rectifier diodes are needed.

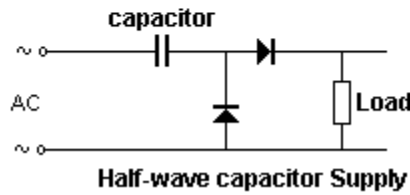
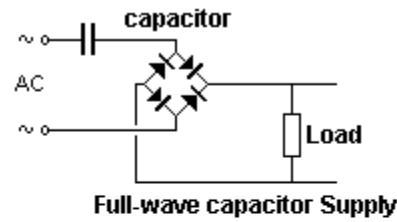
The LEDs are the "rectifiers." Very clever. You must have LEDs in both

directions to charge and discharge the capacitor. The resistor is provided to take a heavy surge current through one of the strings of LEDs if the circuit is switched on when the mains is at a peak. **A 100n cap will deliver 7mA RMS or 10mA peak in full wave or 3.5mA RMS (5mA peak) in half-wave.** The LEDs above detect peak current.

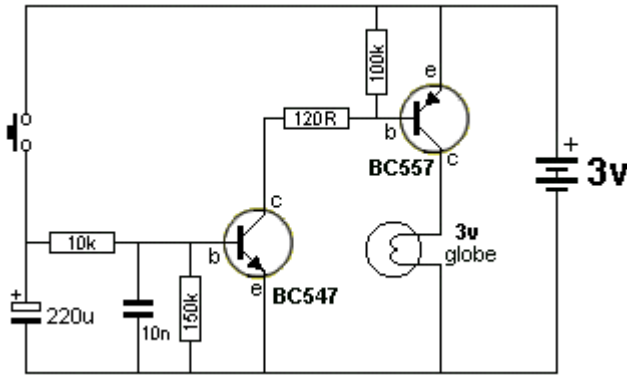
The current-capability of a capacitor needs more explanation. In the diagram on the left we see a capacitor feeding a full-wave power supply. This is exactly the same as the **LEDs on 240v** circuit above. Imagine the LOAD resistor is removed. Two of the diodes will face down and two will face up. This is exactly the same as the LEDs facing up and facing down in the circuit above. The only difference is the mid-point is joined. Since the voltage on the mid-point of one string is the same as the voltage at the mid-point of the other string, the link can be removed and the circuit will operate the same.

capacitance will deliver 3.5mA RMS or In the half-wave supply, the capacitor peak for each 100n to the load and 3.5mA RMS is lost in the diode that

to keep the total voltage-drop in each actually working on DC, it's not constant zero DC for 1/2 cycle then a gradual voltage-drop for each LED over a 1/4 to zero over another 1/4 cycle, then 0v for turn on and off, you may observe some two strings should be placed together.

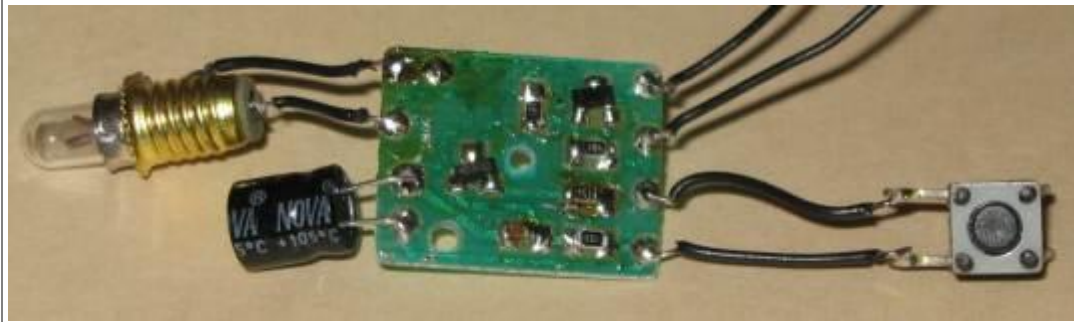


This means each 100n of 5mA peak on each half-cycle. delivers 3.5mA RMS or 5mA during the other half-cycle the discharges the capacitor. You can use any LEDs and try string equal. Each string is DC but varying DC. In fact is it increase to full characteristic cycle, then a gradual decrease 1/2 cycle. Because the LEDs flickering and that's why the

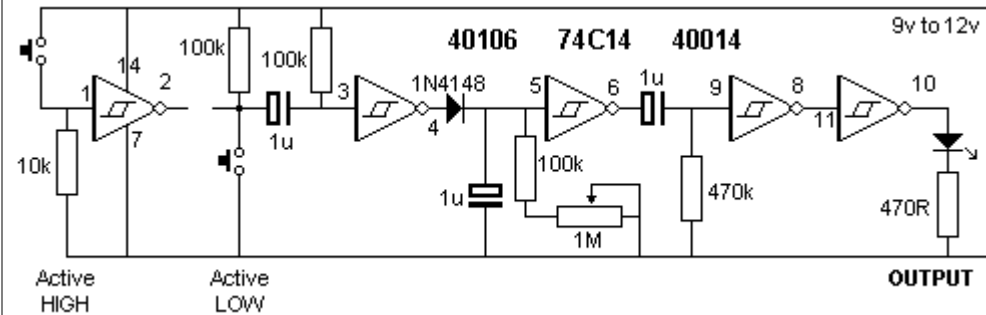


BOOK LIGHT

This circuit keeps the globe illuminated for a few seconds after the switch is pressed. There is one minor fault in the circuit. The 10k should be increased to 100k to increase the "ON" time. The photo shows the circuit built with surface-mount components:

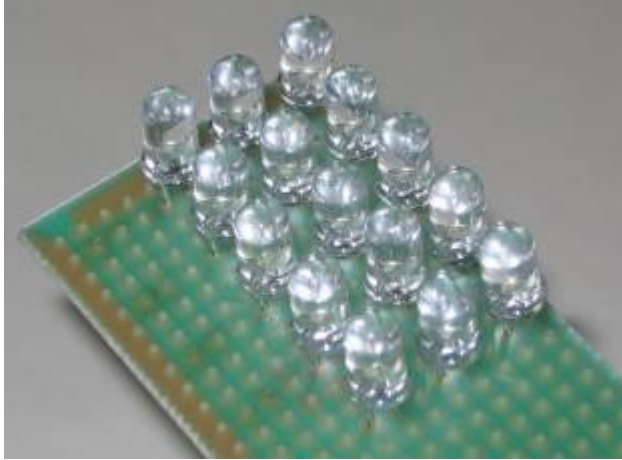


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CAMERA ACTIVATOR

This circuit was designed for a customer who wanted to trigger a camera after a short delay. The output goes HIGH about 2 seconds after the switch is pressed. The LED turns on for about 0.25 seconds. The circuit will accept either active HIGH or LOW input and the switch can remain pressed and it will not upset the operation of the circuit. The timing can be changed by adjusting the 1M trim pot and/or altering the value of the 470k.

MAKE YOUR OWN:**15 LEDs on Matrix board**

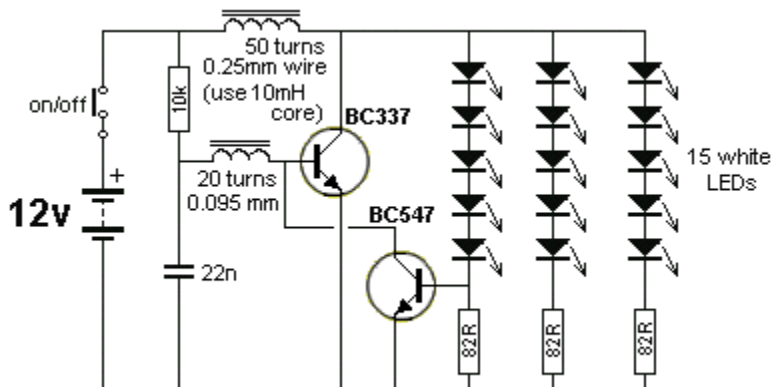
The transformer consists of 50 turns 0.25mm wire connected to the pins. The feedback winding is 20 turns 0.095mm wire with "fly-leads."

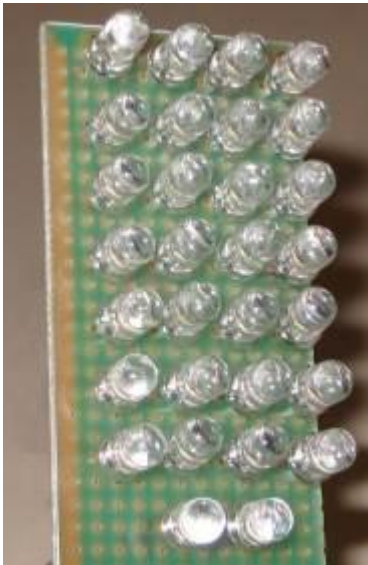
1-WATT LED

This circuit drives 15 LEDs to produce the same brightness as a 1-watt LED. The circuit consumes 750mW but the LEDs are driven with high-frequency, high-voltage spikes, and become more-efficient and produce a brighter output than if driven by pure-DC.

The LEDs are connected in 3 strings of 5 LEDs. Each LED has a characteristic voltage of 3.2v to 3.6v making each chain between 16v and 18v. By selecting the LEDs we have produced 3 chains of 17.5v. Five LEDs (in a string) has been done to allow the circuit to be powered by a 12v battery and allow the battery to be charged while the LEDs are illuminating. If only 4 LEDs are in series, the characteristic voltage may be as low as 12.8v and they may be over-driven when the battery is charging. (Even-up the characteristic voltage across each chain by checking the total voltage across them with an 19v supply and 470R dropper resistor.) The transformer is shown above. It is wound on a 10mH choke with the original winding removed. This circuit is called a **"boost circuit."** It is not designed to drive a single 1-watt LED (a buck circuit is needed).

The LEDs in the circuit are 20,000mcd with a viewing angle of 30 degrees (many of the LED specifications use "half angle." You have to test a LED to make sure of the angle). This equates to approximately 4 lumens per LED. The 4-watt CREE LED claims 160 lumens (or 40 lumens per watt). Our design is between 50 - 60 lumens per watt and it is a much-cheaper design.



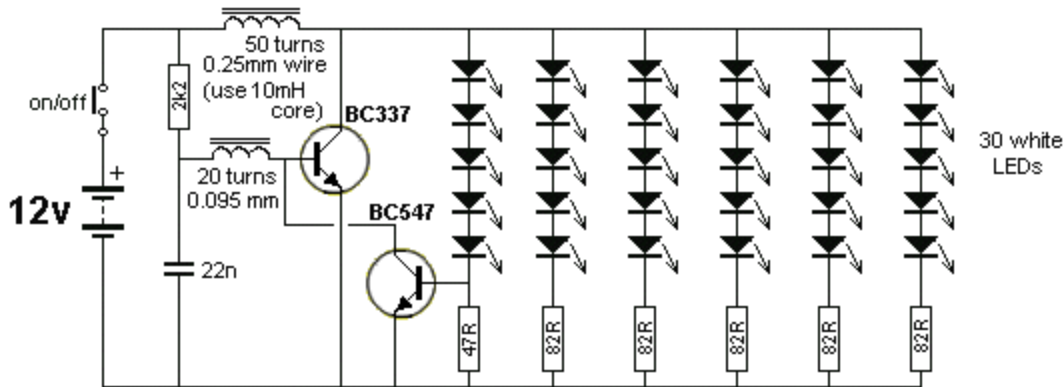


30 LEDs on Matrix board

1.5 WATT LED

The circuit below can be modified to drive up to 30 white LEDs.

The effectiveness of a LED array increases when they are spread out slightly and this makes them more efficient than a single 1 watt or 2 watt LED. The two modifications to the circuit make the BC337 work harder and this is the limit of the inductor. The current consumption is about 95mA. The winding details for the transformer are shown above.



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DRIVE 20 LEDs FROM 12v - approx 1watt circuit

This is another circuit that drives a number of LEDs or a single 1 watt LED. It is a "Buck Circuit" and drives the LEDs in parallel. They should be graded so that the characteristic voltage-drop across each of them is within 0.2v of all the other LEDs. The circuit will drive any number from 1 to 20 by changing the "sensor" resistor as shown on the circuit. The current consumption is about 95mA @ 12v and lower at 18v. The circuit can be put into dim mode by increasing the drive resistor to 2k2. The UF4004 is an ultra fast 1N4004 - similar to a high-speed diode. You can use 2 x 1N4148 signal diodes.



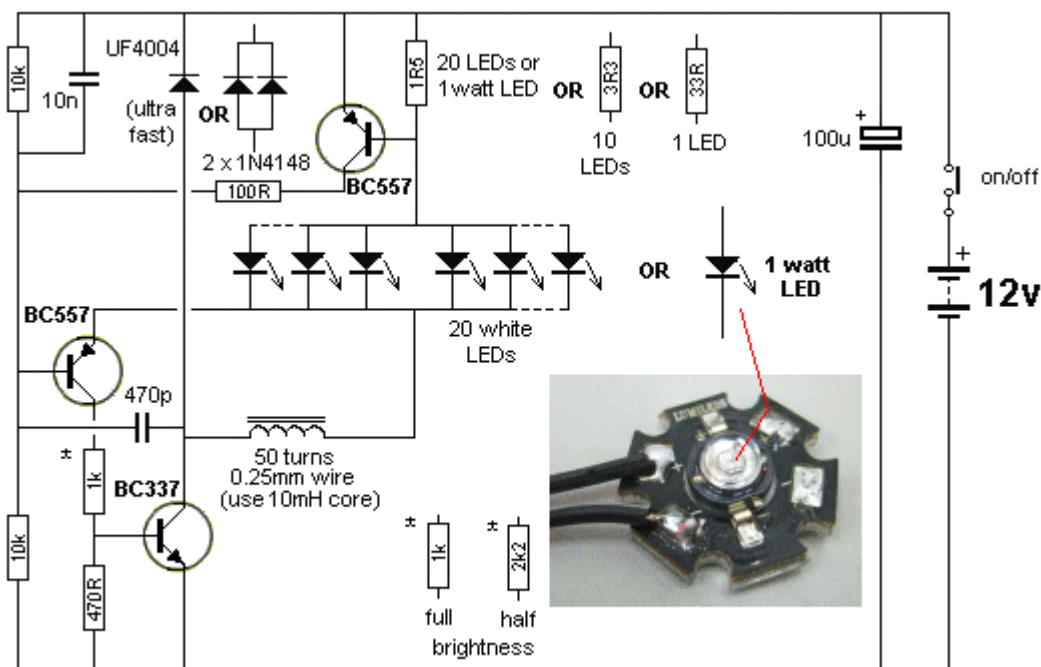
The circuit will not drive two LEDs in series - it runs out of voltage (and current) when the voltage across the load is 7v. It oscillates at approx 200kHz. Build both the 20 LED and 1 watt LED version and compare the brightness and effectiveness. The photo of the 1 watt LED on the left must be heatsinked to prevent the LED overheating. The photo on the circuit diagram shows the LED mounted on a heatsink and the connecting wires.



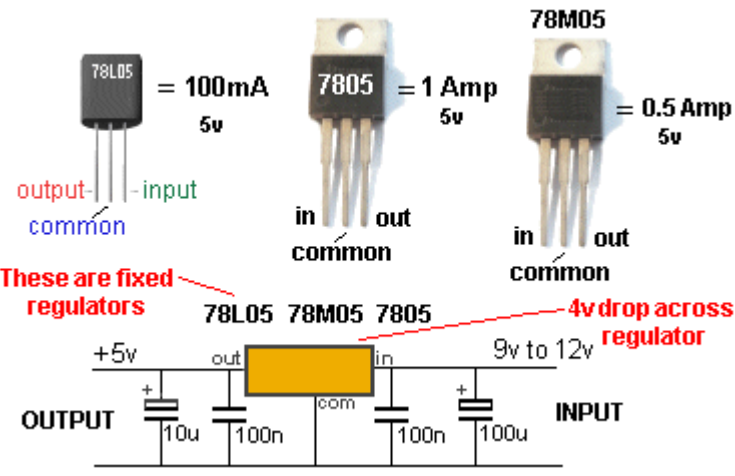
A 1-watt demo board showing the complex step-up circuitry.

This is a Boost circuit to illuminate the LED and is completely different to our design. It has been included to show the size of a 1 watt LED.

The reason for a Boost or Buck circuit to drive one or more LEDs is simple. The voltage across a LED is called a "characteristic voltage" and comes as a natural feature of the LED. We cannot alter it. To power the LED with exactly the correct amount of voltage (and current) you need a supply that is EXACTLY the same as the characteristic voltage. This is very difficult to do and so a resistor is normally added in series. But this resistor wastes a lot of energy. So, to keep the losses to a minimum, we pulse the LED with bursts of energy at a higher voltage and the LED absorbs them and produces light. With a Buck circuit, the transistor is turned on for a short period of time and illuminated the LEDs. At the same time, some of the energy is passed to the inductor so that the LEDs are not damaged. When the transistor is turned off, the energy from the inductor also gives a pulse of energy to the LEDs. When this has been delivered, the cycle starts again.



POWER SUPPLIES - FIXED:



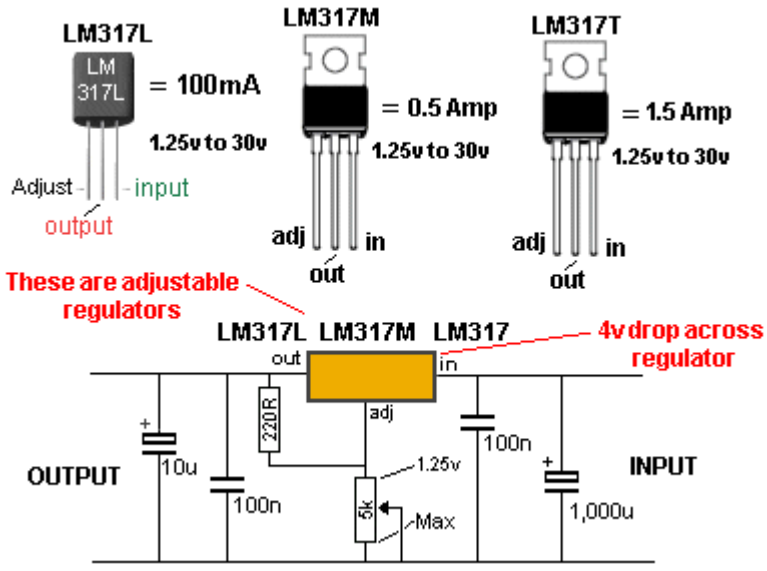
A simple power supply can be made with a component called a "3-pin regulator or 3-terminal regulator" It will provide a very low ripple output (about 4mV to 10mV provided electrolytics are on the input and output.

The diagram above shows how to connect a regulator to create a power supply. The 7805 regulators can handle 100mA, 500mA and 1 amp, and produce an output of 5v, as shown.

These regulators are called **linear regulators** and drop about 4v across them - minimum. If the current flow is 1 amp, 4watts of heat must be dissipated via a large heatsink. If the output is 5v and input 12v, 7volts will be dropped across the regulator and 7watts must be dissipated.

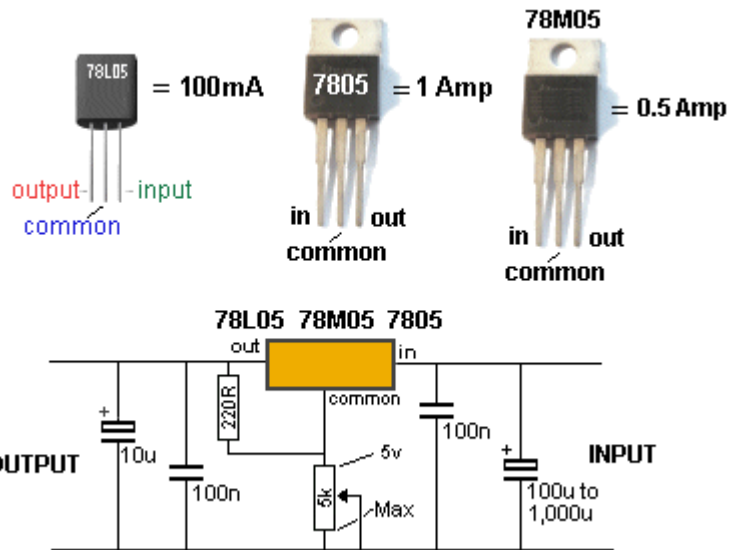
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POWER SUPPLIES - ADJUSTABLE:



The LM317 regulators are adjustable and produce an output from 1.25 to about 35v. The LM317T regulator will deliver up to 1.5amp.

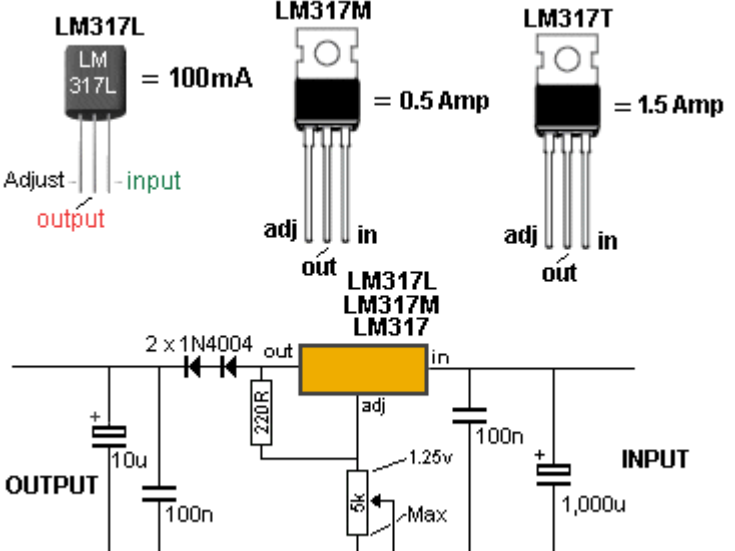
POWER SUPPLIES - ADJUSTABLE using 7805:



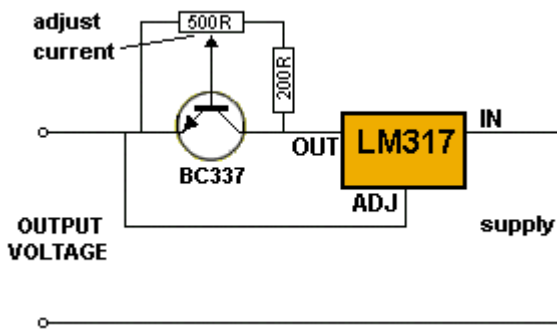
The 7805 range of regulators are called "fixed regulators" but they can be turned into adjustable regulators by "jacking-up" their output voltage. For a 5v regulator, the output can be 5v to 30v.

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POWER SUPPLIES - ADJUSTABLE from 0v:



The LM317 regulator is adjustable from 1.25 to about 35v. To make the output 0v to 35v, two power diodes are placed as shown in the circuit. Approx 0.6v is dropped across each diode and this is where the 1.25v is "lost."



CONSTANT CURRENT

This constant current circuit can be adjusted to any value from a few milliamp to about 500mA - this is the limit of the BC337 transistor.

The circuit can also be called a current-limiting circuit and is ideal in a bench power supply to prevent the circuit you are testing from being damaged.

Approximately 4v is dropped across the regulator and 1.25v across the current-limiting section, so the input voltage (supply) has to be 5.25v above the required output voltage. Suppose you want to charge 4 Ni-Cad cells. Connect them to the output and adjust the 500R pot until the required charge-current is obtained.

The charger will now charge 1, 2, 3 or 4 cells at the same current. But you must remember to turn off the charger before the cells are fully charged as the circuit will not detect this and over-charge the cells.

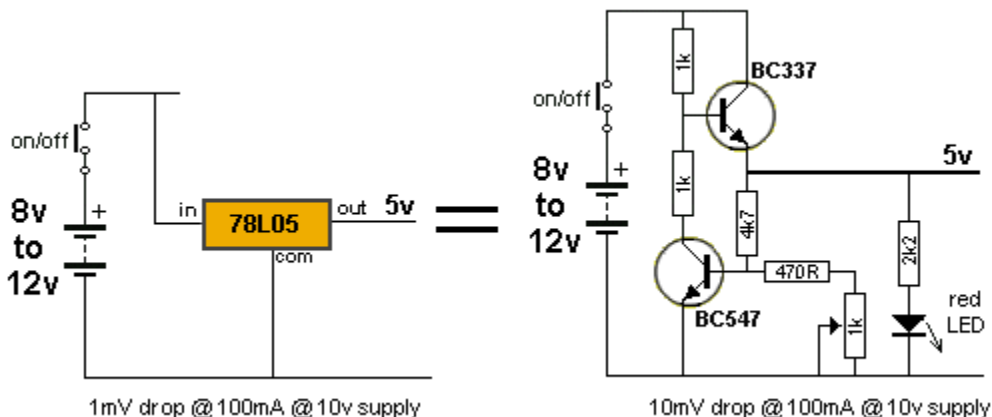
The LM 317 3-terminal regulator will need to be heatsinked.

This circuit is designed for the LM series of regulator as they have a voltage differential of 1.25v between "adj" and "out" terminals.

7805 regulators can be used but the losses in the BC337 will be 4 times greater as the voltage across it will be 5v.

5v FROM OLD CELLS - circuit 1

This circuit takes the place of a 78L05 3-terminal regulator. It produces a constant 5v @ 100mA. You can use any old cells and get the last of their energy. Use an 8-cell holder. The voltage from 8 old cells will be about 10v and the circuit will operate down to about 7.5v. The regulation is very good at 10v, only dropping about 10mV for 100mA current flow (the 78L05 has 1mV drop). As the voltage drops, the output drops from 5v on no-load to 4.8v and 4.6v on 100mA current-flow. The pot can be adjusted to compensate for the voltage-drop. This type of circuit is called a LINEAR REGULATOR and is not very efficient (about 50% in this case). See circuit 2 below for BUCK REGULATOR circuit (about 85% efficient).





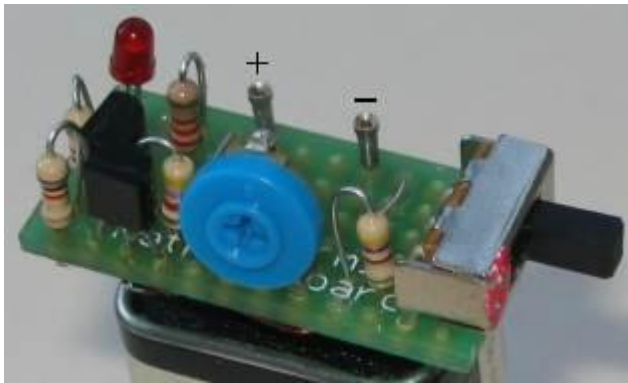
The regulator connected to a 12v battery pack



The regulator connected to a 9v battery



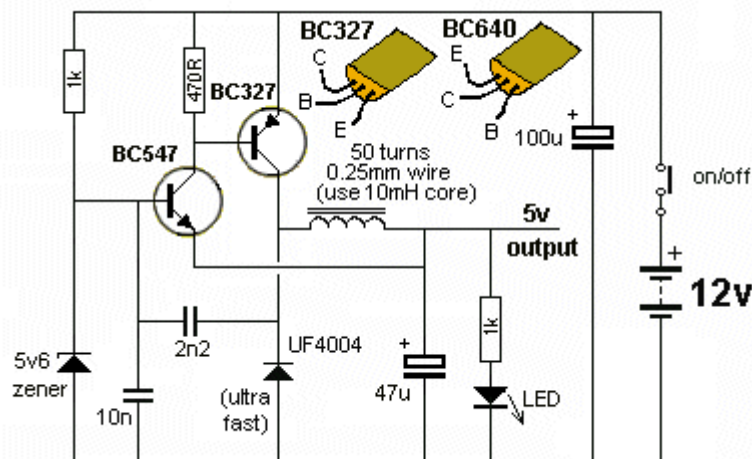
The battery snap plugs into the pins on the 5v regulator board with the red lead going to the negative output of the board as the battery snap is now DELIVERING voltage to the circuit you are powering.

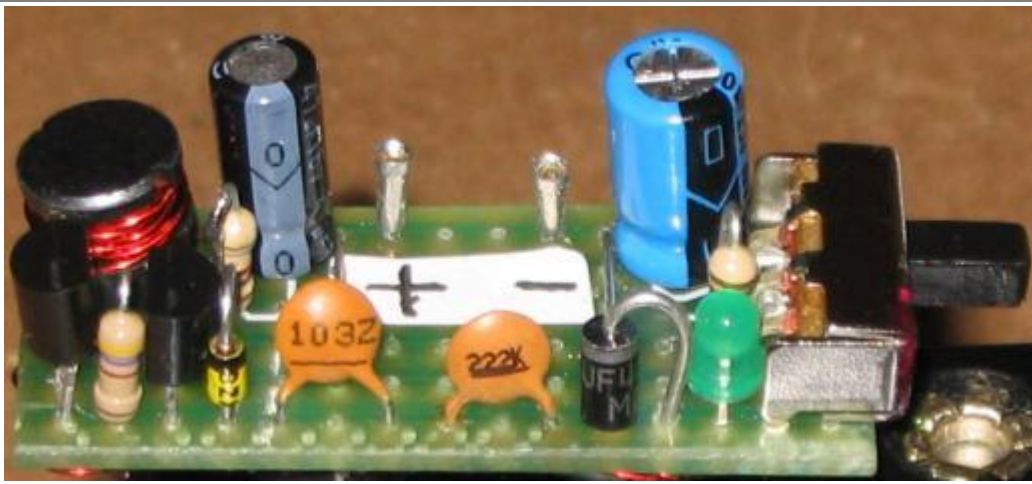


A close-up of the regulator module

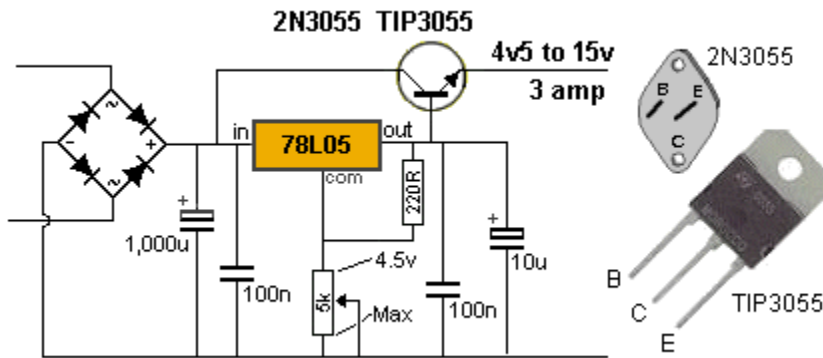
5v FROM OLD CELLS - circuit 2

This circuit is a BUCK REGULATOR. It can take the place of a 78L05 3-terminal regulator, but it is more efficient. It produces a constant 5v @ up to 200mA. You can use any old cells and get the last of their energy. Use an 8-cell holder. The voltage from 8 old cells will be about 10v and the circuit will operate down to about 7.5v. The regulation is very good at 10v, only dropping 10mV for up to 200mA output.



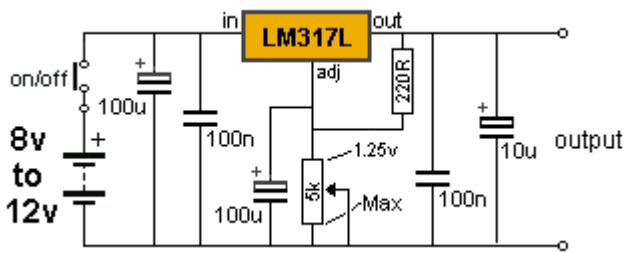


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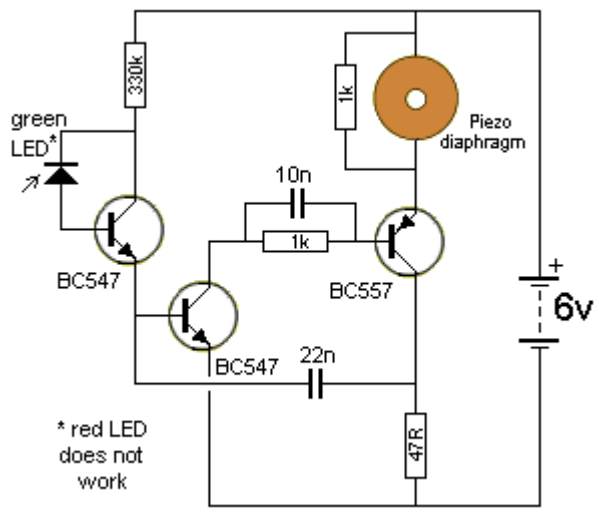
INCREASING THE OUTPUT CURRENT

The output current of all 3-terminal regulators can be increased by including a pass transistor. This transistor simply allows the current to flow through the collector-emitter leads. The output voltage is maintained by the 3-terminal regulator but the current flows through the "pass transistor." This transistor is a power transistor and must be adequately heatsinked. Normally a 2N3055 or TIP3055 is used for this application as it will handle up to 10 amps and creates a 10 amp power supply. The regulator can be 78L05 as all the current is delivered by the pass transistor.



SOFT START

The output voltage of a 3-terminal regulator can be designed to rise slowly. This has very limited application as many circuits do not like this.



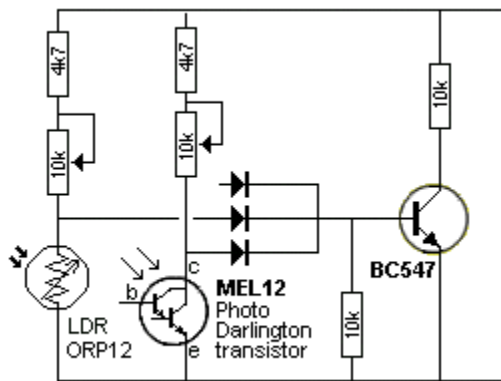
LED DETECTS LIGHT

The LED in this circuit will detect light to turn on the oscillator. Ordinary red LEDs do not work. But green LEDs, yellow LEDs and high-bright white LEDs and high-bright red LEDs work very well.

The output voltage of the LED is up to 600mV when detecting very bright illumination. When light is detected by the LED, its resistance decreases and a very small current flows into the base of the first transistor. The transistor amplifies this current about 200 times and the resistance between collector and emitter decreases. The 330k resistor on the collector is a current limiting resistor as the middle transistor only needs a very small current for the circuit to oscillate. If the current is too high, the circuit will "freeze."

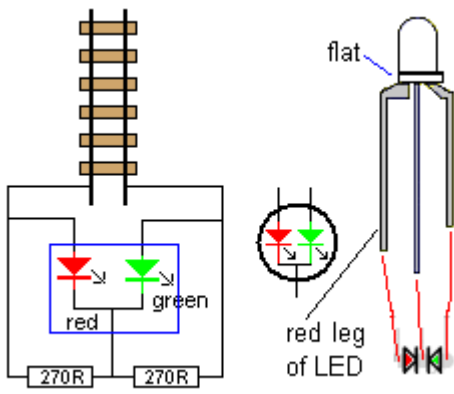
The piezo diaphragm does not contain any active components and relies on the circuit to drive it to produce the tone. A different **LED Detects Light** circuit in eBook 1:

[1 - 100 Transistor Circuits](#)



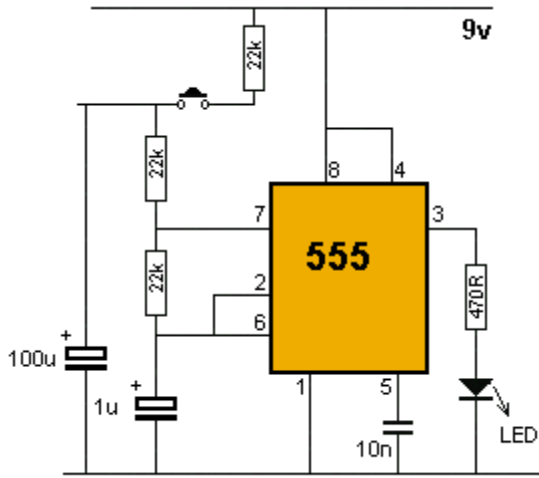
TRAIN DETECTORS

In response to a reader who wanted to parallel TRAIN DETECTORS, here is a diode OR-circuit. The resistor values on each detector will need to be adjusted (changed) according to the voltage of the supply and the types of detector being used. Any number of detectors can be added. See Talking Electronics website for train circuits and kits including Air Horn, Capacitor Discharge Unit for operating point motors without overheating the windings, Signals, Pedestrian Crossing Lights and many more.



TRACK POLARITY

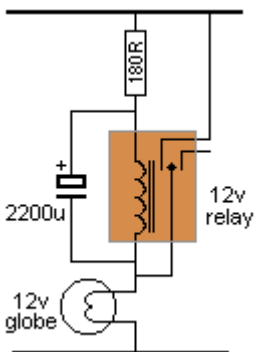
This circuit shows the polarity of a track via a 3-legged LED. The LED is called dual colour (or tri-colour) as it shows red in one direction and green in the other (orange when both LEDs are illuminated).



DECAYING FLASHER

In response to a reader who wanted a flashing LED circuit that slowed down when a button was released, the above circuit increases the flash rate to a maximum and when the button is released, the flash rate decreases to a minimum and halts.

SIMPLE FLASHER

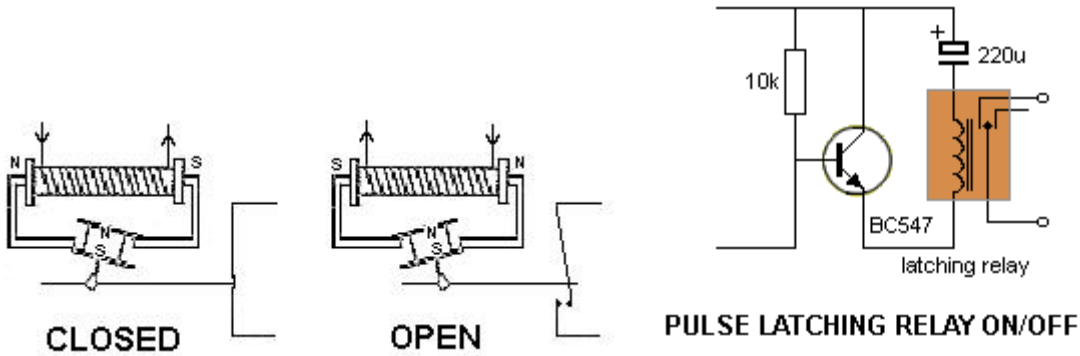


This simple circuit flashes a globe at a rate according to the value of the 180R and 2200u electrolytic.

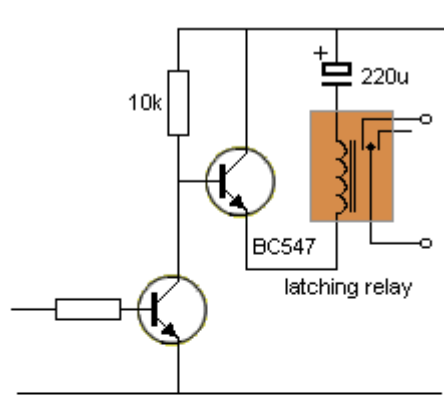
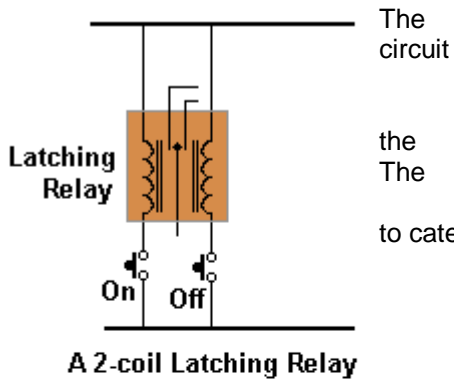
LATCHING RELAY

To reduce the current in battery operated equipment a relay called LATCHING RELAY can be used. This is a relay that latches itself ON when it receives a pulse in one direction and unlatches itself when it receives a pulse in the other direction.

The following diagram shows how the coil makes the magnet click in the two directions.

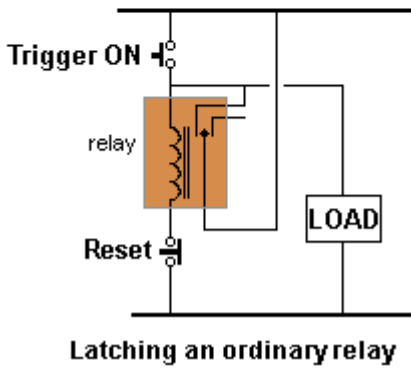


To operate this type of relay, the voltage must be reversed to unlatch it. The circuit above produces a strong pulse to latch the relay ON and the input voltage must remain HIGH. The 220uF gradually charges and the current falls to a very low level. When the input voltage is removed, the circuit produces a pulse in the opposite direction to unlatch the relay.

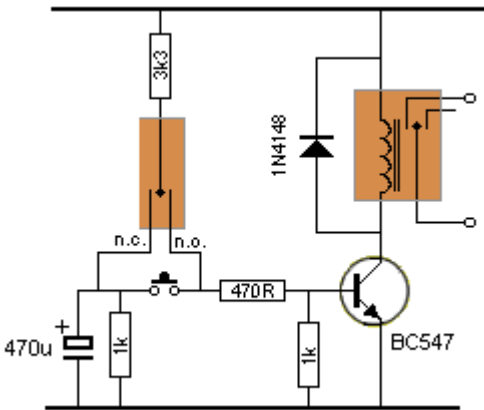


pulse-latching above can be connected to a microcontroller via circuit at the left. electrolytic can be increased to 1,000u for relays with a low resistance.

PULSE LATCHING RELAY ON/OFF via a MICROCONTROLLER



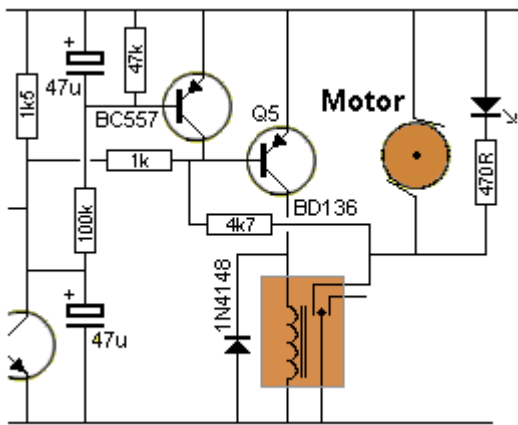
If you want to latch an ordinary relay so it remains ON after a pulse, the circuit at the left can be used. Power is needed all the time to keep the relay ON.



Latching Relays are expensive but a 5v Latching Relay is available from: [Excess Electronics](#) for \$1.00 as a surplus item. It has 2 coils and requires the circuit at the left. A 5v Latching Relay can be use on 12v as it is activated for a very short period of time.

A double-pole (ordinary) relay and transistor can be connected to provide a toggle action. The circuit comes on with the relay de-activated and the contacts connected so that the 470u charges via the 3k3. Allow the 470u to charge. By pressing the button, the BC547 will activate the relay and the contacts will change so that the 3k3 is now keeping the transistor ON. The 470u will discharge via the 1k. After a few seconds the electro will be discharged. If the press-button is now pushed for a short period of time, the transistor will turn off due to the electro being discharged.

A single-coil latching relay normally needs a reverse-voltage to unlatch but the circuit at the left provides forward and reverse voltage by using 2 transistors in a very clever H-design. The pulse-ON and pulse-OFF can be provided from two lines of the microcontroller.

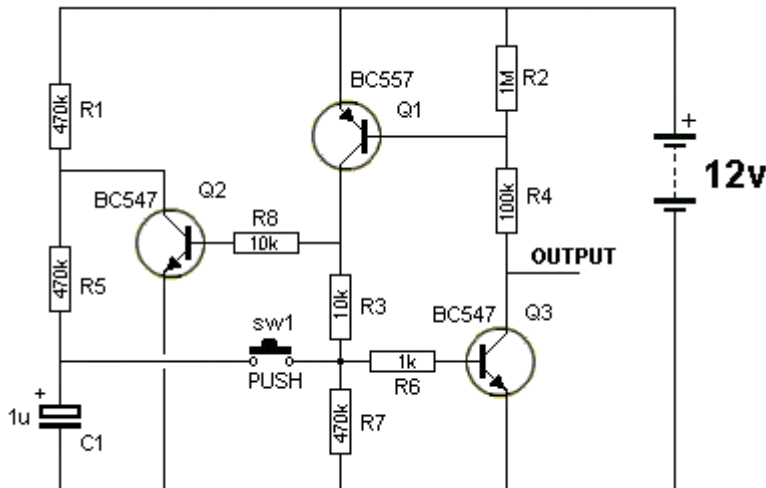


A normal relay can be activated by a short tone and de-activated by a long tone as shown via the circuit on the left. This circuit can be found in "[27MHz Links](#)" Page 2.

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LATCHING A PUSH BUTTON

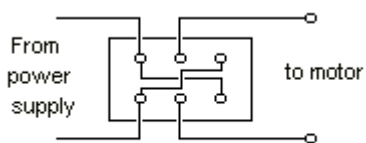
When the circuit is turned on, capacitor C1 charges via the two 470k resistors. When the switch is pressed, the voltage on C1 is passed to Q3 to turn it on. This turns on Q1 and the voltage developed across R7 will keep Q1 turned on when the button is released. Q2 is also turned on during this time and it discharges the capacitor. When the switch is pressed again, the capacitor is in a discharged state and this zero voltage will be passed to Q3 turn it off. This turns off Q1 and Q2 and the capacitor begins to charge again to repeat the cycle.



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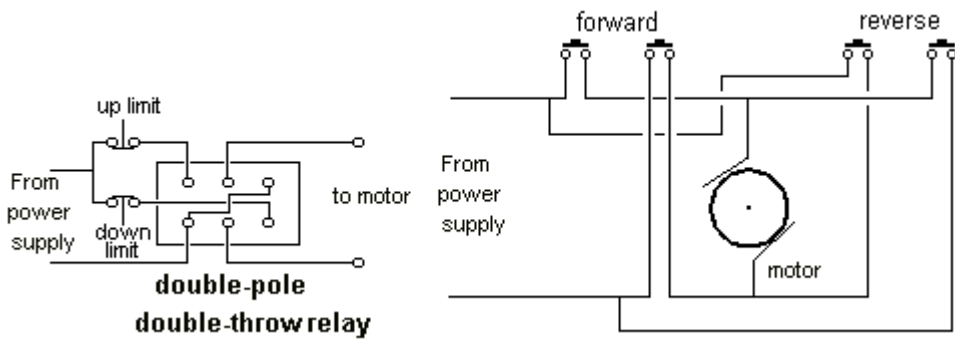
REVERSING A MOTOR-1

There are a number of ways to reverse a motor. The following diagrams show how to connect a double-pole double throw relay or switch and a set of 4 push buttons. The two buttons must be pushed at the same time or two double pole push-switches can be used. See H-Bridge below for more ways to reverse a motor.



double-pole double-throw relay

Adding limit switches:

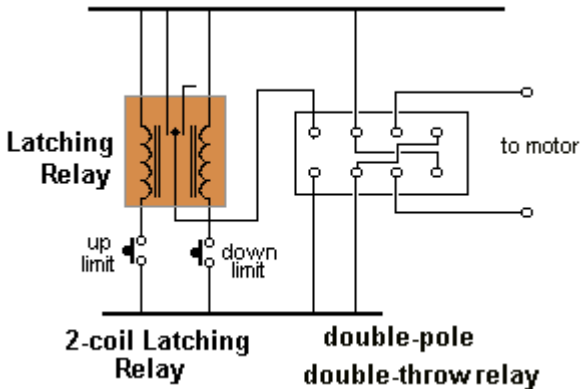


The way the dpdt relay circuit (above) works is this:
 The relay is powered by say 12v, via a MAIN SWITCH. When the relay is activated, the motor travels in the forward direction and hits the "up limit" switch. The motor stops. When the MAIN SWITCH is turned off, the relay is de-activated and reverses the motor until it reaches the "down-limit" switch and stops. The MAIN SWITCH must be used to send the motor to the "up limit" switch.

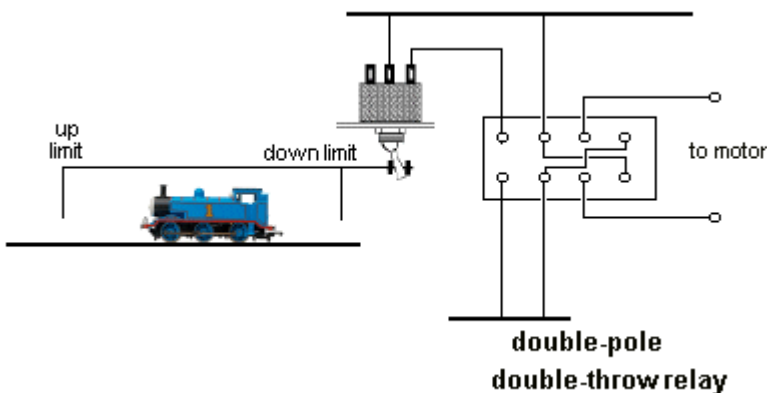
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REVERSING A MOTOR-2 AUTOMATIC FORWARD-REVERSE

The following circuit allows a motor (such as a train) to travel in the forward direction until it hits the "up limit" switch. This sends a pulse to the latching relay to reverse the motor (and ends the short pulse). The train travels to the "down limit" switch and reverses.

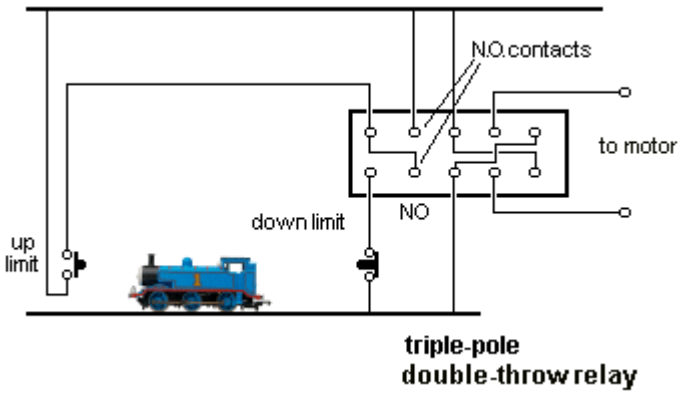


If the motor can be used to click a switch or move a slide switch, the following circuit can be used:



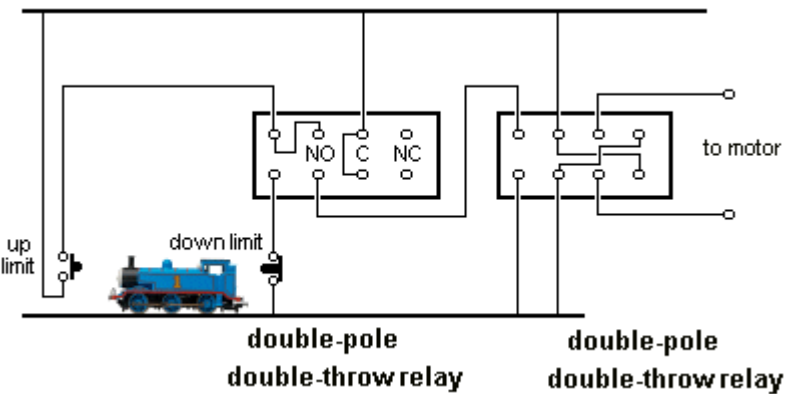
REVERSING A MOTOR-3

If the train cannot physically click the slide switch in both directions, via a linkage, the following circuit should be used:



When power is applied, the relay is not energised and the train **must** travel towards the "up limit." The switch is pressed and the relay is energised. The Normally Open contacts of the relay will close and this will keep the relay energised and reverse the train. When the down limit is pressed, the relay is de-energised.

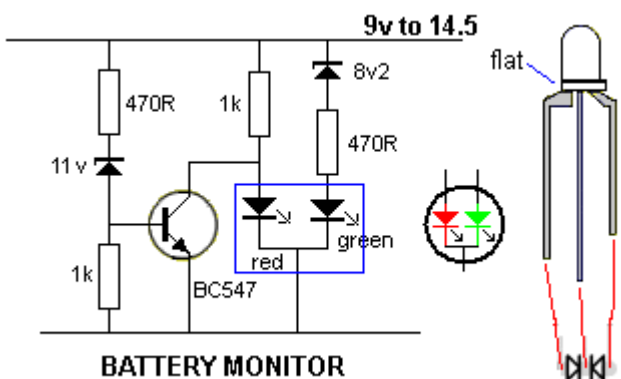
If you cannot get a triple-pole change-over relay, use the following circuit:



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BATTERY MONITOR Mk1

A very simple battery monitor can be made with a dual-colour LED and a few surrounding components. The LED produces orange when the red and green LEDs are illuminated. The following circuit turns on the red LED below 10.5v. The orange LED illuminates between 10.5v and 11.6v. The green LED illuminates above 11.6v.



BATTERY MONITOR MkII

This battery monitor circuit uses 3 separate LEDs.

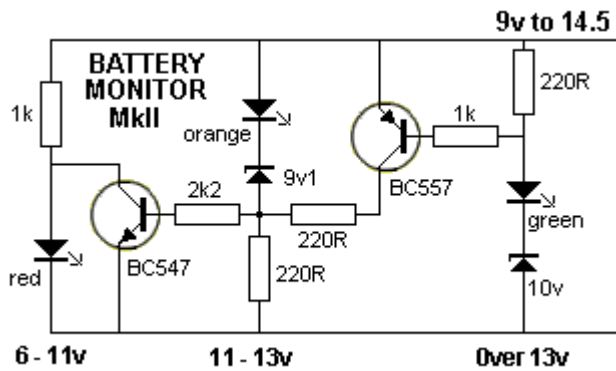
The red LED turns on from 6v to below 11v.

It turns off above 11v and

The orange LED illuminates between 11v and 13v.

It turns off above 13v and

The green LED illuminates above 13v



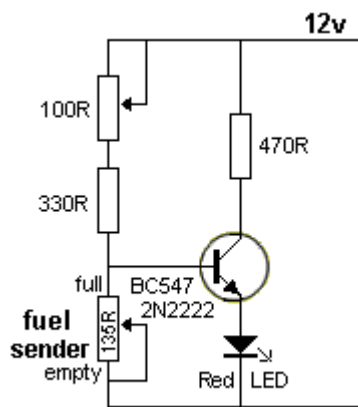
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LOW FUEL INDICATOR

This circuit has been designed from a request by a reader. He

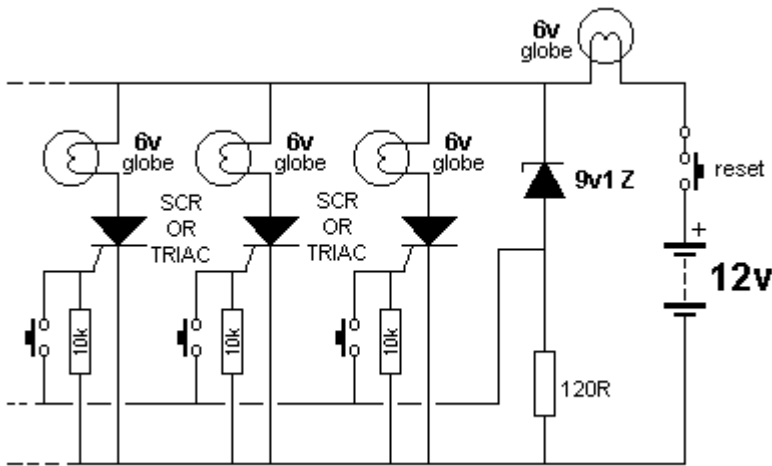
wanted a low fuel indicator for his motorbike. The LED illuminates when the fuel gauge is 90 ohms. The tank is empty at 135 ohms and full at zero ohms. To adapt the circuit for an 80 ohm fuel sender, simply reduce the 330R to 150R.

(The first thing you have to do is measure the resistance of the sender when the tank is empty.)



QUIZ TIMER

This circuit can be used to indicate: "fastest finger first." It has a globe for each contestant and one for the Quiz Master.

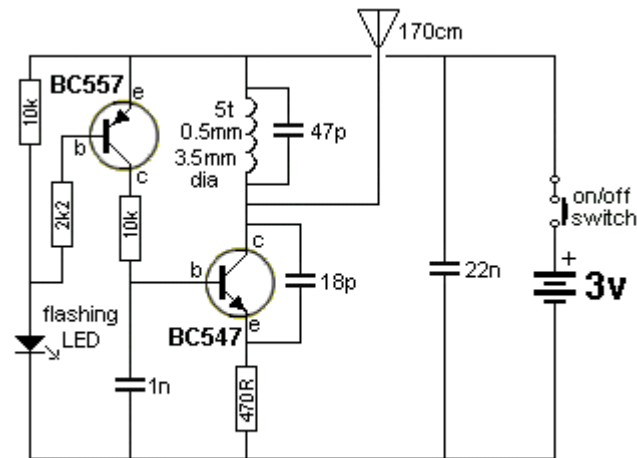


When a button is pressed the corresponding globe is illuminated. The Quiz Master globe is also illuminated and the cathode of the 9v1 zener sees approx mid-rail voltage. The zener comes out of conduction and no voltage appears across the 120R resistor. No other globes can be lit until the circuit is reset.

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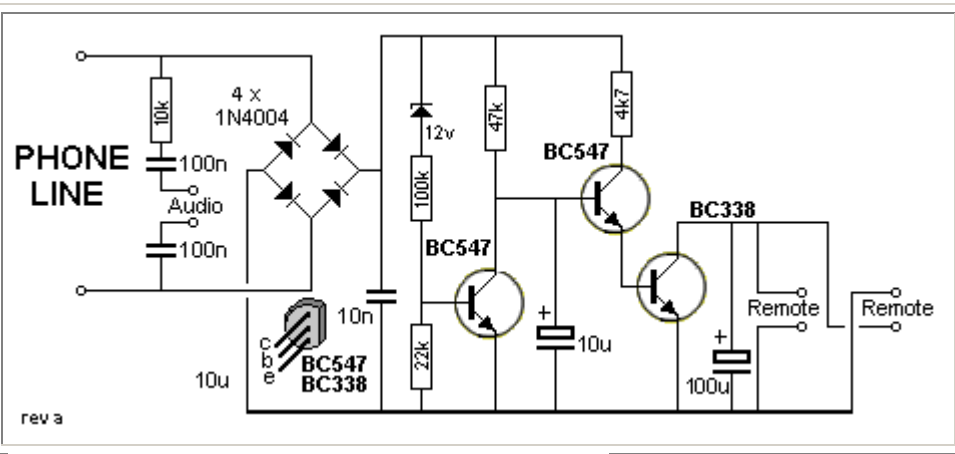
TRACKING TRANSMITTER

This circuit can be used to track lots of items.



TRACKING TRANSMITTER MK1

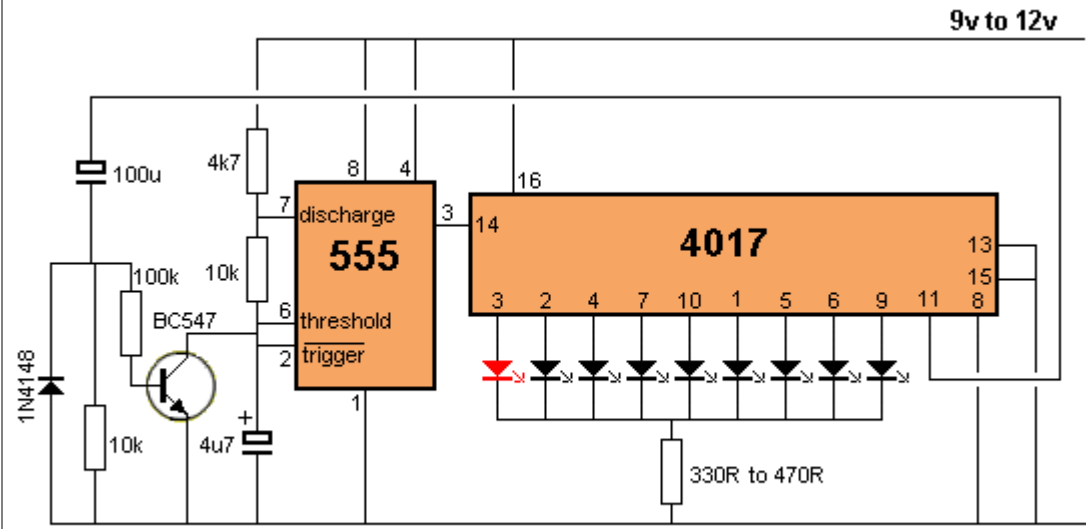
It has a range of 200 - 400 metres depending on the terrain and the flashing LED turns the circuit ON when it flashes. The circuit consumes 5mA when producing a carrier (silence) and less than 1mA when off (background snow is detected).



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SEQUENCER

This circuit has been requested by a reader. He wanted to have a display on his jacket that ran 9 LEDs then stopped for 3 seconds. The animated circuit shows this sequence:

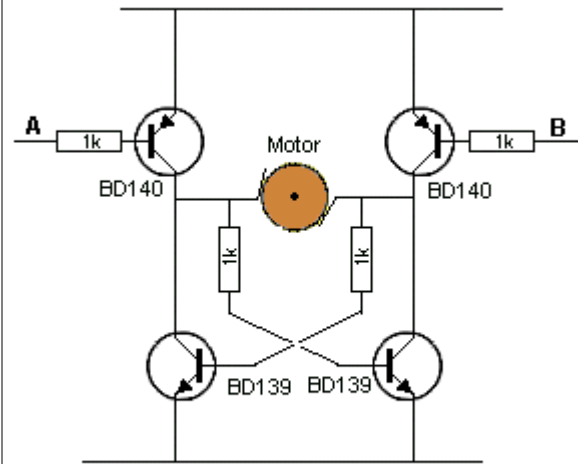


SEQUENCER WITH 3 SECOND INTERVAL

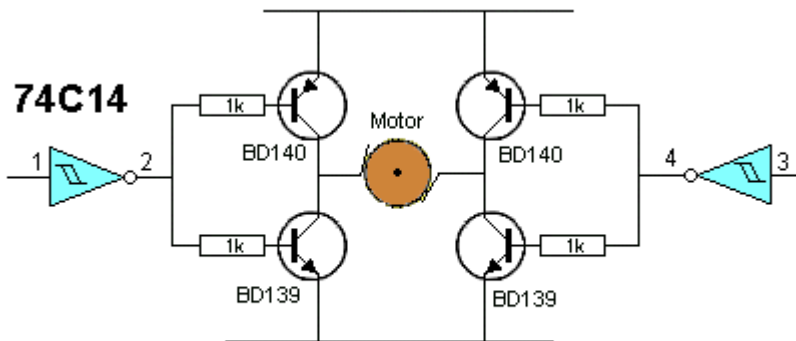
Note the delay produced by the 100u and 10k produces 3 seconds by the transistor inhibiting the 555 (taking pin 6 LOW). Learn more about the 555 - see the article: **"The 555"** on Talking Electronics website by clicking the title on the left index. See the article on CD 4017. See **"Chip Data eBook"** on TE website in the left index.

H-BRIDGE

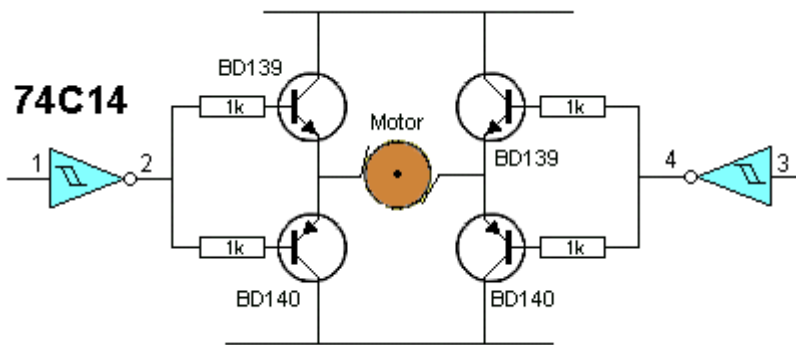
These circuits reverse a motor via two input lines. Both inputs must not be LOW with the first H-bridge circuit. If both inputs go LOW at the same time, the transistors will "short-out" the supply. This means you need to control the timing of the inputs. In addition, the current capability of some H-bridges is limited by the transistor types.



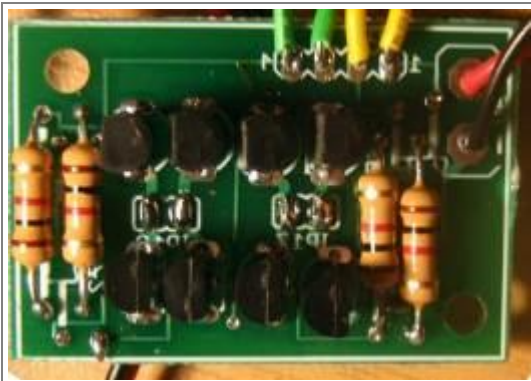
A and B must NEVER both be low



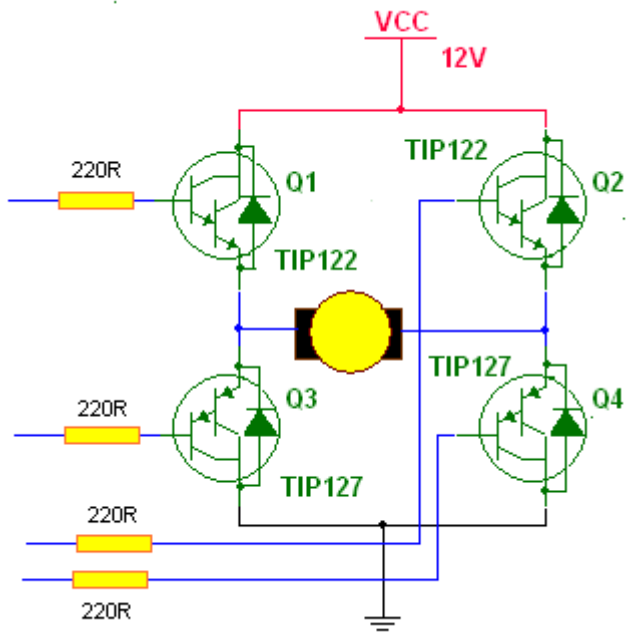
When A and B are equal, motor does not run



The driver transistors are in "emitter follower" mode in this circuit.



Two H-Bridges on a PC board

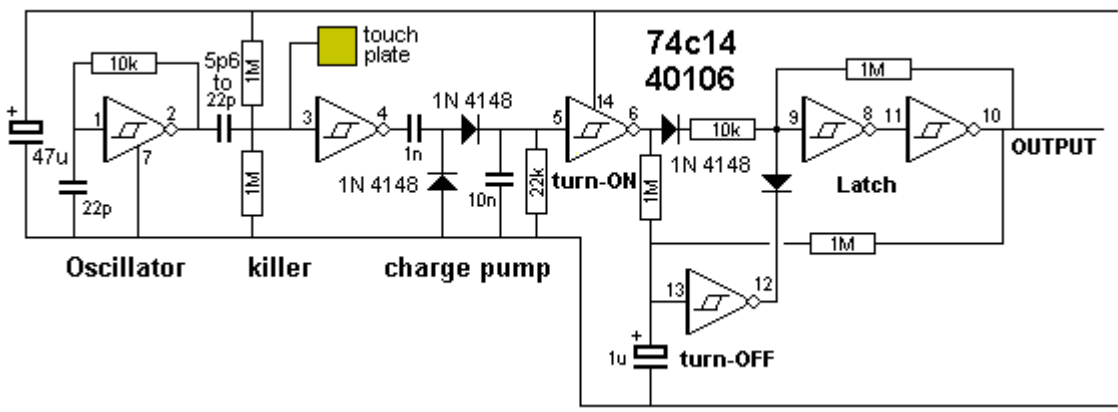


H-Bridge using Darlington transistors

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TOUCH-ON TOUCH-OFF SWITCH

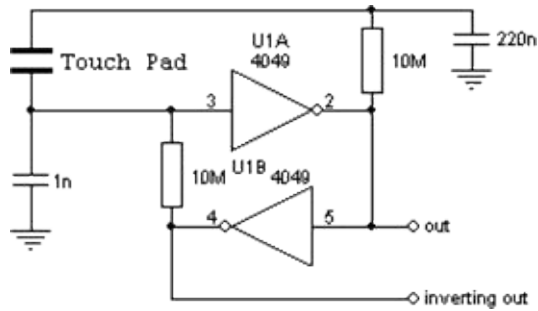
This circuit will create a HIGH on the output when the Touch Plate is touched briefly and produce a low when the plate is touched again for a slightly longer period of time. Most touch switches rely on 50Hz mains hum and do not work when the hum is not present. This circuit does not rely on "hum."



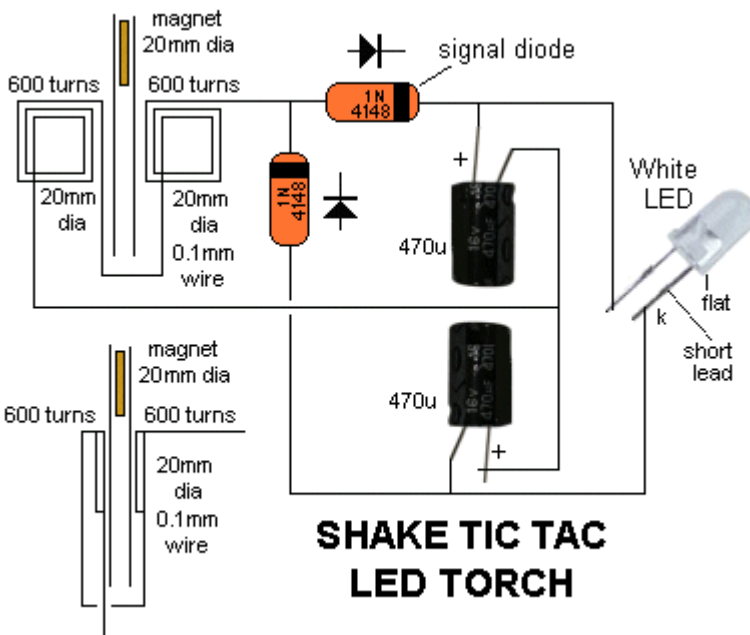
TOUCH-ON TOUCH-OFF SWITCH

SIMPLE TOUCH-ON TOUCH-OFF SWITCH

This circuit will create a HIGH on the output when the Touch Plate is touched briefly and produce a low when the plate is touched again.



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SHAKE TIC TAC LED TORCH

SHAKE TIC TAC LED TORCH

In the diagram, it looks like the coils sit on the "table" while the magnet has its edge on the table. This is just a diagram to show how the parts are connected. The coils actually sit flat against the slide (against the side of the magnet) as shown in the diagram: The output voltage depends on how quickly the magnet passes from one end of the slide to the other. That's why a rapid shaking produces a higher voltage. You must get the end of the magnet to fully pass through the coil so the voltage will be a maximum. That's why the slide extends past the coils at the top and bottom of the diagram.

The circuit consists of two 600-turn coils in series, driving a voltage doubler. Each coil produces a positive and negative pulse, each time the

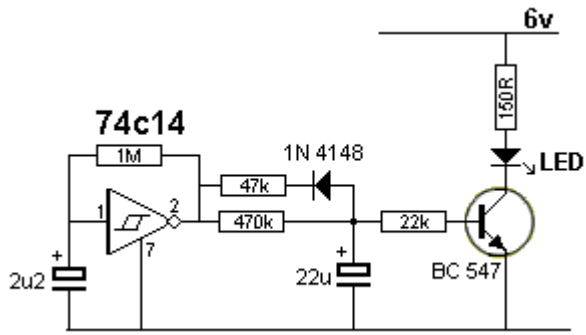
magnet passes from one end of the slide to the other.

The positive pulse charges the top electrolytic via the top diode and the negative pulse charges the lower electrolytic, via the lower diode.

The voltage across each electrolytic is combined to produce a voltage for the white LED. When the combined voltage is greater than 3.2v, the LED illuminates. The electrolytics help to keep the LED illuminated while the magnet starts to make another pass.

FADING LED

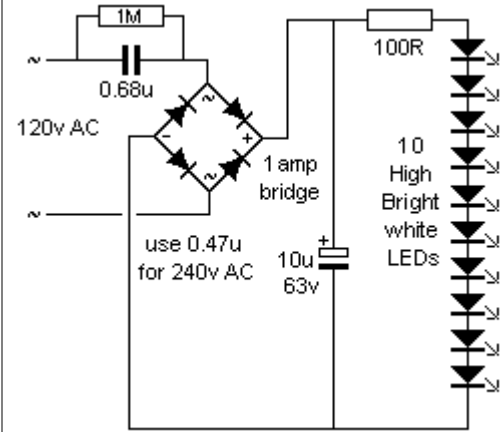
The circuit fades the LED ON and OFF at an equal rate. The 470k charging and 47k discharging resistors have been chosen to create equal on and off times.



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MAINS NIGHT LIGHT

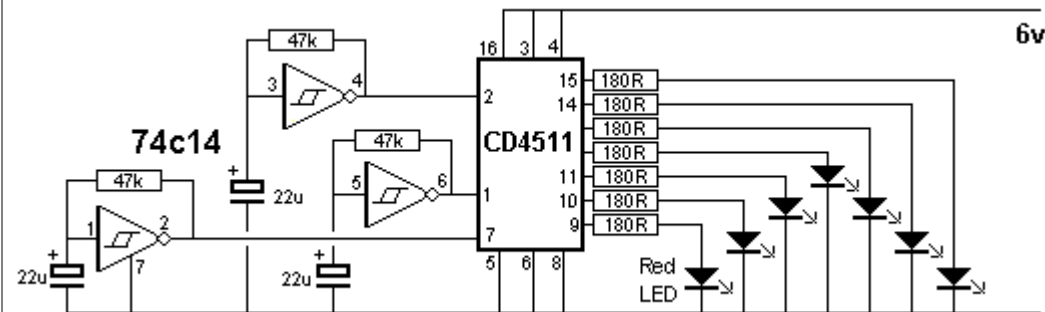
The circuit illuminates a column of 10 white LEDs. The 10u prevents flicker and the 100R also reduces flicker.



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RANDOM BLINKING LEDS

This circuit blinks a set of LEDs in a random pattern according to the slight differences in the three Schmitt Trigger oscillators. The CD4511 is BCD to 7-segment Driver



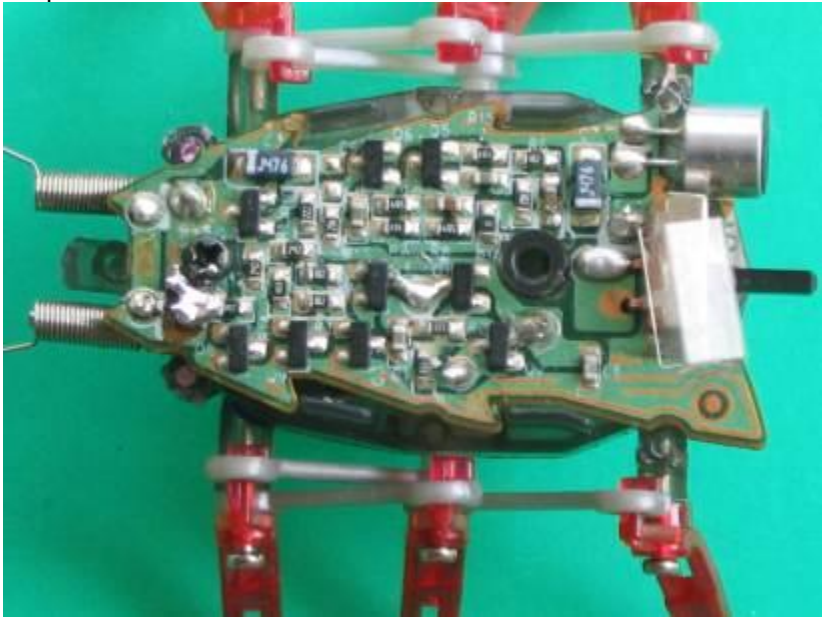
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HEX BUG

This is the circuit from a HEX BUG. It is a surface-mount bug with 6 legs. The pager motor is driven by an H-Bridge and "walks" to a wall where a feeler (consisting of a spring with a stiff wire down the middle) causes the motor to reverse.

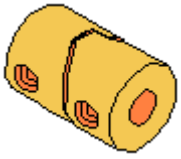
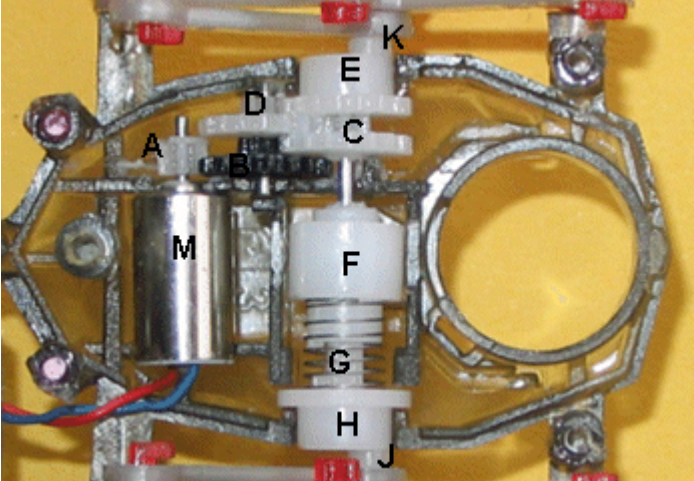
In the forward direction, both sets of legs are driven by the compound gearbox but when the motor is reversed, the left legs do not operate as they are connected by a clutch consisting of a

spring-loaded inclined plane that does not operate in reverse. This causes the bug to turn around slightly. The circuit also responds to a loud clap. The photo shows the 9 transistors and accompanying components:



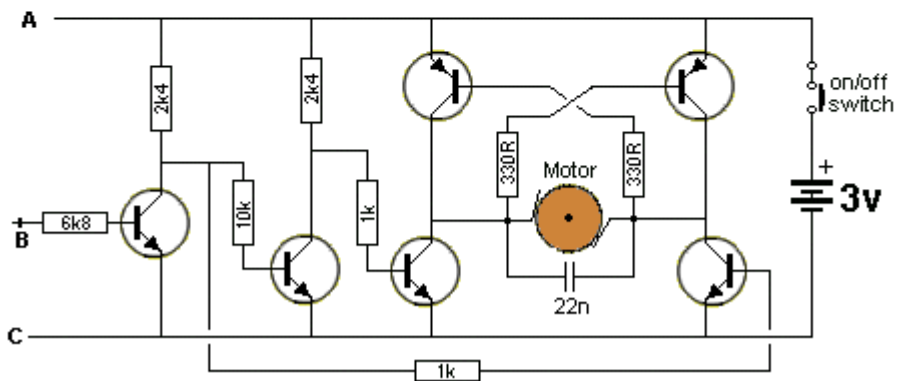
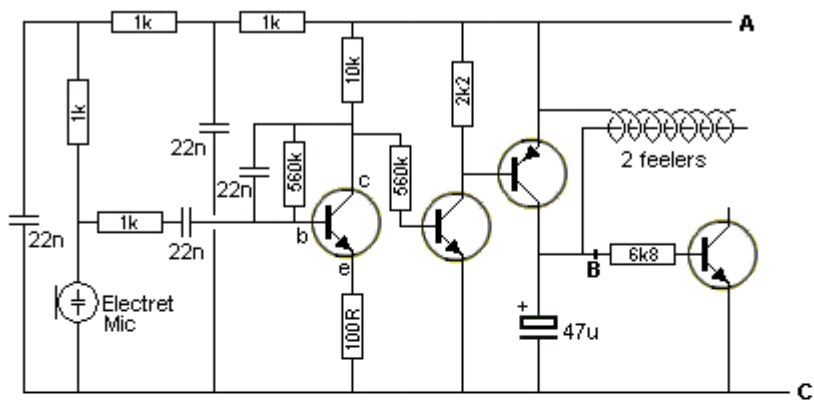
HEX

BUG CIRCUIT



Inclined Dog Clutch

HEX BUG GEARBOX



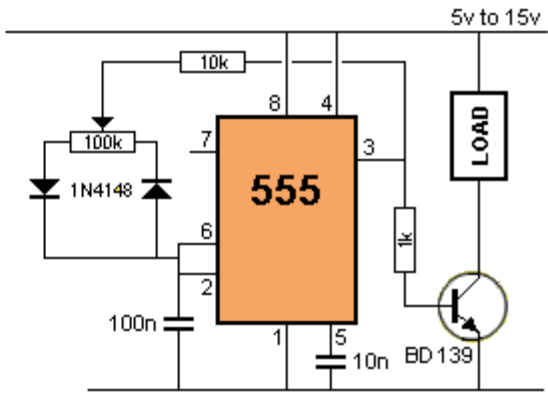
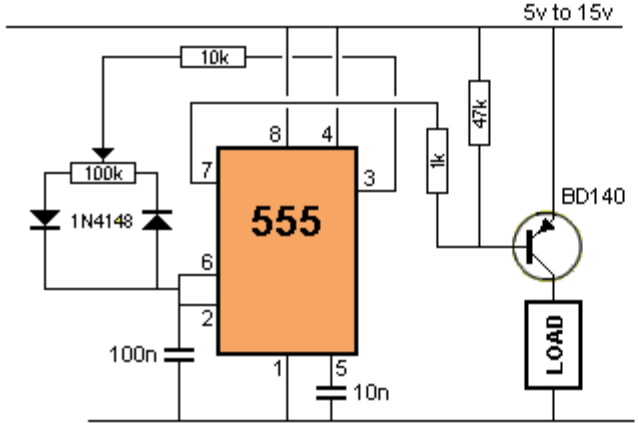
Hex Bug gearbox consists of a compound gearbox with output "K" (eccentric pin) driving the legs. You will need to see the project to understand how the legs operate. When the motor is reversed, the clutch "F" is a housing that is spring-loaded to "H" and drives "H" via a square shaft "G". Gearwheel "C" is an idler and the centre of "F" is connected to "E" via the shaft. When "E" reverses, the centre of "F" consists of a driving inclined plane and pushes "F" towards "H" in a clicking motion. Thus only the right legs reverse and the bug makes a turn. When "E" is driven in the normal direction, the centre of "F" drives the outer casing "F" via an action called an "Inclined Dog Clutch" and "F" drives "G" via a square shaft and "G" drives "H" and "J" is an eccentric pin to drive the legs.

The drawing of an Inclined Dog Clutch shows how the clutch drives in only one direction. In the reverse direction it rides up on the ramp and "clicks" once per revolution. The spring "G" in the photo keeps the two halves together.

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PWM CONTROLLER

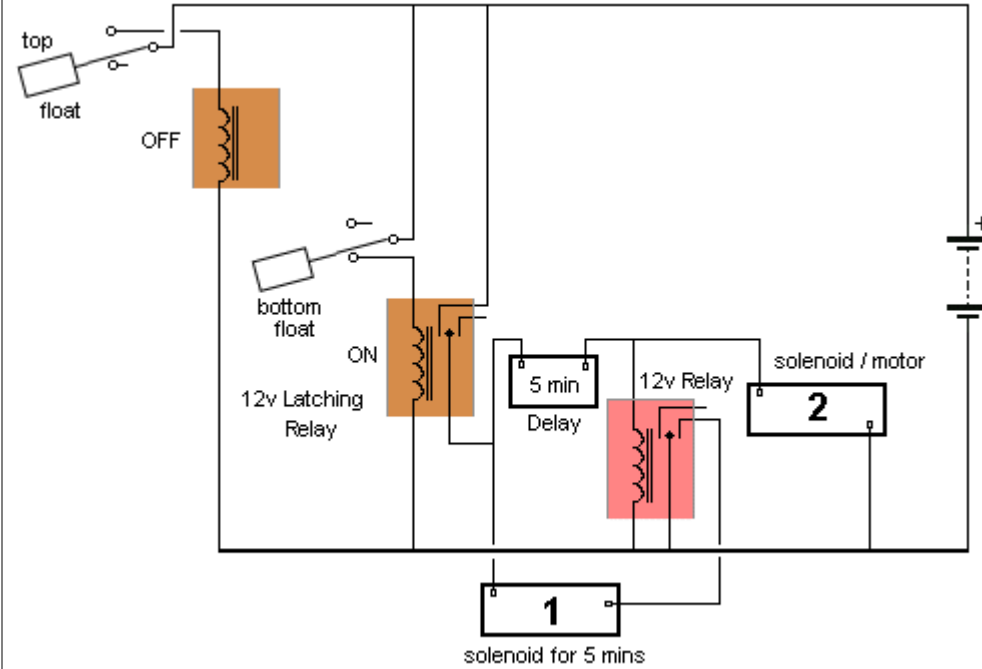
This 555 based PWM controller features almost 0% to 100% pulse width regulation using the 100k variable resistor, while keeping the oscillator frequency relatively stable. The frequency is dependent on the 100k pot and 100n to give a frequency range from about 170Hz to 200Hz.



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LIMIT SWITCHES

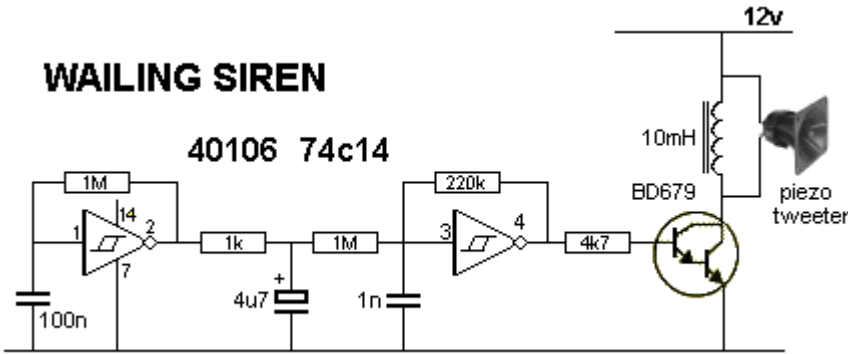
This circuit detects when the water level is low and activates solenoid (or pump) 1 for 5 minutes (adjustable) to allow dirty water to be diverted, before filling the tank via solenoid 2.



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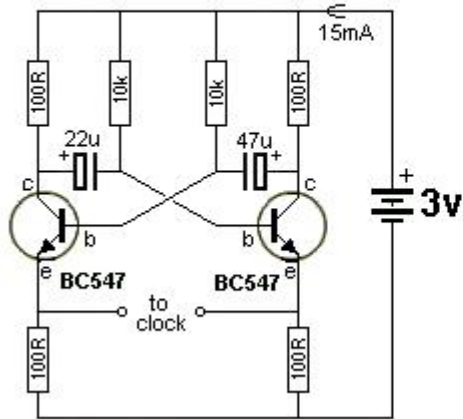
WAILING SIREN

This circuit produces a penetrating (deafening) up/down siren sound.

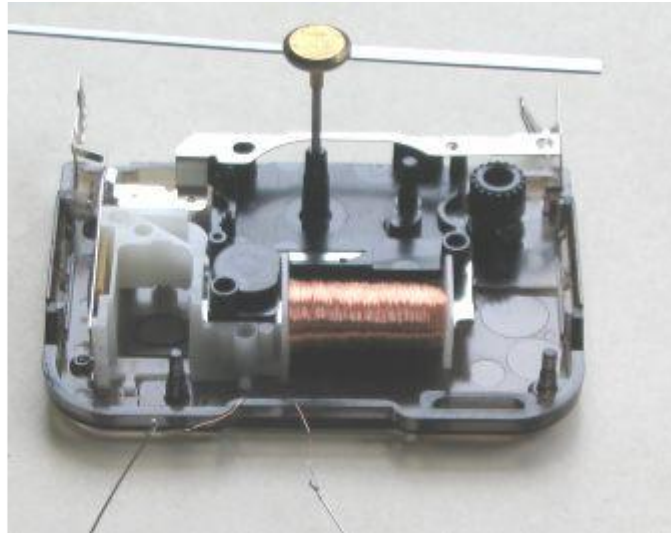


MODEL RAILWAY TIME

Here is a simpler circuit than MAKE TIME FLY from our first book of 100 transistor circuits. For those who enjoy model railways, the ultimate is to have a fast clock to match the scale of the layout. This circuit will appear to "make time fly" by revolving the seconds hand once every 6 seconds. The timing can be adjusted by the electrolytics in the circuit. The electronics in the clock is disconnected from the coil and the circuit drives the coil directly. The circuit takes a lot more current than the original clock (1,000 times more) but this is the only way to do the job without a sophisticated chip.

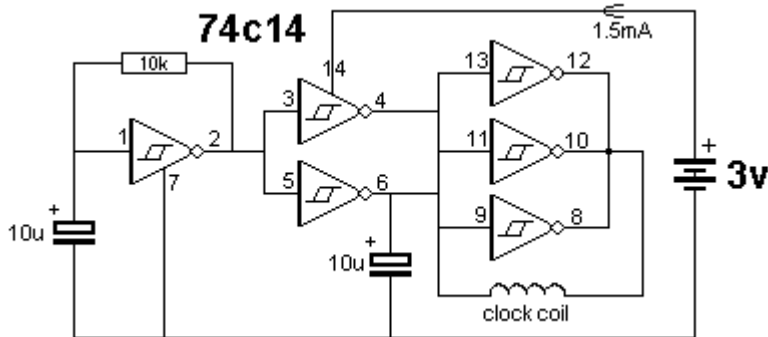


Model Railway Time Circuit



Connecting the circuit to the clock coil

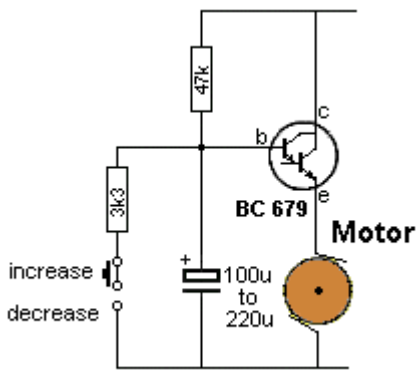
For those who want the circuit to take less current, here is a version using a Hex Schmitt Trigger chip:



Model Railway Time Circuit using a 74c14 Hex Schmitt Chip

SLOW START-STOP

To make a motor start slowly and slow down slowly, this circuit can be used. The slide switch controls the action. The Darlington transistor will need a heatsink if the motor is loaded.



Slow Start-Stop Circuit

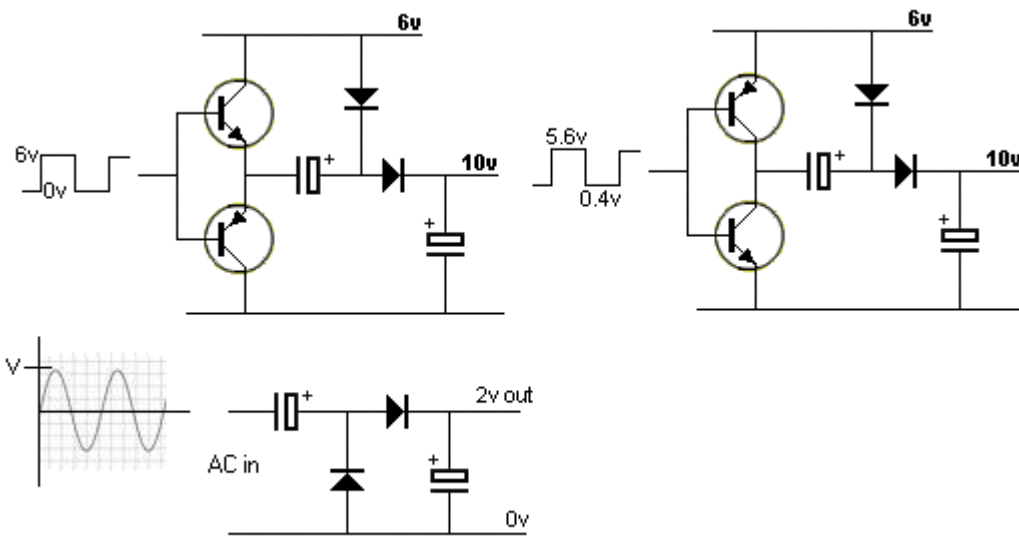
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VOLTAGE MULTIPLIERS

The first circuit takes a square wave (any amplitude) and doubles it - minus about 2v losses in the diodes and base-emitter of the transistors.

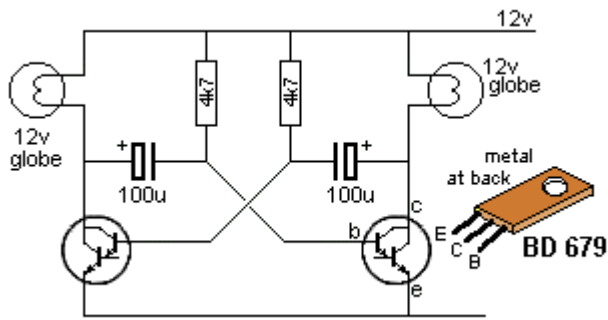
The second circuit must rise to at least 5.6v and fall to nearly 0.4v for the circuit to work. Also the rise and fall times must be very fast to prevent both transistors coming on at the same time and short-circuiting.

The third circuit doubles an AC voltage. The AC voltage rises "V" volts above the 0v rail and "V" volts below the 0v rail.



VOLTAGE DOUBLER CIRCUITS

WARNING BEACON

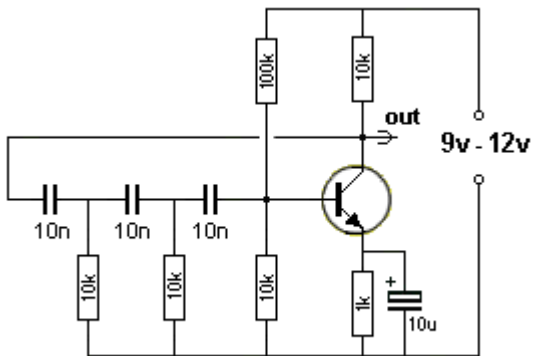


Here is a 12v Warning Beacon suitable for a car or truck break- down on the side of the road. The key to the operation of the circuit is the high gain of the Darlington transistors. The circuit must be kept "tight" (thick wires) to be sure it will oscillate.

A complete kits of parts and PC board costs \$5.00 plus postage from: Talking Electronics. Email [HERE](#) for details.

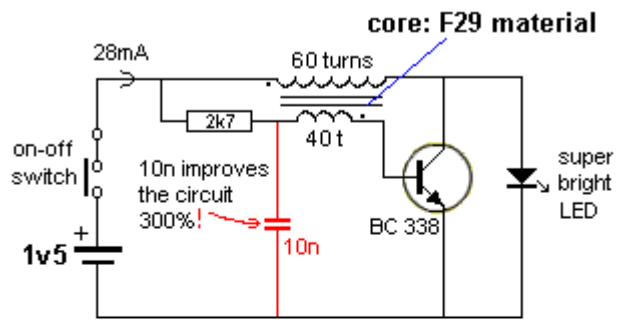
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PHASE-SHIFT OSCILLATOR also called SINEWAVE OSCILLATOR

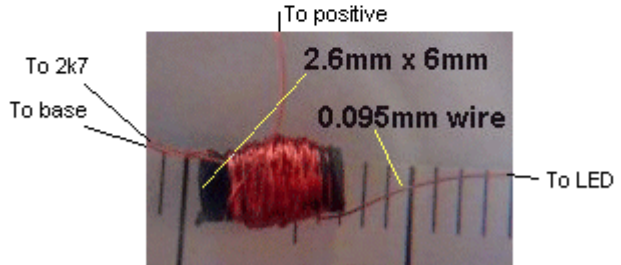


This circuit produces a sinewave very nearly equal to rail voltage. The important feature is the need for the emitter resistor and 10uF bypass electrolytic. It is a most-important feature of the circuit. It provides reliable start-up and guaranteed operation. For 6v operation, the 100k is reduced to 47k. The three 10nF capacitors and two 10k resistors (actually 3) determine the frequency of operation (700Hz). The 100k and 10k base-bias resistors can be replaced with 2M2 between base and collector. This type of circuit can be designed to operate from about 10Hz to about 200kHz.

BLOCKING OSCILLATOR also called FLYBACK OSCILLATOR



LED TORCH CIRCUIT



Transformer Details

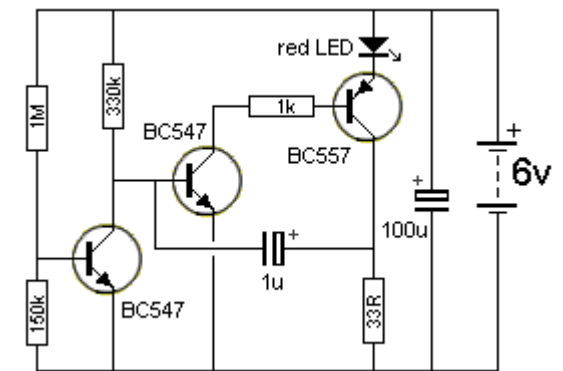
The circuit produces high voltage pulses (spikes) of about 40v p-p (when the LED is not connected), at a frequency of 200kHz. The super-bright LED on the output absorbs the pulses and uses the energy to produce illumination. The voltage across the LED will be about 3.6v

The winding to the base is connected so that it turns the transistor ON harder until it is saturated. At this point the flux cannot increase any more and the transistor starts to turn off. The collapsing magnetic field in the transformer produces a very high voltage and that's why we say the transformer operates in FLYBACK mode.

This type of circuit will operate from 10kHz to a few MHz.

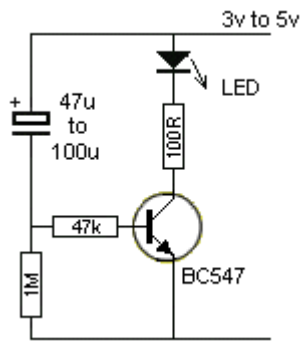
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LOW VOLTAGE FLASHER



This circuit flashes when the voltage drops to 4v. The voltage "set-point" can be adjusted by changing the 150k on the base of the first transistor.

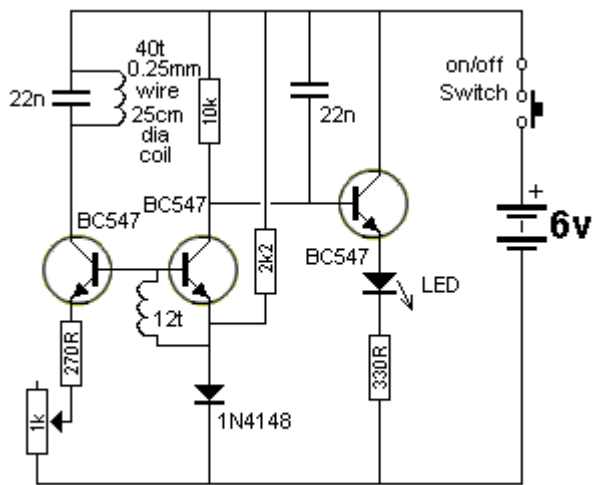
POWER ON



This LED illuminates for a few seconds when the power is turned on. The circuit relies on the 47uF capacitor discharging into the rest of the circuit so that it is uncharged when the circuit is turned on again.

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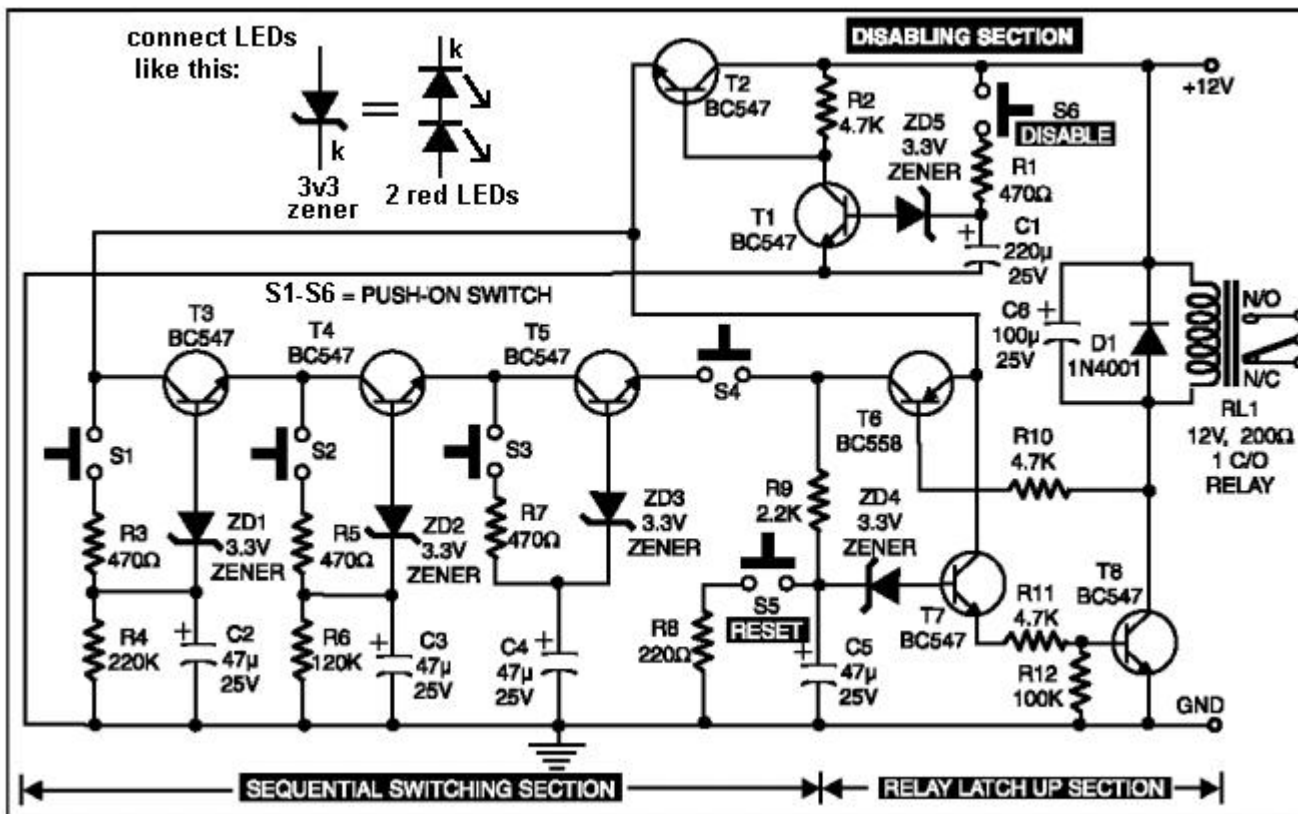
CAR LOOP DETECTOR



VEHICLE DETECTOR

A 25cm dia coil (consisting of 40 turns and 12 turns) is placed in the centre of a driveway (between two sheets of plastic). When a vehicle is driven over the coil, it responds by the waveform collapsing. This occurs because the tank circuit made up of the 40 turns is receiving just enough feedback signal from the 12 turns to keep it oscillating. When metal is placed near the coil, it absorbs some of the electromagnetic waves and the amplitude decreases. This reduces the amplitude in the 12 turns and the oscillations collapse. The second transistor turns off and the 10kΩ resistor pulls the base of the third transistor (an emitter-follower) to the 6V rail and turns on the LED.

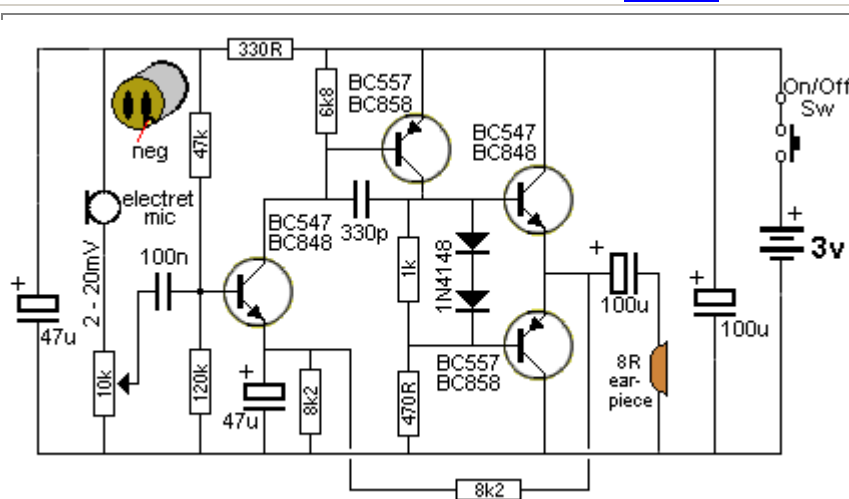
ALARM USING 4-BUTTONS



To open the lock, buttons S1, S2, S3, and S4 must be pressed in this order. They must be pressed for more than 0.7 seconds and less than 1.3 seconds.

Reset button S5 and disable button S6 are also included with the other buttons and if the disable button is pressed, the circuit will not accept any code for 60 seconds. Each of the 3V3 zeners can be replaced with two red LEDs and this will show how you are progressing through the code. Make sure the LEDs are not visible to other users.

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AUDIO AMPLIFIER (mini)

This project is called "mini" because its size is small and the output is small. It uses [surface mount](#) technology.

HOW THE CIRCUIT WORKS

The output is push-pull and consumes less than 3mA (with no signal) but drives the earpiece to a very loud level when audio is detected.

The whole circuit is DC coupled and this makes it extremely difficult to set up. Basically you don't know where to start with the biasing. The two most critical components are 8k2 between the

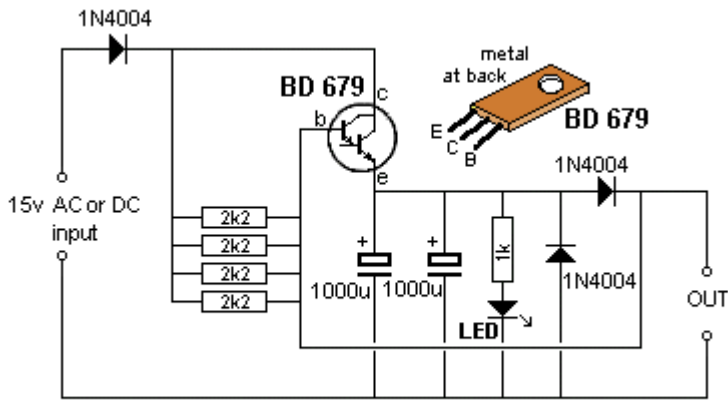
emitter of the first transistor and 0v rail and the 470R resistor.

The 8k2 across the 47u sets the emitter voltage on the BC 547 and this turns it on. The collector is directly connected to the base of a BC 557, called the driver transistor. Both these transistors are now turned on and the output of the BC 557 causes current to flow through the 1k and 470R resistors so that the voltage developed across each resistor turns on the two output transistors. The end result is mid-rail voltage on the join of the two emitters.

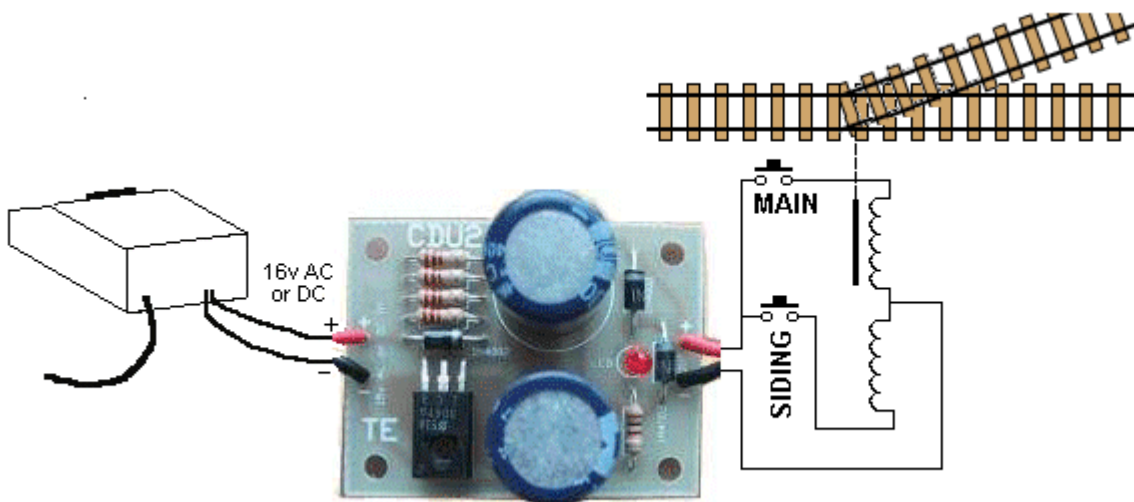
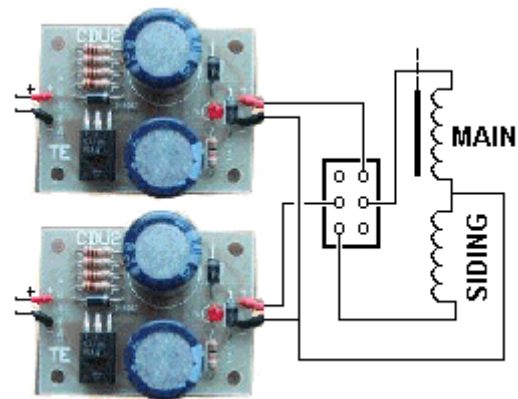
The 8k2 feedback resistor provides major negative feedback while the 330p prevents high-frequency oscillations occurring.

CAPACITOR DISCHARGE UNIT MkII (CDU2)

This project is available as a kit for \$10.80 plus \$6.50 post. email [Talking Electronics](#) for details.



CAPACITOR DISCHARGE UNIT MKII

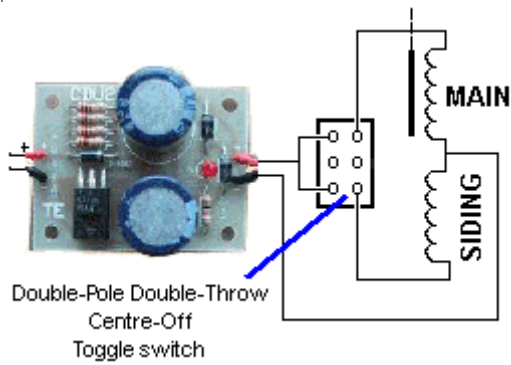


This circuit will operate a two-solenoid point-motor and prevent it overheating and causing any damage. The circuit produces energy to change the points and ceases to provide any more current. This is carried out by the switching arrangement within the circuit, by sampling the output voltage.

If you want to control the points with a DPDT toggle switch or slide switch, you will need two CDU2 units.

HOW THE CIRCUIT WORKS

The circuit is supplied by 16v AC or DC and the diode on the input is used to rectify the voltage if AC is supplied. If nothing is connected to the output, the base of the BD679 is pulled high and the



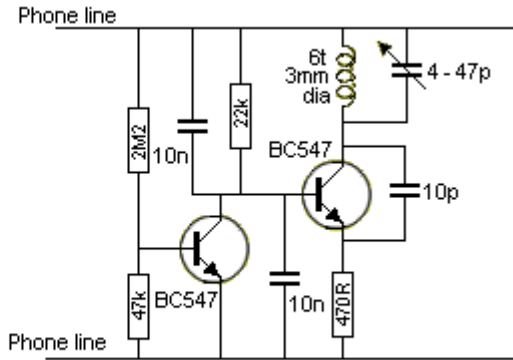
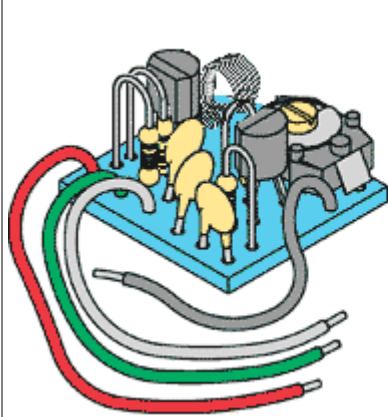
emitter follows. This is called an emitter-follower stage. The two 1,000u electrolytics charge and the indicator LED turns on. The circuit is now ready. When the Main or Siding switch is pressed, the energy from the electrolytics is passed to the point motor and the points change. As the output voltage drops, the emitter-follower transistor is turned off and when the switch is released, the electrolytics start to charge again.

The point-motor can be operated via a Double-Pole Double-Throw Centre-Off toggle switch, providing the switch is returned to the centre position after a few seconds so that the CDU unit can charge-up.

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PHONE BUG see also Phone Transmitter 1 and 2 (1-100 circuits)

This circuit connects to a normal phone line and when the voltage drops to less than 15v, the first transistor is turned off and enables the second transistor to oscillate at approx 100MHz and transmit the phone conversation to a nearby FM radio.

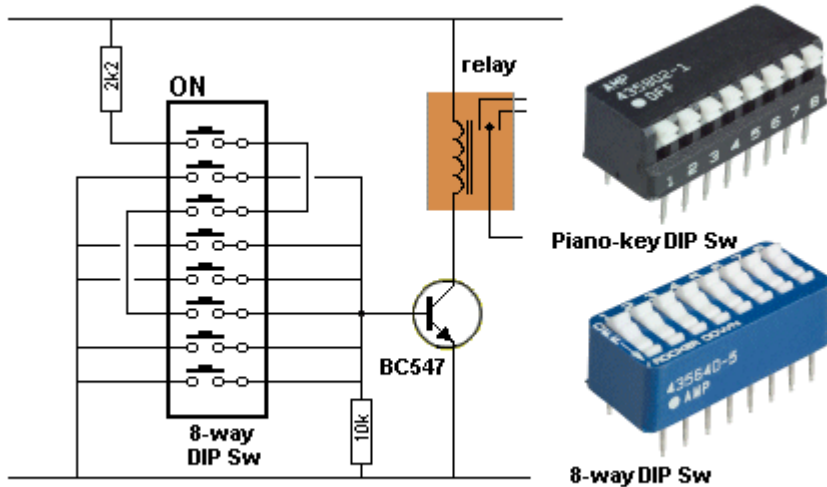


TELEPHONE BUG

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CODE LOCK

This circuit turns on a relay when the correct code is entered on the 8-way DIP switches. Two different types of DIP switches are shown. Keep the top switch off and no current will be drawn by the circuit. There are 256 different combinations and because the combination is in binary, it would be very difficult for a burglar to keep up with the settings of the switches.

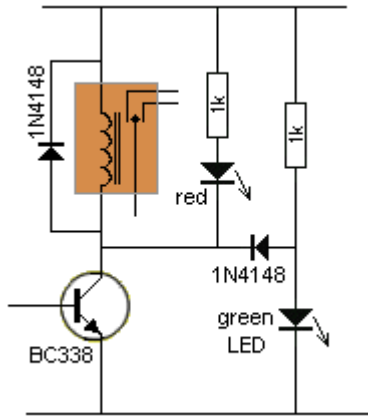


CODE LOCK

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LEDS SHOW RELAY STATE

The green LED indicates the relay is not energised and the red LED shows the relay is energised.



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VOLTAGE DOUBLER

This is a voltage doubler circuit from a bicycle dynamo design found on the web. The dynamo produces 6v AC and charges a 3.3FARAD super cap via 2 diodes and an electrolytic. As you will see, C2, D3 and D4 are not needed and can be removed. This is how the circuit works.

The voltage at the mid point of diodes D1 and D2 can fall to -0.6v and rise to rail voltage plus 0.6v without any current being supplied from the dynamo.

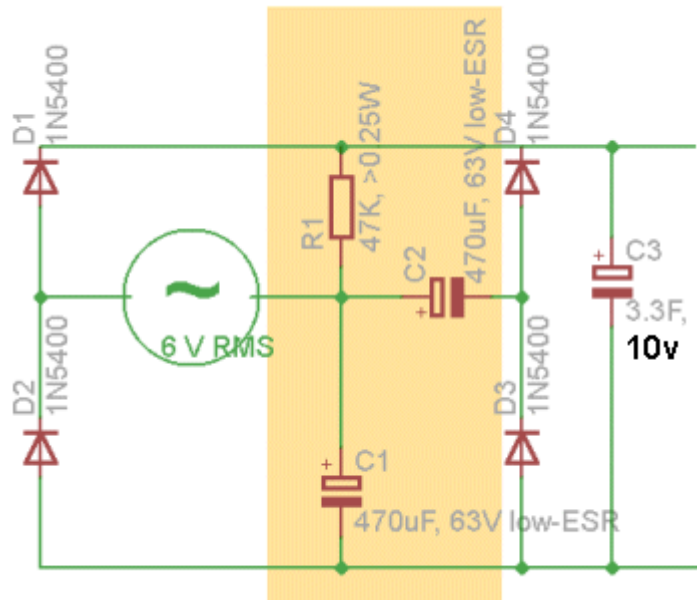
When the voltage rises more than 0.6v above rail voltage, the dynamo needs to deliver current and this will allow the rail voltage to increase. We start with the dynamo producing negative from the left side and positive on the right side.

The left side will fall to -0.6v below the 0v rail and the right side will charge C1 and C2 will simply rise in exactly the same manner as we described the left side of the dynamo being able to rise.

Suppose C1 charges to about 7v (which it will be able to do after a few cycles). The voltage from the dynamo now reverses and the left side is positive and

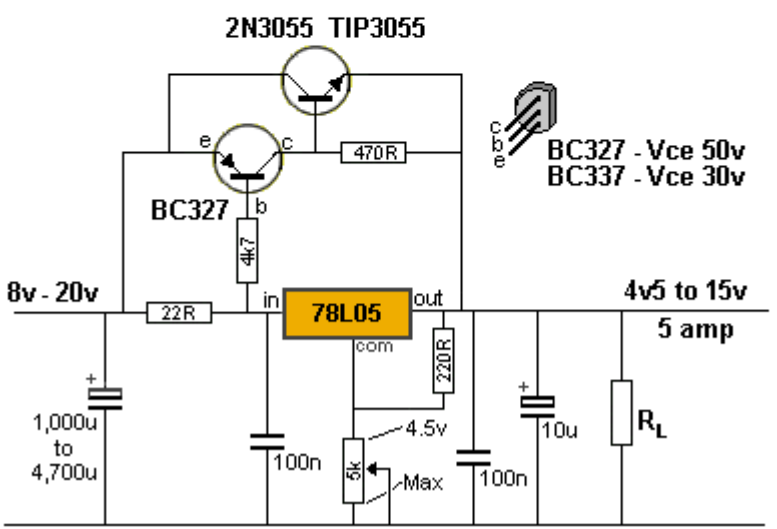
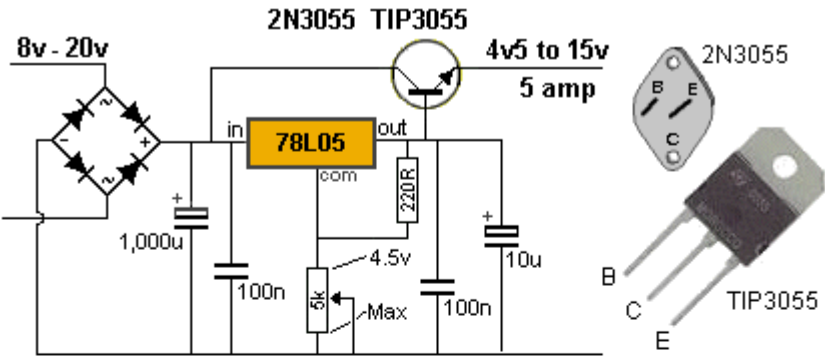
the right side is negative. The right side is already sitting at a potential of 7v (via C1) and as the left side increases, it raises the rail voltage higher by an amount that could be as high as 7v minus 0.6v.

The actual rail voltage will not be as high as this as the 3.3 Farad capacitor will be charging, but if energy is not taken from the circuit it will rise to nearly 14v or even higher according to the peak voltage delivered by the dynamo. When the dynamo is delivering energy to the positive rail, it is "pushing down" on the C1 and some of its stored energy is also delivered. This means it will have a lower voltage across it when the next cycle comes around. C2, D3 and D4 are not needed and can be removed. In fact, C1 will always have rail voltage on it due to the 47 resistor, so the voltage doubling will start as soon as the dynamo operates.



Adjustable High Current Regulated Power Supply

There are two ways to add a 2N3055 (TIP3055) as the pass transistor for a high current power supply. This is handy as most hobbyists will have one of these in their parts box.

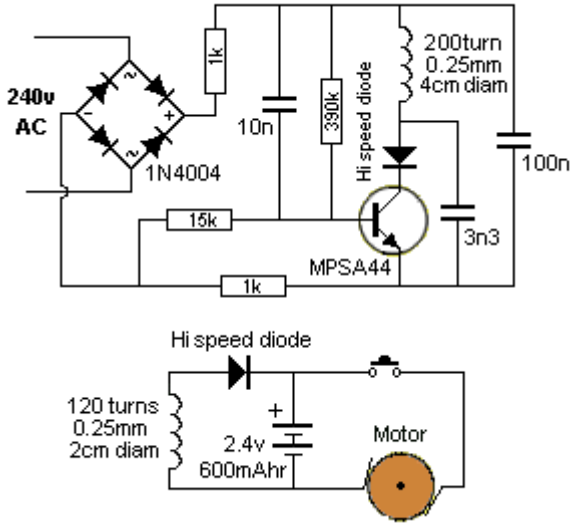


RL must be low enough to guarantee at least a 30mA. It can be a separate resistor or part of the actual load.

INDUCTIVELY COUPLED POWER SUPPLY

This circuit is from an Interplak Model PB-12 electric toothbrush.

A coil in the charging base (always plugged in and on) couples to a mating coil in the hand unit to form a step down transformer. The MPSA44 transistor is used as an oscillator at about 60 kHz which results in much more efficient energy transfer via the air core coupling than if the system were run at 50 or 60Hz. The amplitude of the oscillations varies with the full wave rectified 100Hz or 120Hz unfiltered DC.



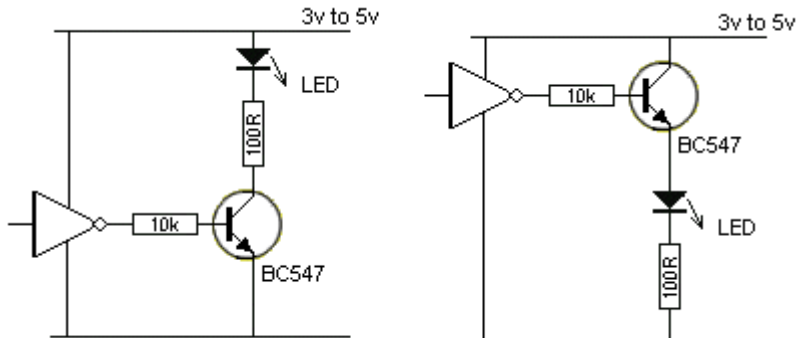
The battery charger is nothing more than a diode to rectify the signal from the 120 turn coil in the charging base. Thus the battery is in constant trickle charge as long as the hand unit is in the base. The battery pack is a pair of 600mAh AA NiCd cells.

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POWERING A LED

Sometimes the output of a gate does not have sufficient current to illuminate a LED to full brightness.

Here are two circuits. The circuits illuminate the LED when the output signal is HIGH. Both circuits operate the same and have the same effect on loading the output of the gate.

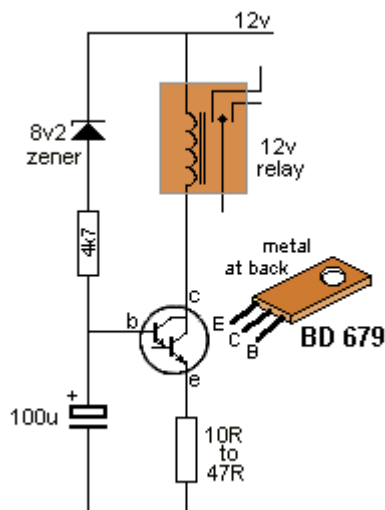


LOW VOLTAGE CUT-OUT

This circuit will detect when the voltage of a 12v battery reaches a low level. This is to prevent deep-discharge or maybe to prevent a vehicle battery becoming discharged to a point where it will not start a vehicle. This circuit is different to anything previously presented. It has Hysteresis. Hysteresis is a feature where the upper and lower detection-points are separated by a gap.

Normally, the circuit will deactivate the relay when the voltage is 10v and when the load is removed. The battery voltage will rise slightly by as little as 50mV and turn the circuit ON again. This is called "Hunting." The off/on timing has been reduced by adding the 100u. But to prevent this totally from occurring, a 10R to 47R is placed in the emitter lead. The circuit will turn off at 10v but will not turn back on until 10.6v when a 33R is in the emitter.

The value of this resistor and the turn-on and turn-off voltages will also depend on the resistance of the relay.



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THE DARLINGTON TRANSISTOR

Normally a single transistor-stage produces a gain of about 100.

If you require a very high gain, two stages can be used. Two transistors can be connected in many ways and the simplest is DIRECT COUPLING. This is shown in the circuit below. An even simpler method is to combine two transistors in one package to form a single transistor with very high gain, called DARLINGTON TRANSISTOR.

These are available as:

BD679 NPN-Darlington
2N6284 NPN-Darlington
BC879 NPN-Darlington
BC880 PNP-Darlington
TIP122 NPN-Darlington
TIP127 PNP-Darlington

These devices consist of two NPN or PNP transistors but the same result can be obtained by using a PNP/NPN pair. This is called a Sziklai pair. This arrangement will have to be created with two separate transistors.

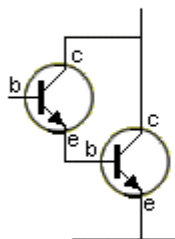
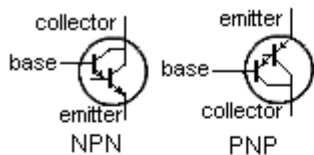
The Darlington transistor can also be referred to as:

"Super Transistor, Super Alpha Pair, Sziklai pair, Complementary Pair, Darlington transistors have a gain of 1,000 to 30,000. When the gain is 1,000:1 an input of 1mA will produce a current of 1 amp in the collector-emitter circuit.

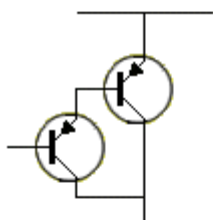
The only disadvantage of a Darlington Transistor is the minimum voltage between collector-emitter when fully saturated. It is 0.6v to 1.5v depending on the current through the transistor.

A normal transistor has a collector-emitter voltage (when saturated) of 0.2v to 0.5v.

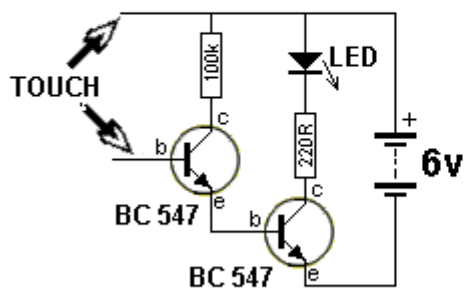
The higher voltage means the transistor will heat up more and requires good heatsinking. In addition, a Darlington transistor needs 1.2v between base and emitter before it will turn on. A Sziklai pair only requires 0.6v for it to turn on.



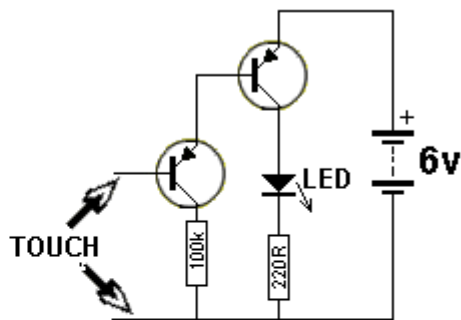
Darlington using two NPN transistors



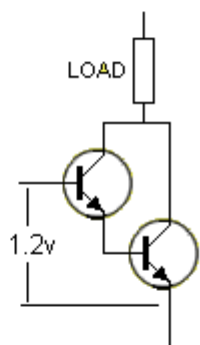
Darlington using two PNP transistors



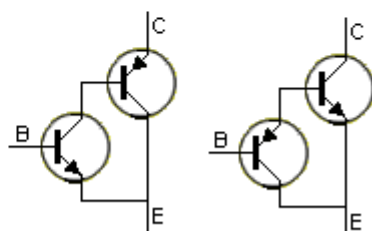
Circuit shows the HIGH GAIN of two NPN transistors



Circuit shows the HIGH GAIN of two PNP transistors



Super Alpha Pair NPN



Sziklai Pair

Sziklai Pair

PIC PROGRAMMER

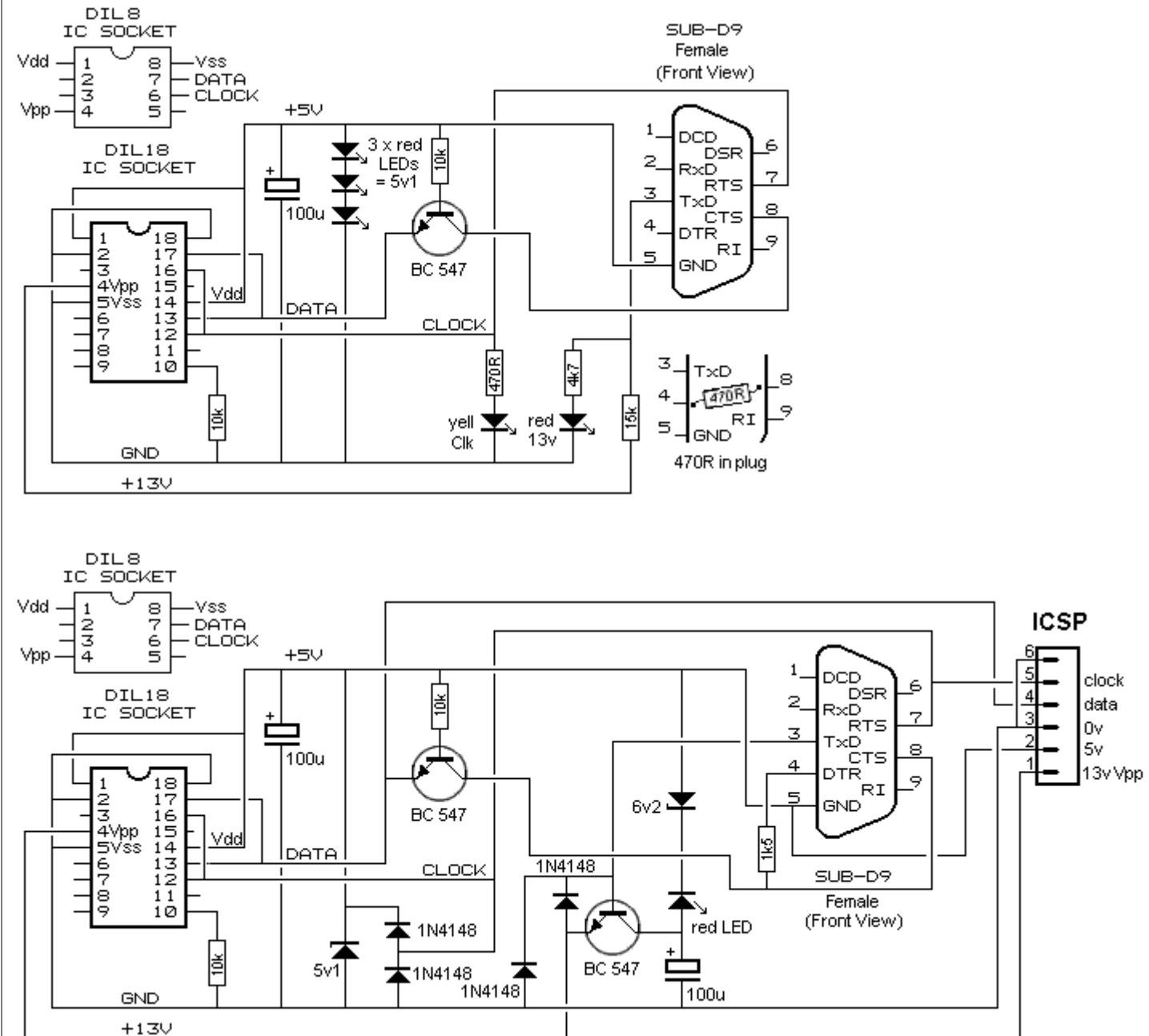
The simplest programmer to program PIC chips is connected to your computer via the serial port. This is a 9-pin plug/socket arrangement called a SUB-D9 with the male plug on the computer and female on a lead that plugs into the computer.

The signals that normally appear on the pins are primarily designed to talk to a modem but we use the voltages and the voltage-levels to power a programmer. The voltages on the pins are **On** or **Off**. On (binary value "1") means the pin is between -3 and -25 volts, while Off (binary value "0") means it is between +3 and +25 volts, depending on the computer. But many serial ports produce voltages of only +8v and -8V and the programmer circuit uses this to produce a voltage of about 13.5v to put the PIC chip into programming mode. This is the minimum voltage for the programmer to work. Any computers with a lower voltage cannot be used. That's why the circuit looks so unusual. It is combining voltages to produce 13v5.

Here are two circuits.

The first circuit is used in our [PIC PROGRAMMER - 12 parts](#) project.

Circuit 2 uses more components to produce the same result and circuit 3 uses less components.



ZAPPER - 160v

This project will give you a REAL SHOCK. It produces up to 160v and outputs this voltage for a very short period of time.

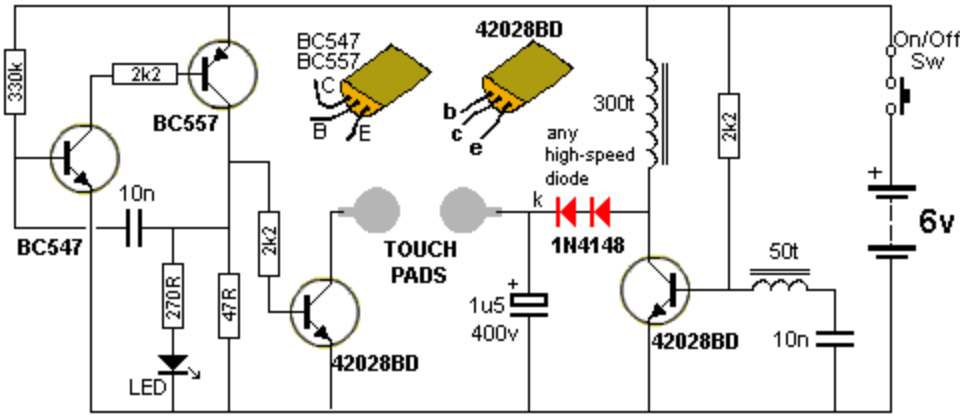
The components are taken from an old CFL (Compact Fluorescent Lamp) as the transistors are high voltage types and the 1u5 electro @400v can also be taken from the CFL as well as the ferrite core for the transformer.

The CFL has a 1.5mH choke with a DC resistance of 4 ohms. This resistance is too low for our circuit and the wire is removed and the core rewound with 50 turns for the feedback winding and 300 turns of 0.1mm wire to produce a winding with a resistance of about 10 ohms for the primary.

The oscillator is "flyback" design that produces spikes of about 160v and these are fed to a high-speed diode (two 1N4148 diodes in series) to charge a 1u5 electrolytic to about 160v. If you put your fingers across the electrolytic you will hardly feel the voltage. You might get a very tiny tingle at the end of your fingers.

But if this voltage is delivered, then turned off, you get an enormous shock and you pull yours fingers off the touch pads.

That's what the other part of the circuit does. It turns on a high-voltage transistor for a very short period of time and this is what makes the circuit so effective.

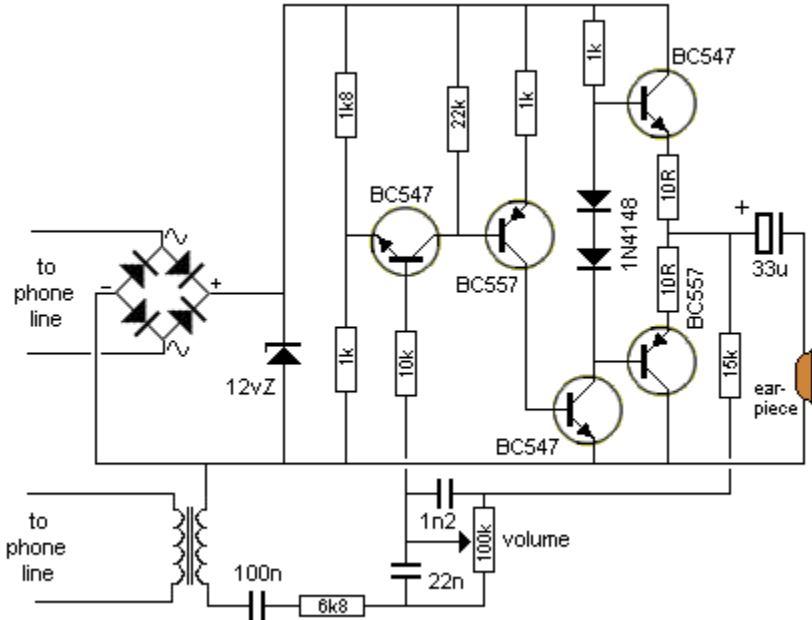


TELEPHONE AMPLIFIER

This amplifier circuit is used in all home telephones to amplify the signal from the line to the earpiece.

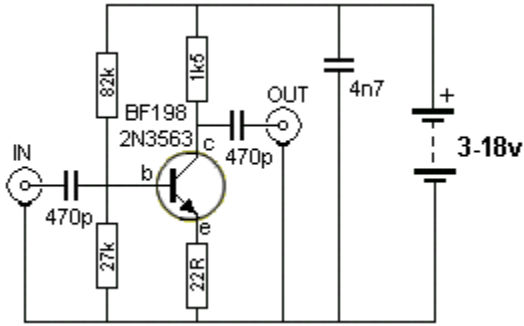
The voltage is taken from the line via a bridge that delivers a positive rail, no matter how the phone wires are connected.

A transformer is used to pick off a signal from the phone line and this is passed through a 22n to the input of the amplifier. Negative feedback is provided by a 15k and 1n2 capacitor. The operating point for the amplifier is set by the 100k pot and this serves to provide an effect on the gain of the amplifier and thus the volume.



VHF AERIAL AMPLIFIER

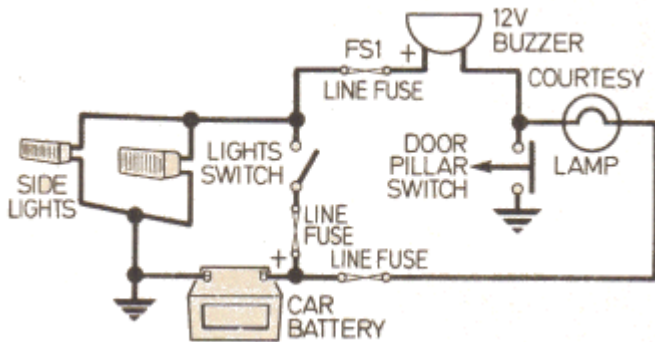
This amplifier circuit can be used to amplify VHF television signals. The gain is between 5dB and 28dB. 300ohm twin feeder can be used for the In/Out leads.



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CAR LIGHTS ALERT

This circuit will alert the driver if the lights have been left on. A warning sound will be emitted from the 12v buzzer when the driver's door is opened and the lights are on.

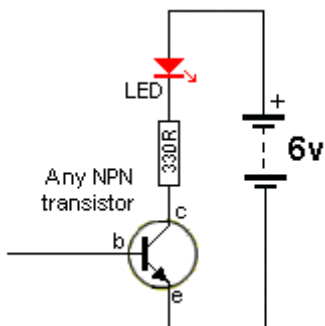


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MAINS DETECTOR

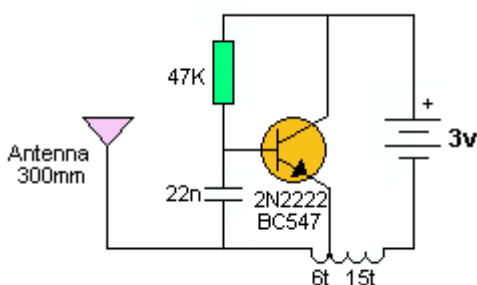
This circuit detects the "Active" wire of 110v AC or 240v AC via a probe and does not require "continuity." This makes it a safe detector.

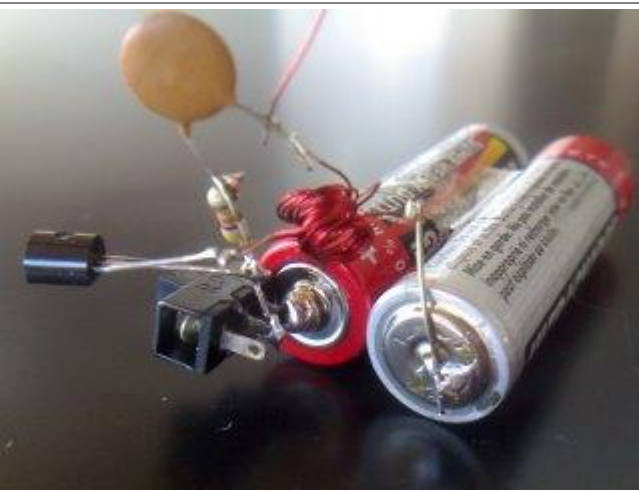
It uses the capacitance of your body to create current flow in the detecting part of the circuit and the sensitivity will depend on how you hold the insulating case of the project. No components of the circuit must be exposed as this will result in ELECTROCUTION.



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SIMPLEST FM BUG





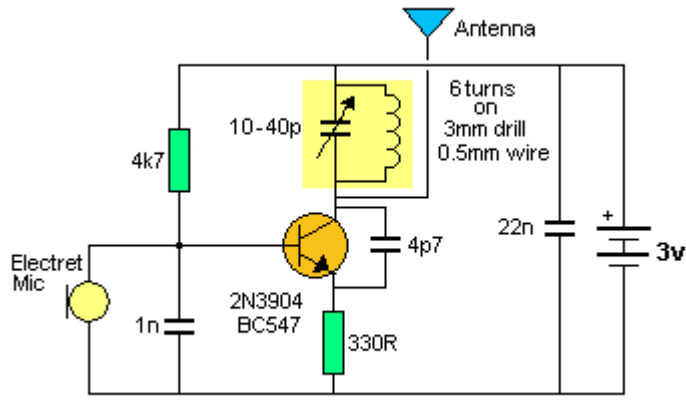
This circuit is the simplest FM circuit you can get. It has no microphone but the coil is so MICROPHONIC that it will pick up noises in the room via vibrations on a table.

The circuit does not have any section that determines the frequency. In the next circuit and all those that follow, the section that determines the frequency of operation is called the TUNED CIRCUIT or TANK CIRCUIT and consists of a coil and capacitor. This circuit does not have this feature. The transistor turns on via the 47k and this puts a pulse through the 15 turn winding. The magnetic flux from this winding passes through the 6 turn winding and into the base of the transistor via the 22n capacitor. This pulse is amplified by the transistor and the circuit is kept active.

The frequency is determined by the 6 turn coil. By moving the turns together, the frequency will decrease. The circuit transmits at 90MHz. It has a very poor range and consumes 16mA. The coil is wound on a 3mm drill and uses 0.5mm wire.

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A GOOD ONE-TRANSISTOR CIRCUIT

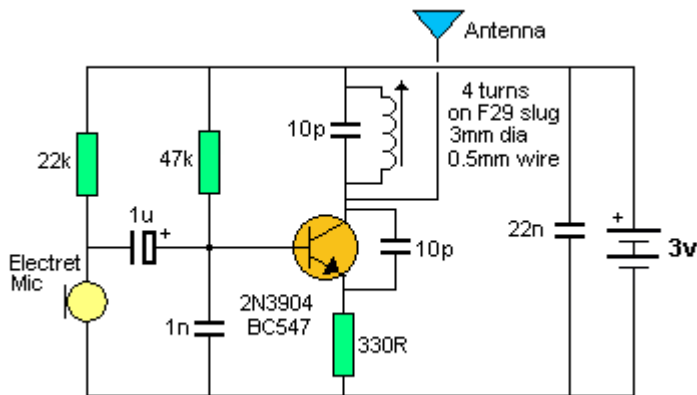


6-3-2011

This circuit uses a TUNED CIRCUIT or TANK CIRCUIT to create the operating frequency. For best performance the circuit should be built on a PC board with all components fitted close to each other. The photo below shows the components on a PC board:



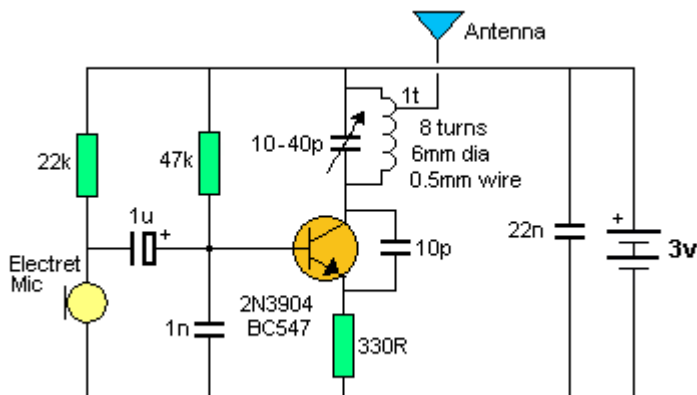
AN IMPROVED DESIGN



This design uses a "slug tuned coil" to set the frequency. This means the slug can be screwed in and out of the coil. This type of circuit does not offer any improvement in stability over the previous circuit. (In later circuits we will show how to improve stability. The main way to improve stability is to add a "buffer" stage. This separates the oscillator stage from the output.)

The antenna is connected to the **collector of the transistor** and this "loads" the circuit and will cause drift if the bug is touched. The range of this circuit is about 200 metres and current consumption is about 7mA. The microphone has been separated from the oscillator and this allows the gain of the microphone to be set via the 22k resistor. Lowering the resistor will make the microphone more sensitive. This circuit is the best you can get with one transistor.

MORE STABILITY



If you want more stability, the antenna can be tapped off the top of the tank circuit. This actually does two things. It keeps the antenna away from the highly active collector and turns the coil into an auto-transformer where the energy from the 8 turns is passed to a single turn. This effectively increases the current into the antenna. And that is exactly what we want.

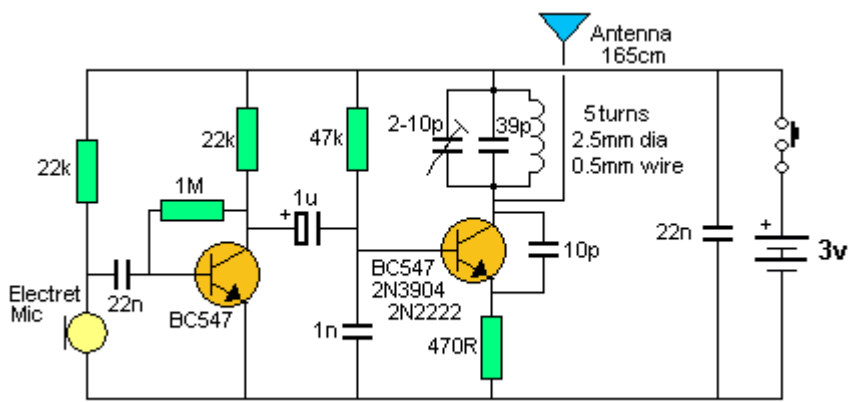
The range is not as far but the stability is better. The frequency will not drift as much when the bug is held. As the tap is taken towards the collector, the output increase but the stability deceases.

2-TRANSISTOR CIRCUIT

The next progressive step is to add a transistor to give the electret microphone more sensitivity. The electret microphone contains a Field Effect Transistor and you can consider it to be a stage of amplification. That's why the electret microphone has a very good output.

A further stage of amplification will give the bug extremely good sensitivity and you will be able to pick up the sound of a pin dropping on a wooden floor.

Many of the 1 transistor circuits over-drive the microphone and this will create a noise like bacon and eggs frying. The microphone's used by Talking Electronics require a load resistor of 47k for a 6v supply and 22k for a 3v supply. The voltage across the microphone is about 300mV to 600mV. Only a very simple self-biasing common-emitter stage is needed. This will give a gain of approx 70 for a 3v supply. The circuit below shows this audio amplifier, added to the previous transmitter circuit. This circuit is the best design using 2 transistors on a 3v supply. The circuit takes about 7mA and produces a range of about 200 - 400metres.



Five points to note in the circuit above:

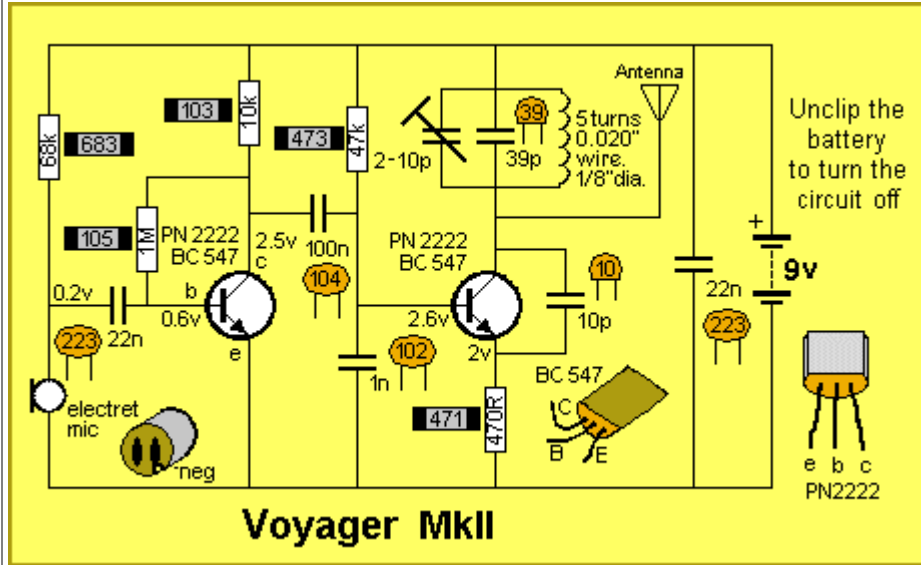
1. The tank circuit has a fixed 39p and is adjusted by a 2-10p trimmer. The coil is stretched to get the desired position on the band and the trimmer fine tunes the location.
2. The microphone coupling is a 22n ceramic. This value is sufficient as its capacitive reactance at 3-4kHz is about 4k and the input to the audio stage is fairly high, as noted by the 1M on the base.
3. The 1u between the audio stage and oscillator is needed as the base has a lower impedance as noted by the 47k base-bias resistor.
4. The 22n across the power rails is needed to keep the rails "tight." Its impedance at 100MHz is much less than one ohm and it improves the performance of the oscillator enormously.
5. The coil in the tank circuit is 5 turns of enameled wire with air core. The secret to long range is high activity in the oscillator stage. The tank circuit (made up of the coil and capacitors across it) will produce a voltage higher than the supply voltage due to the effect known as "collapsing magnetic field" and this occurs when the coil collapses and passes its reverse voltage to the capacitor. The antenna is also connected to this point and it receives this high waveform and passes the energy to the atmosphere as electromagnetic radiation. When the circuit is tightly constructed on a PC board, the frequency will not drift very much if the antenna is touched.

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THE VOYAGER

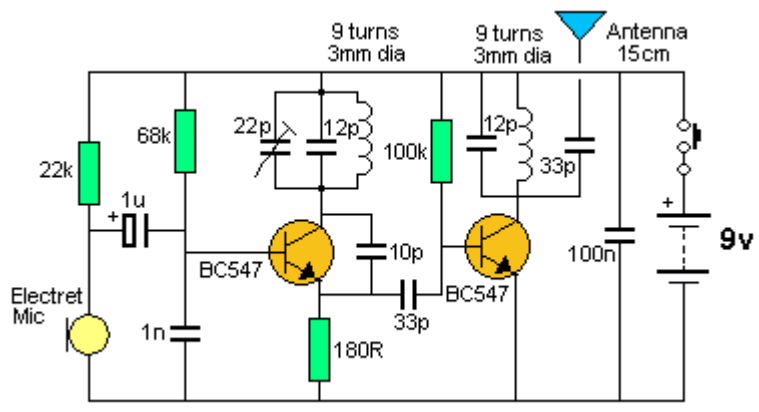
The only way to get a higher output from two transistors is to increase the supply voltage.

The following circuit is available from Talking Electronics as a surface-mount kit, with some components through-hole. The project is called [THE VOYAGER](#).



All the elements of good design have been achieved in this project. The circuit has a slightly higher output than the 3v circuit above, but most of the voltage is lost across the emitter resistor and not converted to RF. The main advantage of this design is being able to connect to a 9v battery. In a technical sense, about half the energy is wasted as the stages actually require about 4v - 5v for maximum output.

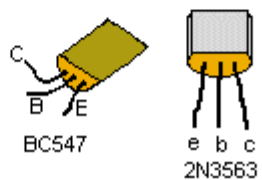
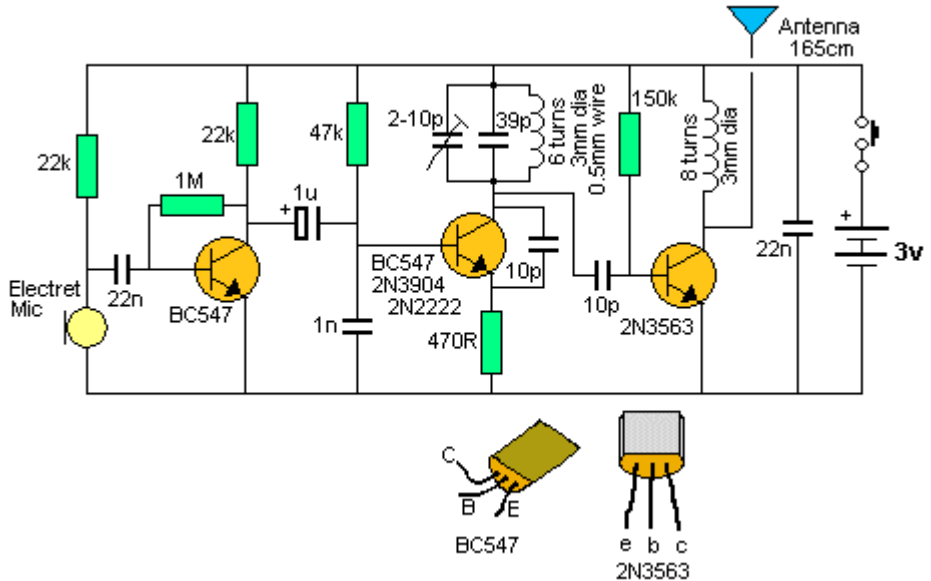
HAND-HELD MICROPHONE



This circuit is suitable for a hand-held microphone. It does not have an audio stage but that makes it ideal as a microphone, to prevent feedback. The output has a buffer stage to keep the oscillator away from the antenna. This gives the project the greatest amount of stability -rather than the highest sensitivity.

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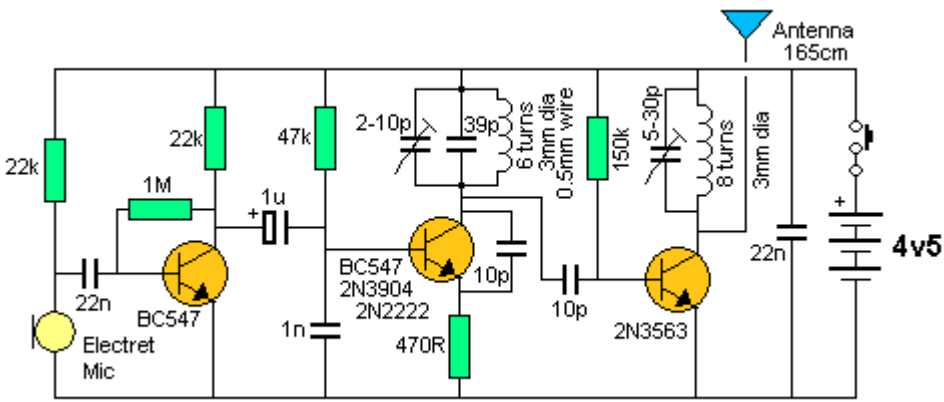
INCREASING THE RANGE



To increase the range, the output must be increased. This can be done by using an RF transistor and adding an inductor. This effectively converts more of the current taken by the circuit (from the battery) into RF output. The output is classified as an untuned circuit. A BC547 transistor is not suitable in this location as it does not amplify successfully at 100MHz. It is best to use an RF transistor such as 2N3563.

MORE RANGE

More output can be obtained by increasing the supply voltage and adding a capacitor across the inductor in the output stage to create a tuned output. The 5-30p must be adjusted each time the frequency of the bug is changed. This is best done with a field strength meter. See Talking Electronics [Field Strength Meter](#) project.



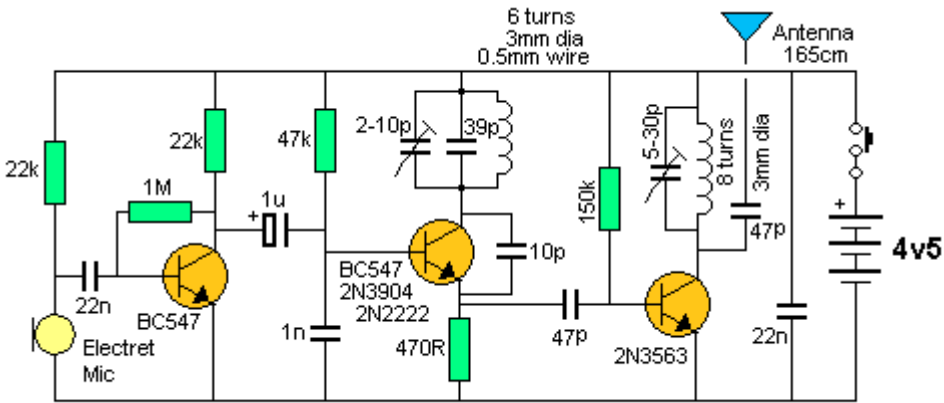
A tuned output stage delivers more output

The 2N3563 is capable of passing 15mA in the buffer stage and about 30% is delivered as RF. This makes the transmitter capable of delivering about 22mW.

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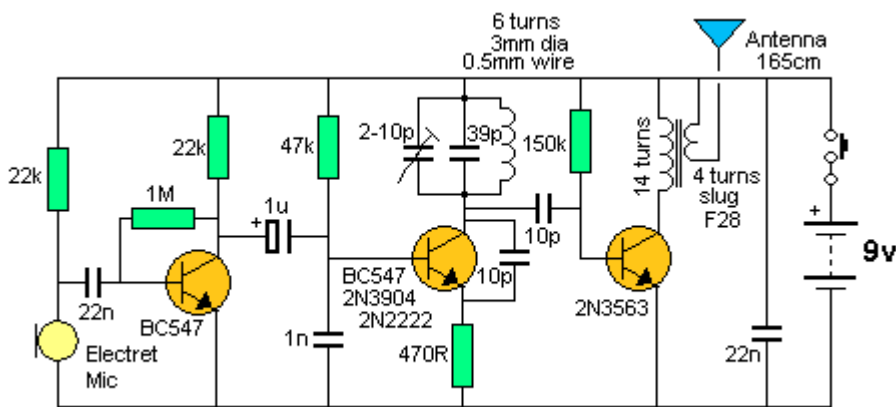
EMITTER TAP

The following circuit taps the emitter of the oscillator stage. The collector or the emitter can be tapped to produce about the same results. The 47pF capacitor is adjusted to "pick-off" the desired amount of energy from the oscillator stage. It can be reduced to 22pF or 10pF.



Tapping the emitter of the oscillator transistor

GOING FURTHER



THE RF TRANSFORMER

The next stage to improve the output, matches the impedance of the output stage to the impedance of the antenna.

The impedance of the output stage is about 1k to 5k, and the impedance of the antenna is about 50 ohms.

This creates an enormous matching problem but one effective way is with an RF transformer.

An RF transformer is simply a transformer that operates at high frequency. It can be air cored or ferrite cored. The type of ferrite needed for 100MHz is F28. The circuit above uses a small ferrite slug 2.6mm dia x 6mm long, F28 material.

To create an output transformer for the circuit above, wind 11 turns onto the slug and 4 turns over the 11 turns. The ferrite core will do two things. Firstly it will pass a high amount of energy from the primary winding to the antenna and secondly it will prevent harmonics passing to the antenna. The transformer approximately doubles the output power of the transmitter.

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MORE CIRCUITS TO BE ADDED HERE:

Th

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Circuit Symbols

The list below covers almost every symbol you will find on an electronic circuit diagram. It allows you to identify a symbol and also draw circuits. It is a handy reference and has some symbols that have never had a symbol before, such as a Flashing LED and electroluminescence panel.

Once you have identified a symbol on a diagram you will need to refer to specification sheets to identify each lead on the actual component.

The symbol does not identify the actual pins on the device. It only shows the component in the circuit and how it is wired to the other components, such as input line, output, drive lines etc. You cannot relate the shape or size of the symbol with the component you have in your hand or on the circuit-board.

Sometimes a component is drawn with each pin in the same place as on the chip etc. But this is rarely the case.

Most often there is no relationship between the position of the lines on the circuit and the pins on the component.

That's what makes reading a circuit so difficult.

This is very important to remember with transistors, voltage regulators, chips and so many other components as the position of the pins on the symbol are not in the same places as the pins or leads on the component and sometimes the pins have different functions according to the manufacturer. Sometimes the pin numbering is different according to the component, such as positive and negative regulators.

These are all things you have to be aware of.















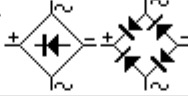




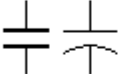
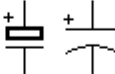




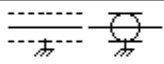


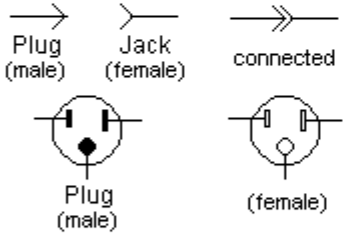



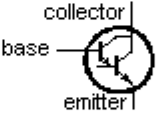






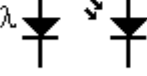
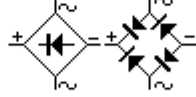




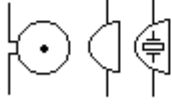
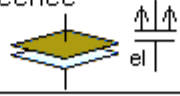

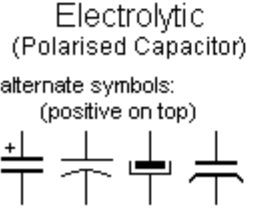



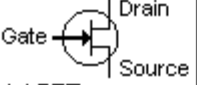
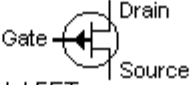

You must to refer to the manufacturer's specification sheet to identify each pin, to be sure you have identified them correctly.

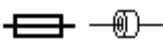
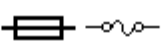
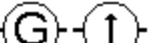

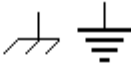

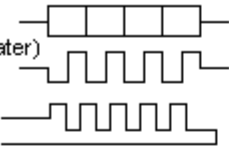



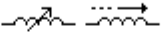


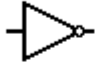










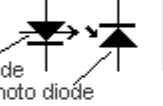


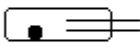















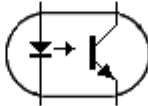
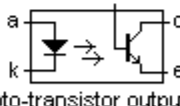
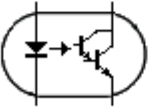
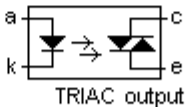










Colin Mitchell

CIRCUIT SYMBOLS

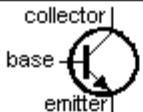






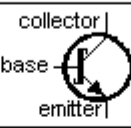

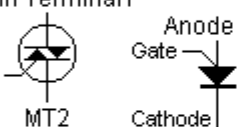
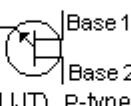

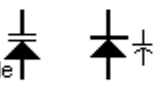
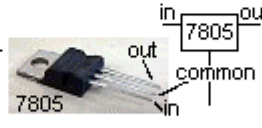

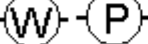

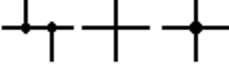
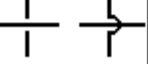



Some additional symbols have been added to the following list. See Circuit Symbols on the index of [Talking Electronics.com](http://TalkingElectronics.com)

CIRCUIT SYMBOLS by TALKING ELECTRONICS

<p>AC current: </p> <p>voltage: </p>	<p>ALTERNISTOR TRIAC</p> <p>A TRIAC and 33 - 43v DIAC</p> <p>Main Terminal 1</p> <p>Gate</p> <p>Main Terminal 2</p> 	<p>Ammeter (amp meter)</p> 
<p>AND Gate</p> 	<p>AND Gate</p> 	<p>Antenna balanced</p> 
<p>Antenna Loop, Shielded</p> 	<p>Antenna Loop, Unshielded</p> 	<p>Antenna unbalanced</p> 
<p>Attenuator, fixed (see Resistor)</p> 	<p>Attenuator, variable (see Resistor)</p> 	<p>Battery</p> 
<p>Bilateral Switch (DIAC)</p> 	<p>Bridge Rectifier (Diode Bridge)</p> 	<p>BUFFER (Amplifier Gate)</p> 
<p>BUFFER (Amplifier Gate)</p> 	<p>Buzzer</p> 	<p>Capacitor feedthrough</p> 
<p>Capacitor non-polarised</p> 	<p>Capacitor polarised (see electrolytic)</p> 	<p>Capacitor Variable</p> 
<p>Cavity Resonator</p> 	<p>Cell</p> 	<p>Circuit Breaker</p> 
<p>Coaxial Cable</p> 	<p>CRO - Cathode Ray Oscilloscope</p> 	<p>Crystal Microphone (Piezoelectric)</p> 
<p>Connectors</p> <p>Plug (male)</p> <p>Jack (female)</p> <p>connected</p> 	<p>Crystal Piezoelectric</p> 	<p>DC current: </p> <p>voltage: </p>
	<p>Darlington Transistor</p> <p>collector</p> <p>base</p> <p>emitter</p> 	<p>Delay Line</p> 
	<p>DIAC (Bilateral Switch)</p> 	<p>Diode</p> 
<p>Diode - Gunn</p> 	<p>Diode - Light Emitting (LED)</p> 	<p>Diode Photo Sensitive</p> 
<p>Diode Photovoltaic</p> 	<p>Diode Bridge (Bridge Rectifier)</p> 	<p>Diode - Pin</p> 
<p>Diode - Varactor</p> 	<p>Diode - Zener</p> 	<p>Earth Ground</p> 
<p>Earpiece (earphone, crystal earpiece)</p> 	<p>Electroluminescence</p> 	<p>Electret Microphone (Condenser mic)</p> 
<p>Electrolytic (Polarised Capacitor)</p> <p>alternate symbols: (positive on top)</p> 	<p>Electrolytic - Tanatalum</p> <p>positive end</p> <p>black band or chamfer</p> <p>10u tantalum</p> 	<p>Exclusive-OR Gate (XOR Gate)</p> 
		<p>Exclusive-OR Gate (XOR Gate)</p> 
<p>Field Effect Transistor (FET) n-channel also: N-Channel J FET</p> <p>Gate</p> <p>Drain</p> <p>Source</p> 	<p>Field Effect Transistor (FET) p-channel also: P-Channel J FET</p> <p>Gate</p> <p>Drain</p> <p>Source</p> 	<p>Flashing LED (Light Emitting Diode)</p> <p>(Indicates chip inside LED)</p> 

Ferrite Bead 	Fuse 	Galvanometer 
Globe 	Ground Chassis 	Ground Earth 
Heater (immersion heater) (cooker etc) 	IC Integrated Circuit  power ground	Inductor Air Core 
Headphone 	Inductor Variable 	Inductor Iron Core or ferrite core 
Inductor Tapped 	INVERTER (NOT Gate) 	Integrated Circuit 
Jack Co-axial 	Jack Phone (Phone Jack) 	Jack Phone (Switched) 
Jack Phone (3 conductor) 	Key Telegraph (Morse Key) 	Lamp Incandescent 
Lamp - Neon 	LASCR (Light Activated Silicon Controlled Rectifier) 	LDR (Light Dependent Resistor) 
LASER diode  laser diode photo diode	Light Emitting Diode (LED) 	Light Emitting Diode (LED - flashing)  (Indicates chip inside LED)
Mercury Switch 	Micro-amp meter (micro-ammeter) 	Microphone (see Electret Mic) 
Microphone (Crystal - piezoelectric) 	Milliamp meter (milli-ammeter) 	Motor 
NAND Gate 	NAND Gate 	Nitinol wire "Muscle wire" 
Negative Voltage Connection 	NOR Gate 	NOR Gate 
NOT Gate Inverter 	NOT Gate Inverter 	Ohm meter 
Operational Amplifier (Op Amp) 	Optocoupler (Transistor output) 	Opto Coupler (Opto-isolator)  Photo-transistor output
Optocoupler (Darlington output) 	Opto Coupler (Opto-isolator)  TRIAC output	OR Gate 
OR Gate 	Oscilloscope see CRO 	Outlet (Power Outlet) 
Piezo Diaphragm 	Photo Cell (photo sensitive resistor) 	Photo Diode 
Photo Darlington Transistor 	Photo FET (Field Effect Transistor)  Gate Drain Source	Photo Transistor 

Photovoltaic Cell (Solar Cell)		Piezo Tweeter (Piezo Speaker)		Positive Voltage Connection	
Potentiometer (variable resistor)		Programmable Unijunction Transistor PUT		Rectifier Silicon Controlled (SCR)	
Rectifier Semiconductor		Reed Switch		Relay - spst	
Relay - spdt		Relay - dpst		Relay - dpdt	
Resistor Fixed		Resistor Non Inductive		Resistor preset	
Resistor variable		Resonator 3-pin		RFC Radio Frequency Choke	
Rheostat (Variable Resistor)		Saturable Reactor		Schmitt Trigger (Inverter Gate)	
Schottky Diode (also Shottky) Low forward voltage 0.3v Fast switching also called Schottky Barrier Diode		Shielding		Shockley Diode 4-layer PNP device Remains off until forward current reaches the forward break-over voltage.	
Silicon Bilateral Switch (SBS)		Signal Generator		Silicon Controlled Rectifier (SCR)	
Silicon Unilateral Switch (SUS)		Solar Cell			
Surface Mount		Switch - spst		Switch - process activated normally open: normally closed:	
		Switch - spdt			
		Switch - dpst			
		Switch - dpdt			
		Switch - mercury tilt switch			
		Spark Gap		Speaker	
Switch - push (Push Button)		Switch - push off (used in alarms etc)		Switch - Rotary	
Test Point		Thyristors: Main Terminal 1		Thermocouple	
Thermal Probe		Bilateral Switch		Tilt switch mercury	
		DIAC		Touch Sensor	
		SCR			
		TRIAC			
		TRIAC			
Transformer Air Core		Transformer Iron Core		Transformer (Tapped Primary/Sec)	

Transistor Bipolar - NPN 	Transistor Bipolar - PNP 	Transistor n-channel Field Effect 
Transistor p-channel Field Effect 	Transistor Metal Oxide Single Gate 	Transistor Metal Oxide Dual Gate 
Transistor Photosensitive 	Transistor Schottky - NPN 	Transistor Unijunction - UJT Unijunction Transistor (UJT) N-type 
TRIAC 	Transistor Unijunction - UJT Unijunction Transistor (UJT) P-type 	Tunnel Diode 
Varactor varactor diode 	Voltage Regulator (7805 etc) 	Voltmeter 
Wattmeter 	Wires 	Wires Connected 
Wires Not Connected 	XOR Gate (exclusive OR) 	XOR Gate (exclusive OR) 
Zener Diode 	Learn BASIC ELECTRONICS Go to: http://www.talkingelectronics.com	

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IC PINOUTS

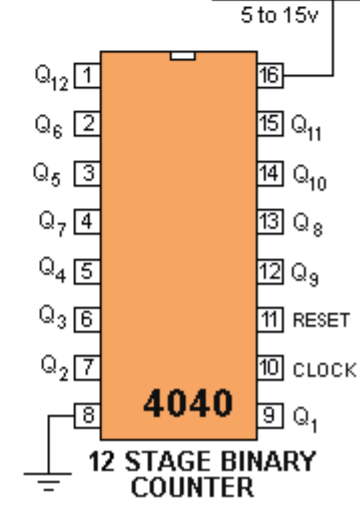
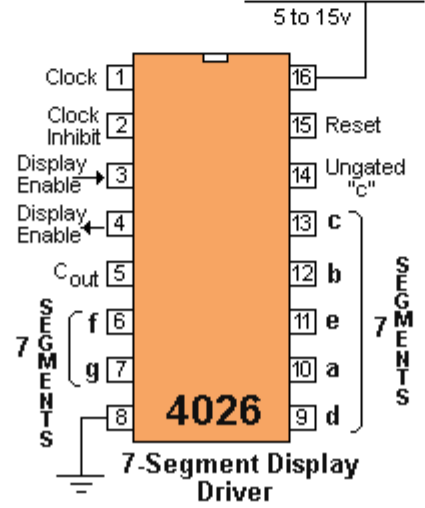
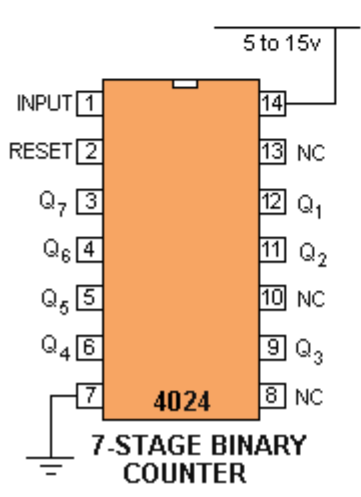
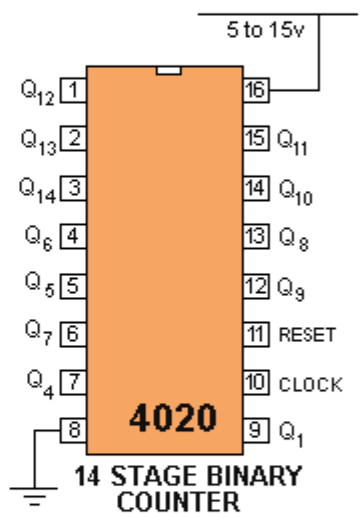
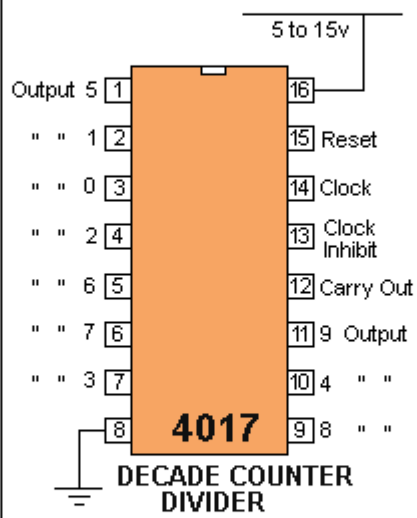
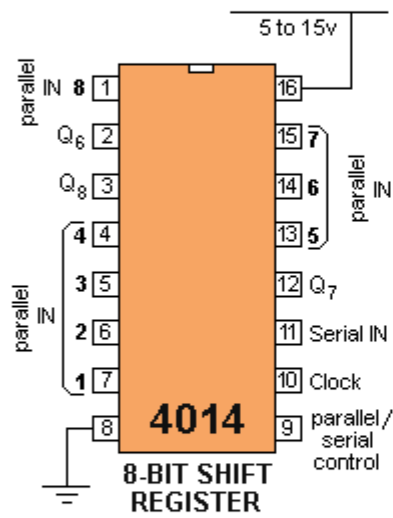
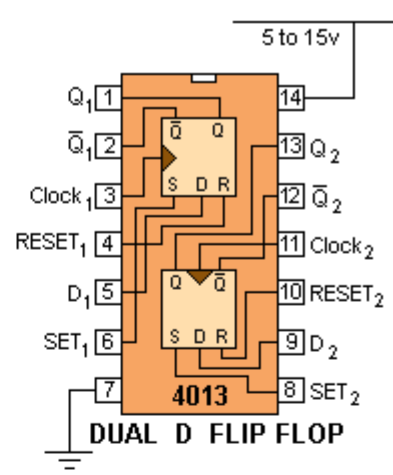
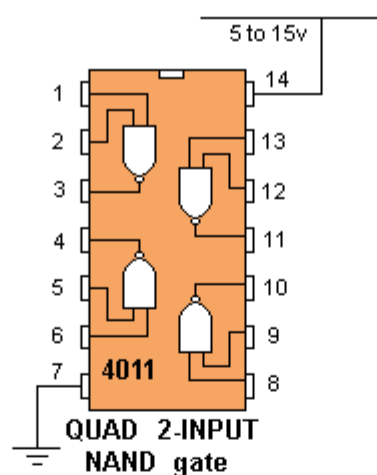
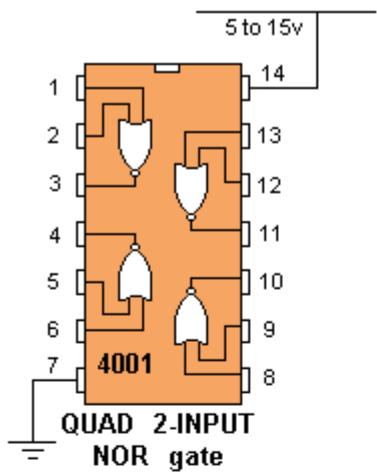
The following list covers just a few of the IC's on the market and these are the "simple" or "basic" or "digital" or "op-amp" IC's suitable for experimenting.

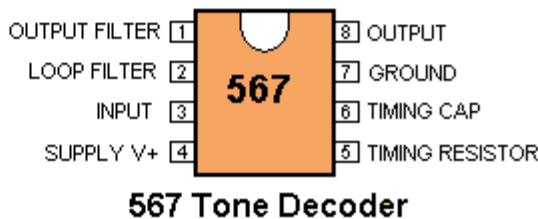
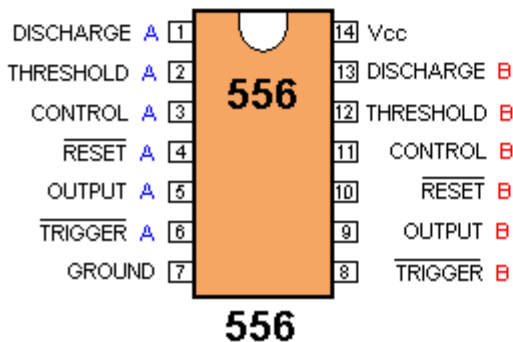
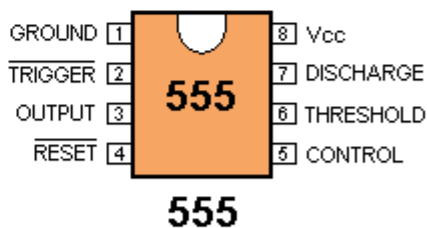
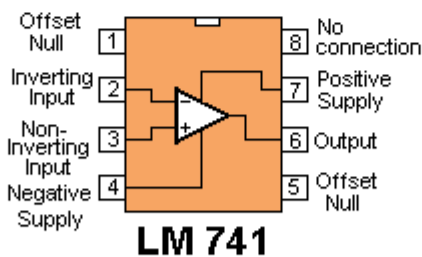
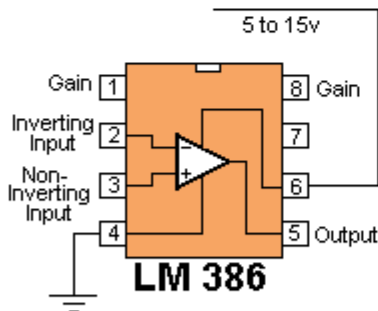
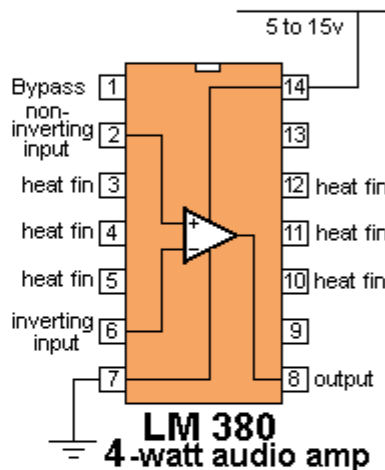
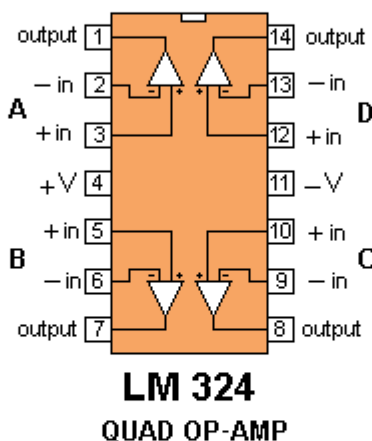
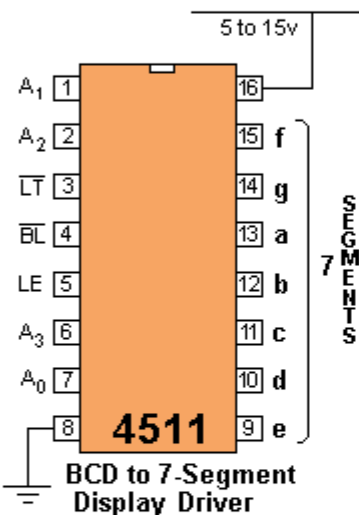
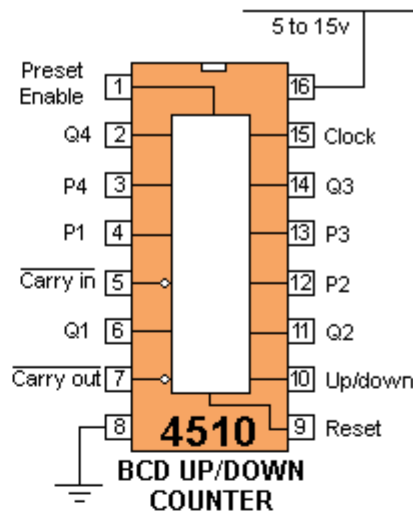
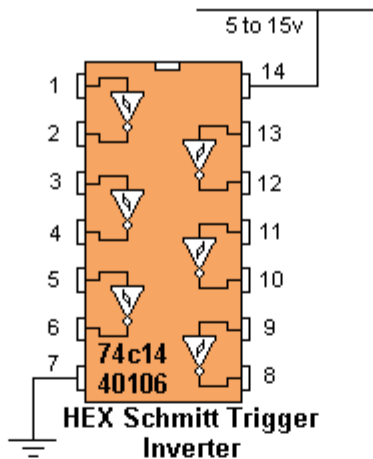
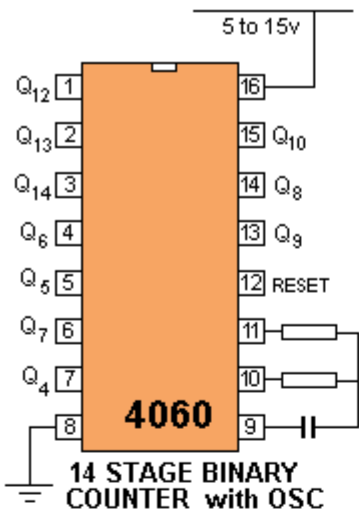
When designing a circuit around an IC, you have to remember two things:

1. Is the IC still available? and
2. Can the circuit be designed around a microcontroller?

Sometimes a circuit using say 3 or 4 IC's can be re-designed around an 8-pin or 16-pin microcontroller and the program can be kept from prying eyes due to a feature called "code protection." A microcontroller project is more up-to-date, can be cheaper and can be re-programmed to alter the features.

This will be covered in the next eBook. It is worth remembering - as it is the way of the future.




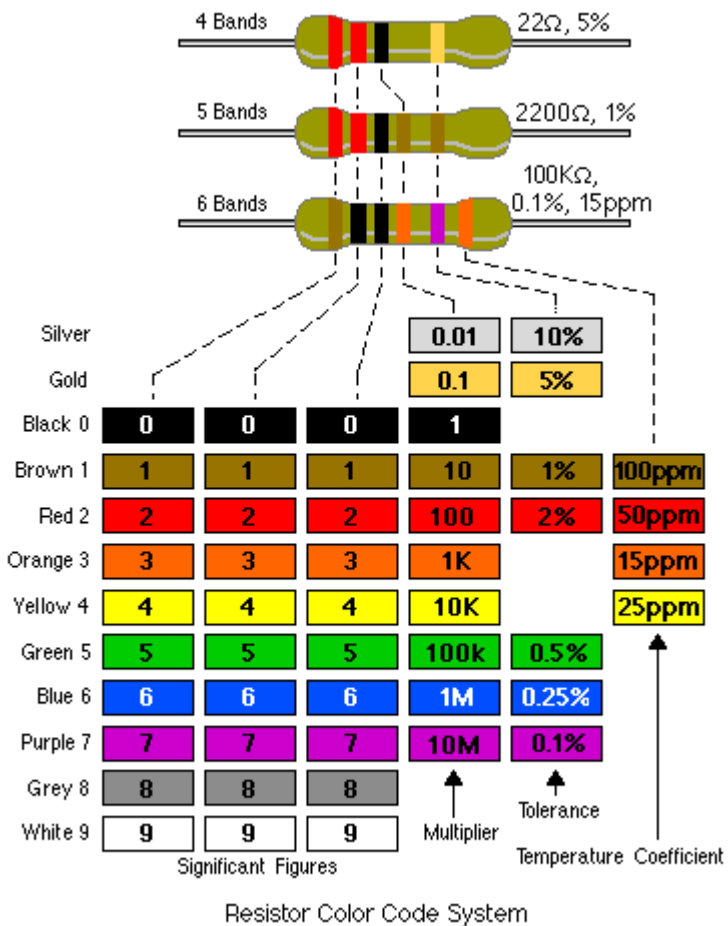


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All the resistor colours:

This is called the "normal" or "3 colour-band" (5%) range. If you want the 4 colour-band (1%) series, refer to Talking Electronics website and click: **Resistors 1%** on the left index. Or you can use the table below.

1R0	10R	100R	1k0
1R2	12R	120R	1k2
1R5	15R	150R	1k5
1R8	18R	180R	1k8
2R2	22R	220R	2k2
2R7	27R	270R	2k7
3R3	33R	330R	3k3
3R9	39R	390R	3k9
4R7	47R	470R	4k7
5R6	56R	560R	5k6
6R8	68R	680R	6k8
8R2	82R	820R	8k2
10k	100k	1M0	10M
12k	120k	1M2	22M
15k	150k	1M5	
18k	180k	1M8	0R1
22k	220k	2M2	R22
27k	270k	2M7	0R0
33k	330k	3M3	zero ohm (link)
39k	390k	3M9	
47k	470k	4M7	$\frac{1}{10}$ th watt
56k	560k	5M6	and
68k	680k	6M8	0.25 watt
82k	820k	8M2	



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MAKE ANY RESISTOR VALUE:

If you don't have the exact resistor value for a project, don't worry. Most circuits will work with a value slightly higher or lower. But if you want a particular value and it is not available, here is a chart. Use 2 resistors in series or parallel as shown:

Required Value	R1	Series/Parallel	R2	Actual value:
10	4R7	S	4R7	9R4
12	10	S	2R2	12R2
15	22	P	47	14R9
18	22	P	100	18R
22	10	S	12	22
27	22	S	4R7	26R7
33	22	S	10	32R
39	220	P	47	38R7
47	22	S	27	49
56	47	S	10	57
68	33	S	33	66
82	27	S	56	83

There are other ways to combine 2 resistors in parallel or series to get a particular value. The examples above are just one way.
4R7 = 4.7 ohms

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MAKE ANY CAPACITOR VALUE:

If you don't have the exact capacitor value for a project, don't worry. Most circuits will work with a value slightly higher or lower.

But if you want a particular value and it is not available, here is a chart.

Use 2 capacitors in series or parallel as shown. "p" is "puff" but can be "n" (nano) or "u" (microfarad).

Required Value	C1	Series/ Parallel	C2	Actual value:
10	4p7	P	4p7	9p4
12	10	P	2p2	12p2
15	22	S	47	14p9
18	22	S	100	18p
22	10	P	12	22
27	22	P	4p7	26p7
33	22	P	10	32p
39	220	S	47	38p7
47	22	P	27	49
56	47	P	10	57
68	33	P	33	66
82	27	P	56	83

There are other ways to combine 2 capacitors in parallel or series to get a particular value. The examples above are just one way. 4p7 = 4.7p