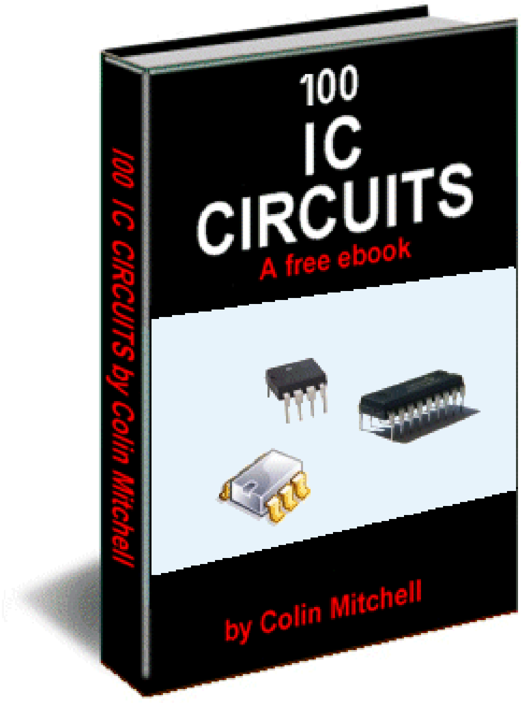


For our other three free eBooks,
Go to: 1 - 100 Transistor Circuits
Go to: 101 - 200 Transistor Circuits
Go to: 50 - 555 Circuits

33 IC CIRCUITS as of 14-4-2012

Talking Electronics

See TALKING ELECTRONICS WEBSITE

email Colin Mitchell: talking@tpg.com.au

INTRODUCTION

This is the third part of our **Circuits** e-book series. It contains a further 100 circuits. This time we have concentrated on circuits containing one or more IC's.
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. It is also the basis of a "Memory Cell" as will will hold a piece of information.
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" (Boolean logic) and "gates."
Integrated Circuits started with a few transistors in each "chip" and increased to 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).

In this **IC Circuits ebook**, we have presented about 100 interesting circuits using Integrated Circuits.
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 or the components they replace.
In all, they are a fantastic way to get something working with the least componentry.
A list of of some of the most common 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
TALKING ELECTRONICS.
talking@tpg.com.au

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

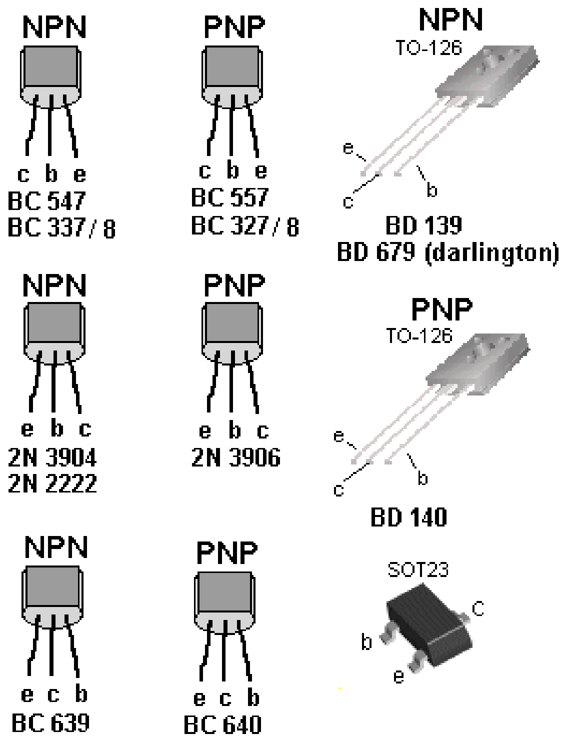
We have said this before abut we will say it again: **There are two ways to learn electronics.**
One is to go to school and study theory for 4 years and come out with all the theoretical knowledge in the world but very little practical experience. The other is to "learn on the job."

I am not saying one approach is better than the other but most electronics enthusiasts are not "book worms" and many have been dissuaded from entering electronics due to the complex mathematics surrounding University-type courses.
Our method is to get around this by advocating designing, building, constructions and even more assembly with lots of experimenting and when you get stuck with a mathematical problem, get some advice or read about it via the thousands of free test books on the web.
Anyone can succeed in this field by applying themselves to constructing projects. You actually learn 10 times faster by doing it yourself and we have had lots of examples of designs from students in the early stages of their career.
And don't think the experts get it right the first time. Look at all the recalled electronics equipment from the early days.
The most amazing inventions have come from almost "newcomers" as evidenced by looking through the "New Inventions" website.
All you have to do is see a path for your ideas and have a goal that you can add your ideas to the "Word of Invention" and you succeed.
Nothing succeeds like success. And if you have a flair for designing things, electronics will provide you a comfortable living for the rest of your life.
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" 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.
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.
If you just follow these ideas, you will succeed.

A few of the basics are also provided in this eBook, the first is transistor outlines:

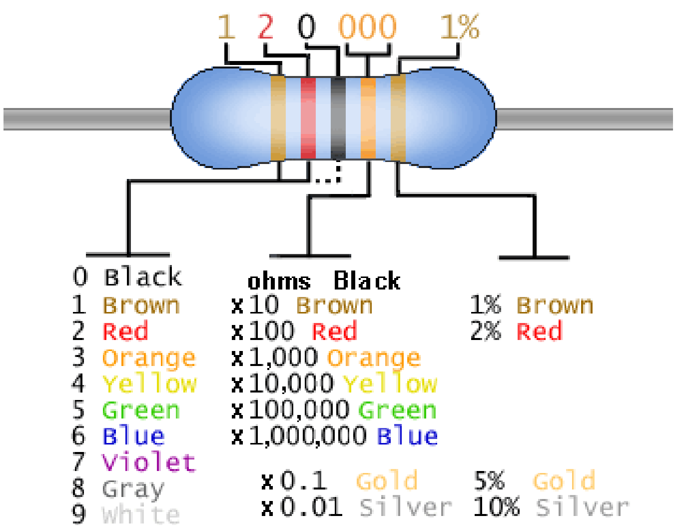
TRANSISTORS

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.
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
e
c
b
BD 139
BD 679 (darlington)
NPN
e b c
2N 3904
2N 2222
PNP
e b c
2N 3906
PNP
TO-126
e
c
b
BD 140
NPN
e c b
BC 639
PNP
e c b
BC 640
SOT23
c
b
e

CONTENTS

RESISTOR COLOUR CODE

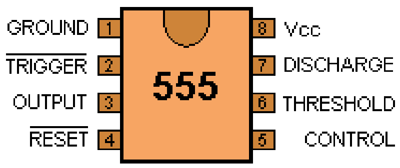


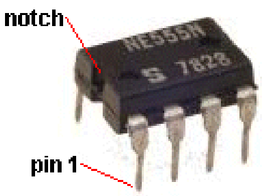
See resistors from 0.22ohm to 22M in full colour at end of book and another resistor table

THE 555

The 555 is everywhere. It is possibly the most-frequency used chip and is easy to use.
But if you want to use it in a "one-shot" or similar circuit, you need to know how the chip will "sit."
For this you need to know about the UPPER THRESHOLD (pin 6) and LOWER THRESHOLD (pin 2):
The 555 is fully covered in a 3 page article on Talking Electronics website (see left index: 555 P1 P2 P3)

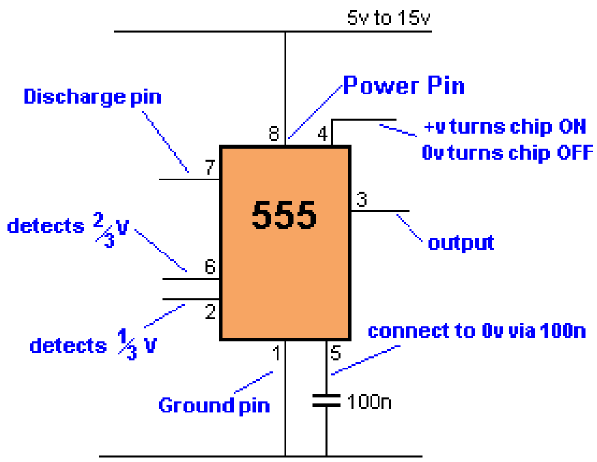
Here is the pin identification for each pin:



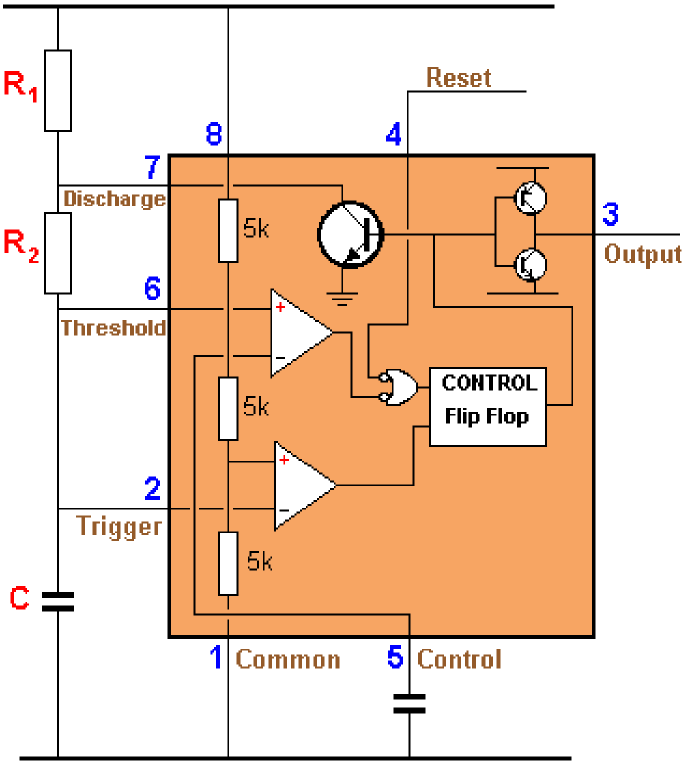


555 PINOUT

When drawing a circuit diagram, always draw the 555 as a building block with the pins in the following locations. This will help you instantly recognise the function of each pin:



The Function of each PIN



INSIDE THE 555 CHIP

Note: Pin 7 is "in phase" with output Pin 3 (both are low at the same time).
Pin 7 "shorts" to 0v via the transistor. It is pulled HIGH via R1.
Maximum supply voltage 16v - 18v
Current consumption approx 10mA
Output Current sink @5v = 5 - 50mA   @15v = 50mA
Output Current source @5v = 100mA   @15v = 200mA
Maximum operating frequency 300kHz - 500kHz

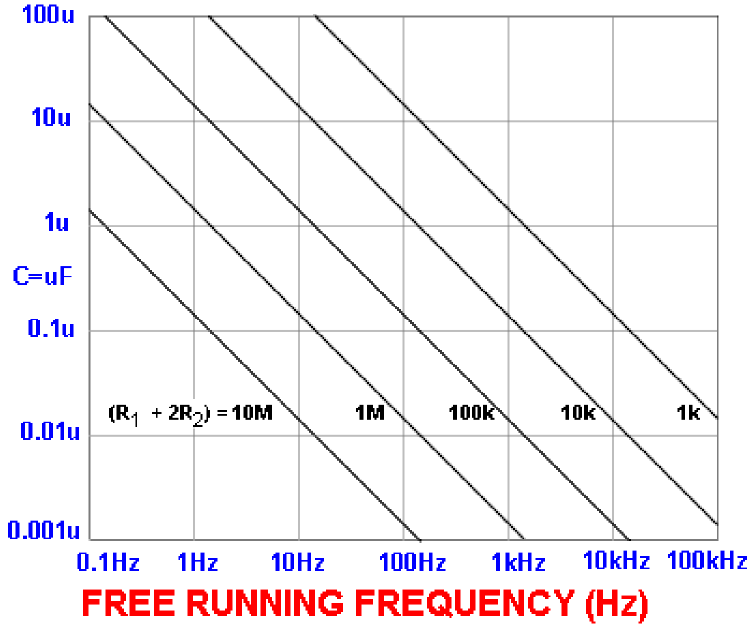
Faults with Chip:
Consumes about 10mA when sitting in circuit
Output voltage up to 2.5v less than rail voltage
Output is 0.5v to 1.5v above ground
Sources up to 200mA but sinks only 50mA

HOW TO USE THE 555

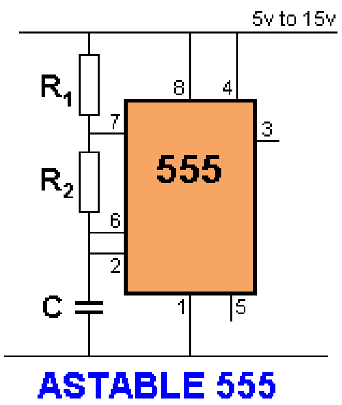
There are many ways to use the 55.
(a) Astable Multivibrator - constantly oscillates
(b) Monostable - changes state only once per trigger pulse - also called a ONE SHOT
(c) Voltage Controlled Oscillator

ASTABLE MULTIVIBRATOR

The output frequency of a 555 can be worked out from the following graph:



The graph applies to the following Astable circuit:



The capacitor C charges via R1 and R2 and when the voltage on the capacitor reaches 2/3 of the supply, pin 6 detects this and pin 7 connects to 0v. The capacitor discharges through R2 until its voltage is 1/3 of the supply and pin 2 detects this and turns off pin7 to repeat the cycle.
The top resistor is included to prevent pin 7 being damaged as it shorts to 0v when pin 6 detects 2/3 rail voltage.
Its resistance is small compared to R2 and does not come into the timing of the oscillator.

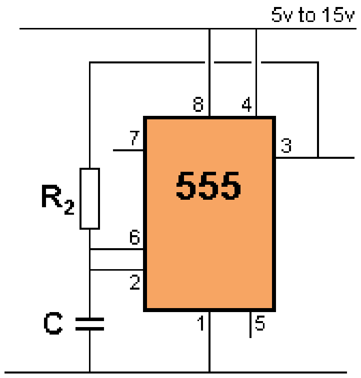
Using the graph:
Suppose R1 = 1k, R2 = 10k and C = 0.1 (100n).
Using the formula on the graph, the total resistance = 1 + 10 + 10 = 21k
The scales on the graph are logarithmic so that 21k is approximately near the "1" on the 10k. Draw a line parallel to the lines on the graph and where it crosses the 0.1u line, is the answer. The result is approx 900Hz.

Suppose R1 = 10k, R2 = 100k and C = 1u
Using the formula on the graph, the total resistance = 10 + 100 + 100 = 210k
The scales on the graph are logarithmic so that 210k is approximately near the first "0" on the 100k. Draw a line parallel to the lines on the graph and where it crosses the 1u line, is the answer. The result is approx 9Hz.

The frequency of an astable circuit can also be worked out from the following formula:

$$\textbf{frequency} = \frac{1.4}{(R_1 + 2R_2) \times C}$$

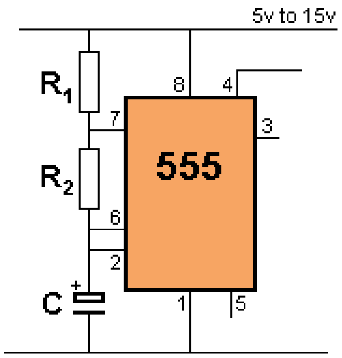
555 astable frequencies			
C	R_1 = 1k R_2 = 6k8	R_1 = 10k R_2 = 68k	R_1 = 100k R_2 = 680k
0.001µ	100kHz	10kHz	1kHz
0.01µ	10kHz	1kHz	100Hz
0.1µ	1kHz	100Hz	10Hz
1µ	100Hz	10Hz	1Hz
10µ	10Hz	1Hz	0.1Hz



SIMPLEST ASTABLE

The simplest Astable uses one resistor and one capacitor. Output pin 3 is used to charge and discharge the capacitor.

LOW FREQUENCY OSCILLATORS



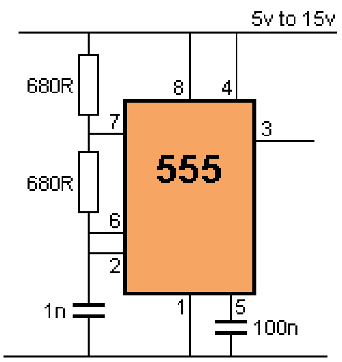
LOW FREQUENCY 555

If the capacitor is replaced with an electrolytic, the frequency of oscillation will reduce. When the frequency is less than 1Hz, the oscillator circuit is called a timer or "delay circuit." The 555 will produce delays as long as 30 minutes but with long delays, the timing is not accurate.

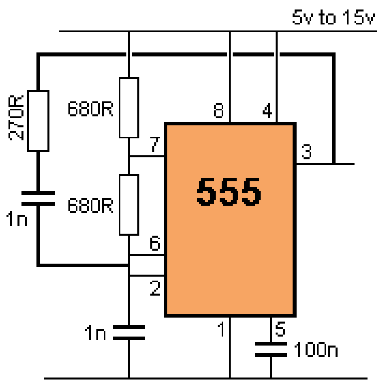
555 Delay Times:			
C	R_1 = 100k R_2 = 100k	R_1 = 470k R_2 = 470k	R_1 = 1M R_2 = 1M
10µ	2.2sec	10sec	22sec
100µ	22sec	100sec	220sec
470µ	100sec	500sec	1000sec

555 ASTABLE OSCILLATORS

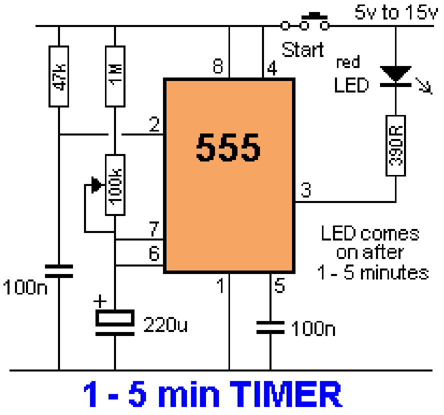
Here are circuits that operate from 300kHz to 30 minutes:
(300kHz is the absolute maximum as the 555 starts to malfunction with irregular bursts of pulses at this high frequency and 30 minutes is about the longest you can guarantee the cycle will repeat.)

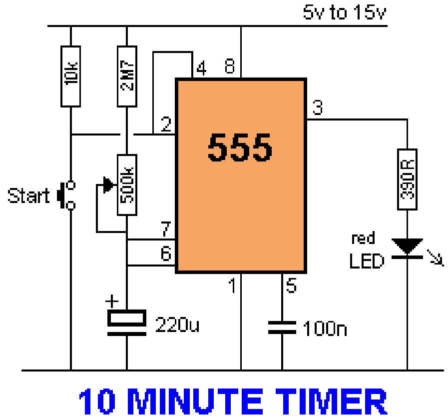


360kHz

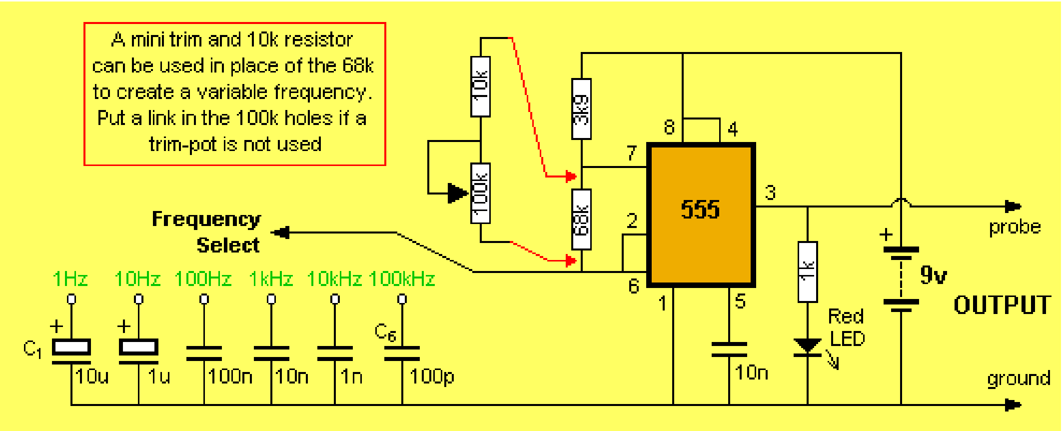


360kHz - mods

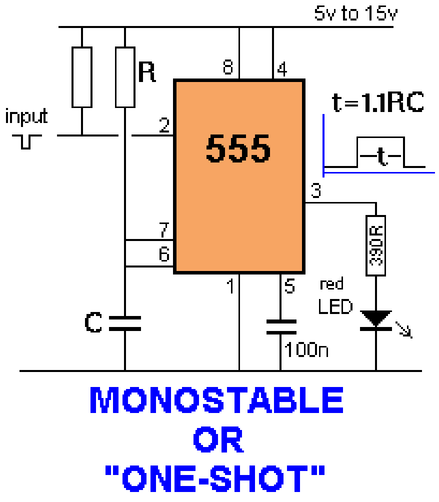




SQUARE WAVE OSCILLATOR



A square wave oscillator kit can be purchased from Talking Electronics for approx $10.00
See website: Square Wave Oscillator
It has adjustable (and settable) frequencies from 1Hz to 100kHz and is an ideal piece of Test Equipment.



555 Monostable or "one Shot"

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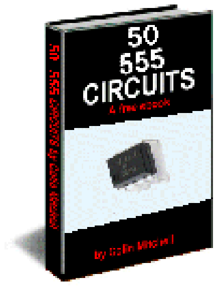
50 - 555 CIRCUITS



50 555 Circuits eBook can be accessed on the web or downloaded as a .doc or .pdf It has more than 50 very interesting 555 circuits and data on using a 555.

Table of Contents: (more has been added - see: 50 - 555 circuits)

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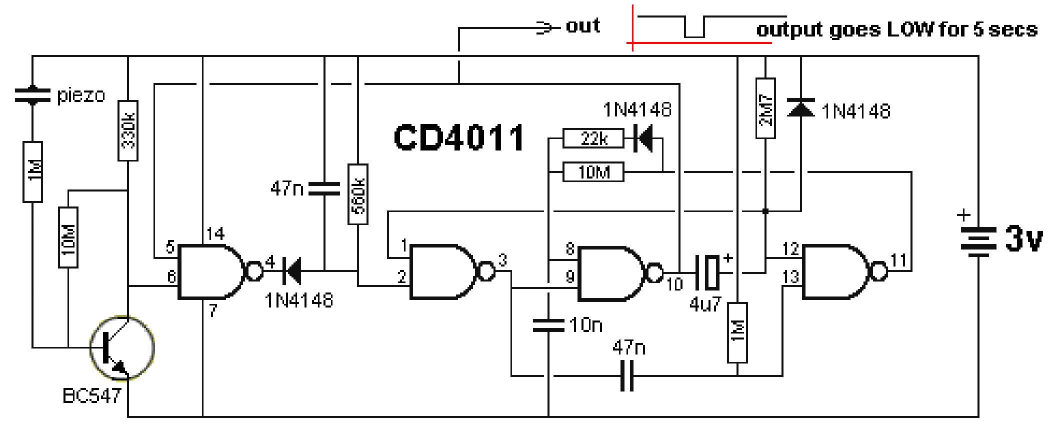

KNOCK KNOCK DOORBELL

This very clever circuit only produces an output when the piezo detects two taps. It can be used as a knock-knock doorbell. A PC board containing all components (soldered to the board) is available from talking electronics for $5.00 plus postage. Email **HERE** for details.

The circuit takes only a few microamp and when a tap is detected by the piezo, the waveform from the transistor produces a HIGH on pin 6 and the HIGH on pin 5 makes output pin 4 go low. This very quickly charges the 47n and it is discharged via the 560k to produce a brief pulse at pin 3.

The 47n is mainly to stop noise entering pin 2. Pin 1 is HIGH via the 2M7 and the LOW on pin 2 causes pin 3 to produce a HIGH pulse. The 47n is discharged via the internal diodes on pin 13 and when it goes LOW, pin 11 goes HIGH and charges the 10n via the 22k and diode.

This puts a HIGH on pin 8 for approx 0.7 seconds and when a second tap is detected, pin 9 sees a HIGH and pin 10 goes LOW. This puts a LOW on pin 12 and a HIGH on pin 8. The LOW on pin 12 goes to pin 1. A HIGH and LOW on the second NAND gate produces a HIGH on pin 3 and the third NAND gate has a HIGH on both inputs. This makes pin 10 LOW and the 4u7 starts to charge via the 2M7 resistor. After 5 seconds pin 12 sees a HIGH and pin 11 goes LOW. The 10n is discharged via the 10M and when pin 8 sees a LOW, pin 10 goes HIGH. The output sits HIGH and goes LOW for about 7 seconds.

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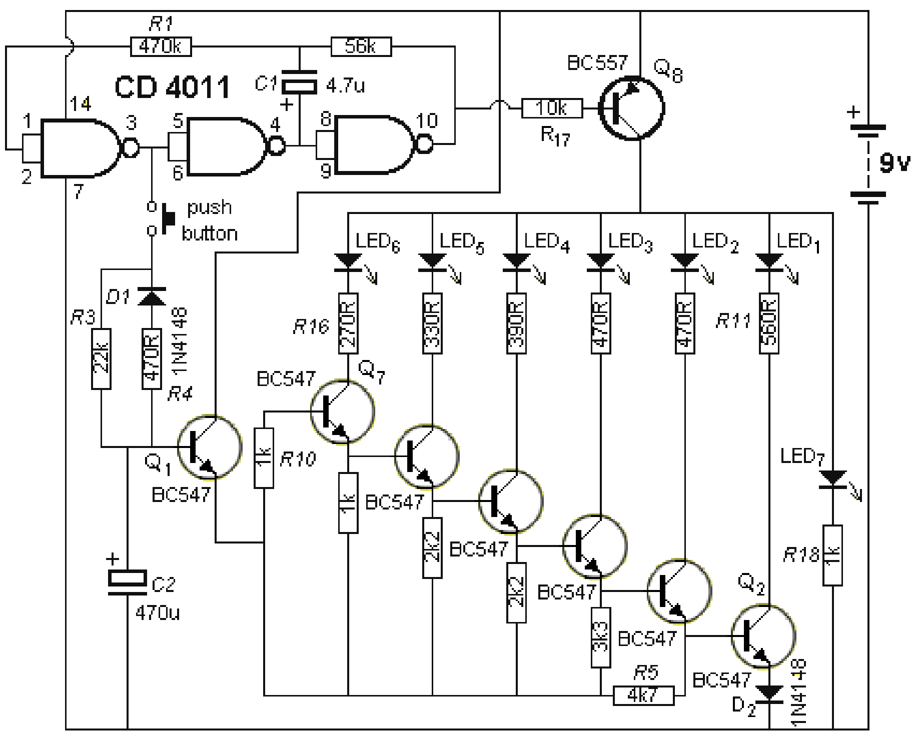
LED ZEPPELIN

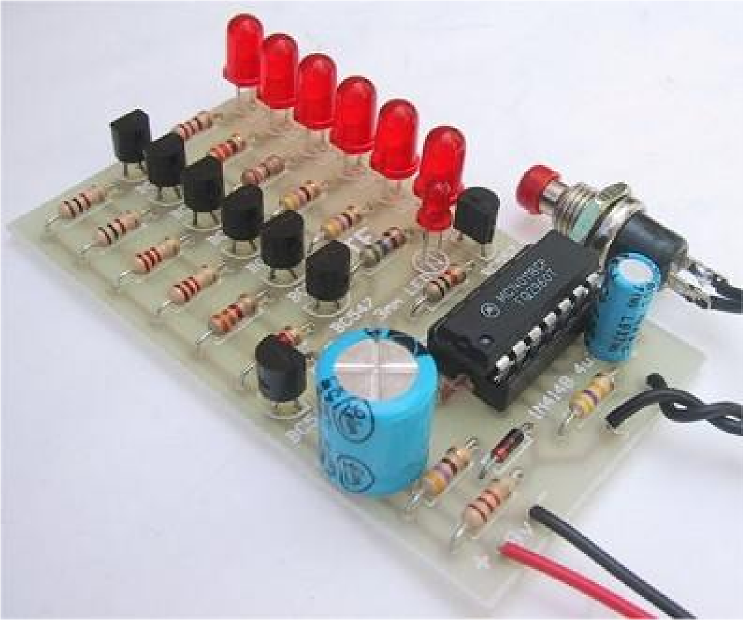
This circuit is a game of skill. See full article: LED Zeppelin. The kit is available from talking electronics for $15.50 plus postage. Email **HERE** for details.

The game consists of six LEDs and an indicator LED that flashes at a rate of about 2 cycles per second. A push button is the "Operations Control" and by carefully pushing the button in synchronisation with the flashing LED, the row of LEDs will gradually light up.

But the slightest mistake will immediately extinguish one, two or three LEDs. The aim of the game is to illuminate the 6 LEDs with the least number of pushes.

We have sold thousands of these kits. It's a great challenge.





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BFO METAL DETECTOR

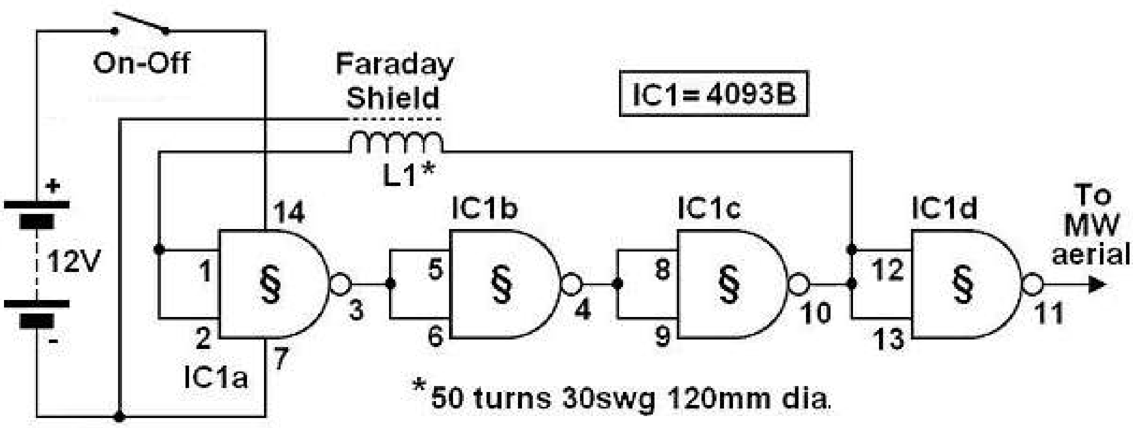
The circuit shown must represent the limits of simplicity for a metal detector. It uses a single 4093 quad Schmitt NAND IC and a search coil -- and of course a switch and batteries. A lead from IC1d pin 11 needs to be attached to a MW radio aerial, or should be wrapped around the radio. If the radio has a BFO switch, switch this ON.

Since an inductor resists rapid changes in voltage (called reactance), any change in the logic level at IC1c pin 10 is delayed during transfer back to input pins 1 and 2. This is further delayed through propagation delays within the 4093 IC. This sets up a rapid oscillation (about 2 MHz), which is picked up by a MW radio. Any change to the inductance of L1 (through the presence of metal) brings about a change to the oscillator frequency. Although 2 MHz is out of range of the Medium Waves, a MW radio will clearly pick up harmonics of this frequency.

The winding of the coil is by no means critical, and a great deal of latitude is permissible. The prototype used 50 turns of 22 awg/30 swg (0.315 mm) enamelled copper wire, wound on a 4.7"/120 mm former. This was then wrapped in insulation tape. The coil then requires a Faraday shield, which is connected to 0V. A Faraday shield is a wrapping of tin foil around the coil, leaving a small gap so that the foil does not complete the entire circumference of the coil. The Faraday shield is again wrapped in insulation tape. A connection may be made to the Faraday shield by wrapping a bare piece of stiff wire around it before adding the tape. Ideally, the search coil will be wired to the circuit by means of twin-core or figure-8 microphone cable, with the screen being wired to the Faraday shield.

The metal detector is set up by tuning the MW radio to pick up a whistle (a harmonic of 2 MHz). Note that not every such harmonic works best, and the most suitable one needs to be found. The presence of metal will then clearly change the tone of the whistle. The metal detector has excellent stability, and it should detect a large coin at 80 to 90 mm, which for a BFO detector is relatively good. It will also discriminate between ferrous and non-ferrous metals through a rise or fall in tone.

The author may be contacted at scarboro@iafrica.com



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SIMPLE BFO METAL LOCATOR

This circuit uses a single coil and nine components to make a particularly sensitive low-cost metal locator. It works on the principle of a beat frequency oscillator (BFO).

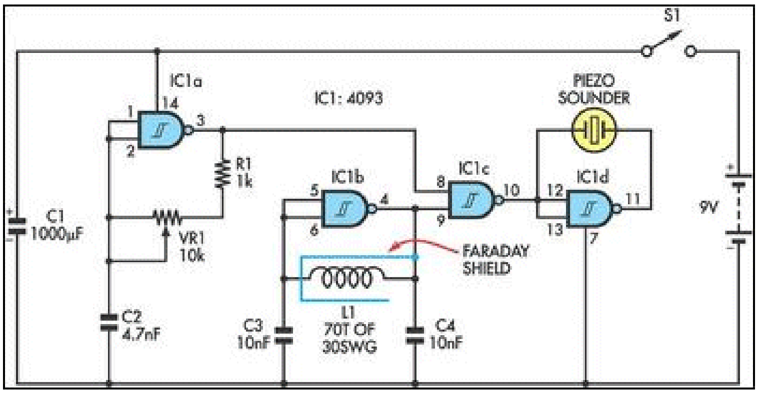
The circuit incorporates two oscillators, both operating at about 40kHz. The first, IC1a, is a standard CMOS oscillator with its frequency adjustable via VR1.

The frequency of the second, IC1b, is highly dependent on the inductance of coil L1, so that its frequency shifts in the presence of metal. L1 is 70 turns of 0.315mm enamelled copper wire wound on a 120mm diameter former. The Faraday shield is made of aluminum foil, which is wound around all but about 10mm of the coil and connected to pin 4 of IC1b.

The two oscillator signals are mixed through IC1c, to create a beat note. IC1d and IC1c drive the piezo sounder in push-pull fashion, thereby boosting the output.

Unlike many other metal locators of its kind, this locator is particularly easy to tune. Around the midpoint setting of VR1, there will be a loud beat frequency with a null point in the middle. The locator needs to be tuned to a low frequency beat note to one or the other side of this null point.

Depending on which side is chosen, it will be sensitive to either ferrous or non-ferrous metals. Besides detecting objects under the ground, the circuit could serve well as a pipe locator.



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1.5v to 5v PHONE CHARGER

Look at the photos. The circuit is simple. It looks like two surface-mount transistors, an inductor, diode, capacitor, resistor and LED.

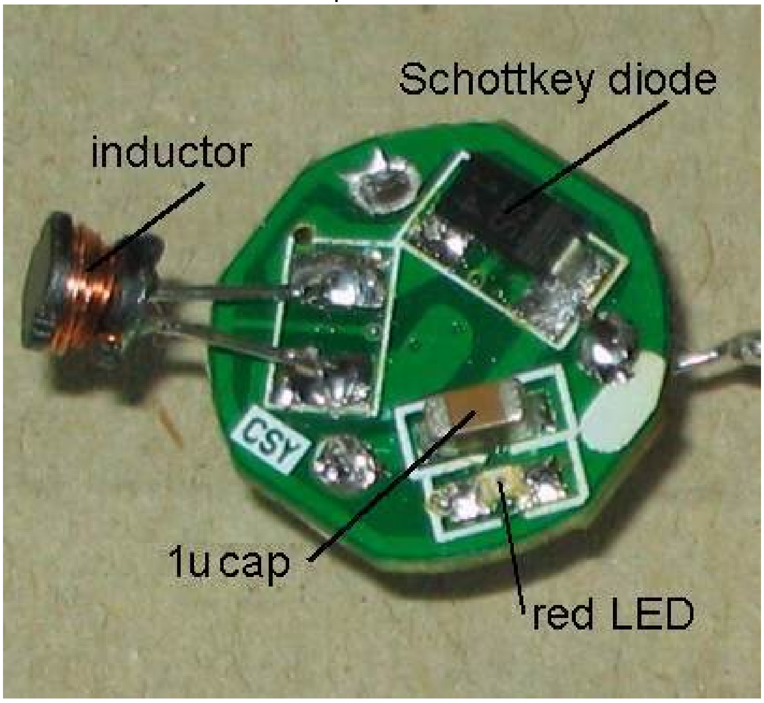
But you will be mistaken.

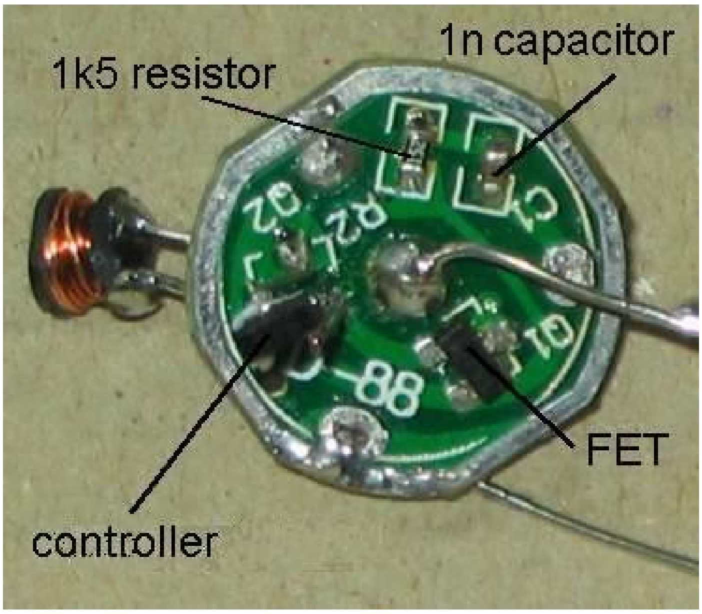
One of the "transistors" is a controller and the other is a FET.

The controller is powered from the output (5v) of the circuit and when it detects no-load, it shuts down and requires a very small current.

When the 1v5 batter is connected, the controller starts up at less than 1v5 due to the Schottkey diode and charges the 1u capacitor by driving the FET and using the flyback effect of the inductor to produce a high voltage. When the output voltage is 5v, the controller turns off and the only load on the 1u is the controller. When the voltage drops across this capacitor, the controller turns on in bursts to keep the 1u charged to exactly 5v. The charger was purchased for $3.00 so it is cheaper to buy one and use it in your own project. It also comes with 4 adapter leads!

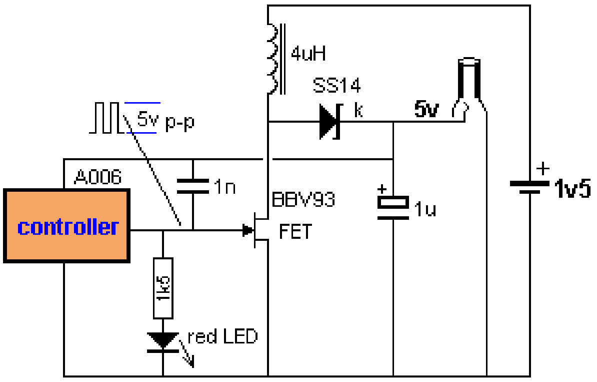
The AA case and 4 adapter leads - cost: $3.00!!





The controller has been placed on extension wires to test its operation.

The LED and 1u capacitor can be clearly seen in this photo.



PHONE CHARGER

Sometimes it is better to use something that is already available, rather than trying to re-invent the wheel. This is certainly the case with this project. You could not buy the components for the cost of the complete phone charger and extension leads.
The circuit will deliver 70mA at 5v and if a higher current is drawn, the voltage drops slightly.
These chargers were originally priced at $30.00 !!

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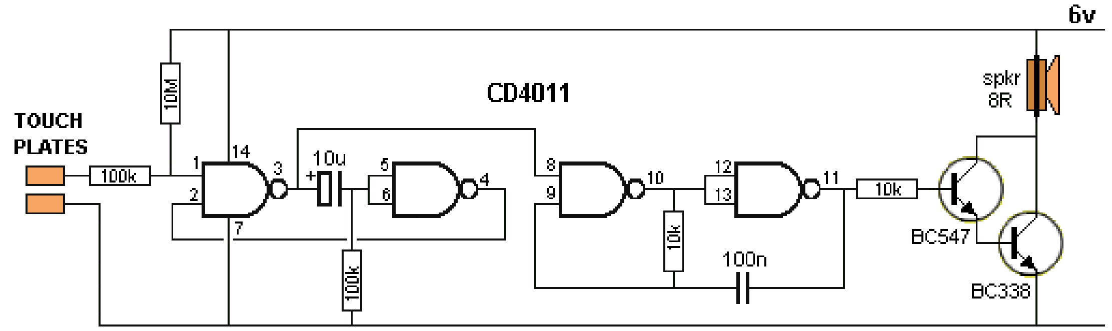
10 SECOND ALARM

This circuit is activated for 10 seconds via the first two gates. They form a LATCH to keep the oscillator (made up of the next two gates) in operation, to drive the speaker.
The circuit consumes a few microamps in quiescent mode and the TOUCH PLATES can be any type of foil on a door knob or item that is required to be protected. The 10u sits in an uncharged condition and when the plates are touched, the voltage on pin 1 drops below 50% rail and makes pin 3 HIGH. This pulls pins 5 and 6 HIGH and makes pin 4 LOW. This keeps pin 3 HIGH, no matter if a HIGH or LOW is on pin1. This turns on the oscillator and the 10u starts to charge via the 100k resistor. After about 10 seconds, the voltage on pins 5 and 6 drops to below 50% rail voltage and pin 4 goes HIGH. If the TOUCH PLATES are not touched, pin 3 will go LOW and the oscillator will stop.



10 SECOND ALARM

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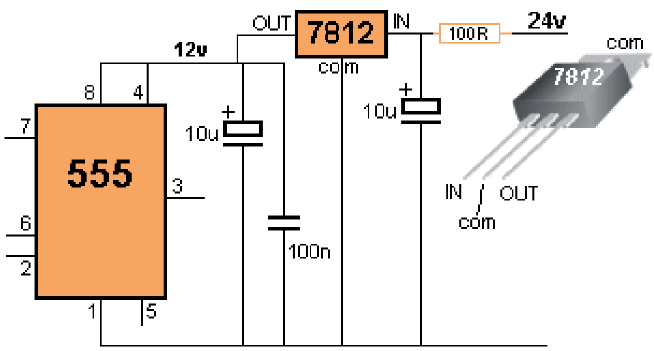
USING A VOLTAGE REGULATOR

This circuit shows how to use a voltage regulator to convert a 24v supply to 12v for a 555 chip. Note: the pins on the regulator (commonly called a 3-terminal regulator) are: IN, COMMON, OUT and these must match-up with: In, Common, Out on the circuit diagram.
If the current requirement is less than 500mA, a 100R "safety resistor" can be placed on the 24v rail to prevent spikes damaging the regulator.



using a voltage regulator

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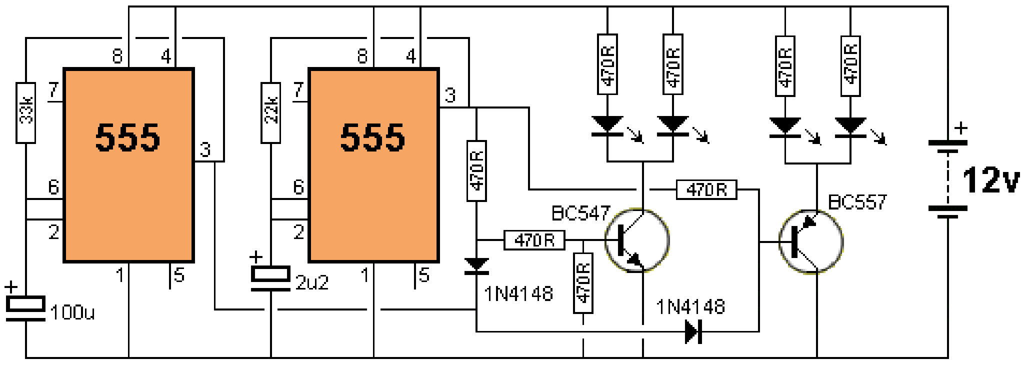
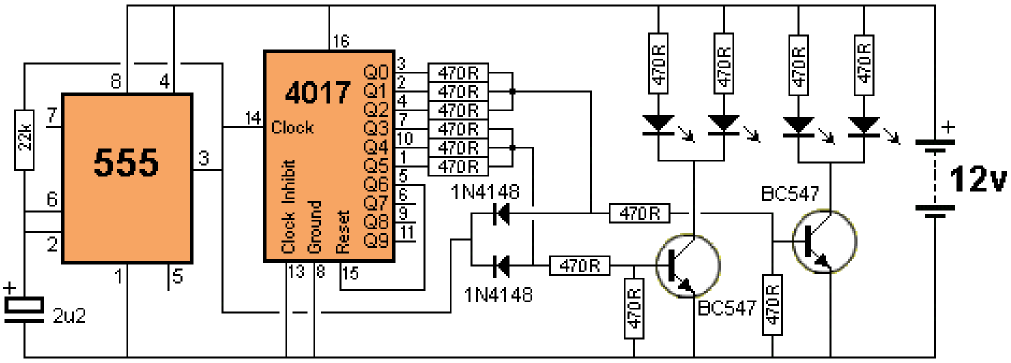
POLICE LIGHTS

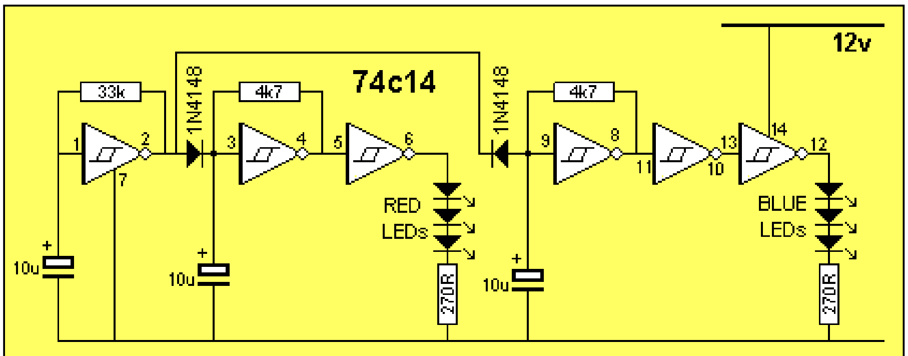
These three circuits flash the left LEDs 3 times then the right LEDs 3 times, then repeats. The only difference is the choice of chips.



POLICE LIGHTS



POLICE LIGHTS - 2



POLICE LIGHTS-3

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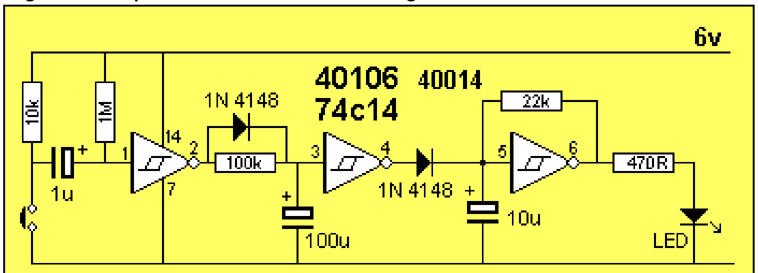
FLASH LEDS FOR 20 SECONDS

This circuit comes from a request from a reader. It flashes a LED for 20 seconds after a switch is pressed. In other words, for 20 seconds as soon as the switch is pressed. The values will need to be adjusted to get the required flash-rate and timing.



Flashes a LED for 20 seconds

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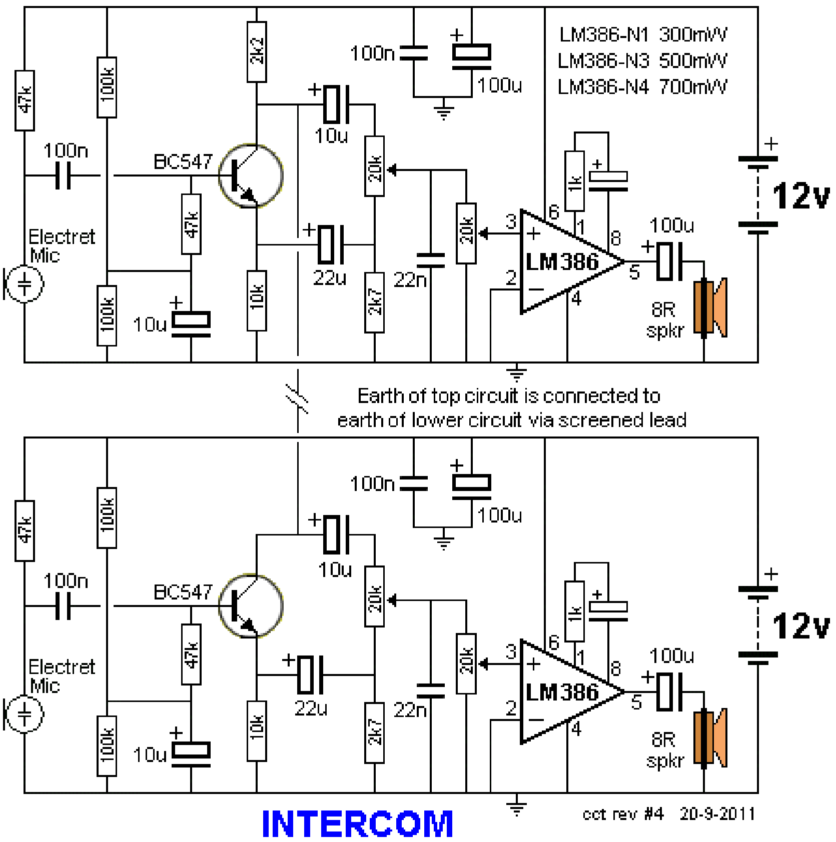
INTERCOM



This circuit uses a single transistor and LM386 amplifier IC to produce an intercom that allows hands-free operation.
As both microphones and loudspeakers are always connected, the circuit is designed to avoid feedback - known as the "Larsen effect".
The microphone amplifier transistor is 180° phase-shifted and one of the audio outputs is taken at the collector and its in-phase output taken at the emitter. These are mixed by the 10u, 22u, 20k pot and 2k7 so that the two signals almost cancel out. In this way, the loudspeaker will reproduce a very faint copy of the signals picked-up by the microphone.
At the same time, as both collectors of the two intercom units are tied together, the 180° phase-shifted signal will pass to the audio amplifier of the second unit without attenuation, so it will be loudly reproduced by its loudspeaker.
The same operation will occur when speaking into the microphone of the second unit. When the 20k pot is set correctly, almost no output will be heard from the loudspeaker but a loud and clear reproduction will be heard at the output of the other unit. The second 20k pot adjusts the volume.

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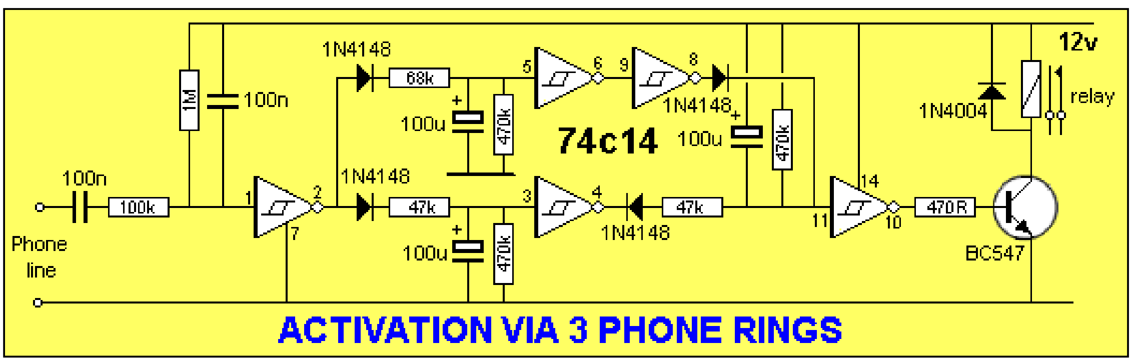
ACTIVATE VIA 3 PHONE RINGS

This circuit connects to a phone line. When the phone rings for 3 or 4 rings, the relay is activated for about 1 minute. But if the phone rings for 6 or more rings, the circuit is not activated.
The circuit takes less than 100uA when in quiescent state and when the phone rings, the ring voltage is passed to pin 1 via the 100k and 100n capacitor. This causes pin 2 to go HIGH and charge two 100u electrolytics. The lower 100u charges in 7 seconds and the upper charges in 12 seconds. If the phone rings for only 3 rings, pin 4 goes LOW and charges the third 100u via a 47k resistor. After a further 7 seconds, pin 10 goes HIGH. If the phone stops ringing after 3 rings, the lower 100u starts to discharge via the 470k and after about 40 seconds pin 4 goes HIGH. The third 100u now starts to discharge via the 470k across it and the relay turns off.
If the phone rings for more than 5 rings, the top 100u will charge and pin 6 will go LOW and cause pin 8 to go HIGH and prevent pin 11 going LOW via the gating diode.



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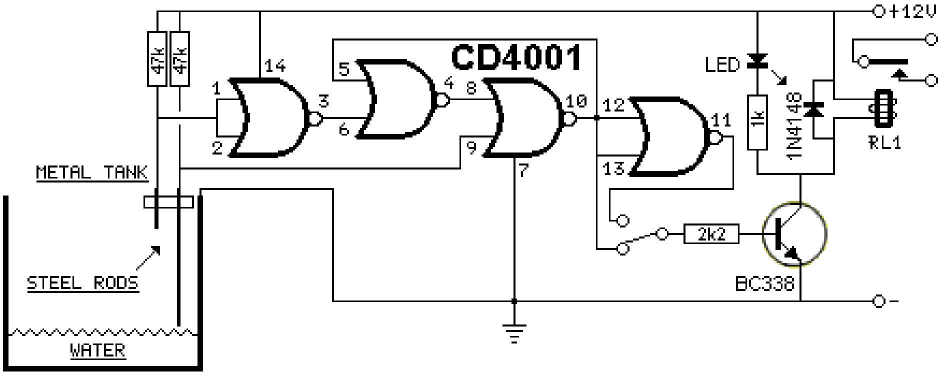
WATER LEVEL PUMP CONTROLLER

This circuit provides automatic level control of a water tank.
The shorter steel rod is the "water high" sensor and the longer is the "water low" sensor. When the water level is below both sensors, pin 10 is low. If the water comes in contact with the longer sensor the output remains low until the shorter sensor is reached. At this point pin11 goes high and the transistor conducts. The relay is energized and the pump starts operating. When the water level drops the shorter sensor will be no longer in contact with the water, but the output of the IC will keep the transistor tuned ON until the water falls below the level of the longer rod. When the water level falls below the longer sensor, the output of the IC goes low and the pump will stop.
The switch provides reverse operation. Switching to connect the transistor to pin 11 of the IC will cause the pump will operate when the tank is nearly empty and will stop when the tank is full. In this case, the pump will be used to fill the tank and not to empty it.
Note: The two steel rods must be supported by a small insulated (wooden or plastic) board. The circuit can be used also with non-metal tanks, provided a third steel rod having about the same height as the tank is connected to the negative.
Adding an alarm to pin 11 will let you know the tank is nearly empty.



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BRAKE LIGHTS

This circuit makes the brake lights flash a number of times then stay ON. The circuit shows how a MOSFET works. The MOSFET is turned on with a voltage between the gate and source. This occurs in the circuit when the gate is LOW. The P-channel MOSFET can be replaced by a PNP transistor with the addition of a 2k2 between the diode and base, to prevent the transistor being damaged when output pin 3 goes LOW. Ideally the PNP transistor should be replaced with a Darlington transistor.
This circuit originally designed by:

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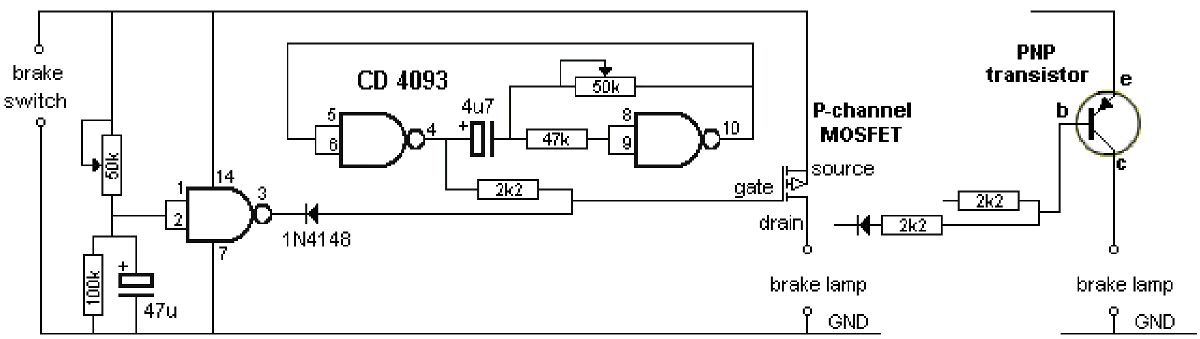
Scientific Instrumentation
Macalester College
1600 Grand Avenue
St Paul MN 55105
moffett@macalester.edu

See the full article:
http://www.sentex.net/~mec1995/circ/motflash.html .pdf of article



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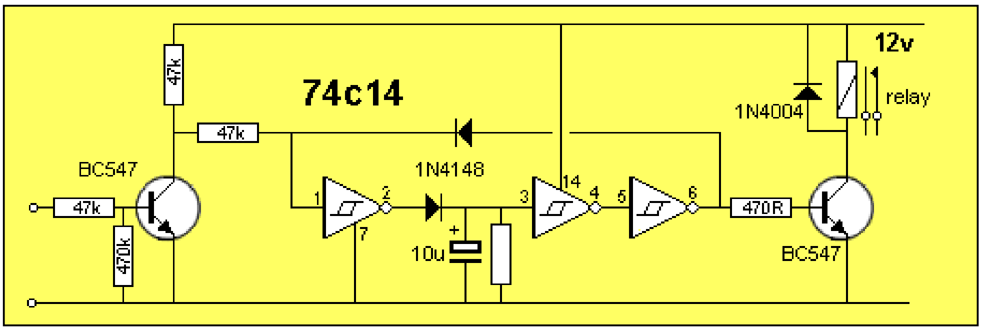
ACTIVE FOR 1 SECOND

This circuit is active for 1 second after it detects a signal on the base of the input transistor. The length of activation depends on the value of the resistor across the 10u electrolytic.
When pin 1 goes LOW, pin 2 goes HIGH and charges the 10u. Pin 3 goes HIGH, pin 4 goes LOW and pin 6 goes HIGH to turn on the transistor and activate the relay.
At the same time a HIGH is passed to pin 1 to keep it HIGH.
Pin 2 will be kept LOW and the 10u will discharge via the resistor across it and eventually pin 3 will go LOW and the relay will turn off. If a signal is still present on the base of the input transistor, the relay will remain energised as the circuit will charge the 10u again.



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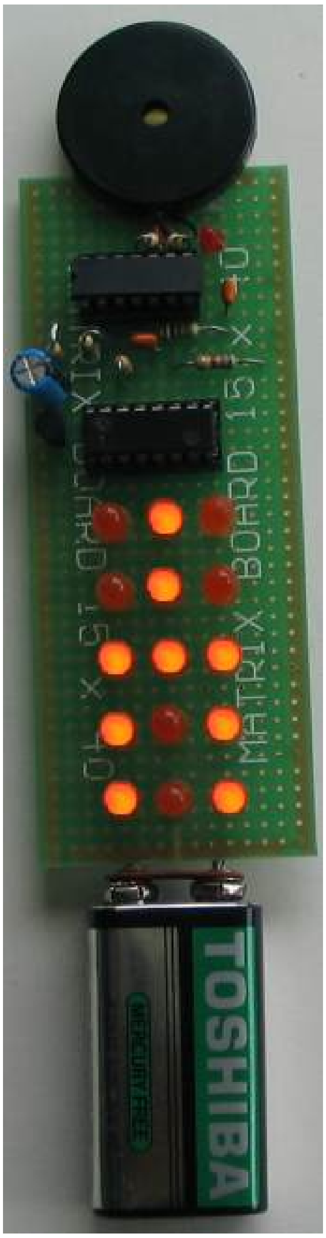
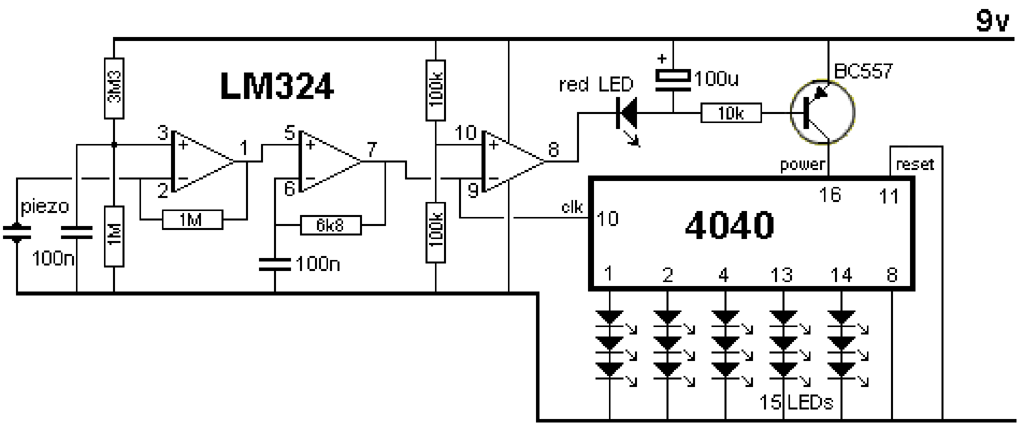
THE DOMINO EFFECT   see full project HERE



Here's a project with an interesting name. The original design was bought over 40yearsa ago, before the

introduction of the electret microphone. They used a crystal earpiece.
We have substituted it with a piezo diaphragm and used a quad op-amp to produce two building blocks.
The first is a high-gain amplifier to take the few millivolts output of the piezo and amplify it sufficiently to drive the input of a counter chip. This requires a waveform of at least 6v for a 9v supply and we need a gain of about 600.
The other building block is simply a buffer that takes the high-amplitude waveform and delivers the negative excursions to a reservoir capacitor (100u electrolytic). The charge on this capacitor turns on a BC557 transistor and this effectively takes the power pin of the counter-chip to the positive rail via the collector lead.
The chip has internal current limiting and some of the outputs are taken to sets of three LEDs.
The chip is actually a counter or divider and the frequency picked up by the piezo is divided by 128 and delivered to one output and divided by over 8,000 by the highest-division output to three more LEDs The other lines have lower divisions.
This creates a very impressive effect as the LEDs are connected to produce a balanced display that changes according to the beat of the music.
The voltage on the three amplifiers is determined by the 3M3 and 1M voltage-divider on the first op-amp. It produces about 2v. This makes the output go HIGH and it takes pin 2 with it until this pin see a few millivolts above pin3. At this point the output stops rising.
Any waveform (voltage) produced by the piezo that is lower than the voltage on pin 3 will make the output go HIGH and this is how we get a large waveform.
This signal is passed to the second op-amp and because the voltage on pin 6 is delayed slightly by the 100n capacitor, is also produces a gain.
When no signal is picked up by the piezo, pin 7 is approx 2v and pin 10 is about 4.5v. Because pin 9 is lower than pin 10, the output pin 8 is about 7.7v (1.3v below the supply rail) as this is as high as the output will go - it does not go full rail-to-rail.
The LED connected to the output removes 1.7v, plus 0.6v between base and emitter and this means the transistor is not turned on.
Any colour LEDs can be used and a mixture will give a different effect.
Click the link above for more details on the project, including photos and construction notes.



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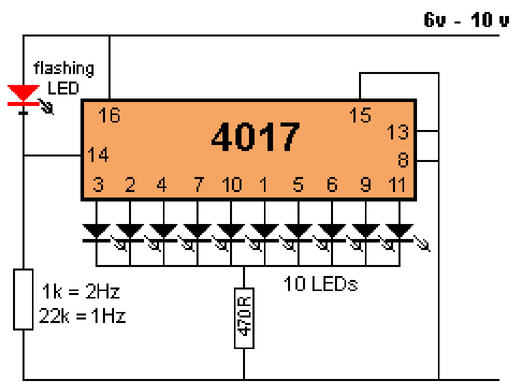
10 LED CHASER

Here's an interesting circuit that creates a clock pulse for a 4017 from a flashing LED. The flashing LED takes almost no current between flashes and thus the clock line is low via the 1k to 22k resistor. When the LED flashes, the voltage on the clock line is about 2v -3v below the rail voltage (depending on the value of the resistor) and this is sufficient for the chip to see a HIGH.



(circuit designed on 9-10-2010)

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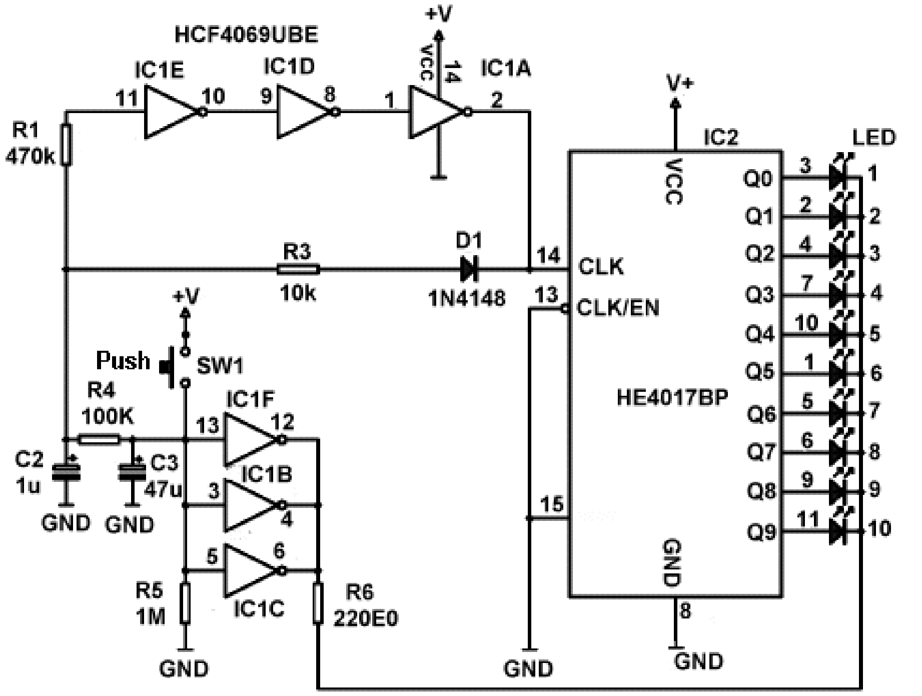
WHEEL OF FORTUNE

Here's a circuit from Vellemann.
The slow-down circuit consists of the top three gates, R3, D1, C2, R4 and C3.
Sw1 is pressed for a brief period.
This charges the 47u and the 1u is charged via the 100k.
The voltage on the 1u rises until it puts a HIGH on input pin 11.
This puts a LOW on pin 2 and the voltage on the 1u drops until the voltage on pin 11 is a LOW.
The voltage fluctuates at about half rail voltage as it puts a HIGH and LOW on Pin 11. It is charged by the 100k and discharged by the 10 and diode.
The HIGH on pin 2 allows the 1u to charge via the 100k and this gradually reduces the voltage on the 47u.
As the voltage on the 47u falls, the time taken to charge the 1u increases and creates the slow-down effect. Eventually the voltage on the 1u is not enough to put a HIGH on Pin 11 and the circuit freezes.



Wheel of Fortune

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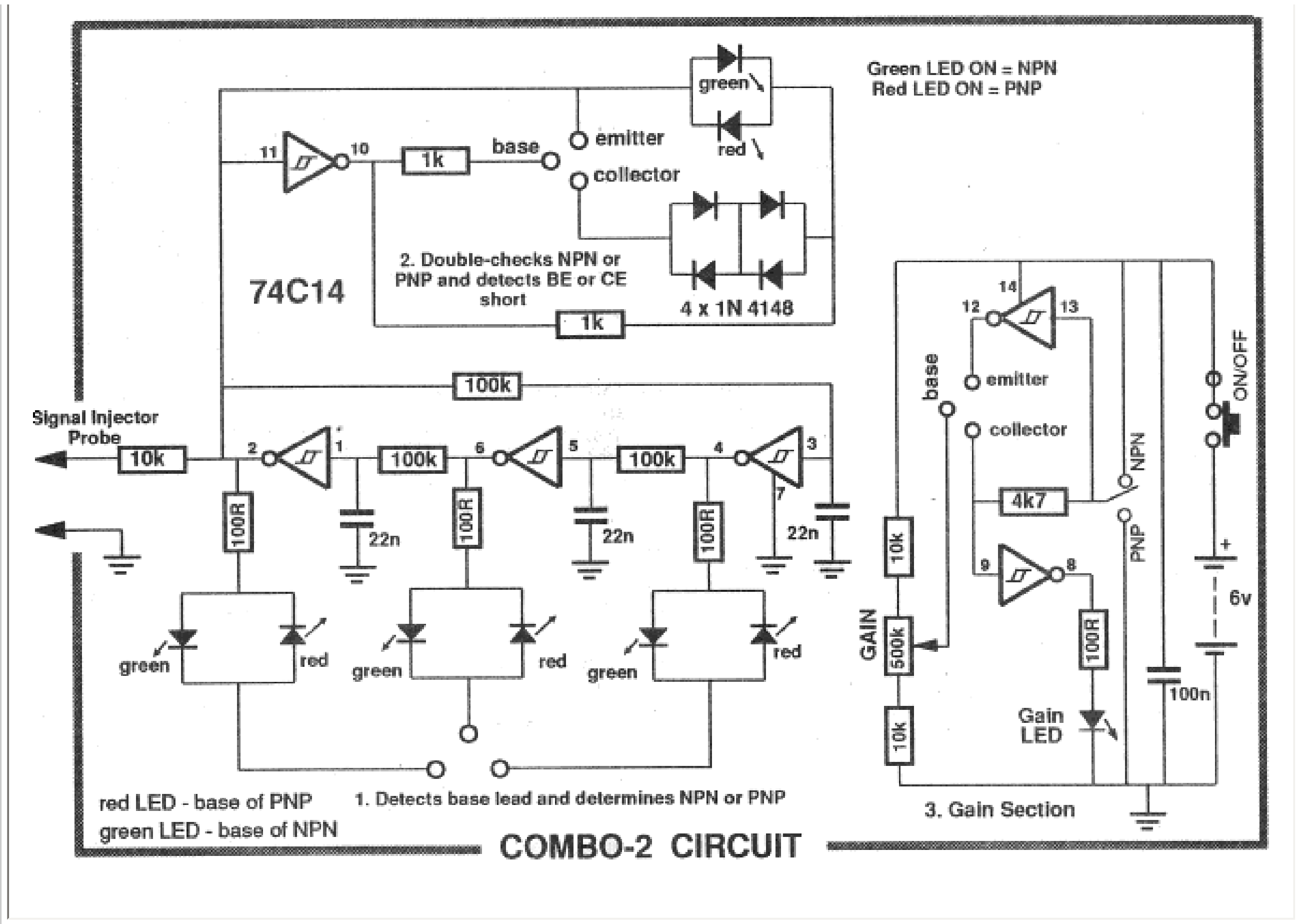
TRANSISTOR TESTER   COMBO-2

The circuit uses a single IC to perform 3 tests:
Test 1: Place the transistor in any orientation into the three terminals of circuit 1 (below, left) and a red LED will detect the base of a PNP transistor an a green LED will indicate the base of an NPN transistor.
Test 2: You now now the base lead and the type of transistor. Place the transistor in Test 2 circuit (top circuit) and when you have fitted the collector and emitter leads correctly (maybe have to swap leads), the red or green LED will come on to prove you have fitted the transistor correctly.
Test 3: The transistor can now be fitted in the GAIN SECTION. Select PNP or NPN and turn the pot until the LED illuminates. The value of gain is marked on the PCB that comes with the kit. The kit has ezy clips that clip onto the leads of the transistor to make it easy to use the project.
The project also has a probe at one end of the board that produces a square wave - suitable for all sorts of audio testing and some digital testing.
Project cost: $22.00 from Talking Electronics.



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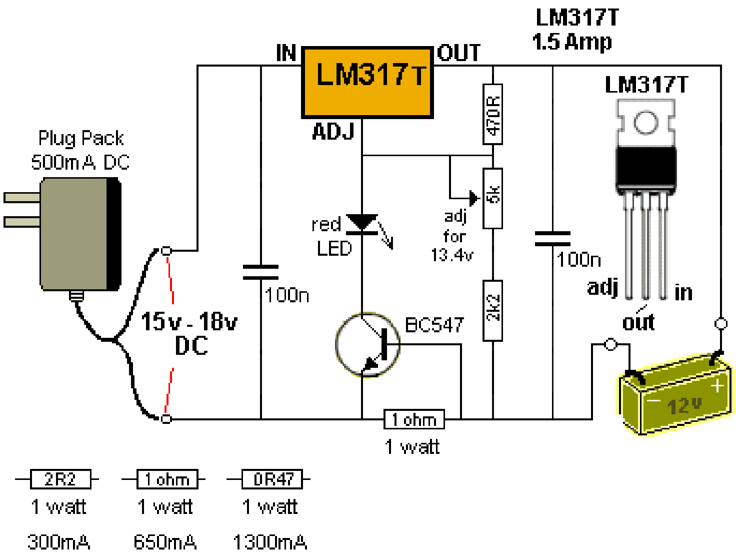
GELL CELL BATTERY CHARGER

This circuit will charge gell cell batteries at 300mA or 650mA or 1.3A, depending on the CURRENT SENSING resistor in the 0v rail. Adjust the 5k pot for 13.4v out and when the battery voltage reaches this level, the current will drop to a few milliamps. The plug pack will need to be upgraded for the 650mA or 1.3A charge-current. The red LED indicates charging and as the battery voltage rises, the current-flow decreases. The maximum is shown below and when it drops about 5%, the LED turns off and the current gradually drops to almost zero.



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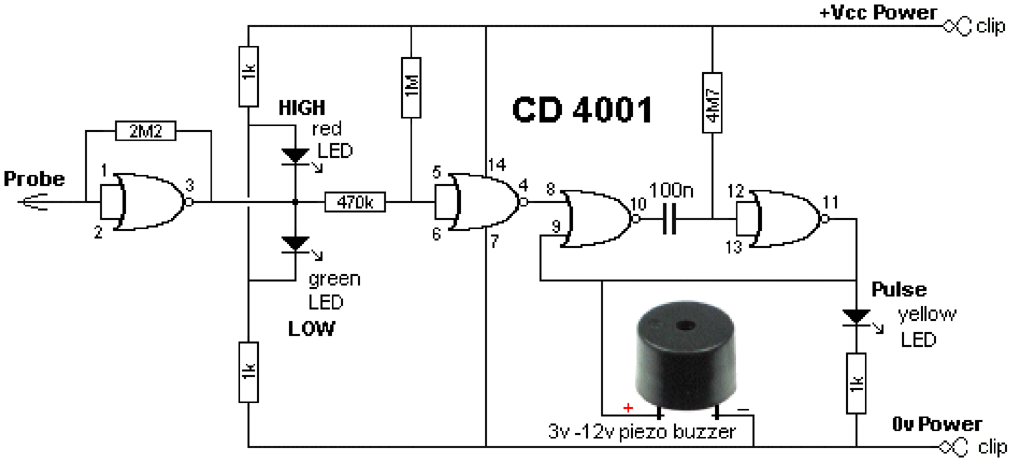
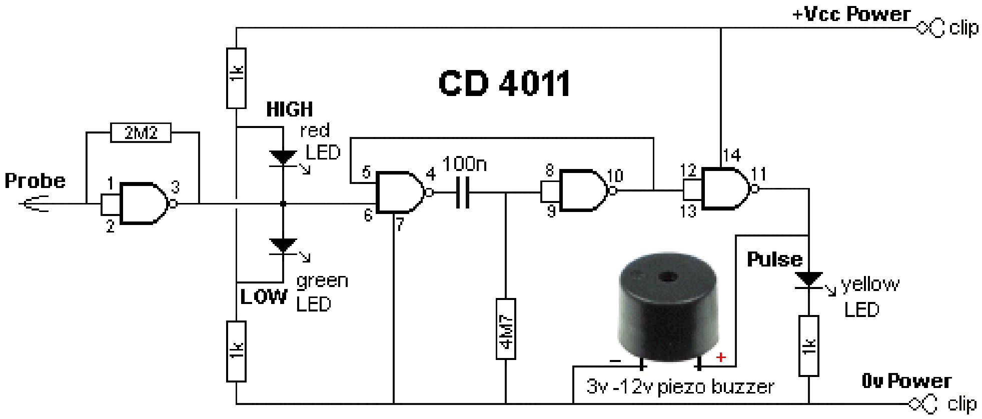
SIMPLE LOGIC PROBE

Here is a simple Logic Probe using a single chip. The circuits have been designed for the CD4001 CMOS quad NOR gate and CD4011 CMOS NAND gate. The output has an active buzzer that produces a beep when the pulse LED illuminates (the buzzer is not a piezo-diaphragm but an active buzzer containing components).



LOGIC PROBE USING CD 4001



LOGIC PROBE USING CD 4011

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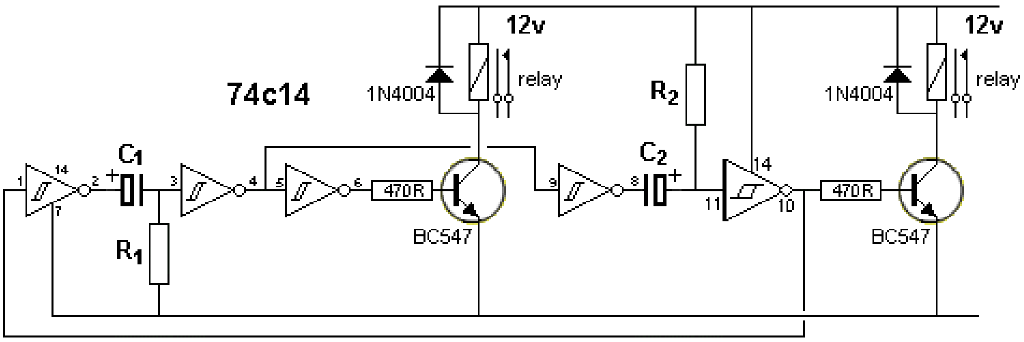
10 MINUTE AND 30 MINUTE TIMER



This circuit turns on the first relay for any period of time as determined by the value of C1 and R1. When relay 1 turns off, relay 2 turns ON for any period of time as determined by C2 and R2. When relay 2 turns off, relay 1 turns ON and the cycle repeats.

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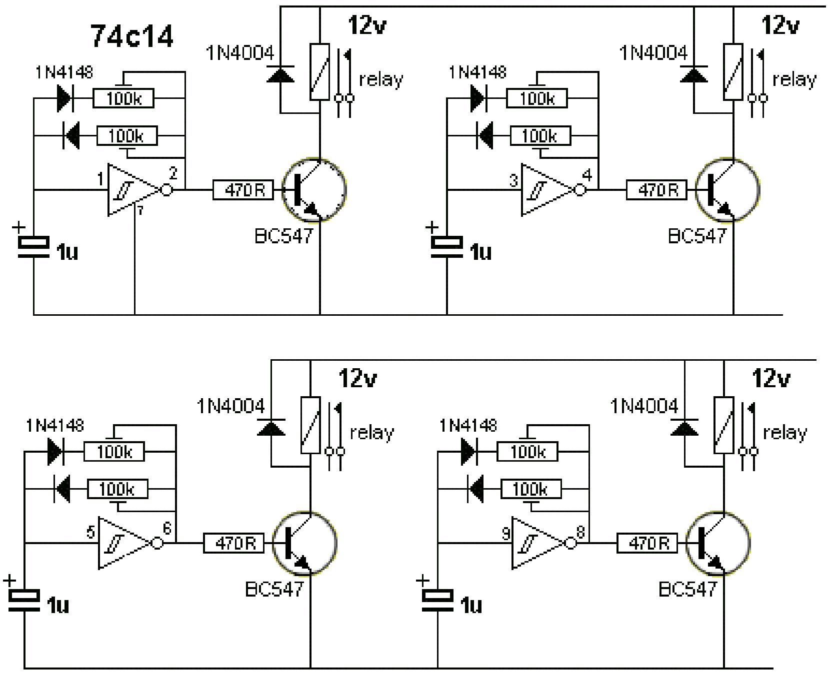
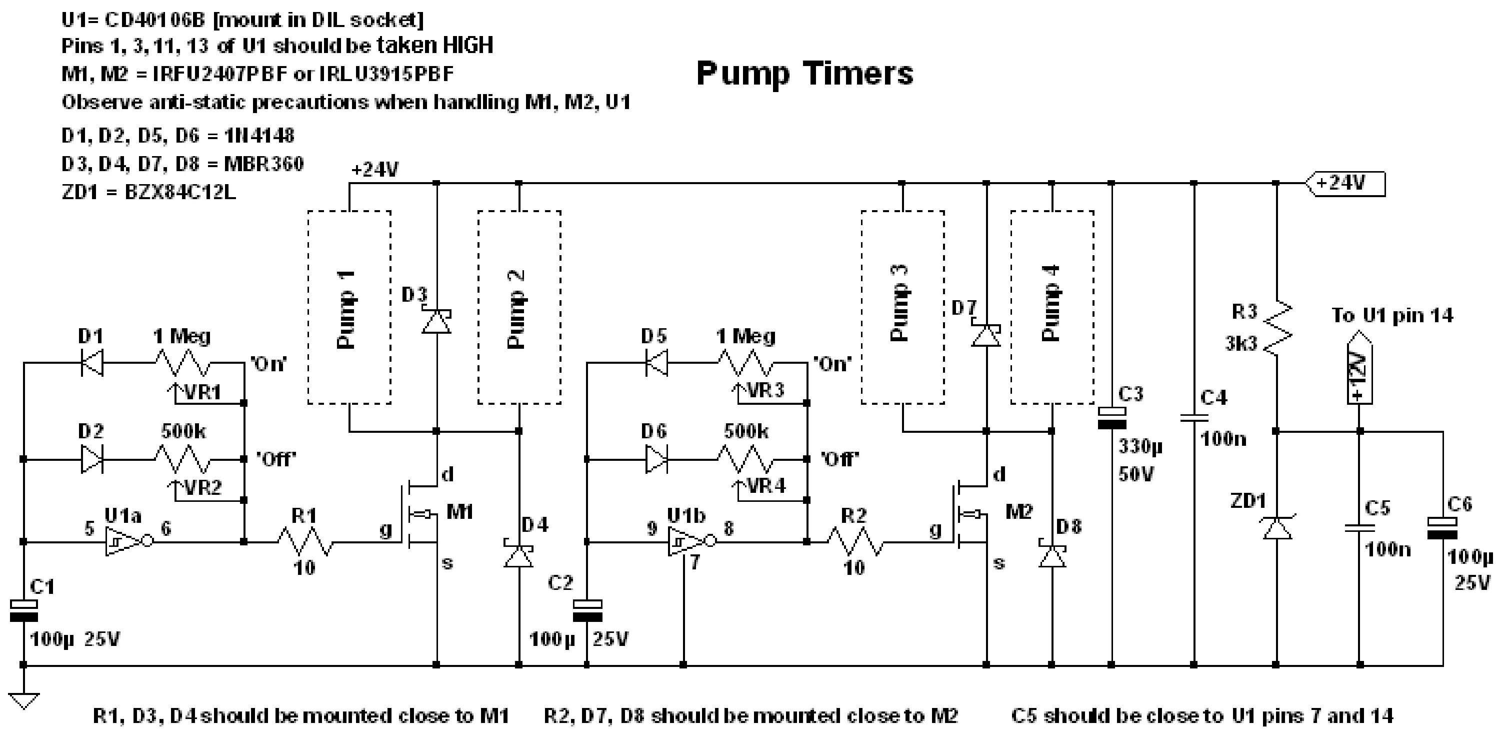
4 PUMPS

This circuit has been requested by a reader. He wanted 4 pumps to operate randomly in his water-fountain feature. A 74C14 IC can be used to produce 4 timing circuits with different on-off values. The trim-pots can be replaced with resistors when the desired effect has been created.





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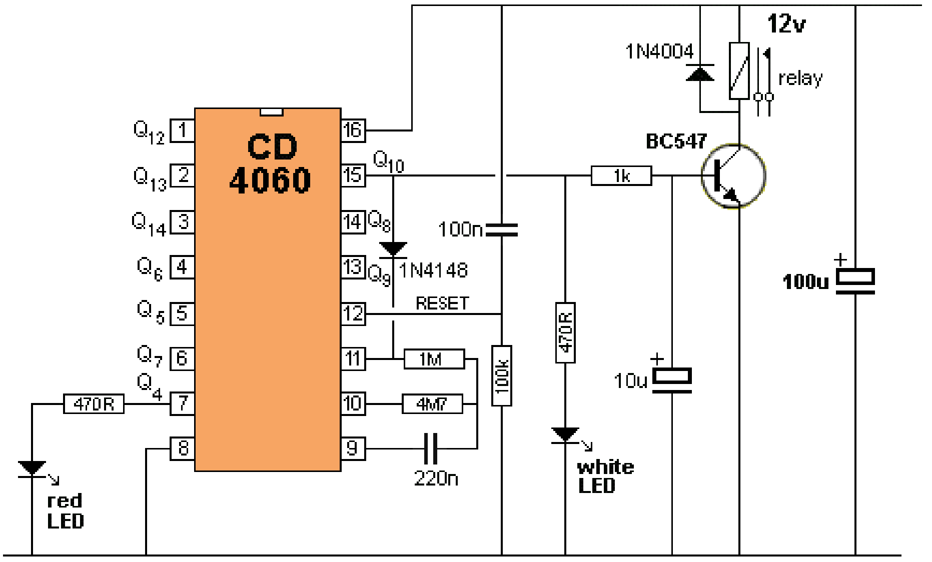
LONG DURATION TIMER

To get a long duration timer we can create an oscillator, called a CLOCK OSCILLATOR, and feed it to a number of flip-flops. A flip-flop is a form of bi-stable multivibrator, wired so an input signal will change the output on every second cycle. In other words it divides (halves) the input signal. When two of these are connected in a "chain" the input signal divides by 4. The CD4060 IC has 14 stages. These are also called BINARY DIVIDERS and the chip is also called a COUNTER.

The IC also has components (called gates or inverters) on pins 9,10 and 11 that can be wired to produce an oscillator. Three external components are needed to produce the duration of the oscillations. In other words the frequency of the "clock signal."

The output of the oscillator is connected (inside the chip) to the Binary Dividers and each stage goes HIGH then LOW due to the signal it is receiving. Each stage rises and falls at a rate that is half the previous stage and the final stage provides the long time delay as it takes 2^{13} clock cycles before going HIGH. We have only taken from Q10 in this circuit and

the outline of the chip has been provided in the circuit so different outputs can be used to produce different timings.
The diode on the output "jams" the oscillator and stops it operating so the relay stays active when the time has expired.



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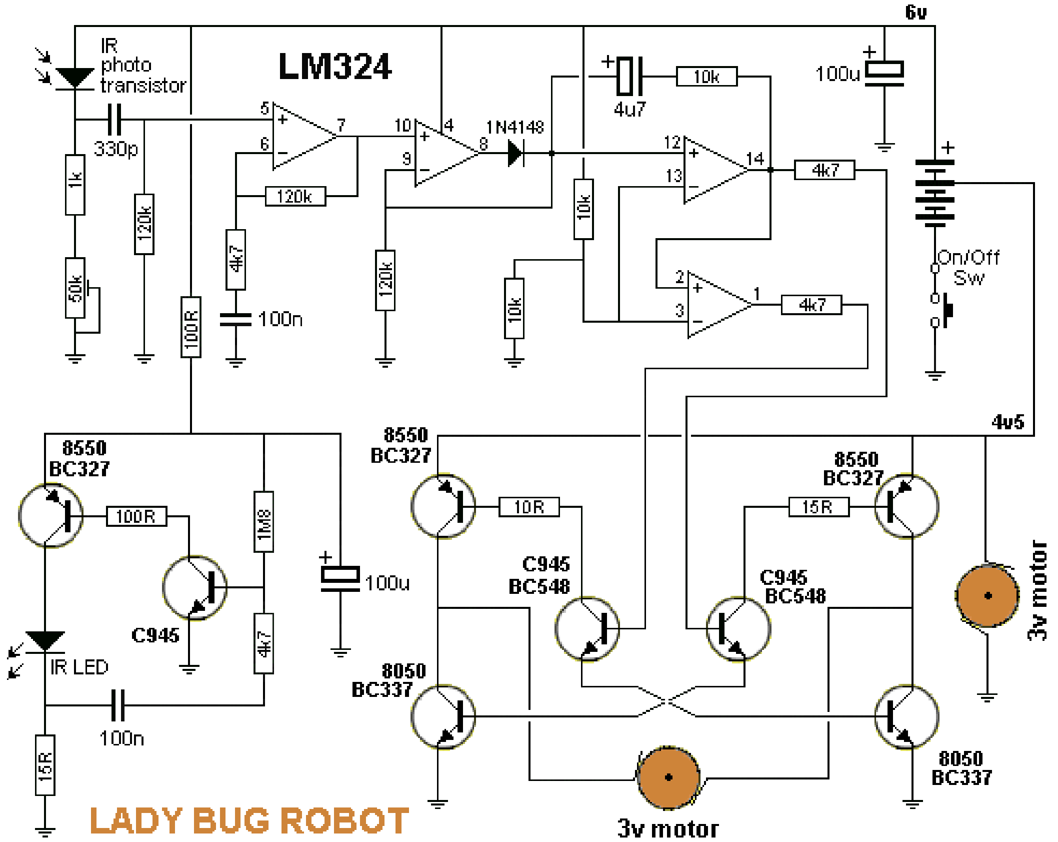
LADYBUG ROBOT

Ladybug Robot moves with its six legs and makes use of infrared emitting diodes as its eyes to avoid obstacles along its path. Ladybug automatically makes a left turn the moment it detects an object in its path. It continues to move forward again when no obstacle is in the way.



See Hex Bug in "200 Transistor Circuits" for a transistor version of this circuit.

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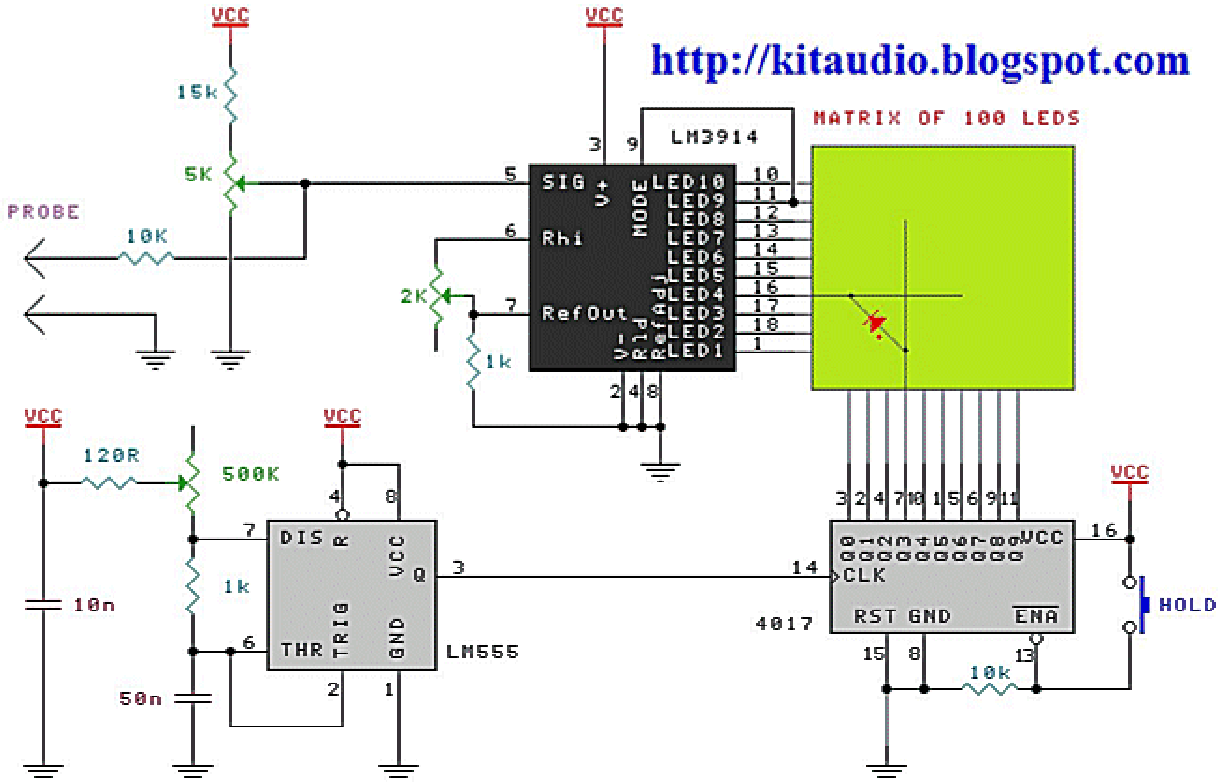
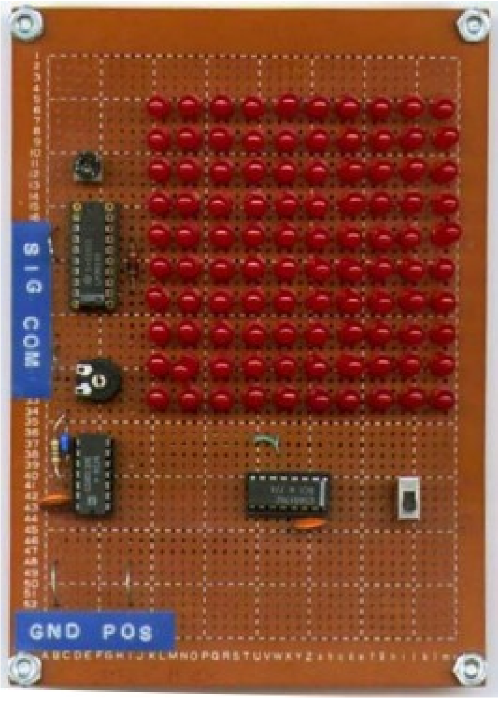
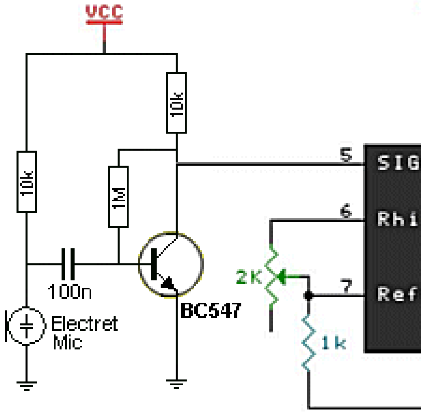
100 LED CRO



This circuit produces a "trace" on a set of 100 LEDs, just like a Cathode Ray Oscilloscope. It is only suitable for low frequency signals such as audio but can also reproduce low-frequency square waves. It's fun to talk into the microphone and see the result on the screen. Add the audio amplifier below to the input of the LM3914 dot/bar Display Driver (that has been set to dot-mode). To see a trace across the centre of the screen. The audio will raise and lower the trace to produce a waveform.
The photo on the right shows the authors model.





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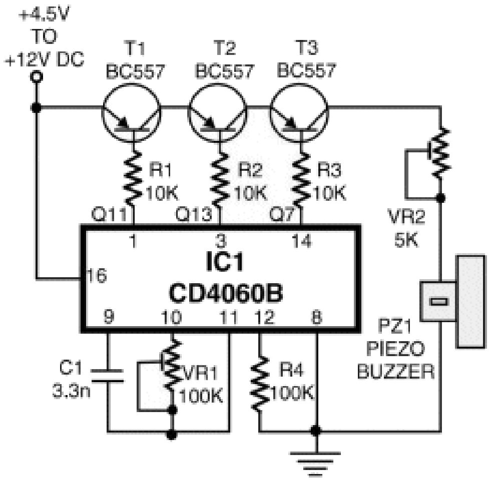
PHONE RINGER

This circuit shows how a very complex set of pulses can be produced via a very simple circuit.
The CD4060B IC produce three kinds of pulses. Preset VR1 is fine-tuned to get 0.3125Hz pulses at pin 3 of IC1. At the same time, pulses obtainable from pin 1 will be of 1.25 Hz and 20 Hz at pin 14. The three output pins of IC1 are connected to base terminals of transistors T1, T2, and T3 through resistors R1, R2, and R3, respectively.
 Working with a built-in oscillator-type piezo buzzer generates about 1kHz tone. In this particular circuit, the piezo-buzzer is turned 'on' and 'off' at 20 Hz for ring tone sound by transistor T3. 20Hz pulses are obtainable at the collector of transistor T3 for 0.4-second duration. Just after a time interval of 0.4 second, 20Hz pulses become again obtainable for another 0.4-second duration. This is followed by two seconds of no sound interval. Thereafter the pulse pattern repeats by itself.



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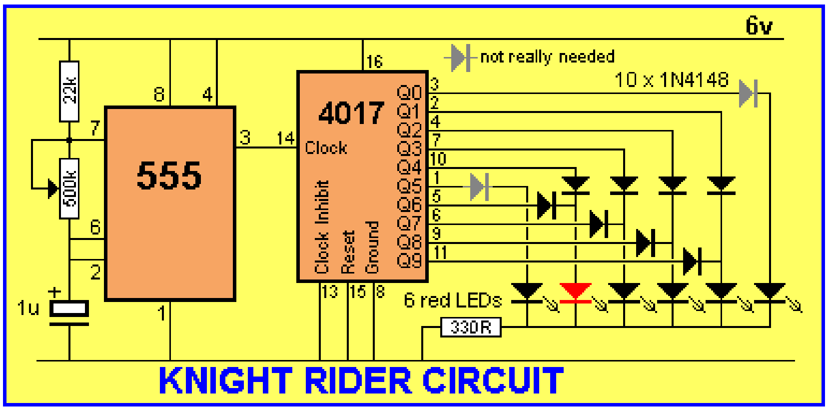
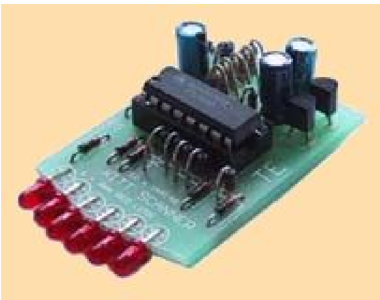
KNIGHT RIDER

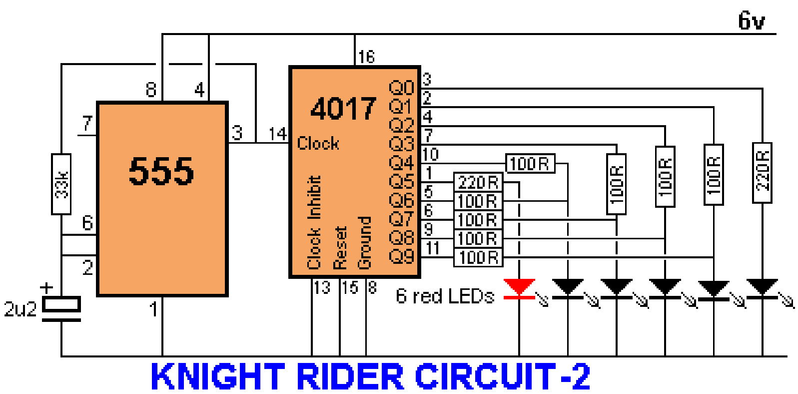
In the Knight Rider circuit, the 555 is wired as an oscillator. It can be adjusted to give the desired speed for the display. The output of the 555 is directly connected to the input of a Johnson Counter (CD 4017). The input of the counter is called the CLOCK line.
The 10 outputs Q_0 to Q_9 become active, one at a time, on the rising edge of the waveform from the 555. Each output can deliver about 20mA but a LED should not be connected to the output without a current-limiting resistor (330R in the circuit above).
The first 6 outputs of the chip are connected directly to the 6 LEDs and these "move" across the display. The next 4 outputs move the effect in the opposite direction and the cycle repeats. The animation above shows how the effect appears on the display.
Using six 3mm LEDs, the display can be placed in the front of a model car to give a very realistic effect. The same outputs can be taken to driver transistors to produce a larger version of the display.



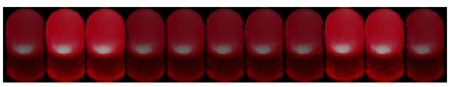
The Knight Rider circuit is available as a kit for less than $15.00 plus postage as Kitt Scanner.

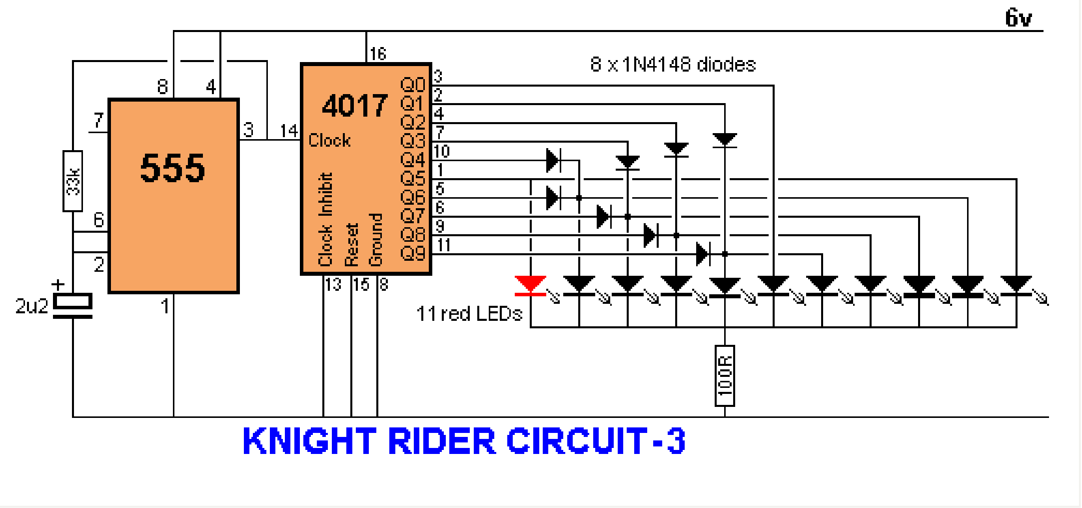


Here is a simple Knight Rider circuit using resistors to drive the LEDs. This circuit consumes 22mA while only delivering 7mA to each LED. The outputs are "fighting" each other via the 100R resistors (except outputs Q0 and Q5).



This circuit drives 11 LEDs with a cross-over effect:





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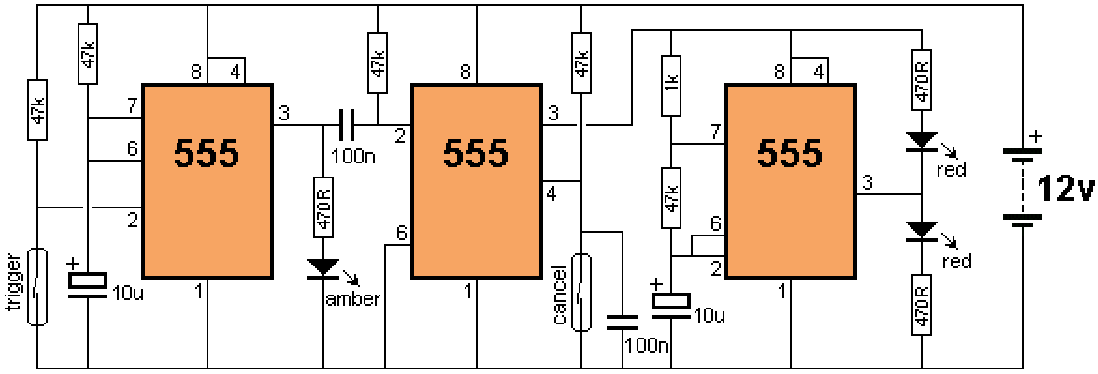
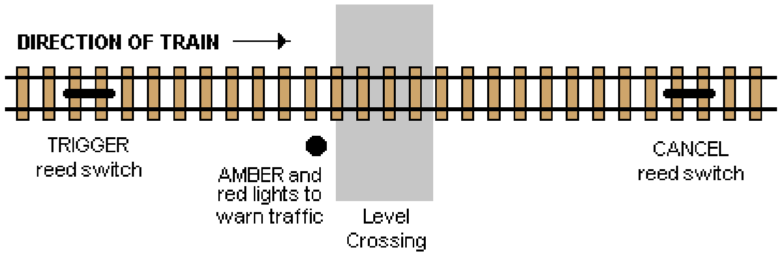
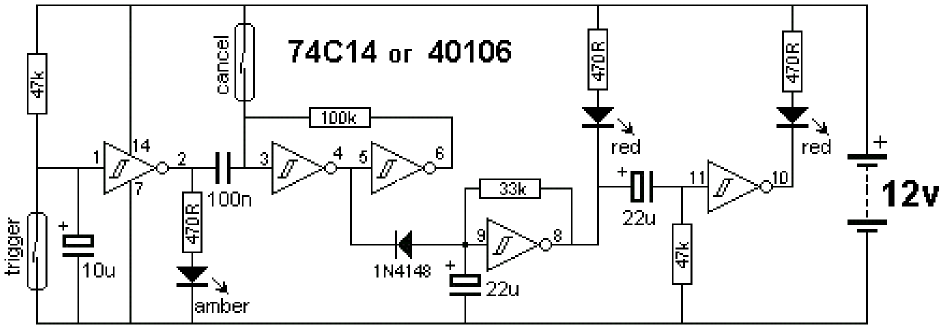
CROSSING LIGHTS

A magnet on the train activates the TRIGGER reed switch to turn on the amber LED for a time determined by the value of the first 10u and 47k.
When the first 555 IC turns off, the 100n is uncharged because both ends are at rail voltage and it pulses pin 2 of the middle 555 LOW. This activates the 555 and pin 3 goes HIGH. This pin supplies rail voltage to the third 555 and the two red LEDs are alternately flashed. When the train passes the CANCEL reed switch, pin 4 of the middle 555 is taken LOW and the red LEDs stop flashing.
See it in action: Movie (4MB)





The circuit can also be constructed with a 40106 HEX Schmitt trigger IC (74C14). The 555 circuit consumes about 30mA when sitting and waiting. The 40106 circuit consumes less than 1mA.



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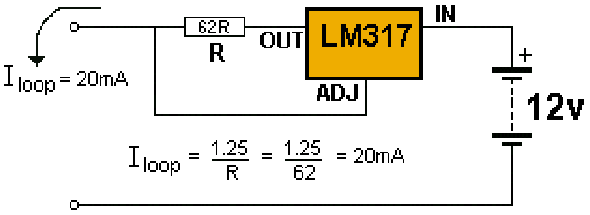
20mA CONSTANT-CURRENT GENERATOR

This circuit produces a constant 20mA current with an output voltage approx 3v lower than the battery voltage.
It uses an LM317 adjustable regulator which has a voltage-drop of about 3v between the IN and OUT terminals. If the battery voltage is 12v, the circuit will deliver about 9v at 20mA. The regulator has an internal voltage reference of 1.25v between OUT and ADJUST pins and when a resistor is placed between the OUT pin and the circuit being supplied, the current flowing through the resistor will produce a voltage-drop. As the current required by the circuit increases, the voltage across this resistor will increase. When it is 1.25v, the current will be 20mA. If the current increases due to the output resistance decreasing, the voltage across the resistor increases and the LN317 reduces the output voltage. This causes the current to reduce to 20mA. This is how the circuit produces a constant current.
The output current can be changed to any value according to the formula shown below.



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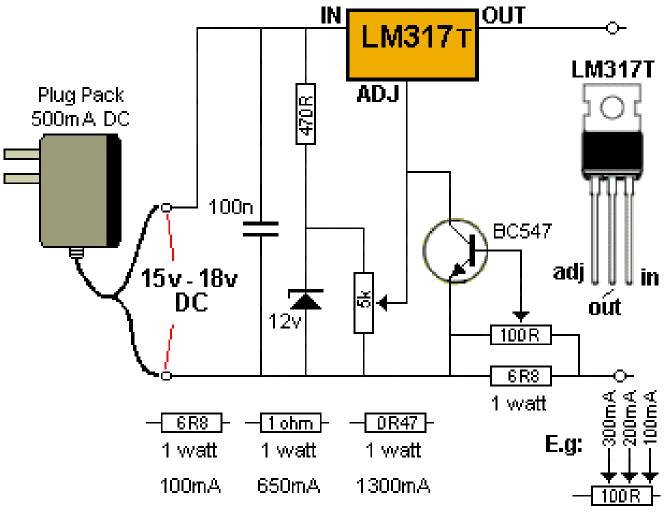
ADJUSTABLE VOLTAGE AND CURRENT LIMITING

The single regulator in this circuit will provide a variable voltage from 1.225v to 12v or more, depending on the voltage of the plug pack and the zener diode. The current will also depend on the rating of the plug pack.
As soon as the current reaches the limit set by the 100R pot, the BC547 transistor starts to turn on and rob the regulator of voltage on the Adj pin. The output voltage starts to reduce. If the output is shorted, the output voltage will reduce to almost zero.



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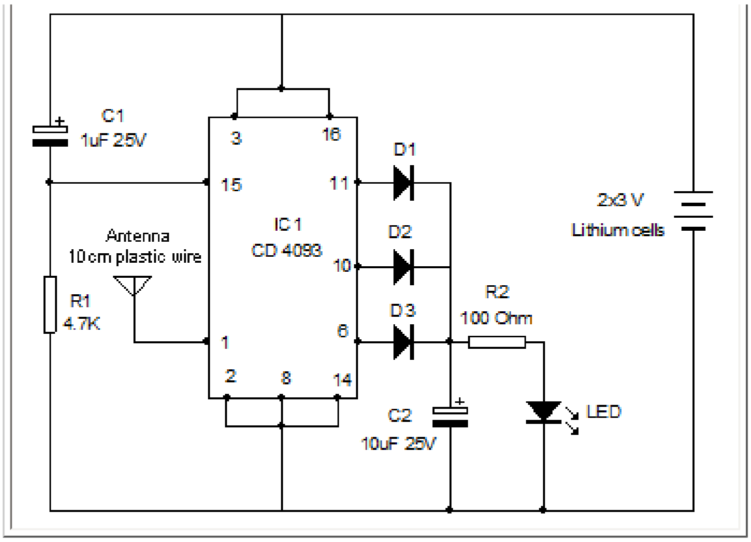
MAINS DETECTOR

This circuit will detect active mains at 15cm. Mains wiring must not be touched. Many CMOS chips can be used for this purpose. CD 4017, 4020, 4040 as they all have very sensitive inputs.



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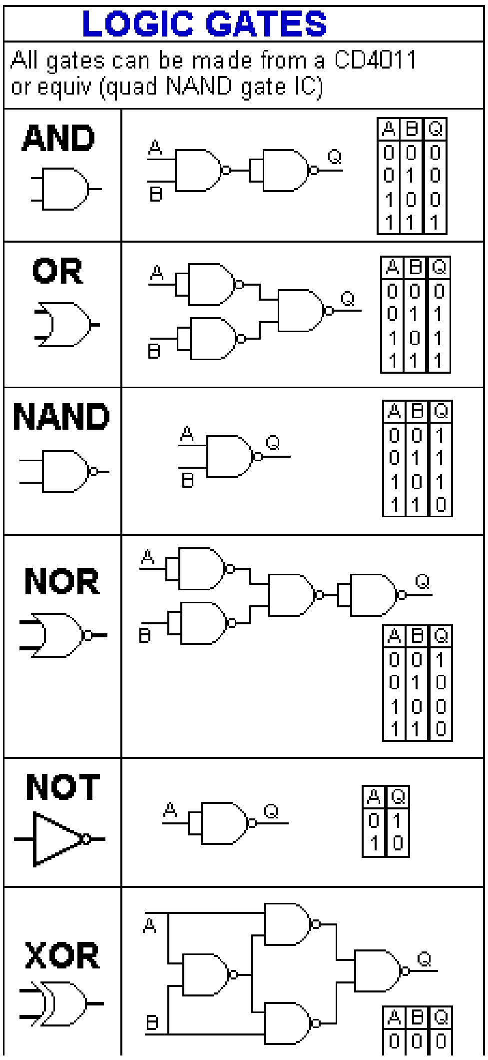

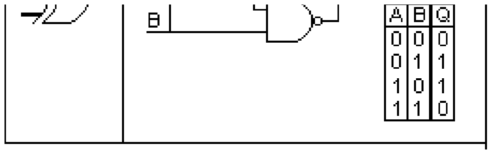

LOGIC GATES
It's very handy to remember that all the logic gates can be made from a Quad NAND gate such as CD4011.

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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 complex.

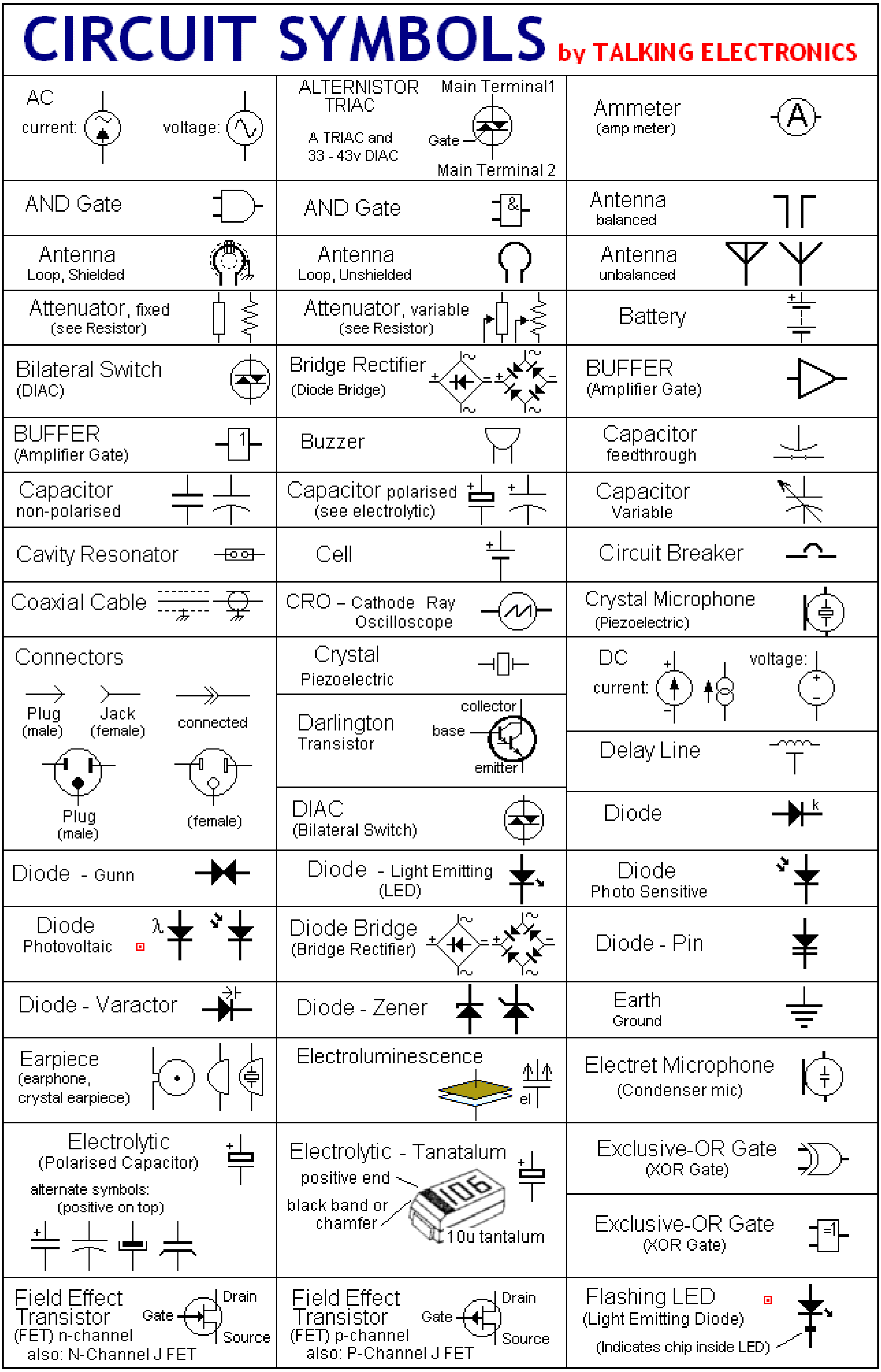
This is very important to remember with transistors, voltage regulators, chips and so many other components as the position of the pins on the symbol are not in the same places as the pins or leads on the component and sometimes the pins have different functions according to the manufacturer. Sometimes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

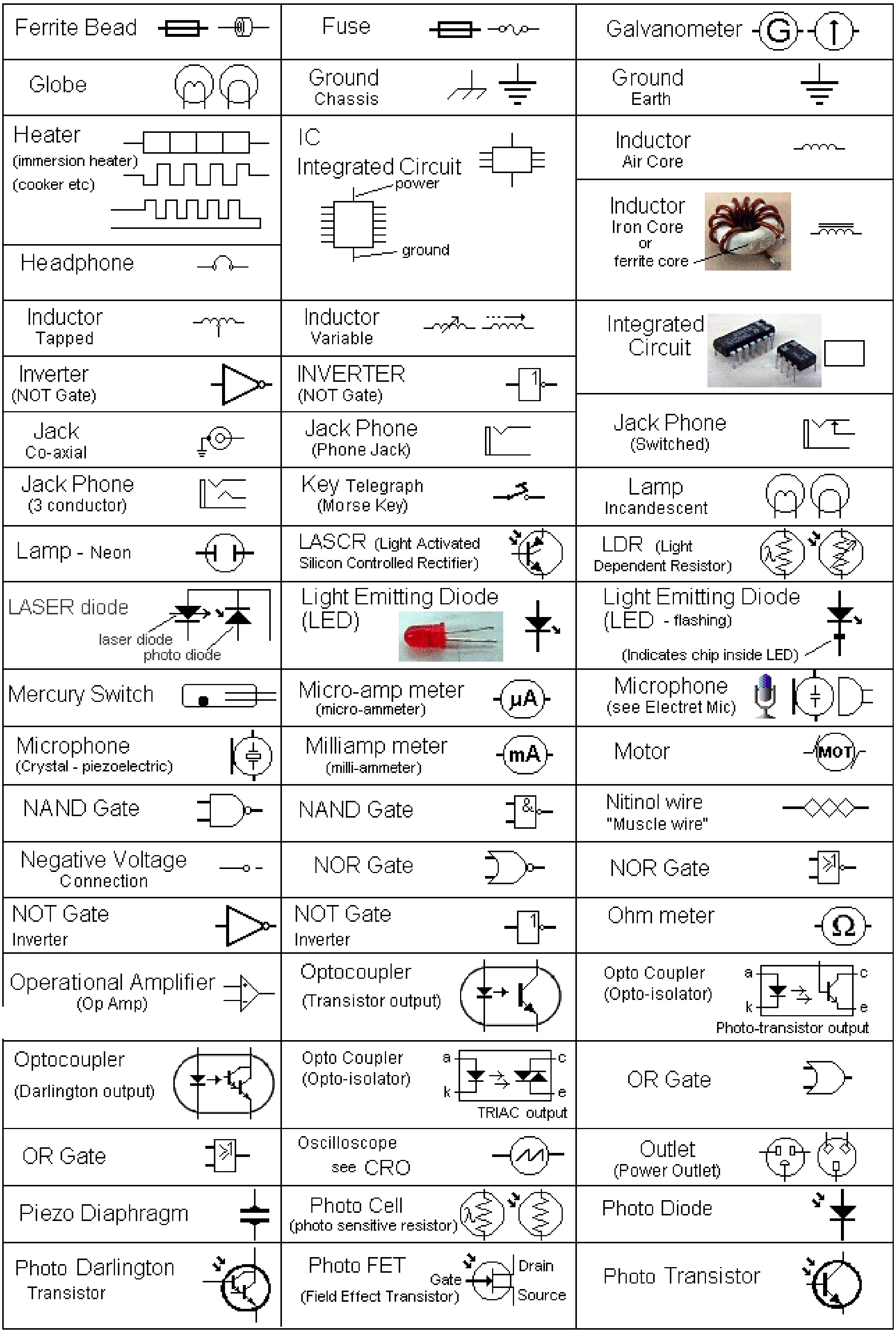
You must to refer to the manufacturer's specification sheet to identify each pin, to be sure you have identified them correctly.

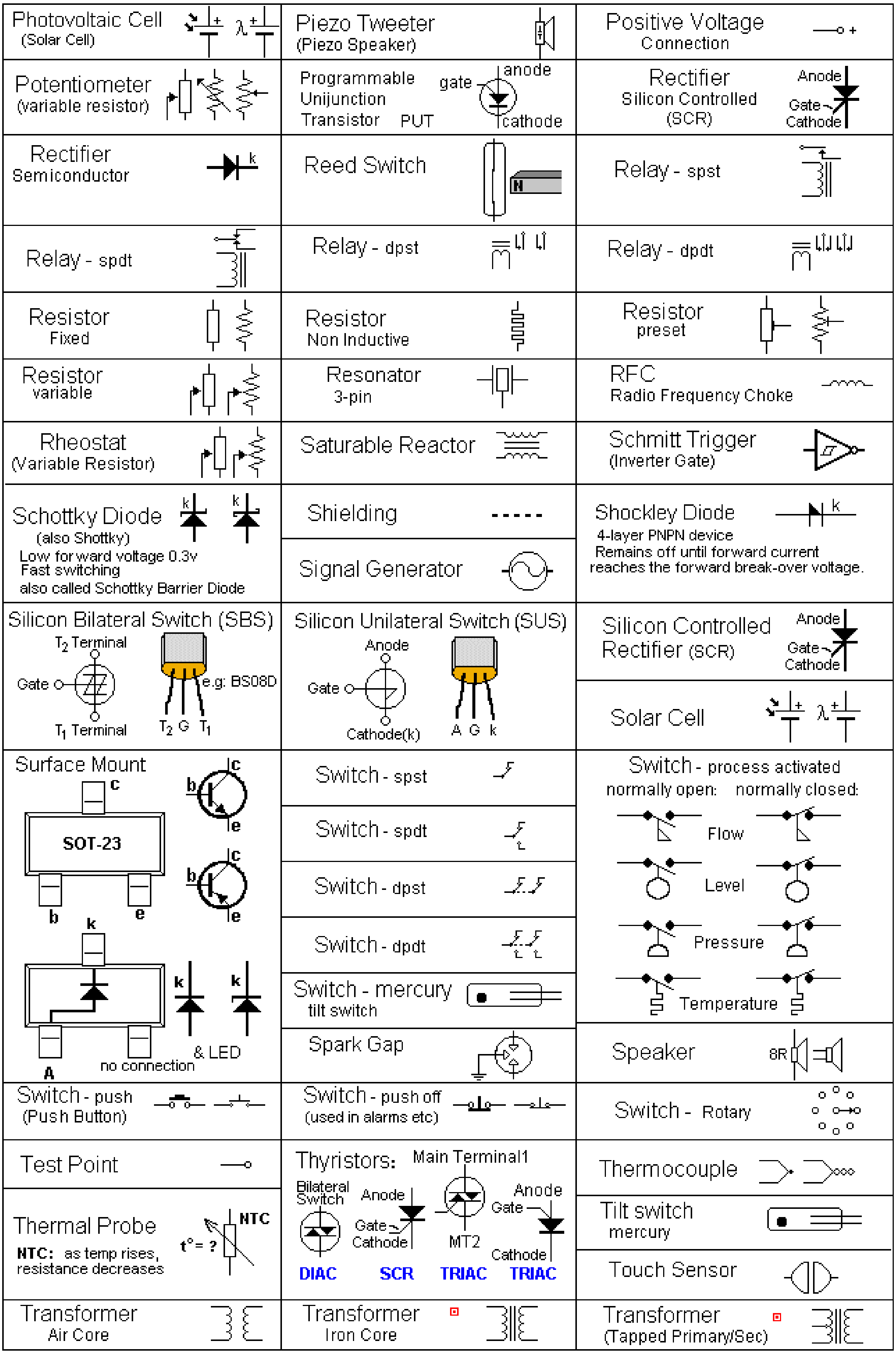
Colin Mitchell

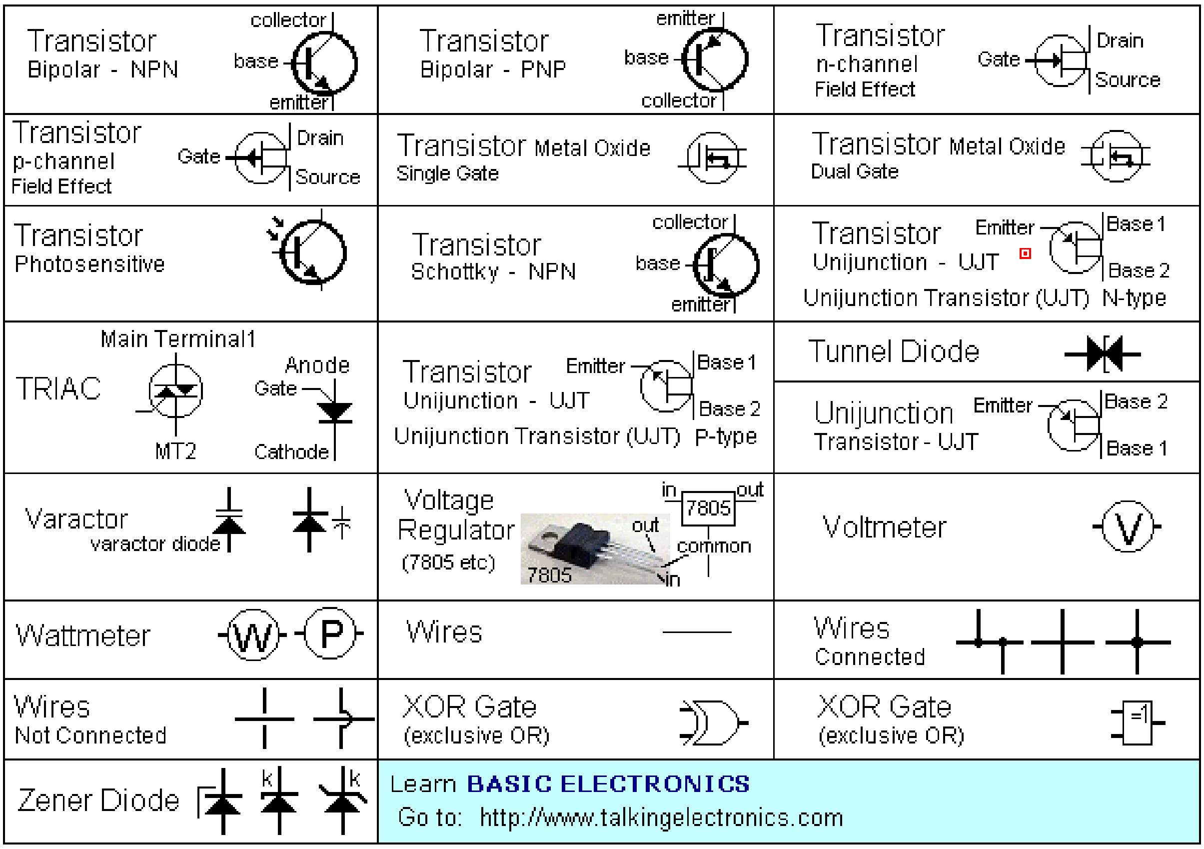
CIRCUIT SYMBOLS

Some additional symbols have been added to the following list. See **Circuit Symbols** on the index of Talking Electronics.com for the latest additions.


CIRCUIT SYMBOLS by TALKING ELECTRONICS
AC
current:
voltage:
ALTERNISTOR
TRIAC
A TRIAC and
33 - 43v DIAC
Main Terminal1
Gate
Main Terminal 2
Ammeter
(amp meter)
A
AND Gate
AND Gate
&
Antenna
balanced
Antenna
Loop, Shielded
Antenna
Loop, Unshielded
Antenna
unbalanced
Attenuator, fixed
(see Resistor)
Attenuator, variable
(see Resistor)
Battery
Bilateral Switch
(DIAC)
Bridge Rectifier
(Diode Bridge)
BUFFER
(Amplifier Gate)
BUFFER
(Amplifier Gate)
1
Buzzer
Capacitor
feedthrough
Capacitor
non-polarised
Capacitor polarised
(see electrolytic)
Capacitor
Variable
Cavity Resonator
Cell
Circuit Breaker
Coaxial Cable
CRO – Cathode Ray
Oscilloscope
Crystal Microphone
(Piezoelectric)
Connectors
Plug
(male)
Jack
(female)
connected
Plug
(male)
(female)
Crystal
Piezoelectric
DC
current:
voltage:
Darlington
Transistor
collector
base
emitter
Delay Line
DIAC
(Bilateral Switch)
Diode
k
Diode - Gunn
Diode - Light Emitting
(LED)
Diode
Photo Sensitive
Diode
Photovoltaic
λ
Diode Bridge
(Bridge Rectifier)
Diode - Pin
Diode - Varactor
Diode - Zener
Earth
Ground
Earpiece
(earphone,
crystal earpiece)
Electroluminescence
el
Electret Microphone
(Condenser mic)
Electrolytic
(Polarised Capacitor)
alternate symbols:
(positive on top)
Electrolytic - Tanatalum
positive end
black band or
chamfer
106
10u tantalum
Exclusive-OR Gate
(XOR Gate)
Exclusive-OR Gate
(XOR Gate)
=1
Field Effect
Transistor
(FET) n-channel
also: N-Channel J FET
Gate
Drain
Source
Field Effect
Transistor
(FET) p-channel
also: P-Channel J FET
Gate
Drain
Source
Flashing LED
(Light Emitting Diode)
(Indicates chip inside LED)


Ferrite Bead
Fuse
Galvanometer
G
Globe
Ground Chassis
Ground Earth
Heater
(immersion heater)
(cooker etc)
IC
Integrated Circuit
power
ground
Inductor Air Core
Inductor Iron Core or ferrite core
Headphone
Inductor Tapped
Inductor Variable
Integrated Circuit
Inverter (NOT Gate)
INVERTER (NOT Gate)
1
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)
λ
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)
μA
Microphone (see Electret Mic)
Microphone (Crystal - piezoelectric)
Milliamp meter (milli-ammeter)
mA
Motor
MOT
NAND Gate
NAND Gate
&
Nitinol wire "Muscle wire"
Negative Voltage Connection
NOR Gate
NOR Gate
NOT Gate Inverter
NOT Gate Inverter
1
Ohm meter
Ω
Operational Amplifier (Op Amp)
Optocoupler (Transistor output)
Opto Coupler (Opto-isolator)
a
c
k
e
Photo-transistor output
Optocoupler (Darlington output)
Opto Coupler (Opto-isolator)
a
c
k
e
TRIAC output
OR Gate
OR Gate
Oscilloscope see CRO
Outlet (Power Outlet)
Piezo Diaphragm
Photo Cell (photo sensitive resistor)
λ
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
gate anode cathode
Rectifier Silicon Controlled (SCR)
Anode Gate Cathode
Rectifier Semiconductor
k
Reed Switch
N
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
Signal Generator
Shockley Diode
4-layer PNPN device
Remains off until forward current reaches the forward break-over voltage.
Silicon Bilateral Switch (SBS)
T2 Terminal
Gate
T1 Terminal
e.g: BS08D
T2 G T1
Silicon Unilateral Switch (SUS)
Anode
Gate
Cathode(k)
A G k
Silicon Controlled Rectifier (SCR)
Anode Gate Cathode
Solar Cell
Surface Mount
SOT-23
b c e
k
A
no connection
& LED
Switch - spst
Switch - spdt
Switch - dpst
Switch - dpdt
Switch - mercury tilt switch
Spark Gap
Switch - process activated
normally open: normally closed:
Flow
Level
Pressure
Temperature
Speaker
8R
Switch - push (Push Button)
Switch - push off (used in alarms etc)
Switch - Rotary
Test Point
Thermal Probe
NTC: as temp rises, resistance decreases
NTC
t° = ?
Thyristors:
Main Terminal1
Bilateral Switch
Anode Gate Cathode
MT2
DIAC SCR TRIAC TRIAC
Thermocouple
Tilt switch mercury
Touch Sensor
Transformer Air Core
Transformer Iron Core
Transformer (Tapped Primary/Sec)



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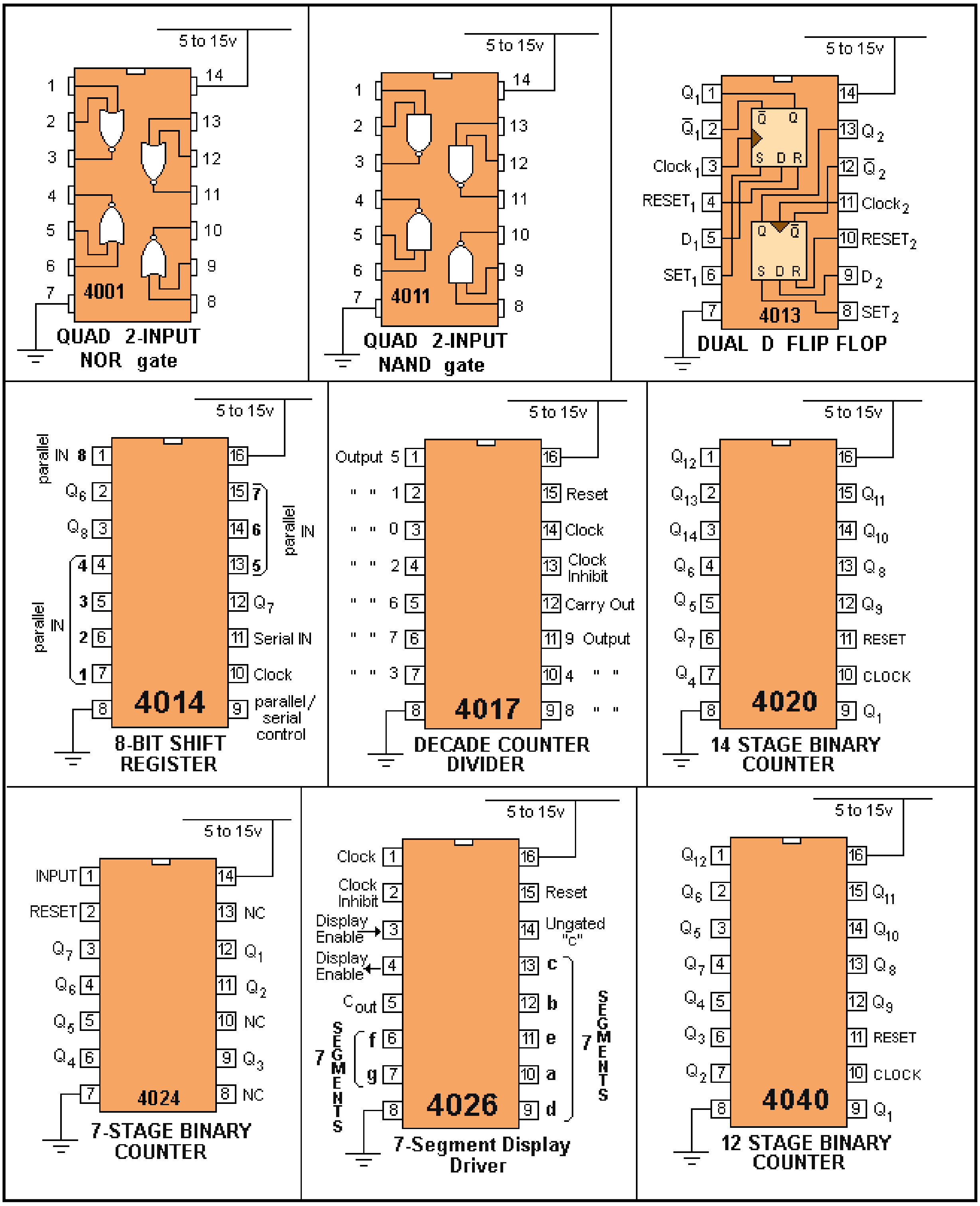
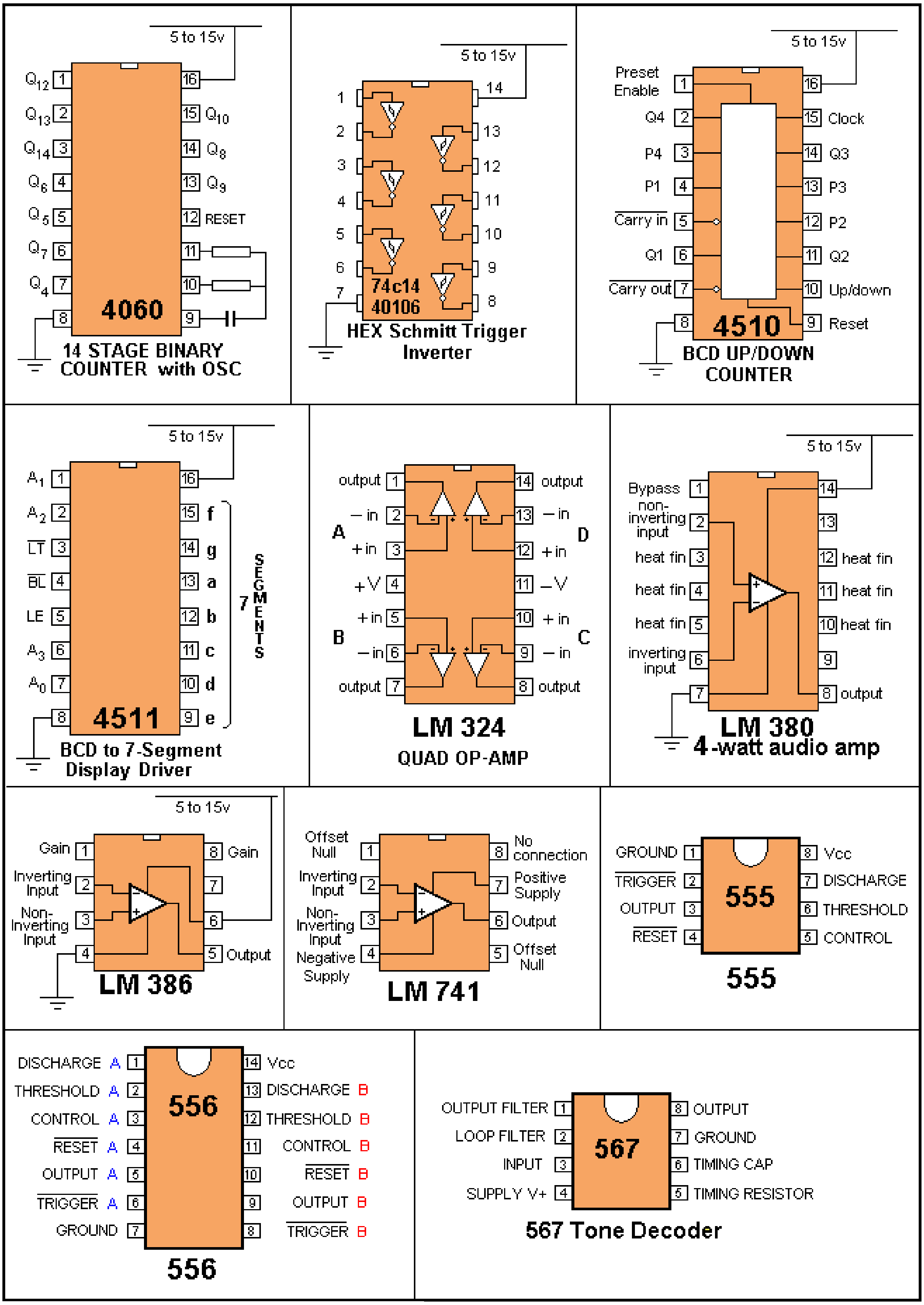
IC PINOUTS

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 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.


5 to 15v
4001
QUAD 2-INPUT NOR gate
4011
QUAD 2-INPUT NAND gate
4013
DUAL D FLIP FLOP
Q1, Q̄1, Clock1, RESET1, D1, SET1
Q2, Q̄2, Clock2, RESET2, D2, SET2
4014
8-BIT SHIFT REGISTER
parallel IN
Q6, Q8, Q7
Serial IN
Clock
parallel / serial control
4017
DECADE COUNTER DIVIDER
Output
Reset
Clock
Clock Inhibit
Carry Out
4020
14 STAGE BINARY COUNTER
Q12, Q13, Q14, Q6, Q5, Q7, Q4, Q11, Q10, Q8, Q9, Q1
RESET
CLOCK
4024
7-STAGE BINARY COUNTER
INPUT
RESET
NC
Q7, Q6, Q5, Q4, Q1, Q2, Q3
4026
7-Segment Display Driver
Clock
Clock Inhibit
Display Enable
Cout
Reset
Ungated "c"
7 SEGMENTS
4040
12 STAGE BINARY COUNTER
Q12, Q6, Q5, Q7, Q4, Q3, Q2, Q11, Q10, Q8, Q9, Q1
RESET
CLOCK



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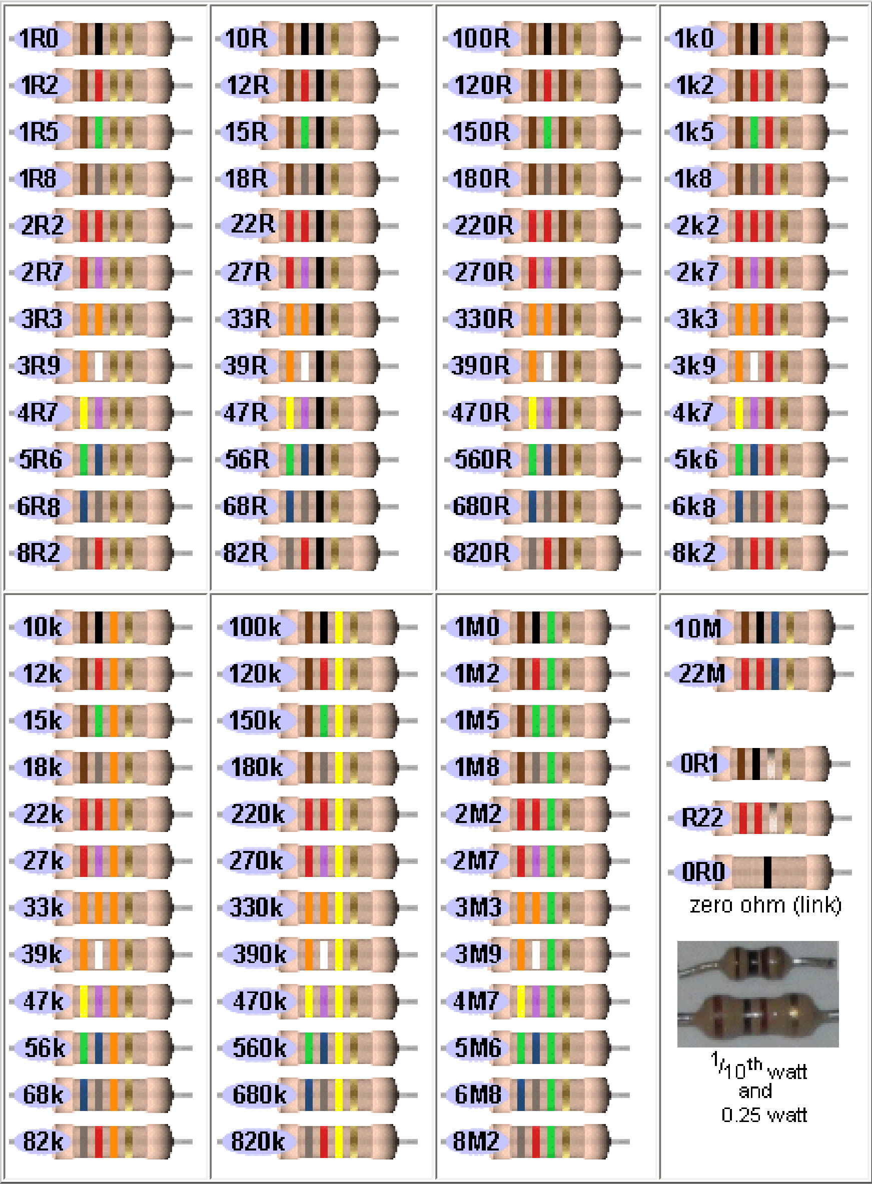
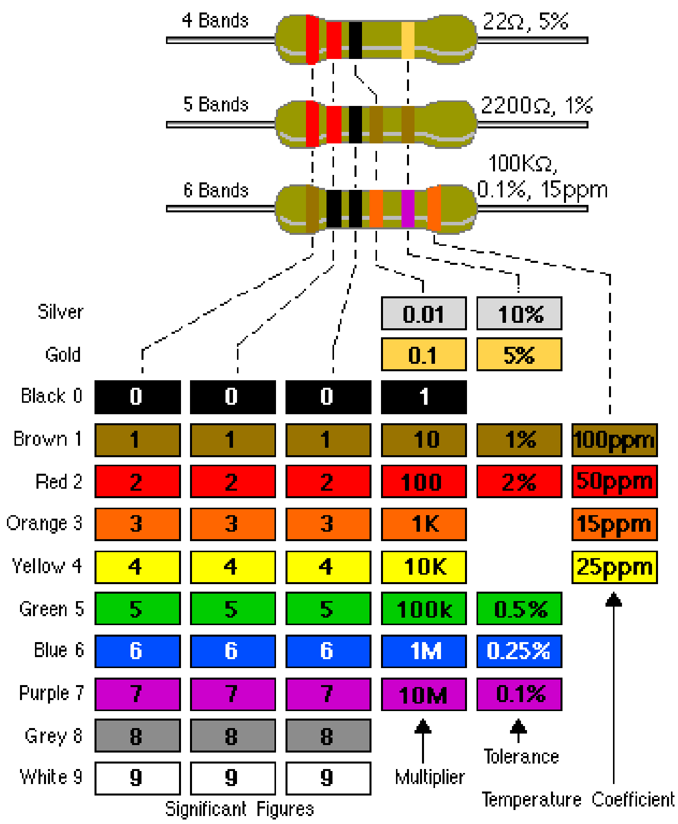
All the resistor colours:

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.





Resistor Color Code System

Resistor Color Code System

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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	P	33	66
82	27	P	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:

Required Value	C1	Series/ Parallel	C2	Actual value:
10	4.7	P	4.7	9.4
12	10	P	2.2	12.2
15	22	S	47	14.9
18	22	S	100	18
22	10	P	12	22
27	22	P	4.7	26.7
33	22	P	10	32
39	220	S	47	38.7
47	22	P	27	49
56	47	P	10	57
68	33	S	33	66
82	27	S	56	83

The value "10" in the chart above can be 10p, 10n or 10u. The chart works for all decades (values).