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THE FUTURE OF LIGHTING!

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LED Information and Technical Data

Links to technical data, text and schematics for the beginner and the experienced LED user. These links will help you determine what to purchase, how to work with the LED products, where are some of the resources, and to provide as much in depth technical knowledge as we can to those who require more than a passing knowledge of LEDs. These links were provided by your fellow visitors and customers. If you have a link or other information source to share, or find a dead link here, please e-mail it to sales@theledlight.com.

Energy Policy Reform - Residential Solar TAX CREDIT!
Read what is involved and understand how you can obtain solar power and receive year end tax credit while lowering your energy consumption.

Simplest Ways To Connect LEDs and Which Resistor To Use
An excellent tutorial with series and parallel wiring diagrams; resistor selection; and a very good resistance calculator.

LED Basics
An introduction for the beginner

MORE advanced ... "How To Connect LEDs and Which Resistor To Use"

LED Application Notes
More basics, information about color, intensity, visibility, operating life, voltage, precautions when working with LEDs

Battery Technical Data
Battery sizes and capacities

Color Technical Data
Chromacity charts, backlighting, and so forth

WebEE Primers
A collection of many pdf files to learn from

LED Application Documents
Another large collection of application notes.

[The Light Measurement Handbook](...)
What is light? How does light behave? Measurement geometries and so forth.

[Calculating Resistance](...)

[More Color Information](...)
Fig. 10.1 - Relative eye sensitivity and efficacy measured in lumens per watt of optical power.
Fig. 10.2 - CIE chromaticity diagram. Mono-chromatic colors are located on the perimeter and white light is located in the center of the diagram

[What are Lumens and Foot-Candles?](...)

[Lighting FAQ](...)
What does "candela" mean? Footcandle to lux conversion, beam angle, lumens, and so forth

[More Color Information](...)
We'd like to thank the Energy Outlet of Eugene, Oregon, and their sponsors, Eugene Water and Electric Board, Emerald People's Utility District, and Blachly-Lane Electric Co-op, for permission to use following Color Temperature and Color Rendering Index (CRI) Chart. If you are from Oregon, or nearby, please stop by and visit the Energy Outlet Resource Center, or their website. They have good, useful information, products and resources that anyone, anywhere can utilize.

[**The LED Light Online Catalog**]

[**Other Printable PDF Files**]

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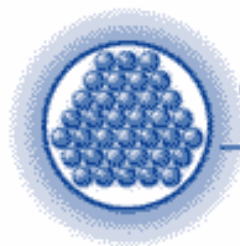* American Express * PayPal *

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The LED Light.com's Bargain Basement
Annual SUPER LED Sale!

We are making room for new LED products! GREAT LED products, GIGANTIC LED deals now available! Sooooo... if you're a LED collector? LED Bargain hunter? You've come to the right place! The best LED deals at the best online LED store.

First come, first served. New items added when we accumulate a stockpile. Some items are 'close-outs' and some are inventory reductions. We have included the 'scratch 'n dent' items here to make shopping easier and faster!

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● ORANGE Order Buttons: When you see an **ORANGE** order button, the manufacturer's warranty is stated on the product's packaging. No Returns, No Exchanges, No Credit from TheLEDLight.com. Any warranty issues to be taken up with manufacturer.

● GREEN Order Buttons: When you see a **GREEN** order button, the items have full manufacturer's warranty as stated on product packaging and can be returned to the manufacturer if you wish, for repair or replacement should a defect arise. Any items returned to TheLEDLight must be for either exchange or store credit. No Refunds. No Replacements from regular stock at this price. No Postage Credits. Defective or spent batteries included with the product by the manufacturer will not be replaced.

LED flashlight sale! Also, LED clusters, LED fixtures, LED bulbs, many other LED items.

Exchanges, Returns, Samples, Demonstration models, Scratch 'n Dent, Factory Repair Items!

Item #	Pieces	Description	Price	Order It
#1	1ea	72" x 1" O.C. spacing Flexible LED Board; white; reflectors, with some missing; all LEDs are okay - customer return; good condition; **NO warranty**; Reg Price $360.00	$180.00	
#2	1 ea	LED Brick LB-9 12vdc; green; customer sample; excellent condition; **NO warranty;** Reg. price $55.55	$30.00	
#10	1 ea	LED Brick LB-9 12vdc; 9 red LEDs; excellent condition; red LED test piece; **NO warranty**; Reg. price $55.55	$30.00	
#21	1 ea	Trek60 6000 Dive light; 60 white LEDs, yellow body; customer does not know how to operate; like brand new!; Reg. price $270.00	$240.00	
#31	3 ea	Photon Fusion IR, infraredHeadlamps; ordering error; for use with night vision equipment; **Any returns go to Photon**; Reg. price $95.95	75.00 ea	
#41	1 ea	Surefire L1 LumaMax; Luxeon LED; 2 Cr123A; hard anodize coating; our live test model; brand new condition; Reg. price $125.00	$112.00	

Hottest Deals In Town! ALL BRAND NEW, most with manufacturer warranty. There are a few items with no warranty and no tech support, and are priced accordingly. Great Stuff! Super Prices!

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Item #	Pieces	Description	Sale Price	Order It
#51	8 ea	MR-16 red; 12vdc only; 18 red LEDs; standard halogen replacement; dimmable; **1 year warranty;** Reg. price $80.00	$65.00	
#52	1 ea	Mark II 120vac; 36 white LED wall or ceiling light - interior or exterior floodlight; for hardwiring - no on/off switch; **1 year warranty;** Reg price $195.00	$148.50 ea	
#53	6	Nova 36 24VDC; 36 white LED flush mount light; new condition; **1 year warranty**; Regular price $225.00	$180.00 ea	
#55	38 ea	LW3000, 7 LED flashlight in bulk poly bag packing; Brand New!; exactly the same LW3000 in retail blister pack; Reg. price $48.50	$41.00 ea	
#56	20 ea	ARC UV; 1 AAA ulta-violet keychain light; 395nm wavelenth; brand new with **10 year manufacturer warranty - No returns to TheLEDLight;** Reg. price$49.95	$39.00 ea	
#59	9 ea	CMG 0-4 keychain light; single 20° white LED w/red translucent case; Reg. price $10.95	$8.50 ea	
#62	15 ea	CMG 0-4 keychain light; single 20° white LED w/yellow translucent case; Reg. price $10.95	$8.50 ea	

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#68	8 ea	[Quiqlite Pocket Clip light](); single blue LED; adjustable light beam; Reg. price $19.95	$16.75 ea	
#69	28 ea	[Glo-Toob Dive Marker Light;]() amber LED; 11,500' depth rated; Reg. price $34.00	$25.50 ea	
#70	42 ea	[Glo-Toob Dive Marker Light;]() blue LED; 11,500' depth rated; Reg. price $34.00	$25.50 ea	
#71	45 ea	[Glo-Toob Dive Marker Light;]() green LED; 11,500' depth rated; Reg. price $34.00	$25.50 ea	
#72	24 ea	[Glo-Toob Dive Marker Light;]() red LED; 11,500' depth rated; Reg. price $34.00	$25.50 ea	
#75	2 ea	[Jetstream EM72A 72-LED Lantern](); 36 LEDs on low, 72/7 hours on high; 5 amp hour battery; 360 dgree light pattern; NO warranty; Reg. price $241.00	$165.00 ea	
#76	1 ea	[Jetstream EM48A 48-LED Lantern](); 12LEDs on low, 48/10.5 hours on high; 5 amp hour battery; 360 dgree light pattern; NO warranty; Reg. price $185.39	$122.00 ea	
#77	4 ea	[Jetstream AC to DC Adapter kit](); can be used for other light or devices running on 12vdc; NO warranty; Reg. price $72.84	$45.00 ea	

LED flashlight sale! Also, LED clusters, LED fixtures, LED bulbs, many other LED items.

#78	3 ea	[Jetstream DC to DC Adapter kit](); can be used for other light or devices running on 12vdc; NO warranty; Reg. price $53.16	$35.00 ea	
#79	52 ea	[eternaLight Elite X-Ray](); 4 white LED; 7 modes of operation; blue translucent body; water resistant - floats with Lithium batteries installed; Reg. price $70.00	$50.00 ea	
#82	7 ea	[PLW Flashlight w/Flex Cable](); single white LED attached to end of 18" long cable; includes PLW body, PLW-1 One LED module, clear lens, red lens, black lens boot; 1 year warranty; Reg. price $35.00	$26.25 ea	
#83	3 ea	[Sunspot SP-18](); 18 ea, 20° white LEDs; unpaid for custom order; very bright focused spotlights; 1 year warranty; Reg. price $138.00	$99.45 ea	
#84	3 ea	[Strip Light S12 *48vdc*](); 12 white LED; unpaid for custom order; 1 year warranty; Reg. price $90.00	$56.10 ea	
#86	75 ea	[ARC LSL2 - original Twist Switch CR123A Lithium Battery Pack](); low dome Luxeon Star LED; Reg. price $110.00 **Manufacturer warranty - No returns to TheLEDLight;**	$85.00 ea	

LED flashlight sale! Also, LED clusters, LED fixtures, LED bulbs, many other LED items.

#88	23 ea	[ARC LSL2 new type Push Button switch 2 AA Battery Pack](#); low dome Luxeon Star LED; Reg. price $130.00 **Manufacturer warranty - No returns to TheLEDLight;**	$95.00 each	
#89	1 ea	[ARC Holster](#); for Twist-to-turn-on tailcap CR123A Battery Pack ,or the new push button tailcap CR123A Battery Pack; does not fit the 2AA push button tailcap; Reg. price $15.95 No Warranty	$9.00 ea	
#90	306 ea	[Traffic Baton](#), 7 red / 7 green LEDs; red or green flashing mode only; clear lens; Reg. price $17.70	$13.25 ea	
#90A	193 ea	[Traffic Baton](#), 3 Blue LEDs; flashing and constant-on modes; super law enforcement / military signal or traffic directing batons! Reg. price $14.75	$10.65 ea	
#91	13 ea	[Phoenix Motion Sensing Lantern](#); incandescent bulb; Reg. price $38.00	$29.95 ea	
#93	Overstock	[Inova X5 Tactical, Red LED, Titanium Body](#), overstock condition. Price good while overstock remains. Regular price 46.95. Full warranty.	$39.90	

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To order now, simply review the information and proceed to the bottom of this page. If you wish, you may modify the order, or continue shopping.

Item	Description	Unit Price	#	Total
	Subtotal (S&H not included)			$0.00
	Enter any coupon code here			

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Thank you for your business.

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Office Hours: Mon-Fri 9 AM - 5 PM PST
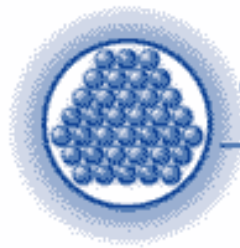
Senate passed, Energy Policy Reform.

SEC. 25C. RESIDENTIAL SOLAR ENERGY PROPERTY.

(a) ALLOWANCE OF CREDIT- In the case of an individual, there shall be allowed as a credit against the tax imposed by this chapter for the taxable year an amount equal to the sum of--
(1) 15 percent of the qualified photovoltaic property expenditures made by the taxpayer during such year, and
(2) 15 percent of the qualified solar water heating property expenditures made by the taxpayer during the taxable year.

(b) LIMITATIONS-
(1) MAXIMUM CREDIT- The credit allowed under subsection (a) shall not exceed--
(A) $2,000 for each system of property described in subsection (c)(1), and
(B) $2,000 for each system of property described in subsection (c)(2).
(2) SAFETY CERTIFICATIONS- No credit shall be allowed under this section for an item of property unless--
(A) in the case of solar water heating equipment, such equipment is certified for performance and safety by the non-profit Solar Rating Certification Corporation or a comparable entity endorsed by the government of the State in which such property is installed, and
(B) in the case of a photovoltaic system, such system meets appropriate fire and electric code requirements.
(3) LIMITATION BASED ON AMOUNT OF TAX- The credit allowed under subsection (a) for the taxable year shall not exceed the excess of--
(A) the sum of the regular tax liability (as defined in section 26(b)) plus the tax imposed by section 55, over
(B) the sum of the credits allowable under this subpart (other than this section and sections 23, 25D, and 25E) and section 27 for the taxable year.

(c) DEFINITIONS- For purposes of this section--
(1) QUALIFIED SOLAR WATER HEATING PROPERTY EXPENDITURE-
The term `qualified solar water heating property expenditure' means an expenditure for property to heat water for use in a dwelling unit located in the United States and used as a residence if at least half of the energy used by such property for such purpose is derived from the sun.
(2) QUALIFIED PHOTOVOLTAIC PROPERTY EXPENDITURE-
The term `qualified photovoltaic property expenditure' means an expenditure for property that uses solar energy to generate electricity for use in a dwelling unit.
(3) SOLAR PANELS- No expenditure relating to a solar panel or other property installed as a roof (or portion thereof) shall fail to be treated as

property described in paragraph (1) or (2) solely because it constitutes a structural component of the structure on which it is installed.

(4) LABOR COSTS- Expenditures for labor costs properly allocable to the onsite preparation, assembly, or original installation of the property described in paragraph (1) or (2) and for piping or wiring to interconnect such property to the dwelling unit shall be taken into account for purposes of this section.

(5) SWIMMING POOLS, ETC., USED AS STORAGE MEDIUM- Expenditures which are properly allocable to a swimming pool, hot tub, or any other energy storage medium which has a function other than the function of such storage shall not be taken into account for purposes of this section.

(d) SPECIAL RULES-

(1) DOLLAR AMOUNTS IN CASE OF JOINT OCCUPANCY- In the case of any dwelling unit which is jointly occupied and used during any calendar year as a residence by 2 or more individuals the following shall apply:

(A) The amount of the credit allowable under subsection (a) by reason of expenditures (as the case may be) made during such calendar year by any of such individuals with respect to such dwelling unit shall be determined by treating all of such individuals as 1 taxpayer whose taxable year is such calendar year.

(B) There shall be allowable with respect to such expenditures to each of such individuals, a credit under subsection

(a) for the taxable year in which such calendar year ends in an amount which bears the same ratio to the amount determined under subparagraph (A) as the amount of such expenditures made by such individual during such calendar year bears to the aggregate of such expenditures made by all of such individuals during such calendar year.

(2) TENANT-STOCKHOLDER IN COOPERATIVE HOUSING CORPORATION- In the case of an individual who is a tenant-stockholder (as defined in section 216) in a cooperative housing corporation (as defined in such section), such individual shall be treated as having made his tenant-stockholder's proportionate share (as defined in section 216(b)(3)) of any expenditures of such corporation.

(3) CONDOMINIUMS-

(A) IN GENERAL- In the case of an individual who is a member of a condominium management association with respect to a condominium which he owns, such individual shall be treated as having made his proportionate share of any expenditures of such association.

(B) CONDOMINIUM MANAGEMENT ASSOCIATION- For purposes of this paragraph, the term `condominium management association' means an organization which meets the requirements of paragraph (1) of section 528(c) (other than subparagraph (E) thereof) with respect to a condominium project substantially all of the units of which are used as residences.

(4) ALLOCATION IN CERTAIN CASES- If less than 80 percent of the use of an item is for nonbusiness purposes, only that portion of the expenditures for such item which is properly allocable to use for nonbusiness purposes shall be taken into account.

(5) WHEN EXPENDITURE MADE; AMOUNT OF EXPENDITURE-

(A) IN GENERAL- Except as provided in subparagraph (B), an expenditure with respect to an item shall be treated as made when the original installation of the item is completed.

(B) EXPENDITURES PART OF BUILDING CONSTRUCTION- In the case of an expenditure in connection with the construction or reconstruction of a structure, such expenditure shall be treated as made when the original use of the constructed or reconstructed structure by the taxpayer begins.

(C) AMOUNT- The amount of any expenditure shall be the cost thereof.

(6) PROPERTY FINANCED BY SUBSIDIZED ENERGY FINANCING- For

purposes of determining the amount of expenditures made by any individual with respect to any dwelling unit, there shall not be taken in to account expenditures which are made from subsidized energy financing (as defined in section 48(a)(4)(A)).

(e) BASIS ADJUSTMENTS- For purposes of this subtitle, if a credit is allowed under this section for any expenditure with respect to any property, the increase in the basis of such property which would (but for this subsection) result from such expenditure shall be reduced by the amount of the credit so allowed.

(f) TERMINATION- The credit allowed under this section shall not apply to taxable years beginning after December 31, 2006 (December 31, 2008, with respect to qualified photovoltaic property expenditures).'.

(b) CONFORMING AMENDMENTS-

(1) Subsection (a) of section 1016 is amended by striking `and' at the end of paragraph (27), by striking the period at the end of paragraph (28) and inserting `, and', and by adding at the end the following new paragraph: `(29) to the extent provided in section 25C(e), in the case of amounts with respect to which a credit has been allowed under section 25C.'.

(2) The table of sections for subpart A of part IV of subchapter A of chapter 1 is amended by inserting after the item relating to section 25B the following new item: `Sec. 25C. Residential solar energy property.'.

(c) EFFECTIVE DATE- The amendments made by this section shall apply to taxable years ending after December 31, 2001.

[**Solar Power**] [**Solar Fans**]

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LED Circuitry Tutorial

You'll want to bookmark or link to this page for future reference

Circuitry 101: How to Hook Up LEDs

The direct url for this guide is: http://tutorial.lsdiodes.com

Below we've created a **very** basic guide to help people unfamiliar with circuits get their LEDs up and running without blowing them out and wasting all their money. IT IS VERY BASIC!! Current is hardly ever mentioned, not because it's not important, but because we've found it makes things confusing when trying to teach people about this sort of thing. If we've done a bad job explaining things or if you have a question this doesn't answer, use the contact form at the bottom of this page to let us know what's up.
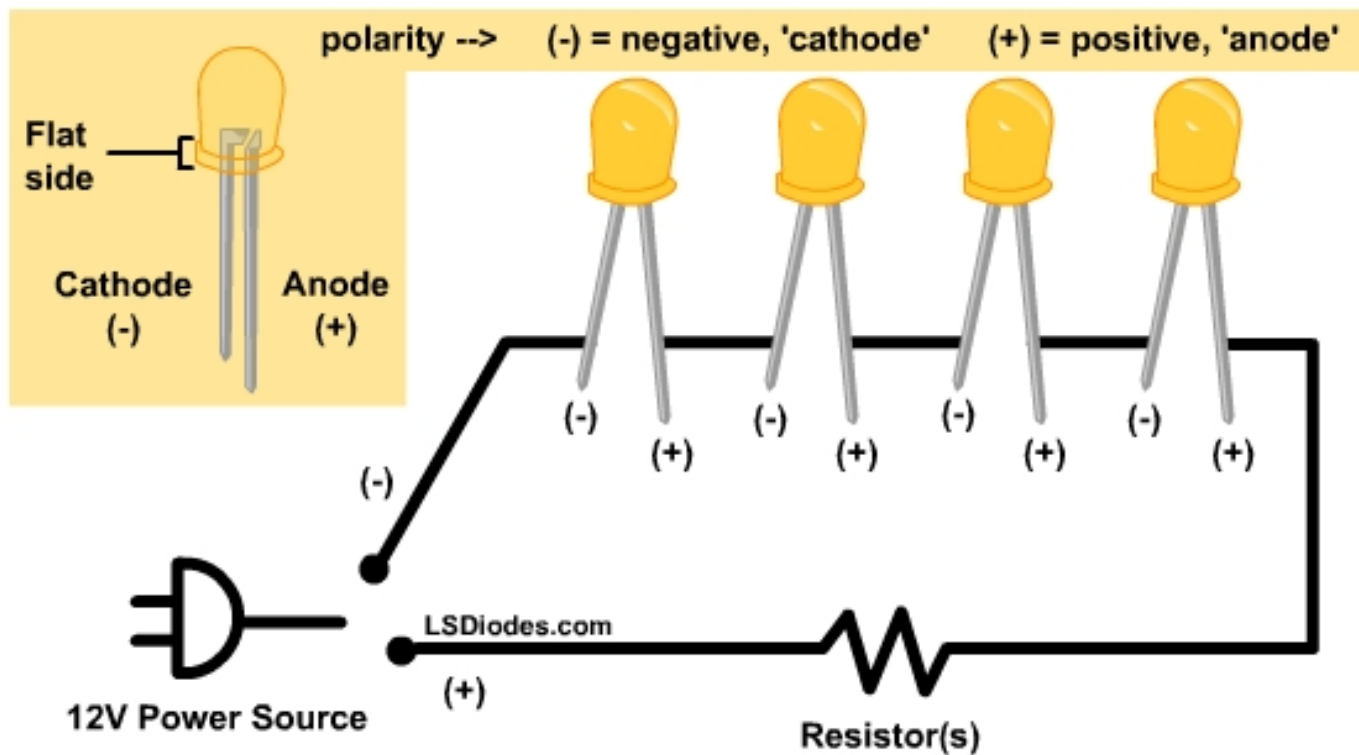
There's two basic types of circuits: **Series** and **Parallel.**

Series or "How do I power lots of LEDs off a higher voltage source?"

When LEDs are placed in a series, the voltage is dispersed between the LEDs, meaning less voltage goes to each LED. This can be very useful. For example, if a 12 volt adapter were powering one LED, there'd be 12V going through that LED which is way too much for any LED to handle and would result in a rather unpleasant burning smell.

However, if you take that same 12V power source and put 4 LEDs in series, there would be 3V going to each LED and (assuming the LEDs are made to run off 3V) each would be powered and just dandy. Check out this illustration:

polarity -->   (-) = negative, 'cathode'   (+) = positive, 'anode'

Flat side

Cathode (-)   Anode (+)

(-)   (-)   (-)   (-)
(+)   (+)   (+)   (+)

(-)

LSDiodes.com

(+)

12V Power Source

Resistor(s)

$$\frac{\text{Volts}}{\text{LEDs}} = \frac{12}{4} = 3V \text{ going through each LED}$$

It's important to notice how the LEDs are positioned: (-) (+), (-) (+), etc. making sure that the end (-) connects to the (-) wire and the end (+) connects to the (+) wire, if any LEDs are backwards nothing bad will happen, they just won't turn on.

If three LEDs were in series with a 12V source, each would receive 4V, if six were in series, each would receive 2V, etc.

"But what if I have four LEDs powered from a 12V source and I want each to receive less than than 3V/ea?" This is where the little 'Resistor(s)' squiggly comes in. By adding a resistor it's possible to tone down the amount of voltage each receives. To find out what value resistor you should use, use an led calculator such as [this one](). Go to the middle form where it says 'LEDs in series' and simply type in your power sources' voltage, the LEDs' voltage you'd like and the LEDs current capability (use 20mA.) It then tells you what ohmage resistor to stick in the circuit.

Parallel or "How d o I power lots of LEDs off a lower voltage source?"

Let's say you wanted to power three of your brand new LEDs off a 3V battery pack (two 1.5V AA's in series, make sense?) you found lying around. If you were to series the three LEDs there'd be 1V going to each (3 Volts / 3 LEDs = 1V for each LED). That's not enough to power your LEDs! You want them to have the full 3V going to each. Here's how:

One wire connects all the (-) legs and heads to the (-) lead of the source.

Other wire connects all the (+) legs and heads to the (+) lead of the source.

Only works if the LEDs are the same color!
(Or have the *exact* same specifications.)

(-)   (-)   (-)

(-)   (+)   (+)   (+)

LSDiodes.com   (+)

3V Power Source   **Resistor(s)**
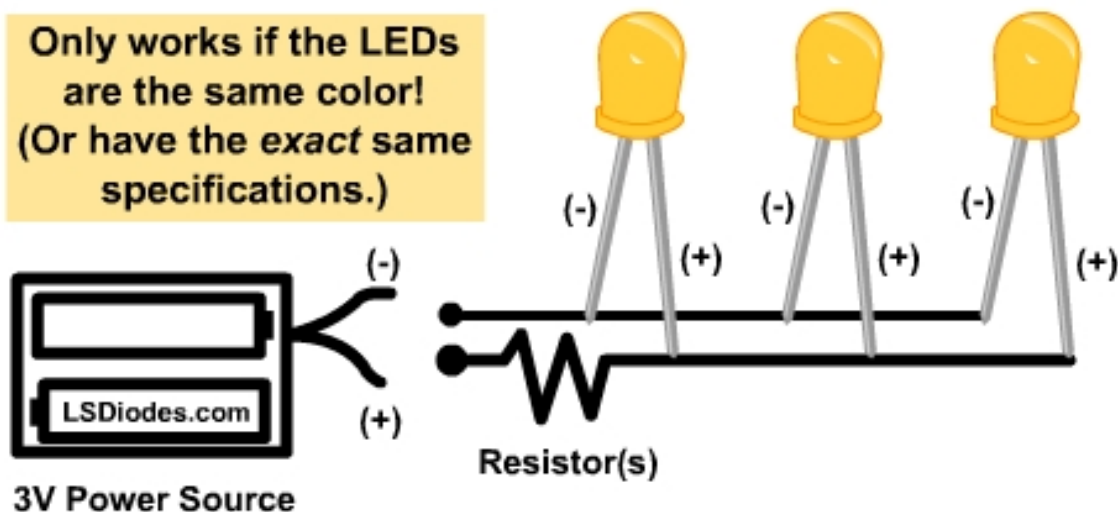
Each LED receives 3V

How this works is that while every LED receives the same amount of voltage, the current of the source is dispersed between the LEDs. What this means for you is that you have 20 LEDs paralleled off a battery, it's going to drain the battery a lot quicker than if you only had 2 LEDs in parallel. If you're paralleling off a wall adapter, for instance though, the source can constantly renew itself so you can essentially parallel as many as you'd like without fear of draining the wall ;P.

To use resistors in a parallel circuit, say if you'd like each LED above to receive 2.5V instead of 3V, use an LED calculator (make sure you're in the parallel section) to find the right ohmage and then stick it somewhere in the circuit!

"Why do the LEDs have to be the same color?" If you mix colors, say if you paralleled a red (~2.3V) and two blue (~3.5V), the blue LEDs would not light. Why's this? Because the electricity is going to take the easiest path it can to complete the circuit and in this scenario the red LED requires less energy, leaving the two blue unpowered and lonely. To fix this you would need to stick a resistor onto the leg of each LED to 'equalize' all of the LEDs. Note illustration:

| 2.3V | 3.5V | 3.5V |

6V Power Source

(-)

(+)

LSDiodes.com

(-) (+) 200 Ohm Resistor
(-) (+) 130 Ohm Resistor
(-) (+) 130 Ohm Resistor
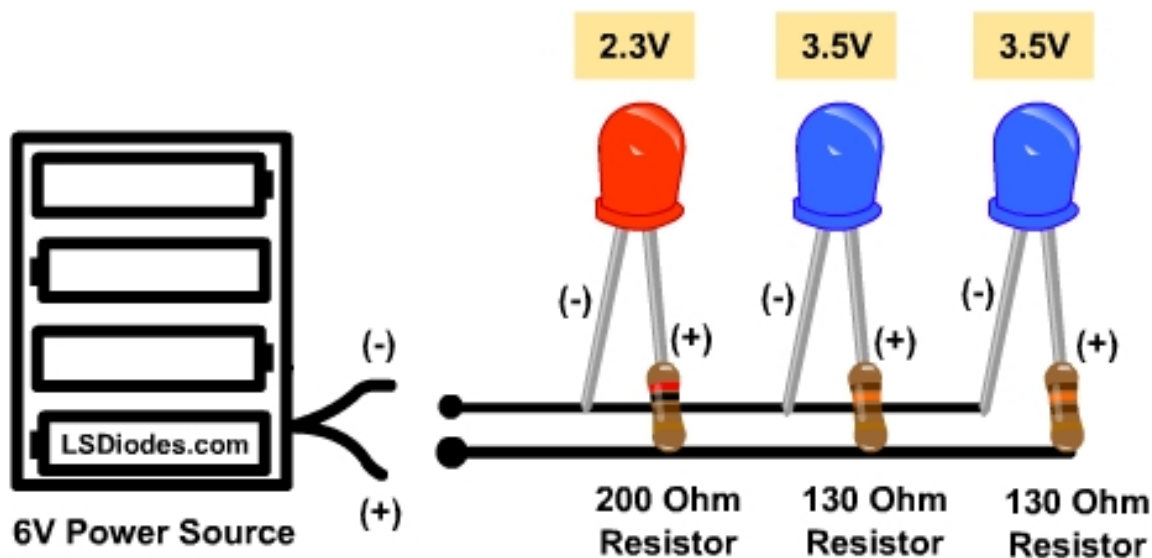
Each LED receives its necessary voltage and the circuit treats each LED equally.

To find the resistor you'd need for each LED, use the 'Single LED' portion of an [LED calculator](#) , type in the supply voltage, LED's voltage and 20mA for each LED and there you go. Now each LED will turn on and each will receive it's desired amount of power. Thanks to Mike Moorrees for pointing this out, "The resistors act like 'shocks' in a car, they give the power source some 'squish' and let each LED find its happy place (forward voltage)."

Courtesy of LSDiodes.com (Skylar and Chris)   Aug, '03

[[Back to Technical Pages Index](#)]

The following links might interest you. Or, you can click the "Online Catalog" button below to go back to the main page for other LED products.

[[LED Fixtures](#)] [[LED Clusters and Flex Board](#)] [[LED Bricks and Strips](#)] [[LED Bulbs](#)]
[[LED Billboard and Street Lights](#)] [[Submersibles](#)] [[Loose LEDs](#)] [[Solar Power](#)] [[Solar Fans](#)]
[[LED Landscape Lighting](#)] [[Low Voltage Controls](#)]
[[LED Flashlights](#)]
[[The Bargain Basement - Closeouts, Scratch 'n Dent, Special Buys](#)]

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LED Circuitry tutorial: how to hook up LEDs.

Technical Information

L.E.D Basics

Most LEDs have their characteristics specified at a current of 20 mA. If you want really good reliability and you are not certain you don't have worse-than-average heat conductivity in your mounting, heat buildup in wherever you mount them, voltage/current variations, etc. then design for 15 milliamps.

Now for how to make 15 milliamps flow through the LED:

First you need to know the LED voltage drop. It is safe enough to assume 1.7 volts for non-high-brightness red, 1.9 volts for high-brightness, high-efficiency and low-current red, and 2 volts for orange and yellow, and 2.1 volts for green. Assume 3.4 volts for bright white, bright non-yellowish green, and most blue types. Assume 4.6 volts for 430 nM bright blue types such as Everbright and Radio Shack. Design for 12 milliamps for the 3.4 volt types and 10 milliamps for the 430 NM blue.

You can design for higher current if you are adventurous or you know you will have a good lack of heat buildup. In such a case, design for 25 ma for the types with voltage near 2 volts, 18 ma for the 3.4 volt types, and 15 ma for the 430 NM blue.

Meet or exceed the maximum rated current of the LED only under favorable conditions of lack of heat buildup. Some LED current ratings assume some really favorable test conditions - such as being surrounded by air no warmer than 25 degrees Celsius and some decent thermal conduction from where the leads are mounted. Running the LED at specified laboratory conditions used for maximum current rating will make it lose half its light output after rated life expectancy (20,000 to 100,000 hours) - optimistically! You can use somewhat higher currents if you heat-sink the leads and/or can tolerate much shorter life expectancy.

Next, know your supply voltage. It should be well above the LED voltage for reliable, stable LED operation. Use at least 3 volts for the lower voltage types, 4.5 volts for the 3.4 volt types, and 6 volts for the 430 NM blue.

The voltage in most cars is 14 volts while the alternator is successfully charging the battery. A well-charged 12 volt lead-acid battery is 12.6 volts with a light load discharging it. Many "wall wart" DC power supplies provide much higher voltage than specified if the load is light, so you need to

measure them under a light load that draws maybe 10-20 milliamps.

Next step is to subtract the LED voltage from the supply voltage. This gives you the voltage that must be dropped by the dropping resistor. Example: 3.4 volt LED with a 6 volt supply voltage. Subtracting these gives 2.6 volts to be dropped by the dropping resistor.

The next step is to divide the dropped voltage by the LED current to get the value of the dropping resistor. If you divide volts by amps, you get the resistor value in ohms. If you divide volts by milliamps, you get the resistor value in kilo-ohms or k.

Example: 6 volt supply, 3.4 volt LED, 12 milliamps. Divide 2.6 by .012. This gives 217 ohms. The nearest standard resistor value is 220 ohms.

If you want to operate the 3.4 volt LED from a 6 volt power supply at the LED's "typical" current of 20 ma, then 2.6 divided by .02 yields a resistor value of 130 ohms. The next higher popular standard value is 150 ohms.

If you want to run a typical 3.4 volt LED from a 6 volt supply at its maximum rated current of 30 ma, then divide 2.6 by .03. This indicates 87 ohms. The next higher popular standard resistor value is 100 ohms. Please beware that I consider the 30 ma rating for 3.4-3.5 volt LEDs to be optimistic.

One more thing to do is to check the resistor wattage. Multiply the dropped voltage by the LED current to get the wattage being dissipated in the resistor. Example: 2.6 volts times .03 amp (30 milliamps) is .078 watt. For good reliability, I recommend not exceeding 60 percent of the wattage rating of the resistor. A 1/4 watt resistor can easily handle .078 watt. In case you need a more powerful resistor, there are 1/2 watt resistors widely available in the popular values.

You can put LEDs in series with only one resistor for the whole series string. Add up the voltages of all the LEDs in the series string. This should not exceed 80 percent of the supply voltage if you want good stability and predictable current consumption. The dropped voltage will then be the supply voltage minus the total voltage of the LEDs in the series string.

Do not put LEDs in parallel with each other. Although this usually works, it is not reliable. LEDs become more conductive as they warm up, which may lead to unstable current distribution through paralleled LEDs. LEDs in parallel need their own individual dropping resistors. Series strings can be paralleled if each string has its own dropping resistor.

[Back to Technical Info Index Page]

[The Online Catalog]

Disclaimer: The information provide herein are basics to educate one on the operating properties and user characteristics of LEDs. We do not imply that the information is accurate or applicable to every aspect of LED usage. Each application will have to be performed on its own merits and with full understanding that damages and injury are the sole responsibility of the "builder". We do not dispense engineering advice. You need to determine the specific products you will need for your specific application.

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Bowden's Hobby Circuits

A small collection of electronic circuits for the hobbyist or student. Site includes over 100 circuit diagrams, links to related sites, commercial kits and projects, newsgroups and educational areas. Most of the circuits can be built with common components available from Radio Shack or salvaged from scrap electronic equipment. Most all of the circuits have been built and tested and believed to perform as described, however possible mistakes may be found.

[Additions and Corrections (12/04/03)](#)

Digital/Computer

- [16 Bit PC Serial Port Receiver (CMOS)](#)
- [24 bit ISA card](#) Installs into your computer. Parts, plans, schematics and programmng available. Also may be purchased as a kit.
- [32 Bit Serial Receiver (57.6 K Baud TTL & CMOS)](#)
- [Parallel Port Relay Interface Circuit](#)
- [Reading Data From The Parallel Port](#)
- [1 Second Time Base From Crystal Osc.](#)
- [32.768 KHz Oscillator Using A Common Watch Crystal](#)
- [Digital Electronic Lock](#)

Telephone Circuits

- [Use Old Telephones as Intercom](#)

Power Circuits

- [Simple Variable Voltage Source](#)
- [LM317 Variable Voltage Regulator](#)
- [LM317 Regulator With Pass Transistor](#)

- [Telephone In-Use LED Indicator](#)
- [Telephone In-Use Relay Circuit](#)
- [Telephone Ring Generator Using 60Hz Power Transformer](#)
- [Telephone Ring Generator Using Switching Power Supply](#)
- [Telephone Audio Interface](#)

LED Circuits

- [40 LED Bicycle Light (555 Timer - 6 volt)](#)
- [28 LED Clock](#)
- [72 LED Clock](#)
- [Binary Coded Decimal (BCD) Clock](#)
- [Digital LED Clock and Timer](#)
- [Astable Multivibrator](#)
- [Expandable 16 Stage LED Sequencer](#)
- [16 Stage Bi-Directional LED Sequencer](#)
- [10 Stage LED Sequencer](#)
- [9 Second LED Relay Timer](#)
- [9 Second Digital Readout Timer](#)
- [Two Transistor LED Flasher](#)
- [1.5 Volt LED Flashers](#)
- [LED Photo Sensor Circuit](#)
- [Fading Red Eyes](#)
- [12 Volt Lamp Fader (LEDs or incandescent)](#)

- [Variable 3 - 24 Volt / 3 Amp Power Supply](#)
- [Variable Voltage and Current Power Supply](#)
- [2 watt switching power supply](#)
- [Low Power DC to DC Converter](#)
- [Constant Current Battery Charger](#)
- [120VAC Lamp Chaser Using Solid State Relays](#)
- [120 VAC Lamp Dimmer (full wave SCR)](#)
- [Varying Brightness AC Lamp](#)
- [12 Volt Lamp Fader (Automatic)](#)
- [1.5 Hour Lamp Fader (Sunset Lamp)](#)
- [12 Volt Lamp Dimmer (using a pot)](#)
- [Interfacing 5 volt CMOS to 12 volt loads](#)
- [Low Voltage , High Current Time Delay Circuit](#)
- [High Current Regulated Power Supply](#)
- [Thermostat for 1KW Space Heater (SCR controlled)](#)

Miscellaneous

- [Triangle and Squarewave Generator](#)
- [Transistor Schmitt Trigger Oscillator](#)
- [Descrete Set/Reset Flip Flop](#)
- [Discrete Bistable Flip Flop](#)
- [Toggle Switch Debounced Pushbutton](#)
- [High Current MOSFET Flip Flop With Debounced Pushbutton](#)
- [Monostable Flip Flops (one shot)](#)
- [Ignition Coil High Voltage Circuit](#)
- [Ignition Coil Buzz Box](#)
- [Capacitor Discharge Ignition Circuit](#)
- [Generating Long Time Delays](#)
- [Flashing Neons (NE-51 / NE-2)](#)
- [Sequencing Neons (NE-51 / NE-2)](#)
- [555 Tone Generator (8 Ohm Speaker)](#)
- [Generating Negative 5 Volts from 9 Volt Battery](#)

- [LED Battery Condition Indicator](#)
- [8 Stage LED VU Meter](#)
- [Battery Equal Charge Indicator](#)
- [IR Remote Control Tester](#)
- [AC Line Powered LEDs](#)
- [LED Traffic Lights](#)

Analog / RF Circuits

- [LED Decibel Meter](#)
- [Whistle On - Whistle Off](#)
- [Long Loopstick AM Radio Antenna](#)
- [Micro Power AM Broadcast Transmitter](#)
- [FM Beacon Transmitter (88-108 MHz)](#)
- [Op-Amp Basics](#) -
  The text information for the basic Op-Amp operation, 2nd order filters and bandpass filters was obtained in part from the paper back book "Design of Active Filters, With Experiments" by Howard M. Berlin, 1977. The book is out of print but possibly can be found at used book stores, or through [Amazon.com](#)
- [Active 2nd Order Filters](#)
- [Bandpass Filter (Single Op-Amp)](#)
- [Low Power Op-Amp - Audio Amp (Intercom)](#)
- [Crystal Radio Circuits](#)

- [Touch Activated Lamp](#)
- [Game Show Who's First Indicator Lights](#)
- [Salt Water Battery](#)
- [Transistor, Diode, IC outlines](#)

Circuits Controlling Relays

- [Push Button Relay Toggle Circuit With One Transistor](#)
- [CMOS Toggle Flip Flop Using Push Button (CD4013)](#)
- [CMOS Toggle Flip Flop Using Laser Pointer](#)
- [555 Timer Monostable Circuit Using Pushbutton](#)
- [Generating a Delayed Pulse With a dual 555 Timer](#)
- [Light Activated Relay (toggled)](#)
- [Photo Electric Street Light](#)
- [Power-On Time Delay Relay Circuit](#)
- [Power-Off Time Delay Relay Circuit](#)
- [Electronic Thermostat Relay Circuit](#)
- [AC Line Current Detector](#)
- [Pinewood Derby Finish Line Lights](#)
- [Pinewood Derby Finish Line Using a Computer](#) - Scores times and places.
- [Controlling relays with logic voltages](#)
- ....

- [Simple Op-Amp Radio](#)
- [Low Frequency Sinewave Generator](#)
- [3 Transistor Audio Amp (50 milliwatt)](#)
- [RC Notch Filter (Twin T)](#)
- [Analog Milliamp Meter Used as Voltmeter](#)

Semiconductor Data Sheets

[TI Semiconductors (search)](#)   [National Semiconductors (search)](#)   [Motorola](#) [NTE](#)

[Software (Moved to separate page)](#)

Java Script Calculators

[Resistor Color Code Calculator -](#) Graphical resistor color code calculator by Danny Goodman. Uses pulldown menus and a realistic picture of a resistor.

[Another Resistor Color Code Calculator -](#) This one uses check boxes instead of pulldown menus and also calculates the equivalent value of two resistors in parallel. My own creation.

[Ohm's Law Calculator -](#) Java Script to solve Ohm's Law for Voltage, Current, Resistance and Power. Enter any two unknowns and solve for the other two.

[Voltage Divider Calculator -](#) Solves voltage, current, and power dissipation problems for two element resistive voltage dividers.

[L or C Reactance Calculator -](#) Java Script to calculate capacitive or inductive reactance and resonant frequency. For ideal devices only, resistance not included.

[Allen Newman's Impedance Calculator -](#) Solves passive series RLC networks, for reactance, impedance and phase angle.

[RC Time Calculator -](#) Java Script to solve R and C values for given values of time or instantaneous voltages.

[RL Time Calculator -](#) Java Script to solve R and L values for given values of time or instantaneous current.

[555 Timer - Frequency and Time Interval Calculator -](#) Calculates positive and negative time intervals for the 555 timer based on R and C values. Also contains descriptions and operation of each input and output of the timer and schematics for the two basic modes of operation (monostable

or "one-shot" and astable or "rectangular wave oscillator"). Also contains a pictorial diagram of the timer connected as a LED flasher and a table of connections for the 556 timer (dual 555 timer).
[LED Series Resistor Calculator](#) - Finds the series resistance needed for various series LED combinations and supply voltages.
[The Electronics Calculator Website](#) - Several calculators for Ohm's law, capacitor or inductor impedance, tuned circuits and RC time constants.
[Several JavaScript Calculators by John Owen.](#) - Audio op-amp filter, Op-amp circuit, Decibels, Zener Diodes and more...
[Gregorian Calendar](#) - Displays any month from Oct 1582 forward.

Links to Other Hobby Electronics Sites and Useful Information

[Don Klipstein's LED Website](#) - Lots of useful LED information, FAQs, and sources for the brightest and most efficient LEDs.
[Circuit Archive](#) - University of Washington Circuit Archive, lots of good circuits and links.
[EDUCYPEDIA](#) - The educational encyclopedia (Electronics section)
[Tomi Engdahl's Electronic Info](#) - Links to a wide variety of analog and digital circuits.
[Imagineering On-Line Magazine ,The Design Corner, over 100 circuits in pdf format.](#)
[Tom Loredo's Electronics Bookmarks](#) - Many resources for electronics hardware and software.
[Harry's Homebrew Homepage](#) - For building amateur radio equipment. Antennas, Receivers, Transmitters and other useful circuits.
[Links for FM Transmitter Kits, Circuits, Electronics ...](#)
[Electronics Links and Resources](#) -Links to circuits, components, educational sites and more..
[Tony's Website](#) - R/C Gadgets and electronic circuits for the hobbyist.
[Steve Walz's FTP Site](#) - FTP Resource Site, 1000 Files in 50 Directories.
[Wenzel & Associates (Circuits)](#) - Technical Library, Hobby Circuits.
[Samuel M. Goldwasser Homepage](#) - Silicon Sam's Technology Resource - FAQs, Links, Troubshooting & Repair, Laser info, Circuits.
[Diana's Electronics info page](#)
[Beyond Logic](#) - Information on the PC Parallel, Serial and USB ports.
[How Stuff Works](#) - Interesting site on how things work, but you will have to clear your screen of many pop up ads.
[Deep Cycle Battery Frequently Asked Questions](#)
[Energizer Battery Data](#) - Capacity, Weight, Size, etc.
[www.saroff.com](#) Has some useful search engines for locating parts and

data sheets.

Commercial Electronic Kits and Projects

- [TheLEDLight.com](#) Luxeon LEDs, LED bulbs, fixtures, flashlights, lanterns, clusters, arrays, and more...
- [lsdiodes.com](#) Basic collection of bright LEDs in several colors at low prices. Brightness ranges from 4000 mcd to 12,000 mcd for the white LEDs.
- [JDR Microcontrollers](#) Books, Kits, Test Equipment and more.
- [Alltronics Electronic Kits](#)

Electronics Educational Sites

- [PIC Microcontroller Tutorial](#) A very good introduction to PIC micros that includes 13 tutorial pages to get you started programming PICs. You will also need a programmer to load the finished program (.HEX file) into the PIC. The DOS programmer software and schematic for the programmer can be downloaded from [David Tait's PIC archive](#)The file you need is PIC84V05.ZIP. The file contains DOS software and programmer schematic that will work with the PIC16C84, PIC16F84 or the newer PIC16F628 which can be purchased on e-bay for about $2.68 or obtained from [www.glitchbuster.com](#)

- [Lessons In Electric Circuits](#) - A free series of textbooks on the subjects of electricity and electronics.
- [Play Hookey](#) Basic ideas about op-amps, analog circuits, optics, computers and digital logic.
- [Alex's Electronic Resource Library](#) An online guide to useful electrical and electronic information.
- [Electronics Tutorials](#) A good comprehensive site with detailed examples and book recommendations.
- [Basic Electronics Tutorial (Iguana Labs)](#)
- [The Art of Electronics (Purchase the book)](#) 1125 large format pages, 80 component-selection tables,1500 figures, extensive practical advice, back-of-the-envelope techniques, exhaustive 4000-entry index.

- KitZ Electronic Kits
- Electronics USA - LED Digital and Binary Clocks, LED Timers (Up and down counting), LED flashlights, and a few other items, as kits or assembled.
- Centerpointe Electronics Store
- Hobbytron - The largest selection of fun electronics and toys!
- Almost All Digital Electronic Kits
- DTE Microsystems
- Hallbar Electronic Kits and Projects
- Kits-R-Us Electronic Kits
- Microchip Technology Inc. (PIC) Controllers
- Circuits For Sale -Subscribe and receive schematics for 1000 circuits, plus FREE software - SuperCAD Lite, SuperPCB Lite, to draw circuit diagrams and build printed circuit boards.
- Mental Automation's products ECAD tools: schematic capture, printed circuit board design/layout, autorouting, circuit simulation, SPICE, and CD ROM Encyclopedia of Electronic Circuits, all running under Windows.
- Express Printed Circuit Boards Download PCB software to layout your project, E-mail the resulting file and receive delivery of finished circuit boards via Federal Express in 3 working days.
- PCB Express 1-Day Delivery, Economical, Easy to order and track, Lot charge as low as $80, E-Mail Help
- Used Electronic Equipment For Sale at E-Bay Online auction community, buy, sell, trade.
- C. Crane Company LED Flashlights, windup radios, and other specialty items.
- Cyber Circuits Software and Demos

- CircuitMaker Student Version (3.4M) Get ahead in class with the FREE CircuitMaker Student Version. You will be able to build and simulate circuits in a fraction of the time it takes in the lab.
- DC Circuits Department of Physics, University of Guelph.
- Elements of AC Electricity
- John Adams Beginners Electronics
- Electronics For Beginners

Newsgroups

- sci.electronics.basics
- sci.electronics.components
- sci.electronics.design
- sci.electronics.repair
- sci.electronics.misc
- sci.electronics.cad
- sci.electronics.components
- sci.electronics.equipment
- alt.engineering.electrical
- Search Newsgroup Discussions

Electronic Component Suppliers

- Mouser Electronics
- DIGI-KEY Corporation
- Allied Electronics
- Surplus Traders (Solar panels)
- Jameco
- Hosfelt Electronics
- Radio Shack
- Electronix Express - Components and test equipment for schools, colleges and industry. Very nice site.

- [SpamCop](#) - Locate the source of unsolicitated mail (Spam) and file a report with the postmaster or abuse department of the originating site. All spam received at my e-mail address will be forwarded to the abuse department of this web page host.
- ....

- [Dan's Small Parts and Kits](#) -Good selection of small components at low cost.
- [Bill's Surplus Parts For Sale](#)- Resistors, capacitors, semiconductors and a few other items. I don't have a large inventory, just more than I need.

[Go to top](#)

Having trouble building a circuit similar to something on this site?

Try posting a message with circuit details to one of the electronic newsgroups, either [sci.electronics.basics](#) or [sci.electronics.design](#) Many readers of those groups will offer ideas and a few specifics at no charge. If you need more detailed help and follow up advice, maybe I can help.

Send a detailed description of your circuit and objective. If it is within my expertise and relates to the projects on this site, I will work with you via email to help solve the problem. I can also test and refine the circuit on a vector board for a nominal fee.

1 3 4 2 8 5 9. . . Visits Since Oct. 1997
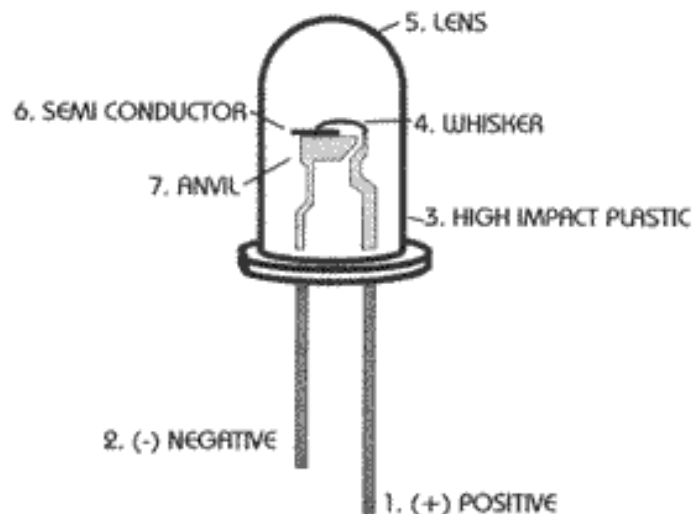
Web page counter provided by - [www.digits.com](#)
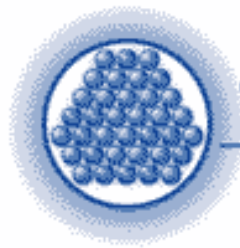
Application Notes

Eye Protection

LEDs are very bright. DO NOT look directly into the LED light!! The light can be intense enough to injure human eyes.

Basics On LEDs

How does a LED work? This is a very simple explanation of the construction and function of LEDs. White LEDs need 3.6VDC and use approximately 30 milliamps of current, a power dissipation of 100 milliwatts. The positive power is applied to one side of the LED semiconductor through a lead (1 anode) and a whisker (4). The other side of the semiconductor is attached to the top of the anvil (7) that is the negative power lead (2 cathode). It is the chemical makeup of the LED semiconductor (6) that determines the color of the light the LED produces. The epoxy resin enclosure (3 and 5) has three functions. It is designed to allow the most light to escape from the semiconductor, it focuses the light (view angle), and it protects the LED semiconductor from the elements.

As you can see, the entire unit is totally embedded in epoxy. This is what make LEDs virtually indestructible. There are no loose or moving parts within the solid epoxy enclosure.

Therefore, a light-emitting diode (LED) is essentially a PN junction semiconductor diode that emits light when current is applied. By definition, it is a solid-state device that controls current without heated filaments and is therefore very reliable. LED performance is based on a few primary characteristics:

Color

LEDs are highly monochromatic, emitting a pure color in a narrow frequency range. The color emitted from an LED is identified by peak wavelength (lpk) and measured in nanometers (nm).
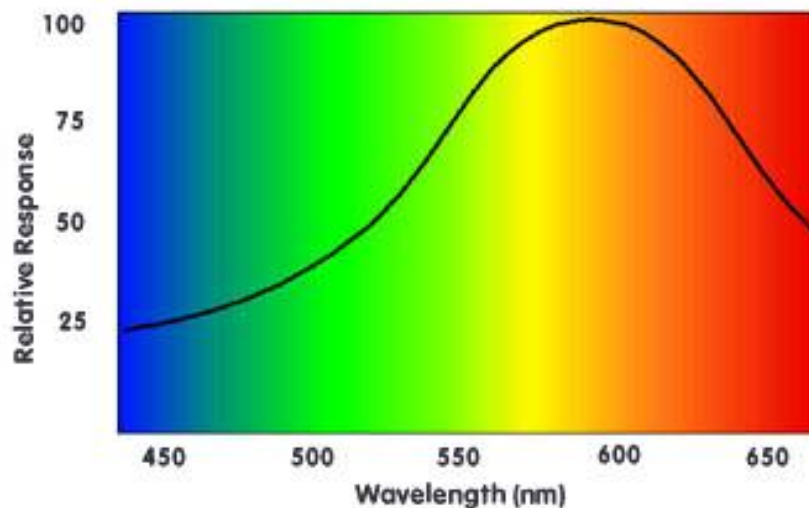
Peak wavelength is a function of the LED chip material. Although process variations are ±10 NM, the 565 to 600 NM wavelength spectral region is where the sensitivity level of the human eye is highest. Therefore, it is easier to perceive color variations in yellow and amber LEDs than other colors.

LEDs are made from gallium-based crystals that contain one or more additional materials such as phosphorous to produce a distinct color. Different LED chip technologies emit light in specific regions of the visible light spectrum and produce different intensity levels.

Comparison of chip technologies for wide-angle, non-diffused LEDs

LED Color	Standard Brightness				High Brightness			
	Chip Material	Ipk (NM)	Iv (mcd)	Viewing Angle	Chip Material	Ipk (NM)	Iv[3] (mcd)	Viewing Angle
Red	GaAsP/GaP	635	120	35	AS AlInGaP	635	900	30
Orange	GaAsP/Gap	605	90	30	AS AlInGaP	609	1,300	30
Amber	GaAsP/Gap	583	100	35	AS AlInGaP	592	1,300	30
Yellow	Gap	570	160	30	--	--	--	--
Green	Gap	565	140	24	GaN	520	1,200	45
Turquoise	--	--	--	--	GaN	495	2,000	30
Blue	--	--	--	--	GaN	465	325	45

White Light

When light from all parts of the visible spectrum overlap one another, the additive mixture of colors appears white. However, the eye does not require a mixture of all the colors of the spectrum to perceive white light. Primary colors from the upper, middle, and lower parts of the spectrum (red, green, and blue), when combined, appear white. To achieve this combination with LEDs requires a sophisticated electro-optical design to control the blend and diffusion of colors. Variations in LED color and intensity further complicate this process.

Presently it is possible to produce white light with a single LED using a phosphor

layer (Yttrium Aluminum Garnet) on the surface of a blue (Gallium Nitride) chip. Although this technology produces various hues, white LEDs may be appropriate to illuminate opaque lenses or backlight legends. However, using colored LEDs to illuminate similarly colored lenses produces better visibility and overall appearance.

Intensity

LED light output varies with the type of chip, encapsulation, efficiency of individual wafer lots and other variables. Several LED manufacturers use terms such as "super-bright," and "ultra-bright" to describe LED intensity. Such terminology is entirely subjective, as there is no industry standard for LED brightness.

The amount of light emitted from an LED is quantified by a single point, on-axis luminous intensity value (Iv). LED intensity is specified in terms of millicandela (mcd). This on-axis measurement is not comparable to mean spherical candlepower (MSCP) values used to quantify the light produced by incandescent lamps.
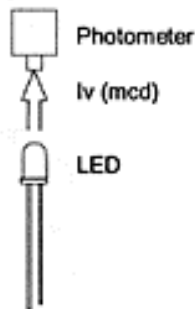
Luminous intensity is roughly proportional to the amount of current (If) supplied to the LED. The greater the current, the higher the intensity. Of course, there are design limits. Generally, LEDs are designed to operate at 20 milliamps (mA). However, operating current must be reduced relative to the amount of heat in the application. For example, 6-chip LEDs produce more heat than single-chip LEDs. 6-chip LEDs incorporate multiple wire bonds and junction points that are affected more by thermal stress than single-chip LEDs. Similarly, LEDs designed to operate at higher design voltages are subject to greater heat. LEDs are designed to provide long-life operation because of optimal design currents considering heat dissipation and other degradation factors.

Eye Safety Information

The need to place eye safety labeling on LED products is dependent upon the product design and the application. Only a few LEDs produce sufficient intensity to require eye safety labeling. However, for eye safety, do not stare into the light beam of any LED at close range
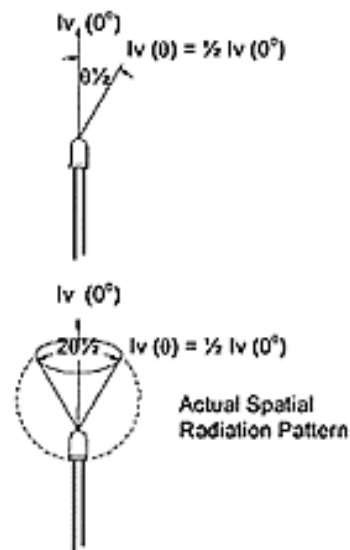
Visibility

Luminous intensity (Iv) does not represent the total light output from an LED. Both the luminous intensity and the spatial radiation pattern (viewing angle) must be taken into account. If two LEDs have the same luminous intensity value, the lamp with the larger viewing angle will have the higher total light output.
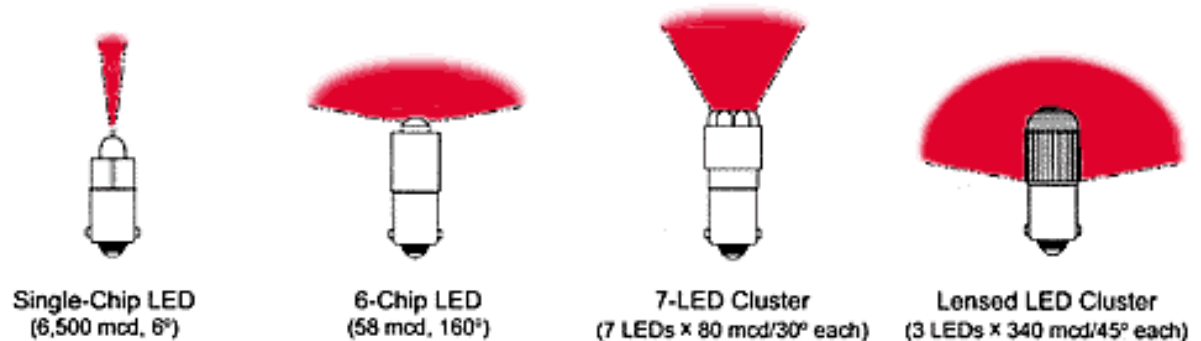
Theta one-half (q½) is the off-axis angle where the LED's luminous intensity is half the intensity at direct on-axis view. Two times q½ is the LEDs' full viewing angle; however, light emission is visible beyond the q½ point. Viewing angles listed in this catalog are identified by their full viewing angle (2q½ °).

LED viewing angle is a function of the LED chip type and the epoxy lens that distributes the light. The highest luminous intensity (mcd rating) does not equate to the highest visibility. The light output from an LED chip is very directional. A higher light output is achieved by concentrating the light in a tight beam. Generally, the higher the mcd rating, the narrower the viewing angle.

Iv (0°)

Iv (0) = ½ Iv (0°)

θ½

Iv (0°)

20% Iv (0) = ½ Iv (0°)

Actual Spatial Radiation Pattern

The shape of the encapsulation acts as a lens magnifying the light from the LED chip. Additionally, the tint of the encapsulation affects the LED's visibility. If the encapsulation is diffused, the light emitted by the chip is more dispersed throughout the encapsulation. If the encapsulation is non-diffused or water clear, the light is more intense, but has a narrower viewing angle. Non-diffused and water clear LEDs have identical viewing angles; the only difference is, water clear encapsulations do not have a tint to indicate color when the LED is not illuminated.

Overall visibility can be enhanced by increasing the number of LED chips in the encapsulation, increasing the number of individual LEDs, and utilizing secondary optics to distribute light. To illustrate, consider similar red GaAlAs LED chip technology in four different configurations:

Single-Chip LED
(6,500 mcd, 8°)

6-Chip LED
(58 mcd, 160°)

7-LED Cluster
(7 LEDs × 80 mcd/30° each)

Lensed LED Cluster
(3 LEDs × 340 mcd/45° each)

In each case, the amount of visible light depends on how the LED is being viewed. The single chip may be appropriate for direct viewing in competition with high ambient light. The 6-chip may be better suited to backlight a switch or small legend, while the cluster or lensed LED may be best to illuminate a pilot light or larger lens.

Operating Life

Because LEDs are solid-state devices they are not subject to catastrophic failure when operated within design parameters. DDP® LEDs are designed to operate upwards of 100,000 hours at 25°C ambient temperature. Operating life is characterized by the degradation of LED intensity over time. When the LED degrades to half of its original intensity after 100,000 hours it is at the end of its useful life although the LED will continue to operate as output diminishes. Unlike standard incandescent bulbs, DDP® LEDs resist shock and vibration and can be cycled on and off without excessive degradation.

Voltage/Design Current

LEDs are current-driven devices, not voltage driven. Although drive current and light output are directly related, exceeding the maximum current rating will produce excessive heat within the LED chip due to excessive power dissipation. The result will be reduced light output and reduced operating life.

LEDs that are designed to operate at a specific voltage contain a built-in current-limiting resistor. Additional circuitry may include a protection diode for AC operation or full-bridge rectifier for bipolar operation. The operating current for a particular voltage is designed to maintain LED reliability over its operating life.

Precautions While Working With LEDs

General

We cannot assume any responsibility for any accident or damage caused when the products are used beyond the maximum ratings specified herein.

The user of these products must confirm the performance of the LEDs after they are actually assembled into the user's products/systems. It is strongly advised that he user design fail-safe products/systems. We will not be responsible for legal matters which are caused by the malfunction of these products/systems.

LED Lamps

Static Electricity and Surge

Static electricity and surge damage LEDs. It is recommended to use a wrist band or anti-electrostatic glove when handling the LEDs. All devices, equipment and machinery must be electrically grounded.
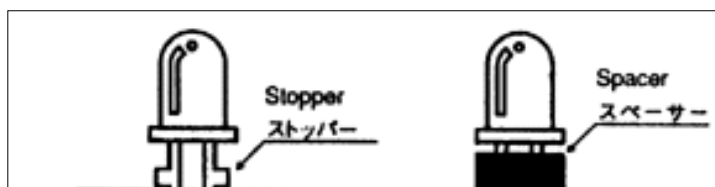
Lead Forming

The leads should be bent at a point at least 3mm from the epoxy resin of the LEDs.

Bending should be performed with the base firmly fixed by means of a jig or radio pliers.
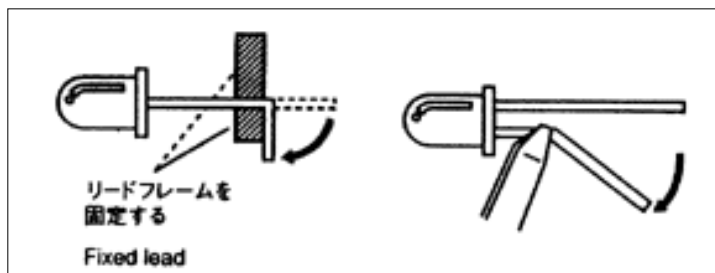
Mounting Method

The leads should be formed so they are aligned exactly with the holes on the PC board.

This will eliminate any stress on the LEDs.

Use LEDs with stoppers or resin spacer to accurately position the LEDs. The epoxy resin base should not be touching the PC board when mounting the LEDs. Mechanical stress to the resin may be caused by the warping of the PC board when soldering.

The LEDs must not be designed into a product or system where the epoxy lens is pressed into a plastic or metal board. The lens part of the LED must not be glued onto plastic or metal. The mechanical stress to the leadframe must be minimized.
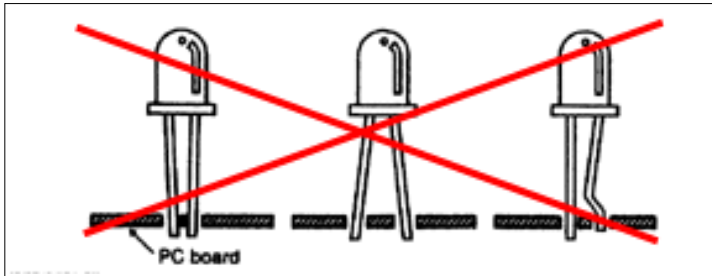
Soldering

Solder the LEDs no closer than 3mm from the base of the epoxy resin.

For solder dipping, it may be necessary to fix the LEDs for correct positioning. When doing this, any mechanical stress to the LEDs must be avoided.

When soldering, do not apply any mechanical force to the leadframe while heating.

Repositioning after soldering must be avoided.

Soldering conditions:

	Soldering Iron	Dip Soldering	Reflow Soldering
Lamp LED	300degC(max), 3sec(max)	260degC(max), 5sec(max)	Not allowed.
Chip LED	300degC(max), 3sec(max) with Twin Head iron	Not allowed.	

Cleaning

Avoid exposure to chemicals as they may attack the LED surface and cause discoloration. When washing is required, "isopropyl alcohol" is to be used.

The influence of ultrasonic cleaning on the LEDs differs depending on factors such as oscillator output and the way in which the LEDs are mounted.

Therefore, ultrasonic cleaning should only be performed after making certain that it will not cause any damage.

Emission color

LED emission wavelengths vary. LEDs are classified by emission color into different ranks. When a large volume of LEDs are purchased, LEDs with different color ranks will be delivered

Packaging

The leadframes of the LEDs are coated with silver. Care must be taken to maintain a clean storage atmosphere. If the LEDs are exposed to gases such as hydrogen sulfide, it may cause discoloration of the leadframes.

Moistureproof packing is used to keep moisture away from the chip type LEDs. When storing chip type LEDs, please use a sealable package with a moisture absorbent material inside.

LED Cluster Lamp and LED Dot Matrix Unit

Assembly

Please refer to the recommended distance between the leads when designing lead holes on the PC board.

Close attention must be paid on the correct positioning of O-rings and other water proof seals when assembling products/systems.

LEDs are vulnerable to static electricity. When handling the LEDs, necessary precautions regarding static electricity must always be taken into consideration.

Installation of LEDs

Make certain that the lead position and polarity are correct when installing the LEDs.

The interface cable must be as short as possible.

The power supply and ground line must be selected according to their current capacity.

Heat Dissipation

When many LEDs are mounted into a small area, heat generation must be taken into consideration. If there is a possibility that the ambient temperature may exceed 60 degrees centigrade, some kind of forced cooling system will be needed

The ambient operating temperature must be taken into consideration when a product/ system is being designed. There are certain limits to maximum current, at certain temperatures which must be kept in mind.

Handling

When the surface of the LEDs must be cleaned, the LEDs should be wiped softly with detergent. The surface may be damaged and the effect of the lens may be reduced with violent scrubbing.

Others

EMI countermeasures must be taken as a system.

When instantaneous power failure, or a current surge by lightning stops the controller at abnormal conditions, the abnormally high electric current may continue running through the LEDs for an extended period of time. This can damage the LEDs in the system. Circuit protection against abnormally high current must be built into the system to protect against this.

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Disclaimer: The information provide herein are basics to educate one on the operating properties and user characteristics of LEDs. We do not imply that the information is accurate or applicable to every aspect of LED usage. Each application will have to be performed on its own merits and with full understanding that damages and injury are the sole responsibility of the "builder". We do not dispense engineering advice. You need to determine the specific products you will need for your specific application.

<div align="center">

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Li/MnO₂

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NiMH

Technical Marketing

Li/MnO₂

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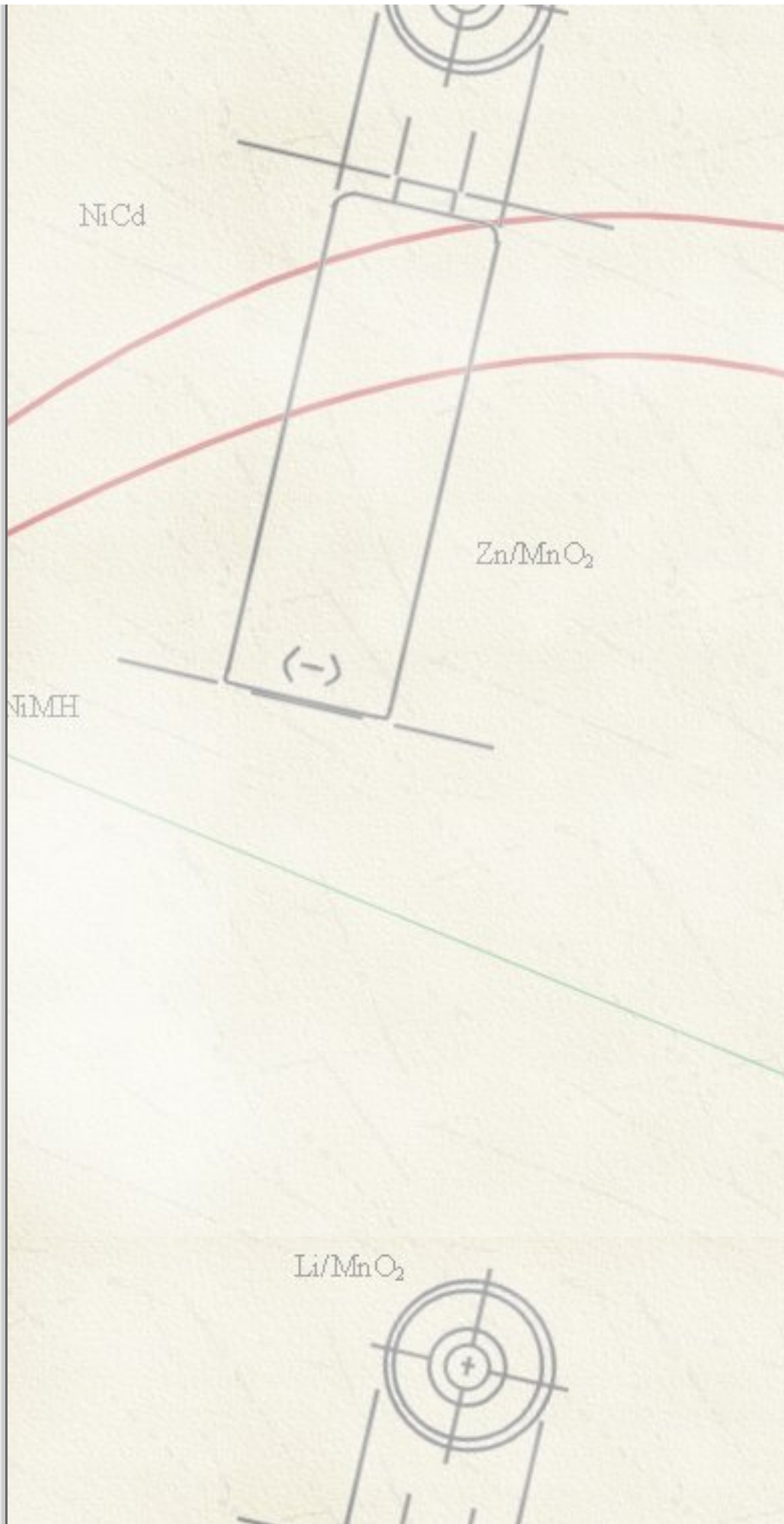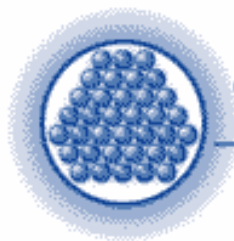
Technical Stuff for the Buffs

The LED color chart below does NOT represent what The LED Light carries. This chart is only to be used as reference for the various types of LEDs being manufactured today, and to show what their basic properties are.

LED Color Chart

	Wavelength (nm)	Color Name	Fwd Voltage (Vf @ 20ma)	Intensity 5mm LEDs	Viewing Angle	LED Dye Material
	940	Infrared	1.5	16mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Arsenide
	880	Infrared	1.7	18mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Arsenide
	850	Infrared	1.7	26mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Aluminum Arsenide
	660	Ultra Red	1.8	2000mcd @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Aluminum Arsenide
	635	High Eff. Red	2.0	200mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	633	Super Red	2.2	3500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	620	Super Orange	2.2	4500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	612	Super Orange	2.2	6500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	605	Orange	2.1	160mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	595	Super Yellow	2.2	5500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	592	Super Pure Yellow	2.1	7000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	585	Yellow	2.1	100mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	4500K	"Incan-descent" White	3.6	2000mcd @20mA	20°	SiC/GaN -- Silicon Carbide/Gallium Nitride
	6500K	Pale White	3.6	4000mcd @20mA	20°	SiC/GaN -- Silicon Carbide/Gallium Nitride
	8000K	Cool White	3.6	6000mcd @20mA	20°	SiC/GaN - Silicon Carbide / Gallium Nitride
	574	Super Lime Yellow	2.4	1000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	570	Super Lime Green	2.0	1000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide

	565	High Efficiency Green	2.1	200mcd @20mA	15°	GaP/GaP - Gallium Phosphide/Gallium Phosphide
	560	Super Pure Green	2.1	350mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	555	Pure Green	2.1	80mcd @20mA	15°	GaP/GaP - Gallium Phosphide/ Gallium Phosphide
	525	Aqua Green	3.5	10,000mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride
	505	Blue Green	3.5	2000mcd @20mA	45°	SiC/GaN - Silicon Carbide / Gallium Nitride
	470	Super Blue	3.6	3000mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride
	430	Ultra Blue	3.8	100mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride

Click Here for Chromaticity Chart

Relative Intensity vs Wavelength (P)
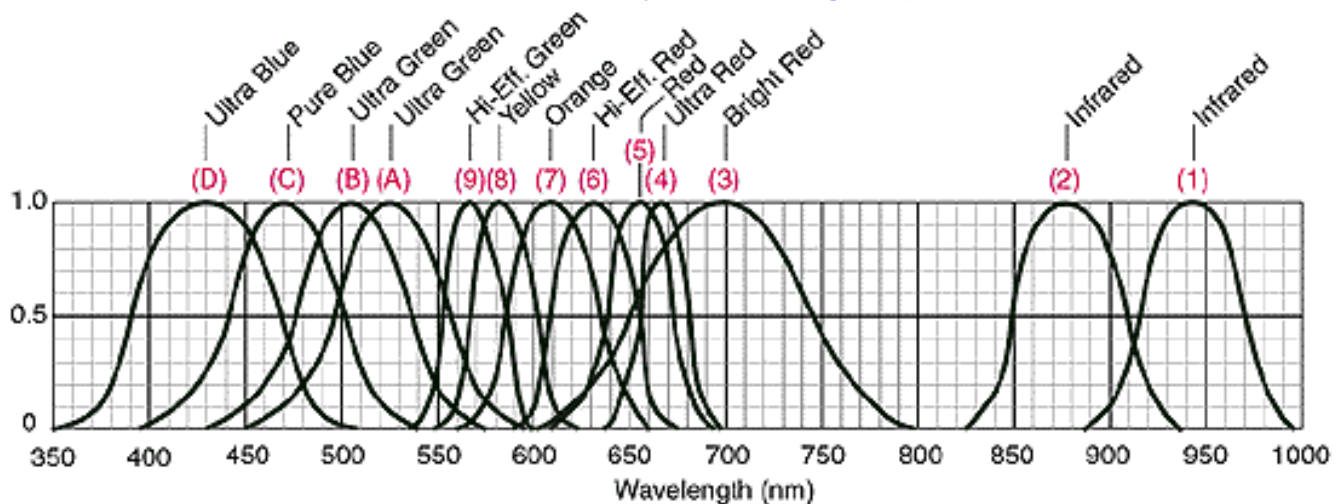
Forward Current vs Forward Voltage
Red 5, Ultra Red 4, HE Red 6, Orange 7, Bright Red 3, HE Green 9, Yellow 8
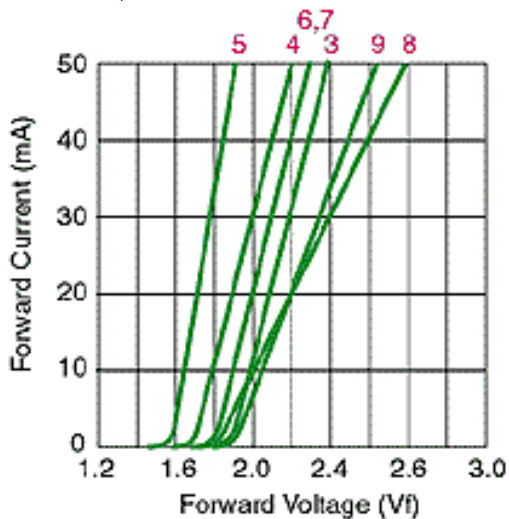
Relative Luminous Intensity vs Forward Current
Ultra Red 4, HE Red 6, Orange 7, Yellow 8, HE Green 9 Red 5, Bright Red 3, Pure Blue C
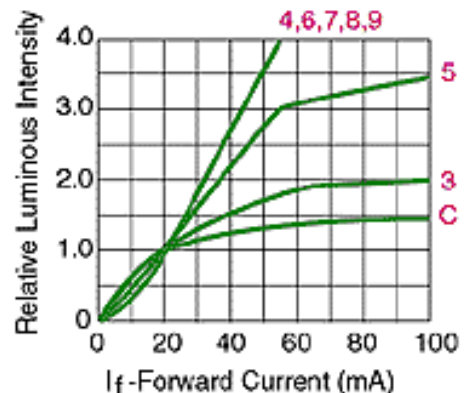
Forward Current vs
Ambient Air Temperature
Red 5, Ultra Red 4, HE Red 6, Orange 7,
HE Green 9, Ultra Blue D, Yellow 8, Bright Red 3
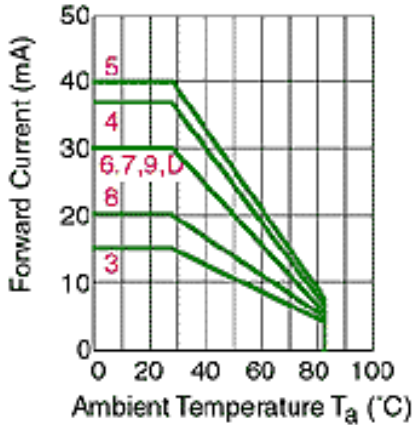
Relative Luminous Intensity vs
Ambient Temperature
Red 5, Bright Red 3, Ultra Red 4, HE Green 9, Yellow 8
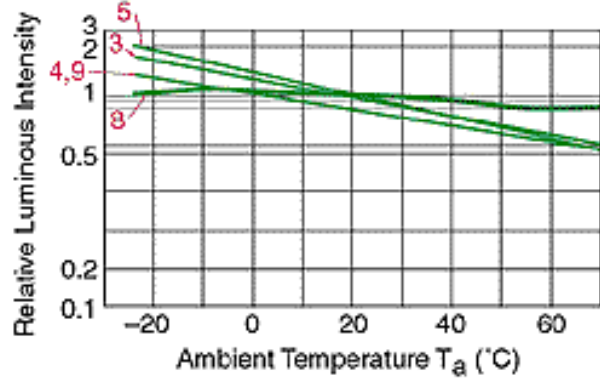
Maximum Tolerable Peak Current
vs Pulse Duration
Ultra Red, Red, HE Red, Orange, Yellow, HE Green,
Ultra Green (523nm), Ultra Green (502nm), Pure Blue, Ultra Blue

Bright Red
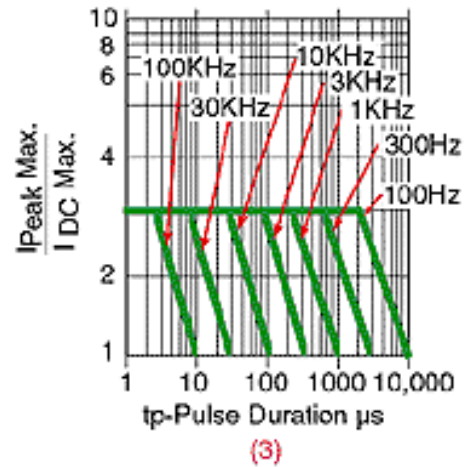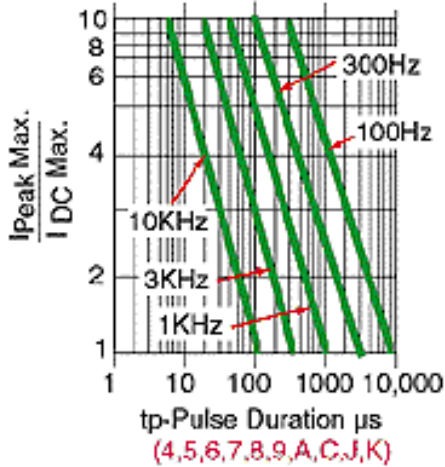
Backlighting Surfaces Using LEDs

Backlit Surface

Angle of Illumination

L206
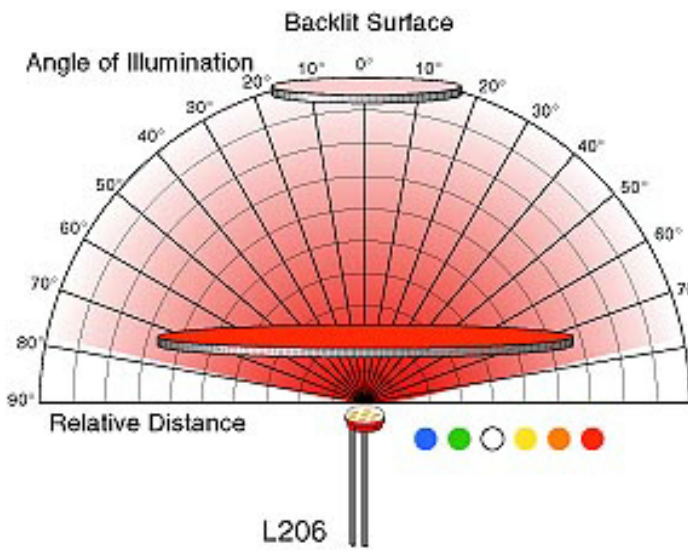
Extra wide illumination angle (160°)
Very short illumination distance

Backlit Surface

Angle of Illumination

LDF190
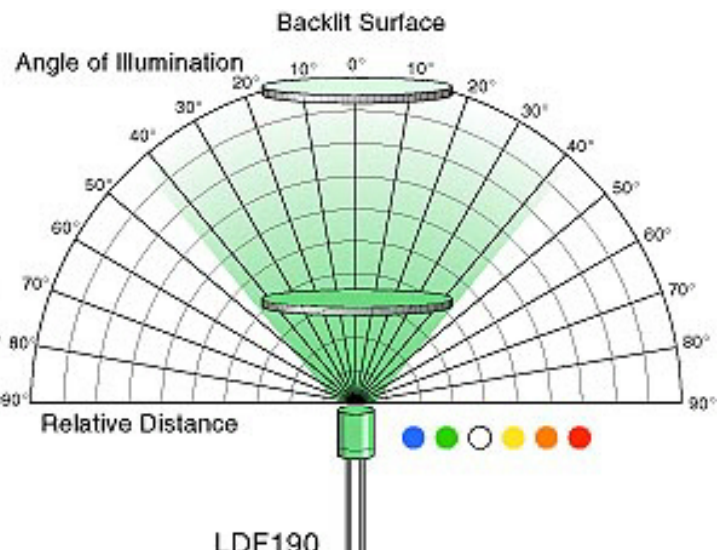
Wide illumination angle (120°)
Short illumination distance

Backlit Surface

Angle of Illumination

LD190
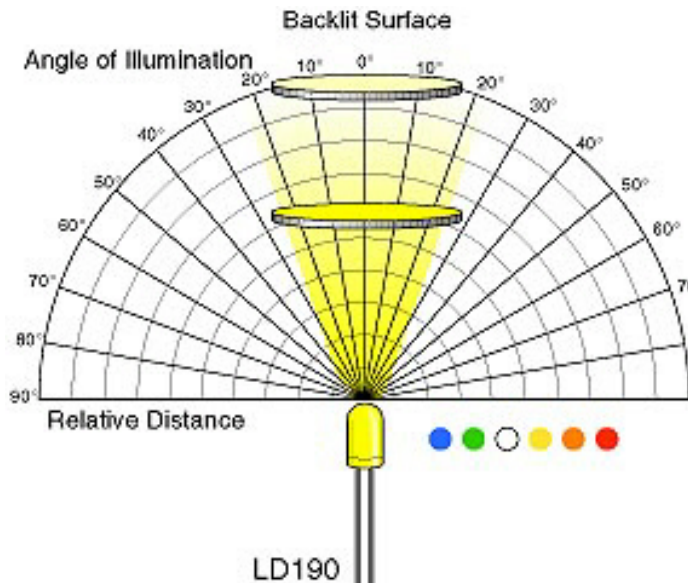
Medium illumination angle (30° - 45°)
Medium illumination distance

Backlit Surface

Angle of Illumination

Hotspot

L200
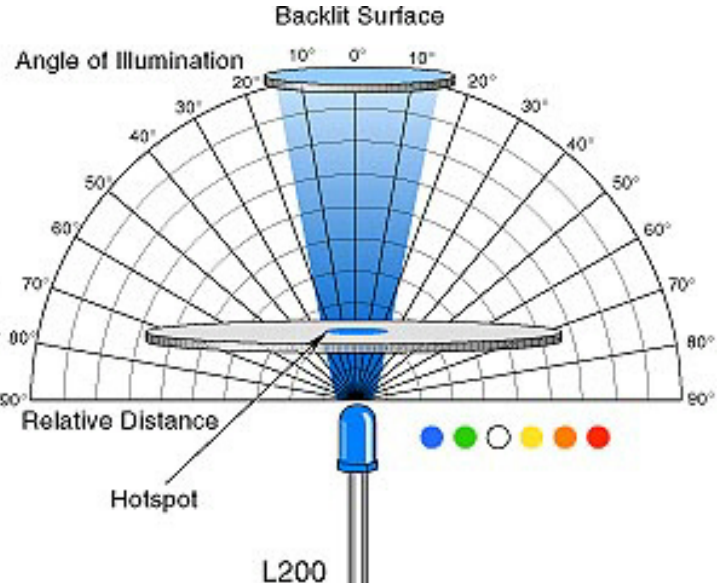
Narrow illumination angle (8° - 20°)
Long illumination distance

Tables, Graphs and Images are through the courtesy of LEDtronics 07/10/00

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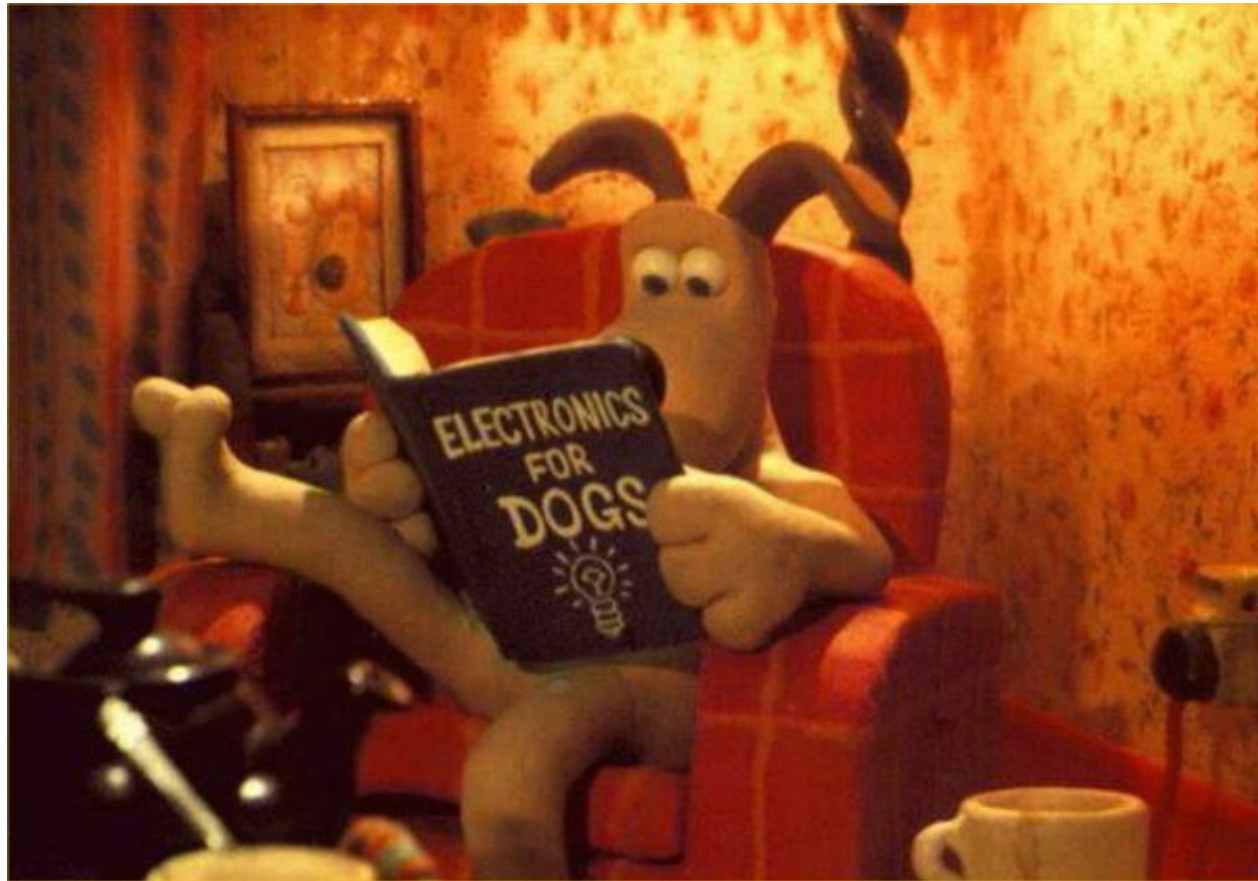
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Product suggestions for various Applications

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Product suggestions for various Markets

Design Folders

A central location for information related to a design topic

Designing Electronic Signs and Signals using Agilent High-Brightness LEDs

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Agilent's LEDs Recommended for Handsets

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Product DataSheets

Technical datasheets and option datasheets contain basic product descriptions and technical specifications.

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4mm Precision Optical Performance InGaN Oval LED Lamp

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HANDBOOK PAGE

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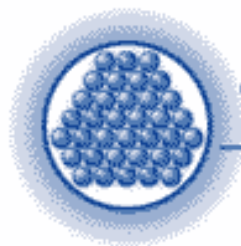
CURRENT LIMITING RESISTOR CALCULATOR

FOR LIGHT EMITTING DIODES

The calculators on this page can be used to find current limiting resistors and currents for Light Emitting Diodes.

The first calculator determines the resistance for a desired LED current while the second calculates the current for a given resistance.

LED - Current and Resistance Calculator Diagram

LED - CURRENT LIMITING RESISTOR CALCULATOR

Supply Voltage   Voltage Drop Across LED   Desired LED Current

VOLTS   **VOLTS**   **MILLIAMPS**

Calculated Limiting Resistor   Calculated Resistor Wattage

OHMS   **WATTS**

Voltages in Volts - Current in Milliamps - Resistance in Ohms
When selecting resistors - It is advisable to choose the next higher standard value.

A browser capable of running Javascript is required for this calculator.

If LED's are connected in series - ADD their voltage drops together to get the total voltage drop.

Entering a zero for the LED voltage drop will yield the resistance and wattage for a resistance only circuit.

Courtesy of Rob Paisley

The following links might interest you. Or, you can click the "Online Catalog" button below
to go back to the main page for other LED products.

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Disclaimer

Lumens, Illuminance, Foot-candles and bright shiny beads….

In defining how bright something is, we have two things to consider.

1. How bright it is at the source- How Bright is that light?
2. How much light is falling on something a certain distance away from the light.

Lets' do some definitions now……

We're in America, so we are going to talk about units of measurement that concern distance in feet and inches. So, we will use some terms that folks in Europe don't use. We're going to talk about "foot-candles".

This one's simple. Get a birthday cake candle. Get a ruler. Stick the candle on one end of the ruler. Light the candle. Turn out the lights. Sing Happy Birthday to Doc. It was his 47th on the 23rd. OK, quiet down. Enough of that nonsense. One foot-candle of light is the amount of light that birthday cake candle generates one foot away.

That's a neat unit of measurement. Why? Say you have a lamp. You are told it produces 100 foot candles of light. That means at one foot from the lamp, you will receive 100 foot candles of light.

But here's where it gets tricky. The further away you move the light from what you want to illuminate, the less bright the light seems! If you measure it at the light, it's just as bright. But when you measure at the object you want illuminated, there is less light! A Physics teacher is going to tell you that light measured on an object is INVERSELY PROPORTIONAL to the distance the object is from the light source. That's a very scientific and math rich way of saying, the closer you are to the light bulb, the brighter that bulb is. Or, think of it this way. You can't change how much light comes out of your light bulb. So, to make more light on an object, you have to either move the light closer, or add more lights.

Now, lets get to LUMENS.

A LUMEN is a unit of measurement of light. It measures light much the same way. Remember, a foot-candle is how bright the light is one foot away from the source. A lumen is a way of measuring how much light gets to what you want to light! A LUMEN is equal to one foot-candle falling on one square foot of area.

So, if we take your candle and ruler, lets place a book at the opposite end from the candle. We'd have a bit of a light up if we put the book right next to the candle, you know. If that book happens to be one foot by one foot, it's one square foot. Ok, got the math done there. Now, all the light falling on that book, one foot away from your candle equals both…….1 foot candle AND one LUMEN!

Ahh, we've confused you. Let's split off from this and talk about the difference between RADIANCE and ILLUMINANCE.

RADIANCE is another way of saying how much energy is released from that light source. Again, you measure it at the source. Unless you're talking about measuring the radiance of something intensely hot, like the Sun. Then you might want to measure it at night, when it's off.

ILLUMINANCE is what results from the use of light. You turn your flashlight on in a dark room, and you light something up. That's ILLUMINANCE. Turning on a light in a dark room to make the burglar visible gives you ILLUMINANCE. It also gives you another problem when you note the burglar is pointing your duck gun at your bellybutton.

Illuminance is the intensity or degree to which something is illuminated and is therefore not the amount of light produced by the lightsource. This is measured in foot-candles again! And when people talk about LUX, it's illuminance measured in metric units rather than English units of measure. To reinforce that, LUX is the measurement of actual light available at a given distance. A lux equals one lumen incident per square meter of illuminated surface area. They're measuring the same thing, just using different measurement units.

Pretend you're an old photographer, like O. Winston Link, or Ansel Adams. These two gods of black and white photography (and a print made by either can fetch quite a hefty sum of money these days) used a device called a light meter to help them judge their exposure. (There is another way of judging exposure-that's when someone whispers in our ear at a cocktail party, "You silly twit, your fly's come undone!").

These light meters were nifty devices. You could use it to show how much light was falling on an object, light from the sun, and reflected light energy from every thing else. Or you could use it to show how much light energy was reflected off the object itself.

All this brings back two points. Well, three.

The first point is if we measure the output of a light at the source that gives us one thing.

The second point is that we use an entirely different unit of measure if we are measuring the results of that light's output.

The third point is the instructor is right off his trolley, isn't he?

Now back to the book at the end of the ruler.

We've measured two different things. We have a unit of measure for how much light is produced. We Yankees express that as a foot-candle. Being lazy, we use it all over the place.

More Confusion! Candlepower!

Candlepower is a way of measuring how much light is produced by a light bulb, LED or by striking an arc in a Carbon-Arc spotlight. Is it a measure of how much light falls upon an object some distance away? No. That's illuminance. Is it a measure of how well we see an object that is illuminated by that light source? No. That's something all together different, and we are not going there!

Nowadays we use the term CANDELA instead of candlepower. Candlepower, or CANDELA is a measure of how much light the bulb produces, measured at the bulb, rather than how much falls upon the thing you want to light up. Further confusing the matter is beam focus. That's how much candlepower can be focused using a reflector/lens assembly. Obviously, if you project all your light bulbs intensity at a given spot, or towards something, it will be more intense, and the illuminance will be higher.

And here comes the confuser! A candlepower as a unit of measure is not the same as a foot-candle. A candlepower is a measurement of the light at the source, not at the object

you light up.

And a candela is the metric equivalent of the light output of that one candle, based on metric calculations. And since using a candle is rather imprecise, the definition was amended to replace a light source using carbon filaments with a very specific light source, see the following:
The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

The above from the National Institute of Standards Reference on Constants, Units, and Uncertainty.

Candlepower is a measure of light taken at the source-not at the target. Foot-candles tell us how much of that light is directed at an object we want to illuminate.

Now, lets convert the lumens, a metric unit of light measurement, to candlepower.

We understand a candle radiates light equally in all directions, its output, in this consideration is not focused by any mechanical means (lenses or reflectors). Pretend for a moment that a transparent sphere one meter in radius surrounds your candle. We know that there are 12.57 square meters of surface area in such a sphere. Remember your Solid Geometry classes?

That one candle (1 Candlepower/Candela) is illuminating equally the entire surface of that sphere. The amount of light energy then reflected from that surface is defined thusly:

The amount of energy emanating from one square meter of surface is one lumen. And if we decrease the size of the sphere to one foot radius, we increase the reflected energy 12.57 times of that which fell on the square meter area.

LUX is an abbreviation for Lumens per square meter.
Foot-candles equal the amount of Lumens per square feet of area.

So, that one candlepower equivalent equals 12.57 lumens.

And for you figuring out LED equivalents, first you must know how many lumens your LED's each produce. Then divide that value by 12.57 and you have candlepower of the LED. You don't have foot-candles, remember foot-candles are illuminance. And we are measuring radiance.

Summing it all up:

Candlepower is a rating of light output at the source, using English measurements.
Foot-candles are a measurement of light at an illuminated object.
Lumens are a metric equivalent to foot-candles in that they are measured at an object you want to illuminate.
Divide the number of lumens you have produced, or are capable of producing, by 12.57 and you get the candlepower equivalent of that light source.

We've now converted a measurement taken some distance from the illuminated object, converted it from a metric standard to an English unit of measure, and further converted it from a measure of illumination to a measure of radiation!

This has been an ideal proof of the superiority of the metric system. Then again, the metric system is a product of those wonderful folks that brought us:

Renault, Peugeot, Citroen, and Airbusses. Not to mention simply awful Bordeaux.

And, if you're happy with this, send those little gems to:

Robert H (Doc) Bryant
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I hope you have enjoyed this as much as I have. You ought to see me up in front of a classroom. My classes are absolute laugh riots. But people learn!

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Lighting F.A.Q.

By Mikhail Dubinovskiy

- What does "Candela", "Lumen", etc. mean?
- Footcandle to Lux conversion
- What does "inverse square law"
- What does "cosine law" mean
- What is the difference between Lumen and Watt
- How to calculate beam angle
- How to calculate lumens output

What does "Candela", "Lumen", etc. mean?

The formal definition can be found in many handbooks, so here are informal and, hopefully more useful, definitions:

Luminous intensity (or **candlepower**) is the light density within a very small solid angle, in a specified direction. In other words, this is the total number of lumens from a surface emitted in a given direction. The unit of measure is **candela**. In modern standards, the candela is the basic of all measurements of light and all other units are derived from it. Candlepower measurements are often taken at various angles around the source and the results plotted to give a *candlepower distribution curve.* Such a curve shows luminous intensity (how "bright" the source seems) in any direction.

Luminous flux is the <u>time</u> rate of flow of light. The unit of measure is the **Lumen**. One lumen may be defined as the light flux emitted in one unit solid angle by a one-candela uniform-point source. The lumen differs from the candela in that it is a measure of light flux irrespective of direction. The lumen is used to express a quantity of light flux: total output of a source, output within a specific angular zone, amount of absorbed light, etc.

However, if you need to calculate something which is not related to the human eye, for example temperature increase due to absorbed light, do not use luminous flux, instead we need to use the correct unit of power, the Watt (see below).

Illumination is the density of luminous flux on a surface This parameter shows how "bright" the surface point appears to the human eye. The appropriate units of measure are **Footcandle** and **Lux**. One footcandle is the illumination produced by one lumen uniformly distributed over one square foot of a surface, or conversely this is the illumination at the point of a surface which is one foot from, and perpendicular to, a uniform point source of one candela. So, footcandles incident on a surface=Lumens/Area(sq.feet). Lux is used in the International System. Both have a similar objective, but meters are used for Lux and feet are used for Candelas. Therefore, one lux=0.0929 footcandles. Or, approximately, 1 Fc=10 Lux.

Luminance or **Brightness** is a luminous intensity of a surface in a given direction per unit of projected area of the surface. Luminance can be expressed in two ways: in candelas per unit area or in lumens per unit area. I don't want do go too into this subject, because it is so seldom used. There are many different standard units of measurement. For example: **Candela per square inch (cd/in²) , Footlambert** (luminance of a surface emitting one lumen per square foot), **Lambert** (similar, but per square cm).

1 cd/in.² =452 Footlamberts

1 Lambert=929 Footlamberts=2.054 cd/in².

Actually, our eye sees brightness, not illumination. Every visible object has brightness. Usually, brightness is proportional to the object's illumination, so a well illuminated object seems brighter. For a

perfectly diffusing reflecting surface:

Footlamberts = Footcandles * Surface Reflectance

Footcandle to Lux Conversion

One footcandle is the illumination produced by one lumen uniformly distributed over one square foot of surface, and lux is the illumination over one square meter of surface. Therefore, one lux=0.0929 footcandles. Or, approximately, 1 Fc=10 Lux.

What does "inverse square law" mean?

Illumination at the center=E_2

Illumination at the center=E_1

Distance=D_2
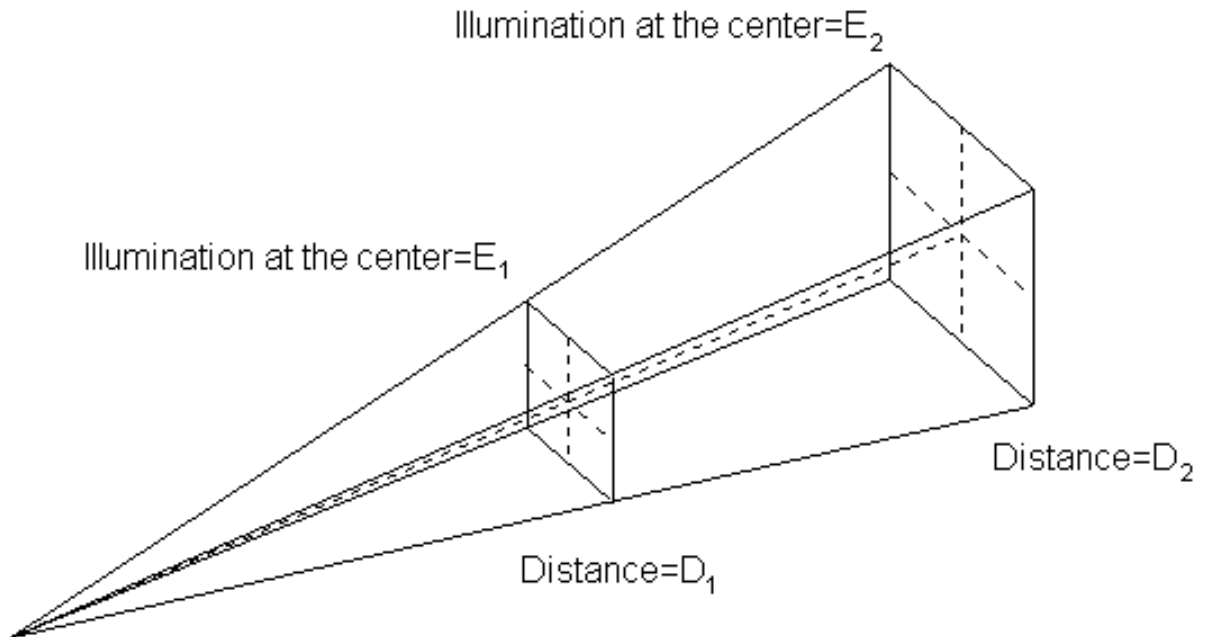
Distance=D_1

Point Source

The inverse square law tells is that the illumination is inversely proportional to the square of the distance between the point source and the surface, i.e.:

$$\frac{E_1}{E_2} = \frac{D_2^2}{D_1^2}$$

If you have a fixture (which can be treated as a point source if the distance from the surface is large) and you measure the illumination at 20 feet as 2000 Fc at the beam center, then at 40 feet the illumination is 500 Fc at the beam center.

What does "cosine law" mean?

Effective illumination is proportional to the cosine of the angle of incidence of the light on the surface (angle between the direction of the light and the perpendicular to the surface)

Source

90°

α

β

E_1

O

E_2
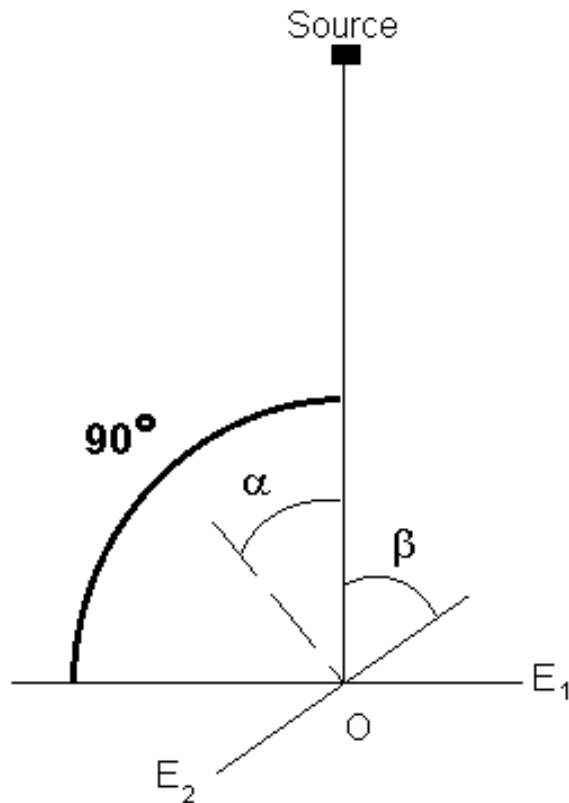
Illumination at the O point on surfaces 1 and 2:

$$E_2 = E_1 \cos \alpha = E_1 \sin \beta$$

Here are a few cases:

When the surface is tilted by an angle of 30⁰, the illumination is reduced by a factor of 0.87

45⁰ - 0.71

60⁰ - 0.5

What is the difference between Lumen and Watt?

Lumen is a unit of the photometric system and Watt belongs to the radiometry system.

Both characterize a power of light flow. However, lumen is power "related" to the human eye sensitivity. Therefore, lights with the same power in watts, but different colors have different luminous fluxes, because the human eye has different sensitivity at different wavelengths. At a wavelength of 555 nm (maximum eye sensitivity) 1 Watt equals 683 Lm.

Very powerful sources of infrared radiation produce no lumen output, because the human eye can't see it. However, if you need to calculate total power absorbed by a surface (to estimate temperature increase, for example), you have to transfer lumen flux to watt. This can be done by using a spectral luminous efficiency curve, which can be found in many photometry handbooks.

How to calculate beam angle.

This is easy. If you know the distance from a fixture to the screen (much larger than fixture length) and the image diameter, then:

D - image diameter

L - distance

α

Fixture
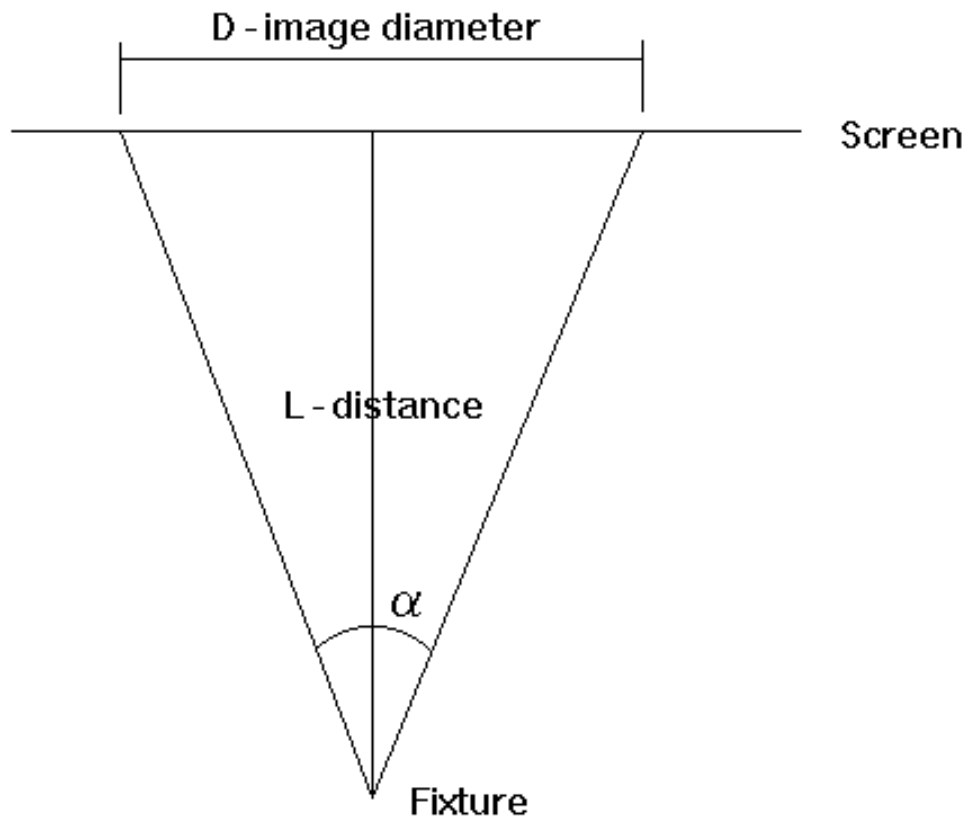
$$\alpha = 2 \arctan \frac{D}{2L}$$

In most practical cases the following approximation is true:

$$\alpha = 57.3 * \frac{D}{L}$$

Of course, both measurements must be in the same units (meters, feet, inches, etc.)

(Example: distance = 20 feet, image diameter=5 feet. Exact formula gives 14.25 °, second – 14.32°)

In the case of "soft edge" light image diameter, usually, is measured at point where illumination is 50% (beam angle) or 10% (field angle) of the center illumination.

How to calculate lumens output.

The best way is to use a photometric sphere, however the number of people who have one is much less than the number of people who want to know total lumen output (luminous flux) of a fixture.

Another way is to measure illumination (which is the density of luminous flux on a surface) at a number of points and then integrate the resulting values.

Assuming that the beam has axial symmetry (if not – you're in trouble. You have to measure many points all over the beam) and fixture beam angle is small (we can neglect cosine-cube coefficient from cosine-law and inverse-square-law, that is less than 5% for the 20° beam and 1% for the 10° beam), we have the following formula:

Beam Profile
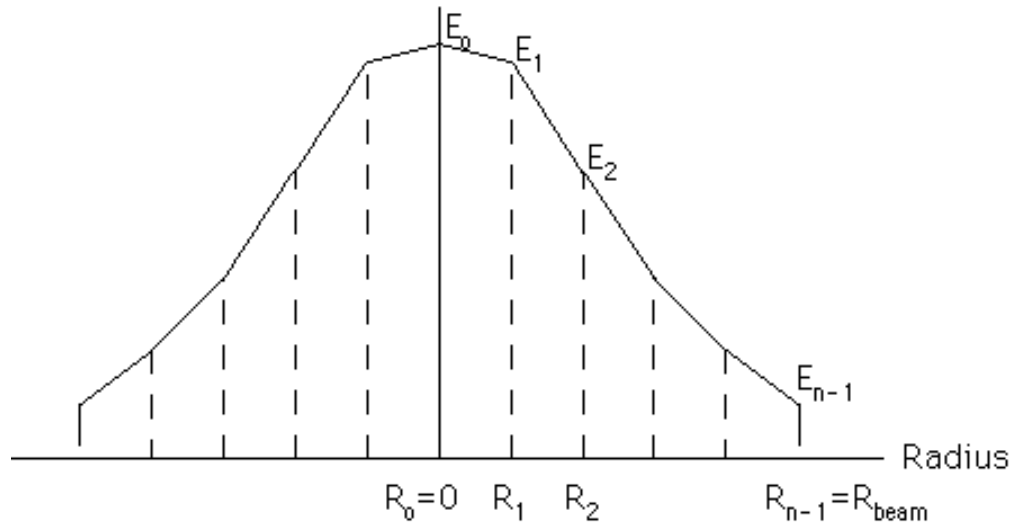
Beam radius is divided into n equal part (radiuses and illumination reading values are indexed from 0, at the beam center, to n-1, at the beam edge).

2 points (center and edge readings only):

$$P = 2.1R^2\left(E_1 + 0.5E_0\right)$$

3 points (center, middle, and edge):

$$P = 1.3R^2\left(E_2 + 1.2E_1 + 0.2E_0\right)$$

4 points:

$$P = 0.93R^2\left(E_3 + 1.5E_2 + 0.75E_1 + 0.125E_0\right)$$

5 points:

$$P = 0.72R^2\left(E_4 + 1.64E_3 + 1.09E_2 + 0.55E_1 + 0.09E_0\right)$$

8 points:

$$P = 0.43R^2\left(E_7 + 1.8E_6 + 1.5E_5 + 1.2E_4 + 0.9E_3 + 0.6E_2 + 0.3E_1 + 0.05E_0\right)$$

Here:
P - total lumens
R - beam radius
E - illumination

There is nothing magical about these equations. They are obtained by using integrating rules over the beam.

In the case of "soft edge" fixture, where the image size is taken at 10% of the center illumination (field angle), the first formula becomes very simple:

$$P = 1.26R^2 E_{center}$$

To get the result in lumens, you should use proper units. If you use footcandles, then the radius must be in feet. If you use lux, then the radius must be in meters.

And last, it doesn't make any sense to calculate luminous flux with 2-3 digits after the decimal point by this method. Assumptions which were made (illumination distribution is perfectly symmetrical, etc.) inevitably result in some error in the final calculation, so instead of 14231.41 Lm it is more practical to use 14KLm.

Back

Proprietary Notice

Energy-Efficient Lighting for Kitchens and Bathrooms

Color Temperature and Color Rendering Index (CRI)

Color temperature is how cool or warm the light source appears. Incandescent lamps have a warmer appearance than mercury vapor yard lights, for example.

CRI is a relative measure of the shift in surface color of an object when lit by a particular lamp, compared with how the object would appear under a reference light source of similar color temperature. Commonly used as references are incandescent lamps (warm light sources) and natural daylight (a cool light source). Incandescent lamps and daylight have a CRI of 100, the highest possible CRI. The higher the CRI of the light source, the "truer" it renders color.

The chart gives the CRI and color temperature of various light sources.

You can see that fluorescents come in a variety of color temperatures and CRIs. If you want to use fluorescent lamps in a room that also has incandescent lamps, consider the warmer 3000K long fluorescents or 2700K compact fluorescents. Their warmer color temperature makes them a better match for incandescent lamps.

Color Temperature and Color Rendering Index

Consider "color temperature"--how cool or warm the light source appears--when choosing lamps. The Color Rendering Index (CRI) is a relative measure of the shift in surface color of an object when lit by a particular lamp, compared with how the object would appear under a reference light source of similar color temperature. The higher the CRI of the light source, the "truer" it renders color.

Degrees Kelvin		Approximate CRI	
26000	Blue northwest sky		
22000			
18000			
16000			
14000			
12000			
10000			
8000			
7000	Uniform overcast sky		
	Daylight fluorescent	75	
6000	Clear mercury	25	
	Clear metal halide	60	
5000	5000K fluorescent	80-90	
	Average noon sunlight		
	Coated metal halide	75	
4500	Coated mercury	45	
	Cool white fluorescent	65	
	4100K fluorescent	70-85	
4000	Deluxe mercury	45	
	Compact metal halide	60-90	
	Sunlight, 1 hour after sunrise		
3500	3500K fluorescent	70-85	
	White fluorescent	60	
	Warm white mercury	45	
	Tungsten halogen	95	
	Warm white fluorescent	55	
3000	3000K fluorescent	70-85	
	Standard incandescent	95	
	2700K fluorescent	70-85	
2500			
	High pressure sodium	25	
2000			
	Sunlight at sunrise		
	Candle flame		

Skylight

Sunlight

Cool tones

Nuetral tones

Warm tones

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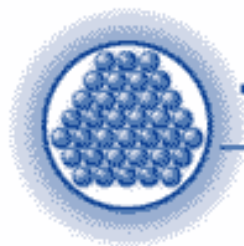
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The Products
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LED Clusters, LED Arrays and LED Assemblies are names that refer to the same thing; a grouping of LEDs soldered to a circuit board with the appropriate resistor to operate the LEDs at the desired voltage. Do-It-Yourself DIY-3 3 LED clusters to DIY-36 36 LED clusters. We also have Flexible LED Boards, Submersible MicroStar LEDs, and the Versalux 10 LED Module here.

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imagination takes you. Most LED fixtures are available in 12vdc to 48vdc, and more than a few in 120vac.

LED Flashlights! for general utility or special use such as Ultra-Violet LED Lights; LED Micro lights, small LED flashlights and BIG LED flashlights; special microprocessor controlled LED flashlights; colored LED flashlights for a variety of user applications, and the new Luxeon Star LED Flashlights.. Keep tuned to TheLEDLight.com's LED Flashlight section as it is frequently updated with new LED goodies! Not sure which color LED to select? Click here for a basic color guide.

Flashlight Accessories Lanyards, clips, holsters, shields, lenses, boots, flashlight bicycle mounts, and batteries that fit the flashlights we sell.

Gadgets, Gifts and LED Fun Stuff Zzz mood lights, a key finder/LED flashlight combination, and even a LED/fiber optic flying disc for fun and enjoyment. Recently added, a LED Book Light.

LED Headlamps 3 LED/krypton bulb Tridents, 4 LED Illuminators, 7 LED Fusions and 7 LED Septors. One will be the right size for you! Even an Infared Fusion and various colored LED headlamp choices!

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LEDs - Light Emitting Diode Index in all colors including RGB and UV diodes. Loose pieces for individuals and commercial users. Printable data sheets are provided for each LED we stock and we strongly suggest that you print them out prior to ordering.

Color		Dominant Wavelength/ Color Temperature
○	White	5500k
●	Royal Blue	455nm
●	Blue	470nm
●	Cyan	505nm
●	Green	530nm
●	Amber	590nm
●	Red	625nm

Luxeon Star LEDs, Emitters, Stars w/Optics. I watt models and blue 5 watt models are in stock. White models due sometime in 2003.

Night Vision! Green LEDs and InfraRed LED lights to help you see in the dark.

LED Emergency Lights - LED lanterns, motion sensing LED lights and solar power stations provide needed light any time, anywhere.

Portable LED Lights such as lanterns, tent lights, Power Stations, even a security light. Use these items daily or as emergency lighting and back-ups.

Safety and Security Equipment from LED traffic batons to LED flashers to LED emergency utility lamps. We have USCG Xenon Strobes, red LED safety flashers, LED boating navigation lights, and portable Power Stations.

Solar Powered Fans from the 4 inch Outhouse type to our huge 16 inch Attic Vent Fans. These will run at 12vdc or 24vdc for the 12" and 16" models.

Solar Powered Lights which can be installed permamnently, semi-permanently or be portable. Use for sheds, barns, garages, as a portable emergency light, or for night security lighting. We also stock 12vdc Trickle Chargers for vehicles, boats, farm equipment and RVs.

For the Bargain Hunters and Frequent Visitors

What's New What's and "Coming Soon"! is our way of keeping you all up to date with new products and LED Technology offered at The LED Light. Bookmark this page for sure!

Bargain Basement! Repaired, returned, errors, scratch and dent, overstocks, great values at reduced prices.

Information and Resources

LEDs DO NOT generate RF wavelengths that cause radio interference, or emit UV, Ultra-Violet light (unless specified as a UV diode), so LEDs will not readily attract bugs and other insects.

Technical Information Get the Facts! Color spectrum graphs, LED

Product list of white LEDs, Luxeon LEDs, LED bulbs, LED fixtures, LED flashlights, UV and IR LED lights.

types, which resistor to use, L.E.D. information and technical how-to.

Un-Solicited Testimonials from our happy and satisfied customers! These are unsolicited feedback we receive from customers who get to "experience the LED Light", the product line and our support and service.

LEDs in model trains See how some of our customers are using LEDs as locomotive headlights and accessory lights.

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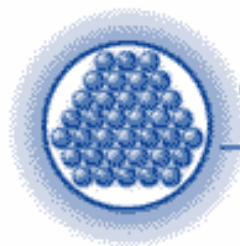
The LED Light's Online Printer Friendly Catalog in PDF Format

If you do not have Adobe Acrobat Reader, you can download a free copy **here**

We receive many requests for printed catalogs but can not possibly keep up with anything in print as our product lines continue to grow so rapidly. We'll continue to add PDF files here for your convenience. Feel free to print any or all of the topics for your personal use.

Subject Matter A-L	Subject Matter M-Z	LED Flashlights	Light Emitting Diodes
Exit Sign Replacement Lamps	**Solar Power:**	PLW Series Flashlights	LED 20 Degree White
Flashers	Solar Panel Wiring Diagram		Luxeon Stars Sheet 1
	Solar Panel Installation Instructions		Luxeon Stars Sheet 2
	Power Station Info Sheet - How Does This Work?		Luxeon Stars Sheet 3
	Questions and Answers About Solar		Luxeon Stars Sheet 4
			Luxeon 5W Star Emitter

Power

Sample
Designs
for
Solar
Panels
with
our
Billboard
Lighting

StarLEDs:

TriCluster
Dimensions

Splicing
Instructions
for
Garden
Stakes

Technical Info
Pages

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LED Fixtures

**LEDs for Walls - LEDs for Ceilings - LEDs for In-Ground - LEDs for Submersion - LEDs for Rough Duty - LEDs for Accenting - LEDs for Counters - LEDs for Boats - LEDs for Planes - LEDs for your Business -
LED Fixtures for just about any application.**

All fixtures are set up for **12vdc** power unless stated otherwise. The LEDs used are the 50 degree, 1800mcd White LED, with the 20 degree, 6400mcd model as a no-charge option. These fixtures are complete as shown and ready for connection to your power source - 12vdc system, or through a voltage step-down transformer, or solar panel w/battery, or direct from a battery. We also have various 12vdc Controls that you may need or want to install.

Note that manyof these items can be used anywhere your imagination takes you. They are not restricted to the placement category they are listed in, especially the In-Ground and Submersibles, which are a very versatile line of fixtures.

LED Wall Fixtures

Brass Plated LED Lights
3-18 White LEDs

ABS Cabin LED Lights
3-18 White LEDs

Mark2 LED Wall-Ceiling
36 White LEDs

Mark1 LED Wall Accent
18 White LEDs

LED fixtures, LED wall lights, LED ceiling lights, LED in-ground lights, LED submersible lights, LED rough duty lights are in stock.

Cabin LED Light Head Only
3 or 6 White LEDs

Ecopa Motion Sensing LED Light
5 White LEDs

LED Sunspots
6 - 36 White LEDs

LED Ceiling Fixtures
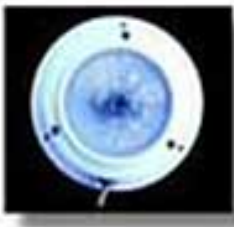
Moonglow and Comet LED Lights
1-3 White LEDs

4.5" Saucer LED Light
36 White LEDs

Big LED Brick
36 or 72 White LEDs

Nova LED Lights
6-36 LEDs White or Colors

2" & 3" LED Saucers
3 or 6 LED Fixtures

LED Copper Hang Light
6, 9 or 18 LEDs

Waterproof In-Ground and Submersible LED Lights

Cockpit LED Lights
1 or 3 LEDs

MicroStar LED
Single 3mm Fixture

StarLED Tri-Cluster
Three 3mm Fixture

LED fixtures, LED wall lights, LED ceiling lights, LED in-ground lights, LED submersible lights, LED rough duty lights are in stock.

2" & 3" LED Saucer
3 or 6 LED Fixtures

4.5" LED Saucer Light
36 White LEDs

LED In-Ground 36
36 LED Can

LED Under Counter and Accent Lighting

36 LED Disk Brick 12vdc
Spot or Accent Light

View of Ribbed Sides; Diffuses the Light

LED Strip Lights 12vdc
3 to 72 LEDs

LED Brick Long 12vdc
18 or 36 LEDs

LED Brick 12vdc
3 to 36 LEDs

Go to 120VAC Bricks

LED Rough Duty and Vandal Resistant

LED fixtures, LED wall lights, LED ceiling lights, LED in-ground lights, LED submersible lights, LED rough duty lights are in stock.

LED In-Ground 36
36 LED Can

4.5" LED Saucer Light 12vdc
36 White LEDs

Big LED Brick 12vdc
36 or 72 White LEDs

LED Brick 12vdc
3 to 36 LEDs

12vdc LED Brick Long
18 or 36 LEDs

[Go to 120vac Fixtures]

The following links might interest you. Or, you can click the "Online Catalog" button below
to go back to the main page for other LED products.

[LED Fixtures] [LED Clusters and Flex Board] [LED Bricks and Strips] [LED Bulbs]
[LED Billboard and Street Lights] [Submersibles] [Loose LEDs] [Solar Power] [Solar Fans]
[LED Landscape Lighting] [Low Voltage Controls]
[LED Flashlights]
[The Bargain Basement - Closeouts, Scratch 'n Dent, Special Buys]

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LED Clusters

LED clusters - LED arrays - LED assemblies - LED modules - LED strips - Flexible LED Boards, refer to LEDs pre-installed on circuit boards with resistors at a predetermined voltage.

The standard cluster uses the 50 degree, 1800mcd White LED, with the 20 degree, 6400mcd model as a no-charge option. All sizes are set up for **12vdc** power. The term DIY refers to 'do-it-yourself', meaning you can install these assemblies anywhere, any way you want to, into anything you can think of, at the correct voltage - 12vdc.

In most cases, you will need a controlled power source to properly run the DIYs for your project. Check into the link at the bottom of this page for a *regulated transformer*, the right product to complete your project, or to give you ideas on what you can accomplish with those controls.

DIYs range from 3 LEDs on up to 36 LEDs as standard in-stock assemblies. Optional sizes range from 72 LEDs, with or without reflectors, to 1000 LEDs. LED strips and the Flexible LED Boards are available with 6 up to 72 LEDs; LED spacing of 1" or 1/2"; with or without reflectors on 1" spacing models.

These LED clusters and arrays come with identified positive and negative wire leads for easy installation or connection. **DIY-3 Red, DIY-6 Red**, **DIY-3 Green and DIY-6 Green** clusters are now stock items. Other colors and sizes are available with a 3 piece minimum - Special Order. **email us.**

DIY LED Clusters
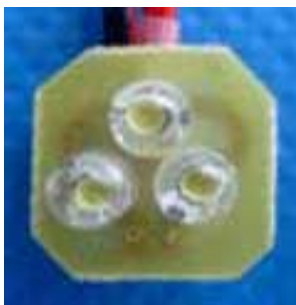
DIY-3
3 LED cluster, 1/2" dia on a 3/4" x 3/4" board. 5/8" overall height. Power usage 30ma **White, Red or Green** LED. Select LED color from ▼

$15.00

LED clusters - LED arrays - LED assemblies - LED modules - LED Strip... to pre-installed LEDs on circuit boards at a predetermined voltage.
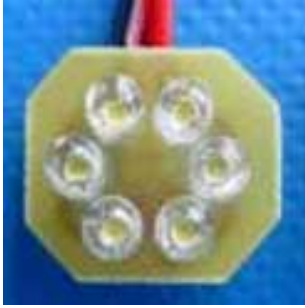
DIY-6
6 LED cluster, 3/4" dia on a 7/8" x 7/8" board. 5/8" overall height. Power usage 60ma
White, Red or Green LED. Select LED color from

$30.00

DIY-9
9 LED cluster, White. 7/8" dia on a 1 1/16" x 1 1/16" board. 5/8" overall height. Power usage 90ma

$45.00
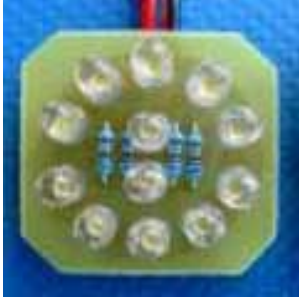
DIY-12
12 LED cluster, White. 1" dia on a 1 3/8" x 1 3/8" board. 5/8" overall height. Power usage 120ma

$60.00
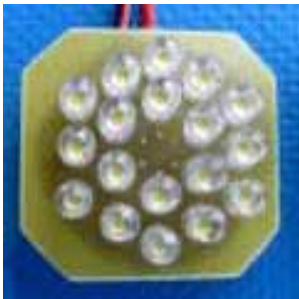
DIY-18
18 LED cluster, White. 1 1/4" dia on a 1 1/2" x 1 1/2" board. 5/8" overall height. Power usage 180ma

$90.00

LED clusters - LED arrays - LED assemblies - LED modules - LED Strip... to pre-installed LEDs on circuit boards at a predetermined voltage.

DIY-18R
18 LED cluster with individual reflectors - 2 1/2" dia.; 2 1/4" x 2 5/8" x 3/4" high. Power usage 180ma. Brighter and more controlled beam pattern.

$95.00

DIY-24 RING LED are for those who want to experiment with building an onboard light source for photography, and other applications where a center hole is useful. Center hole diameter of 5/8"; 2" dia, 5/8" overall height. The DIY 24 can also be used for any application calling for a 24 LED array. Power usage 240ma

$120.00
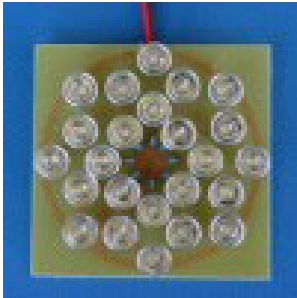
DIY-24R
24 LED cluster with reflectors gives you a option on your light projects. Brighter and more controlled beam pattern. 3 1/4" dia x 5/8" high. Power usage 240ma

$125.00

DIY-36
36 LED cluster, White. 2 1/4" dia on a 2 3/8" sq. board. 5/8" overall height. Power usage 360ma.

$180.00
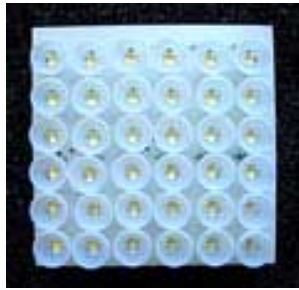
DIY-36R
36 LED cluster with Reflectors - 3 3/8" x 3 3/8". 3/4" overall height. Power usage 360ma. Brighter and more controlled beam pattern.

$185.00

Flexible LED Board Arrays

Click any image for larger view
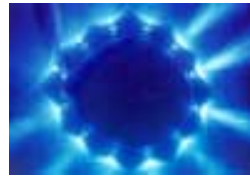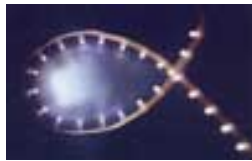
The Flex LED Board Array
can be bent, twisted, or curved to fit your design needs. Max bend is 3" radius. LEDs can be set at 90 degrees to the board for channel letter lighting. Standard LED is the white wide angle 50 degree unless the 20 degree LED is specified. Review LED specs here. Subject to change without notice. If you need something specific, e-mail us.

SPECS: 10ma @12vdc per LED; 5/16" wide x XX length x 5/8" tall. Standard spacing is 1/2" or 1" O/C. (On Center) with Optional 1 1/2", 2" or 3" spacing by request. Must specify exact length required.

Colors are available per order of 3 or more of the same color.

Pricing - 1" O. C.			Pricing - 1/2" O. C.		
6"	6 LEDs	34.20	6"	12 LEDs	68.40
12"	12 LEDs	68.40	12"	24 LEDs	136.80
18"	18 LEDs	102.60	18"	36 LEDs	205.20
24"	24 LEDs	136.80	24"	48 LEDs	273.60
36"	36 LEDs	205.20	36"	72 LEDs	410.40
48"	48 LEDs	273.60	48"	96 LEDs	547.20
60"	60 LEDs	342.00	60"	120 LEDs	684.00
72"	72 LEDs	410.40	72"	144 LEDs	820.80

Select LED Color, Length, and either 1" O/C or 1/2" O/C spacing

The VersaLux Utility Light Module is comprised of 10 white LEDs and power supply circuitry for use in many applications. It is the very first utility light module with the all the advantages of White LEDs (long life, small size, durability, balanced color output, energy efficiency) and, an exclusive Demand Pulse Technology™ which provides additional circuitry for adjustable regulated light power output AND power consumption regulation over the broad range of its DC input voltage. **Click here** for more details and to order.

We stock a variety of controls that would make your installation and application go easier. Check into **Controls** for the product that will make your project or OEM work right.

The item shown to the left is a Voltage Doubler. It will take a 6vdc power source and boost it to 12vdc. Avoids having to redo your electrical system or to change the power source, especially for antique/foreign vehicles.

LED Technical Information and Help

The following links might interest you. Or, you can click the "Online Catalog" button below to go back to the main page for other LED products.

[LED Fixtures] [LED Clusters and Flex Board] [LED Bricks and Strips] [LED Bulbs]
[LED Billboard and Street Lights] [Submersibles] [Loose LEDs] [Solar Power] [Solar Fans]
[LED Landscape Lighting] [Low Voltage Controls]
[LED Flashlights]
[The Bargain Basement - Closeouts, Scratch 'n Dent, Special Buys]

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LED clusters - LED arrays - LED assemblies - LED modules - LED Strip... to pre-installed LEDs on circuit boards at a predetermined voltage.

Don't forget to bookmark us.
This *is the original* "TheLEDLight.Com"
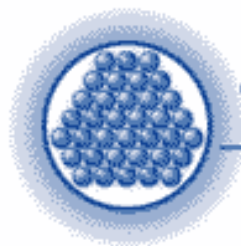
LED Brick and Strip Lights

White LED Brick and Strip lights for special vehicle application, commercial/residential interior or exterior use, vandalism tolerant lighting for bus stops, phone booths, equipment compartments, appliance interiors, refrigerators, freezers, cabinetry. There is a huge variety of other applications for ambulances, fire engines, search and rescue vehicles, helicopters, RVs, delivery vans, boat and plane interiors, bookcases, displays, recessed night lights, function/activity indicators, storage sheds, security lighting, most any type of residential, commercial, industrial or military use a user can think of.

The "Brick" is a solid acrylic 'brick' with a diamond pattern light diffusing face. An external switch can be wired to the LED Brick, then to your 12vdc power source; or use our dimmer and transformers. Installation can be flush with the surface and screwed down, or with a manufactured lip and set in from the top of a ceiling and secured with a flange to prevent 'pushthrough' or from being pulled out.

LB36-Long: is a 12VDC fixture that is 11" long x 1 3/4" wide x 3/4" deep/thick to fit in those tight spaces. Light volume approximates a 6 watt fluorescent or a 30 watt incandescent. Counter top lighting, freezers, refrigerator, custom design for special vehicles and applications. All LED Brick features apply to the LB-36Long.

LED Brick-6
6 LED - 3 watt - 60mA @12vdc - 60 lumen
Measures 2" x 3" x 1" Thick   **$40.80**

LEDBrick-9
9 LED - 6 watt - 90mA @12vdc - 90 lumen
Measures 2" x 3" x 1" Thick   **55.55**

LEDBrick-12
12 LED - 9 watt - 120mA @12vdc - 120 lumen
Measures 2" x 3" x 1" Thick   **76.20**

White LED Brick and Strip lights for special vehicle application, commercial/residential interior or exterior use.

LEDBrick-18
18 LED - 15 watt - 180mA @12vdc - 180 lumen   **110.00**
Measures 2" x 3" x 1" Thick

LEDBrick-36R
36 LED - 30 watt - 360mA @12vdc - 360 lumen   **210.00**
Now 4" x 4" Sq. w/Reflectors; 2 mounting holes

LEDBrick-36 Long
36 LED - 30 watt - 360mA @12vdc - 360 lumen   **225.15**
Measures 11" x 1 3/4" x 3/4" Thick

PSP-36 This 36 LED model is a tough, compact, waterproof, easily mountable light for a large variety of applications from equipment illumination to art/object lighting; indoor or outdoor use. It measures 3" in diameter by 1" thick and is a solid epoxy disc. Comes with mounting bracket. 360 milliamps (4.32 watts). Available for 120VAC by Special Order.

PSP36 - 30 watt -   **214.00**
360mA @12vdc - 360
lumen

4X4LB72 New! 4x4 LED Brick/72 LEDs; 12VDC only - 720mA
Ideal for overhead **spot** lighting applications, the 4x4 Brick is intended _for indoor use only_. Side ventilation holes provide movement for air and heat disspiation. Available with mounting accessories, similar to our PSP36 model above. Can be provided with a clear or diffusing lens. The hole for wiring can be placed where you need it, on any side or out the back. Select clear or diffused lens from the first dropdown arrow below. Select wiring option from second dropdown below. The picture at left depicts a LB72 wired from the side. Allow 5-10 days lead time. These are made to order.

LB72 - 720mA @12vdc   **360.00**

White LED Brick and Strip lights for special vehicle application, commercial/residential interior or exterior use.

4.5" SAUCER 36 - Circular acrylic disc is sealed for outdoor use. Low profile LED easily mounts into place. 36 bright white LED provide more than enough light to see or work by. Light is available in Red and Blue upon request. 1 1/4 " tall, this light can be set into ceilings, walls, or wherever the need is. 30 watt - 360mA at 12VDC. 360 lumen.

$216.00

2" and 3" SAUCER - This circular acrylic disc houses 3 or 6 LEDs to provide marker lighting for boat decks or walkways. This low profile LED light easily mounts into a hole and can be glued into place. 1 1/4" Tall. 12VDC. **Saucer is stocked in White LED**. Also available in Red, Blue and Green. **Minimum order of 4 pcs for colors.**

Saucer 3 LED 2" Dia	Saucer 6 LED 3" Dia
$23.00 ea	**$40.00 ea**

Big Brick with 36 or 72 White LEDs - 12VDC (120VAC also available - click here). Good for ceiling replacements in 12VDC applications, RVs and boats where a wide spread soft light is desired which will still be bright enough for normal activities. Can be used with our AC2 or AC3 transformer in other areas/applications where the power source is 120VAC. For 240VAC applications, purchaser will have to obtain a step-down voltage transformer locally. Prismatic lens; wire leads attached. Big Brick 36 measures 9 1/2" x 5 3/4" x 1 1/4" deep. The Big Brick-72/120vac with reflectors measures 4 1/2"W x 16 5/8"L x 1 1/16" Thick.
Click for larger image

Big Brick 36 LED 12VDC	Big Brick 72 LED 12VDC
$225.00	**$423.00**

LED Strip Lights

White LED Brick and Strip lights for special vehicle application, commercial/residential interior or exterior use.

View of Ribbed Sides; Diffuses the Light

LED

Front View; LEDs Flush w/Surface
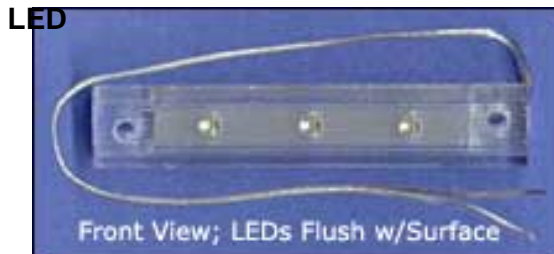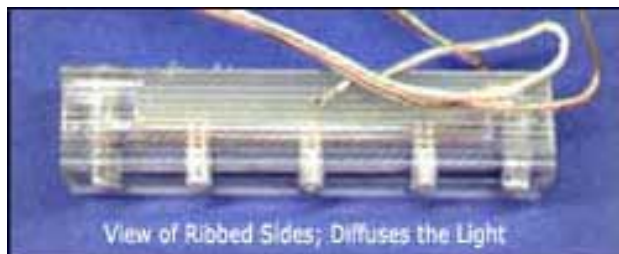
"STRIP LIGHTS" have one LED every inch. Each strip light is made of custom extruded, 3/4" x 3/4" clear plastic with mounting holes on each end for easy installation. The bottoms are sealed with a solid setting adhesive, making these lights weatherproof. Super lights for theaters, steps and stairs, as aquarium lights, as counter lights and accent lighting, in sheds, on railings. Strip Lights can fill many needs for task lighting. It can be used for lighting in a boat, RV, solar home, cabin, hand rails, or docks. STRIP LIGHTS can also be used commercially for solar powered phone booths, small bus stops, and rest areas. Optional 1/2" spacing and color LEDs (3 per color minimum) by request!

S-3 4 1/4" L - 30mA @12vdc - 30 lumen	**21.20**
S-6 7 1/4" L - 3 watt - 60mA @12vdc - 60 lumen	**42.20**
S-12 13 1/4" L - 9 watt - 120mA @12vdc - 120 lumen	**$90.00**
S-18 19 1/4" L - 15 watt - 180mA @12vdc - 180 lumen	**$120.00**
S-24 25 1/4" L - 20 watt - 240mA @12vdc - 240 lumen	**$160.00**
S-36 37 1/4" L - 30 watt - 360mA @12vdc - 360 lumen	**$240.00**
S-48 49 1/4" L - 40 watt - 480mA @12vdc - 480 lumen	**$280.00**
S-72 73 1/4" L - 65 watt - 720mA @12vdc - 720 lumen	**$420.00**

The following links might interest you. Or, you can click the "Online Catalog" button below to go back to the main page for other LED products.

[LED Fixtures] [LED Clusters and Flex Board] [LED Bricks and Strips] [LED Bulbs]
[LED Billboard and Street Lights] [Submersibles] [Loose LEDs] [Solar Power] [Solar Fans]
[LED Landscape Lighting] [Low Voltage Controls]

White LED Brick and Strip lights for special vehicle application, commercial/residential interior or exterior use.

[LED Flashlights]

[The Bargain Basement - Closeouts, Scratch 'n Dent, Special Buys]

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AC LED Lighting

120vac LED Products: LED Medium Base Bulbs - LED Floodlight Bulbs - LED Spotlight Fixtures - LED Interior and Exterior Fixtures - LED Billboard Lights - LED Street Lights - LED Bricks

These products use the 50 degree, 1800mcd White LED with the 20 degree, 6400mcd White LED as an option. Also optional are colored LEDs - email us for this option.

The products range from a simple 3 LED bulb to lighting up billboards with 36 or more white LEDs. We can also provide "streetlight" type post lamps on connectable posts with 72 to 1000 LEDs as well as retrofitting any antique, special made, or classic lamp or fixture

LED lighting is energy efficient, anti polluting, and conserves our fossil fuel by using only one-tenth the energy consumed by incandescents. LED lights excel as "task specific" lights by focusing the light beam to where its useful. There is no excess, wasted light (and power consumption) that goes unused, and is many times unwanted. LEDs are non-explosive light sources, and environmentally clean as there is no glass to break or have no harmful gases to escape into the atmosphere. They do not generate heat and add to your Air Conditioner load.

Commercially, LED lights are superior to incandescents and fluorescents in that they are much more efficient in consuming energy, are virtually maintenance free, and will last for years, not hours per year. LED light bulbs are perfect for those areas where accessibility is a challenge, where light is difficult to install and maintain, or where power is absent and difficult to obtain. Where heat or cold is a problem, LEDs will operate from -40C to 85C.

AC LED Bulbs: ****Go here for 12v DC Bulbs**

3 and 6 LED bulb; Medium Base; approx. dimensions: from contact tip to top of bulb, 3 3/4 " tall with a 1 1/18" diameter. Conical, forward projecting light pattern of 150-180 degrees plus. AC-3 compares to 1 watt; AC-6 compares to 3 watts. 30 and 60 lumen. Both consume only 30 mA at 120vac

AC-3   **$20.65ea
2$/37.20
4/$67.00**

AC-6   **$42.70 ea**
2/$76.80
4/$138.20

18 LED bulb; Medium base; approx. dimensions: from contact tip to top of bulb, 5" tall with a 2" diameter; comparable to a 15 watt incandescent. 180 lumen. Consumes 30mA at 120vac.

Select quantity and

voltage from

120vac or
240vac
AC-18   **$89.00 ea**
2/$160.74
4/$289.40

Short 36 LED bulb; Medium base; approx. 3 1/4" tall x 2 1/2" diameter; comparable to a 30 watt incandescent bulb. 360 lumen. Consumes 30mA at 120vac

Select quantity and voltage

from

120vac or
240vac
AC-36   **$180.50 ea**
2/$324.90
4/$484.80

Refractor or globe screw-in replacement that will radiate the light horizontally in a 360 degree pattern allowing bulb to be installed into table lamps, and other applications calling for horizontal light spread. LEDs shine up into the refractor and then spreads outwards. Optional for AC-36 bulbs.

Refractor	**For AC-36** **$6.00 ea**

[**Go To 12vdc bulbs**]

English 220/240vac - Bi-Pin Bayonet Base used in England, Scotland, Ireland and British Colonies can be requested on any of our Edison base bulbs shown below from 3 LEDs up to 36 LEDs. We can design a light to fit almost any 220VAC light fixture. **E-mail us** with your application.

72 LED Bulb is a very good overhead, porch, or back door light. It can be retrofitted into an existing fixture. Medium base. 4" diameter. Lens is a prismatic diffuser type. Available in 120vac or 240vac. AC-72 compares to a 60 watt bulb. Consumes only 120mA at 120vac. May require socket extender from local hardware store. 720 lumen.

Select quantity and voltage from

AC-72	**120vac or 240vac** **$353.00 ea** **2/$670.70** **4/$1274.40**

e-mail us for pricing on quantity of 10 or more AC LED Bulbs

AC LED Fixtures:

**Go here for 12v DC Fixtures

In-Ground 36 - 36 LED are enclosed within this water tight housing made of 1/4" thick black "ABS" plastic. This light is intented to be placed within the ground to give you upward illumination for yard or decorational applications. This light can be provided in either AC or DC. Approx. dimensions are 4.5" OD X 7"H. 6 feet of direct burial wire is included. This unit can be buried in concrete, rock or soil to provide the most discreet lighting. 30watts - 30mA @120vac. 360 lumen.

Inground 36

AC HANG LIGHT - This light is designed to accent an object or area from above while retaining a decorative appealing look. Housed within a sealed 3" copper tube and a diffuser lens, this light is rugged and will age with grace. Includes 5 feet of lead wires. 30mA at 120vac; 9 - 18 - 36 LEDs; 6 watt / 90 lumen - 15 watt / 180 lumen - 30 watt / 360 lumen, respectively. Hand crafted; allow extra delivery time.

	9 LED
	$110.00
AC	**- 18**
Hang	**LED**
Light	**$220.00**
	36 LED
	$439.00

SUNSPOTS are waterproof outdoor lights. The head measures 4 3/4" x 3"; pre-drilled cast aluminum base has a 4 1/4" diameter. Applications include lighting for signs, secured areas, driveways, porches, security gates, high level area lighting, swimming pool area lights.

SP-6 6 LEDs - 30 mA - 3 watts - 60 lumen	$48.80
SP-9 9 LEDs - 30mA - 6 watts - 90 lumen	$70.00
SP-12 12 LEDs - 30mA - 10 watt - 120 lumen	$90.00
SP-18 18 LEDs - 30mA - 15 watts - 180 lumen	$138.00
SP-36 36 LEDs - 30mA - 30 watts - 360 lumen	$234.00

36 LED Mark-2 Wall and Ceiling Lights - Indoor or Outdoor Use. Weather tight cast aluminum housing and single gang mounting plate, with acrylic diffuser lens for a nice floodlight. Vertically and horizontally adjustable head; use with a sunrise/sunset switch, a dimmer, your own alarm or security light system. 30mA at 120vac - 30 watt, 360 lumen.

Mark-2 120vac or 240vac	$195.00	This item is being discontinued. Find remaining stock at a special price in the Bargain Basement. Click Here. Reference item #52

18 LED Mark-1 Accent or Wall Light Same features as the Mark-2, but is more for highlighting, accenting objects, areas, entry ways, small sheds, etc. Beam pattern is controlled to avoid side light annoyance. The LED cluster and lens is set back into the head housing. 30mA at 120vac - 15 watt, 150 lumen.

Mark1
120vac or 240vac   **$103.00**

This item is being discontinued. Find remaining stock at a special price in the Bargain Basement. Click Here. Reference item #54

The **120vac "LED Brick"** has a diamond patterned light diffusing face and bead blasted sides. The LED "BRICK" is designed for those places where you have vandalism or need a tough light. Solar powered bus stops and phone booths are a prime spot for this light. Backlighting of displays is a possibility for the "Brick", as is any application you can think of. The 2" x XX" x 1" thick 120vac "Brick" is available with 18 or 36 LEDs. Uses 180ma or 360ma.

The LB-18/120vac approximates a 15 watt incandescent. Long, as shown on the right in the photo. Comparable to a15 watt incandescent. It draws only 30mA at 120vac.

LB-18 -
120vac or   **$110.00**
240vac

LB36-Long/120vac is a 120vac fixture that is approximately 13 1/4" long x 1 3/4" wide x 1 1/4" deep/thick to fit in those tight spaces. Light volume approximates a 6 watt fluorescent or a 30 watt incandescent. As with the other LED Bricks, these are good for replacement of under-counter lights whose counter tops are no more than 30" from the light. Comparable to a 30 watt incandescent. Consumes 30mA at120vac; 360 lumen.

LB-36Long/120vac
36 LED Epoxy Enclosure, Long

$225.15

The LB-36/120vac approximates a 30 watt incandescent, as shown on the left of the photo. This is the most widely used Brick size and shape at 7" x 5" x 1" thick. It draws only 30mA at 120vac; 360 lumen.

LB-36/120vac
36 LED Epoxy Enclosure

$210.00

Compact PSP-36 is a tough, compact, waterproof, easily mountable light for a large variety of applications from equipment illumination to sign lighting, indoor or outdoors, or installed as is. It measures 3" in diameter by 3/4" thick and is a solid epoxy disc. Comes with u shape stainless steel mounting bracket. 30mA at 120vac - 30 watt - 360 lumen. (120vac models have a separate ballast/inverter component/board soldered to the PSP's wire leads, or can be glued to the bottom of the PSP.)

PSP36/120vac $214.00
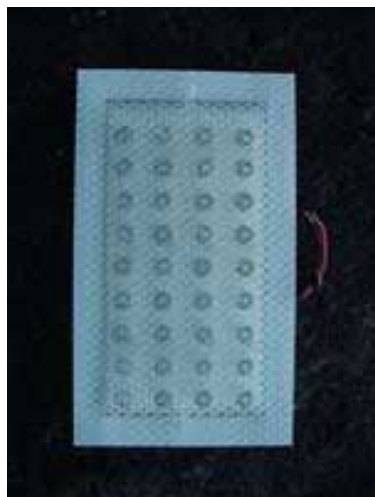
Big Brick with 36 (30 watts) or 72 (60watts) White LEDs Good for ceiling replacements where a wide spread soft yet bright light is desired for normal activities. Prismatic diffuser lens; wire leads attached. Big Brick 36 measures 9 1/2" x 5 3/4" x 1 1/4" deep. The Big Brick-72/120vac with reflectors measures 4 1/4"W x 16 5/8"L x 1 1/16" Thick. The BIg Brick-72 compares to a 70watt incandescent. The Big Brick-36 compares to a 40 watt Incndescent. Both models consume approx. 120mA at 120vac; 360 and 720 lumen respectively.

Big Brick 36 LED 120vac	Big Brick 72 LED 120vac
$225.00	$423.00

Go here for 12v DC fixtures

LED Sign, Billboard and Street Lights
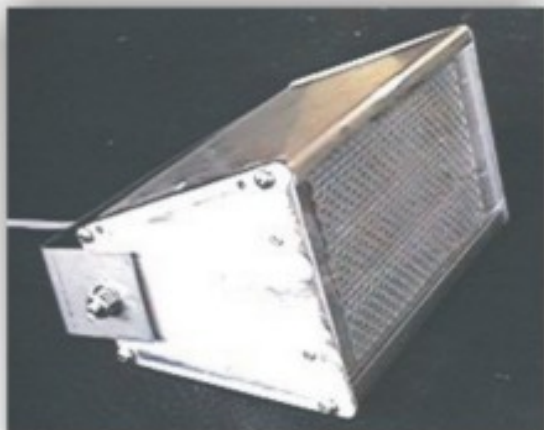
Billboard/Signage Light for Billboard, sign, secured area illumination, for workshops, and a variety of other indoor or outdoor applications. The Billboard light has a stainless steel enclosure, diffuser lens, stainless steel adjustable "U" mounting bracket, 1/2" pipe thread fitting for attachment to posts. It will illuminate a 4' x 6' sign. Unit is weatherproof; available with auto sunset/sunrise on/off switch or timer. Available with 36 (30 watts), 72 (60 watts), 108 (80watts) or 144 (100 watts) LEDs; 12vdc, 120vac or 240vac (special order). Other sizes are made to order. 12vdc models available by requsting 12vdc in 'comments box' on order form.

BB36
Stainless Steel Body
30 watt - 360 lumen 120vac or 240vac

$210.00

BB72
Stainless Steel Body
60 watt - 720 lumen 120vac or 240vac

$420.00

BB108
Stainless Steel Body
100 watt - 1080 lumen 120vac or 240vac

$630.00

BB144
Stainless Steel Body
130 watt - 1440 lumen 120vac or 240vac

$840.00

*From Guam after a nasty Typhoon: ([click here for photos](#)) We were contracted to install 6 **STL-108** lights in the southern end of the island on the pier where recreational boats load and dock at. It also provides lighting to a handicapped walkway. Not even one month, Typhoon Pongsona smashed through the island, packing 155 mile per hour winds with gust to 185 miles an hour. Houses torn apart, buses, cars flipped over, concrete power poles snapping in half, containers thrown 100 yards away, I couldn't image that thoses light will survive near the water. Two days after the storm, the contractor called me and I assumed that he wanted talk about replacing the lights, but to my surprise, he called me congratulating me about the durability and dependability on those lights! They were still working! I was surprised about the strength of the lights. All stainless materials made this happen with good construction techniques. 5 out of 6 lights where working, the 6th light received received minor damage and was repaired right away.*

I applaud The LED light company for their lights and highly recommend this to anyone out there who need lighting in areas. Very durable and easy to maintain. If these lights can survive here in typhoon alley, then it will survive anywhere else!

Jerry Gogue
SolCom, Guam
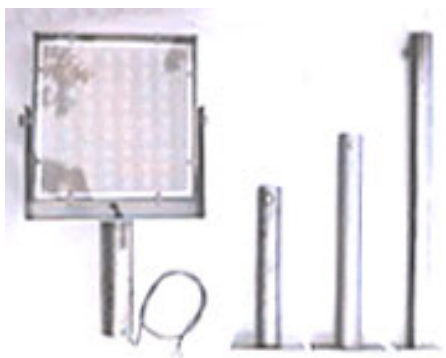
STREET LIGHT is designed to take real punishment. Solid 8"W x 8"L x 3"D stainless steel enclosure; ½" thick clear acrylic lens; adjustable mounting bracket; 2" dia. x 1', 2' or 3' long mast attached to a base plate w/4 drilled holes; weather proof. Auto Sunrise/Sunset on/off switch or timer is optional, as is a solar panel connection. Available with 72 (60 watts), 108 (80 watts), 144 (100 watts), or 252 (200 watts) LEDs, or made to order up to 1,000 LEDs. 120vac or 240vac. 12vdc models available by requsting 12vdc in 'comments box' on order form.

STL72
72 LED - 60 watt - 720 lumen 120vac or 240vac   **$486.00**

STL108
108 LED - 100 watt - 1080 lumen 120vac or 240vac   **$729.00**
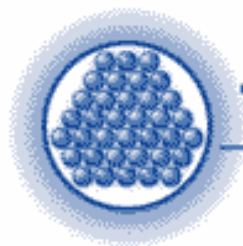
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DC Direct Current LED Bulbs.

EverLED Luxeon Bulbs – PR Flange LED Bulb– New Beam LED Bulbs – Petzl Screw-In LED Bulb - MR-16 LED Bulb – LED Bayonet Bulb - Medium Base LED bulbs

Go Here for AC Bulbs

LED Flashlight Bulbs

PR Flange Base: Drop-in replacement for any 3 cell/battery flashlight or lantern with **3 each, 1.5v batteries, or 4.5v MAX!** 6400mcd per LED, 20° 6500K. In white only.

PEZ Screw Base: drop-in replacement bulb for Petzl, Mega and other headlamps with screw-in sockets. Will also fit any lighting device that uses a 9mm screw base. White LED only.

Warning! Lithiums and Duracell Ultras run at 1.6vdc to 1.7vdc, and will cause some LEDs to "blow" or die. **Do not** use on these bulbs!

See features guide here

NOTE: If after replacing your bulb and it does not light up, remove the battery pack, pull the connecting spades and reverse the connections.

See features guide here

PR Flange Base $18.95

PEZ Screw Base $18.95

The NewBeam LED Module comes as a retrofit kit for use with current model AA MINI MAGLITE® flashlights. The kit consists of the NewBeam LED Module, an adapter ring which replaces the original reflector, and a replacement abrasion-resistant lens. Instructions are included with the kit, and assembly takes only a few minutes. No tools required.

[See Features and Installation Guide here.](#)

NewBeam Module $26.00
Now priced lower! at $24.00

EverLED™

... this could be the last flashlight replacement bulb you will have to ever buy!

The EverLED™ is a solid state flashlight bulb that replaces traditional incandescent PR-flange bulbs in common flashlights. The EverLED™ uses the latest LED technology and an effecent electronic circuit to provide an ordinary flashlight with impact resistant, long life, bright light. Because of the advanced LuxDrive™ circuitry contained within the housing, **this one bulb can be used in 1, 2, 3, 4, 5, or even 6 cell flashlights** made by most any company, including MAGLITE® flashlights. EverLED™ uses a top quality **Luxeon LED Emitter** as it's light source!

[See the EverLED Features here.](#)

EverLED™ Bulb

Use this button to order just one. $41.90 each. Select LED Color from

Use this button to order two or more. 2 for $79.75. Select LED Colors from

DC LED Bayonet Bulbs

HORIZONTAL BAYONET BULB .. BAY6H Bi-Pin with **one pin positive and one pin negative.** Great replacement bow light and other placements. 60 mA at 12vdc. Approximately 60 lumens.

Bay6H 12vdc $50.00

SINGLE PIN BAYONET BASE is a standard for low voltage D/C lighting systems. The pin contact is positive while the shell is negative. Side lock pins are directly opposite each other, not offset. These are available with 3 to 24 LEDs for boats, RVS and other uses. 30mA to 240mA at 12vdc ... 30 to 240 lumen.

BI-PIN BAYONET BASE has one negative and one positive terminal in the base. **Check your wire leads before ordering.** Side lock pins are directly opposite each other, not offset. Same

features as
the Single Pin
models.

**Bayonet Base Bulb Dimensions

3 LED ... 5/8" dia x 1 1/2" tall
6 LED ... 7/8" dia x 1 1/2" tall
9 LED ... 1 1/8" dia x 1 1/2" tall
12 LED ... 1 1/4" dia x 1 1/2" tall
18 LED ... 1 5/8" dia x 1 1/2" tall
24 LED ... 2" dia x 1 12/" tall

MR-16 LED Bulb, 18 LEDs are housed within a Halogen MR16 reflective enclosure to replace 12VDC Halogen lights with a G4 base. Halogens consume large amounts of energy and produce a great deal of heat. This can prove to be dangerous to your home, RV or boat. No more! LEDs use very little energy and produce little, if no, heat at all. For indoor use only. This unit must use our approved power supply, transformers, to function properly and be **dimmable**. 60mA at 12vdc; 180 lumen; approximately 15 watts.

MR-16 12vdc   **$80.00**

DC LED Medium Base (Edison) Bulbs
Go Here for AC Bulbs

3 or 6 LED bulb; approx. dimensions: from contact tip to top of bulb, 3 3/4 " tall with a 1 1/18" diameter. Conical, forward projecting light pattern of 150-180 degrees plus. AC-3 compares to 1 watt; AC-6 compares to 3 watts. 30 and 60 lumen. Both consume only 30 mA at 120vac

AC-3 - 12vdc   **$20.65 ea
2/$37.20
4/$67.00**

Luxeon LED PR bulb, EverLED bulbs, LED bayonet base, flange base and medium screw base bulbs for flashlights and fixtures.

| AC-6 - 12vdc | $42.70 ea
2/$76.80
4/138.20 |

18 LED bulb; approx. dimensions: from contact tip to top of bulb, 5" tall with a 2" diameter; comparable to a 15 watt incandescent. 180 lumen. Consumes 30mA at 120vac.

| AC-18 - 12vdc | $89.00 ea
2/$160.74
4/$289.40 |

Short 36 LED bulb; approx. 3 1/4" tall x 2 1/2" diameter; comparable to a 30 watt incandescent bulb. 360 lumen. Consumes 30mA at 120vac

| AC-36 - 12vdc | $180.50 ea
2/$324.90
4/$584.80 |

Refractor or globe screw-in replacement that will radiate the light horizontally in a 360 degree pattern allowing bulb to be installed into table lamps, and other applications calling for horizontal light spread. LEDs shine up into the refractor and then spreads outwards. Optional for AC-36 bulbs.

Refractor
$6.00 ea   **AC-36**

Go Here for AC Bulbs

The following links might interest you. Or, you can click the "Online Catalog" button below to go back to the main page for other LED products.

[LED Fixtures] [LED Clusters and Flex Board] [LED Bricks and Strips] [LED Bulbs]
[LED Billboard and Street Lights] [Submersibles] [Loose LEDs] [Solar Power] [Solar Fans]
[LED Landscape Lighting] [Low Voltage Controls]
[LED Flashlights]
[The Bargain Basement - Closeouts, Scratch 'n Dent, Special Buys]

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MetkuMods - Because you love your hardware!

(if possible, please, link this page, not just rip it)

Current limiting resistor calculator

.:Single led - .:Leds in series - .:Leds in parallel

v1.0 08.05.2003 Initial release
v1.1 31.05.2003 Opera support

.:Single led

Some good values to try:

As supply voltage:
 From molex; 5, 7 and 12 volts

As led forward voltages:
 Red and green; 2 volts
 Blue and white; 3.5 - 4 volts

Supply Voltage
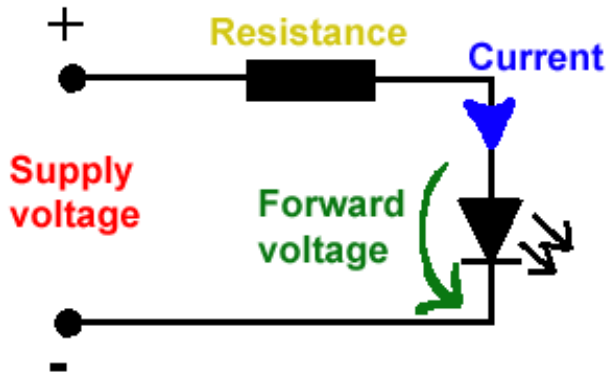
VOLTS
Voltage Drop Across LED

VOLTS
Desired LED Current

MILLIAMPS

Calculated Limiting Resistor

OHMS
Nearest higher rated 10% resistor

Calculated Resistor Wattage

WATTS
Safe pick is a resistor with
power rating of

WATTS

.:Leds in series

Supply Voltage

VOLTS
Voltage Drop Across LED

VOLTS
Desired LED Current

MILLIAMPS
How many leds connected

Calculated Limiting Resistor

OHMS
Nearest higher rated 10% resistor

Calculated Resistor Wattage

WATTS
Safe pick is a resistor with
power rating of

WATTS

.:Leds in parallel

Supply Voltage

VOLTS
Voltage Drop Across LED

VOLTS
Desired LED Current

MILLIAMPS
How many leds connected

Calculated Limiting Resistor

OHMS
Nearest higher rated 10% resistor

Calculated Resistor Wattage

WATTS
Safe pick is a resistor with
power rating of

WATTS

ModTheBox
Nexus Hardware
OcMod (NOR)
OCPortugal (POR)
OSFocus.net
OverclockersClub
OzCaseModz
PC Dreams
PlanetModz
Primotechnology
Quantummods (BEL)
Radikalmod (HUN)
Raptor-Mods
RauterMods
R&B Mods
SweMOD.Com
TechNewS (FRA)
The Modfathers
The Tech Lounge
TweakNews.net
TwistedMods.com
Ultraportal
Unique Hardware
Virtual-Hideout
World Overclockers

LM317T Variable Voltage Regulator

The LM317T is a adjustable 3 terminal positive voltage regulator capable of supplying in excess of 1.5 amps over an output range of 1.25 to 37 volts. The device also has built in current limiting and thermal shutdown which makes it essentially blow-out proof.

Output voltage is set by two resistors R1 and R2 connected as shown below. The voltage across R1 is a constant 1.25 volts and the adjustment terminal current is less than 100uA. The output voltage can be closely approximated from Vout=1.25 * (1+(R2/R1)) which ignores the adjustment terminal current but will be close if the current through R1 and R2 is many times greater. A minimum load of about 10mA is required, so the value for R1 can be selected to drop 1.25 volts at 10mA or 120 ohms. Something less than 120 ohms can be used to insure the minimum current is greater than 10mA. The example below shows a LM317 used as 13.6 volt regulator. The 988 ohm resistor for R2 can be obtained with a standard 910 and 75 ohm in series.

When power is shut off to the regulator the output voltage should fall faster than the input. In case it doesn't, a diode can be connected across the input/output terminals to protect the regulator from possible reverse voltages. A 1uF tantalum or 25uF electrolytic capacitor across the output improves transient response and a small 0.1uF tantalum capacitor is recommended across the input if the regulator is located an appreciable distance from the power supply filter. The power transformer should be large enough so that the regulator input voltage remains 3 volts above the output at full load, or 16.6 volts for a 13.6 volt output.

[LM317 Data Sheet](#)
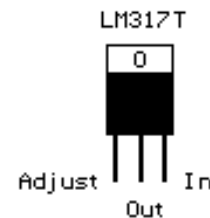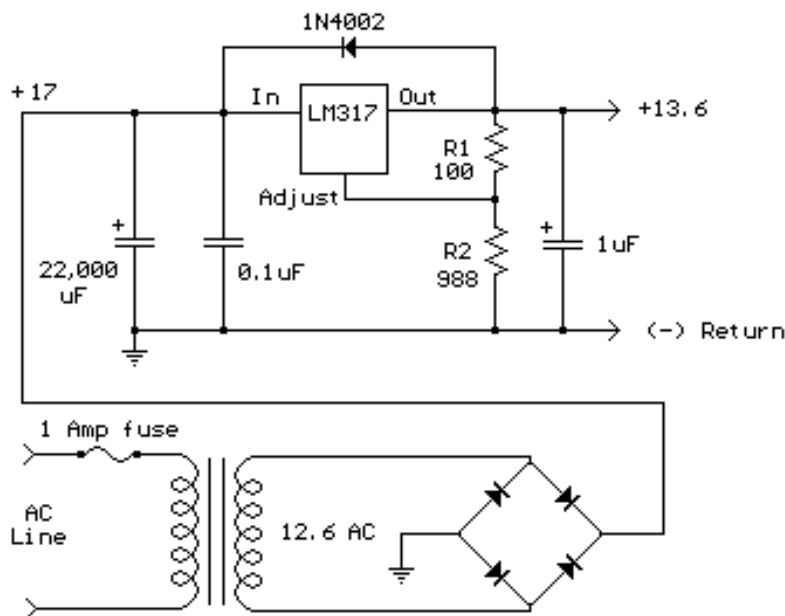
R1	R2	Out
100	988	13.6
100	860	12
100	620	9
100	380	6
100	140	3
100	20	1.5

Drawn by - Bill Bowden - 07/10/98

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LM317T Voltage Regulator with Pass Transistor

The LM317T output current can be increased by using an additional power transistor to share a portion of the total current. The amount of current sharing is established with a resistor placed in series with the 317 input and a resistor placed in series with the emitter of the pass transistor. In the

figure below, the pass transistor will start conducting when the LM317 current reaches about 1 amp, due to the voltage drop across the 0.7 ohm resistor. Current limiting occurs at about 2 amps for the LM317 which will drop about 1.4 volts across the 0.7 ohm resistor and produce a 700 millivolt drop across the 0.3 ohm emitter resistor. Thus the total current is limited to about 2+ (.7/.3) = 4.3 amps. The input voltage will need to be about 5.5 volts greater than the output at full load and heat dissipation at full load would be about 23 watts, so a fairly large heat sink may be needed for both the regulator and pass transistor. The filter capacitor size can be approximated from C=IT/E where I is the current, T is the half cycle time (8.33 mS at 60 Hertz), and E is the fall in voltage that will occur during one half cycle. To keep the ripple voltage below 1 volt at 4.3 amps, a 36,000 uF or greater filter capacitor is needed. The power transformer should be large enough so that the peak input voltage to the regulator remains 5.5 volts above the output at full load, or 17.5 volts for a 12 volt output. This allows for a 3 volt drop across the regulator, plus a 1.5 volt drop across the series resistor (0.7 ohm), and 1 volt of ripple produced by the filter capacitor. A larger filter capacitor will reduce the input requirements, but not much.

Drawn by - Bill Bowden - 7/10/98
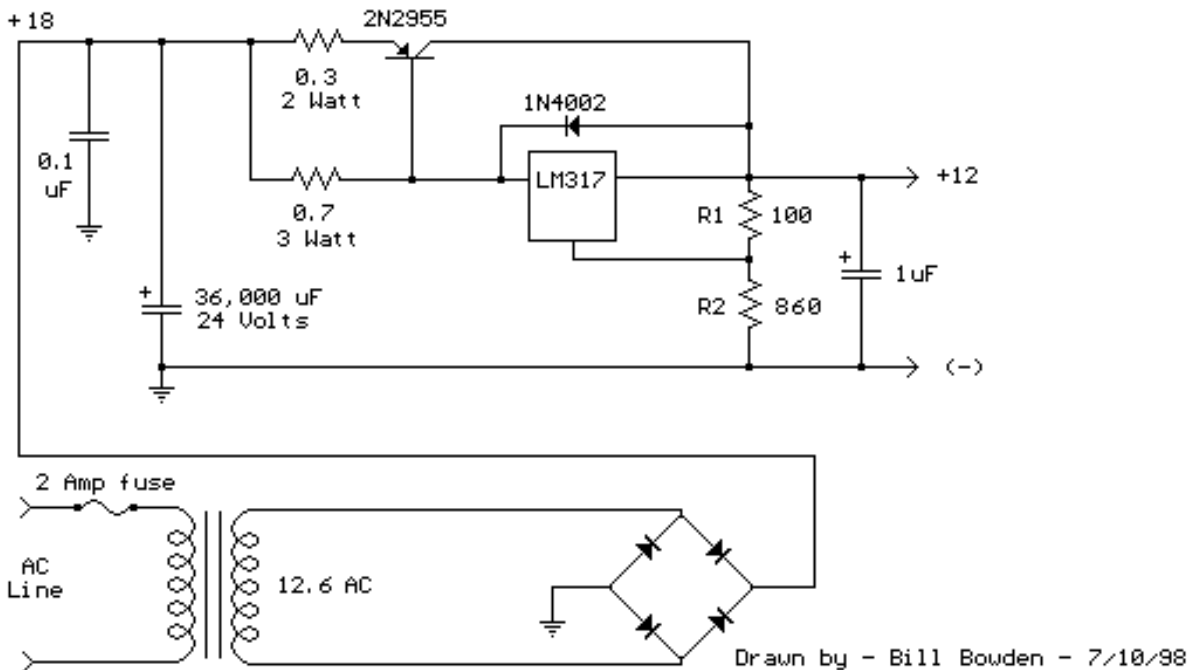
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High Current Regulated Supply

The high current regulator below uses an additional winding or a separate transformer to supply power for the LM317 regulator so that the pass transistors can operate closer to saturation and improve efficiency. For good efficiency the voltage at the collectors of the two parallel 2N3055 pass transistors should be close to the output voltage. The LM317 requires a couple extra volts on the input side, plus the emitter/base drop of the 3055s, plus whatever is lost across the (0.1 ohm) equalizing resistors (1volt at 10 amps), so a separate transformer and rectifier/filter circuit is used that is a few volts higher than the output voltage. The LM317 will provide over 1 amp of current to drive the bases of the pass transistors and assuming a gain of 10 the combination should deliver 15 amps or more. The LM317 always operates with a voltage difference of 1.2 between the output terminal and adjustment terminal and requires a minimum load of 10mA, so a 75 ohm resistor was chosen which will draw (1.2/75 = 16mA). This same current flows through the emitter resistor of the 2N3904 which produces about a 1 volt drop across the 62 ohm resistor and 1.7 volts at the base. The output voltage is set with the voltage divider (1K/560) so that 1.7 volts is applied to the 3904 base when the output is 5 volts. For 13 volt operation, the 1K resistor could be adjusted to around 3.6K.

The regulator has no output short circuit protection so the output probably should be fused.

Drawn by – Bill Bowden – 08/20/99
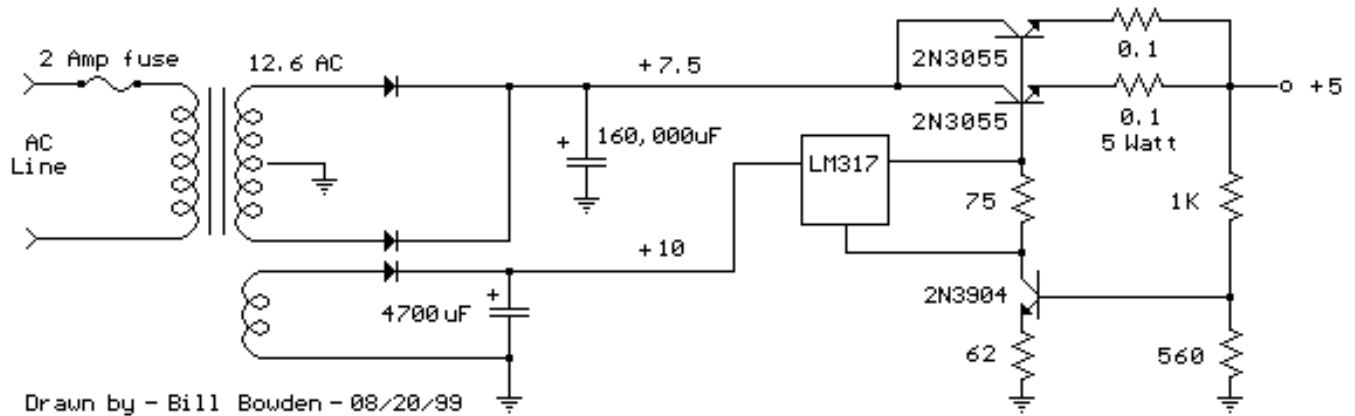
Simple Adjustable Voltage Source

A simple but less efficient methode of controlling a DC voltage is to use a voltage divider and transistor emitter follower configuration. The figure below illustrates using a 1K pot to set the base voltage of a medium power NPN transistor. The collector of the NPN feeds the base of a larger PNP power transistor which supplies most of the current to the load. The output voltage will be about 0.7 volts below the voltage of the wiper of the 1K pot so the output can be adjusted from 0 to the full supply voltage minus 0.7 volts. Using two transistors provides a current gain of around 1000 or more so that only a couple milliamps of current is drawn from the voltage divider to supply a couple amps of current at the output. Note that this circuit is much less efficient than the 555 timer dimmer circuit using a variabe duty cycle switching approach. In the figure below, the 25 watt/ 12 volt lamp draws about 2 amps at 12 volts and 1 amp at 3 volts so that the power lost when the lamp is dim is around (12-3 volts * 1 amp) = 9 watts. A fairly large heat sink is required to prevent the PNP power transistor from overheating. The power consumed by the lamp will be only (3 volts * 1 amp) = 3 watts which gives us an efficiency factor of only 25% when the lamp is dimmed. The advantage of the circuit is simplicity, and also that it doesn't generate any RF interference as a switching regulator does. The circuit can be used as a voltage regulator if the input voltage remains constant, but it will not compensate for changes at the input as the LM317 does.

Telephone In-Use Indicator

Phone line (+)

3.3 Meg

0.1 uF

3.3 Meg

Phone line (-)

680K

+ 3 Volt Battery

100 Ohms

2N3906

2N3904

LED

Battery (-)

Notes:

Circuit to illuminate an LED when any phone extension is off-hook. LED should illuminate when circuit is not connected to phone line, or when phone is off-hook. If LED fails to extinguish, check for 3 to 4 volts across the 680K resistor and check polarity of connections to phone line.

Drawn by - Bill Bowden - 01/19/96

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Telephone In-Use Relay Controller

+ 12

Phone line (+)

3.3 Meg

0.1 uF

3.3 Meg

3.3 Meg

10K

Phone line (-)

Relay

1N914

D

G   S

N-channel MOSFET
IFR510 or 511
Radio Shack
(276-2072)
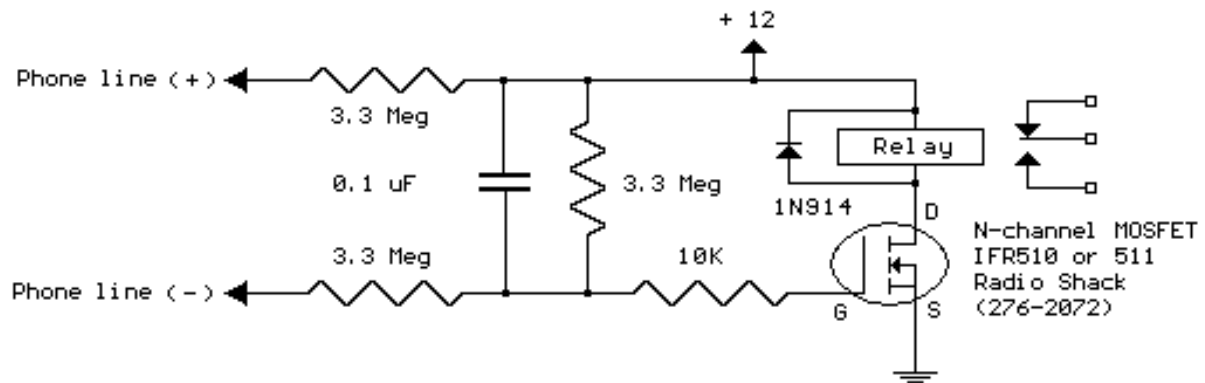
Circuit to close a relay when any phone extension is off-hook. Voltage at the gate of the MOSFET should be negative (1-3 volts) with respect to the source when phones are on-hook. Voltage at the gate should be positive (8-10 volts) with respect to the source (ground) when any phone extension is off-hook. A high impedance meter is needed to measure the on-hook voltages accurately. Circuit should draw less than 5 microamps from the phone line. Relay used is a 12 volt DC / 120 ohm coil, but most any small 12 volt DC relay should work. Power supply regulation should be +/- 2 volts.

Drawn by - Bill Bowden - 06/09/97

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Astable Multivibrator
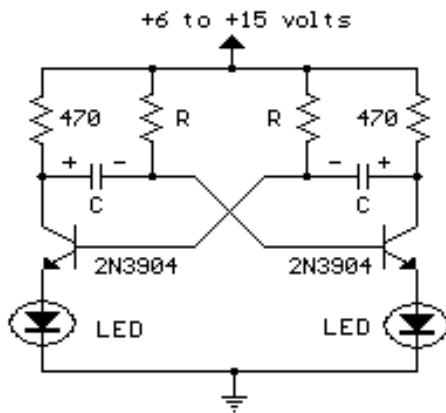
This is an astable multivibrator circuit to alternately flash two LEDs. The R and C values determine the frequency and the 470 ohm collector load resistors set the current to about 20 milliamps when the circuit is operated at 12 volts. Frequency is about 1 cycle per second using 22 uF capacitors and 47K resistors. Smaller R or C values will increase frequency. The LEDs may also be wired in series with the collector resistors and other transistors can be used. Reverse the supply voltage connections and LED connections if PNP type transistors are used.

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LM317 Product Folder

3-Terminal Adjustable Regulator

See Also: **LM1117** - LOWER DROPOUT VOLTAGE/SMALLER PACKAGE

General Description	Features	Datasheet	Package & Models	Samples & Pricing	Reliability Metrics	Design Tools	Application Notes

Parametric Table

Temperature Min (deg C)	-40,
Temperature Max (deg C)	125
Multiple Output Capability	No
On/Off Pin	No
Error Flag	No
InputMin Voltage (Volt)	4.20

Parametric Table

InputMax Voltage (Volt)	40, 37
Output Current (mA)	1000, 1500, 500
Watchdog	No
RegType	Linear Regulator
Output Min (Volt)	1.20
Output Max (Volt)	37

Datasheet

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
LM117 LM317A LM317 3-Terminal Adjustable Regulator	736 Kbytes	2-Jun-03	View Online	Download	Receive via Email
LM117 LM317A LM317 3-Terminal Adjustable Regulator (JAPANESE) 本サイトの日本語版データシートは最新版ではない場合があります。ご検討およびご採用にあたっては、最新の英語版データシートを必ずご確認下さい。	294 Kbytes		オンラインで見る	ダウンロード	Eメールで受けとる

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Package Availability, Models, Samples & Pricing

Part Number	Package			Status		Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking
	Type	Pins	MSL/Lead-Free Availability	Lead Time	Qty	SPICE	IBIS		Qty	$US each		
				Full production							reel	

Part	Package		Status	Availability		N/A	N/A		1K+	Price	Packaging	Marking
LM317AEMP	SOT-223	4	Status	15-17 weeks	50000	N/A	N/A	Samples / Buy Now	1K+	$0.60	of 1000	XYTT N07A
LM317EMP	SOT-223	4	Status	Full production / 14-16 weeks	50000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.36	reel of 1000	XYTT N01A
LM317AEMPX	SOT-223	4	Status	Full production / 15-16 weeks	50000	N/A	N/A		1K+	$0.60	reel of 2000	XYTT N07A
LM317EMPX	SOT-223	4	Status	Full production / 15-16 weeks	50000	N/A	N/A	Buy Now	1K+	$0.36	reel of 2000	XYTT N01A
LM317AT	TO 220	3	Status	Full production / 14-16 weeks	45000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.48	rail of 45	NSUZXYTT LM317AT P+
LM317T	TO 220	3	Status	Full production / 14-16 weeks	300000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.33	rail of 45	NSUZXYTT LM317T P+
LM317AMDT	TO 252	3	Status	Full production / 8-10 weeks	20000	N/A	N/A	Samples / Buy Now	1K+	$0.41	rail of 75	NSUZXYTT LM317 AMDT
LM317MDT	TO 252	3	Status	Full production / 10-12 weeks	100000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.36	rail of 75	NSUZXYTT LM317 MDT
LM317AMDTX	TO 252	3	Status	Full production / 8-10 weeks	20000	N/A	N/A		1K+	$0.41	reel of 2500	NSUZXYTT LM317 AMDT
LM317MDTX	TO 252	3	Status	Full production / 11-13 weeks	60000	N/A	N/A	Buy Now	1K+	$0.24	reel of 2500	NSUZXYTT LM317 MDT
LM317S	TO 263	3	Status	Full production / 13-15 weeks	50000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.37	rail of 45	NSUZXYTT LM317S P+
LM317SX	TO 263	3	Status	Full production / 14-16 weeks	50000	N/A	N/A	Buy Now	1K+	$0.37	reel of 500	NSUZXYTT LM317S P+
LM317AH	TO-39	3	Status	Full production / 3-6 weeks	3000	N/A	N/A	Buy Now	1K+	$2.35	bag of 500	NSZXYTT LM317AHP+

LM317H	TO-39	3	Status	Full production		N/A	N/A	Buy Now	1K+	$1.70	bag of 500	NSZXYTT LM317HP+
				3-6 weeks	3000							
LM317K STEEL	TO-3	2	Status	Full production		N/A	N/A	Buy Now	1K+	$2.25	tray of 50	-
LM317K MDC	Unpackaged Die			Full production		N/A	N/A	Samples			tray of N/A	-
LM317H MWC	Wafer			Full production		N/A	N/A				wafer jar of N/A	-
LM317K MWC	Wafer			Full production		N/A	N/A				wafer jar of N/A	-
				9-12 weeks	5000							

Obsolete Parts

Obsolete Part	Alternate Part or Supplier	Source	Last Time Buy Date
LM317AK	LM317K	NATIONAL SEMICONDUCTOR	06/14/94
LM317AK STEEL	LM317K STEEL	NATIONAL SEMICONDUCTOR	07/15/95
LM317AS	LM317AEMP	NATIONAL SEMICONDUCTOR	09/03/2002
LM317ASX	LM317SX	NATIONAL SEMICONDUCTOR	09/08/98
LM317ASX	LM317AEMPX	NATIONAL SEMICONDUCTOR	09/03/2002
LM317KC	LM317K STEEL	NATIONAL SEMICONDUCTOR	06/14/94
LM317MP	NSC LM317T	NATIONAL SEMICONDUCTOR	07/14/96

General Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet.

Features

- Guaranteed 1% output voltage tolerance (LM317A)
- Guaranteed max. 0.01%/V line regulation (LM317A)
- Guaranteed max. 0.3% load regulation (LM117)
- Guaranteed 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- P+ Product Enhancement tested
- 80 dB ripple rejection
- Output is short-circuit protected

Reliability Metrics

Part Number	Process	Early Failure Rate - Rejects	Sample Size (EFR)	PPM *	Rel. Rejects	Device Hours	Long Term Failure Rates (FITS)	MTTF
LM317A MDC	SLM	0	32200	0	0	1300000	3	368878485
LM317AEMP	SLM	0	32200	0	0	1300000	3	368878485
LM317AEMPX	SLM	0	32200	0	0	1300000	3	368878485
LM317AMDT	SLM	0	32200	0	0	1300000	3	368878485
LM317AMDTX	SLM	0	32200	0	0	1300000	3	368878485
LM317AT	SLM	0	32200	0	0	1300000	3	368878485
LM317EMP	SLM	0	32200	0	0	1300000	3	368878485
LM317EMPX	SLM	0	32200	0	0	1300000	3	368878485
LM317MDT	SLM	0	32200	0	0	1300000	3	368878485
LM317MDTX	SLM	0	32200	0	0	1300000	3	368878485
LM317S	SLM	0	32200	0	0	1300000	3	368878485
LM317SX	SLM	0	32200	0	0	1300000	3	368878485
LM317T	SLM	0	32200	0	0	1300000	3	368878485

For more information on Reliability Metrics, please click here.

Design Tools

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
LM317MDT Qualification Package	803 Kbytes	19-Oct-1999	View Online	Download	Receive via Email

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Application Notes

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
AN-1148: Application Note 1148 Linear Regulators: Theory of Operation and Compensation	200 Kbytes	25-Sep-02	View Online	Download	Receive via Email
AN-1149: Application Note 1149 Layout Guidelines for Switching Power Supplies	113 Kbytes	26-Sep-02	View Online	Download	Receive via Email
AN-1164: Application Note 1164 LM3647 Reference Design User's Manual	197 Kbytes	9-Mar-01	View Online	Download	Receive via Email
AN-1165: Application Note 1165 Configuration Guide for LM3647 Reference Design	32 Kbytes	28-Sep-00	View Online	Download	Receive via Email
AN-178: Application Note 178 Applications for an Adjustable IC Power Regulator	115 Kbytes	3-Oct-02	View Online	Download	Receive via Email
AN-181: Application Note 181 3-Terminal Regulator is Adjustable	165 Kbytes	3-Oct-02	View Online	Download	Receive via Email
AN-182: Application Note 182 Improving Power Supply Reliability with IC Power Regulators	56 Kbytes	3-Oct-02	View Online	Download	Receive via Email
AN-556: Application Note 556 Introduction to Power Supplies	159 Kbytes	25-Sep-02	View Online	Download	Receive via Email
LB-35: Linear Brief 35 Adjustable 3-Terminal Regulator for Low-Cost Battery Charging Systems	70 Kbytes	3-Oct-02	View Online	Download	Receive via Email
LB-46: Linear Brief 46 A New Production Technique for Trimming Voltage Regulators	71 Kbytes	3-Oct-02	View Online	Download	Receive via Email
LB-47: Linear Brief 47 High Voltage Adjustable Power Supplies	52 Kbytes	3-Oct-02	View Online	Download	Receive via Email

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[Information as of 15-Feb-2004]

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Some of the schematics for PHONE-IN-USE indicators have been confirmed to be defective or plain useless. I will upload a corrected version in the near future. Until then, use CAUTION!

This one has been confirmed to work and work well.

Telephone-related ASCII Schematics V1.01

Contents:

[Document Version: **1.00**] [Last Updated: **12/12/96**]

1. Telephone in use light

From: dthomas@bbx.basis.com (Dave Thomas)

```
               +----+------------+-------+-------- +9VDC
               |    |            |       |
               |    |           |\     R5      R6
               |    +-------|-\    |       |
               |    |            | >--+           |
               |    |        +--|+/    |      LED1
               ^    |        |  |/     |       v
              CR2  R4        |         |       |
               |    |        |  |\     |      C+
               |    |        |  |-\    |     | /
  <+>--R1--+--R3--+----+--> |  <--+--|-\    |    |/
           |      |    |    |        | >--+-B-|
  phone    |      |    |    +-------|+/      |\
```

```
line       |        |     ^     |          |/          | \
         R2        C1   CR1   CR3                       E+
           |        |     |     v          U1         Q1  |
           |        |     |     |                         |
<->------+------+----+----+-------------------+-------- GND
```
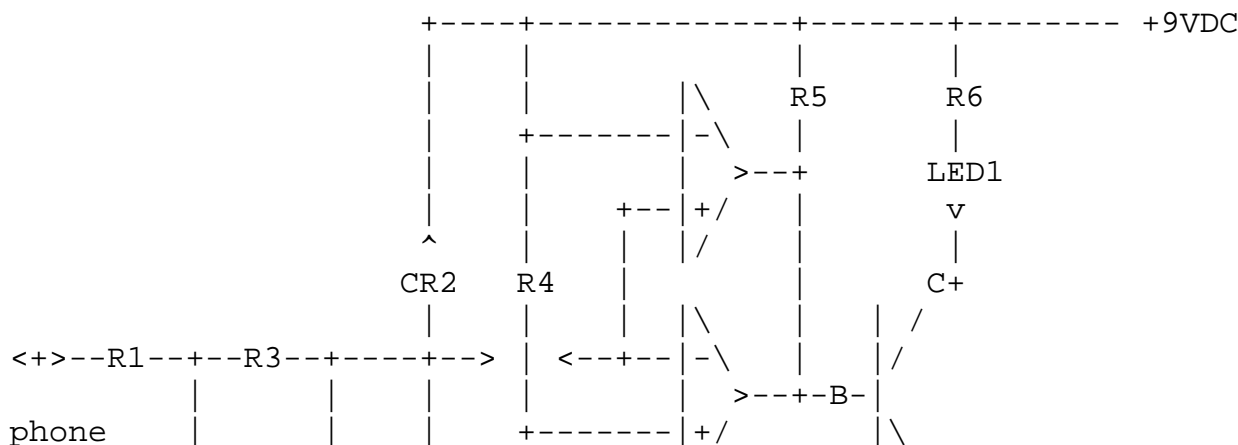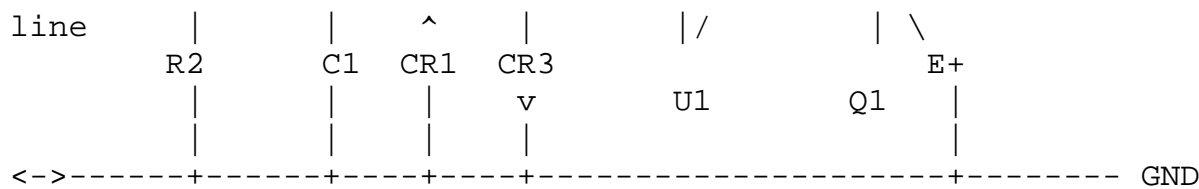
```
R1,R2              1 Meg
R3                 10 K
R4                 1 K
R5                 4.7 K
R6                 470 ohm
C1                 .005 uF
CR1-3              1N914 diode
LED1               any old led
Q1                 2N2222 or 2N3904
U1                 LM339 quad comparator (be sure to connect power and ground)
--> <--            are connected (jump)
^ or v             cathode of diode
+                  connection
9VDC               any old 9VDC wall transformer works nicely
```

Circuit description

R1 and R2 form a voltage divider, insuring that the phone line sees a high impedance load and that high voltages (such as the ring voltage) are easily dissipated by the protective diodes (CR1 and CR2). Also (obviously) they serve to divide all incoming voltages by two. Capacitor C1 filters out some of the audio signals that might otherwise make the LED flicker with speech.

The voltage across a busy line is generally 5-10 volts, whereas a free line sits at more like 48 volts, and a dead line (definitely not in use!) sits at 0. This circuit uses two comparators (sections of U1) to detect when the voltage is either too high or too low. Normally Q1 is kept turned on by pullup resistor R5, keeping LED1 illuminated. If either comparator detects incorrect voltage, its open-collector output goes into saturation and forces Q1 (and thus the LED) off.

The top comparator section has its negative input connected to the +9V supply, so it will force the LED off if the voltage at its positive pin should exceed 9V. Remember that we are dividing by two, so the phone line voltage would have to exceed 18V in order for this comparator to force the LED off. This would normally happen when the phone is not in use (48V, remember?).

The bottom comparator section has its positive input connected to the anode of a forward biased silicon diode, so it is sitting at 0.6V. If its negaive pin is ever lower than 0.6V, this comparator's output will go into saturation and force the LED off. Remember, again, that we are dividing the phone line voltage by two, so the phone line voltage would have to drop below 1.2V in order for this comparator to turn off the LED. This is clearly a dead line.

Serving Suggestion: Install the circuit in an out-of-the-way place, then connect the collector pin of Q1 and the +9VDC to unused (yellow or black) conductors in your home or office phone wiring. Then you can place additional LEDs (with current limiting resistors like R6) at each phone. I once used a power transistor for Q1 and peppered our electronic repair shop with LEDs at every workstation.

If you have any difficulty understanding my ascii art, the circuit theory, or anything about this posting, please feel free to contact me.

---

2. Detecting a telephone RING

From: dthomas@bbx.basis.com (Dave Thomas)

When a phone line rings, there's 90 V RMS AC at 20 HZ on the line. It's enough to give you a jolt you won't soon forget. Thus, it's hard to miss!

My favorite detection scheme looks like this. This is off the top of my head so you may have to twiddle component values a bit. Also, this is for driving logic circuits. I'll treat your specific problem in a bit.

Detector Schematic
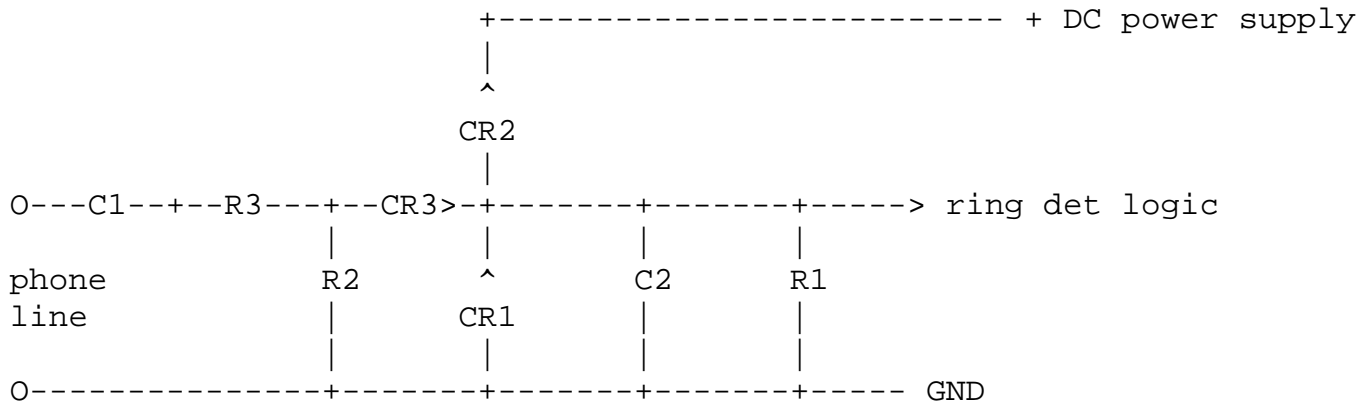
```
                                    +------------------------- + DC power supply
                                    |
                                    ^
                                   CR2
                                    |
O---C1--+--R3---+--CR3>-+-------+-------+-----> ring det logic
        |       |       |       |       |
phone   R2      ^       C2      R1
line    |       CR1     |       |
        |       |       |       |
O-------------+-------+-------+-------+----- GND

C1                 .1 uf
CR1,CR2,CR3        1N914
C2                 10 uF
R1                 100K
R2                 10K
R3                 100K
```

Mostly, there is only DC or small signal AC (audio) on the phone line. C1 blocks the DC, and the R3-R2 voltage divider prevents the low level AC from having any effect.

When the ring signal comes along (90V RMS) enough voltage is developed at the juncture of R3 and R2 that some charge is pumped into C2 via CR3. Protective diodes CR1 and CR2 ensure that the output of this circuit will not grossly exceed the power supply levels and thus damage the logic circuits it may drive.

C2 and R1 have a time constant of 1 second, so one second after each ring ends, the output will fall to a logic zero again. This circuit could easily drive a counter, to count rings. A timer with a longer period could be used to reset the counter if no rings have come in within say 10 seconds.

For the specific problem in the post I'm answering, (" LED should stay ON while the phone rings") you would want to change the design somewhat. Here's how I would make a ring indicator light that stays on until the phone acutally stops ringing:

```
O---C1--+--R1---+--CR2>-+-------+--R2---+
        |       |       |       |       |
phone   ^       C2      LED1
line    CR1     |       v
        |       |       |
O----------------------+-------+-------+
```
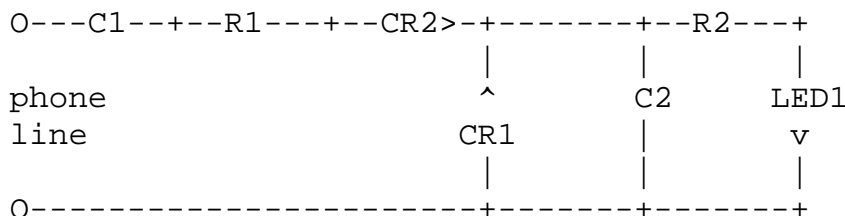
```
C1                1 uF, decent voltage
C2                see text
R1                10 K
CR2               1N914
CR1               zener -- 9v or higher
R2                1 K
LED1              any old LED
```

I haven't built this, but here's my theory: C1 blocks DC, R1 limits the current that the ring voltage could cause. The ring voltage is rectified by CR2, filtered by C2, and limited in amplitude by zener CR1. Then the charge stored in C2 is slowly used to light LED1. As long as C2 is large enough (I'd start with 10 uF and experiment from there) to keep the LED on between rings, and small enough that the LED goes off within a reasonable amount of time after the last ring, you're set.

(From no-idea)

I took ideas from schematics posted here a few days ago and constructed a telephone "line in use" indicator. Here's the circuit...

```
                                                    ----> (to +5)
                  1M              1k          /    E
    >-----              -----\/\/\----+---\/\/\-----|
                                      |              \   C
                                      \              |
                                      / 220k          \
from                                  \              / 1k
phone        bridge                   |              \
line                                  |              |
                                      |             LED
                                      |              |
    >------           -------------+-------------+
                                                  |
                                                 GND
```
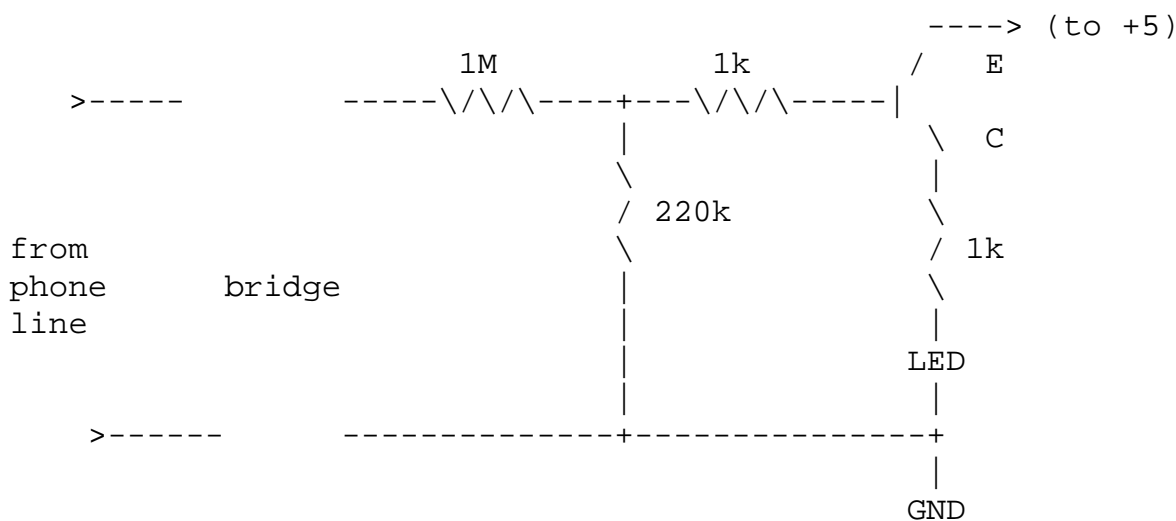
The transistor is a PNP Motorola 3638 with hFE of around 100 (probably doesn't matter). Also, you could use this with different supply voltages if you change the 220k resistor.

Also, in case anybody's interested, I found the on-hook open-circuit voltage of my phone line to be 48.7V, and the short circuit current to be 72.8mA. This leads to the conclusion that the line has a resistance of about 670 ohms. There have been a few calls recently in sci.electronics for phone in use circuits (ie a circuit that lights a LED when an extension phone is off hook).

Following are two circuits I archived some time ago from sci.electronics. The first appears pretty complete and requires an external 5V power supply. The second seems to be a loop current trap that enables you to move from one extension phone to another without leaving the first phone off hook. I don't know how well either of these circuits work as I haven't actually built them.

(From no-idea)

I thought I would try to post the schematic. This circuit requires a separate 5 volt supply. The branch of the circuit that contains C1, C2 & R5, R6 is only used as a passive tap. (So you can record the line when the rest of the circuit says 'off hook'. It can be removed if not needed. If used, it can directly drive a microphone input to a portable recoreder.

The Output of Q2 completes a path to ground when the phone lines gives an off hook reading. This can drive a relay (for a tape recorder motor) or an LED. Be sure to include a current limiting resistor if an LED is used. Also, D1 may be ommited if a non-inductive load is used (Relays and incandescent (sp?) lamps are inductive)

The LED thingy like this that I made for my phone flashes nicely when the phone rings (at the 20..25 Hz ring freq), so I can turn the ringer off, and still get silent ring indication (a feature, not a bug)

Well, its not exactly postscript(tm), but if you stand back and squint, you'll get the idea.

```
<----+-R5-+                          +----------+--------* +6vdc (I use 5 volts)
     |    |                          |          |
   R6     |                          |       D1___
     |    |                    R3    |        / \
     |    |                          |         |              ___
<----+    |                          |         +--------> Out
     |    |                          |       Q2|/
   C1=  C2=       BR1                +--R8-+---|
     |    | R1           __        Q1|/    |   |\v
*----+------/\/--|   |--+--+---|     R4>      |
     |    |      |~+|R7<C3L     |\v      <    |
     |    | R2   |~-|   >  T     |       |    |
*--------+-/\/--|__|--+--+-----+----+-----+--------* Ground
                      |_
                     ///
```
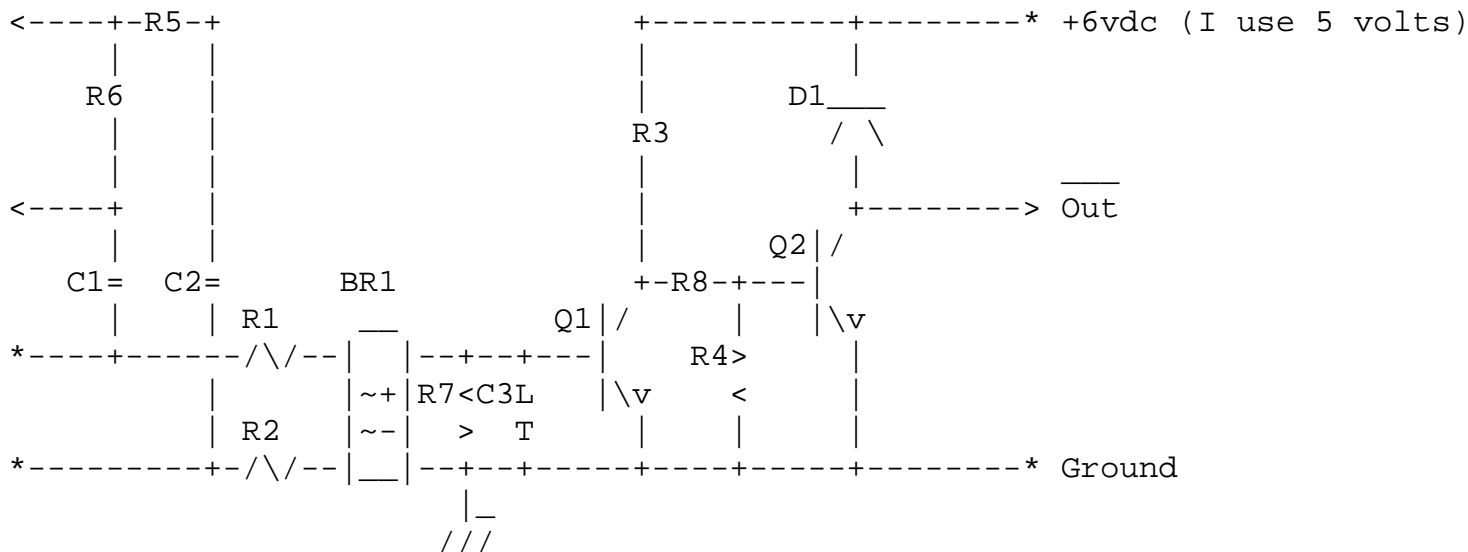
R1, R2	2.2M	Reproduced (kind of) without
R3, R4	470K	permission. Copyright 1980
R5	470	TAB BOOKS Inc.
R6	100	
R7	100K	
R8	220K	
C1, C2	0.01uf, 100V	
C3	1.0 uf	
BR1	Full wave Bridge Rectifier, about 200 VDC (or higher)	
D1	HEP R0052 (I use 1N400*)	
Q1, Q1	HEP S9100 -or- NTE-172a	

(From Aurel Boisvert)

My computer is in the basement and this device tells me if the phone line is in use. I have inserted a N/O switch in the battery connection so that the batteries will last longer as sometime my sons spend a lot of time on the phone. Prior to using my modem I press the switch to find out if the line is busy.

```
                         2N3906          33K           2N3904

        2.2 meg            /----------/\/\/\---+      /------+
                          |/                  |    |/      |    ***
Tip o--/\/\/-----+-------|    PNP             +----|  NPN   \    220
                  \       |\                       |  \      /
                 / 330K   |                        |   \    \
                  \       |              +------------+    |
```

```
Ring          |          |          |          |       ---
   o--/\/\/-----+        |          O -        |      / \ Led
     2.2 meg    |        |         3V          |       |
               |        |          O +         |       |
               |        |          |           |       |
           +-------------------------------------+     |
               |        |          |                   |
           +-----------+------------------+
```

** This resistor may have to be lowered to match the led used. Use alkaline battery, they last longer.

---

3. (manual) Phone In-Use Light

From: barber@beowulf.ucsd.edu (Terri Barber)

```
>>---------------+------+---->> phone line
                 |      |
                 |      o
                 |      /
                 |     /     momentary switch
                 |     |
                 |     /
                 |     \     1200 Ohm
                 |     /
           -----____|
           / \
          /___\   SCR
            |
            /
            \   600 Ohm
            /
            |       ^^
          -----    //
          / \     //
         /___\      LED
            |
            |
>>---------------+-------->> phone line
```

---

4. Phone to audio interface (SSI202 input)

From: jre@earldom.UUCP (Jim Earl)

You have to isolate the chip from the phone line, or you'll have all kinds of problems. Let's see how I can do this with ascii art:

```
            .22 uf              10k pot
```

```
                              400v       ||(----------->
Phone line tip  o-----)(----)||(              <---o to SSI202 input
                              )||(            >
Phone line ring o-----------)||(-----------o---o ground
```

The transformer is a 600-ohm to 600-ohm line transformer. I use the circuit as-is, and works fine. Doesn't take the phone off hook, you'll need to add some circuitry for that. To set the pot, turn it down all the way, (for minimum audio into the decoder) then hold down a tone on the phone while you slowly advance the pot up until the VALID DIGIT line changes on the chip. Then advance the pot a little past that point. That should do it.

Also, it might not be a bad idea to put a couple of diodes back-to-back across the secondary of the transformer. I'm not sure if enough voltage will be generated to harm the SSI chip when the phone rings or not. Mine has never had a problem, but it might be worth the cost of the two diodes for good luck.

---

5. Phone Off-Hook Indicator

Author: Roger Petersen Created: June 1985 or so Overview - What is it?

Runs off 9V battery, Plugs into phone jack, Lights an LED when any phone on the line is off-hook.

Phone Information

Measuring the voltage across the telephone line shows (typical numbers):

```
        On Hook:        40 to 50 VDC
        Off Hook:       4 to 6 VDC
        Ringing:        100 VAC
```

The "standard" impedence of a telephone, when off-hook, is 680 ohms. Hanging a 680 ohm resistor across the telephone line will drop the voltage from 48V to about 5V, causing the line to go "active". This is how HOLD switches work. This probably means that it is bad to load down the phone line when the phone is off hook. I wouldn't want to hang less than a 100Kohm load across it. Should probably measure this, and see how it affects the on-hook voltage.

I haven't seen any official documentation on these numbers. They're empirically derived.

The next question is: What are these voltages referenced to? If anything? It's possible that the most positive phone wire is tied to the GND in your house, or else maybe the neutral wire in your 120VAC outlet. So measuring the phone line voltages with respect to your household GND should show 0V and -48V when the phone is on-hook. But I don't know. It's probably best to not rely on this behavior.

Circuit Design - Off-hook Indicator

Could probably use some sort of transistor design, but I'm a digital weenie.

I used a CMOS 4049 Hex Interter. This part (supposedly) has high drive output. And since it's CMOS, it can operate with Vcc from +3 to +15V. And it has a high input impedence.

```
                                                                    +9V
                                                                     |
Phone+    -----+                                                     |+
               |                                                    LED
```

```
                     R  2.7Mohm                                         |-
                        |                                               |
                        |                                               R  680 ohms
                        |          5 |\  4          3 |\  2             |
                        +-----------|  >o------+-----|  >o--------------+
                        |           |/  4049    |     |/  4049          |
                        |                       |                       |
                        |                       |                       |
                     R  0.56Mohm                |   14 |\  15           |
                        |                        +-----|  >o--------------+
      Phone-   ------+                                 |/  4049
                        |
                        |
                GND
```
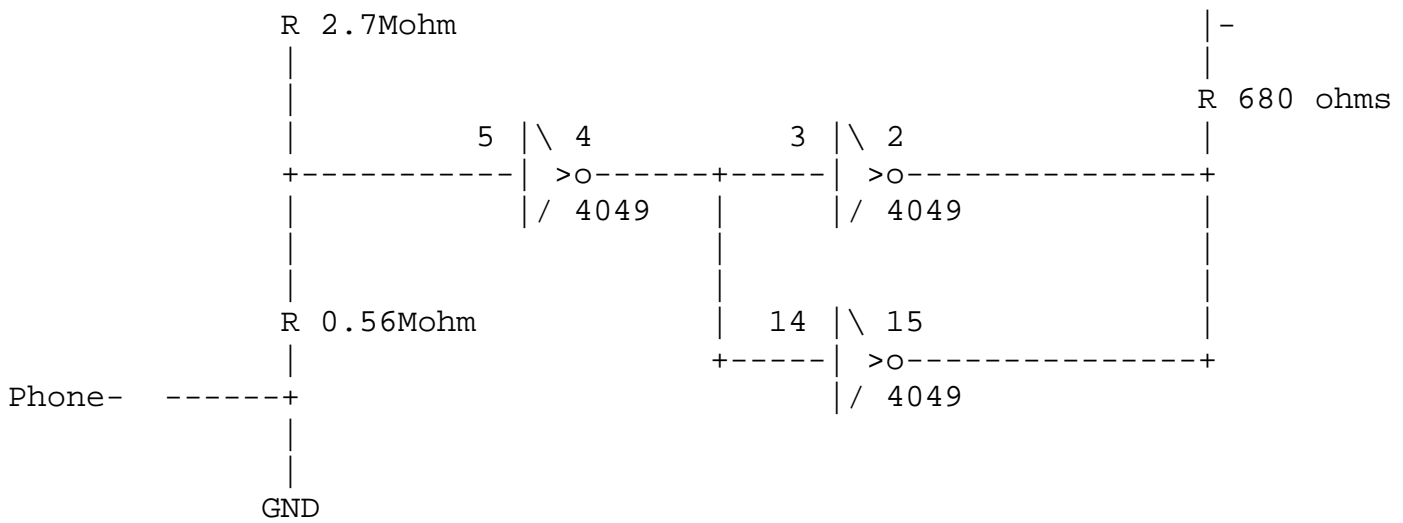
R = resistor. Those other things are inverters.
Connect 9V battery across +9V and GND, above.
Tie all unused inputs (pins 7,9,11) of the 4049 to GND! Don't let 'em float.
Tie Vcc (Pin 1) of 4049 to +9V
Tie GND (Pin 8) of 4049 to GND

Voltage going into pin 4 of 4049 is:
        Phone voltage   Voltage at pin 4
        6V   1V
        48V   8V
        100V   16V

Fancy Features

Not all phone jacks are wired the same way. Some have the two wires reversed. In the old days, before touch-tone, it didn't matter. In the early days of touch-tone, some phones didn't dial when the polarity was backwards. Now days, most phones don't care any more.

But the circuit above does. It requires the phone wires to be connected as shown. If you connect them backwards, it won't work. The light will just stay lit. And the 4049 may eventually be damaged. (4049's seem pretty resilliant). So it would be nice to have an easy way to switch the phone wires

Design Analysis

The 4049 probably takes a lot of abuse in this design. When the phone rings, the 4049 probably sees bursts of 16V. When the battery goes low, the voltage on pin 5 of the 4049 may exceed Vcc on the 4049, which is probably bad. It shouldn't be hard to improve on this circuit.

6. 'phone rang' indicator light

From: massoud@chemteca.sdsu.edu (Massoud Ajami)

This, will detect the ring signal, energize the relay which latches up, and the LED comes on and stays on till you push SW.

_____

```
tip o--CC---RR----o-----D<---o-----o------>D----^  ^----o-----+
                  |         |     |              SW         |     |
                  |         |     |                         |     |
                \-/        |-     R||                       B-    LED
                 Z          C     L|| .............         A     |
                  |        |+     Y||                  __.__ T+    R
                  |         |      |              +--o    o---+    |
                  |         |      |              |               |
                  |         |      |              |               |
ring o----------o---------o-----o--------o--------------+
```
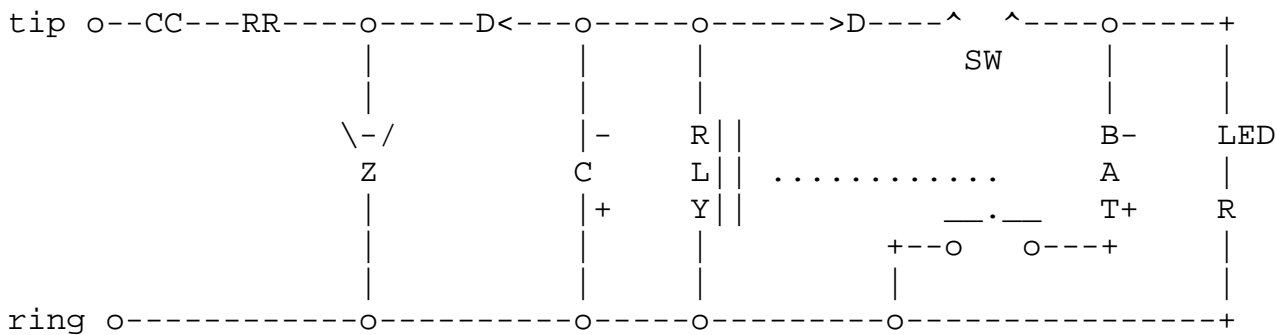
CC=.47 uF 200 V. capacitor
RR= 3k (depends on relay)
D = 200V diode (< > direction od diodes)
Z = 12 zener
RLY= any small relay
SW= normally closed switch
K = relay's contacts
BAT= 9 V. battery
R = 500 ohm (for LED)
C = some (10) uF capacitor

Components are not critical. It should latch on first ring, if not reduce RR. If it took too long to deenergize, reduce the C.

---

7. Phone Line to Audio

From: tpappas@hamp.hampshire.edu

We use telephone audio in our studio all the time. And yes, it's an off the shelf design. I designed and built such a device with scrap door components. I used an audio coupling transformer and a capacitor. The primary windings add in series to 500 ohms. Instead of connecting them directly together I added a cap between them. I think it was somthing like 0.047 micro farads with a 600vlt rating. And the secondary which is 500 ohms runs into the control room mixer.

```
        Tip   >------------/ II
                          / II /-----------<
   (primary winding 1)   / II /
                        / II /
           >-----X------/ II /
                I       II /
     0.047 uF      =      II / ----------CT    (secondary winding)
                I       II /
           >------X------/ II /
                        / II /                        Output Side
                       / II /                            to Mixer
   (primary winding 2)   / II /
                        / II /-------------<
       Ring    >------------/ II
```
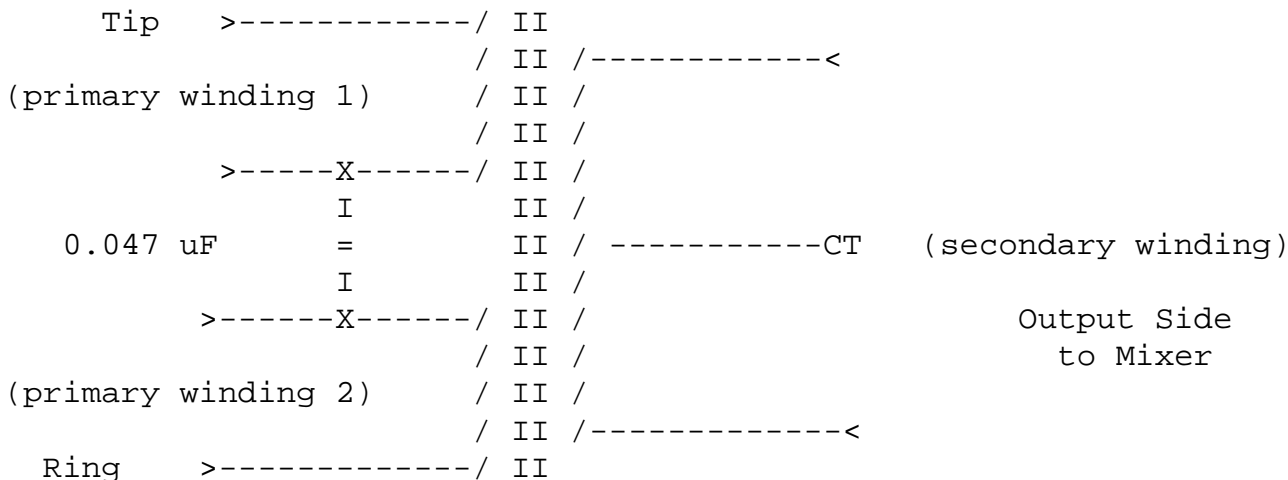
Try this circuit it works great for us in the studio. Just make sure you use properly rated components.

---

8. Phone in-use

From: kcarver@nmsu.edu (Kenneth Carver)

The circuit I built gives a visual indication at each extension when any extension is off-hook. It is line-powered, and the maximum number that can be used on our system is three. Since they all draw power at the same time to light the LEDs, any more indicators would cause an off-hook condition. Some changes could be made to reduce the current draw, to allow using more indicators, but the brightness of each led would suffer. The LEDs I used are tiny, but amazingly bright on just a couple milliamps. I picked them up from a surplus catalog, I can't remember which one. If you were to use battery power for the circuit, you could use almost any number of indicators. I had use only for three, and I did not want to worry about replacing batteries. If I remember correctly, our pbx required a load of about 20 milliamps before the line failed to hang up. This circuit draws about 5 milliamps when off-hook, much less when on-hook. It senses the drop in line voltage from about 46 volts to 6 volts when an extension is picked up. The zener voltage should be well above the off-hook voltage of your system, and well below the on-hook voltage. The transistors are small high-voltage npn types I had on hand. The LED also flashes with the ring voltage. Putting a suitable MOV across the line is a good precaution to prevent lightning damage.

```
(+)------------+--------------+-----------------------+
 green         |              |                       |
               /              /                       /
               \  2200        \ 100K         100K     \
               /              /                       /
1N4148         \              \                       \
     +--------+                |                      |
   __|__   __|__               |               __|__ /
   / \    \   /   LED          |       10V     / / \
  /_____\  __\ /__             |       ZENER   /_____\
    |        |                 |                 |
   +--------+                  |                 |
           | c                 |                 |
           \ |                 |                 |
MPSA42      \|-----------+----------- c          |
           /|            |           \ |         |
          / |          __|__          \|-------+ |
          | e          / \   MPSA42   /|    __|__
          |           /_____\ |      / |    / \
          |     1N4148  |            | e   /_____\
          |             |            |       |
          |             |            |       |
(-)------------+--------------+-----------+-------+
red                                           1N4148
```
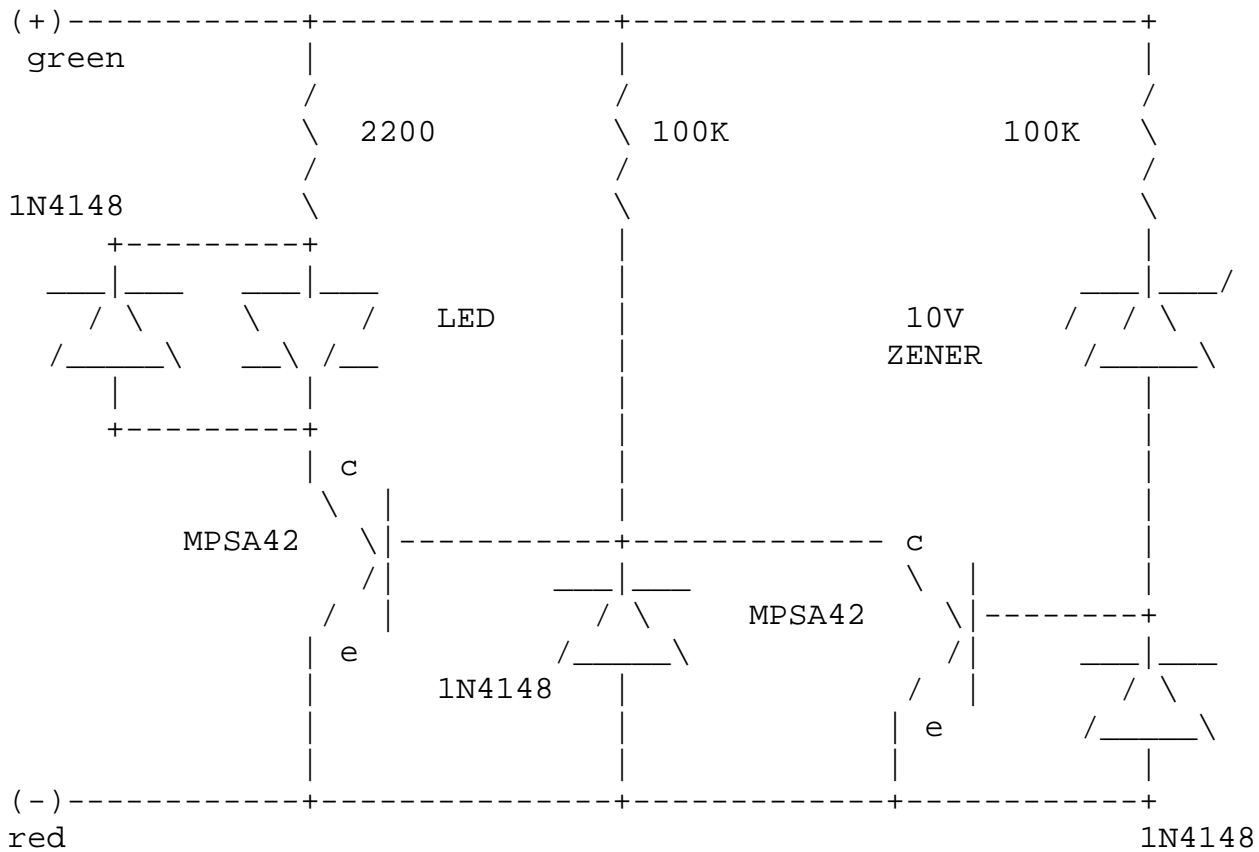
9. Telephone Line Monitor (Plans)

From: jna@geech.gnu.ai.mit.edu (while you were out)

Get yourself a low-voltage DC relay, like a 3v relay... Set it up as follows:

```
           Audio Isolation
           Transformer
  To       <--)||(--------------------+
              )||(                     | <==== Relay Contacts
  Speaker <--)||(---+    +--------o/  o
           600ohm   |    |            mmmmm DC 3v Relay Coil
                    |    |         |    |
  RED     ----------|----+------+     +----------> To Dispatcher's Phone
                    |
  GREEN   ----------+--------------------------> To Dispatcher's Phone

  |                                 |
-+- indicates a connection,      ---  is not connected.
  |                                 |
```
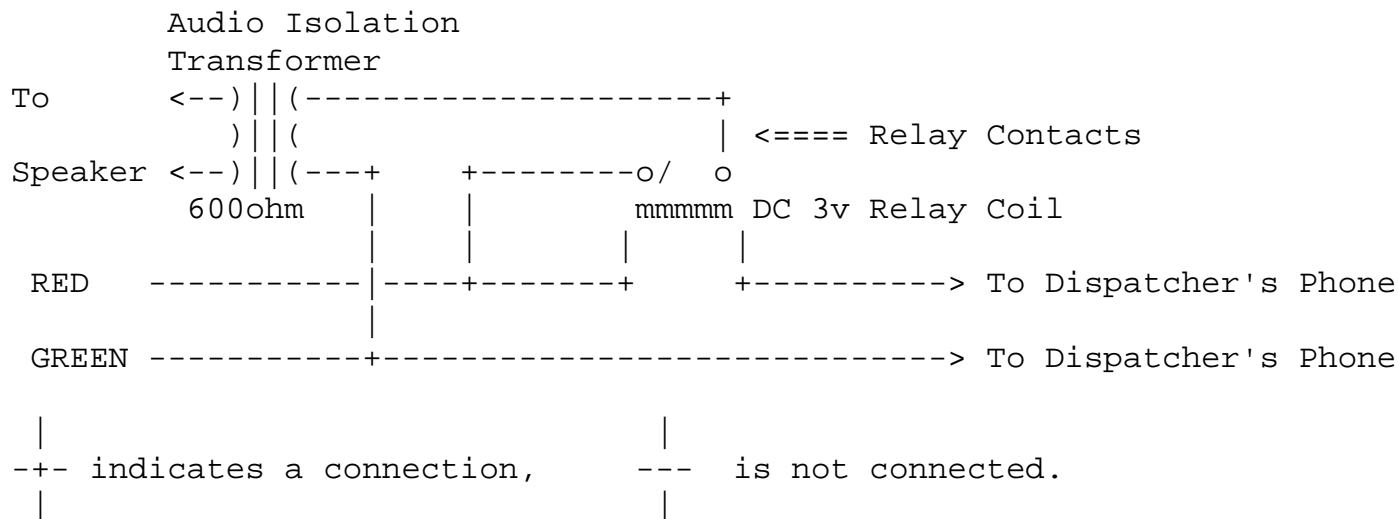
You may have to use a Diode or two to make this telephone-line FCC clean... I'm not saying this is a clean circuit at all. It's cheap and dirty! You may have to use a Op-Amp (Use an LM386, they're good for speakers) on the speaker. Depends. Experiment!

Circuit Theory:

When the Dispatcher picks up the phone (in a standard circuit, I have NO clue what your PBX does.. this will work on standard home phones, and I used to use it for a tape-recording controller) Hey, there's an Idea - spend $25 on a telephone recording device, and hitch it to a nice loud amp and speaker combo, instead of a tape deck. It'll save you loads of time...

Anyhow.. the voltage will turn into DC, approx 6-10VDC when the phone is picked up, (which is why you've gotta put it before the dispatcher's phone) and click the relay. The relay will connect the transformer, and feed the speaker. it might be towards your advantage to use a SPDT relay, and connect **BOTH** ends of the transformer, and not just switch one end in and out. That might prevent some line noise...

---

10. Use old phones as an intercom

From: mwandel@bnr.ca (Markus Wandel)

I have recently thought about this and come up with a kludgy but workable scheme.

Talking over the phones is easy. You put DC current through the phone and it transmits and receives audio. So two phones and a current source (about 25mA) all in series will give you a talking circuit. A suitable current source can be as simple as a 9V battery and a series resistor whose value is adjusted (with both phones offhook) till about 25mA flows. You can then bypass the battery and the resistor with a capacitor to couple the audio straight across and get a loud and clear connection.

What is much harder is signaling the other end. To ring the bell you need to put 90V (RMS) 20Hz AC into the phone (nominally). Lower voltages will work (down to about 40V) but different frequencies won't. You can't ring

the phone at 60Hz. I have a ringing circuit in a PBX I built but it consists of a 20Hz sinewave generator, a push-pull power booster and a big transformer. Much too elaborate for a simple 2-phone intercom circuit, and anyway the ringing voltage could painfully zap a kid.

So forget the bell and look into other forms of signaling. This is what I have come up with:

```
                                +   | | |  -
     +-------+------ - - --+---|||||---/\/\/--+---- - ----+-------+
     |       |             |      | |    R     |          |       |
     |       |             | 24V  | |          |          |       |
     |       |             |      | |          |          |       |
     |      ---            |      | |          |         ---      |
     |     |   |           +---||---------+    |        |   |     |
     |      ---   Sonalert        C          Sonalert    ---      |
     |   C   |                                          |   C     |
     +---||--+                                       +--||---+    |
     |       |                                       |       |    |
     |      _|_,                                    _|_      |    |
     |     / \   15V                          15V   \ /      |    |
    PHONE  -+-  Zener                        Zener  `-+-    PHONE  |
     |       |                                       |       |
     |       |                                       |       |
     +-------+---------------- - - - ----------------+-------+
```
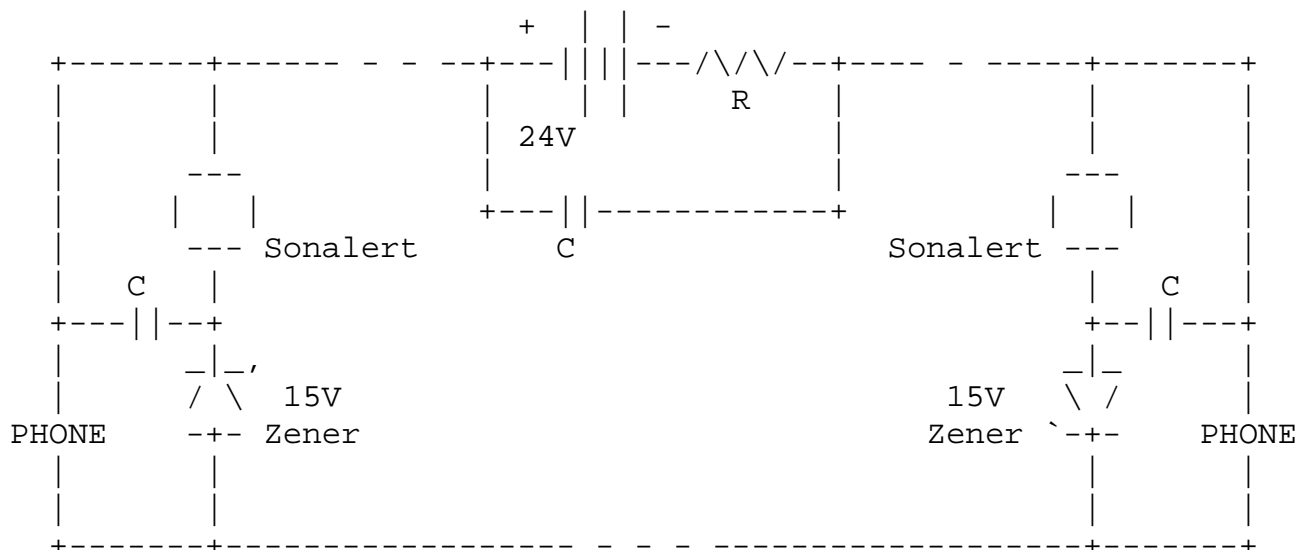
As before, set R to give you a talking current (both phones offhook) of about 25mA. Start with 1K ohm. Leave it in if the phones work well enough; the current is not very critical. The capacitors C are audio bypass capacitors and should be about 0.47uF.

When the phones are onhook they present an open circuit, and the 24V battery voltage is not enough to overcome the 30V series drop of the Zeners and no current flows. When both phones are offhook they present a very low resistance and the talking current (determined by R) flows.

When only one phone is offhook it places its low DC resistance across the Zener diode on its side so that the full 24V supply is applied to the other side. This overcomes the voltage drop of the other Zener diode so the other Sonalert beeps. The wonderful thing about Sonalerts is that they make a loud noise with only a few milliamps of current so the series resistor R doesn't matter. Especially nice is a pulsing Sonalert which goes "Beep beep beep" automatically. While the far-end Sonalert is beeping, you hear the beeping in the near-end receiver (at low volume thanks to the bypass capacitor across the far-end Sonalert) to confirm that the line is working and the other end is being signaled.

The power supply can be three 9V batteries in series but since 80% of the power is lost in series resistor R rather than in powering the phones it seems a little wasteful. A 24V wall wart with clean filtering would be better.

The signaling components can be mounted inside the phones. Only two wires are needed to go to each phone, and the power supply can be mounted centrally, out of harm's way. If R is adequately big (1/2 watt) and has enough ventilation then both lines can be indefinitely shorted out without any fire hazard and there is not enough voltage anywhere to hurt anyone.

I have tested this with 500-type phones and two different types of piezo buzzers (pulsing sonalerts and non-pulsing brand X ones) and it works great. You should be able to get all the needed parts including piezo buzzers at Radio Shack. I love telephones. Too bad I don't have any kids who want an intercom line.

11. Phone-In-Use indicator

From: rstevew@gorn.echo.com (richard steven walz)

```
       ------+-----------+-----------+---------- pos (tip)
             |           |           |
             |           |          ---
             |           |       R3 | |
             |           |          | |
             |           |          ---
    zener    |           |           |
       /------/         ---        -----
      /  \          R2  | |        \ /  LED
       ------           | |        -----
             |          | |           |
             |          ---           |
             |           |            |
             |        -------+----+  ---+
             |      |/          |  |/
             +---|  npn1        +---|  npn2
             |      |\              |\
            ---    -+              -+
         R1 | |      |              |
            | |      |              |
            ---      |              |
             |       |              |
       ------+-----+----------------+------------ neg (ring)
```
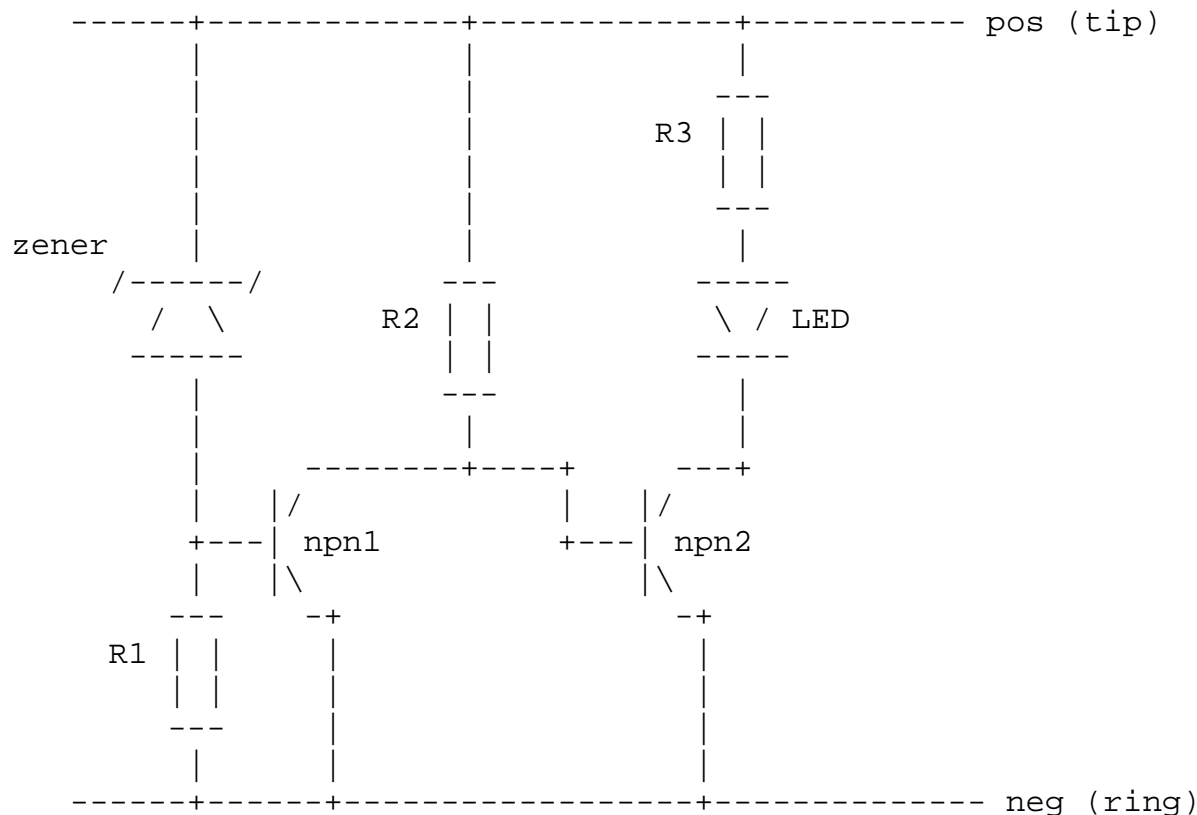
Now here's some logic that should work fine with the right zener and the right resistors and a couple of cheap npn's 2n2222A's or 2n3904's (06's?). If you get close to 25 volts with the new smart test boxes, a 20 volt Z may work fine. Choose R1 to limit current through Z and have enough left to turn on npn1 just enough to deprive npn2, choose R2 for that, and you will need to add a resistor R3 to protect the LED from overcurrent as needed, depending on the phone system you have!

You **MIGHT** need a resistor between the bottom of R2 and the base of npn2 to get it right, but I don't think so because of the B-E 0.7 volt diode junction voltage needed in npn2 to get it out of cutoff.

---

12. Telephone Power?

From: henry@zoo.toronto.edu (Henry Spencer)

" If one were to try [using power from phone line], would phone company had a way of finding out?"

Most assuredly. They aren't in the business of supplying power, and they **ARE** in the business of finding faults in their lines. Any substantial power drain from their lines **WILL** be detected. If it's large, the phone switch will conclude that you've dropped the phone in the bathtub or something like that, and will disconnect your line (and will check periodically to see if the drain has gone away and you can be reconnected). If it's small, the switch will report it to the service people as a possible line problem, to be investigated before it causes a complete failure... and if they investigate and find that you're to blame, they will probably send you a bill for time and trouble. The current you can draw without eventually having it noticed is very small.

13. Hold function for Telephone

From: figment@wam.umd.edu (.)

Here's the schematic that was in the November 1992 issue of Electronics Now. (Nobody sue me)

```
   +-------+------+        R1 = 2.2K
   |       |      |        R2 = 1 K
-| SW      R      |        R3 = 47 ohms
   |       1      |        SCR = 2N5064, TIC47, or MCR104
   |       |      |
   R      LED     |                   Well, that's it, just remember that
   2       |      |                   the cathode of both the SCR and the
   |       |  +----- RING (Red)   LED are towards the bottom.
   +------SCR
   |       |  +----- TIP (Green)
   R       |  |
   3       |  |
   |       |  |
   +-------+------+
```
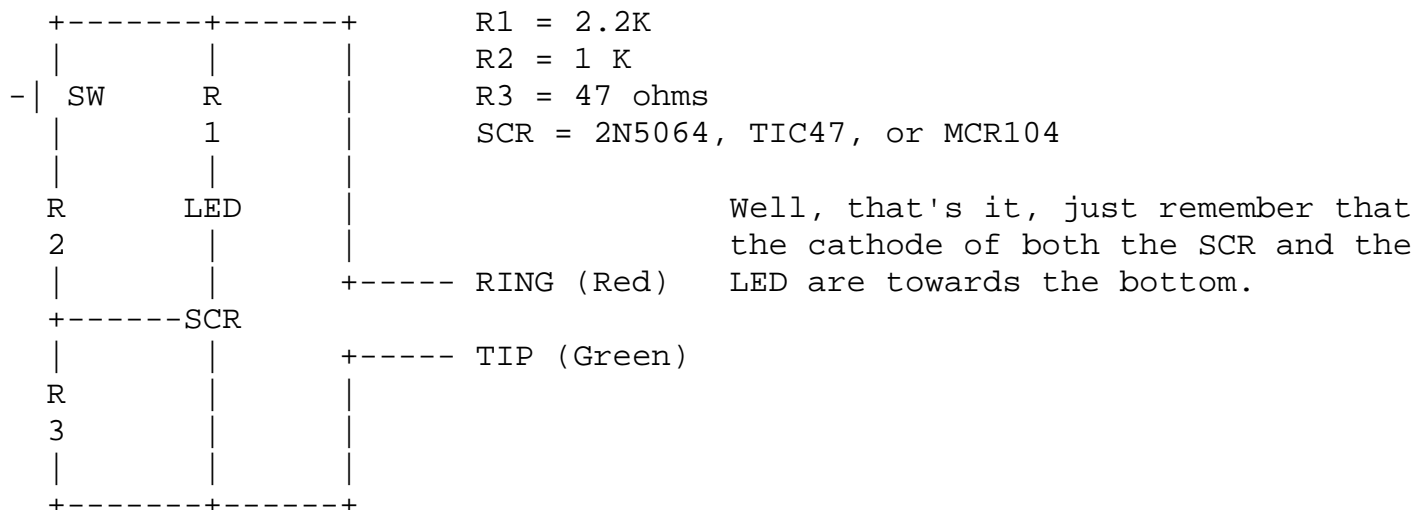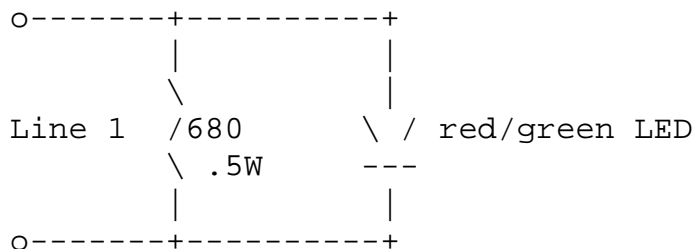
14. Digital/Standard Phone Line Tester

(From Dan Ts'o)

Radio Shack sells a similar device without the high current function. It detects one or two lines on an RJ-11 and tells you its polarity. It costs $6. The schematic is:

```
    o-------+----------+
            |          |
             \         |
   Line 1   /680      \ /  red/green LED
            \ .5W      ---
            |          |
    o-------+----------+
```

The circuit for Line 2 is identical. Note that each red/green LED comes standard as reverse wired (red LED "forward", green LED "reversed").

Based on the above, I think an appropriate modification to include a high current indicator would be: (I've tested it)

```
          20
   o--+-\/\/\/--+----------+----------+
      |         |          |          |
      |         |           \        ---
   +--->|----+         /       / \  red/green LED
```

```
       red/green                  \ 680        |
         LED                      | .5W         |
     o-----------------------+----------+
```
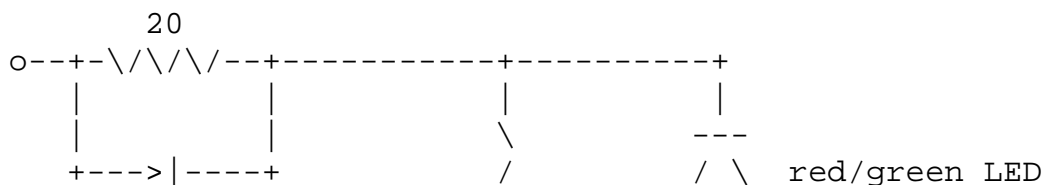
You can adjust the 20ohm resistor value to set what is considered "high current". 20ohms lights the LED at around 90ma. Total parts costs under $4, or if you use Radio Shack's $6 line tester and add the above resistor and LED, then under $7. (I'm not faulting IBM for charging $30).

This whole issue really bothers me because it means that I can't bring a PCMCIA modem with me on trips and count on it working at any given hotel. That means I should carry around my pocket modem just in case. So then what's the point of having the PCMCIA modem!

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1 Second Time Base From Crystal Oscillator

The schematic below illustrates dividing a crystal oscillator signal by the crystal frequency to obtain an accurate (0.01%) 1 second time base. Two cascaded 12 stage counters (CD4040) form a 24 stage binary counter and the appropriate bits are gated together to produce the desired division. Using a crystal of some even multiple of 2 is desirable so that one stage of the counter automatically toggles every second which eliminates the need for the NAND gate and reset circuitry, however the circuit below illustrates using a crystal which is not an even multiple of 2 and so requires additional components.

Using a 50 Khz crystal, a count of 50000 is detected when the appropriate counter bits that add up to 50000 are all high. This corresponds to bits 15 (32768) + 14 (16384) + 9 (512) + 8 (256) + 6 (64) + 4 (16). Bits 14 and 15 are the 3rd and 4th stages of the second counter, bit 0 is the first stage of the first counter (Q1, pin 9). To use a 100 Khz crystal, each bit would be moved one to the right so the total would be (65536 + 32768 + 1024 + 512 + 128 + 32 = 100,000). Using a 1 Mhz crystal, the following bits would be needed:

```
Bit 19 - Right counter - Q8 - pin 13  -  Decimal value = 524288
    18                    7       4                       262144
    17                    6       2                       131072
    16                    5       3                        65536
    14                    3       6                        16384
     9 - Left counter   - 10     14                          512
     6                    7       4                           64
                                                      ---------
                                                      1,000,000
```

At 1 Mhz, the 330K resistor in the oscillator circuit will need to be reduced proportionally to about 15K. When the terminal count is reached, a 7 uS reset pulse is generated by the Schmitt Trigger inverter stage that follows the NAND gate. The 47K resistor and 470 picofarad capacitor sustain the output so that the counters are reliably reset to zero. This is less than one clock cycle at 50Khz and does not introduce an error but would amount to 7 cycles at 1 MHz which would cause the counters to lose 7 microseconds of time per second. It's not much of an error (7 parts in a million) but it would be there. The minimum reset pulse width for the 4040 CMOS counters is about 1.5 uS, so the reset pulse cannot be made much shorter.
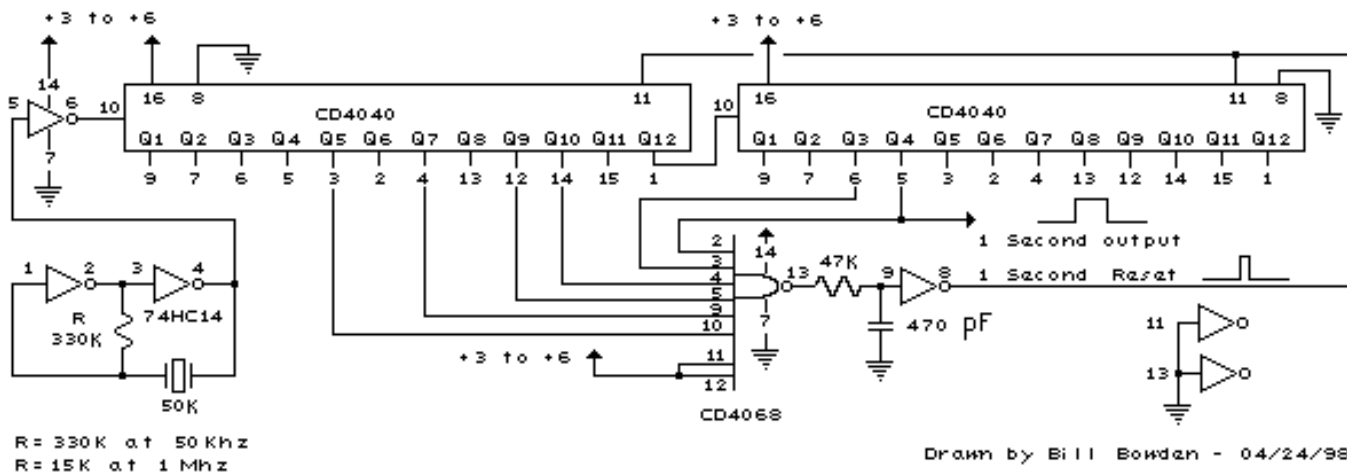
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32.768 KHz oscillator using a watch crystal

Below are a couple circuits you can use to produce a 32.768 KHz square wave from a common watch crystal. The output can be fed to a 15 stage binary counter to obtain a 1 second square wave. The circuit on the left using the 4069 inverter is recommended over the transistor circuit and produces a better waveform. The single transistor circuit produces more of a ramping waveform but the output swings the full supply voltage range so it will easily drive the input to a CMOS binary counter.
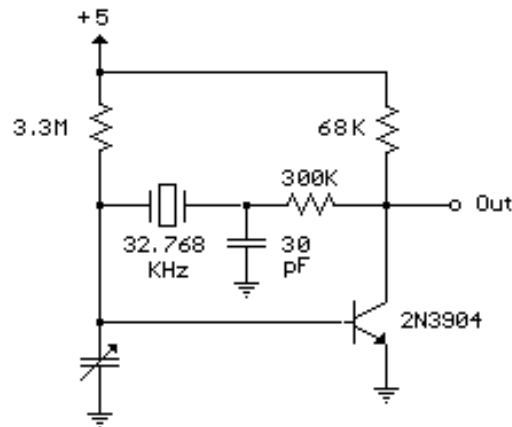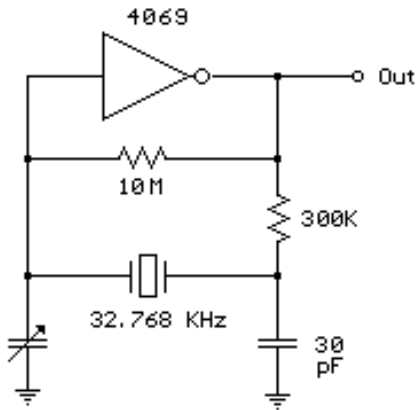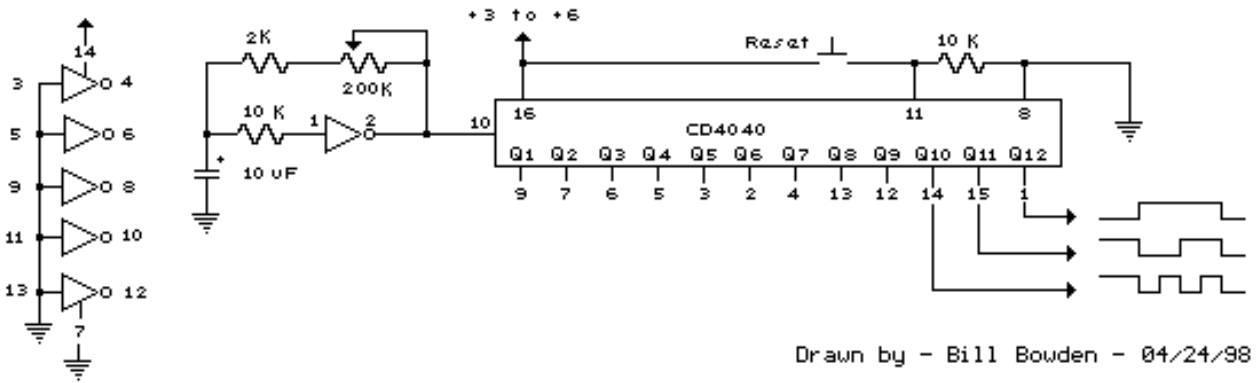

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Generating Long Time Delays

Generating long delays of several hours can be accomplished by using a low frequency oscillator and a binary counter as shown below. A single Schmitt Trigger inverter stage (1/6 of 74HC14) is used as a squarewave oscillator to produce a low frequency of about 0.5 Hertz. The 10K resistor in series with the input (pin 1) reduces the capacitor discharge current through the inverter input internal protection diodes if the circuit is suddenly disconnected from the supply. This resistor may not be needed but is a good idea to use.

The frequency is divided by two at each successive stage of the 12 stage binary counter (CD4040) which yields about 1 hour of time before the final stage (Q12) switches to a high state. Longer or shorter times can be obtained by adjusting the oscillator frequency or using different RC values. Each successive stage changes state when the preceding stage switches to a low state (0 volts), thus the frequency at each stage is one half the frequency of the stage before. Waveform diagrams are shown for the last 3 stages. To begin the delay cycle, the counter can be reset to zero by momentarily connecting the reset line (pin 11) to the positive supply. Timing accuracy will not be as good as with a crystal oscillator and may only be around 1 or 2% depending on the stability of the oscillator capacitor.

Drawn by - Bill Bowden - 04/24/98

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Telephone Ring Generator Using Switching Supply

The telephone ring generator shown below generates the needed high voltage from a simple switching mode power supply (SMPS) which employs a CMOS Schmitt Trigger square wave oscillator, 10 mH inductor, high voltage switching transistor (TIP47 or other high voltage, 1 amp transistor) and a driver transistor (2N3053). The inductor should have a low DC resistance of 1.5 ohms or less. The switching supply must have a load connected to prevent the voltage from rising too high, so a 22K resistor is used across the output which limits the voltage to about 120 DC with the phone ringer disconnected and about 90 volts DC connected. The output voltage can be adjusted by changing the value of the 150K resistor between pins 10 and 11 which will alter the oscillator frequency (frequency is around 800 Hz as shown). The supply is gated on and off by a second Schmitt Trigger oscillator (pins 12/13) so that the phone rings for about 2 seconds and then the circuit idles for about a minute between rings. These times can be adjusted with the 10K and 300K resistors connected to pin 12. The push button shown is used to manually ring the phone. The 25Hz ringing frequency is generated by another Schmitt Trigger oscillator (pins 1/2) which controls the H bridge transistor output circuit. The 6 transistors in the output stage (4 NPN, 2 PNP) should be high voltage types rated at 200 volts collector to emitter or more. The ringer will only draw around 10 mA, so the output transistors can have a low current rating but must have a high voltage rating. I used TIP47s and small signal PNPs of unknown numbers that I had on hand, but other types such as NTE287 (NPN) and NTE288 (PNP) should work. Both have a 300 volt C-E rating and cost about $0.95 from mail order houses.

The two 470 ohm resistors connected to the output serve to limit the current in case the output is shorted. I never tried shorting the output to see how effective the resistors are, but I did lose a couple transistors and then decided to add the resistors. They should limit the surge to around 120 mA which should be low enough to prevent damage. The circuit draws around 250 mA when the ring signal is present so if you want to operate it from batteries, six 'D' type alkaline cells are recommended. It probably won't work with a small 9 volt battery.

Drawn by - Bill Bowden - 01/15/99
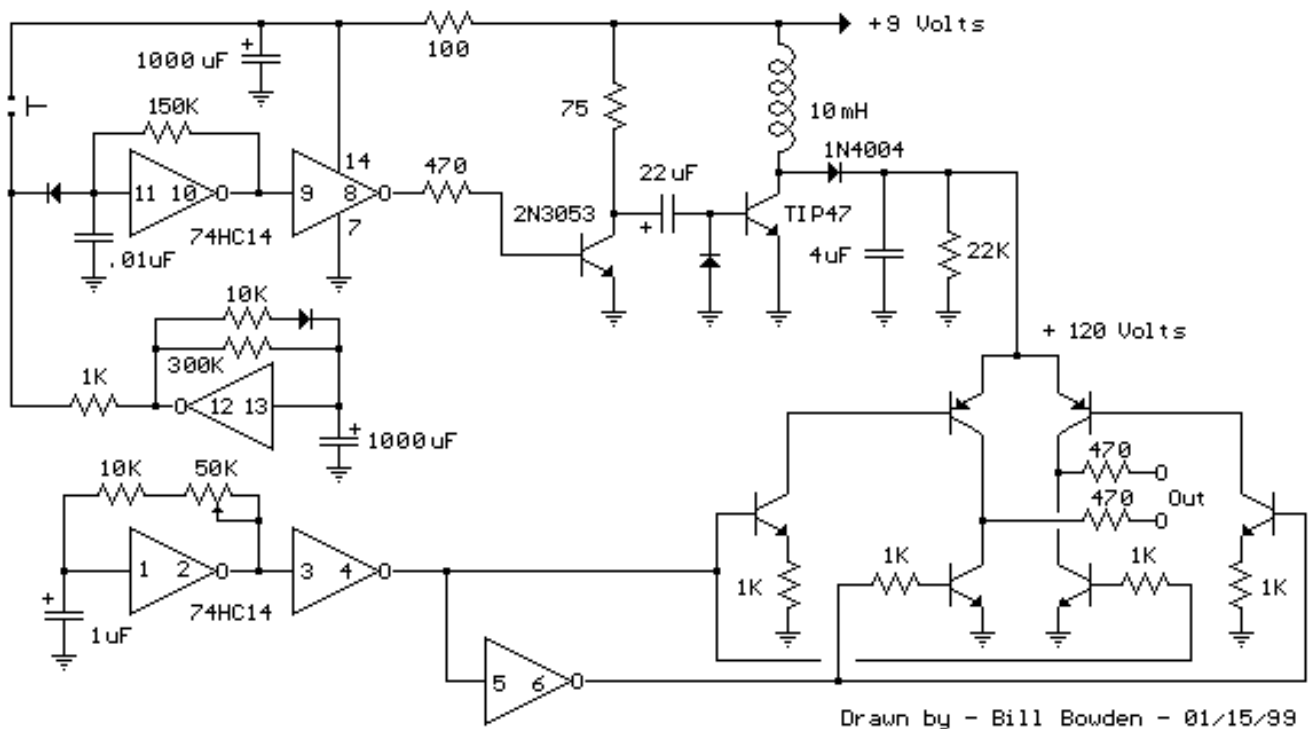
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Telephone Ring Generator Using Small Power Transformer

This ring generator will ring a telephone once every 10 seconds. The interval between rings can be lengthened or shortened by varying the value of the 1 Meg resistor. The 70 volt/ 30 Hz ring voltage is produced from the 120 volt side of a small 12.6 VAC power transformer (Radio Shack 273-1365). Both capacitors connected across the transformer windings are non-polarized / 100 volts. Circuit draws about 300mA from the 12 volt DC power supply during the ringing interval.
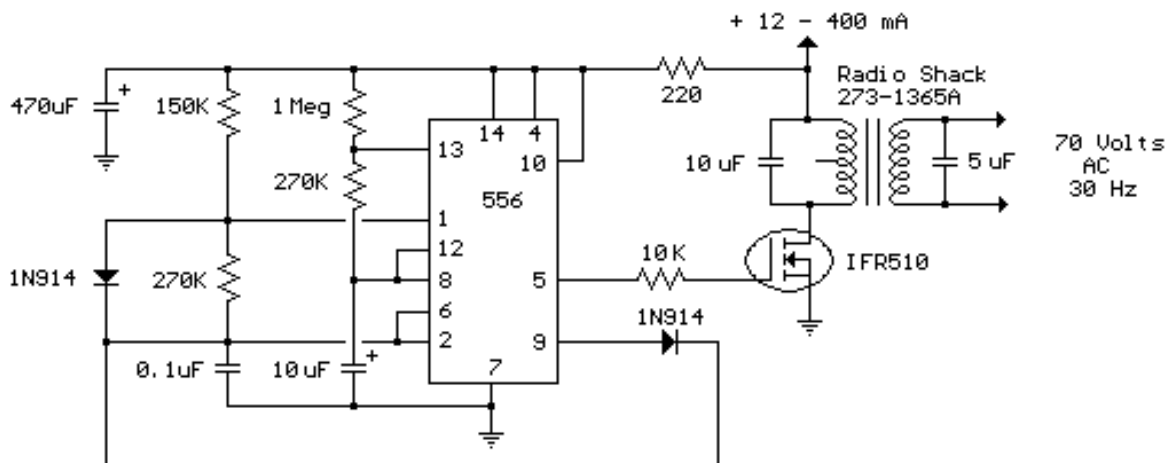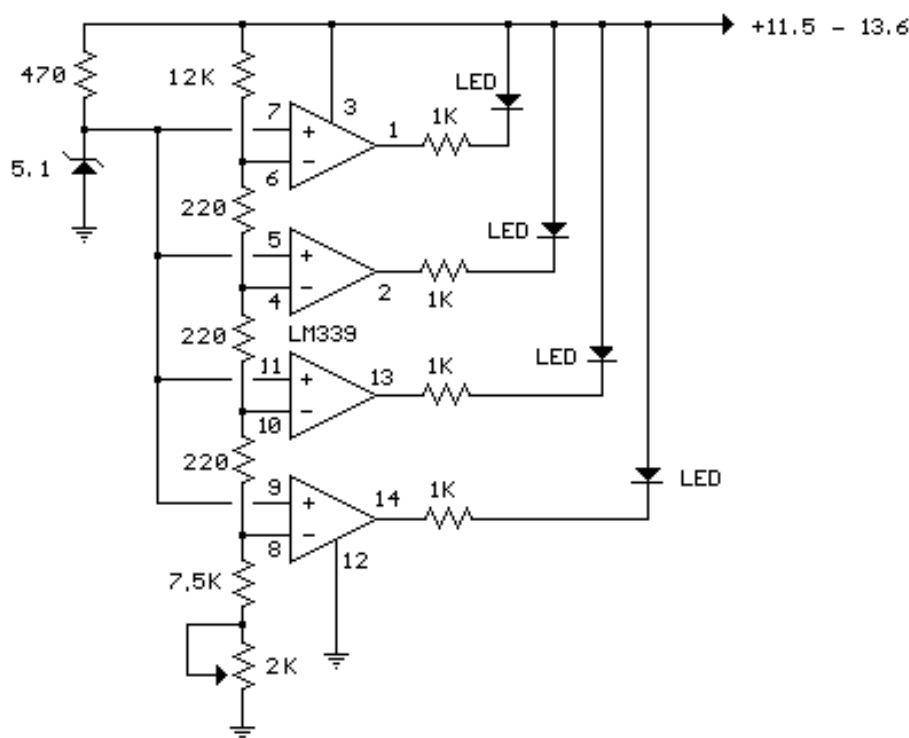

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LED 12 Volt Lead Acid Battery Meter

In the circuit below, a quad voltage comparator (LM339) is used as a simple bar graph meter to indicate the charge condition of a 12 volt, lead acid battery. A 5 volt reference voltage is connected to each of the (+) inputs of the four comparators and the (-) inputs are connected to successive points along a voltage divider. The LEDs will illuminate when the voltage at the negative (-) input exceeds the reference voltage. Calibration can be done by adjusting the 2K potentiometer so that all four LEDs illuminate when the battery voltage is 12.7 volts, indicating full charge with no load on the battery. At 11.7 volts, the LEDs should be off indicating a dead battery. Each LED represents an approximate 25% change in charge condition or 300 millivolts, so that 3 LEDs indicate 75%, 2 LEDs indicate 50%, etc. The actual voltages will depend on temperature conditions and battery type, wet cell, gel cell etc. Additional information on battery maintenance can be found at:
Battery Maintenance Tutorial

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LED VU Meter

The circuit below uses two quad voltage comparators (LM339) to illuminate a series of 8 LEDs indicating volume level. Each of the 8 comparators is biased at increasing voltages set by the voltage divider so that the lower right LED comes on first when the input is about 400 millivolts or about 22 milliwatts peak in an 8 ohm system. The divider voltages are set so that each LED represents about twice the power level as the one before so the scale extends from 22 milliwatts to about 2.5 watts when all LEDs are lit. The sensitivity can be decreased with the input control to read higher levels. I have not built or tested this circuit, so please let me know if you have problems getting it working. The power levels should be as follows:

- 1 LED = 22mW
- 2 LEDs = 42mW

- 3 LEDs = 90mW
- 4 LEDs = 175mW
- 5 LEDs = 320mW
- 6 LEDs = 650mW
- 7 LEDs = 1.2 Watts
- 8 LEDs = 2.5 watts
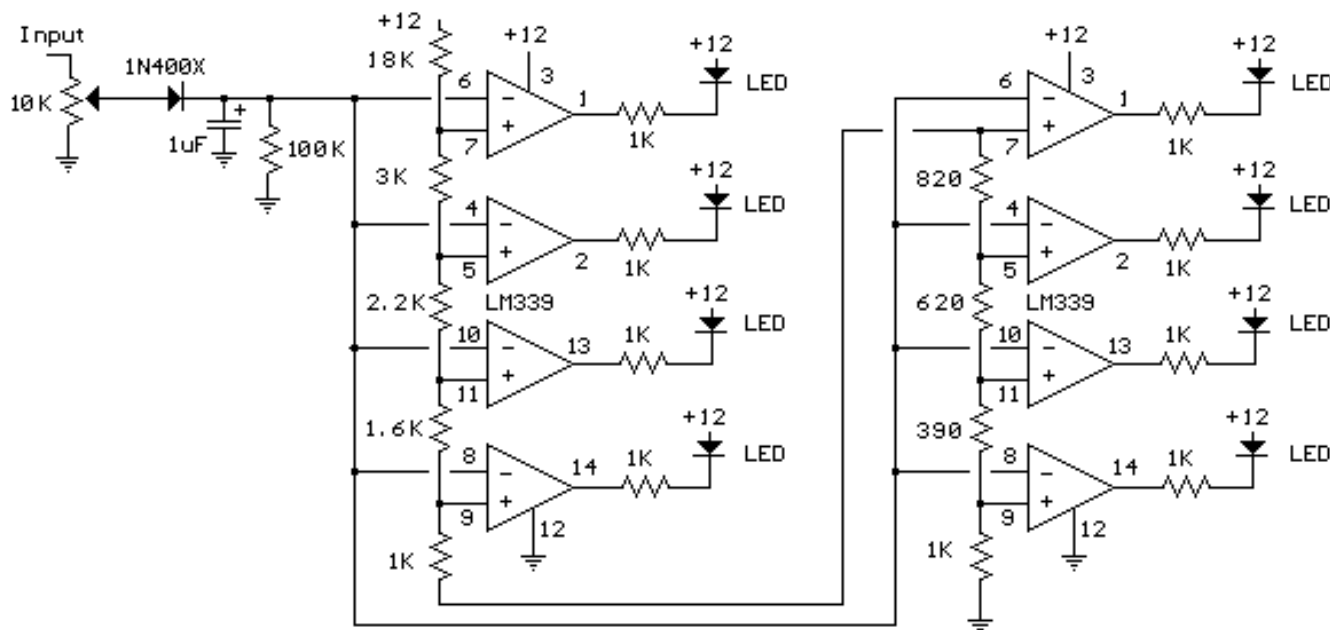
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Analog Milliamp Meter Used as Voltmeter

A milliamp meter can be used as a volt meter by adding a series resistance. The resistance needed is the full scale voltage reading divided by the full scale current of the meter movement. So, if you have a 1 milliamp meter and you want to read 0-10 volts you will need a total resistance of $10/.001 = 10K$ ohms. The meter movement itself will have a small resistance which will be part of the total 10K resistance, but it is usually low enough to ignore. The meter in the example below has a resistance of 86 ohms so the true resistor value needed would be 10K-86 or 9914 ohms. But using a 10K standard value will be within 1% so we can ignore the 86 ohms. For a full scale reading of 1 volt, the meter resistnace would be more significant since it would be about 8% of the total 1K needed, so you would probably want to use a 914 ohm resistor, or 910 standard value. The milliamp meter can also be used to measure higher currents by adding a parallel resistance. The meter resistance now becomes very significant since to increase the range by a factor of ten, we need to bypass 9/10 of the total current with the parallel resistor. So, to convert the 1 milliamp meter to a 10 milliamp meter, we will need a parallel resistor of $86/9 = 9.56$ ohms.

9.6 Ohms

1 milliamp

10 milliamps

1 Milliamp Meter
86 Ohms

10K

10 Volts

100K

100 Volts
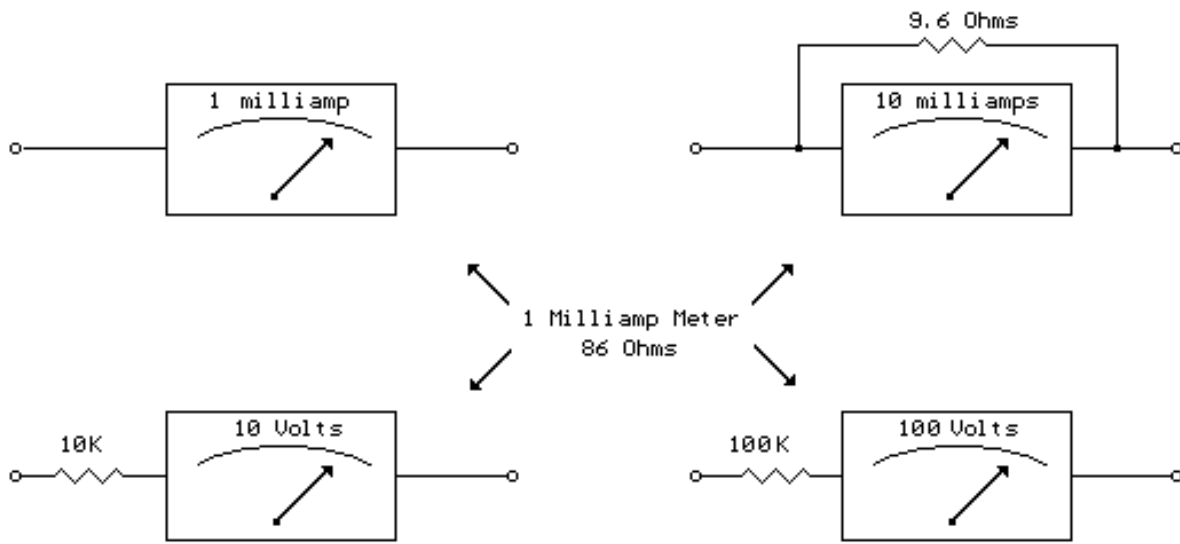
Menu

3 Transistor Audio Amp (50 milliwatt)

Here is a little audio amplifier similar to what you might find in a small transistor radio. The input stage is biased so that the supply voltage is divided equally across the two complimentary output transistors which are slightly biased in conduction by the diodes between the bases. A 3.3 ohm resistor is used in series with the emitters of the output transistors to stabilize the bias current so it doesn't change much with temperature or with different transistors and diodes. As the bias current increases, the voltage between the emitter and base decreases, thus reducing the conduction. Input impedance is about 500 ohms and voltage gain is about 5 with an 8 ohm speaker attached. The voltage swing on the speaker is about 2 volts without distorting and power output is in the 50 milliwatt range. A higher supply voltage and the addition of heat sinks to the output transistors would provide more power. Circuit draws about 30 milliamps from a 9 volt supply.
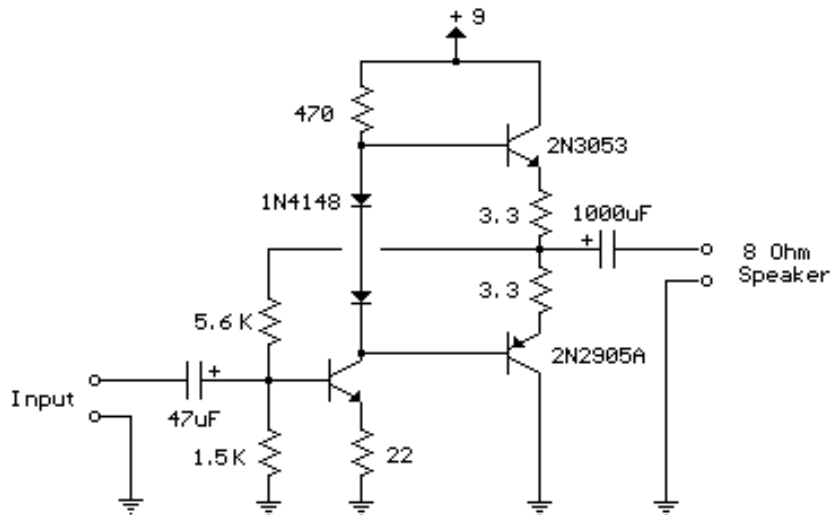
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Telephone Audio Interface

Audio from a telephone line can be obtained using a transformer and capacitor to isolate the line from external equipment. A non-polarized capacitor is placed in series with the transformer line connection to prevent DC current from flowing in the transformer winding which may prevent the line from returning to the on-hook state. The capacitor should have a voltage rating above the peak ring voltage of 90 volts plus the on-hook voltage of 48 volts, or 138 volts total. This was measured locally and may vary with location, a 400 volt or more rating is recommended. Audio level from the transformer is about 100 millivolts which can be connected to a high impedance amplifier or tape recorder input. The 3 transistor amplifier shown above can also be used. For overvoltage protection, two diodes are connected across the transformer secondary to limit the audio signal to 700 millivolts peak during the ringing signal. The diodes can be most any silicon type (1N400X / 1N4148 / 1N914 or other). The 620 ohm resistor serves to reduce loading of the line if the output is connected to a very low impedance.

2 uF 400 Volt
Non-Polarized

To Phone line

620

1N400X

To Amplifier

600 Ohm   1:1
isolation transformer
RS # 273-1374
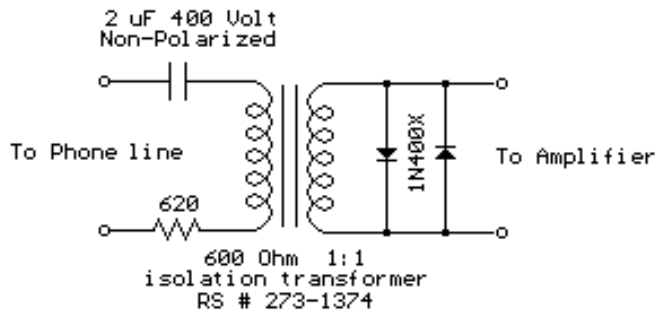
LED Photo Sensor.

Here's a circuit that takes advantage of the photo-voltaic voltage of an ordinary LED. The LED voltage is buffered by a junction FET transistor and then applied to the inverting input of an op-amp with a gain of about 20. This produces a change of about 5 volts at the output from darkness to bright light. The 100K potentiometer can be set so that the output is around 7 volts in darkness and falls to about 2 volts in bright light.

+ 9 Volts

J-FET

D

S

47K

LED   47K   100K

1 Meg

2   8
1
3   4   1458

Output – 7 volts (dark)
          2 volts (light)
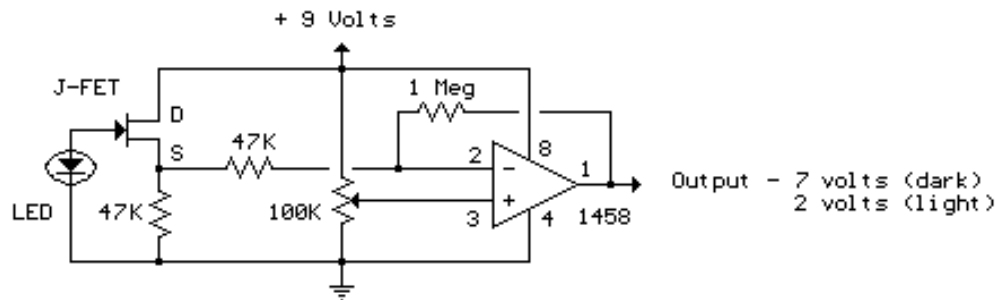
Triangle and Squarewave Generator

Here is a simple triangle/squarewave generator using a common 1458 dual op-amp that can be used from very low frequencies to about 10 Khz. The time interval for one half cycle is about R*C and the outputs will supply about 10 milliamps of current. Triangle amplitude can be altered by adjusting the 47K resistor, and waveform offset can be removed by adding a capacitor in series with the output.
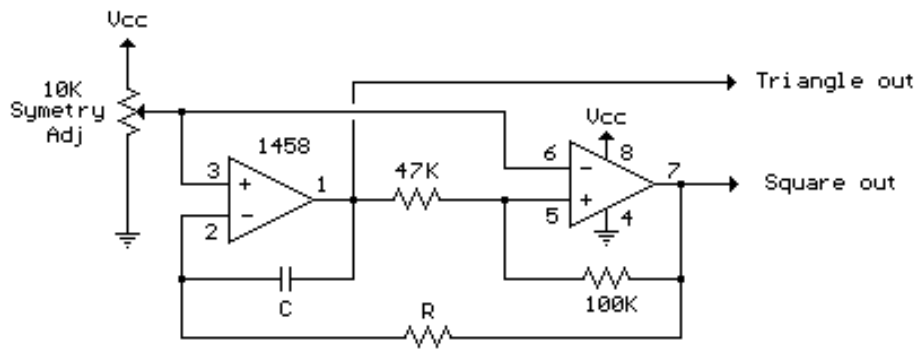
Low Frequency Sinewave Generators

The two circuits below illustrate generating low frequency sinewaves by shifting the phase of the signal through an RC network so that oscillation occurs where the total phase shift is 360 degrees. The transistor circuit on the right produces a reasonable sinewave at the collector of the 3904 which is buffered by the JFET to yield a low impedance output. The circuit gain is critical for low distortion and you may need to adjust the 500 ohm resistor to achieve a stable waveform with minimum distortion. The transistor circuit is not recommended for practical applications due to the critical adjustments needed.

The op-amp based phase shift oscillator is much more stable than the single transistor version since the gain can be set higher than needed to sustain oscillation and the output is taken from the RC network which filters out most of the harmonic distortion. The sinewave output from the RC network is buffered and the amplitude restored by the second (top) op-amp which has gain of around 28dB. Frequency is around 600 Hz for RC values shown (7.5K and 0.1uF) and can be reduced by proportionally increasing the network resistors (7.5K). The 7.5K value at pin 2 of the op-amp controls the oscillator circuit gain and is selected so that the output at pin 1 is slightly clipped at the positive and negative peaks. The sinewave output at pin 7 is about 5 volts p-p using a 12 volt supply and appears very clean on a scope since the RC network filters out most all distortion occurring at pin 1.
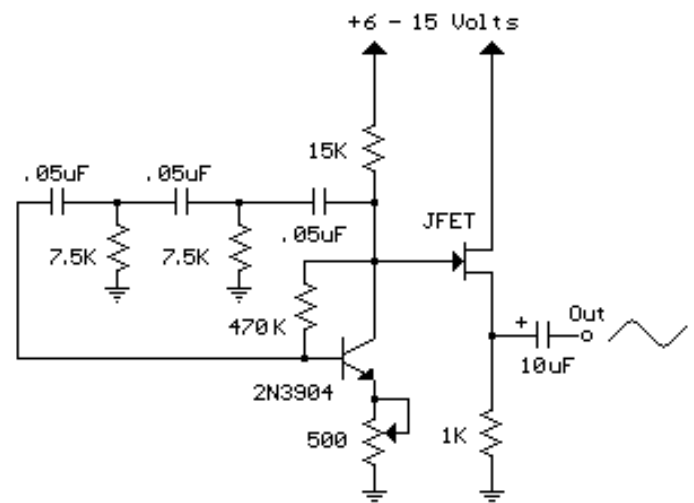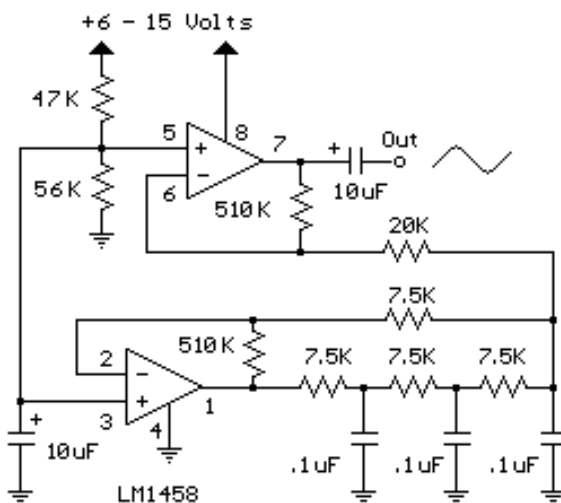

Touch Activated Light

The circuits below light a 20 watt lamp when the contacts are touched and the skin resistance is about 2 Megs or less. The circuit on the left uses a power MOSFET which turns on when the voltage between the source and gate is around 6 volts. The gate of the MOSFET draws no current so the voltage on the gate will be half the supply voltage or 6 volts when the resistance across the touch contacts is equal to the fixed resistance (2 Megs) between the source and gate.

The circuit on the right uses three bipolar transistors to accomplish the same result with the touch contact referenced to the negative or ground end of the supply. Since the base of a bipolar transistor draws current and the current gain is usually less than 200, three transistors are needed to raise the microamp current level through the touch contacts to a couple amps needed by the light. For additional current, the lamp could be replaced with a 12 volt relay and diode across the coil.
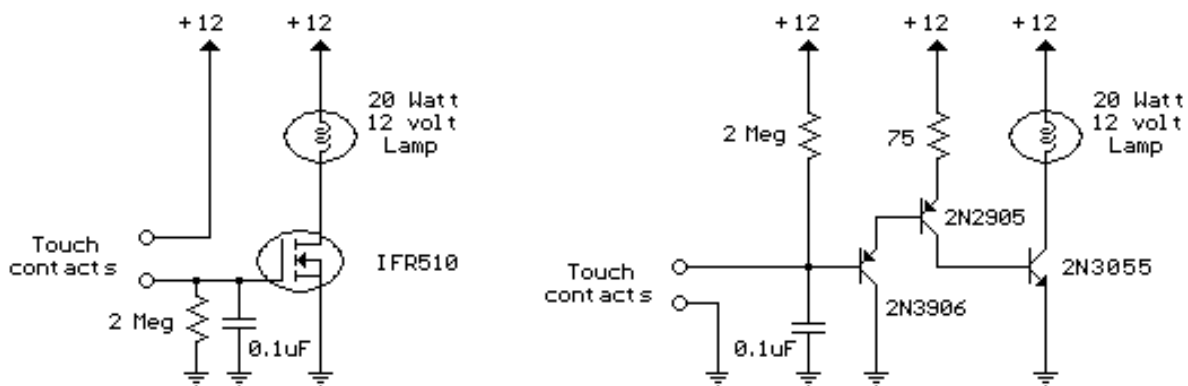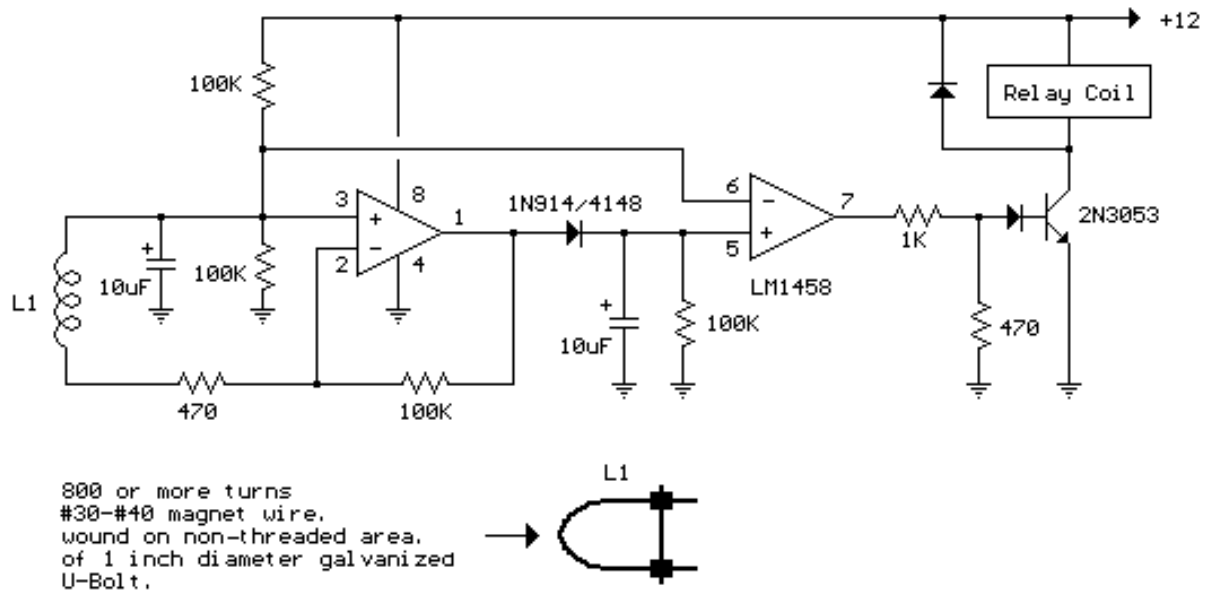

AC Line Current Detector

This circuit will detect AC line currents of about 250 mA or more without making any electrical connections to the line. Current is detected by passing one of the AC lines through an inductive pickup (L1) made with a 1 inch diameter U-bolt wound with 800 turns of #30 - #35 magnet wire. The pickup could be made from other iron type rings or transformer cores that allows enough space to pass one of the AC lines through the center. Only one of the current carrying lines, either the line or the neutral should be put through the center of the pickup to avoid the fields cancelling. I tested the circuit using a 2 wire extension cord which I had separated the twin wires a small distance with an exacto knife to allow the U-bolt to encircle only one wire.

The magnetic pickup (U-bolt) produces about 4 millivolts peak for a AC line current of 250 mA, or AC load of around 30 watts. The signal from the pickup is raised about 200 times at the output of the op-amp pin 7 which is then peak detected by the capacitor and diode connected to pin 7. The second op-amp is used as a comparator which detects a voltage rise greater than the diode drop. The minimum signal needed to cause the comparator stage output to switch positive is around 800 mV peak which corresponds to about a 30 watt load on the AC line. The output 1458 op-amp will only swing within a couple volts of ground so a voltage divider (1K/470) is used to reduce the no-signal voltage to about 0.7 volts. An additional diode is added in series with the transistor base to ensure it turns off when the op-amp voltage is 2 volts. You may get a little bit of relay chatter if the AC load is close to the switching point so a larger load of 50 watts or more is recommended. The sensitivity could be increased by adding more turns to the

pickup.

100K

10uF
L1
100K
470
100K
3 8
2 +
1
4
1N914/4148
100K
10uF
6 −
5 +
7
LM1458
1K
+12
Relay Coil
2N3053
470

800 or more turns
#30-#40 magnet wire,
wound on non-threaded area,
of 1 inch diameter galvanized
U-Bolt.

L1

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The digital lock shown below uses 4 common logic ICs to allow controlling a relay by entering a 4 digit number on a keypad. The first 4 outputs from the CD4017 decade counter (pins 3,2,4,7) are gated together with 4 digits from a keypad so that as the keys are depressed in the correct order, the counter will advance. As each correct key is pressed, a low level appears at the output of the dual NAND gate producing a high level at the output of the 8 input NAND at pin 13. The momentary high level from pin 13 activates a one shot circuit which applies an approximate 80 millisecond positive going pulse to the clock line (pin 14) of the decade counter which advances it one count on the rising edge. A second monostable, one shot circuit is used to generate an approximate 40 millisecond positive going pulse which is applied to the common point of the keypad so that the appropriate NAND gate will see two logic high levels when the correct key is pressed (one from the counter and the other from the key). The inverted clock pulse (negative going) at pin 12 of the 74C14 and the positive going keypad pulse at pin 6 are gated together using two diodes as an AND gate (shown in lower right corner). The output at the junction of the diodes will be positive in the event a wrong key is pressed and will reset the counter. When a correct key is pressed, outputs will be present from both monostable circuits (clock and keypad) causing the reset line to remain low and allowing the counter to advance. However, since the keypad pulse begins slightly before the clock, a 0.1uF capacitor is connected to the reset line to delay the reset until the inverted clock arrives. The values are not critical and various other timing schemes could be used but the clock signal should be slightly longer than the keypad pulse so that the clock signal can mask out the keypad and avoid resetting the counter in the event the clock pulse ends before the keypad pulse. The fifth output of the counter is on pin 10, so that after four correct key entries have been made, pin 10 will move to a high level and can be used to activate a relay, illuminate an LED, ect. At this point, the lock can be reset simply by pressing any key. The circuit can be extended with additional gates (one more CD4011) to accept up to a 8 digit code. The 4017 counting order is 3 2 4 7 10 1 5 6 9 11 so that the first 8 outputs are connected to the NAND gates and pin 9 would be used to drive the relay or light. The 4 additional NAND gate outputs would connect to the 4 remaining inputs of the CD4068 (pins 9,10,11,12). The circuit will operate from 3 to 12 volts on 4000 series CMOS but only 6 volts or less if 74HC parts are used. The circuit draws very little current (about 165 microamps) so it could be powered for several months on 4 AA batteries assuming only intermittent use of the relay.
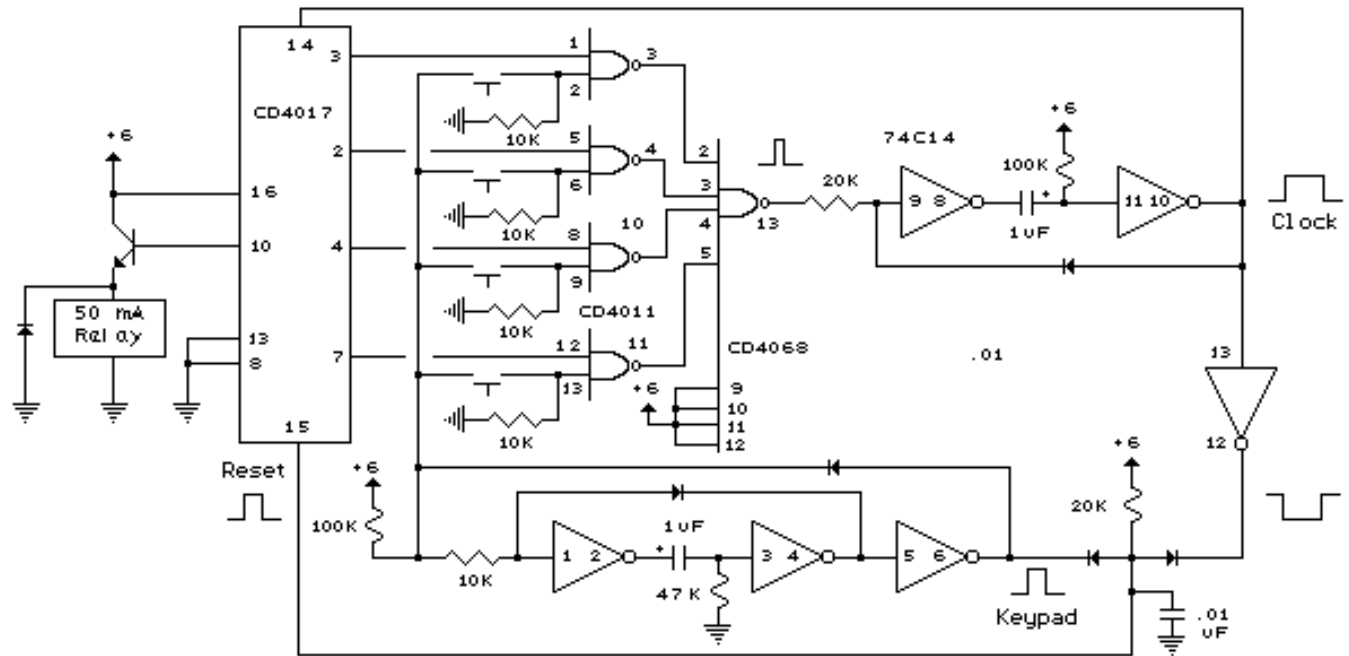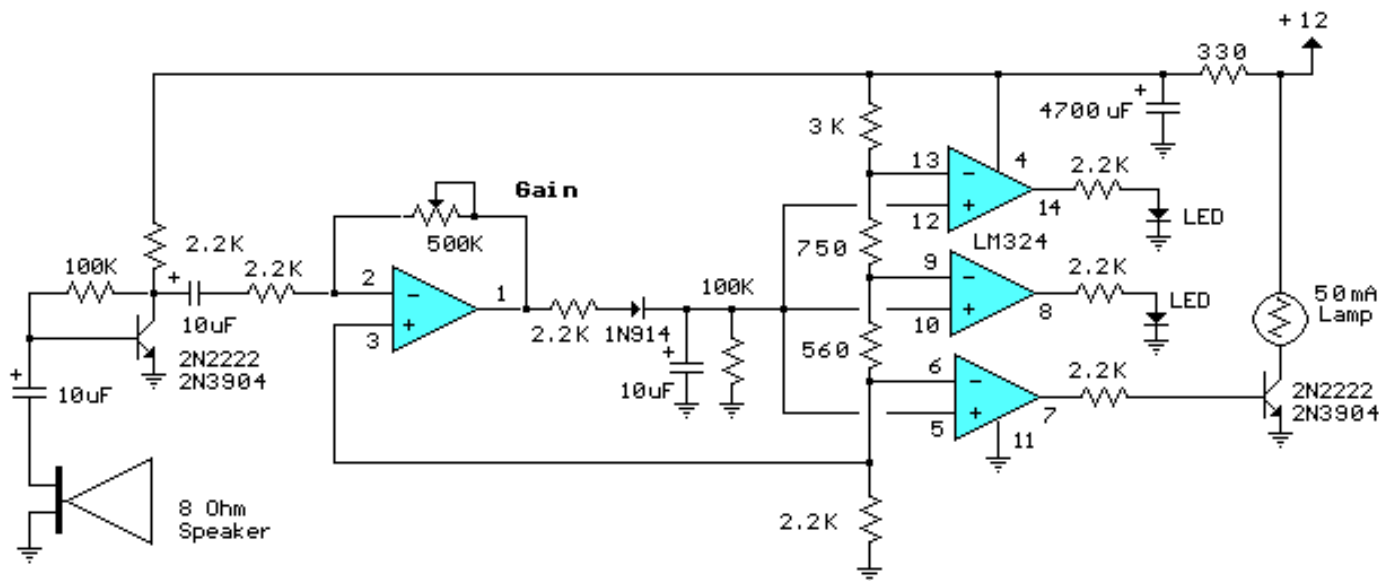
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Decibel Meter

The circuit below responds to sound pressure levels from about 60 to 70 dB. The sound is picked up by an 8 ohm speaker, amplified by a transistor stage and one LM324 op-amp section. You can also use a dynamic microphone but I found the speaker was more sensitive. The remaining 3 sections of the LM324 quad op-amp are used as voltage comparators and drive 3 indicator LEDs or incandescents which are spaced about 3dB apart. An additional transistor is needed for incandescent lights as shown with the lower lamp. I used 12 volt, 50mA lamps. Each light represents about a 3dB change in sound level so that when all 3 lights are on, the sound level is about 4 times greater than the level needed to light one lamp. The sensitivity can be adjusted with the 500K pot so that one lamp comes on with a reference sound level. The other two lamps will then indicate about a 2X and 4X increase in volume.

In operation, with no input, the DC voltage at pins 1,2 and 3 of the op-amp will be about 4 volts, and the voltage on the (+) inputs to the 3 comparators (pins 5,10,12) will be about a half volt less due to the 1N914 diode drop. The voltage on the (-) comparator inputs will be around 5.1 and 6.5 which is set by the 560 and 750 ohm resistors.

When an audio signal is present, the 10uF capacitor connected to the diode will charge toward the peak audio level at the op-amp output at pin 1. As the volume increases, the DC voltage on the capacitor and also (+) comparator inputs will increase and the lamp will turn on when the (+) input goes above the (-) input. As the volume decreases, the capacitor discharges through the parallel 100K resistor and the lamps go out. You can change the response time with a larger or smaller capacitor.

This circuit requires a well filtered power source, it will respond to very small changes in supply voltage, so you probably will need a large filter capacitor connected directly to the 330 ohm resistor. I managed to get it to work with an unregulated wall transformer power source, but I had to use 4700uF. It worked well on a regulated supply with only 1000uF.

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555 Timer - Frequency and Duty Cycle Calculator

Enter values for R1, R2, and C and press the calculate button to solve for positive time interval (T1) and negative time interval (T2). For example, a 10K resistor (R1) and 100K (R2) and 0.1 uF capacitor will produce output time intervals of 7.62 mS positive (T1) and 6.93 mS negative (T2). The frequency will be about 70 Hz. R1 should be greater than 1K and C should be greater than .0005 uF. Scroll down page for basic 555 information (pinout and two basic circuits).

Positive Time Interval (T1) = 0.693 * (R1+R2) * C
Negative Time Interval (T2) = 0.693 * R2 * C
Frequency = 1.44 / ((R1+R2+R2) * C)

R1 (K Ohms)	R2 (K Ohms)	C (Microfarads)
T1 (Milliseconds)	**T2 (Milliseconds)**	**Frequency (Kilohertz)**

The 555 Timer

First introduced by the Signetics Corporation as the SE555/NE555 about 1971.

Pin connections and functions: (See schematic below for basic circuits)

Pin 1 (Ground)   - The ground (or common) pin is the most-negative supply potential
                     of the device, which is normally connected to circuit common when
                     operated from positive supply voltages.

Pin 2 (Trigger)   - This pin is the input which causes the output to go high and
begin
                     the timing cycle. Triggering occurs when the trigger input moves
                     from a voltage above 2/3 of the supply voltage to a voltage below
                     1/3 of the supply. For example using a 12 volt supply, the
trigger
                     input voltage must start from above 8 volts and move down to a
                     voltage below 4 volts to begin the timing cycle. The action is
                     level sensitive and the trigger voltage may move very slowly. To
                     avoid retriggering, the trigger voltage must return to a voltage
                     above 1/3 of the supply before the end of the timing cycle in the
                     monostable mode. Trigger input current is about 0.5 microamps.

Pin 3 (Output)   - The output pin of the 555 moves to a high level of 1.7 volts less
                     than the supply voltage when the timing cycle begins. The output
                     returns to a low level near 0 at the end of the cycle. Maximum
                     current from the output at either low or high levels is
                     approximately 200 mA.

Pin 4 (Reset):   - A low logic level on this pin resets the timer and returns the
                     ouput to a low state. It is normally connected to the + supply
                     line if not used.

Pin 5 (Control)   - This pin allows changing the triggering and threshold voltages by
                     applying an external voltage. When the timer is operating in the
                     astable or oscillating mode, this input could be used to alter or

frequency modulate the output. If not in use, it is recommended installing a small capacitor from pin 5 to ground to avoid possible false or erratic triggering from noise effects.

Pin 6 (Threshold) - Pin 6 is used to reset the latch and cause the output to go low. Reset occurs when the voltage on this pin moves from a voltage below 1/3 of the supply to a voltage above 2/3 of the supply. The action is level sensitive and can move slowly similar to the trigger voltage.

Pin 7 (Discharge) - This pin is an open collector output which is in phase with the main output on pin 3 and has similar current sinking capability.

Pin 8 (V +)   - This is the positive supply voltage terminal of the 555 timer IC. Supply-voltage operating range is +4.5 volts (minimum) to +16 volts (maximum).

The pin connections for the 556 which is a dual 555 timer (2 in one package) are shown in table below. For example, the two outputs for the two timers of the 556 are on pins 5 and 9 which correspond to the output pin 3 of the 555.

|	555	556 timer #1	timer #2
Ground	1	7	7
Trigger	2	6	8
Output	3	5	9
Reset	4	4	10
Control	5	3	11
Threshold	6	2	12
Discharge	7	1	13
+ Power Vcc	8	14	14

The schematics below show the two basic circuits for the 555 timer.
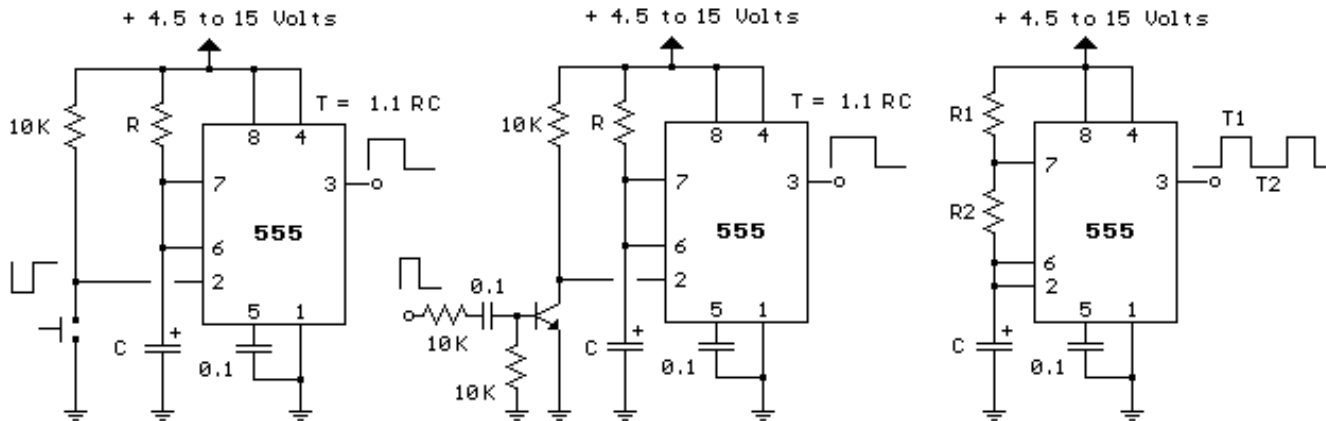
Below is a pictorial view of the 555 timer wired as a LED flasher and powered with a 9 volt battery. The LED will turn on during time T1 and off during time T2.
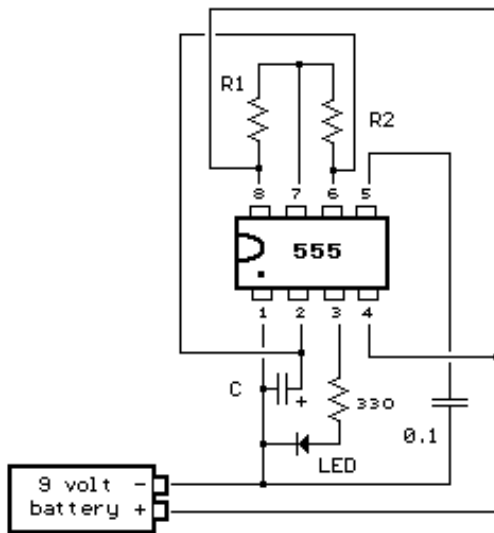
The 555 circuit below is a flashing bicycle light powered with three C or D cells (4.5 volts). The two flashlight lamps will alternately flash at a approximate 1.5 second cycle rate. Using a 4.7K resistor for R1 and a 100K resistor for R2 and a 4.7uF capacitor, the time intervals for the two lamps are 341 milliseconds (T1, upper lamp) and 326 milliseconds (T2 lower lamp). The lamps are driven by transistors to provide additional current beyond the 200 mA limit of the 555 timer. A 2N2905 PNP and a 2N3053 NPN could be used for lamps requiring 500 mA or less. For additional current, a TIP29 NPN and TIP30 PNP could be used up to 1 amp. A PR3 is a 4.5 volt, 500 mA flashlight bulb. Two diodes are placed in series with the PNP transistor base so that the lower lamp turns off when the 555 output goes high during the T1 time interval. The high output level of the 555 timer is 1.7 volts less than the supply voltage. Adding the two diodes increases the forward voltage required for the PNP transistor to about 2.1 volts so that the 1.7 volt difference from supply to the output is not enough to turn on the transistor. You can also use an LED in place of the two diodes as shown in the lower schematic.
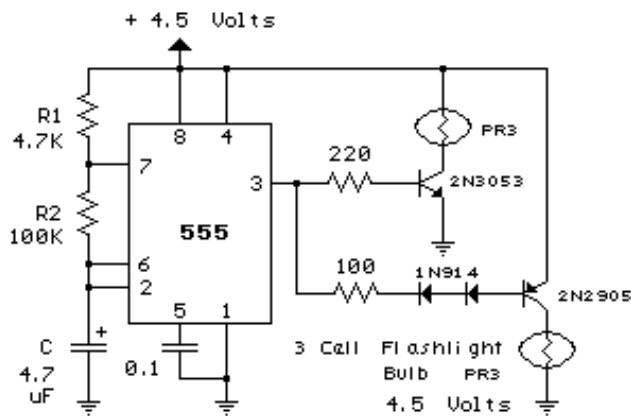
40 LED Bicycle Light

The 555 circuit below is a flashing bicycle light powered with four C,D or AA cells (6 volts). Two sets of 20 LEDs will alternately flash at approximately 4.7 cycles per second using RC values shown (4.7K for R1, 150K for R2 and a 1uF capacitor). Time intervals for the two lamps are about 107 milliseconds (T1, upper LEDs) and 104 milliseconds (T2 lower LEDs). Two transistors are used to provide additional current beyond the 200 mA limit of the 555 timer. A single LED is placed in series with the base of the PNP transistor so that the lower 20 LEDs turn off when the 555 output goes high during the T1 time interval. The high output level of the 555 timer is 1.7 volts less than the supply voltage. Adding the LED increases the forward voltage required for the PNP transistor to about 2.7 volts so that the 1.7 volt difference from supply to the output is insufficient to turn on the transistor. Each LED is supplied with about 20 mA of current for a total of 220 mA. The circuit should work with additional LEDs up to about 40 for each group, or 81 total. The circuit will also work with fewer LEDs so it could be assembled and tested with just 5 LEDs (two groups of two plus one) before adding the others.
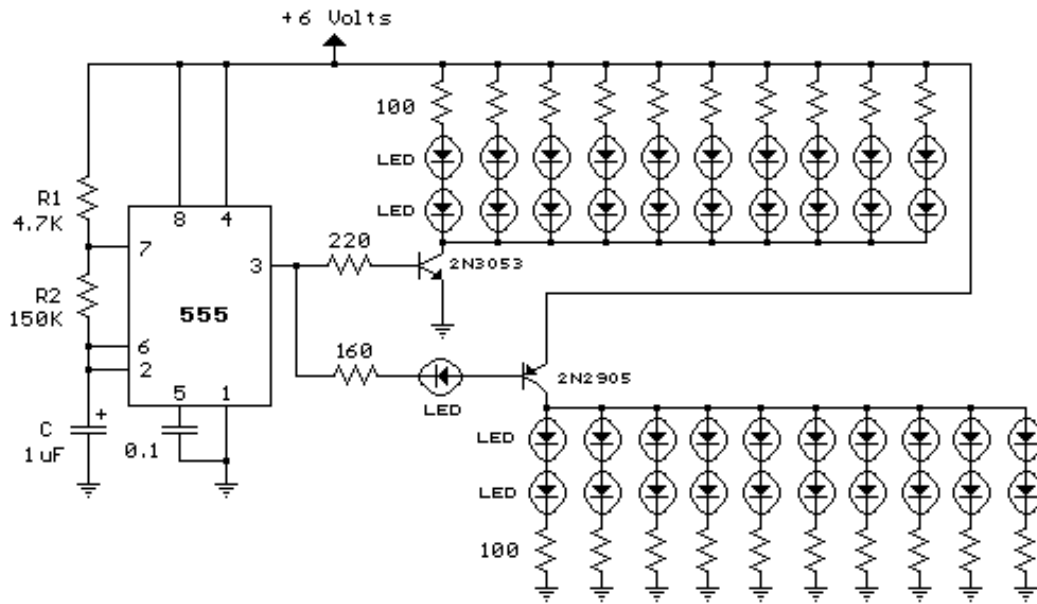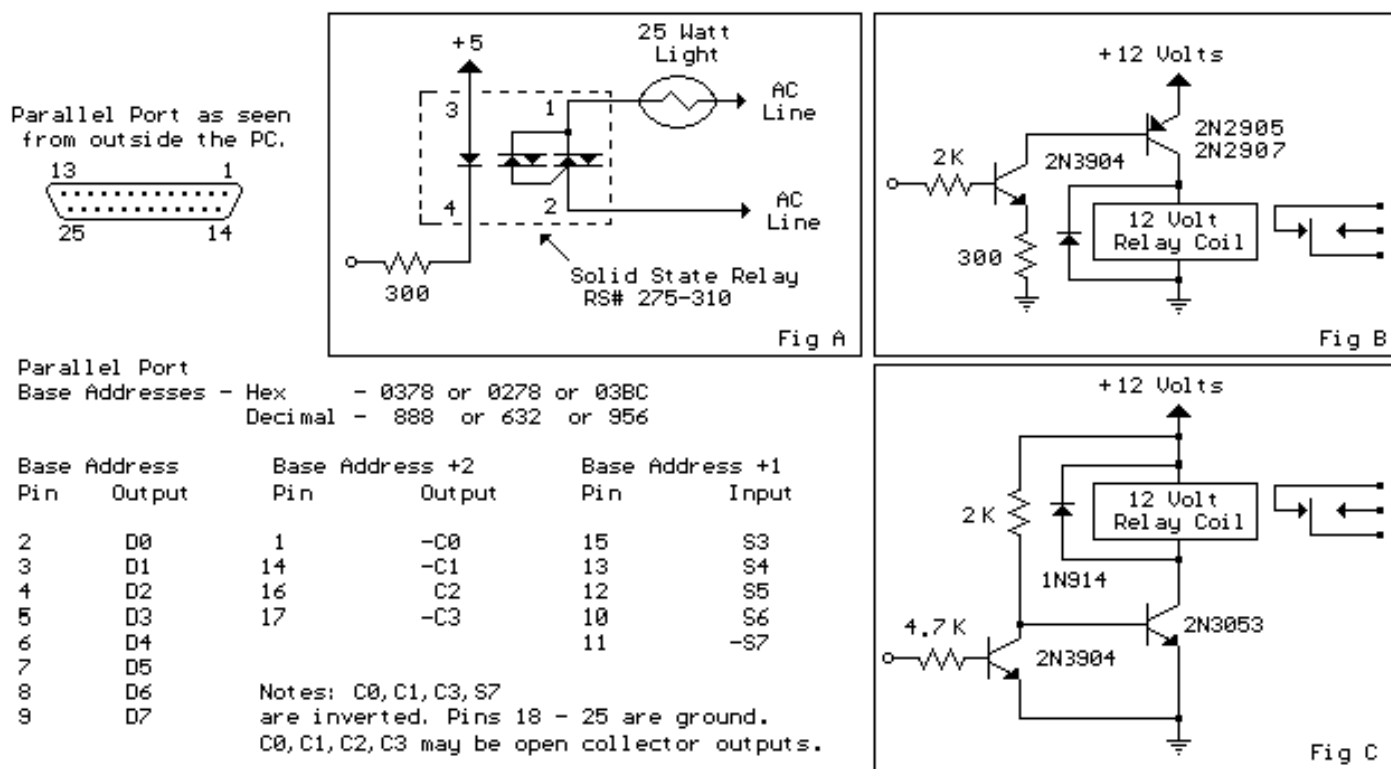
Parallel Port Relay Interface

Below are three examples of controlling a relay from the PC's parallel printer port (LPT1 or LPT2). Figure A shows a solid state relay controlled by one of the parallel port data lines (D0-D7) using a 300 ohm resistor and 5 volt power source. The solid state relay will energize when a "0" is written to the data line. Figure B and C show mechanical relays controlled by two transistors. The relay in figure B is energized when a "1" is written to the data line and the relay in figure C is energized by writing a "0" to the line. In each of the three circuits, a common connection is made from the negative side of the power supply to one of the port ground pins (18-25).

There are three possible base addresses for the parallel port You may need to try all three base addresses to determine the correct address for the port you are using but LPT1 is usually at Hex 0378. The QBasic "OUT" command can be used to send data to the port. OUT, &H0378,0 sets D0-D7 low and OUT, &H378,255 sets D0-D7 high. The parallel port also provides four control lines (C0,C1,C2,C3) that can be set high or low by writing data to the base address+2 so if the base address is Hex 0378 then the address of the control latch would be Hex 037A. Note that three of the control bits are inverted so writing a "0" to the control latch will set C0,C1,C3 high and C2 low.

Fig A

Fig B

Fig C

```
Parallel Port as seen
from outside the PC.
13            1
25           14
```

```
Parallel Port
Base Addresses - Hex     - 0378 or 0278 or 03BC
                 Decimal -  888  or 632  or 956
```

Base Address		Base Address +2		Base Address +1	
Pin	Output	Pin	Output	Pin	Input
2	D0	1	-C0	15	S3
3	D1	14	-C1	13	S4
4	D2	16	C2	12	S5
5	D3	17	-C3	10	S6
6	D4			11	-S7
7	D5				
8	D6	Notes: C0,C1,C3,S7			
9	D7	are inverted. Pins 18 - 25 are ground.			
		C0,C1,C2,C3 may be open collector outputs.			

[Menu]

Reading Data From The Parallel Port

The diagram below shows 5 switches connected to the 5 input lines of the parallel port. An external 5 volt power supply is used to provide high logic levels to the input pins when the switches are open. Three 1.5 volt batteries in series can be used to obtain 4.5 volts which is close enough. The 330 ohm resistors in series with the port connections provide some protection in case a connection is made to the wrong pin. If you are sure of the connections, the 330 ohm resistors can be left out and the switches connected directly to the input pins. The negative side of the power supply should be connected to the ground point, or any pin from 18 to 25.

The following short QBasic program can be used to read the state of the switches. QBASIC.EXE can be found in the "OLDMSDOS" directory of the Windows 95/98 CD Rom. Note that there are three possible printer port address that correspond to LPT1, LPT2 and LPT3 and LPT1 is usually the one to use which is

at address decimal 889. The program waits for the user to press the enter key before reading the state of the 5 input lines. The state of the 5 lines is received as a single 8 bit number between 0-255 which is stored as the value of (V). Each switch input represents a decimal value of 8,16,32,64 and 128 which correspond to pins 15,13,12,10 and 11. The last 3 bits (1,2 and 4) are not used and should return a high level, so the value received with all switches open should be 1+2+4+8+16+32+64=127. If a switch is closed and the input is at ground, the value will be 0 except for pin 11 which is inverted and yields a value of 128 and 0 when high, so the value received when all switches are closed should be 1+2+4+128=135.

```
CLS
DEFINT A-Z
Address = 889: REM 889 = port address, other addresses could be 633 or 957
PRINT "Press the enter key to read printer port pins (15,13,12,10,11)"
PRINT "A (0) reading indicates the pin is at ground level, (1) indicates"
PRINT "the pin is at a high level or unterminated."
INPUT A$
V = INP(Address)
PRINT V
P11 = 1
IF V > 127 THEN P11 = 0: V = V - 128
IF V > 63 THEN P10 = 1: V = V - 64
IF V > 31 THEN P12 = 1: V = V - 32
IF V > 15 THEN P13 = 1: V = V - 16
IF V > 7 THEN P15 = 1
PRINT
PRINT "Pin 15 ="; P15
PRINT "Pin 13 ="; P13
PRINT "Pin 12 ="; P12
PRINT "Pin 10 ="; P10
PRINT "Pin 11 ="; P11
END
```
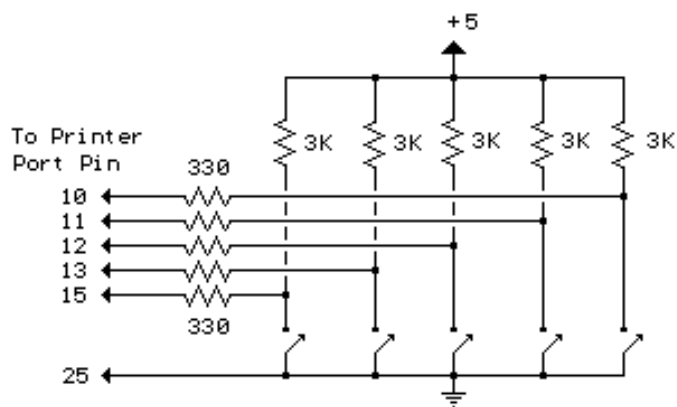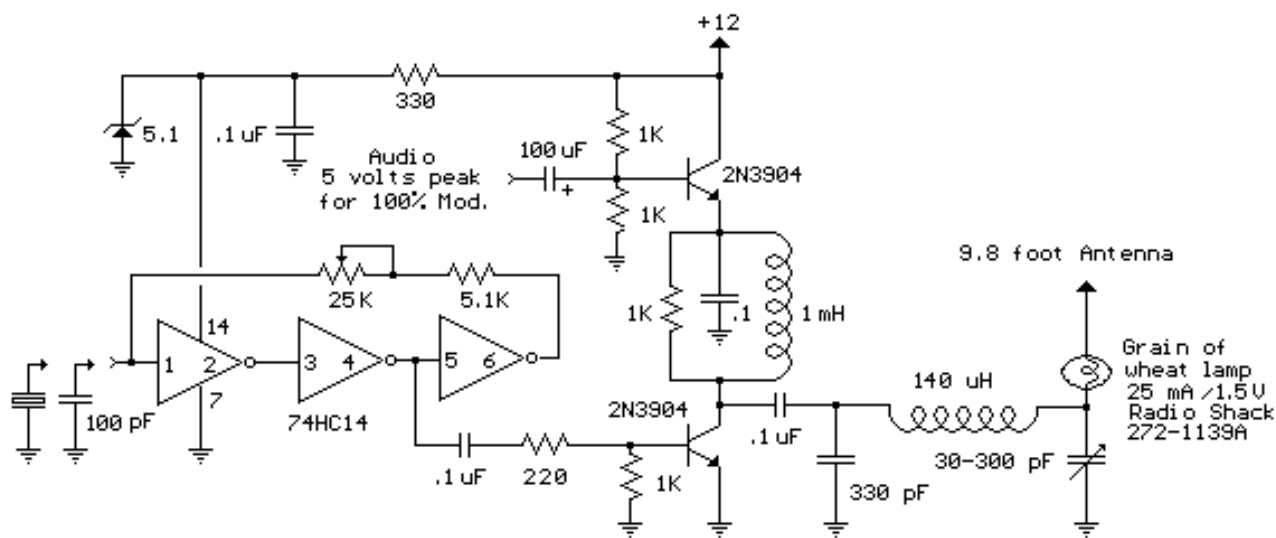
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Micro Power AM Broadcast Transmitter

In this circuit, a 74HC14 hex Schmitt trigger inverter is used as a square wave oscillator to drive a small signal transistor in a class C amplifier configuration. The oscillator frequency can be either fixed by a crystal or made adjustable (VFO) with a capacitor/resistor combination. A 100pF capacitor is used in place

of the crystal for VFO operation. Amplitude modulation is accomplished with a second transistor that controls the DC voltage to the output stage. The modulator stage is biased so that half the supply voltage or 6 volts is applied to the output stage with no modulation. The output stage is tuned and matched to the antenna with a standard variable 30-365 pF capacitor. Approximately 20 milliamps of current will flow in the antenna lead (at frequencies near the top of the band) when the output stage is optimally tuned to the oscillator frequency. A small 'grain of wheat' lamp is used to indicate antenna current and optimum settings. The 140 uH inductor was made using a 2 inch length of 7/8 inch (OD) PVC pipe wound with 120 turns of #28 copper wire. Best performance is obtained near the high end of the broadcast band (1.6 MHz) since the antenna length is only a very small fraction of a wavelength. Input power to the amplifier is less than 100 milliwatts and antenna length is 3 meters or less which complies with FCC rules. Output power is somewhere in the 40 microwatt range and the signal can be heard approximately 80 feet. Radiated power output can be approximated by working out the antenna radiation resistance and multiplying by the antenna current squared. The radiation resistance for a dipole antenna less than 1/4 wavelength is

$R = 80*[(pi)^2]*[(Length/wavelength)^2]*$(a factor depending on the form of the current distribution) The factor depending on the current distribution turns out to be [(average current along the rod)/(feed current)]^2 for short rods, which is 1/4 for a linearly-tapered current distribution falling to zero at the ends. Even if the rods are capped with plates, this factor cannot be larger than 1. Substituting values for a 9.8 foot dipole at a frequency of 1.6 MHz we get R= 790*.000354*.25 = .07 Ohms. And the resistance will be only half as much for a monopole or 0.035 Ohms. Radiated power at 20 milliamps works out to about I^2 * R = 14 microwatts.

Reference: [Radiation impedances of wire and rod antennas.](#)

FM Beacon Broadcast Transmitter (88-108 MHz)

This circuit will transmit a continuous audio tone on the FM broadcast band (88-108 MHz) which could used for remote control or security purposes. Circuit draws about 30 mA from a 6-9 volt battery and can be received to about 100 yards. A 555 timer is used to produce the tone (about 600 Hz) which frequency modulates a Hartley oscillator. A second JFET transistor buffer stage is used to isolate the oscillator from the antenna so that the antenna position and length has less effect on the frequency. Fine frequency adjustment can be made by adjusting the 200 ohm resistor in series with the battery. Oscillator frequency is set by a 5 turn tapped inductor and 13 pF capacitor. The inductor was wound around a #8 X 32 bolt (about 3/16 diameter) and then removed by unscrewing the bolt. The inductor was then streached to about a 3/8 inch length and tapped near the center. The oscillator frequency should come out somewhere near the

center of the band (98 MHz) and can be shifted higher or lower by slightly expanding or compressing the inductor. A small signal diode (1N914 or 1N4148) is used as a varactor diode so that the total capacity in parallel with the inductor varies slightly at the audio rate thus causing the oscillator frequency to change at the audio rate (600 Hz). The ramping waveform at pins 2 and 6 of the timer is applied to the reversed biased diode through a large (1 Meg) resistor so that the capacitance of the diode changes as the ramping voltage changes thus altering the frequency of the tank circuit. Alternately, an audio signal could be applied to the 1 Meg resistor to modulate the oscillator but it may require an additional pullup resistor to reverse bias the diode. The N channel JFET transistors used should be high frequency VHF or UHF types (Radio Shack #276-2062 MPF102) or similar.
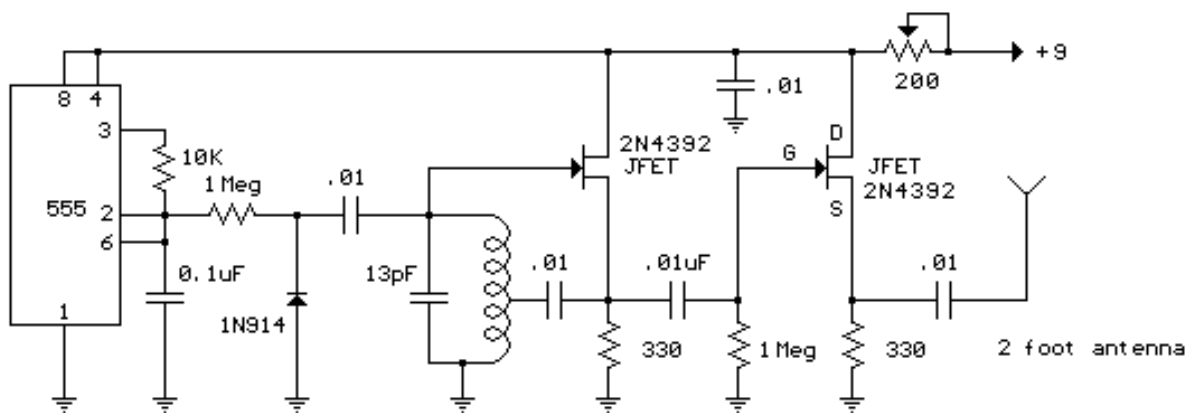
Drawn by - Bill Bowden - 04/15/99
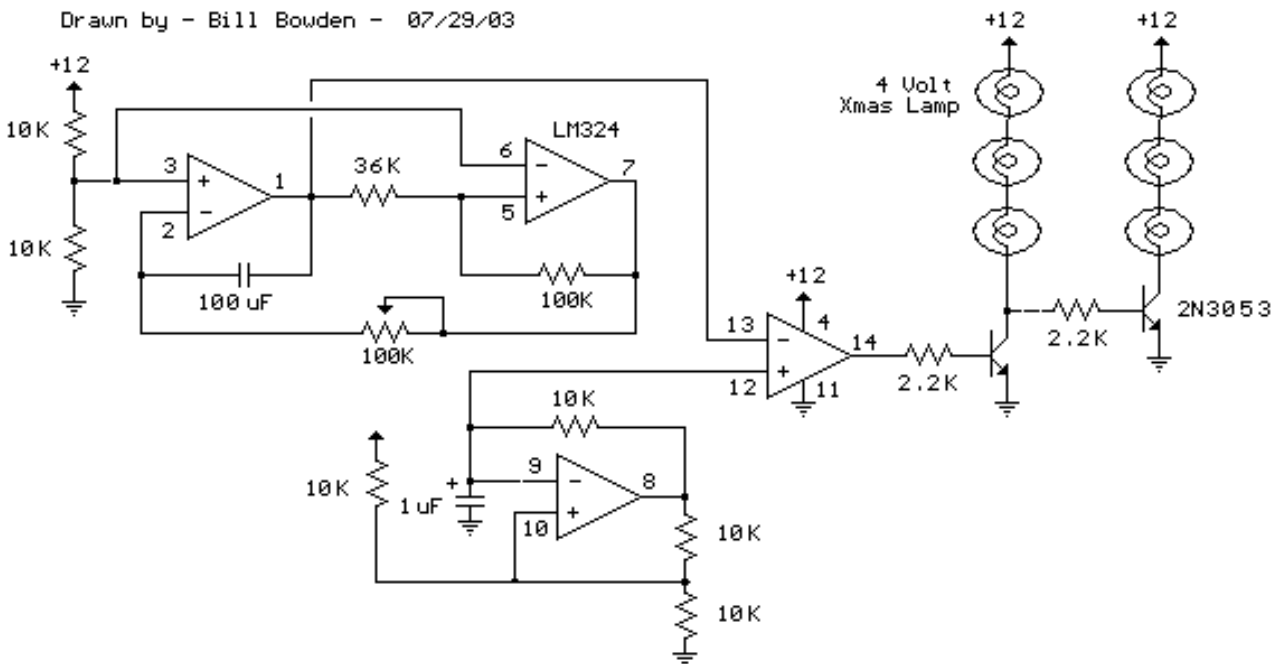
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12 Volt Lamp Dimmer

Here is a 12 volt / 2 amp lamp dimmer that can be used to dim a standard 25 watt automobile brake or backup bulb by controlling the duty cycle of a astable 555 timer oscillator. When the wiper of the potentiometer is at the uppermost position, the capacitor will charge quickly through both 1K resistors and the diode, producing a short positive interval and long negative interval which dims the lamp to near darkness. When the potentiometer wiper is at the lowermost position, the capacitor will charge through both 1K resistors and the 50K potentiometer and discharge through the lower 1K resistor, producing a long positive interval and short negative interval which brightens the lamp to near full intensity. The duty cycle of the 200 Hz square wave can be varied from approximately 5% to 95%. The two circuits below illustrate connecting the lamp to either the positive or negative side of the supply.
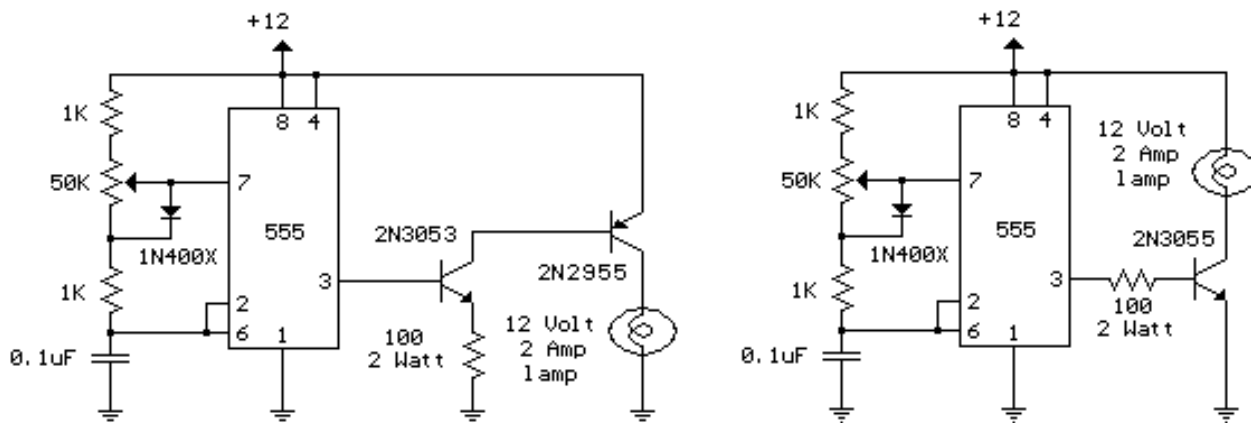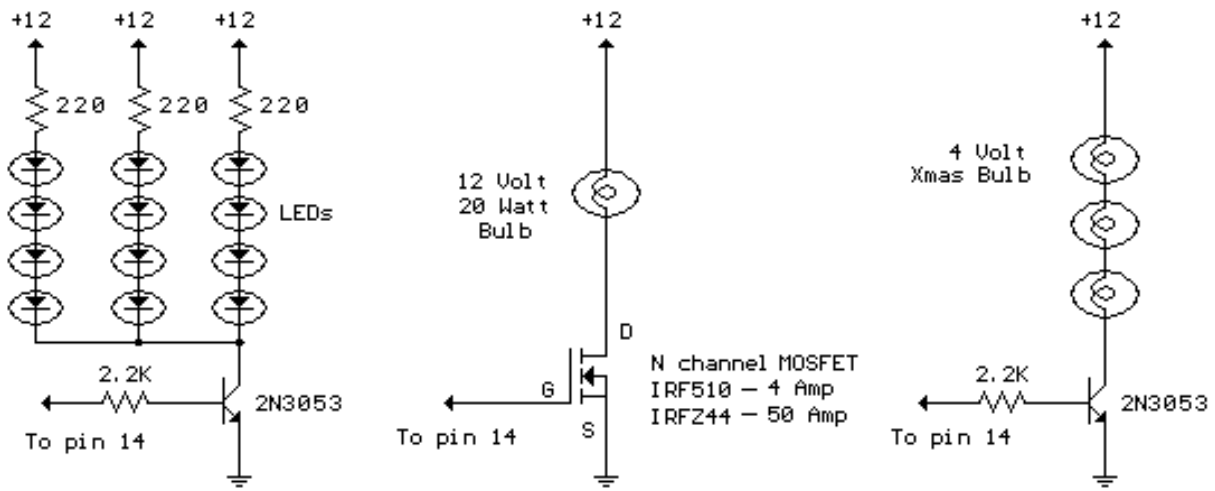
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Automatic 12 Volt Lamp Fader

This circuit is similar to the "Fading Red Eyes" circuit (in the LED section) used to fade a pair of red LEDs. In this version, the lamps are faded by varying the duty cycle so that higher power incandescent lamps can be used without much power loss. The switching waveform is generated by comparing two linear ramps of different frequencies. The higher frequency ramp waveform (about 75 Hz.) is produced from one section of the LM324 quad op-amp wired as a Schmitt trigger oscillator. The lower frequency ramp controls the fading rate and is generated from the upper two op-amps similar to the "fading eyes" circuit. The two ramp waveforms at pins 9 and 1 are compared by the 4th op-amp which generates a varying duty cycle rectangular waveform to drive the output transistor. A second transistor is used to invert the waveform so that one group of lamps will fade as the other group brightens. The 2N3053 will handle up to 500 milliamps so you could connect 12 strings of 4 LEDs each (48 LEDs) with a 220 ohm resistor in series with each group of 4 LEDs. This would total about 250 milliamps. Or you can use three 4 volt, 200 mA Xmas tree bulbs in series. For higher power 12 volt automobile lamps, the transistor will need to be replaced with a MOSFET that can handle several amps of current. See the drawing below the schematic for possible hookups.
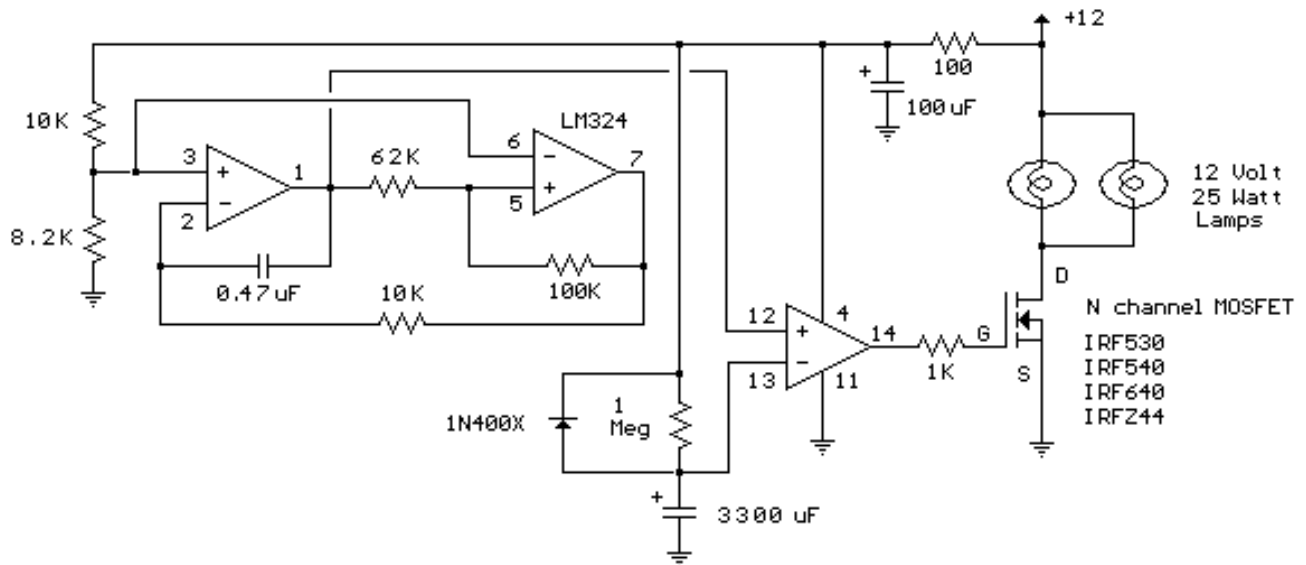

Other possible hookups

+12 +12 +12

220 220 220

LEDs

2.2K
2N3053

To pin 14

12 Volt
20 Watt
Bulb

+12

D

G   N channel MOSFET
    IRF510 — 4 Amp
S   IRFZ44 — 50 Amp

To pin 14

+12

4 Volt
Xmas Bulb

2.2K
2N3053

To pin 14

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1.5 Hour Lamp Fader (Sunset Lamp)

Similar to the one above, the sunset lamp comes on at full brightness and then slowly fades out over 1.5 hours time and stays off until power is recycled.

+12

100

100 uF

10K

LM324

3 + 1
   2 -

0.47 uF   10K   62K   6 - 7
                      5 +
                      100K

1N400X   1 Meg

12 + 4   14
13 - 11
          1K

3300 uF

12 Volt
25 Watt
Lamps

D

G   N channel MOSFET
S   IRF530
    IRF540
    IRF640
    IRFZ44

8.2K

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Simple Op-Amp Radio

This is basically a crystal radio with an audio amplifier which is fairly sensitive and receives several strong stations in the Los Angeles area with a minimal 15 foot antenna. Longer antennas will provide a stronger signal but the selectivity will be worse and strong stations may be heard in the background of weaker ones. Using a long wire antenna, the selectivity can be improved by connecting it to one of the taps on the coil instead of the junction of the capacitor and coil. Some connection to ground is required but I found that standing outside on a concrete slab and just allowing the long headphone leads to lay on the concrete was sufficient to listen to the local news station (KNX 1070). The inductor was wound with 200 turns of #28 enameled copper wire on a 7/8 diameter, 4 inch length of PVC pipe, which yields about 220 uH. The

inductor was wound with taps every 20 turns so the diode and antenna connections could be selected for best results which turned out to be 60 turns from the antenna end for the diode. The diode should be a germanium (1N34A type) for best results, but silicon diodes will also work if the signal is strong enough. The carrier frequency is removed from the rectified signal at the cathode of the diode by the 300 pF cap and the audio frequency is passed by the 0.1uF capacitor to the non-inverting input of the first op-amp which functions as a high impedance buffer stage. The second op-amp stage increases the voltage level about 50 times and is DC coupled to the first through the 10K resistor. If the pairs of 100K and 1 Meg resistors are not close in value (1%) you may need to either use closer matched values or add a capacitor in series with the 10K resistor to keep the DC voltage at the transistor emitter between 3 and 6 volts. Another approach would be to reduce the overall gain with a smaller feedback resistor (470K). High impedance headphones will probably work best, but walkman stereo type headphones will also work. Circuit draws about 10 mA from a 9 volt source. Germanium diodes (1N34A) types are available from Radio Shack, #276-1123.
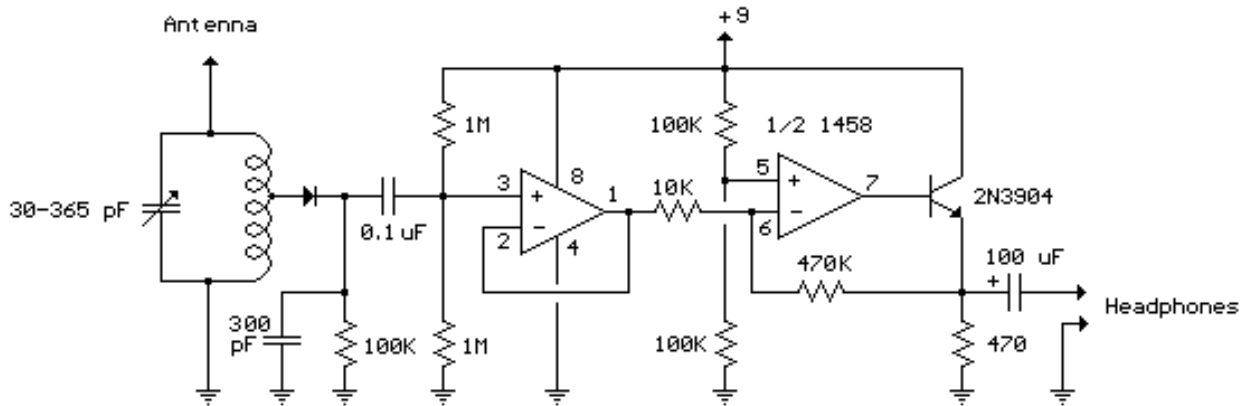
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Variable 3 - 24 Volt / 3 Amp Power Supply

This regulated power supply can be adjusted from 3 to 25 volts and is current limited to 2 amps as shown, but may be increased to 3 amps or more by selecting a smaller current sense resistor (0.3 ohm). The 2N3055 and 2N3053 transistors should be mounted on suitable heat sinks and the current sense resistor should be rated at 3 watts or more. Voltage regulation is controlled by 1/2 of a 1558 or 1458 op-amp. The 1458 may be substituted in the circuit below, but it is recommended the supply voltage to pin 8 be limited to 30 VDC, which can be accomplished by adding a 6.2 volt zener or 5.1 K resistor in series with pin 8. The maximum DC supply voltage for the 1458 and 1558 is 36 and 44 respectively. The power transformer should be capable of the desired current while maintaining an input voltage at least 4 volts higher than the desired output, but not exceeding the maximum supply voltage of the op-amp under minimal load conditions. The power transformer shown is a center tapped 25.2 volt AC / 2 amp unit that will provide regulated outputs of 24 volts at 0.7 amps, 15 volts at 2 amps, or 6 volts at 3 amps. The 3 amp output is obtained using the center tap of the transformer with the switch in the 18 volt position. All components should be available at Radio Shack with the exception of the 1558 op-amp.
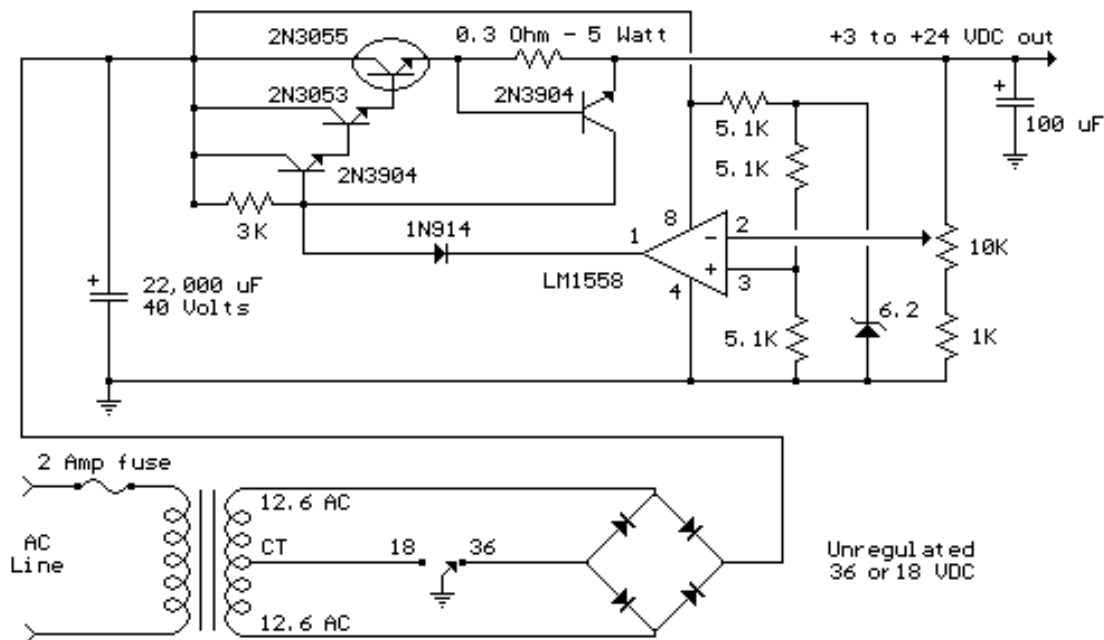

Drawn by - Bill Bowden - 07/15/97

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Variable Voltage and Current Power Supply

Another method of using opamps to regulate a power supply is shown below. The power transformer requires an additional winding to supply the op-amps with a bipolar voltage (+/- 8 volts), and the negative voltage is also used to generate a reference voltage below ground so that the output voltage can be adjusted all the way down to 0. Current limiting is accomplished by sensing the voltage drop across a small resistor placed in series with the negative supply line. As the current increases, the voltage at the wiper of the 500 ohm pot rises until it becomes equal or slightly more positive than the voltage at the (+) input of the opamp. The opamp output then moves negative and reduces the voltage at the base of the 2N3053 transistor which in turn reduces the current to the 2N3055 pass transistor so that the current stays at a constant level even if the supply is shorted. Current limiting range is about 0 - 3 amps with components shown. The TIP32 and 2N3055 pass transistors should be mounted on suitable heat sinks and the 0.2 ohm current sensing resistor should be rated at 2 watts or more. The heat produced by the pass transistor will be the product of the difference in voltage between the input and output, and the load current. So, for example

if the input voltage (at the collector of the pass transistor) is 25 and the output is adjusted for 6 volts and the load is drawing 1 amp, the heat dissipated by the pass transistor would be (25-6) * 1 = 19 watts. In the circuit below, the switch could be set to the 18 volt position to reduce the heat generated to about 12 watts.

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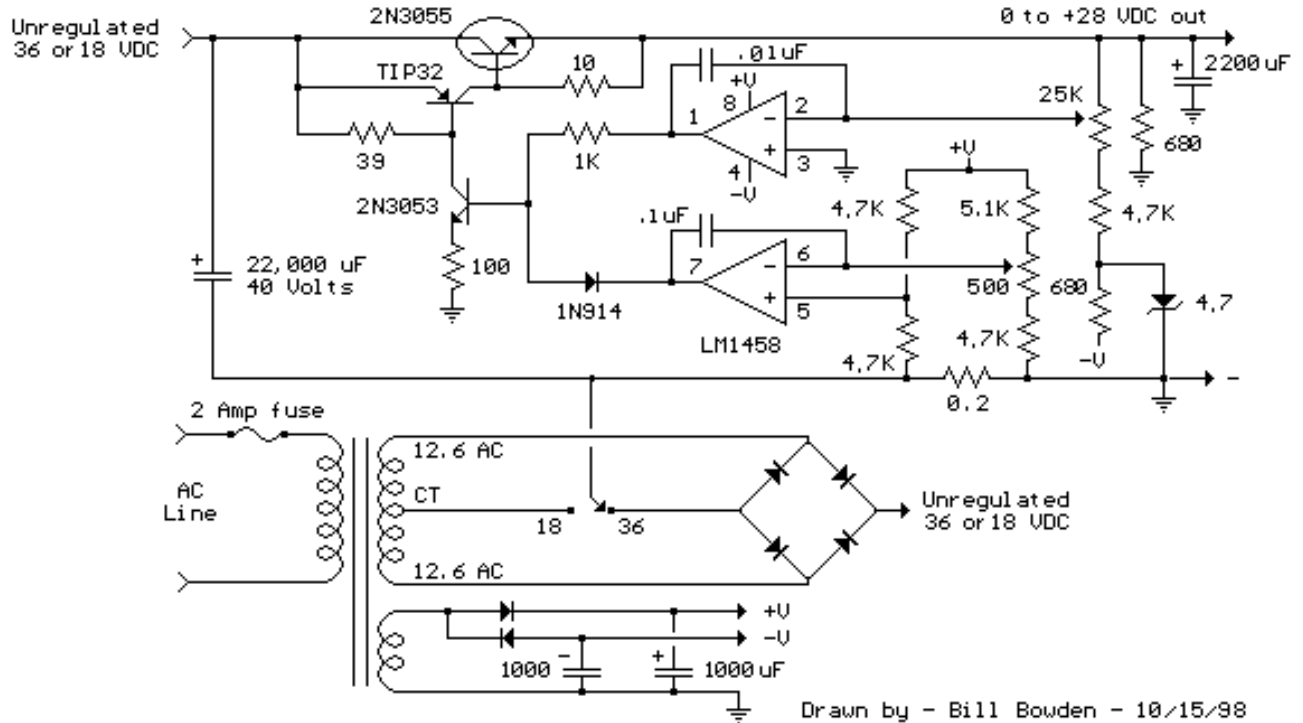
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2 Watt Switching Power Supply

In this small switching power supply, a Schmitt trigger oscillator is used to drive a switching transistor that supplies current to a small inductor. Energy is stored in the inductor while the transistor is on, and released into the load circuit when the transistor switches off. The output voltage is dependent on the load resistance and is limited by a zener diode that stops the oscillator when the voltage reaches about 14 volts. Higher or lower voltages can be obtained by adjusting the voltage divider that feeds the zener diode. The efficiency is about 80% using a high Q inductor.
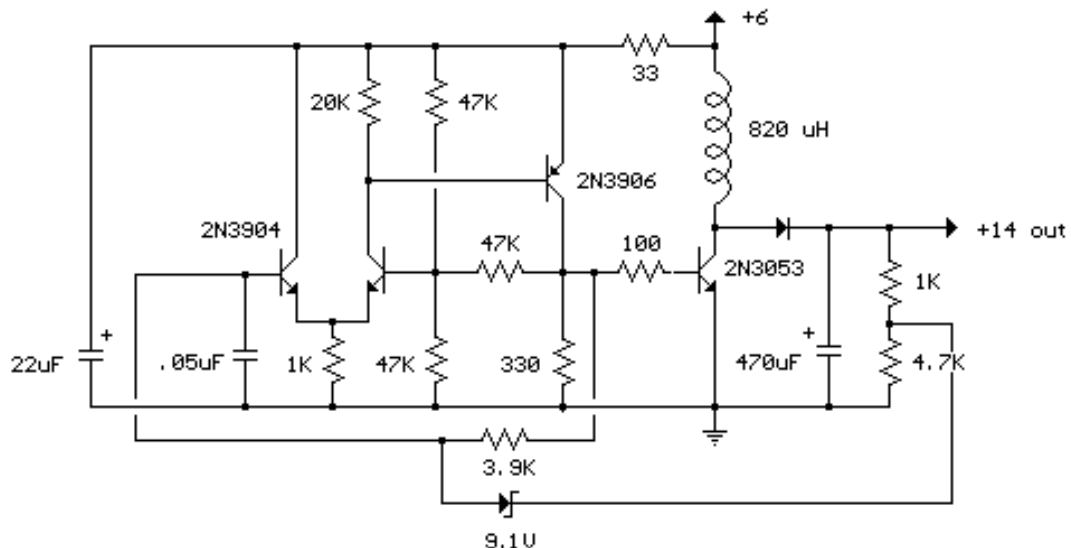
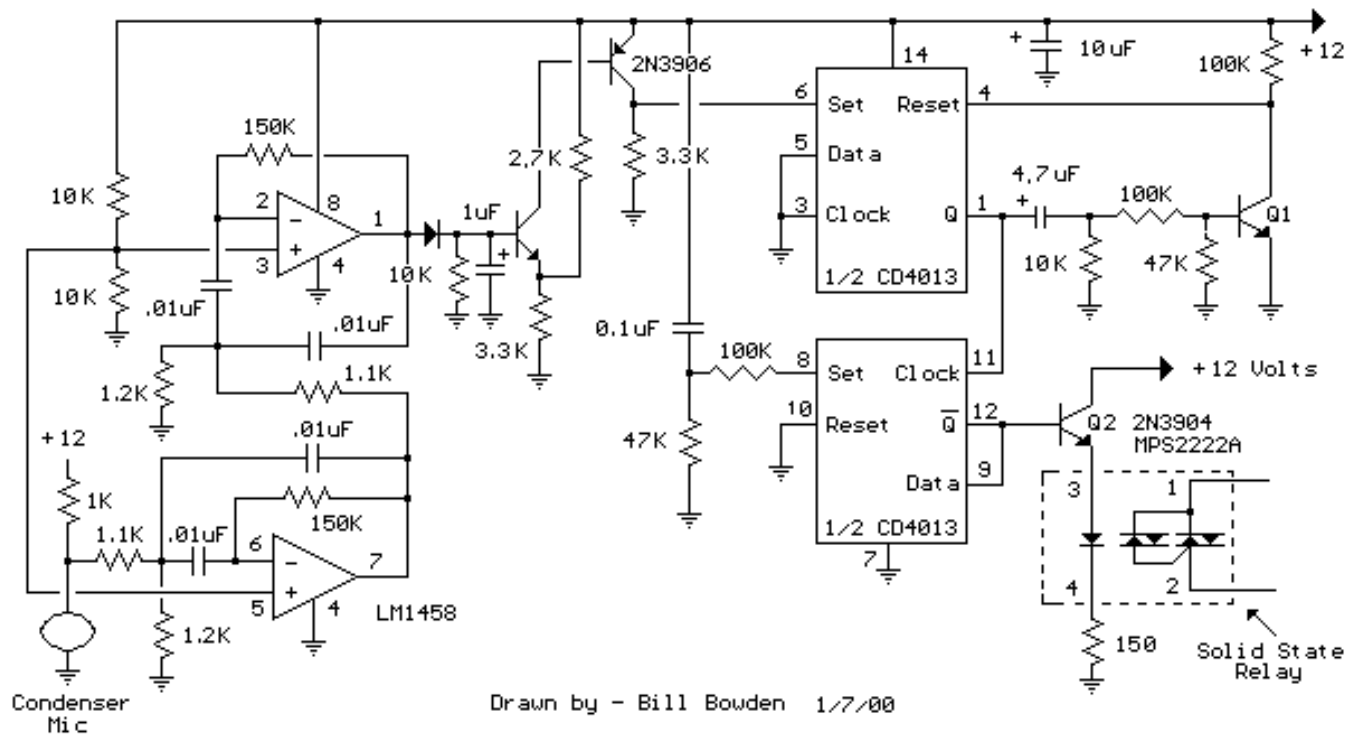
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Whistle On - Whistle Off

This is an extension of the CMOS toggle flip flop circuit shown in the "Circuits controlling relays" section with the addition of two bandpass filters and condenser microphone so the relay can be toggled by whistling at it. The condender mic used is a PC board mount Radio Shack #270-090C. The filters are tuned to about 1700 Hz, or the third Ab above middle C on a piano keyboard which is a fairly easy note for me to whistle. Resistor values for the filter can be computed using the three formulas below but we need to assume a gain and Q factor for the filter and the Q of the circuit must be greater than the square root of (Gain/2). The microphone produces only a couple millivolts so the overall gain needs to be around 4000 or around 65 for each filter. The Q or quality factor is the ratio of the center frequency to the bandwidth (-3dB points) and was chosen to be 8 which is greater than 5.7 which is the minimum value for a gain of 65. Both capacitor values need to be the same for easy computation of the resistor values and were chosen to be 0.01uF which is a common value and usable at audio frequencies. From those assumptions, the resistor values can be worked out from the following formulas.

R1 = Q/(G*C*2*Pi*F) = 8/(65*.01^-6*6.28*1700) = 1152 or 1.1K
R2 = Q / ((2*Q^2)-G)*C*2*Pi*F) = 8/((128-65)*.01^-6*6.28*1700)= 1189 or 1.2K
R3 = (2*Q)/(C*2*Pi*F) = 16/(.01^6*6.28*1700) = 150K

The op-amps are biased using a voltage divider of two 10K resistors so the output will be centered around half the supply voltage or 6 volts. The output of the second filter charges a 1uF cap at the base of a NPN transistor (2N3904 or similar). The emitter voltage is biased at 6.6 volts using the 3.3K and 2.7K resistors so that the transistor will conduct and trigger the flip flop when the peak signal from the filter reaches 8 volts. The 8 volt figure is the emitter voltage (6.6) plus the emitter base voltage drop (0.7) plus the diode drop (0.7). The sensitivity can be adjusted by changing the value of either the 2.7K or 3.3K resistors so that more or less signal amplitude is needed to trigger the flop flop.

Drawn by - Bill Bowden   1/7/00

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DC to DC Converter

The circuit below is a DC to DC converter using a standard 12 VAC center tapped power transformer wired as a blocking oscillator. The circuit is not very efficient but will produce a high voltage usable for low power applications. The input battery voltage is raised by a factor of 10 across the transformer and further raised by a voltage tripler consisting of three capacitors and diodes connected to the high voltage side of the transformer. The circuit draws about 40 milliamps and should operate for about 200 hours on a couple of 'D' alkaline batteries. Higher voltages can be obtained by reducing the 4.7K bias resistor. More information on blocking oscillators can be found here: Blocking Oscillators

```
            12.6 VAC/ 450mA
            Power transformer
            Radio Shack 273-1365    1uF/100 volt

                  +3                              --->  +85 volts/85 uA

    0.1uF                  2uF                          1uF/100 volt
          4.7K

                        2N3053           1N4004          1uF/100 volt
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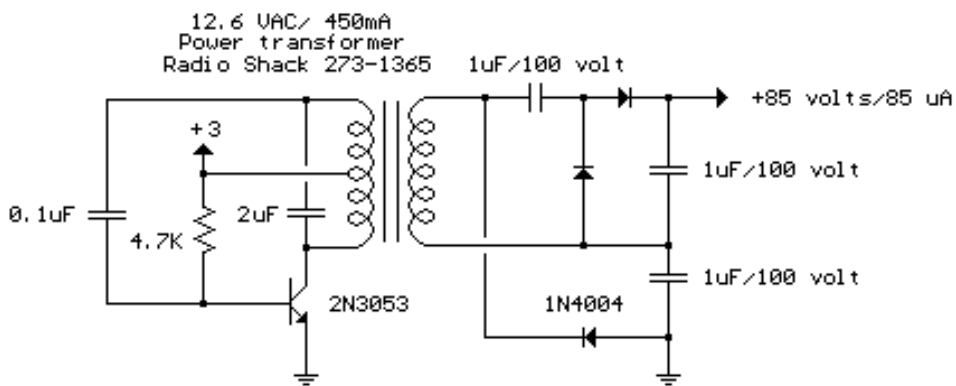
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120 VAC Lamp Dimmer

The full wave phase control circuit below was found in a RCA power circuits book from 1969. The load is placed in series with the AC line and the four diodes provide a full wave rectified voltage to the anode of a SCR. Two small signal transistors are connected in a switch configuration so that when the voltage on the 2.2uF capacitor reaches about 8 volts, the transistors will switch on and discharge the capacitor through the SCR gate causing it to begin conducting. The time delay from the beginning of each half cycle to the point where the SCR switches on is controlled by the 50K resistor which adjusts the time required for the 2uF capacitor to charge to 8 volts. As the resistance is reduced, the time is reduced and the SCR will conduct earlier during each half cycle which applies a greater average voltage across the load. With the resistance set to minimum the SCR will trigger when the voltage rises to about 40 volts or 15 degrees into the cycle. To compensate for component tollerances, the 15K resistor can be adjusted slightly so that the output voltage is near zero when the 50K pot is set to maximum. Increasing the 15K resistor will reduce the setting of the 50K pot for minimum output and visa versa. Be careful not to touch the circuit while it is connected to the AC line.
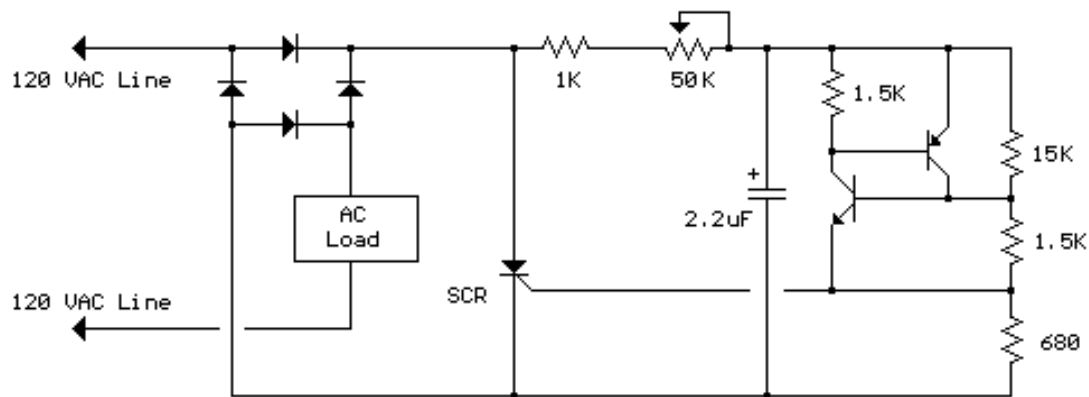
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Varying brightness AC lamp

In this circuit, an SCR is used to slowly vary the intensity of a 120 volt light bulb by controlling the time that the AC line voltage is applied to the lamp during each half cycle.
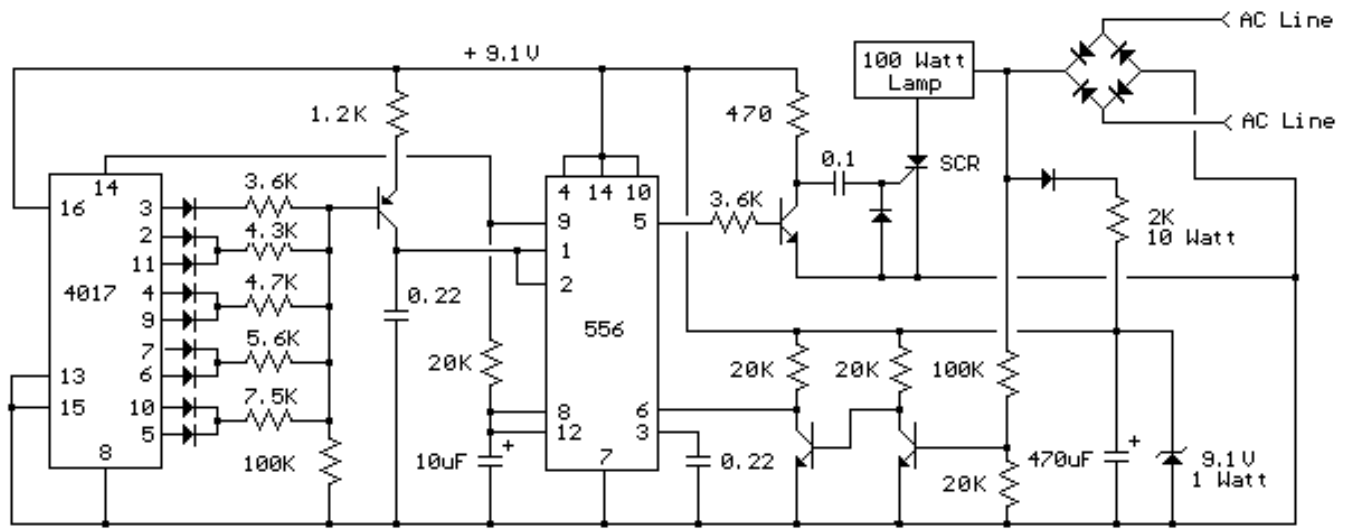
Caution:

The circuit is directly connected to the AC power line and should be placed inside an enclosure that will prevent direct contact with any of the components. To avoid electrical shock, do not touch any part of the circuit while it is connected to the AC power line. A 2K, 10 watt power resistor is used to drop the line voltage down to 9 volts DC. This resistor will dissipate about 7 watts and needs some ventilation.

Operation:

A couple NPN transistors are used to detect the beginning of each half cycle and trigger a delay timer which in turn triggers the SCR at the end of the delay time. The delay time is established by a current source which is controlled by a 4017 decade counter. The first count (pin 3) sets the current to a minimum which corresponds to about 7 milliseconds of delay, or most of the half cycle time so that the lamp is almost off. Full brightness is obtained on the sixth count (pin 1) which is not connected so that the current will be maximum and provide a minimum delay and trigger the SCR near the beginning of the cycle. The remaining 8 counts increment the brightness 4 steps up and 4 steps down between maximum and minimum. Each step up or down provides about twice or half the power, so that the intensity appears to change linearly. The brightness of each step can be adjusted with the 4 resistors (4.3K, 4.7K, 5.6K, 7.5K) connected to the counter outputs.

The circuit has been built by Don Warkentien (WODEW) who suggsted adding a small 47uF capacitor from ground to the junction of the current source transistor (PNP) to reduce the digital stepping effect so the lamp will brighten and fade in a smoother fashion. The value of this capacitor will depend on the 4017 counting rate, a faster rate would require a smaller capacitor.

+ 9.1V

1.2K
3.6K
4.3K
4.7K
5.6K
7.5K
100K

4017
14
16   3
2
11
4
9
7
6
13
15   10
5
8

0.22
20K
10uF

556
4   14   10
9
1
2
5
8   6
12   3
7

470
3.6K
0.1   SCR

100 Watt
Lamp

AC Line
AC Line

20K   20K   100K
20K
0.22

2K
10 Watt

470uF
9.1V
1 Watt

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Circuit to Get High Voltage from an Ignition Coil

```
                                           -------    HV out
                                          )
                                          )
       -------------------                )
       |                 |                )
       |   -------------------------      )
       |   | 8    7     6     5  |        +-----   +12 volts
       |   |                     |        )
       |   )    555 timer IC     |        )
       |   |                     |        |
       |   | 1    2     3     4  |        +-----
       |   -------------------------     D|     |
       |        |      |           G |  --|     |
       ------------+-VVV-+-------------|           V   130 or 150 VAC MOV
       |         Timing              |  --|     |
       |         Resistor          S|     |
       |                    IRF730     +-----
       |                 or IRF740      |
       |                    power       |
     -----    Timing        MOSFET      |
     -----    Capacitor                 |
       |                               Gnd
     Gnd
```
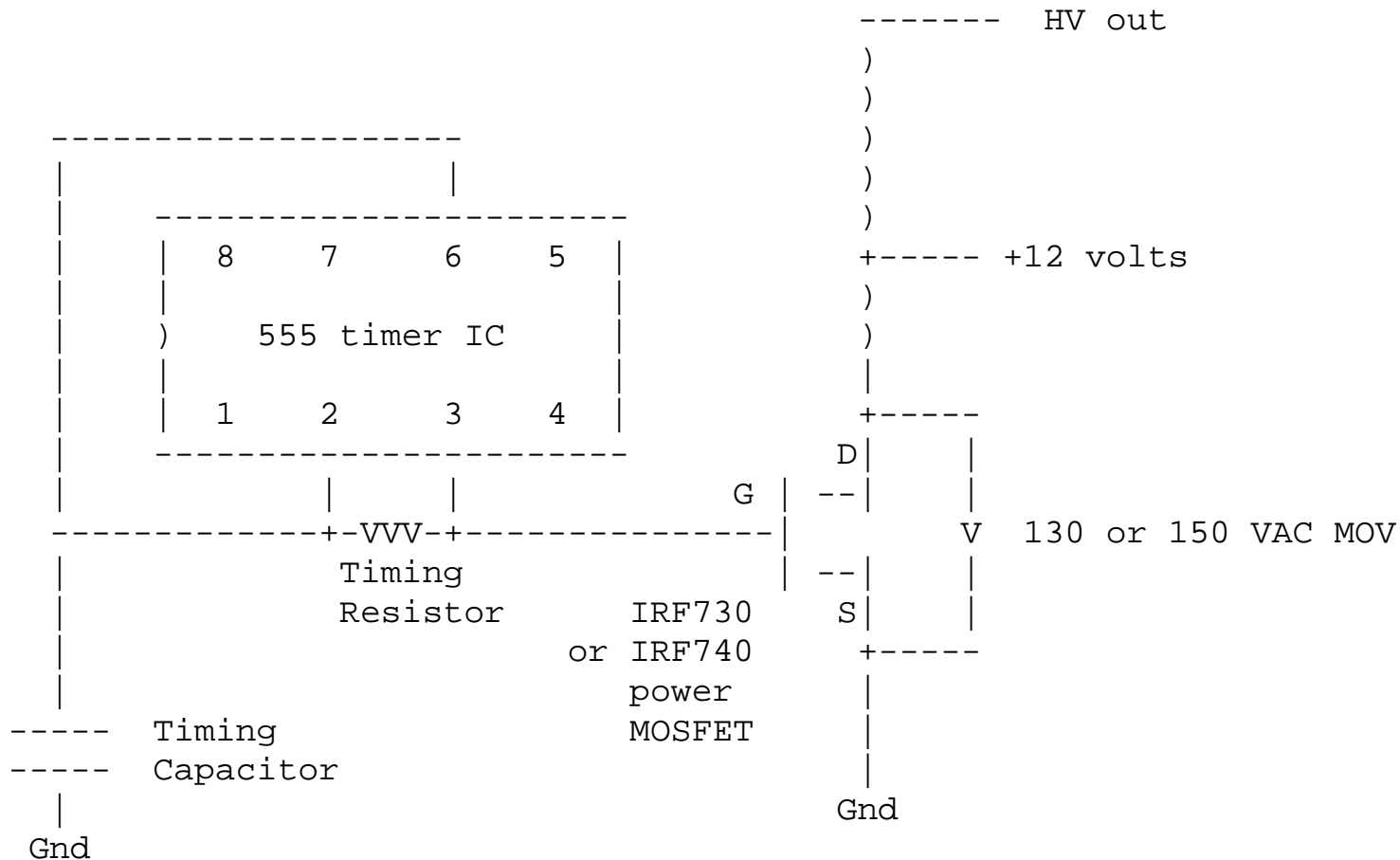
555 timer IC connections not shown:

Pin 1 - Ground

Pins 4 and 8 - Positive DC power supply (B+), typically 12 volts.
A capacitor of at least .1 uF is recommended from B+ to ground, preferably as close as possible to pins 1 and 8.

Pin 5 - A capacitor of typically .1 uF should go from this pin to ground. The value of this is not critical. The circuit often works without this capacitor, but it is recommended to absorb any interference that could affect the 555 through this pin.

Pin 7 - Do not connect to anything.

Timing resistor and capacitor recommendations:

The timing resistor should be a 100K potentiometer used as a variable resistor (use the middle lead and one of the other leads), plus a 4.7K resistor in series with it. The timing capacitor should be .1 uF, and preferably not a ceramic type unless it is known to have good temperature characteristics. Most larger value ceramic capacitors, especially Z5U types, vary wildly with temperature.

The metal oxide varistor is necessary to protect the power MOSFET from excessively high voltage pulses caused by inadvertent poor adjustment of the timing resistor, and also from leakage inductance in the coil. Sometimes, this circuit works slightly better if a capacitor is also placed across the MOSFET. Values around .05 to .1 uF are suggested. The capacitor should be rated for at least 400 volts DC, and preferably have an AC rating of at least 200 volts or a DC rating of at least 600 volts for good reliability in this circuit. Capacitors near or over .2 uF often result in lower output voltages.

It is recommended to only place the capacitor across the mosfet, not across the coil primary. I have known parasitic oscillations to occur from placing the capacitor across the coil primary.

The MOSFET should be mounted on a heat sink.

Operating and adjusting this circuit

Before actually connecting the ignition coil, it is recommended to verify that the rest of the circuit works. One way to do this is by placing a resistor (anything from 10 to 500 ohms) from the mosfet drain to B+, where the coil primary would go. There should be a square wave across this resistor, easily detectable with an oscilloscope or a piezoelectric tweeter.

When the circuit is verified to work, adjust the variable resistor for highest frequency, remove power, then put the ignition coil in place.

Before applying power, connect an insulated wire with stripped ends to either of the coil's primary leads. (I am assuming the usual ignition coil, with two primary terminals and one high voltage terminal.) Also have a short bare wire coming out of the high voltage terminal at the top of the coil.

With power applied, some high voltage should be present. If you bring the end of the wire that is connected to the primary close to the high voltage wire, you should see sparks. You may have to get the wires close together.

UPDATE 10/24/2000 - By some reports from people trying this, at maximum frequency the high voltage output is too weak to make visible sparks. If this happens, try reducing the frequency in minor increments until you get noticeable high voltage (or until something is obviously wrong).

Once the circuit is known to be working and generating high voltage, slowly adjust the variable resistor for a lower frequency. This permits current to build up in the coil to a higher value before being switched off. The result is higher voltage, indicated by sparks being able to jump through a longer gap. It is OK to keep reducing the frequency until the voltage stops increasing. Do not touch any part of the 555 circuit including any leads of the timing resistors or timing capacitor; doing so can inject interference into the circuit.

It is not recommended to reduce the switching frequency below the point at which the voltage stops increasing. Doing so will increase power consumption, increase MOSFET heating, and lead to excessive heating of the metal oxide varistor.

If the metal oxide varistor heats up significantly, increase the switching frequency (lower timing resistance) until the output voltage decreases slightly. If the MOV still gets hot, try placing a capacitor across the mosfet as suggested above. If this does not work, be sure that the MOV is a V130 (or 150) LA20 or equivalent, about 20 mm. (.8 inch) in diameter, or of a larger size. A larger capacitor will eliminate MOV heating, but do not use one larger than necessary, since this will reduce

the output voltage.

The peak output voltage will be approximately 15,000 to 20,000 volts, but this will vary with the ignition coil type and the voltage at which the MOV starts conducting.

If you need more voltage, it is permissible to use a higher voltage MOV, two MOV's in series, or to add zener diodes in series with the MOV, or to use a zener diode bank instead of an MOV. However, whatever you use must conduct heavily (several amps) at a voltage lower than 400 volts in order to protect the mosfet. If you do this, you will have to readjust the switching frequency in order to get the higher voltage.

It is not recommended to short the high voltage terminal of the ignition coil to either primary terminal or to ground unless a 2000 volt diode is in series with the high voltage terminal. Otherwise, you can draw "forward" pulses, which would lead to more heating of the coil and the MOSFET. Two 1,000 volt diodes in series will work. If you need to determine the polarity of the high voltage pulses, use a neon lamp; only the negative electrode will glow. Leave a spark gap also when you do this, otherwise you will put "forward" pulses through the neon lamp, possibly overloading it. If you want to change the polarity of the high voltage output, reverse the coil's two primary terminals.

If you are going to short the high voltage output, it is also recommended to add some resistance. Either around a 10K, 10 watt resistor in series with the high voltage output, or a few ohms (10 or 20 watts) in series with the primary, or around an ohm (10 watts) in series with the source terminal of the MOSFET (makes the MOSFET turn on less when current is high). A primary or source resistor simply limits current flowing through the coil, one in series with the high voltage output speeds up removal of stored energy from the coil.
The lower the resistance of any load connected to the high voltage terminal, the more slowly the magnetic field in the coil will decrease. If magnetic field remains the next time the MOSFET is switched on, the primary current will not gradually build up from zero, but start at a value corresponding to the remaining magnetic field. In such an event, the current may build to excessive amounts and overheat the coil and/or the MOSFET.

No resistor is necessary if the output is loaded down to a couple of kilovolts peak voltage. If the MOSFET is an IRF740, it should be OK to short the high voltage output for a few cycles, such as in charging a capacitor from zero to above a kilovolt or two. Once the capacitor gets past this voltage, the coil will work more normally.

If you want to charge a capacitor with the high voltage output, you will need a diode (or diode bank) that can withstand the peak-to-peak voltage, which is the sum of the main high voltage pulse voltage and the forward pulse voltage. In other words, slightly more than the voltage of the main high voltage pulses.

This circuit works at supply voltages anywhere from about 8 volts to 15 volts. However, you will need to readjust the switching frequency (by adjusting the timing resistor) if you change the supply voltage.

If you want more output power/current, one way is to use a different 555 (or other) oscillator circuit that will turn the MOSFET off for a shorter time than it turns the MOSFET on. In this case, it becomes more important to not short or excessively load the high voltage output, since the magnetic field has less time to collapse.
Another option to get more current/power is a higher supply voltage for the coil. The coil should

work OK at voltages up to 24, maybe 30 volts. Note that the 555 does not want voltages that high, so you will need two different supply voltages. You will also need to make the 555 switching frequency faster since the current through the coil primary will build up faster at higher voltages. In addition, the core losses in the coil will increase, which will make the coil hotter. You may not be able to operate this circuit continuously at voltages higher than about 15 to 20 volts.

CAUTION!

1) This circuit is intended to generate high voltages, which can be dangerous. The voltages/currents put out by this circuit may be able to electrocute someone. Sparks may be able to start fires. Use all due cautions. It is recommended to remove power before making adjustments.

2) Wattages for any power resistors mentioned above are believed to be usually adequate. It is up to you to determine if any power resistors will overheat.

Written by Don Klipstein.

Please read my Copyright and authorship info.

Please read my Disclaimer. This circuit has hazards, some of which (and some safety precautions) may not be included in this document.

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Infrared Remote Control Tester

This is a fairly easy circuit that can be used to test TV and VCR remote controls. The infrared detector module (GP1U52X) (Radio Shack 276-137) produces a 5 volt TTL pulse train corresponding to the digital code of the particular remote control key pressed. In the lower circuit, the module output is normally low with no signal received and becomes a positive going pulse train when a signal is present. Other detector modules are available that have an inverted output as shown in the upper drawing which is the type I used, but I don't have the part number, I believe it was removed from a VCR. The pulse sequence represents the digital code of the particular key pressed along with possible manufacturer information. As the pulse train occurs, the 4.7uF capacitor is charged to about 3 volts and the capacitor voltage minus a diode drop appears across the 470 ohm resistor yielding a collector current from the 2N3904 or 2N3906 of about 5 milliamps. The collector current of the first stage flows into the base of the output transistor (MJE34 or 2N3053) which delivers around 250 mA into the indicator lamps. When the pulse train ends, the capacitor slowly discharges through the base of the first stage transistor allowing the Xmas tree lights to remain on for a about 1 second. The little Xmas lamps will operate over a wide voltage range, so you can use bulbs from almost any string, but bulbs from shorter strings (35 or less) will probably last longer operated at 5 volts.

The circuit can be powered from a small 9-12 volt DC, 250 mA or greater wall transformer. It may also need an additional 1000 uF filter capacitor across the DC output if the wall transformer does not have a built in capacitor. For use with a 9 volt battery, the incandescent lamps can be replaced with a regular LED and 680 ohm resistor and the output transistors can be replaced with small signal transistors (2N3904 or 2N3906). The total current drain will be about 25 mA with the LED lit, and 15 mA standby when the LED is off.
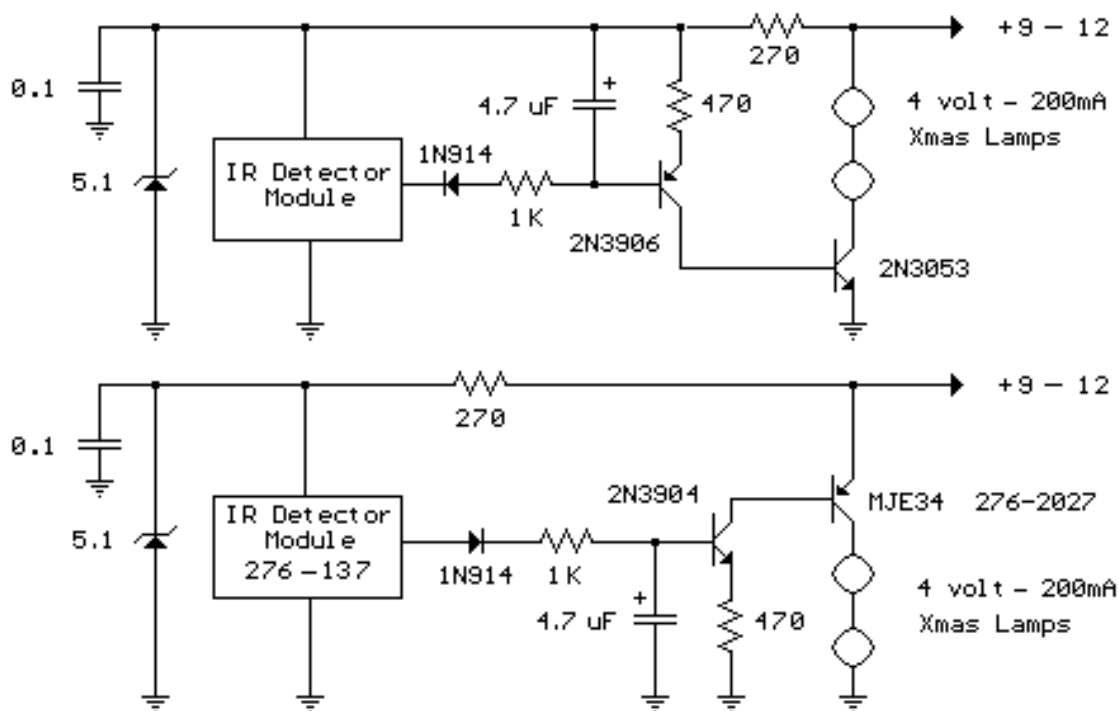
Drawn by - Bill Bowden - 08/02/00

Transistor Schmitt Trigger Oscillator

The Schmitt Trigger oscillator below employs 3 transistors, 6 resistors and a capacitor to generate a square waveform. Pulse waveforms can be generated with an additional diode and resistor (R6). Q1 and Q2 are connected with a common emitter resistor (R1) so that the conduction of one transistor causes the other to turn off. Q3 is controlled by Q2 and provides the squarewave output from the collector.

In operation, the timing capacitor charges and discharges through the feedback resistor (Rf) toward the output voltage. When the capacitor voltage rises above the base voltage at Q2, Q1 begins to conduct, causing Q2 and Q3 to turn off, and the output voltage to fall to 0. This in turn produces a lower voltage at the base of Q2 and causes the capacitor to begin discharging toward 0. When the capacitor voltages falls below the base voltage at Q2, Q1 will turn off causing Q2 and Q3 to turn on and the output to rise to near the supply voltage and the capacitor to begin charging and repeating the cycle. The switching levels are established by R2,R4 and R5. When the output is high, the voltage at the base of Q2 is determined by R4 in parallel with R5 and the combination in series with R2. When the output is low, the base voltage is set by R4 in parallel with R2 and the combination in series with R5. This assumes R3 is a small value compared to R2. The switching levels will be about 1/3 and 2/3 of the supply voltage if the three resistors are equal (R2,R4,R5).

There are many different combinations of resistor values that can be used. R3 should low enough to pull the output signal down as far as needed when the circuit is connected to a load. So if the load draws 1mA and the low voltage needed is 0.5 volts, R3 would be 0.5/.001 = 500 ohms (510 standard). When the output is high, Q3 will supply current to the load and also current through R3. If 10 mA is needed for the load and the supply voltage is 12, the transistor current will be 24 mA for R3 plus 10 mA to the load = 34 mA total. Assuming a minimum transistor gain of 20, the collector current for Q2 and base current for Q3 will be 34/20 = 1.7 mA. If the switching levels are 1/3 and 2/3 of the supply (12 volts) then the high level emitter voltage for Q1 and Q2 will be about 7 volts, so the emitter resistor (R1) will be 7/0.0017 = 3.9K standard. A lower value (1 or 2K) would also work and provide a little more base drive to Q3 than needed. The remaining resistors R2, R4, R5 can be about 10 times the value of R1, or something around 39K.

The combination of the capacitor and the feedback resistor (Rf) determines the frequency. If the switching levels are 1/3 and 2/3 of the supply, the half cycle time interval will be about 0.693*Rf*C which is similar to the 555 timer formula. The unit I assembled uses a 56K and 0.1 uF cap for a positive time interval of about 3.5 mS. An additional 22K resistor and diode were used in parallel with the 56K to reduce the negative time interval to about 1 mS.

In the diagram, T1 represents the time at which the capacitor voltage has fallen to the lower trigger potential (4 volts at the base of Q2) and caused Q1 to switch off and Q2 and Q3 to switch on. T2 represents the next event when the capacitor voltage has risen to 8 volts causing Q2 an Q3 to turn off and Q1 to conduct. T3 represents the same condition as T1

where the cycle begins to repeat. Now, if you look close on a scope, you will notice the duty cycle is not exactly 50% This is due to the small base current of Q1 which is supplied by the capacitor. As the capacitor charges, the E/B of Q1 is reverse biased and the base does not draw any current from the capacitor so the charge time is slightly longer than the discharge. This problem can be compensated for with an additional diode and resistor as shown (R6) with the diode turned around the other way.
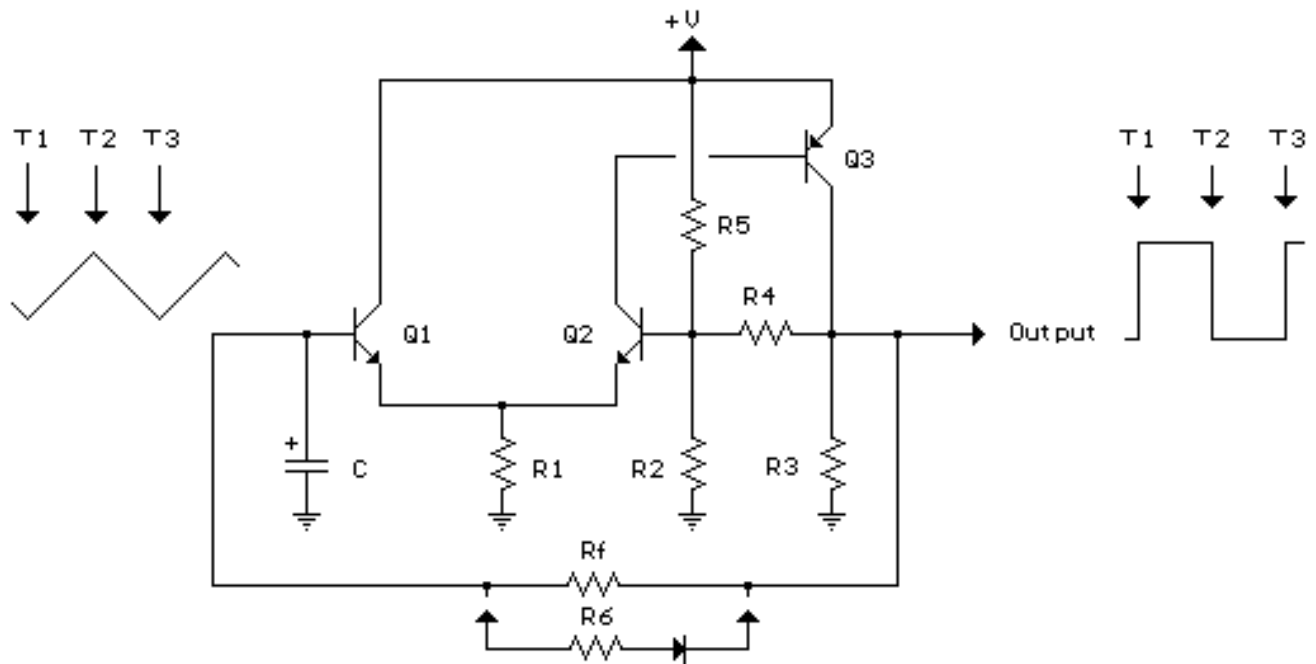
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Battery Equal Charge Indicator

The circuit below illuminates an LED to indicate unequal charges between two 12 volt lead batteries. It can be used to verify that two batteries are connected in parallel or isolated since the LED will be off when the voltages are equal within a tollerance, or on if the voltage difference is greater than 100 millivolts. Three comparators and three voltage dividers are used to determine battery conditions. The upper left comparator (+) input at pin 5 is set to about 10 volts with battery #1 at 12 volts. The negative input (pin 4) is set to a slightly lower voltage by adding an additional 240 ohms to the voltage divider so that the output of the comparator will be positive when both battery voltages are equal and negative if battery 2 rises above battery 1 by 100 millivolts or more. The voltage at pin 5 is used as a reference for the lower comparator and the negative input of the lower comparator is set to a lower voltage with the addition of 510 ohms, so that the output will also be positive when the battery voltages are equal and negative when battery #1 is greater than #2 by 100 millivolts or more. The two comparator outputs are both connected to the positive input of the third comparator at pin 9 so that the LED will illuminate when either condition exists, (Battery #1 > Battery #2) OR (Battery #2 > Battery #1).
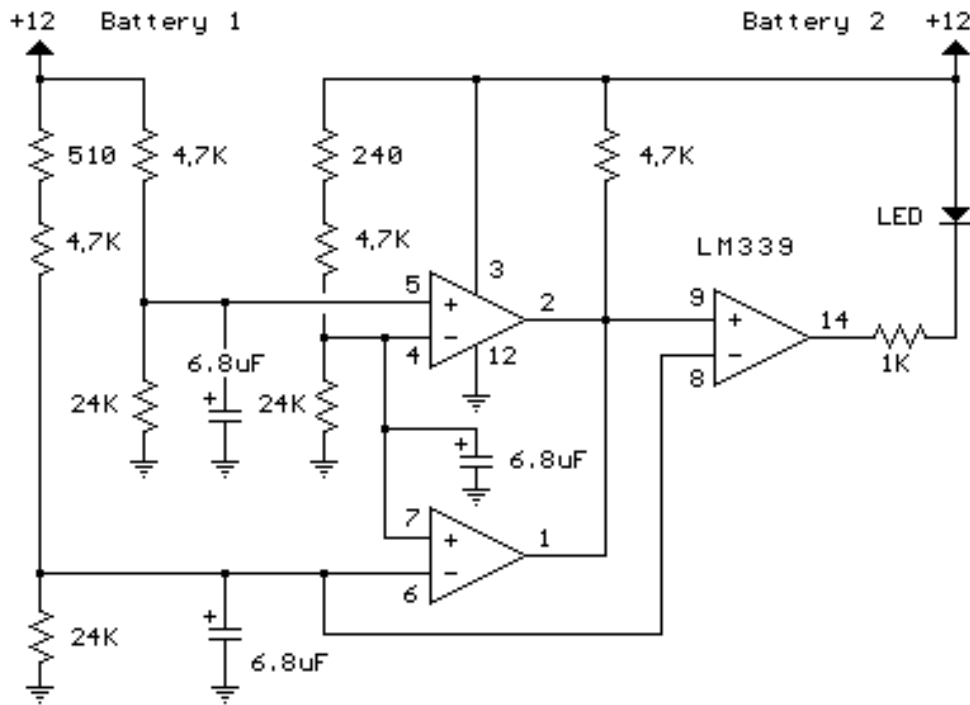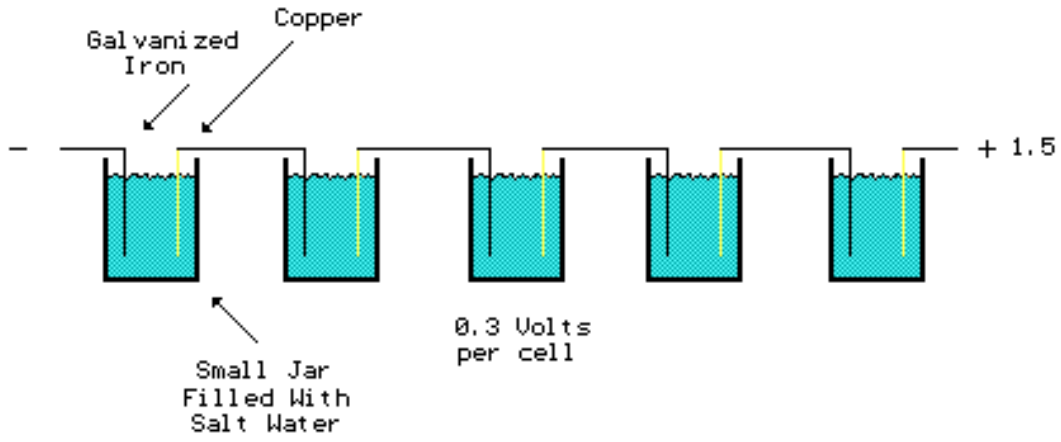
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Salt Water Battery

About 13 years ago, I made a salt water battery to operate a single AA battery quartz clock. It ran for several months until I got tired of adding water to compensate for evaporation. The batttery consisted of 5 cells each producing about 300 millivolts. As I remember, I used 5 small olive jars filled with about a cup of water and a tablespoon of salt to create 5 cells in series each producing about 300 millivolts for a total of around 1.5 volts. The positive electrode was made from a strip of double sided copper circuit board (about 1 inch by 4 inch) and the negative electrode was a similar sized strip of aluminum. I recently tried some galvanized iron instead of aluminum and found it produces a little higher voltage so the battery may be made with only 3 cells. But any two different metals used with salt water or citrus juice will create a low voltage battery. You might experiment using silver coins and copper pennies and various fruit juices to come up with a more powerful battery. The diagram below shows the 5 cells connected in series with the galvanized iron of one cell connected to the copper piece of the next. The battery produces a very low current of around 1 milliamp so it's not practical for much other than a quartz clock. You might get a low current LED to light using a few more cells and larger electrodes with greater surface area. You might also add a capacitor across the battery to supply higher current pulses for a flashing LED. It will probably operate the 1.5 volt flashing LED circuits shown on the main menu at a slow flash rate.

Salt Water Battery
1.5 Volt

555 Tone Generator (8 ohm speaker)

This is a basic 555 squarewave oscillator used to produce a 1 Khz tone from an 8 ohm speaker. In the circuit on the left, the speaker is isolated from the oscillator by the NPN medium power transistor which also provides more current than can be obtained directly from the 555 (limit = 200 mA). A small capacitor is used at the transistor base to slow the switching times which reduces the inductive voltage produced by the speaker. Frequency is about 1.44/(R1 + 2*R2)C where R1 (1K) is much smaller than R2 (6.2K) to produce a near squarewave. Lower frequencies can be obtained by increasing the 6.2K value, higher frequencies will probably require a smaller capacitor as R1 cannot be reduced much below 1K. Lower volume levels can be obtained by adding a small resistor in series with the speaker (10-100 ohms). In the circuit on the right, the speaker is directly driven from the 555 timer output. The series capacitor (100 uF) increases the output by supplying an AC current to the speaker and driving it in both directions rather than just a pulsating DC current which would be the case without the capacitor. The 51 ohm resistor limits the current to less than 200 mA to prevent overloading the timer output at 9 volts. At 4.5 volts, a smaller resistor can be used.


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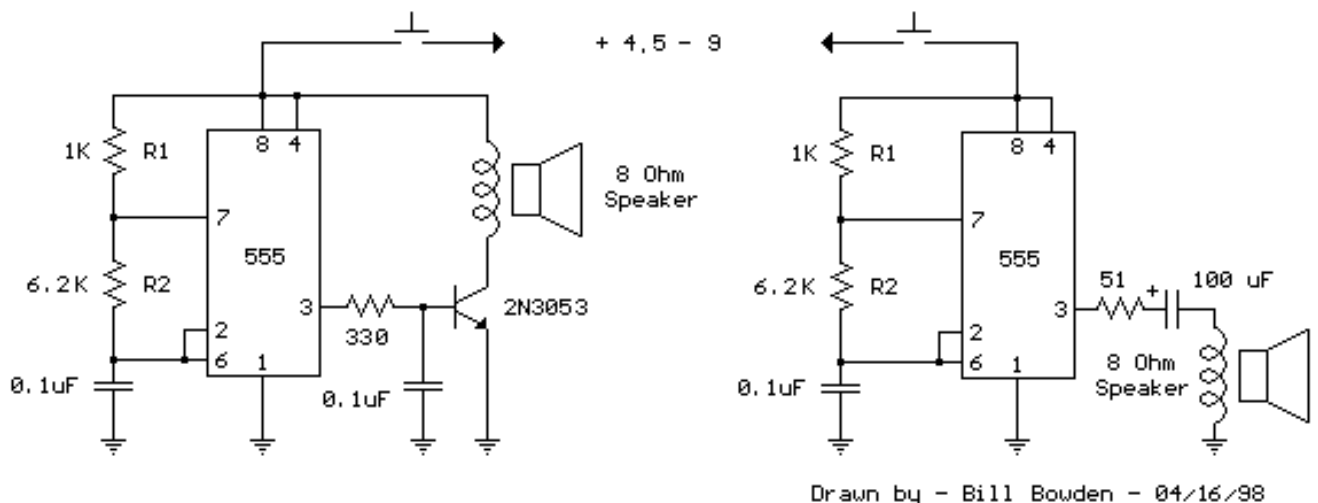
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Generating -5 Volts From a 9 Volt Battery

A 555 timer can be used to generate a squarewave to produce a negative voltage relative to the negative battery terminal. When the timer output at pin 3 goes positive, the series 22 uF capacitor charges through the diode (D1) to about 8 volts. When the output switches to ground, the 22 uF cap discharges through the second diode (D2) and charges the 100 uF capacitor to a negative voltage. The negative voltage can rise over several cycles to about -7 volts but is limited by the 5.1 volt zener diode which serves as a regulator. Circuit draws about 6 milliamps from the battery without the zener diode connected and about 18 milliamps connected. Output current available for the load is about 12 milliamps. An additional 5.1 volt zener and 330 ohm resistor could be used to regulate the +9 down to +5 at 12 mA if a symmetrical +/- 5 volt supply is needed. The battery drain would then be around 30 mA.
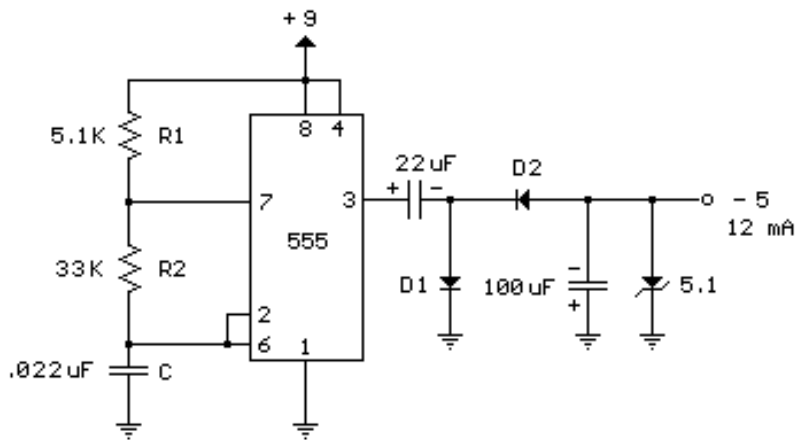

Transistor / Diode / IC (DIP) Outlines
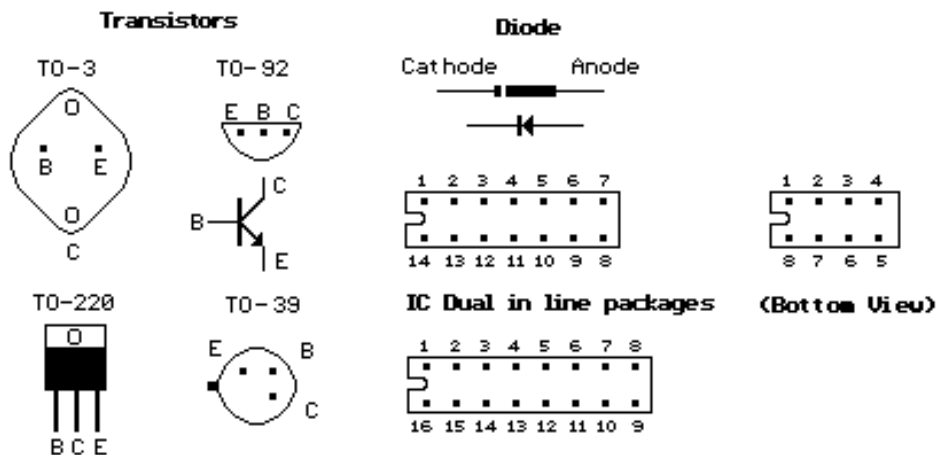
1.5 Volt LED Flashers

The LED flasher circuits below operate on a single 1.5 volt battery. The circuit on the upper right uses the popular LM3909 LED flasher IC and requires only a timing capacitor and LED.

The top left circuit, designed by Andre De-Guerin illustrates using a 100uF capacitor to double the battery voltage to obtain 3 volts for the LED. Two sections of a 74HC04 hex inverter are used as a squarewave oscillator that establishes the flash rate while a third section is used as a buffer that charges the capacitor in series with a 470 ohm resistor while the buffer output is at +1.5 volts. When the buffer output switches to ground (zero volts) the charged capacitor is placed in series with the LED and the battery which supplies enough voltage to illuminate the LED. The LED current is approximately 3 mA, so a high brightness LED is recommended.

In the other two circuits, the same voltage doubling principle is used with the addition of a transistor to allow the capacitor to discharge faster and supply a greater current (about 40 mA peak). A larger capacitor (1000uF) in series with a 33 ohm resistor would increase the flash duration to about 50mS.

The discrete 3 transistor circuit at the lower right would need a resistor (about 5K) in series with the 1uF capacitor to widen the pulse width.
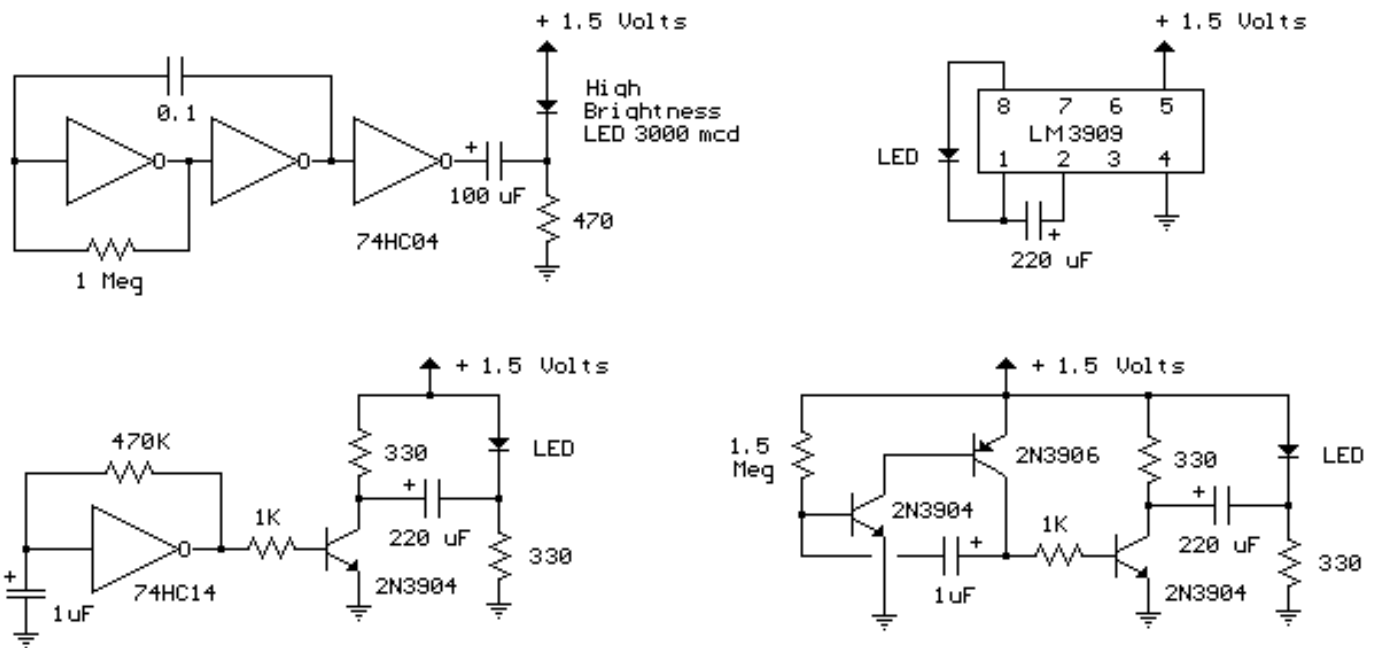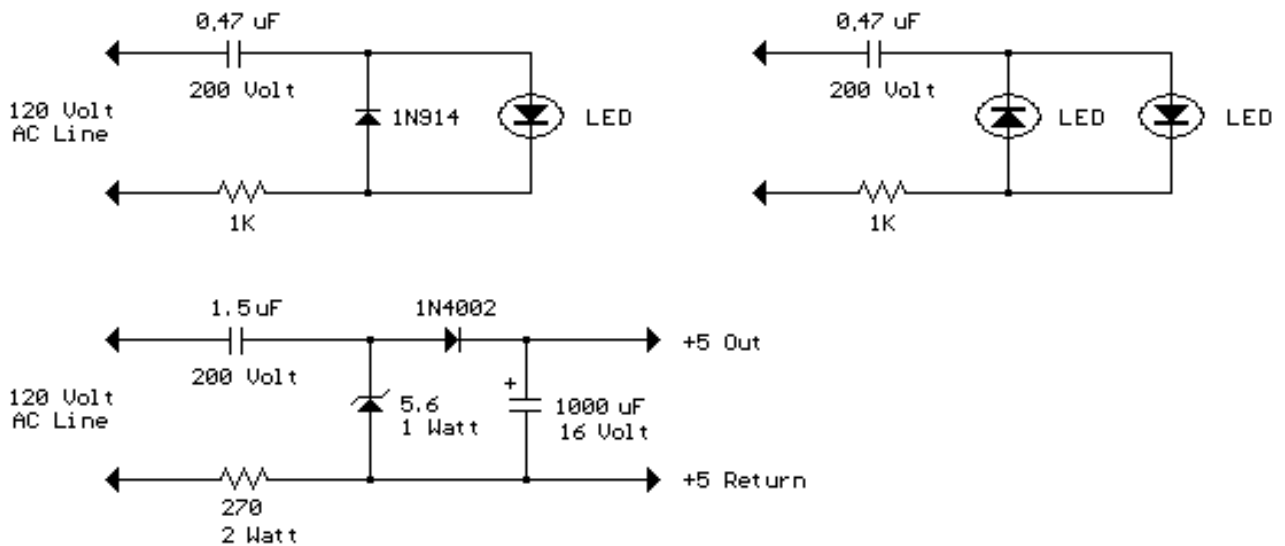

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AC Line powered LEDs

The circuit below illustrates powering a LED (or two) from the 120 volt AC line using a capacitor to drop the voltage and a small resistor to limit the inrush current. Since the capacitor must pass current in both directions, a small diode is connected in parallel with the LED to provide a path for the negative half cycle and also to limit the reverse voltage across the LED. A second LED with the polarity reversed may be subsituted for the diode, or a tri-color LED could be used which would appear orange with alternating current. The circuit is fairly efficient and draws only about a half watt from the line. The resistor value (1K / half watt) was chosen to limit the worst case inrush current to about 150 mA which will drop to less than 30 mA in a millisecond as the capacitor charges. This appears to be a safe value, I have switched the circuit on and off many times without damage to the LED. The 0.47 uF capacitor has a reactance of 5600 ohms at 60 cycles so the LED current is about 20 mA half wave, or 10 mA average. A larger capacitor will increase the current and a smaller one will reduce it. The capacitor must be a non-polarized type with a voltage rating of 200 volts or more.

The lower circuit is an example of obtaining a low regulated voltage from the AC line. The zener diode serves as a regulator and also provides a path for the negative half cycle current when it conducts in the forward direction. In this example the output voltage is about 5 volts and will provide over 30 milliamps with about 300 millivolts of ripple. Use caution when operating any circuits connected directly to the AC line.

LED Traffic Lights

The LED traffic Light circuit controls 6 LEDs (red, yellow and green) for both north/south directions and east/west directions. The timing sequence is generated using a CMOS 4017 decade counter and a 555 timer. Counter outputs 1 through 4 are wire ORed using 4 diodes so that the (Red - North/South) and (Green - East/West) LEDs will be on during the first four counts. The fifth count (pin 10) illuminates (Yellow - East/West) and (Red - North/South). Counts 6 through 9 are also wire ORed using diodes to control (Red - East/West) and (Green - North/South). Count 10 (pin 11) controls (Red - East/West) and (Yellow - North/South). The time period for the red and green lamps will be 4 times longer than for the yellow and the complete cycle time can be adjusted with the 47K resistor. The eight 1N914 diodes could be subsituted with a dual 4 input OR gate (CD4072).
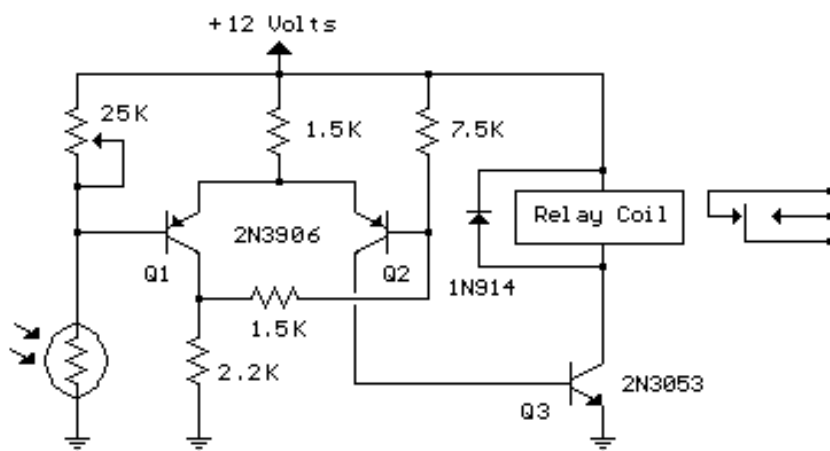

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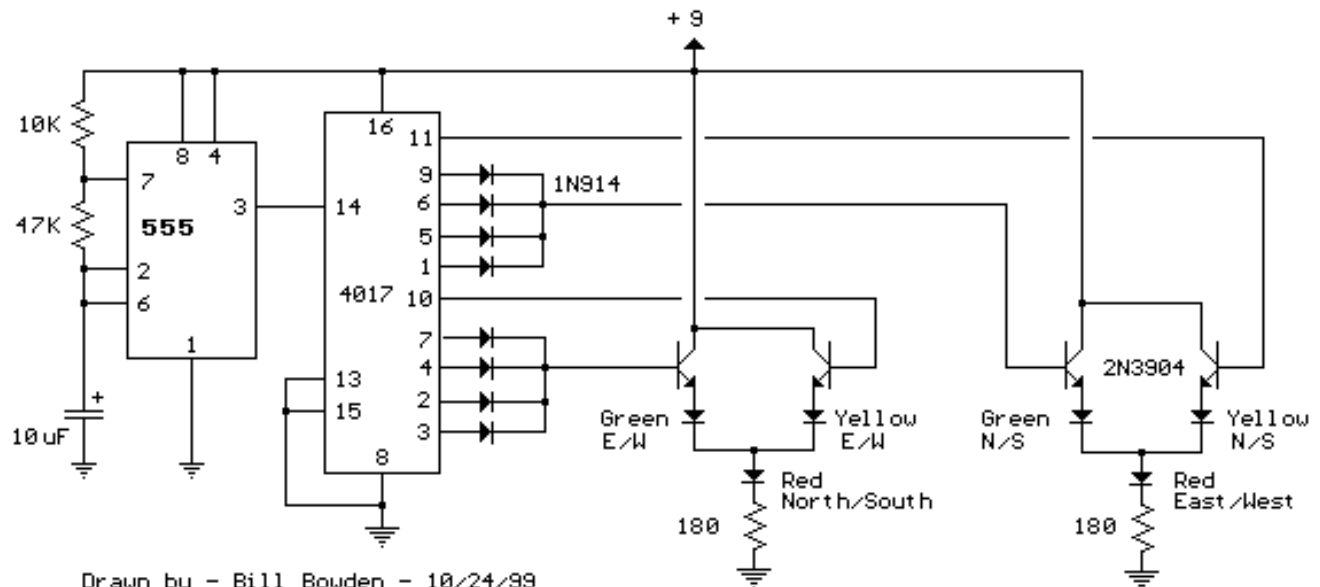
Photo Electric Street Light

This is basically a Schmitt Trigger circuit which receives input from a cadmium sulfide photo cell and controls a relay that can be used to switch off and on a street lamp at dawn and dusk. I have built the circuit with a 120 ohm/12 volt relay and monitored performance using a lamp dimmer, but did not connect the relay to an outside light.

The photo cell should be shielded from the lamp to prevent feedback and is usually mounted above the light on top of a reflector and pointed upward at the sky so the lamp light does not strike the photo cell and switch off the lamp.

The photo cell is wired in series with a potentiometer so the voltage at the junction (and base of transistor) can be adjusted to about half the supply, at the desired ambient light level. The two PNP transistors are connected with a common emitter resistor for positive feedback so as one transistor turns on, the other will turn off, and visa versa. Under dark conditions, the photo cell resistance will be higher than the potentiometer producing a voltage at Q1 that is higher than the base voltage at Q2 which causes Q2 to conduct and activate the relay.

The switching points are about 8 volts and 4 volts using the resistor values shown but could be brought closer together by using a lower value for the 7.5K resistor. 3.3K would move the levels to about 3.5 and 5.5 for a range of 2 volts instead of 4 so the relay turns on and off closer to the same ambient light level. The potentiometer would need to be readjusted so that the voltage is around 4.5 at the desired ambient condition.

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