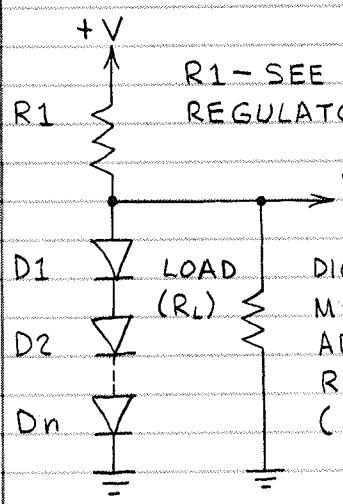
DIODE CIRCUITS

THE VARIOUS KINDS OF DIODES HAVE MANY APPLICATIONS. HERE ARE SOME TYPICAL CIRCUITS:

SMALL SIGNAL DIODES AND RECTIFIERS

☐ VOLTAGE REGULATOR



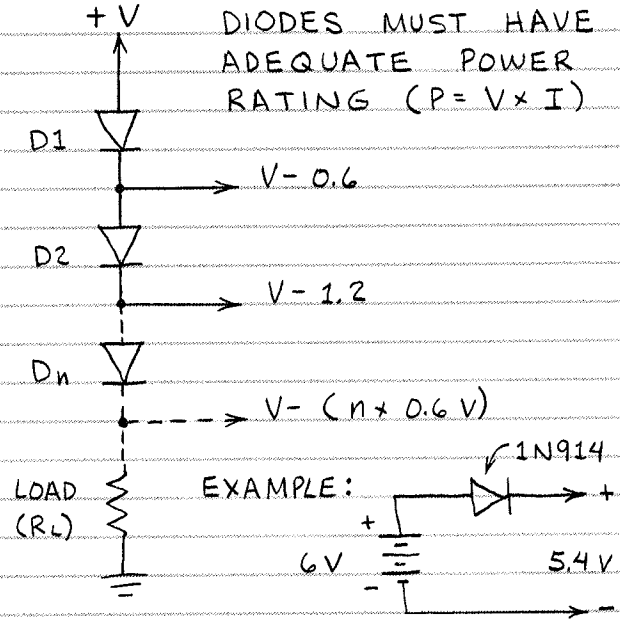
R1 – SEE ZENER DIODE REGULATOR (P. 103)

$V_{OUT} = n \times 0.6V$

DIODE(S) AND R1 MUST HAVE ADEQUATE POWER RATING (SEE P. 103)

ONE OR MORE SILICON DIODES CAN REGULATE A VOLTAGE IN 0.6 VOLT STEPS.

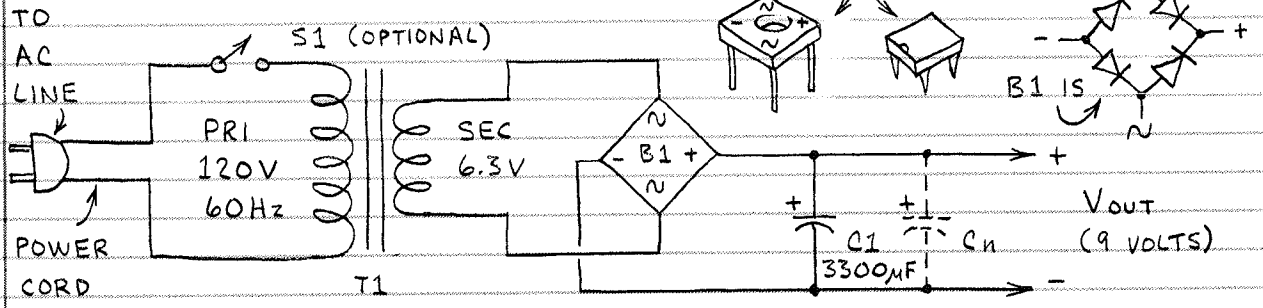
☐ VOLTAGE DROPPER



DIODES MUST HAVE ADEQUATE POWER RATING ($P = V \times I$)

EXAMPLE:

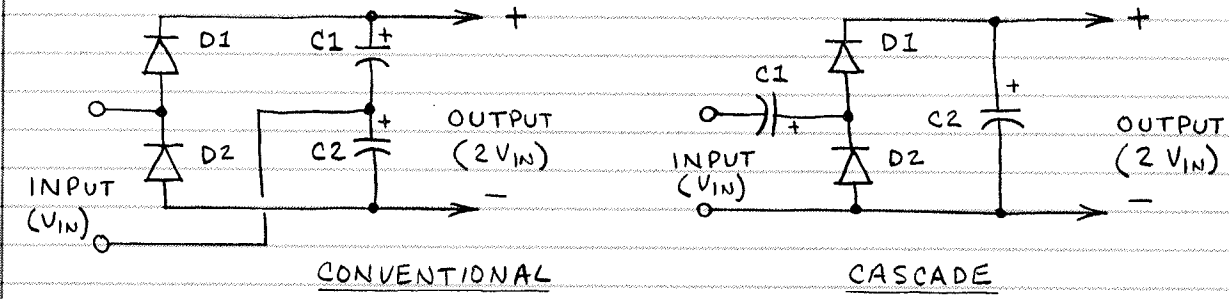
☐ 9 VOLT POWER SUPPLY



THIS IS A BASIC AC LINE OPERATED 9 VOLT POWER SUPPLY. FOR LOW RIPPLE (SUPERIMPOSED AC AT V_{OUT}), USE LARGE VALUE FOR C1. (OK TO ADD ONE OR MORE CAPACITORS (C_n) IN PARALLEL WITH C1 FOR MORE CAPACITANCE.) CAPACITORS MUST HAVE A DC WORKING VOLTAGE (WVDC) OF AT LEAST 12 VOLTS. RECTIFIER BRIDGE B1 MUST HAVE PEAK INVERSE VOLTAGE (PIV) OF AT LEAST 12 VOLTS. T1 AND B1 MUST HAVE ADEQUATE POWER AND CURRENT RATINGS. (USE OHMS LAW...) CAUTION: YOU MUST INSULATE OR ENCLOSE ALL EXPOSED AC LINE CONNECTIONS! THE POWER CORD MUST BE UNPLUGGED WHEN YOU ASSEMBLE OR SERVICE THE CIRCUIT!

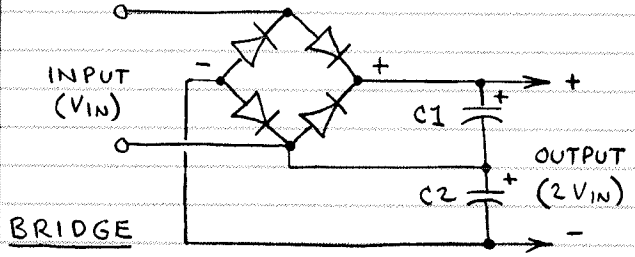
CAUTION: THESE CIRCUITS CAN PRODUCE HIGH VOLTAGE!

☐ VOLTAGE DOUBLERS



CONVENTIONAL CASCADE

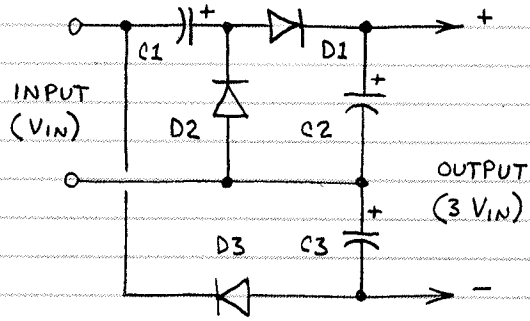
THESE CIRCUITS APPROXIMATELY DOUBLE AN INCOMING AC VOLTAGE. THE OUTPUT IS DC. USE CAPACITORS AND DIODES RATED FOR TWICE THE INPUT VOLTAGE. OUTPUT RIPPLE (~~~) CAN BE REDUCED BY USING LARGE VALUES FOR C1 AND C2.



BRIDGE

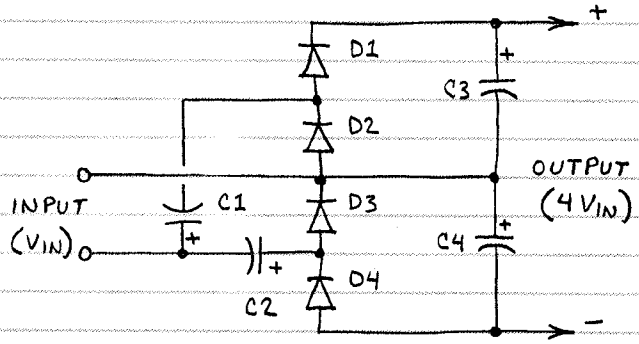
THE BRIDGE DOUBLER IS MORE EFFICIENT THAN THE CONVENTIONAL AND CASCADE DOUBLERS. SINCE 4-DIODE BRIDGE RECTIFIERS ARE AVAILABLE, IT'S EASY TO MAKE.

☐ VOLTAGE TRIPLER



TRIPLES AND CONVERTS TO DC AN INCOMING AC VOLTAGE. C2, D1, D2 AND D3 RATED AT >2 V_{IN}.

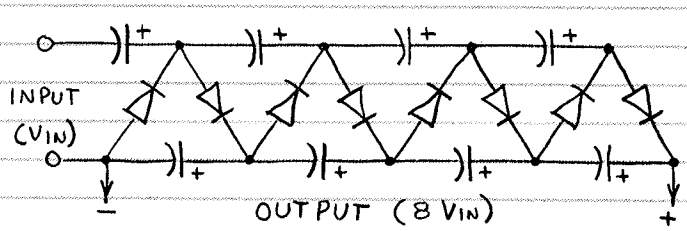
☐ VOLTAGE QUADRUPLER



QUADRUPLES AND CONVERTS TO DC AN INCOMING AC VOLTAGE. ALL COMPONENTS RATED AT >2 V_{IN}.

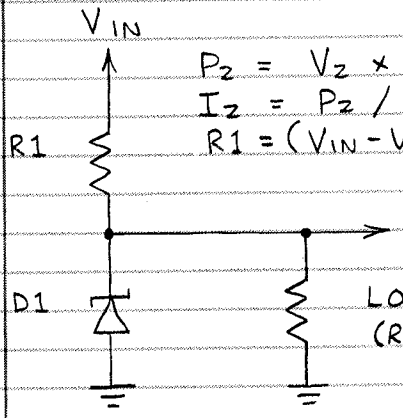
☐ CASCADE MULTIPLIER

ADD MORE STAGES FOR MORE MULTIPLICATION. ALL COMPONENTS RATED AT >2 V_{IN}.



ZENER DIODE CIRCUITS

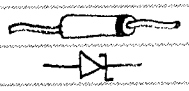
☐ VOLTAGE REGULATOR



$P_z = V_z \times I_L$
$I_z = P_z / V_z$
$R1 = (V_{IN} - V_z) / I$

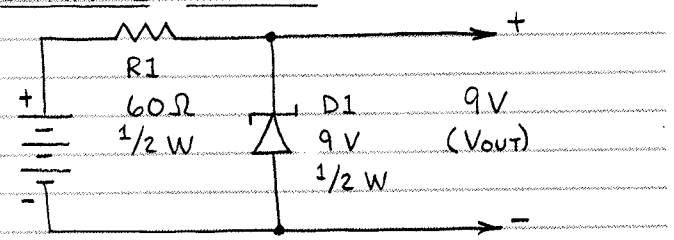
I_L = MAXIMUM LOAD CURRENT
I_z = MAXIMUM ZENER CURRENT
I = CURRENT THROUGH R1
V_z = ZENER DIODE VOLTAGE
P_z = ZENER DIODE POWER

THIS CIRCUIT SUPPLIES A STEADY VOLTAGE (V_{OUT}) TO A LOAD FROM AN UNREGULATED SUPPLY (LIKE A BATTERY). V_{IN} CAN VARY BUT MUST BE AT LEAST 1 VOLT ABOVE DESIRED V_{OUT}. I_L CAN VARY FROM 0 MA TO PLANNED MAXIMUM VALUE. I DOES NOT CHANGE IF I_L FALLS TO 0 MA. SINCE $I = I_L + I_z$, I_z RISES AS I_L FALLS. IN OTHER WORDS, THE REGULATOR ALWAYS USES THE SAME CURRENT, EVEN WHEN THE LOAD IS REMOVED. CAUTION: D1 AND R1 MUST HAVE PROPER POWER RATING. USE OHM'S LAW (P. 14).

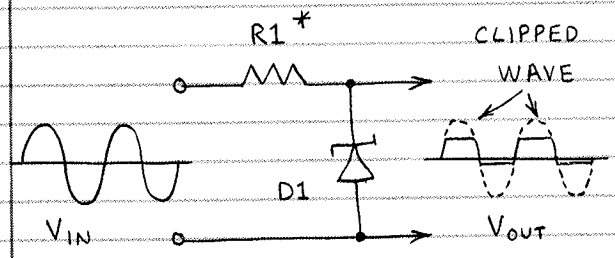


EXAMPLE: A RADIO DRAWS FROM 20 TO 50 MA FROM A 9 VOLT BATTERY. TO POWER IT FROM A 12 VOLT BATTERY, USE A 9 VOLT, 1/2 WATT ZENER DIODE. R1 SHOULD BE CLOSE TO 60 Ω AND RATED FOR AT LEAST 0.15 W.

EXAMPLE CIRCUIT:

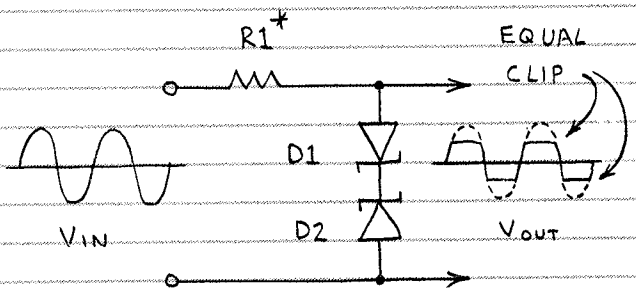


☐ WAVEFORM CLIPPER



THIS CIRCUIT IS HANDY FOR REDUCING AN INCOMING SIGNAL VOLTAGE TO A LOWER, MORE MANAGEABLE LEVEL. IT CAN ALSO CONVERT A SINE OR TRIANGLE WAVE TO AN APPROXIMATION OF A SQUARE WAVE. * R1: SEE ABOVE (LET I = 2 MA MINIMUM).

☐ DUAL WAVEFORM CLIPPER



THIS IS A SYMMETRICAL FORM OF THE ADJACENT CIRCUIT. IT CLIPS BOTH HALVES OF AN INCOMING WAVE EQUALLY (IF V_z = D1 = D2). USE TO PROTECT SPEAKERS AND PHONES FROM EXCESSIVE SIGNAL LEVELS OR TO MAKE SQUARE WAVES.

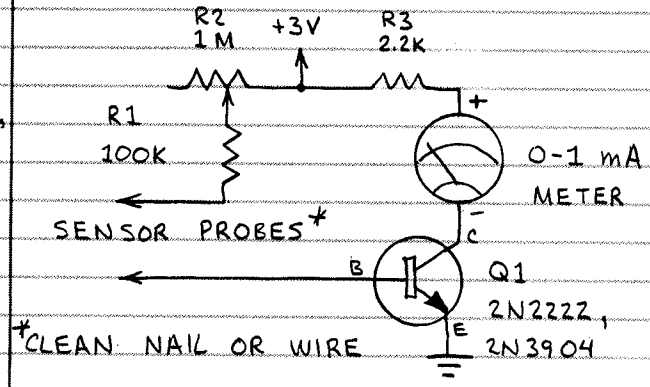
TRANSISTOR CIRCUITS

INTEGRATED CIRCUITS RECEIVE MORE ATTENTION, BUT BOTH BIPOLAR AND FIELD-EFFECT TRANSISTORS HAVE MANY APPLICATIONS.

BIPOLAR TRANSISTOR CIRCUITS

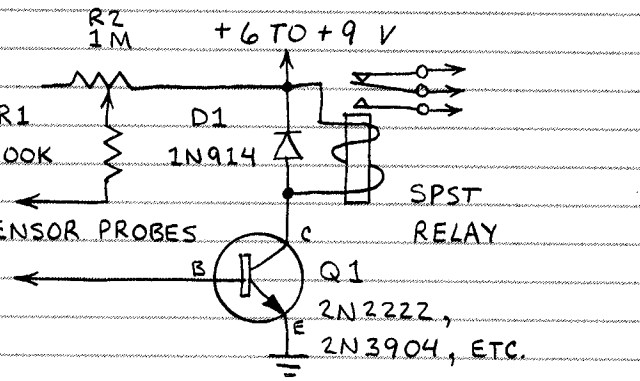
2N2222
2N2907,
ETC.

☐ MOISTURE METER



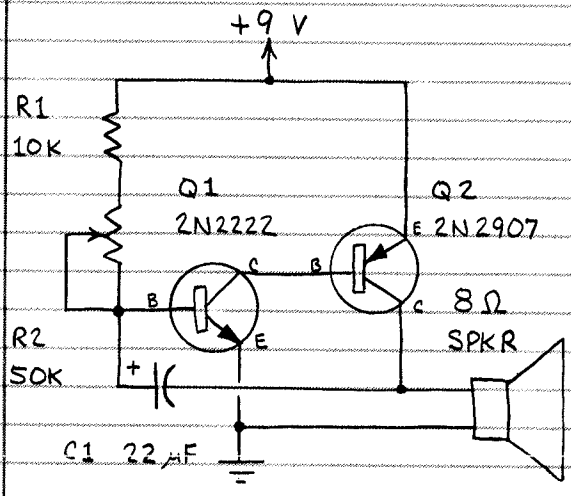
THIS CIRCUIT WILL MEASURE THE MOISTURE LEVEL OF SOIL IN YOUR GARDEN. ADJUST R2 FOR METER READING OF 1 mA WHEN SOIL MOISTURE IS AT DESIRED LEVEL. METER WILL THEN INDICATE LOWER MOISTURE LEVELS.

☐ MOISTURE ACTUATED RELAY



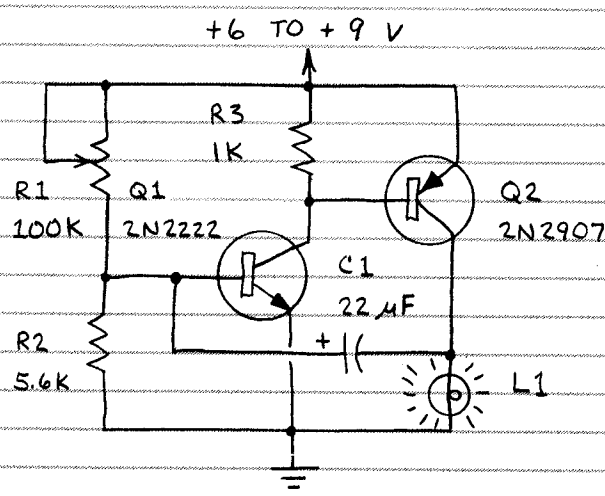
THIS CIRCUIT CLOSES A RELAY (6-9 V, 500 OHM COIL) WHEN MOISTURE LEVEL EXCEEDS A LEVEL SET BY R2. RELAY CONTACTS THEN SWITCH ON A LIGHT OR OTHER DEVICE. CAN DETECT RAIN.

☐ METRONOME



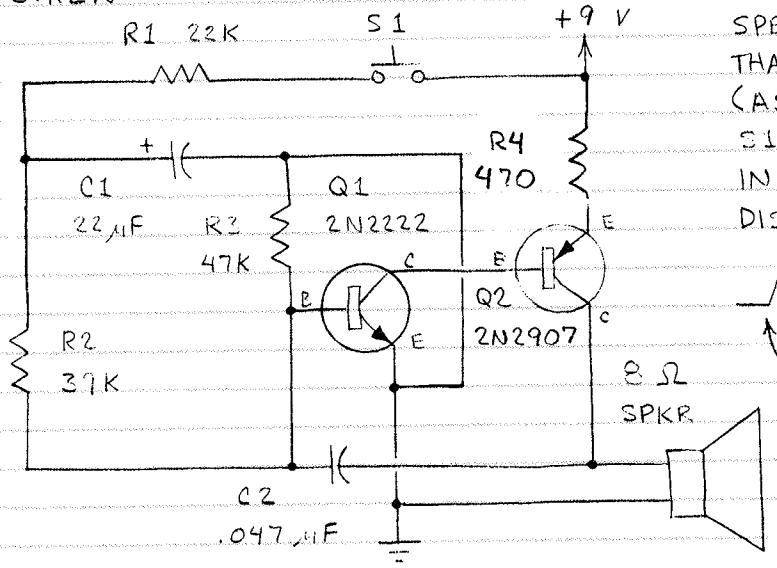
A METRONOME MARKS TIME BY PRODUCING A REGULAR SEQUENCE OF "CLICKS" OR "POCKS." ADJUST THE CLICK RATE BY ADJUSTING R2 OR CHANGING C1's VALUE.

☐ LIGHT FLASHER

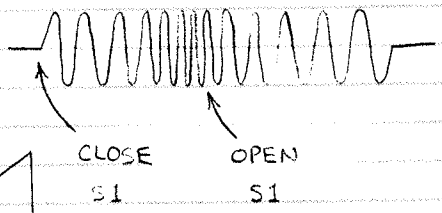


THIS CIRCUIT PRODUCES BRIGHT FLASHES EVERY SECOND OR SO. R1 CONTROLS FLASH RATE. USE NO. 122 OR 222 MINIATURE LAMP FOR L1.

☐ SIREN

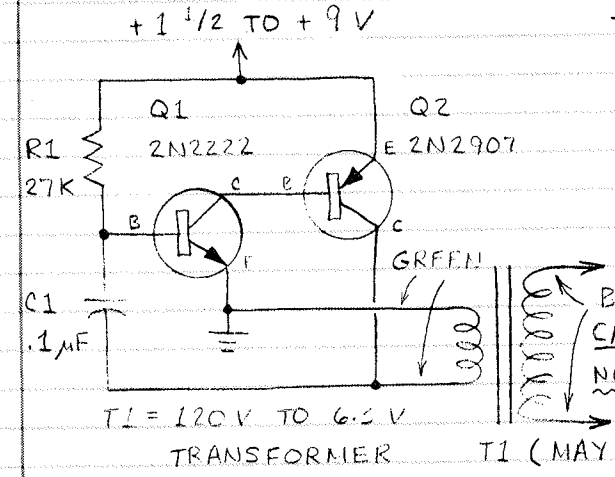


CLOSE S1 AND THE SPEAKER EMITS A TONE THAT RISES IN FREQUENCY (AS C1 CHARGES). OPEN S1 AND THE TONE FALLS IN FREQUENCY (AS C1 DISCHARGES). LIKE THIS:



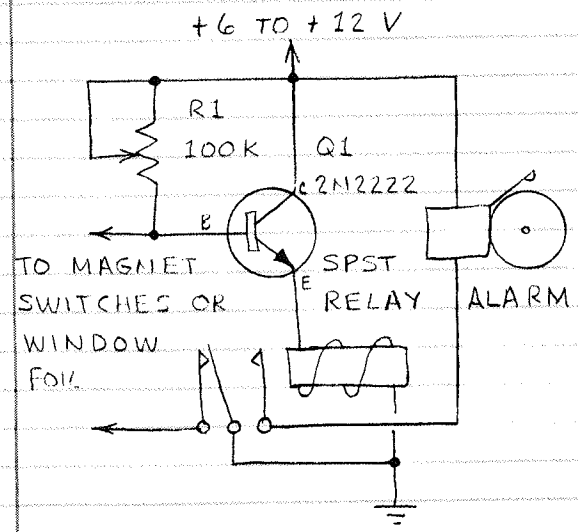
HINT: CHANGE R1 TO CHANGE UP-DOWN TIME.

☐ HIGH VOLTAGE POWER SUPPLY



THIS CIRCUIT PRODUCES 220 VOLT PULSES OF DC WHEN POWERED BY A 9-VOLT BATTERY. IT WILL PRODUCE UP TO 170 VOLTS FROM A FLASHLIGHT CELL (BUT YOU MAY HAVE TO EXPERIMENT WITH C1'S VALUE. THE CIRCUIT WILL POWER ONE OR MORE NEON LAMPS THROUGH A 1M SERIES RESISTOR.

☐ BURGLAR ALARM

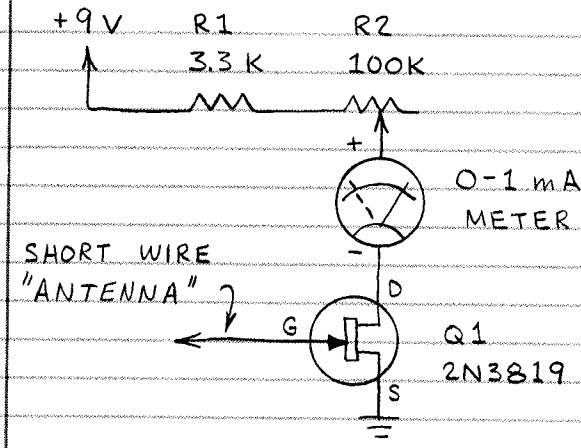


ALARM SOUNDS AND STAYS ON (UNTIL POWER IS DISCONNECTED) WHEN MAGNET SWITCH IS OPENED OR WINDOW FOIL IS BROKEN. R1: SET TO MAXIMUM VALUE. DISCONNECT ONE LEAD TO SWITCHES / FOIL. THEN REDUCE VALUE OF R1 TO JUST PAST POINT WHERE ALARM SOUNDS. CIRCUIT USES ONLY 0.3 MILLIAMPERES AT 6 VOLTS. RELAY: USE 6 V, 500 Ω UNIT WHEN SUPPLY IS 6-9 V. USE 12 V, 1200 Ω UNIT WHEN SUPPLY IS 12 V. NOTE: ASSEMBLE, INSTALL AND CONCEAL THIS SYSTEM WITH CARE.

JUNCTION FET CIRCUITS

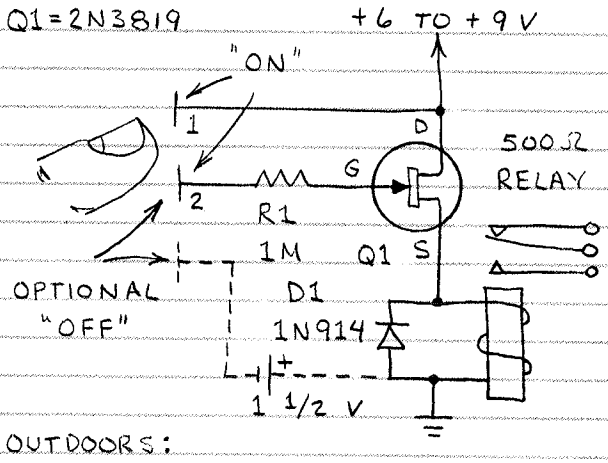
S G D
2N3819

☐ ELECTROMETER



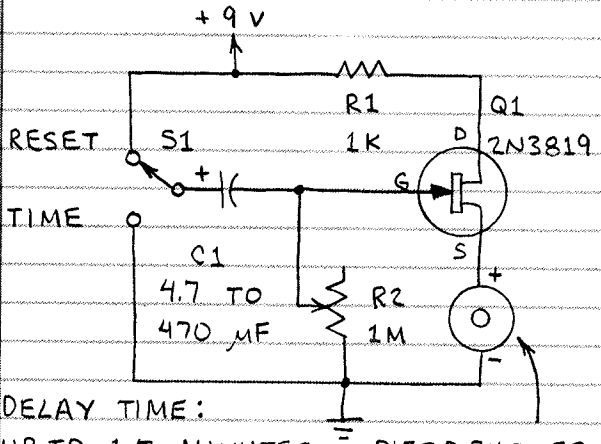
THIS CIRCUIT DETECTS STATIC ELECTRICITY FROM A CHARGED OBJECT (PLASTIC COMB, ETC.) OVER A FOOT AWAY! ADJUST R1 SO METER INDICATES 1 MA. CHARGED OBJECT NEAR "ANTENNA" WILL DECREASE METER READING.

☐ TOUCH SWITCH



OUTDOORS:
AWAY FROM POWER LINES, BRIEFLY TOUCH "ON" CONTACTS TO ACTUATE RELAY. TOUCH CONTACT 2 ONLY TO DEACTUATE RELAY.
INDOORS:
MAY BE NECESSARY TO INCLUDE OPTIONAL "OFF" CIRCUIT.

☐ TIMER

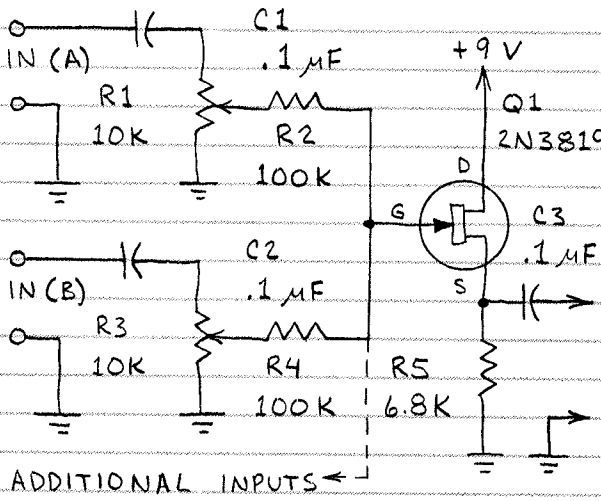


DELAY TIME:
UP TO 1.5 MINUTES

PIEZO BUZZER

SET S1 TO "RESET" (BUZZER WILL SOUND). THEN SET S1 TO "TIME." BUZZER WILL BE SILENT UNTIL DELAY IS COMPLETE. BUZZER WILL THEN SOUND. INCREASE C1 OR R1 FOR LONGER DELAYS. REDUCE R2's RESISTANCE DURING RESET MODE (SPEEDS UP RESET).

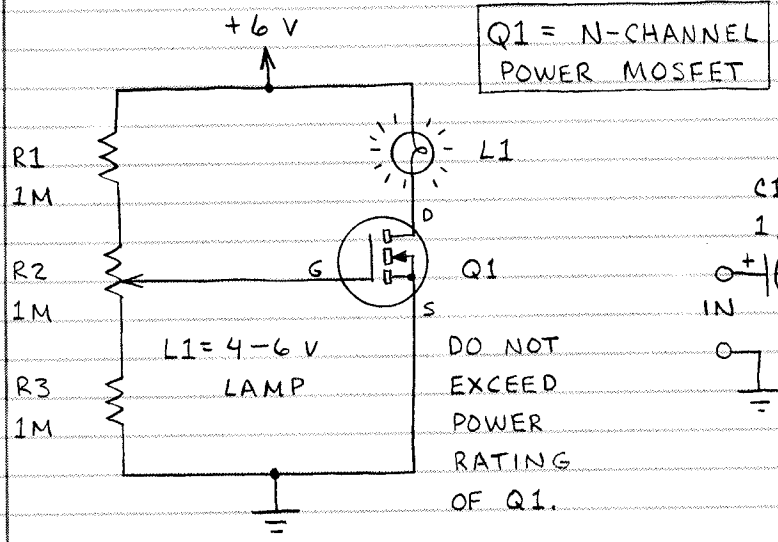
☐ AUDIO MIXER



THIS CIRCUIT ALLOWS TWO (OR MORE) MICROPHONES OR OTHER DEVICES TO BE CONNECTED TO THE SAME AMPLIFIER. R1 AND R3 CONTROL ATTENUATION OF EACH INPUT. THEREFORE R1 AND R3 ARE BALANCE CONTROLS.

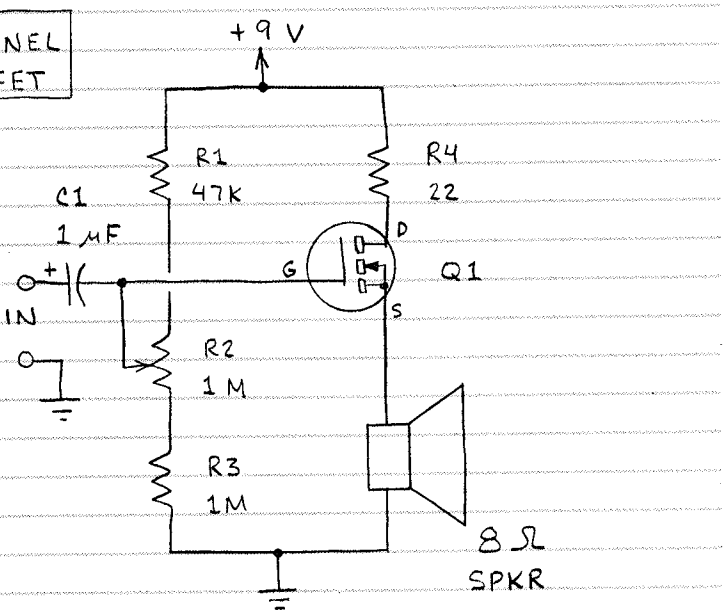
POWER MOSFET (DMOS, VMOS, ETC.) CIRCUITS

☐ LINEAR LIGHT DIMMER



CHANGE SETTING OF R2 TO CHANGE INTENSITY OF LAMP. THIS CIRCUIT SHOWS HOW POWER MOSFET CAN BE USED AS A VARIABLE RESISTOR.

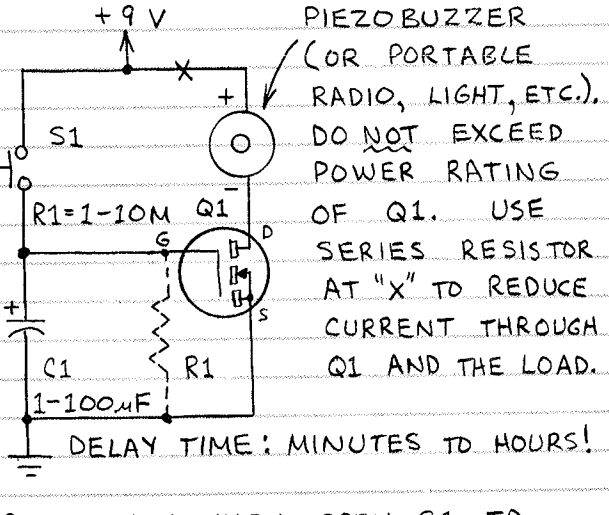
☐ AUDIO AMPLIFIER



USE TO AMPLIFY SIGNALS AND TONES FROM OTHER CIRCUITS. R2 CONTROLS GAIN (VOLUME).

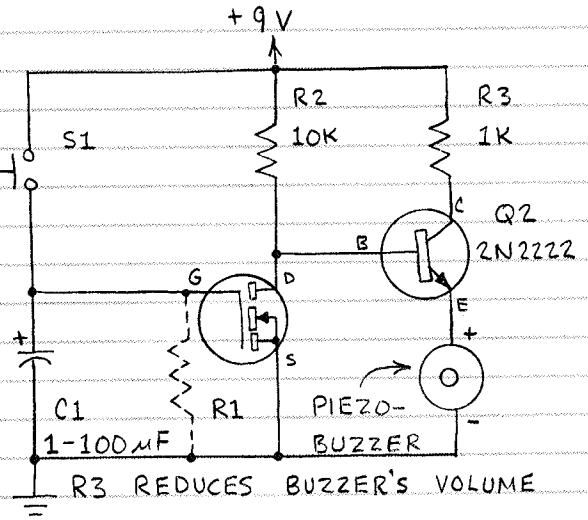
☐ LONG DURATION TIME DELAY CIRCUITS

1. OFF AFTER DELAY



CLOSE AND THEN OPEN S1 TO ACTIVATE BUZZER. AFTER C1 DISCHARGES INTERNALLY OR THROUGH R1 (OPTIONAL), Q1 TURNS OFF AND SILENCES THE BUZZER. LONG DELAYS POSSIBLE.

2. ON AFTER DELAY

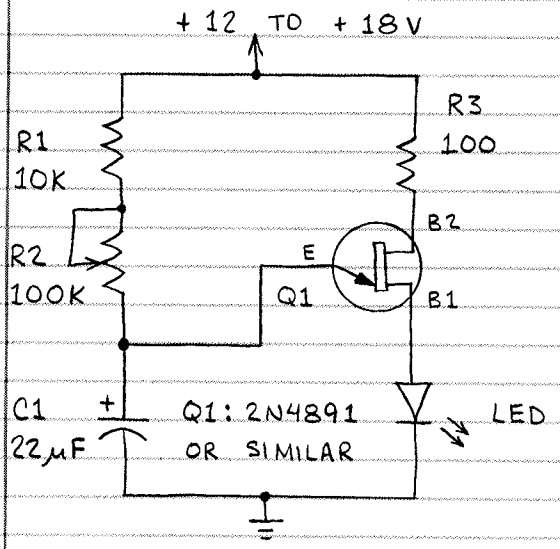


Q2 INVERTS THE STATUS OF Q1. THEREFORE THE BUZZER SOUNDS AFTER THE TIME DELAY IS COMPLETE. INCREASE C1's VALUE TO INCREASE DELAY.

UNIJUNCTION TRANSISTOR CIRCUITS

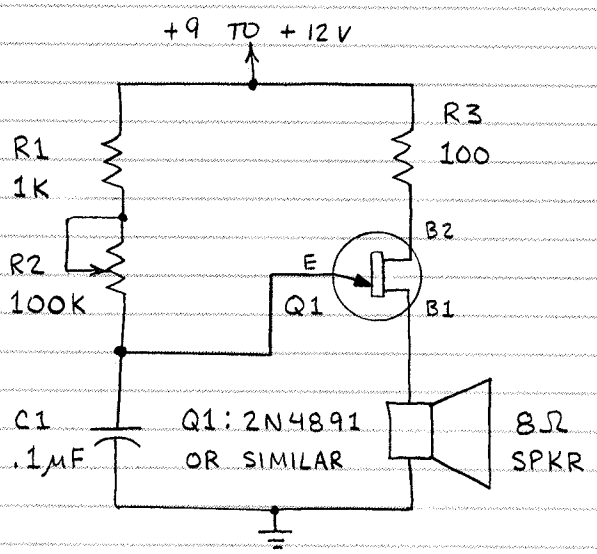
B1 E B2
2N4891

☐ TIME BASE



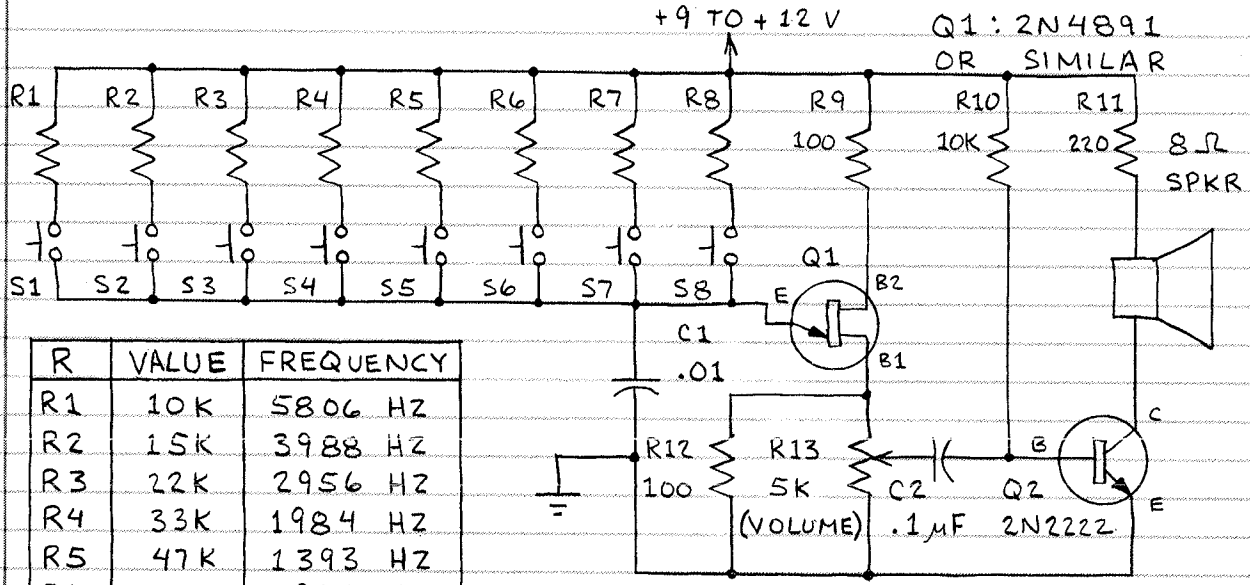
EACH TIME THE UJT (Q1) TURNS ON, THE CHARGE ON C1 IS "DUMPED" THROUGH THE LED. THE LED FLASHES IN RESPONSE. BETWEEN FLASHES, THE LED GLOWS DIMLY. R2 CONTROLS FLASH RATE AND CAN BE SET FOR ONE FLASH PER SECOND (TIME BASE ROLE).

☐ TONE GENERATOR



THIS CIRCUIT IS IDENTICAL IN PRINCIPLE TO THE ADJACENT CIRCUIT. C1 IS MUCH SMALLER TO SPEED UP THE CHARGE-DISCHARGE CYCLE. THE RESULT IS AN AUDIO FREQUENCY TONE WHICH IS EMITTED BY THE SPEAKER. THIS CIRCUIT CAN BE EXPANDED (SEE BELOW).

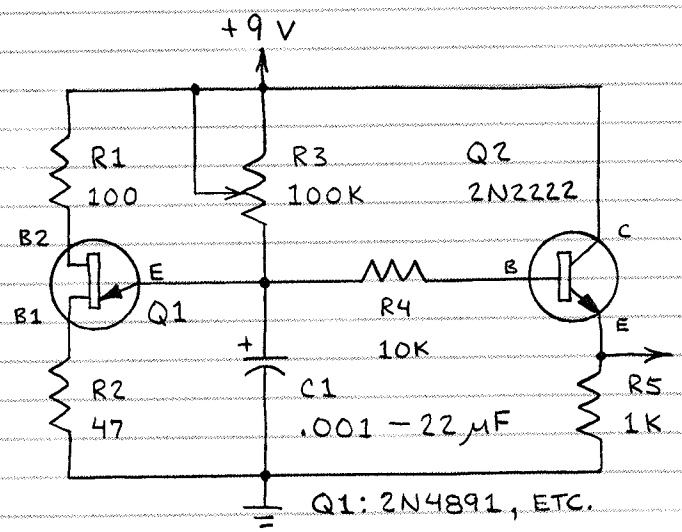
☐ ORGAN



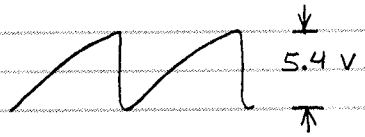
R	VALUE	FREQUENCY
R1	10K	5806 HZ
R2	15K	3988 HZ
R3	22K	2956 HZ
R4	33K	1984 HZ
R5	47K	1393 HZ
R6	68K	941 HZ
R7	100K	583 HZ
R8	150K	430 HZ

TABLE SHOWS TYPICAL FREQUENCIES. CHANGE C1 TO ALTER THE OVERALL FREQUENCY RANGE.

☐ RAMP GENERATOR

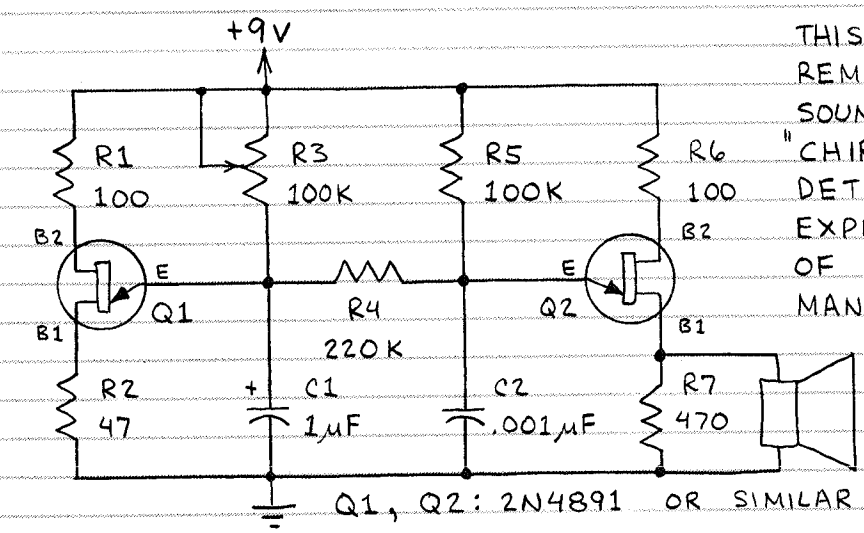


Q2 SAMPLES THE VOLTAGE ON C1 AND OUTPUTS IT AS A RAMP (OR "SAWTOOTH" WAVE). R3 CONTROLS THE RATE AT WHICH RAMPS ARE PRODUCED.



RAMPS SUPPLY GRADUALLY INCREASING VOLTAGE TO MANY KINDS OF CIRCUITS.

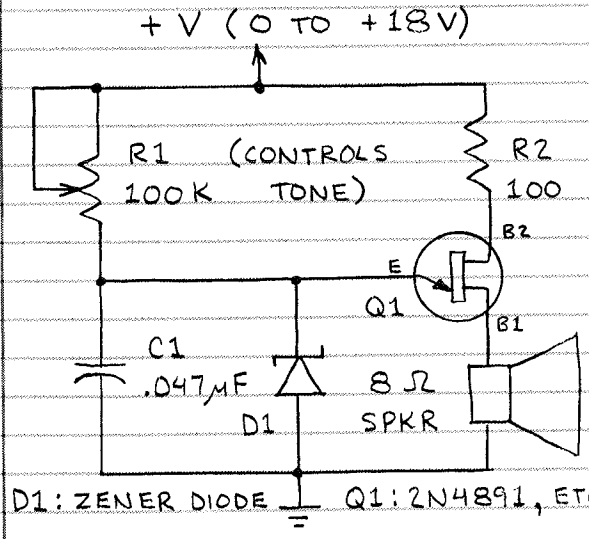
☐ CHIRP GENERATOR



THIS CIRCUIT PRODUCES A REMARKABLE VARIETY OF SOUNDS. AS SHOWN, IT "CHIRPS" AT A RATE DETERMINED BY R3. EXPERIMENT WITH VALUES OF C1, R5 AND C2 FOR MANY OTHER EFFECTS.

PIEZO TWEETER SPEAKER

☐ VOLTAGE SENSITIVE OSCILLATOR



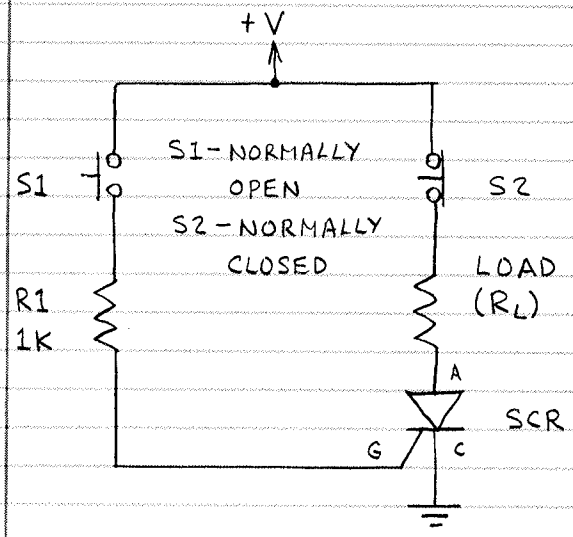
THIS CIRCUIT SOUNDS A TONE WHEN V_{IN} IS BELOW V_Z OF D1. SELECT V_Z OF D1 FOR DESIRED TURN-OFF LEVEL. THIS CIRCUIT CAN BE USED TO INDICATE WHEN VOLTAGE OF A BATTERY (WHICH CAN BE POWERING ANOTHER CIRCUIT) FALLS BELOW A CERTAIN LEVEL. THIS IS AN EXCELLENT EXAMPLE OF A SIMPLE, YET SOPHISTICATED, CIRCUIT.

THYRISTOR CIRCUITS

SILICON CONTROLLED RECTIFIERS AND TRIACS HAVE MANY APPLICATIONS AS SOLID-STATE SWITCHES.

SCR CIRCUITS

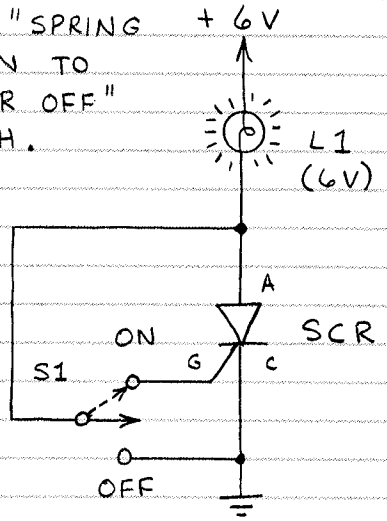
☐ LATCHING SWITCH



CLOSE S1 TO TURN ON THE SCR AND SUPPLY CURRENT TO THE LOAD. THE SCR WILL REMAIN ON AFTER S1 IS OPENED UNLESS THE LOAD IS A DC MOTOR OR UNTIL S2 IS BRIEFLY OPENED.

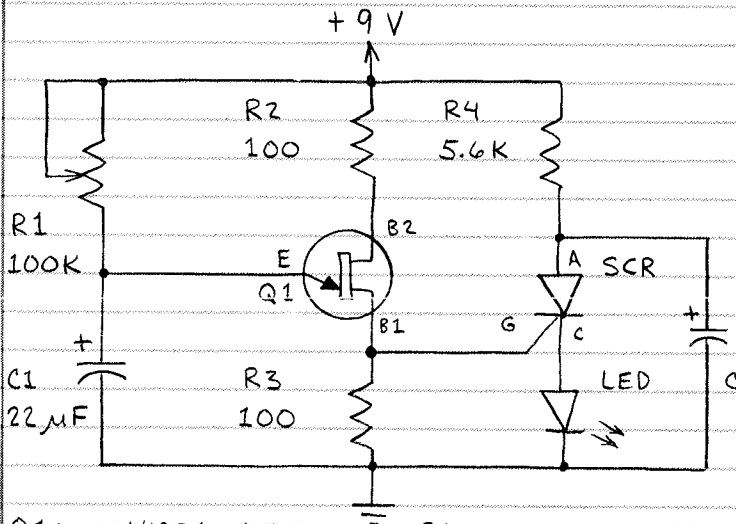
☐ TEST CIRCUIT

S1 IS "SPRING RETURN TO CENTER OFF" SWITCH.



S1 IS AN SPDT SWITCH. IN THE "ON" POSITION, THE SCR IS TURNED ON AND THE LAMP GLOWS. IN THE "OFF" POSITION, CURRENT IS SHUNTED AWAY FROM SCR, THUS TURNING IT OFF.

☐ CAPACITOR DISCHARGE LED FLASHER



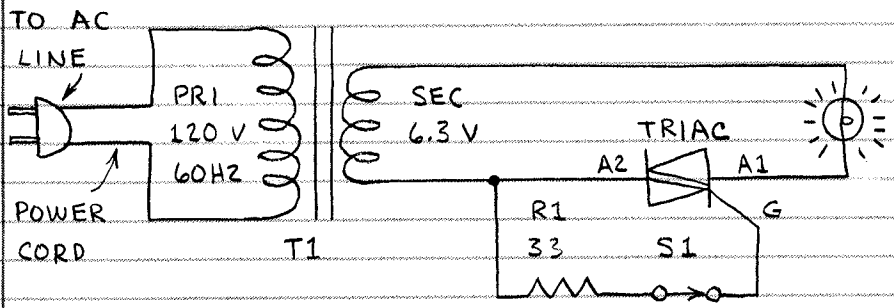
Q1: 2N4891 UJT

R1 CONTROLS RATE.

WHEN THE SCR IS OFF, C2 CHARGES THROUGH R4. WHEN THE SCR IS TURNED ON BY A PULSE FROM UJT Q1, THE CHARGE IN C1 IS RAPIDLY "DUMPED" THROUGH THE LED. THE SCR (AND LED) THEN TURNS OFF SINCE THERE IS NO LONGER SUFFICIENT HOLDING CURRENT. THE CYCLE THEN REPEATS.

TRIAC CIRCUITS

☐ TEST CIRCUIT

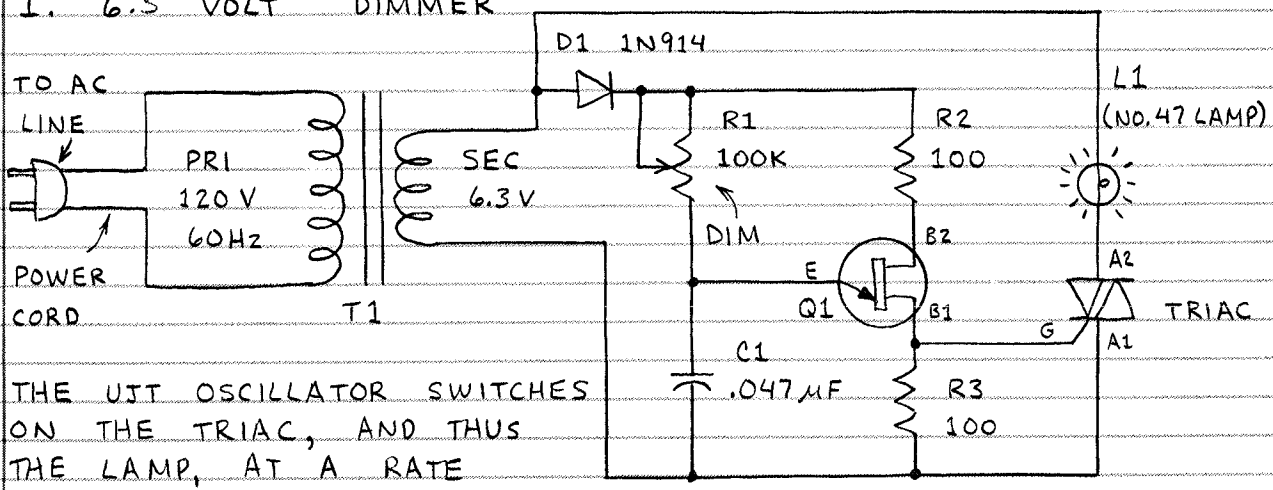


L1 GLOWS WHEN S1 IS CLOSED. L1 DOES NOT GLOW WHEN S1 IS OPEN.

CAUTION:
TRIACS ARE DESIGNED SPECIFICALLY FOR AC OPERATION. BE SURE TO OBSERVE COMMON SENSE SAFETY WHEN WORKING WITH HOUSEHOLD LINE CURRENT! MAKE SURE ALL CONNECTIONS TO AC LINE ARE INSULATED OR ENCLOSED.

☐ LIGHT DIMMER CIRCUITS

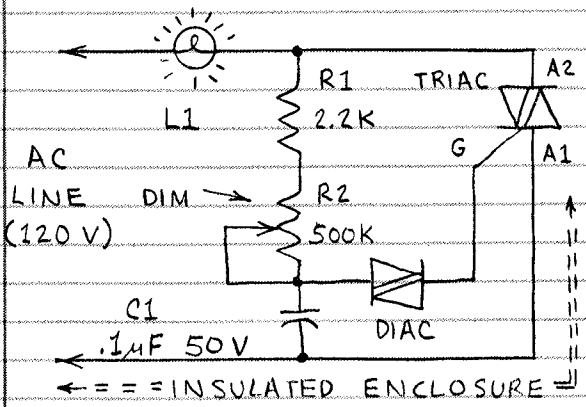
1. 6.3 VOLT DIMMER



THE UJT OSCILLATOR SWITCHES ON THE TRIAC, AND THUS THE LAMP, AT A RATE CONTROLLED BY R1.

Q1: 2N4891 OR SIMILAR UJT.

2. 120 VOLT DIMMER

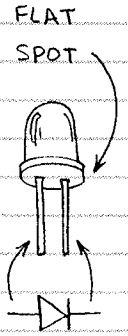


THIS IS HOW MANY HOUSEHOLD DIMMER SWITCHES ARE MADE. L1 CAN BE UP TO 100 WATT (120 VOLT) LAMP. USE HEAT SINK ON TRIAC IF IT BECOMES HOT. THE DIAC IS A BIDIRECTIONAL TRIGGER DIODE.
CAUTION: THIS CIRCUIT MUST BE FULLY ENCLOSED AT ALL TIMES WHEN POWER IS APPLIED!

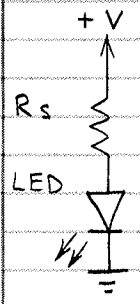
PHOTONIC CIRCUITS

CIRCUITS USING PHOTONIC COMPONENTS ARE AMONG THE MOST VERSATILE AND INTERESTING OF ALL CIRCUITS.

LIGHT EMITTING DIODE (LED) CIRCUITS



☐ LED DRIVE CIRCUIT

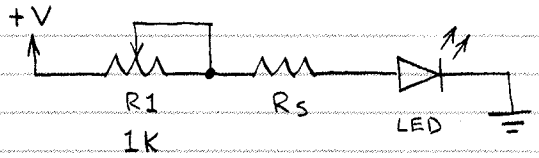


A SERIES RESISTOR MUST BE USED TO LIMIT CURRENT THROUGH AN LED. (EXCEPTIONS: CERTAIN PULSE CIRCUITS AND IC LED DRIVERS.)

$$R_S = \frac{+V - (V_{LED})}{I_{LED}}$$

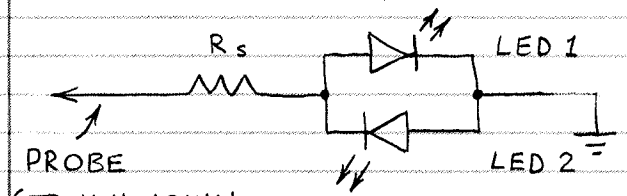
EXAMPLE: ASSUME YOU WANT TO OPERATE A RED LED AT A FORWARD CURRENT (I_{LED}) OF 10 MA (OR 0.01 AMPERE) FROM A 5 VOLT SUPPLY. THE DATA SHEET FOR THE LED LISTS AN LED VOLTAGE (V_{LED}) OF 1.7 VOLTS. THEREFORE R_S IS (5-1.7)/.01 OR 330 OHMS.

☐ VARIABLE BRIGHTNESS LED



ADJUST R1 TO ALTER CURRENT THROUGH THE LED, THUS VARYING ITS BRIGHTNESS. R_S MUST BE USED (SEE ABOVE).

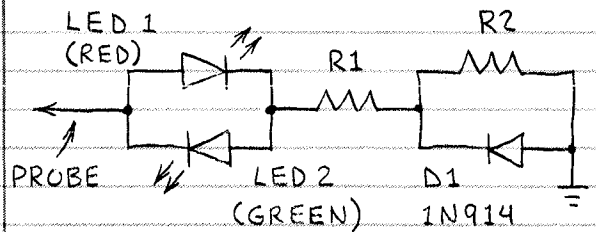
☐ POLARITY INDICATOR



THIS CIRCUIT INDICATES THE POLARITY OF A VOLTAGE. R_S MUST BE USED (SEE ABOVE).

LED	+	−	AC (±)
1	ON	OFF	ON
2	OFF	ON	ON

☐ TRI-STATE POLARITY INDICATOR



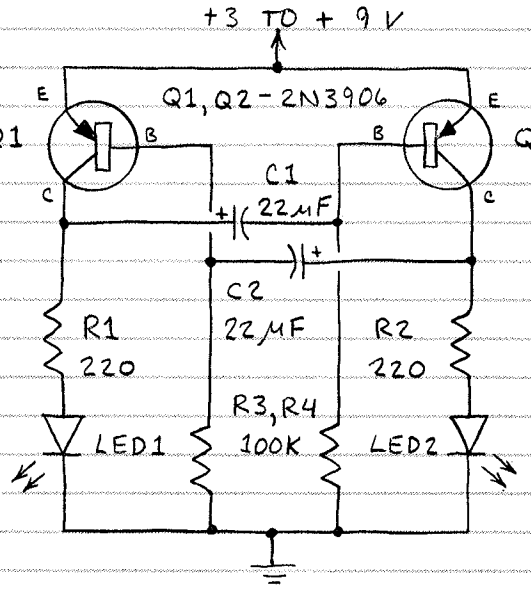
THIS IS A MORE COLORFUL VERSION OF THE CIRCUIT ABOVE.

V_{IN}	COLOR
+	RED
−	GREEN
AC (±)	YELLOW*

$$R1 = \frac{V_{IN} - (V_{LED2} + 0.6)}{I_{LED2}} \qquad R1 + R2 = \frac{V_{IN} - V_{LED1}}{I_{LED1}}$$

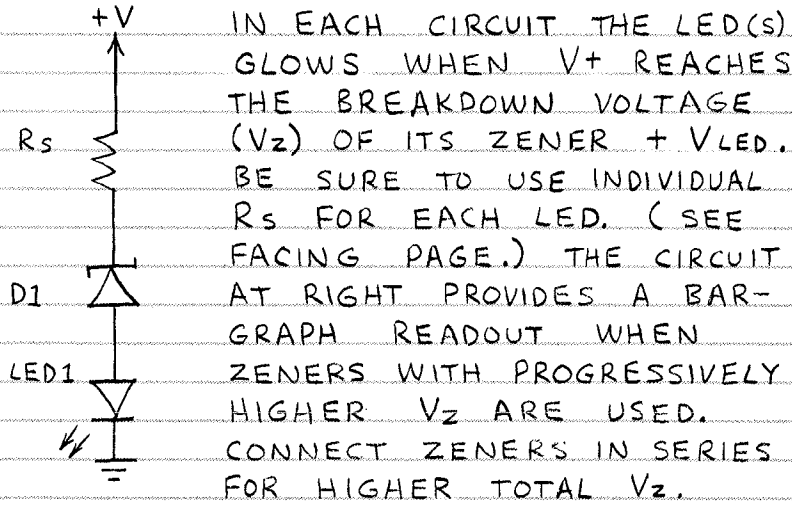
* WHEN TWO-CHIP LED USED.

☐ DUAL LED FLASHER



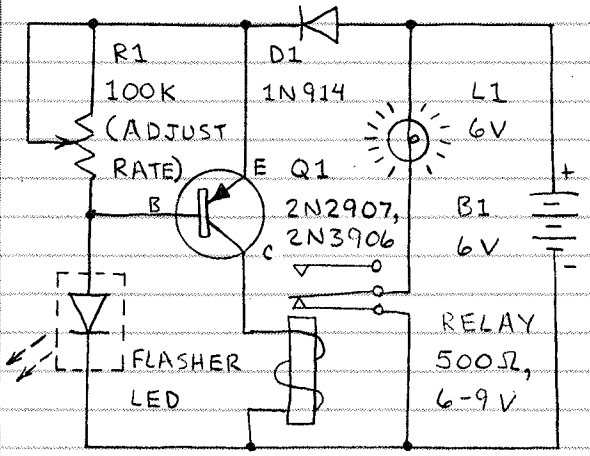
THIS CIRCUIT IS CALLED A FREE-RUNNING MULTIVIBRATOR. IT'S IDENTICAL TO A FLIP-FLOP THAT TRIGGERS ITSELF REPEATEDLY. Q1 AND Q2 ARE GENERAL PURPOSE PNP TRANSISTORS (2N3906, 2N2907, ETC.). R1 AND R2 LIMIT THE CURRENT TO THE LEDs (WHICH FLASH ALTERNATELY). INCREASING THE VALUES OF C1 AND C2 WILL SLOW THE FLASH RATE.

☐ VOLTAGE LEVEL INDICATOR



IN EACH CIRCUIT THE LED(s) GLOWS WHEN V+ REACHES THE BREAKDOWN VOLTAGE (V_Z) OF ITS ZENER + V_{LED}. BE SURE TO USE INDIVIDUAL Rs FOR EACH LED. (SEE FACING PAGE.) THE CIRCUIT AT RIGHT PROVIDES A BAR-GRAPH READOUT WHEN ZENERS WITH PROGRESSIVELY HIGHER V_Z ARE USED. CONNECT ZENERS IN SERIES FOR HIGHER TOTAL V_Z.

☐ FLASHER LED + RELAY

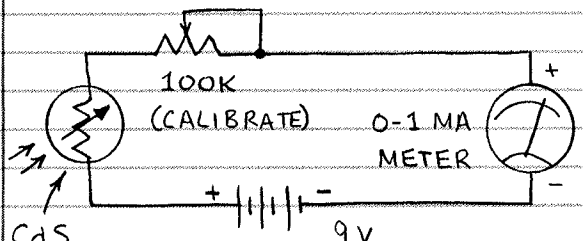


THE FLASHER LED INCLUDES A BUILT-IN IC THAT FLASHES THE LED SEVERAL TIMES EACH SECOND. THIS CIRCUIT SHOWS HOW TO "TAP" THIS FLASH RATE (VIA Q1) TO FORM AN ULTRA-SIMPLE PULSE GENERATOR THAT ACTUATES A RELAY AND, IN TURN, A LAMP. D1 IS NEEDED TO KEEP THE VOLTAGE TO THE FLASHER LED NEAR 5 VOLTS.

SEMICONDUCTOR LIGHT DETECTOR CIRCUITS

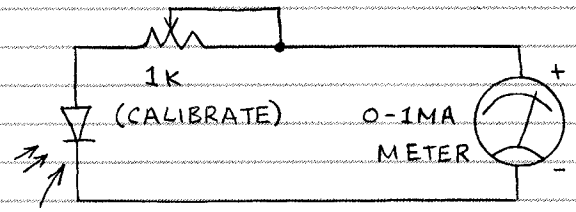
☐ LIGHT METER CIRCUITS

1. PHOTORESISTOR



CdS PHOTORESISTOR

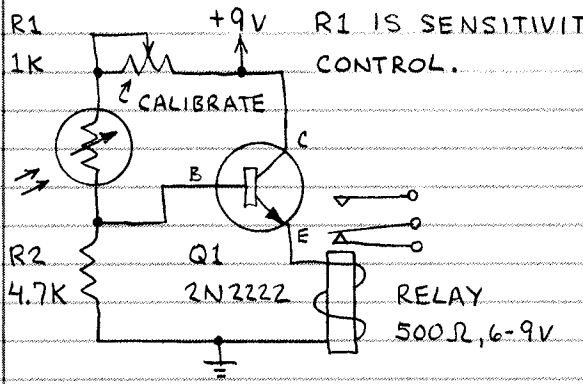
2. SOLAR CELL



SOLAR CELL (OR PHOTODIODE OR PHOTOTRANSISTOR COLLECTOR - BASE)

☐ LIGHT ACTUATED RELAY CIRCUITS

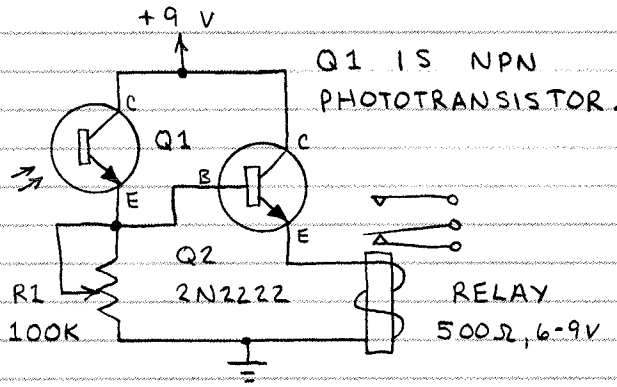
1. PHOTORESISTOR



R1 IS SENSITIVITY CONTROL.

RELAY REMAINS ACTUATED FOR BRIEF TIME AFTER LIGHT REMOVED.

2. PHOTOTRANSISTOR

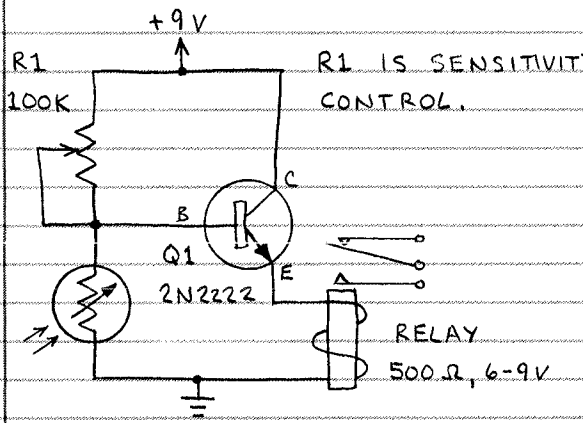


Q1 IS NPN PHOTOTRANSISTOR.

RESPONDS FASTER THAN PHOTORESISTOR CIRCUIT. NO DELAY WHEN LIGHT IS REMOVED.

☐ LIGHT DEACTUATED RELAY CIRCUITS

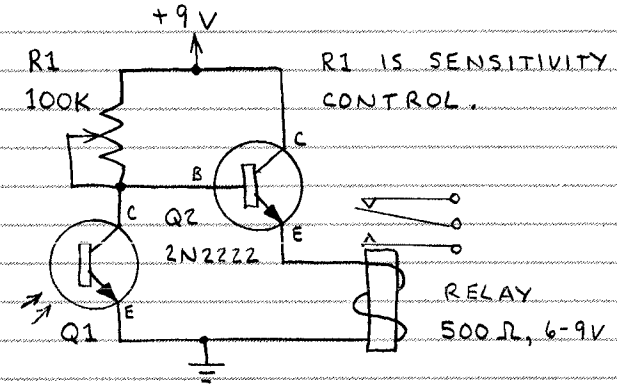
1. PHOTORESISTOR



R1 IS SENSITIVITY CONTROL.

RELAY IS ACTUATED ONLY WHEN THE PHOTORESISTOR IS DARK.

2. PHOTO TRANSISTOR



R1 IS SENSITIVITY CONTROL.

RELAY IS ACTUATED WHEN Q1 IS DARK. LIGHT ON Q1 DEACTUATES RELAY. CALIBRATE WITH R1.