MOTOROLA HEP® Semiconductors

TIPS ON USING LED'S

LED's (Light Emitting Diodes) are electronic marvels that are truly "State-of-the-Art" and will prove to be the "Light-of-the-Future"

Fun for everyone. Projects to amuse and amaze.

6 PROJECTS

- Blinker Circuit
- Roulette Wheel
- Electronic Dice
- "Sex Appeal" Indicator
- Tic-tac-toe
- Battery Voltage Monitor
- LED Tester

Plus design guides

Scientific break-throughs are almost becoming an everyday part of life in the enchanting world of semiconductor electronics. Yet virtually all of these break-throughs are encapsulated in plastic or metal cases that are in turn buried deeply inside a radio, TV, test unit, or a complex computer. Finally a semiconductor phenomena has been discovered whereby a visible light is produced at the anode-cathode junction (invisible infrared devices are also available). These devices are called Light Emitting Diodes (LED's) and it is fairly safe to assume that devices of this type will eventually replace many of the light sources that are in general use today (both filament – and gas-type bulbs).

There is both good news (advantages) as well as bad news (disadvantages) to the LED'S that are readily available today. First, the good news: LED's consume very little power, will operate with either dc or ac (square-wave or sine-wave), generate very little heat, have extremely fast turn-on/turn-off time (no time lag required for a filament to warm up or cool down), no high-voltage supply is required (LED's operate in the 2 volt area), are compatible with IC's, very high reliability, ultra long life (should operate a minimum of 10^6 hours, or in excess of 100 years), are now available at realistic prices for the hobbyist experimenter. Now, the bad news: LED's are available only in red, green, and amber colors (it is anticipated that at some future date all colors plus white will be produced), light output is still limited to low-light applications, extreme care *must* be exercised during soldering (see SOLDERING CAUTION NOTE).

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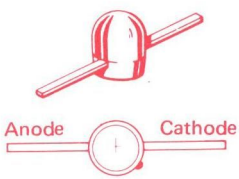
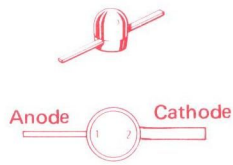
While the HEP HEK-6 kit contains the P2004 LED, any of the other HEP LED's can be used in the circuits presented in this brochure. Figure 1 shows the different case styles and physical sizes of the available HEP LED's.



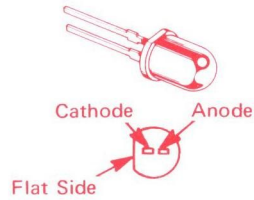
(Cathode identified by small plastic protrusion)

Case 171
HEP P2000
HEP P2003



(Cathode identified by larger lead)

Case 234-02
HEP P2001
HEP P2004



(Cathode identified by flat on side of case)

Case 279
HEP P2005

Figure 1

Figure 2 shows the typical voltage operating range of the HEP LED's.

Figure 2

Figure 3 presents the maximum ratings for each HEP LED.

HEP Type No.	Reverse Voltage V_R (Volts)	Forward Current I_F (mA)	Power Dissipation P_D (mW)	Brightness f_L (Typical)	Case
P2000	4.0	50	100	450	171
P2001	3.0	40	120	750	234-02
P2003	4.0	50	100	50	171
P2004	4.0	20	120	750	234-02
P2005	4.0	60	100	—	279

Figure 3

LED's operate at approximately 1.6 to 2.5 volts with a current not to exceed the maximum device rating. Application of too great a voltage and/or current can result in permanent dimming or burn-out of the LED. Until such time as thorough familiarity and experience are attained with using LED's it is recommended that the circuit components and design be optimized by using a resistor in place of the LED. Figure 4 shows a very simple method of testing and optimizing a typical circuit. By substituting a 39Ω resistor in place of the LED and measuring the voltage drop across the resistor the proper value for the current-limiting resistor can be selected for any value of supply voltage. It should be noted that in most cases 15 to 20 mA will produce sufficient illumination for most purposes.

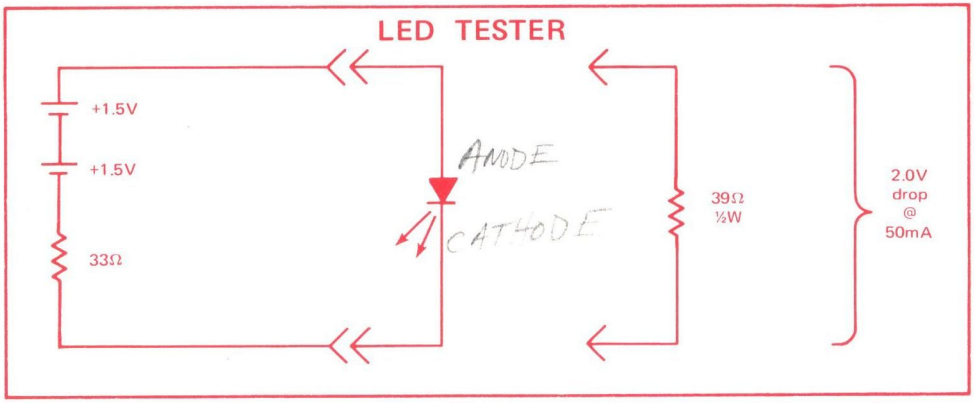


Figure 4

In the folowing pages several interesting as well as practical circuits are presented using the HEP LED's. Any of the HEP devices may be used in these circuits at the builders discretion. It should be borne in mind that these circuits are basically "idea-starters" and that the many and varied uses to which LED's can be adapted are extremely multitudinous.

One of the most popular and useful items in present-day electronic hobby-experimenter projects is the seven-segment readout. Figure 5 shows how a very practical seven-segment readout can be constructed using LED's. Note that the illustration is enlarged several times and that the final physical size and configuration is left up to the builder. Also note that the readout presented here uses 2 LED's connected in series to form each segment, however, any number of LED's may be used. Figure 5a shows the industry-standard alphabetical callouts for each segment. Figure 5b shows the actual layout and Figure 5c shows the schematic diagram. The circuit shown here uses the common-anode configuration, however the common-cathode configuration can be constructed by merely reversing the diodes.

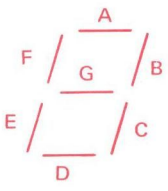


Figure 5a

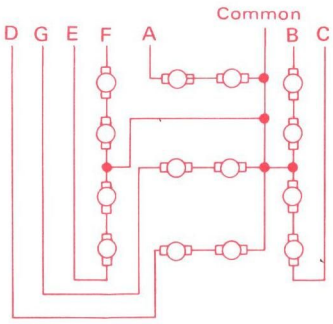


Figure 5b

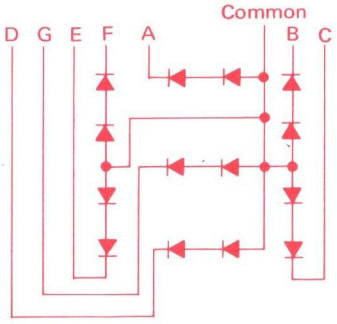
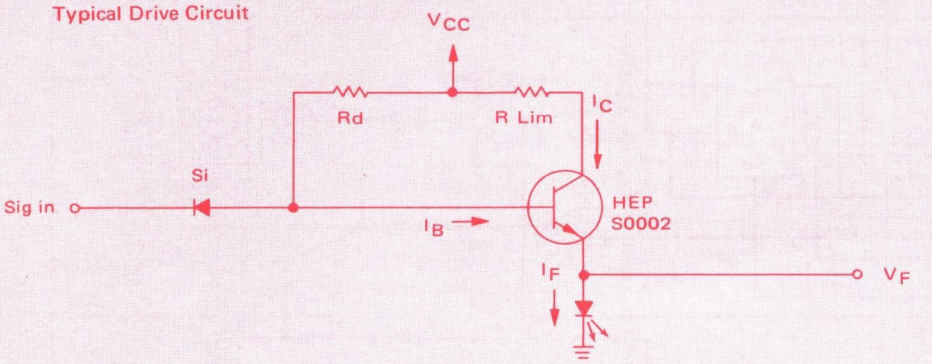


Figure 5c

SOLDERING CAUTION NOTE – Since most LED's utilize a type of plastic case that is sensitive to heat it is imperative that a low-heat pencil-type soldering iron (20 watt, recommended) be used. Also, adequate heat-sinking should be provided between the LED and the solder point during the actual soldering process. Excessive heat can permanently destroy the LED junction.

DESIGN GUIDE

Typical Drive Circuit



$$R\ Lim = \frac{V_{CC} - V_F - 0.3}{I_C}$$

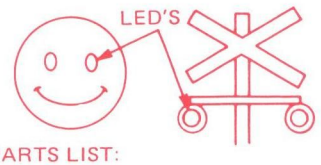
$$R_d = \frac{(V_{CC} - V_F - 0.8)\ (\beta)}{I_F}$$

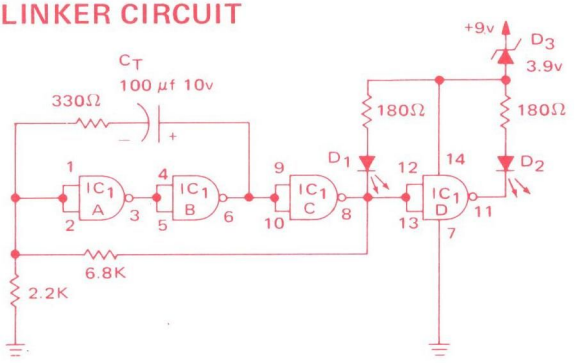
$$I_F = I_C + I_B$$

BLINKER CIRCUIT

FEATURES:

- Compact Size with applications such as a Railroad crossing sign or a Happy Face
- IC reliability
- Blinking Rate controlled by one Capacitor





PARTS LIST:

IC_1	– 1 –	TTL Dual Input Quad NAND Gate HEP C3000
D_1&D_2	– 2 –	Light Emitting Diode HEP P2004
D_3	– 1 –	Zener Diode 3.9v HEP Z0403
	2 –	Resistor 180Ω ¼ or ½ watt
	1 –	Resistor 330Ω ¼ or ½ watt
	1 –	Resistor 2.2kΩ ¼ or ½ watt
	1 –	Resistor 6.8kΩ ¼ or ½ watt
	1 –	Capacitor 100µf 10v
	1 –	9 volt Battery

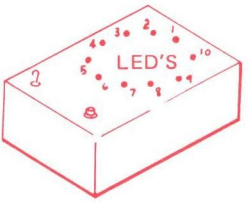
Design Guide Blink Rate

To Change Blinking Rate:
Approximate Value for C_T:

$$C_T = \frac{T_D}{3 \times 10^3}$$

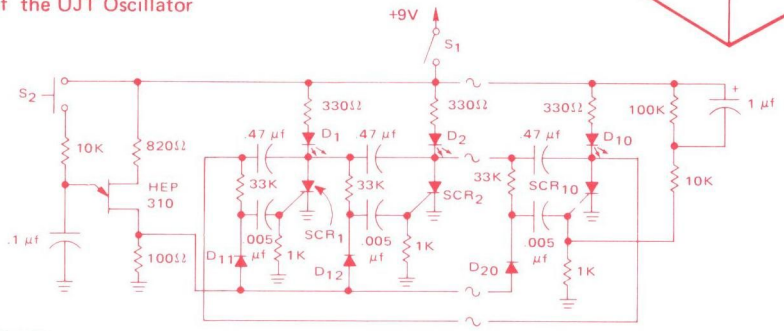
Where C_T = Timing Capacitor
T_D = On time of one LED

ROULETTE WHEEL



FEATURES:

- Sequential chaser Circuit has many Applications
- Segments may be added or subtracted to suit specific applications
- Speed of operation may be varied by changing the frequency of the UJT Oscillator



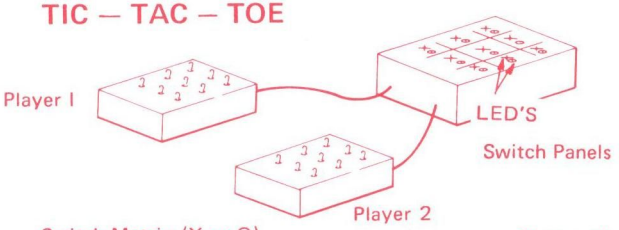
PARTS LIST:

$SCR_1 - SCR_{10}$	10 —	Thyristor HEP R1001
	1 —	Unijunction Transistor HEP 310
$D_1 - D_{10}$ —	10 —	Light Emitting Diode HEP P2004
$D_{11} - D_{20}$ —	10 —	Silicon diode HEP R0050
	1 —	Resistor 100Ω ¼ or ½ Watt
	10 —	Resistor 330Ω ¼ or ½ Watt
	1 —	Resistor 820Ω ¼ or ½ Watt
	10 —	Resistor 1KΩ ¼ or ½ Watt
	2 —	Resistor 10KΩ ¼ or ½ Watt
	10 —	Resistor 33KΩ ¼ or ½ Watt
	1 —	Resistor 100KΩ ¼ or ½ Watt
	10 —	Capacitor 0.005 μf 15v
	10 —	Capacitor 0.47 μf 15v
	1 —	Capacitor 0.1 μf 10v
	1 —	Capacitor 1 μf 15v
S_1 —	1 —	Switch SPST
S_2 —	1 —	Switch — pushbutton SPST
	1 —	9 volt Battery

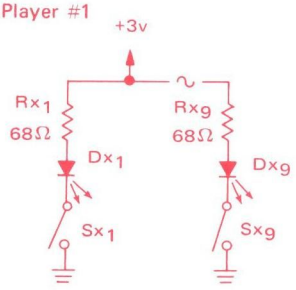
TIC — TAC — TOE

FEATURES:

- Easy to build
- Fun to use



Player #1



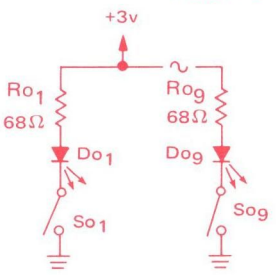
Switch Matrix (X or O)

1	2	3
4	5	6
7	8	9

Board Matrix

$X_1\ O_1$	$X_2\ O_2$	$X_3\ O_3$
$X_4\ O_4$	$X_5\ O_5$	$X_6\ O_6$
$X_7\ O_7$	$X_8\ O_8$	$X_9\ O_9$

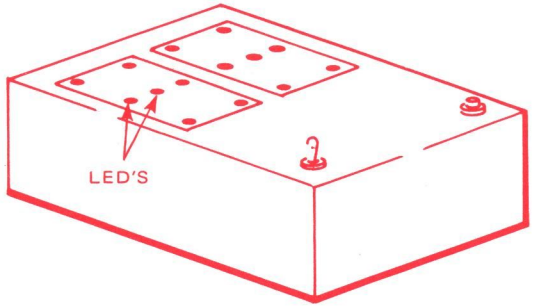
Player #2

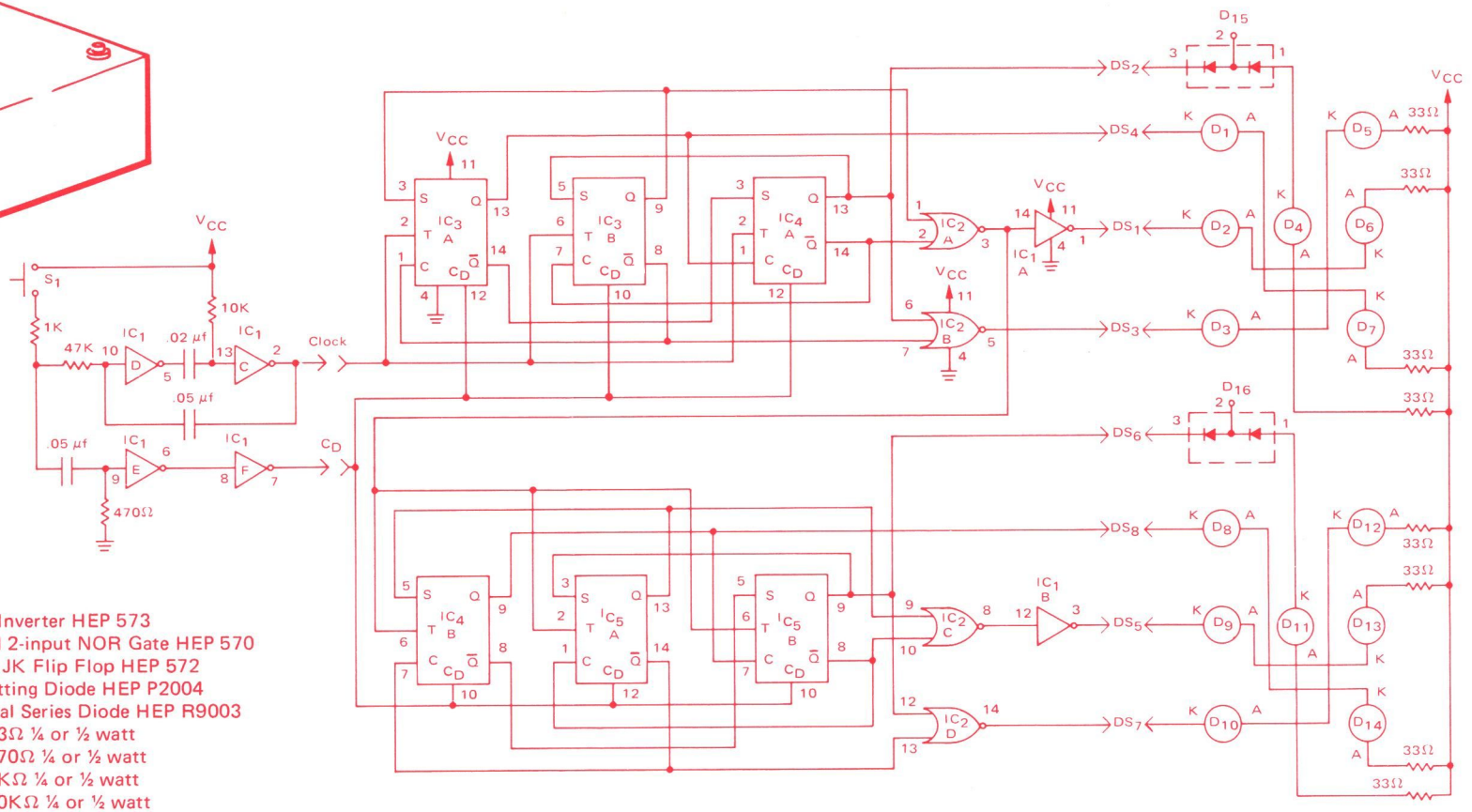


PARTS LIST:

$Dx_1 - Dx_9$ & $Do_1 - Do_9$ —	18 —	Light Emitting Diode HEP P2004
$Rx_1 - Rx_9$ & $Ro_1 - Ro_9$ —	18 —	Resistor 68Ω ¼ or ½ watt
$Sx_1 - Sx_9$ & $So_1 - So_9$ —	18 —	Toggle Switch SPST
	2 —	1.5 volt "D" Cells

ELECTRONIC DICE

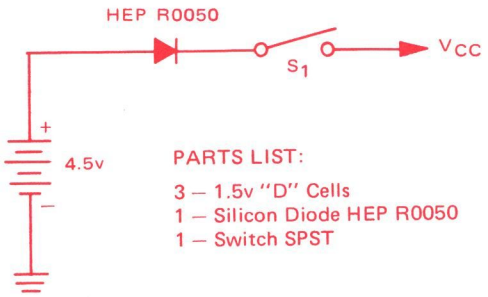




PARTS LIST FOR LED DICE:

IC_1	– 1	–	RTL Hex Inverter HEP 573
IC_2	– 1	–	RTL Quad 2-input NOR Gate HEP 570
$IC_3 - IC_5$	– 3	–	RTL Dual JK Flip Flop HEP 572
$D_1 - D_{14}$	– 14	–	Light Emitting Diode HEP P2004
$D_{15} - D_{16}$	– 2	–	Silicon Dual Series Diode HEP R9003
	8	–	Resistor 33Ω ¼ or ½ watt
	1	–	Resistor 470Ω ¼ or ½ watt
	1	–	Resistor 1KΩ ¼ or ½ watt
	1	–	Resistor 10KΩ ¼ or ½ watt
	1	–	Resistor 47KΩ ¼ or ½ watt
	1	–	Capacitor 0.02 µf 50v Calectro A1-030
	2	–	Capacitor 0.05 µf 50v Calectro A1-031
S1 –	1	–	Switch, Push button SPST Calectro E2-140

Battery Power Source:



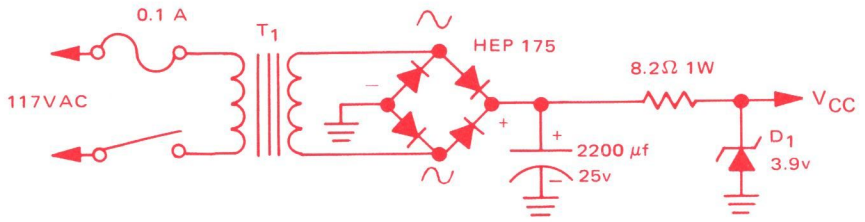
PARTS LIST:

3 – 1.5v "D" Cells
1 – Silicon Diode HEP R0050
1 – Switch SPST

PARTS LIST:

	1	–	Full Wave Bridge HEP 175
D_1 –	1	–	Zener diode 3.9v HEP Z0403
	1	–	Resistor 8.2Ω 1W
	1	–	Capacitor 2200 µf 25v (Calectro A1-134)
	1	–	Switch SPST
	1	–	0.1 A Fuse
	1	–	Transformer 117v to 6.3v (Calectro D1-745)

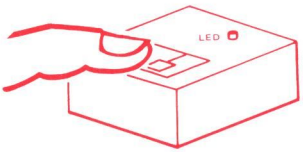
AC Power Source:

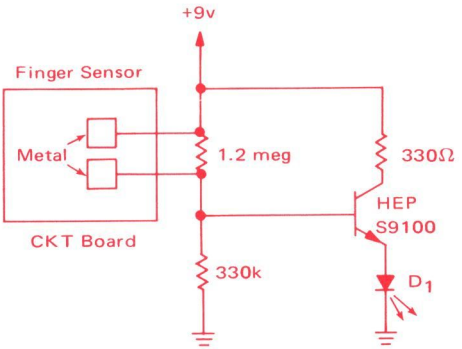


SEX APPEAL INDICATOR

FEATURES:

- Light and Compact
- Portable
- Negligible Battery drain when not in Operation





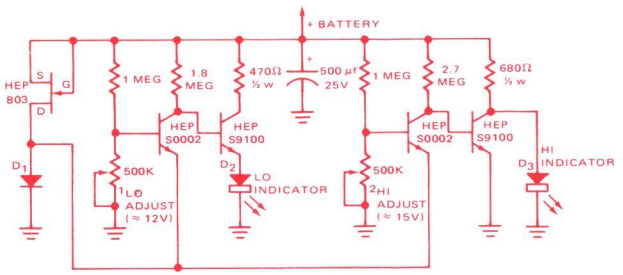
PARTS LIST:

- 1 — Darlington Transistor HEP S9100
- D_1 — 1 — Light Emitting Diode HEP P2004
- 1 — Resistor 330Ω ¼ or ½ watt
- 1 — Resistor 330kΩ ¼ or ½ watt
- 1 — Resistor 1.2 meg ¼ or ½ watt
- 1 — Finger Size Circuit Board with two metal Sensors
- 1 — 9 volt Battery

BATTERY VOLTAGE MONITOR

FEATURES:

- Indicates if battery voltage is too high, resulting from voltage regulator failure
- Indicates if battery voltage is too low, resulting from large current demands on the charging system
- Both Indicators are adjustable to cover various needs



NOTE:

1. SET LO ADJUST SO D_2 LIGHTS WHEN BATTERY VOLTAGE FALLS BELOW 12V.
2. SET HI ADJUST SO D_3 LIGHTS WHEN BATTERY VOLTAGE IS GREATER THAN 15V.

PARTS LIST:

- 1 — P-Channel FET HEP 803
- 2 — Silicon Transistor HEP S0002
- 2 — Darlington Transistor HEP S9100
- D_1 — 1 — Silicon Diode HEP R0050
- D_2 & D_3 — 2 — Light Emitting Diode HEP P2004
- 2 — Resistor 1 meg ¼ or ½ watt
- 1 — Resistor 1.8 meg ¼ or ½ watt
- 1 — Resistor 2.7 meg ¼ or ½ watt
- 1 — Resistor 470Ω ½ watt
- 1 — Resistor 680Ω ½ watt
- 2 — Variable Resistor 500K (Calectro B1-648)
- 1 — Capacitor 500 µf 25V