Educational Project Pack
Design Brief

KI0007EP

BICYCLE TAIL LIGHT
LED FLASHER PROJECT

Curriculum & Standards Framework Systems (Producing) Level 5.

At the completion of this project a student will be able to:
- Plan and carry out a production process according to instructions, with minimum waste materials
- Test the operation of the project and develop it as a part of a system

Tekky Kit

Designed and Supplied by

tekky .com.au

ElectroTech Brands Pty Ltd

www.electrotechbrands.com.au

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Brief description of circuit operation.

This is a relatively simple project aimed at year 9-10 students. The student will end up with a very professional finish at a cost under half the retail price of an equivalent commercial product.

The unit has been designed so as to meet the requirements of the various state laws. It couples a continuous light with flashing lights, and is visible across a full 180°, with maximum intensity to the rear. It is visible from the rear for up to 500m in most conditions.

HOW IT WORKS

The KI0007 LED flasher kit circuit can be divided up into four sections. The sections are identified on the circuit diagram above and are outlined as follows:

Section 1 – This is the power supply and consists of two "AAA" 1.5V batteries connected in series to give a total supply voltage of 3 Volts DC.

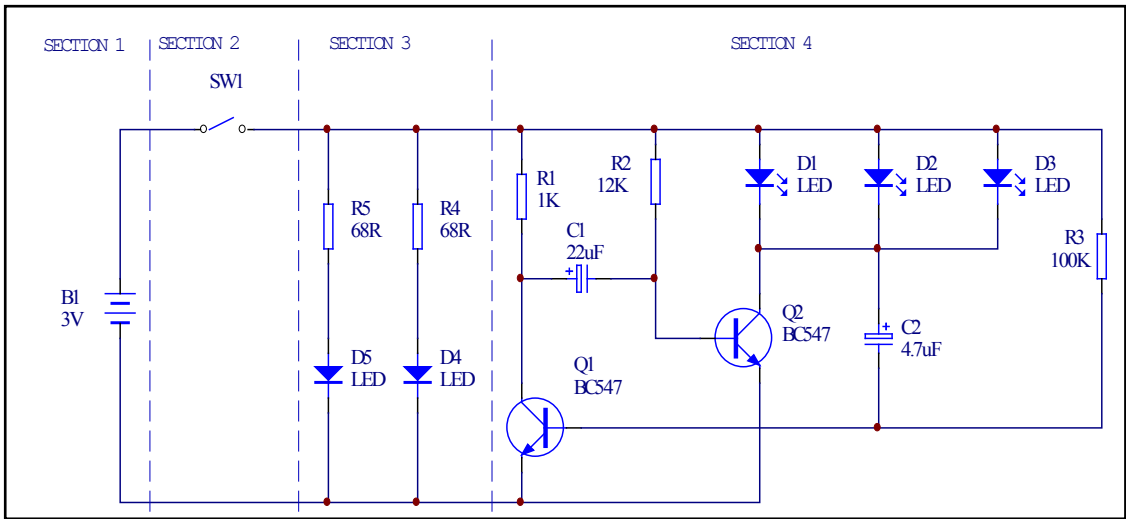
Section 2 – This section simply contains the on/off switch which controls the application of the power supply to the rest of the circuit.

Section 3 – This section has two Ultra Bright red LED's, D4 & D5, that are continuously on when power is supplied.

Section 4 – This section is an oscillator circuit which causes three Ultra Bright red LED's to flash at a fixed rate. (approx 4 times/sec) When the LED's are on Q1 will be turned off and Q2 will be turned on. The LED's stay on for approx 70msecs. When the LED's are off Q1 will be turned on and Q2 will turn off. The LED's stay off for approx 175msec. The students are required to make their own PCB (Printed Circuit Board). PCB material is not provided in the kit. The tail light housing also requires some preparation work and the students will need to design and make their own bracket for attaching the unit to their bikes.

The full kit of components is supplied excluding the PCB, batteries, and material for the mounting bracket.

It is expected that this project will take the student approx 5 double periods to complete.



The KI0007 Flasher Kit provides a very professional finish at a very low cost.

Pre-construction Assignment.

Name_____ Date_____ Yr Level_____

Brief Description:
In your own words explain the design considerations for this project. eg. The unit must be portable and therefore is required to be able to run off batteries.

List a minimum of 5 other design considerations:

1._____

2._____

3._____

4._____

5._____

Component Recognition:

1. RESISTORS

(a) In the circuit, R2 is listed as a 12K what does the K stand for?

_____

(b) The circuit contains the following resistors, write down the colours of the code for each resistor.

	BAND 1	BAND 2	BAND 3	BAND 4
R1 0.25W CARBON FILM 1K Ohm 5%				
R2 0.25W CARBON FILM 12K Ohm 5%				
R3 0.25W CARBON FILM 100K Ohm 5%				
R4, R5 0.25W CARBON FILM 68 Ohm 5%				

2. CAPACITORS

(a) Mark the + ve (positive) and the –ve (negative) leads on the electrolytic capacitor.

(b) The circuit contains a 4.7µF capacitor C2, how many nF would this be?

_____

_____

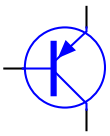
(c) The circuit runs off 3VDC, if the 4.7µF capacitor supplied was a 50V, would the circuit still work? Explain your answer.

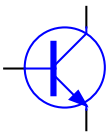
_____

_____

3. TRANSISTORS

(a) The following circuit drawings show the symbol for a NPN and PNP transistor, Label the NPN and PNP symbol and mark the emitter, base and collector with E, B, C.

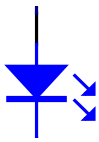




(b) On the photo of the BC547 transistor mark E, B, C, on the appropriate legs.

4. LIGHT EMITTING DIODES (LED's)

(a) On the photo and the symbol of the LED mark the anode and cathode with a & k, also mark the lead that connects to +ve supply.



READING THE CIRCUIT DIAGRAM:

1. (a) Looking at the circuit diagram below, explain in your own words what would happen if the wire to the switch SW1 was broken off at the switch.

_____

_____

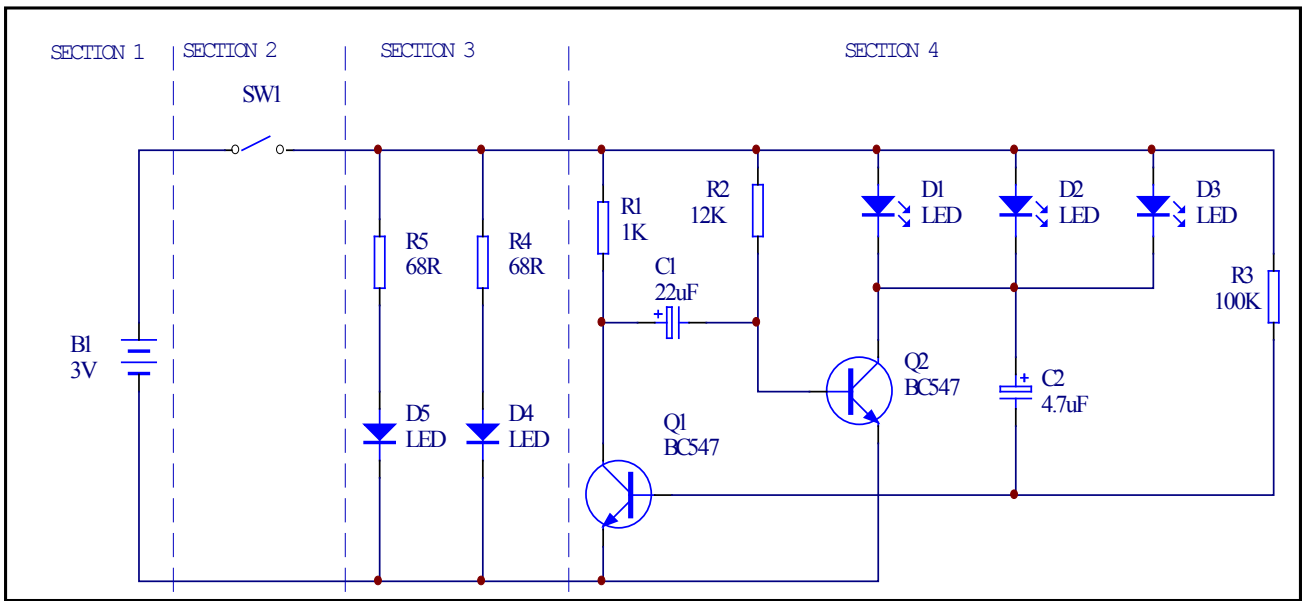
(b) A number of lines on the circuit cross each other. Some of these intersections have a solid dot on them and some don't. Explain the difference.

_____

_____

_____

(c) On the circuit diagram find the battery symbol and mark the negative and positive ends.



* Please hand this work into your teacher for evaluation before starting your project.

COMPONENT LIST

Semiconductors:	
BC547 NPN Transistors (Q1, Q2)	2
LED-SB/R 5mm Ultra Bright	5
Capacitors:	
22µF 25VW Electrolytic	1
4.7µF 50VW Electrolytic	1
Resistors:	
68R ¼W 5% Carbon Film	2
1K0 ¼W 5% Carbon Film	1
12K ¼W 5% Carbon Film	1
100K ¼W 5% Carbon Film	1
Miscellaneous:	
SW1831 PUSH ON – PUSH OFF SPST Switch	1
BA9145 2 x AAA Battery Holder	1
75mm L/D 7/0.16 Hook Up Wire (Yellow)	1
KI0008 Tail Light Case Assembly	1
AAA Batteries	2
NOT INCLUDED IN KIT:	
Single Sided PCB 70 x 25mm	1
Mounting Bracket Material	1

* Check your kit against the parts list and make sure you have all the parts.

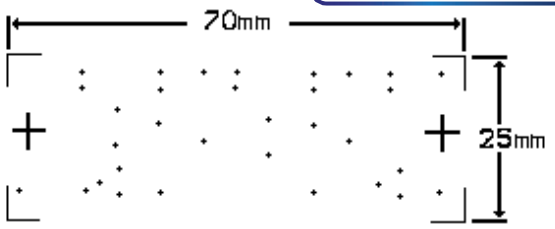


Fig 2. Hole Centre Map marks the centres of all the holes to be drilled in the PCB, from the copper side. (View is from the copper side) Scale 1:1

Fig 3. Hole Size Map shows a total of 34 holes. (View from copper side) 2 x size A = 1.00mm, 2 x size B = 5.0mm and 30 x size c = 0.8mm. (not to scale)

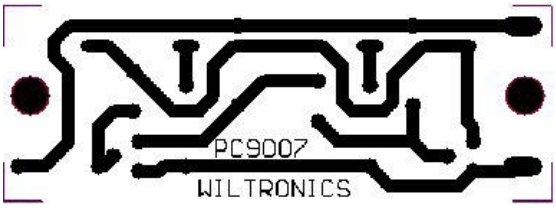


Fig 4. PCB track layout shows the track layout (View from the copper side) (not to scale)

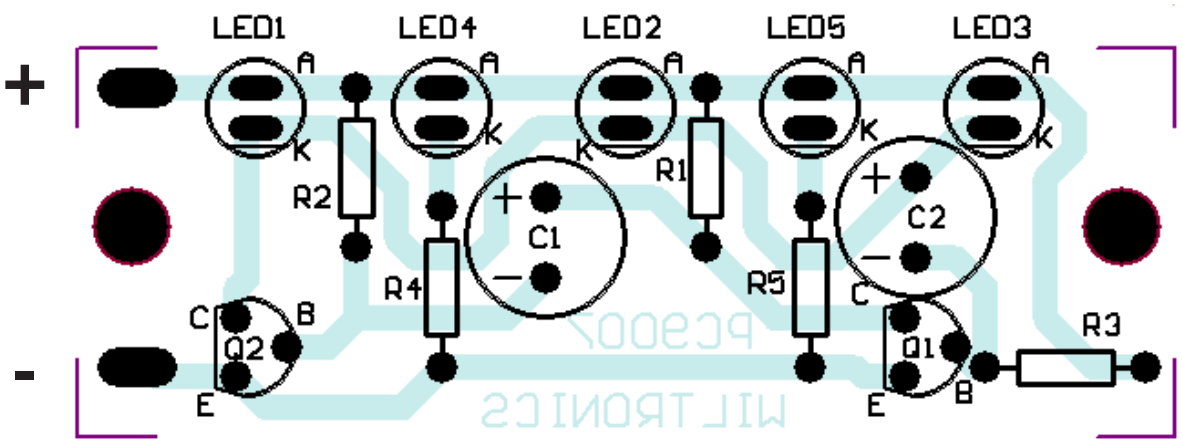
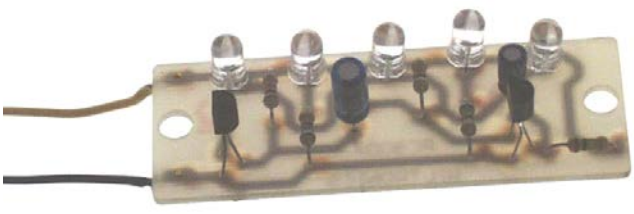


Fig 5. Component overlay shows the component positions and polarities with a view of the copper tracks from the component side of the PCB.

Photo shows a fully assembled Printed Circuit Board (PCB)



Making the PCB.

* Select a small piece of single sided PCB, larger than 70mm x 25mm.

* With a ruler and lead pencil mark out PCB size on the copper side.

* Cut out PCB, cutting on the outside of the lines.

* Using a sanding board, smooth up edges of PCB sanding down to the pencil line.

* Photocopy and cut out the "PCB Hole Centre Map" (Fig 2) and with sticky tape fix it to the copper side of the PCB.

* Using a fine centre punch or a small nail and a light weight hammer, punch a mark into the copper through the paper at each centre. Then remove the paper.

* Now mark the hole sizes, referring to the "Hole Size Map," (Fig 3) use a different coloured permanent marker to mark each hole with a hole size colour.

* Select the required drill bits, wearing safety glasses drill all the holes in the PCB from the copper side.

* Using (non soap) steel wool, thoroughly clean the copper surface. Be sure to remove all drill map ink marks.

* Referring to the PCB track layout (Fig 4) and using a Dalo pen or suitable permanent ink marker carefully draw the track layout onto the PCB. Make sure you complete each track, if you miss one connection your circuit will not work. Try not to get any finger marks onto the copper surface. If you make a mistake, clean off the entire surface with steel wool and start again.

* After a final inspection of the track layout your PCB should be ready to etch. We recommend the use of Ammonia Persulphate as an etching compound. This should be mixed according to the manufactures instructions. Always wear rubber gloves and safety glasses when working with etching compounds. For best results and fast etching your solution should be around 40°C. Hang or place PCB in etchant so that the copper is visible. You must watch your PCB and remove it from the etchant as soon as all the exposed copper has disappeared. If the PCB is left in the etchant too long it may etch through the ink and you would lose your tracks.

* Rinse the PCB in water to remove any remaining etchant.

* Clean the ink off the PCB with steel wool. Using a multimeter check the tracks for short circuits and open circuits. If any track work has been etched through this can be repaired by laying a fine piece of tinned copper wire across the break and soldering it to the track on each side. Be careful not to use too much heat as you can easily lift thin tracks off the fibreglass and cause more damage than what you were trying to fix.

* Apply a light coating of liquid flux on the copper track side of the PCB if you have flux available.

* Your PCB (Printed Circuit Board) should now be complete and ready to use.

ASSEMBLING THE PCB

This circuit is not overly complex so assembly should be quite straight forward.
Referring to the Component Overlay (Fig 5) load the resistors first, followed by the capacitors. Be sure to check the +ve and –ve on the capacitors are placed correctly. Now fit the 2 transistors, then the LED's. Check that you have the anode (a) and cathode (k) around the right way.
When soldering make sure you don't apply too much heat to the joint.
Now solder the black wire from the battery holder to the –ve battery position on the PCB.
Solder one end of the yellow wire into the switch wire position on the PCB.
If all looks okay, fit the batteries to the battery holder and the YELLOW wire from the PCB and short the ends together. The unit should be working, 2 LED's flashing. If your unit is working proceed to the next stage.

FAULT FINDING

Double check that all the components are in their correct positions and that the polarity on the capacitors, transistors and LED's are correct.
Inspect the solder side and make sure all solder joints are solid and shiny.
Check there is no solder bridges between pads or tracks.
When all looks okay, fit the batteries to the battery holder –ve (flat end of the batteries) to the coil springs.
Once the PCB is working, it should be ready to be fitted to the tail light assembly.

Preparing the Tail Light Assembly.

* Using a #1 head screw driver remove the lens from the base.

* Remove the mounting bolt and take out the lamp clip. The lamp clip can be discarded as it is not used in this project. Replace the mounting bolt, make sure the spring washer is fitted on the outside and goes on before the nut.

* We are going to mount the PCB between the screw posts in the base and the lens. The PCB is 1.6mm thick so the lens post needs to be shortened by this amount. The lens is made from a plastic which is quite brittle so care must be exercised. You will note that the lens posts protrude approximately 1.6mm below the rim of the lens. Place the lens on a sanding board. Holding the base of the lens square to the sanding board, carefully move the lens back and forth until the 2 posts are sanded off level with the lens rim.

* The wiring grommet hole in the back of the base is going to be used to mount the on/off switch. Remove the rubber grommet and you will notice that the hole is stepped. The hole needs to be enlarged to the size of the outer ring. This can be done with a tappered reamer or a 15/32" drill. If you are going to use too much pressure or you may crack the base.

* Insert the switch into the hole, fit the spring washer and the nut over the back of the switch and tighten the nut by hand. Using long nose pliers tighten the nut onto the spring washer, do not over tighten.

* The base is now ready for the PCB assembly. First, place the battery holder, batteries down, between the mounting posts, with one wire going one side of the post and the other wire going on the other side of the post. Now place the PCB into position into the 2 screw posts, over the top of the battery holder. The row of LED's should be lined up so that they are on the far side away from the switch. The switch wires can now be soldered onto the two terminals on the of the switch. The red wire from the battery holder should be soldered to one terminal. The yellow wire from the PCB to the other terminal.

* Refit the batteries to the battery holder and check the switch for correct operation.

* The lens can now be fitted. There is a notch in the rim of the base. Make sure these are lined up. Also line up the PCB so that when the unit is screwed together the PC is secured by the 2 screws. **DO NOT OVER TIGHTEN LENS** as the lens plastics will crack very easily.

* Your project is now ready to be mounted to your bike.

* Using a strip of 1.6mm Galvabond Steel or 2mm Aluminium approximately 20-25mm wide. Design a bracket suitable for mounting the tail light flasher to your bike. Make a full drawing of the bracket showing all dimensions.

Proceed to make the bracket to your drawing.

Now complete the
POST CONSTRUCTION ASSIGNMENT.

Photo shows a finished tail light mounted to the rear of a bike.

Post-construction Assignment.

Name_____ Date_____ Yr Level_____

THE MOUNTING BRACKET

Provide a drawing with full dimensions of a mounting bracket suitable for mounting the tail light flasher to your bike. (ATTACH DRAWING TO THIS SHEET)

PROJECT EVALUATION

1. Does the finished project meet all of the design considerations listed in your Design Brief.

(a)._____

(b)._____

(c)._____

(d)._____

(e)._____

2. With the flasher lens removed and the flasher switched off, set a multimeter to read current. Place the multimeter probes onto the switch contacts, +ve probe to the red wire and –ve probe to the yellow wire. The unit should start to work. Measure and record the current flowing in the circuit.
Current Flow = _____

3. If an Eveready E92 AAA alkaline energizer battery has a capacity of 900 mA/H, calculate the length of time these batteries would last if the unit was left on continuously. Show your workings.

_____

_____

4. List any problems you had during the construction of the project, and explain how they were overcome.

_____

_____

_____

5. In your own words describe your impressions of the project.

_____

_____

_____

_____

DETAILED CIRCUIT ANALYSIS FOR KI0007 TAIL LIGHT FLASHER

The LED flasher circuit is an oscillator and therefore is continually changing state. In order to analyse this circuit we must choose a starting point to begin explaining the sequence of events. The starting point we shall begin with is the point where the LED's have just turned off. This corresponds to period T1 shown on the wave forms diagram.

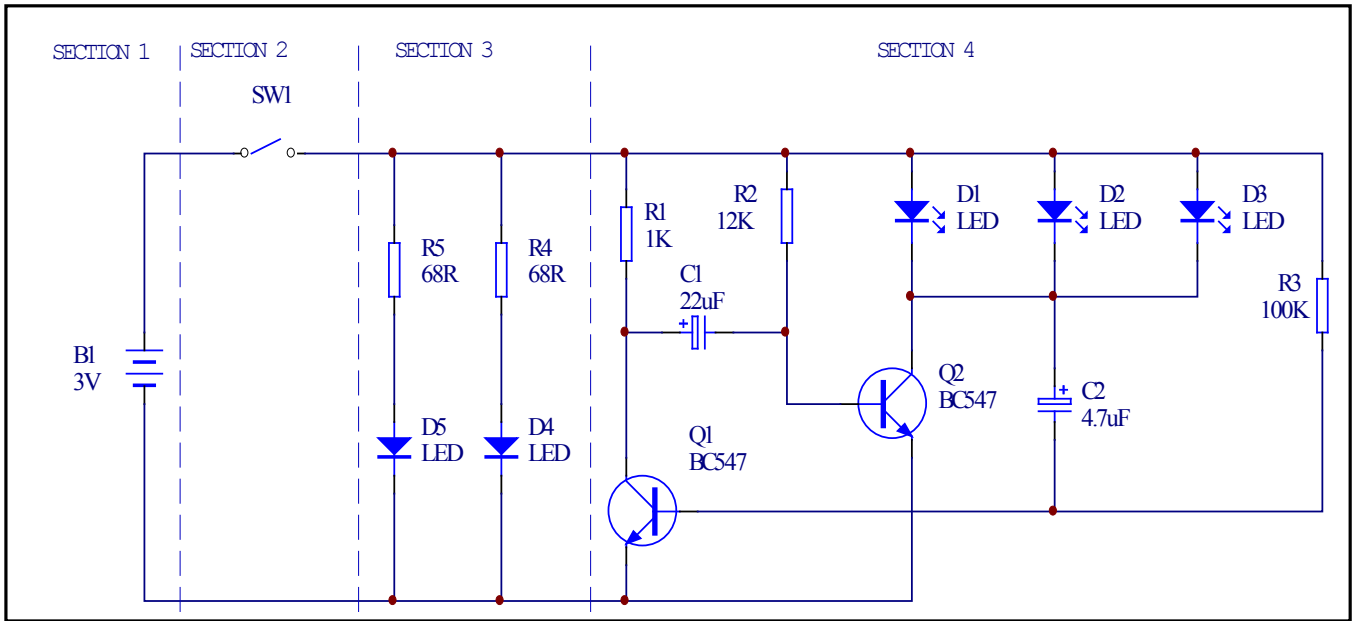
At the beginning of T1, Q1 has just been turned hard on which causes the collector voltage to drop about +0.1V. Referring to the wave form for the collector of Q1 it will be seen that the collector voltage changes by –2.85V. This change in voltage is applied to the base of Q2 via the capacitor C1 thereby pulling the voltage on the base down to –2.1V which turns off Q2 off.

At this point the voltage on the base of Q2 slowly increases as C1 is charged via R2. The charging time is approximately 175mS until the voltage on the base of Q2 reaches 0.5V, at which point Q2 starts to turn on. As Q2 turns on, its collector voltage starts to fall. This negative change in voltage on the collector is applied to the base of Q1 via C2 which in turn starts turning Q1 off. As Q1 turns off, its collector voltage starts to increase. This increase in voltage is applied to the base of Q2 therefore accelerating the rate at which Q2 turns on which in turn increases the rate at which Q1 is being turned off and so on. The result of this is that Q2 turns on very quickly and Q1 turns off very quickly.

When Q1 and Q2 have finished changing state, the base of Q1 will be at approximately 0.1V. Which keeps Q1 turned off. The interval T1 has just finished and T2 now commences. The LED's are conducting during the interval T2.

The voltage on the base of Q1 now starts to increase as C2 charges positively via R3. C2 continues charging for about 70mS until the voltage on the base of Q1 reaches 0.6V. Q1 now starts to conduct which causes its collector voltage to fall. The negative change in collector voltage is applied to the base of Q2 which causes it to start turning off so that its collector voltage starts to increase. The increase in Q2's collector voltage is applied to the base of Q1 via Q2 which accelerates the rate at which Q1 is being turned on. This in turn causes the collector voltage of Q1 to fall more quickly which causes Q2 to be turned off more quickly and so on. When Q1 is turned fully on and Q2 is turned fully off the LED's will not be conducting and T1 will commence again thus repeating the cycle.

It may be noted theat, at the end of T1, the electrolytic capacitor C1 will have a positive voltage of about 0.4V on its cathode with respect to its anode. This is permissible as electrolytic capacitors may be reverse biased by no more than 2V for short periods without damage, (some electrolytic capacitors are rated at 1V maximum permissible reverse voltage). In addition to the flasher circuit described above we have two LED's (Q4 and Q5) that give a continuous light output and therefore draw a steady current (of about 10mA each). The current level is set by the 68ohm resistors.



WAVEFORMS FOR KI0007 TAIL LIGHT FLASHER CIRCUIT