



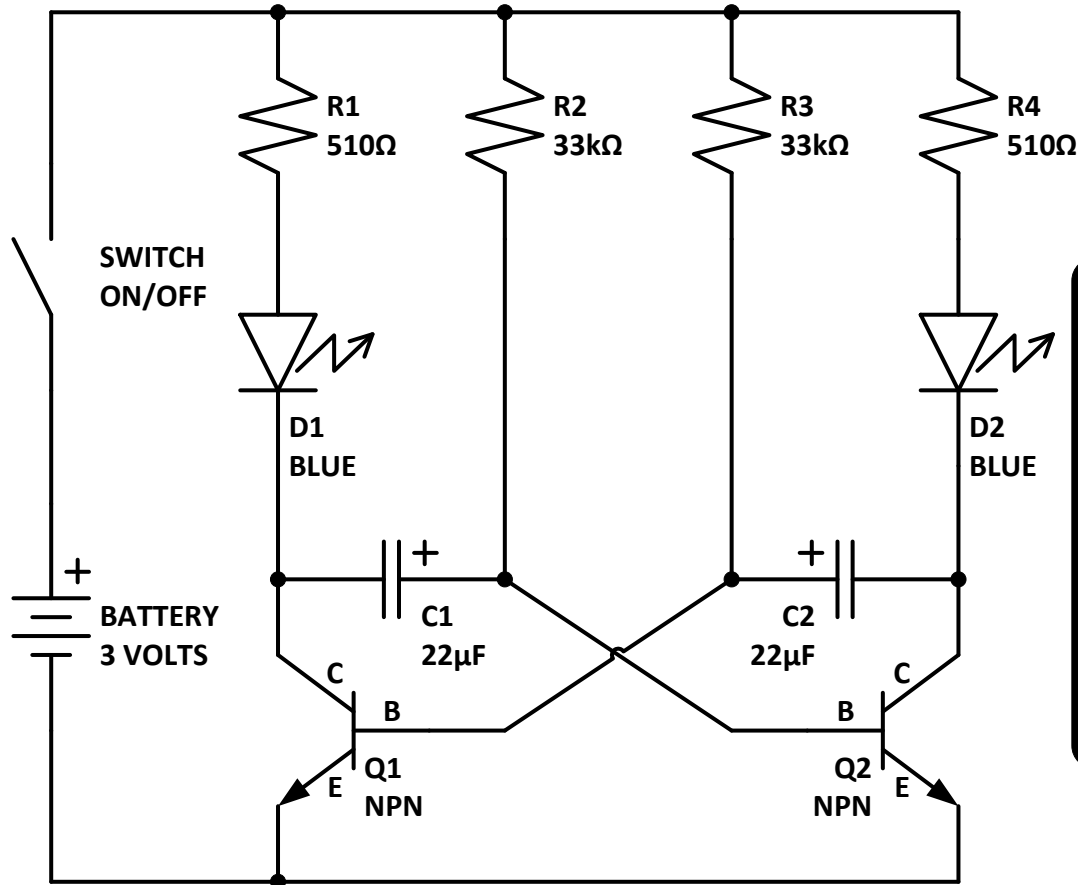
FLASHER

HOW IT WORKS

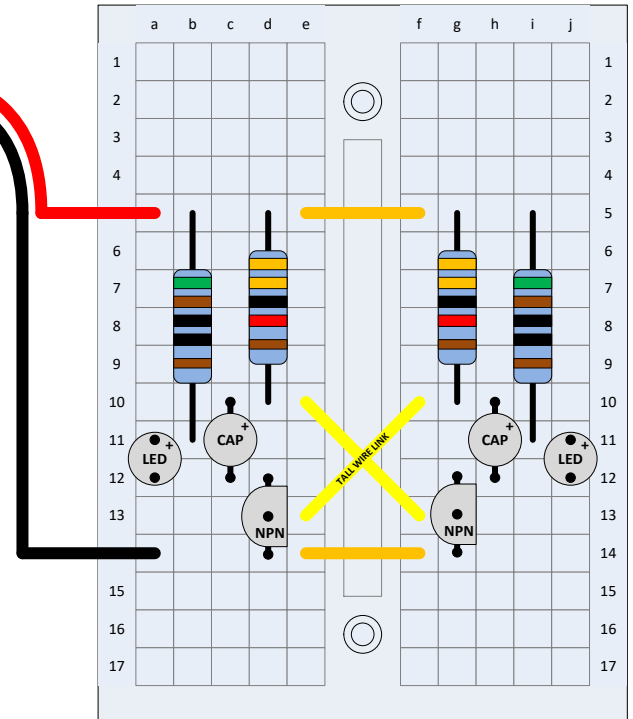
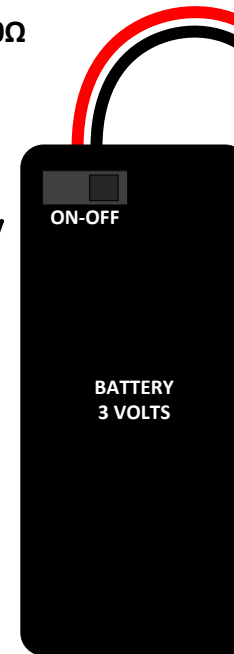
THE ELECTRONIC COMPONENTS ARE REPRESENTED BY SYMBOLS IN THE CIRCUIT DIAGRAM SHOWN BELOW. EACH COMPONENT HAS A DESIGNATOR AND A VALUE. THEY ARE CONNECTED BY BLACK LINES REPRESENTING WIRES. DOTS SHOW WHERE TWO WIRES ARE CONNECTED. EACH COMPONENT HAS A SPECIAL FUNCTION: TWO 1.5 VOLT AA CELLS CONNECTED IN SERIES PRODUCE 3 VOLTS TO POWER THE CIRCUIT. AN ON/OFF SWITCH CONTROLS THE CURRENT INTO THE CIRCUIT. RESISTORS LIMIT THE CURRENT THAT CAN FLOW IN VARIOUS PARTS OF THE CIRCUIT. CAPACITORS CAN BE CHARGED AND DISCHARGED. LIGHT EMITTING DIODES (LEDS) CONVERT CURRENT DIRECTLY INTO LIGHT. TRANSISTORS WORK LIKE AN ON/OFF SWITCH, CONTROLLED BY A SMALL CURRENT FLOWING INTO THEIR BASE (B) CONNECTIONS. WHEN THE SWITCH IS OFF, NO CURRENT FLOWS IN THE CIRCUIT. THE TRANSISTORS AND LEDS ARE TURNED OFF AND THE CAPACITORS ARE DISCHARGED. WHEN THE SWITCH IS FIRST TURNED ON, CURRENT FLOWS DOWN THROUGH R2 INTO Q2 AND R3 INTO Q1. YOU CAN TRACE IT WITH YOUR FINGER. IT IS INITIALLY A RACE TO SEE WHICH TRANSISTOR WILL TURN ON FIRST. SUPPOSE Q1 TURNS ON FIRST. CURRENT WILL FLOW THROUGH R1 AND D1 INTO THE COLLECTOR (C) OF Q1 AND THEN OUT OF ITS EMMITER (E) IN THE DIRECTION OF THE ARROW. R1 LIMITS THE CURRENT THROUGH D1 TO A SAFE VALUE. WHEN Q1 TURNS ON, C1 BEGINS TO CHARGE UP THROUGH R2. Q2 WILL NOT TURN ON UNTIL C1 IS CHARGED. THIS TAKES SOME TIME DEPENDING ON THE VALUES OF R2 AND C1. WHEN C1 IS CHARGED, Q2 TURNS ON. CURRENT FLOWS THROUGH R4, D2 AND Q2, TURNING ON D2 FOR THE FIRST TIME. WHEN Q2 TURNS ON, IT DIVERTS THE CURRENT FLOWING INTO THE BASE OF Q1 FROM R3 TO CHARGE UP C2 INSTEAD. THIS CAUSES Q1 AND D1 TO TURN OFF IMMEDIATELY. THE PROCESS CONTINUES WITH C1 AND C2 BEING CHARGED AND DISCHARGED BY Q1 AND Q2 AND THE LEDS TURNING ON AND OFF ALTERNATELY. THIS FAMOUS CIRCUIT IS CALLED AN "ASTABLE MULTIVIBRATOR". DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 2 - GENERAL PURPOSE NPN TRANSISTOR
- 2 - LIGHT EMITTING DIODE (BLUE)
- 2 - 22μF ELECTROLYTIC CAPACITOR
- 2 - 510Ω 1/4W RESISTOR
- 2 - 33kΩ 1/4W RESISTOR
- 2 - 0.3" WIRE LINK
- 1 - 0.4" WIRE LINK
- 1 - 0.4" WIRE LINK (TALL)



CIRCUIT DIAGRAM



RESISTOR COLOUR CODE									
BAND 1	BAND 2	BAND 3	BAND 4	BAND 5					
DIGIT 1	DIGIT 2	DIGIT 3	# ZEROS	TOL %	VALUE				
5	1	0	0	1	510 OHM 1%				
3	3	0	2	1	33000 OHM 1%				

PROTOTYPE BOARD LAYOUT



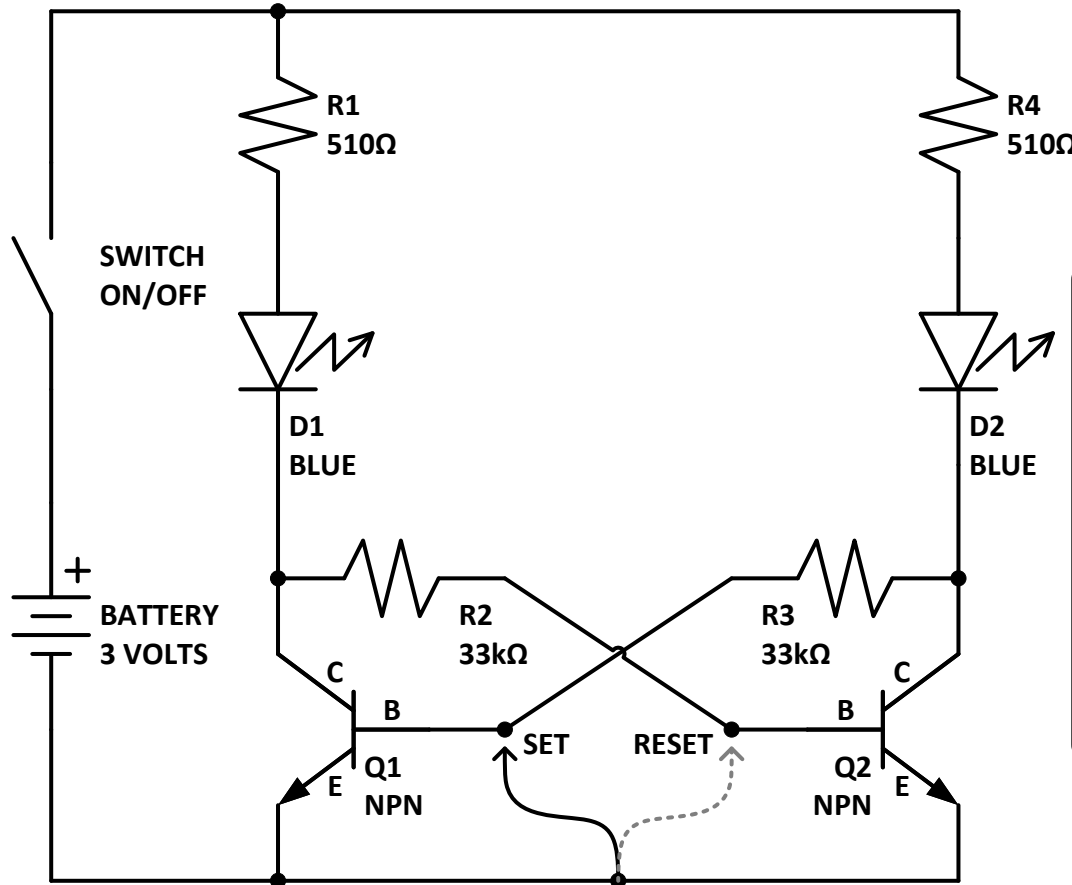
FLIP FLOP

HOW IT WORKS

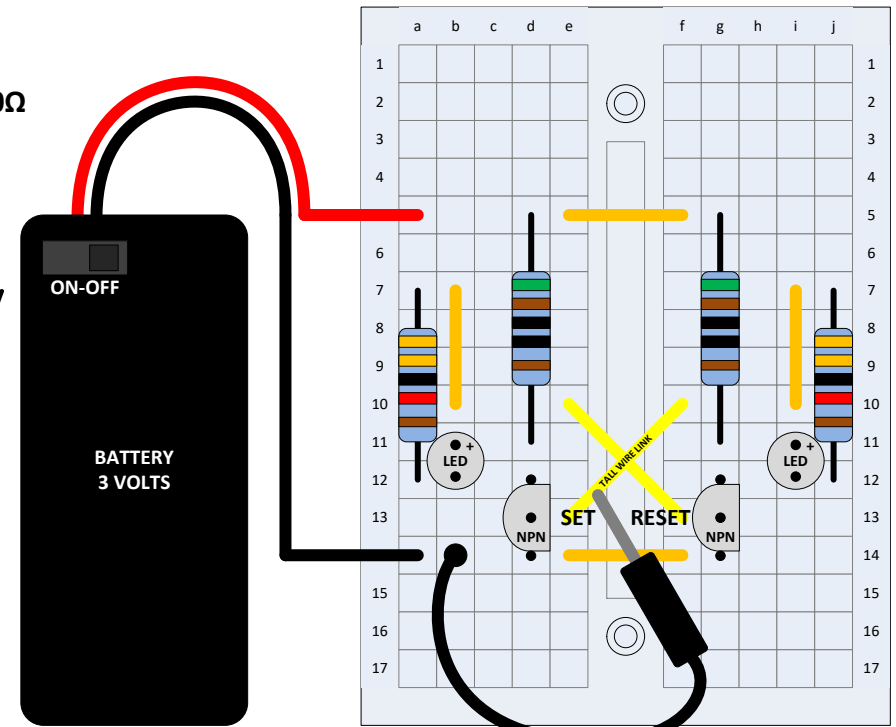
WHEN THE SWITCH IS OFF, NO CURRENT FLOWS IN THE CIRCUIT. WHEN THE SWITCH IS TURNED ON, TWO 1.5 VOLT AA BATTERIES PROVIDE 3 VOLTS. A VERY SMALL CURRENT FLOWS FROM THE BATTERY, THROUGH R1 AND R4 INTO EACH OF THE BASES (B) OF Q1 AND Q2 RESPECTIVELY. IT IS INITIALLY A RACE TO SEE WHICH TRANSISTOR WILL TURN ON FIRST. SUPPOSE Q1 TURNS ON FIRST. CURRENT WILL FLOW THROUGH R1 AND D1 INTO THE COLLECTOR (C) OF Q1 AND THEN OUT OF ITS EMMITER (E) IN THE DIRECTION OF THE ARROW. R1 LIMITS THE CURRENT THROUGH D1 TO A SAFE VALUE. BECAUSE Q1 IS ON, THE VOLTAGE AT THE BASE OF Q2 IS LOW, SO Q2 MUST BE OFF. THE CIRCUIT WILL REMAIN IN THAT STATE UNTIL A PIN LEAD IS USED TO SHORT THE BASE OF Q1 TO GROUND. Q1 WILL TURN OFF AND IT WILL IMMEDIATLEY SET Q2 ON, ILLUMINATING D2. THE CIRCUIT CAN BE RESET TO THE INITIAL STATE BY SHORTING THE BASE OF Q2 TO GROUND. THIS FAMOUS CIRCUIT HAS TWO STABLE STATES INDICATED BY D1 ON OR D2 ON. IT IS CALLED A BI-STATBLE LATCH, OR MORE COMMONLY, A FLIP-FLOP. BECAUSE THE CIRCUIT CAN REMEMBER IF IT HAS BEEN SET OR RESET, EFFECTIVELY STORING ONE SINGLE BIT OF INFORMATION, IT WAS USED AS THE BASIS FOR ALL DIGITAL COMUPTER MEMORY AND SEQUENTIAL LOGIC. DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 2 - GENERAL PURPOSE NPN TRANSISTOR
- 2 - LIGHT EMITTING DIODE (BLUE)
- 2 - 510Ω 1/4W RESISTOR
- 2 - 33kΩ 1/4W RESISTOR
- 2 - 0.3" WIRE LINK
- 1 - 0.4" WIRE LINK
- 1 - 0.4" WIRE LINK (TALL)
- 1 - TEST LEAD



CIRCUIT DIAGRAM



RESISTOR COLOUR CODE									
0	1	2	3	4	5	6	7	8	9
BAND 1	BAND 2	BAND 3	BAND 4	BAND 5	VALUE				
DIGIT 1	DIGIT 2	DIGIT 3	# ZEROS	TOL %					
5	1	0	0	1	510 OHM 1%				
3	3	0	2	1	33000 OHM 1%				

PROTOTYPE BOARD LAYOUT



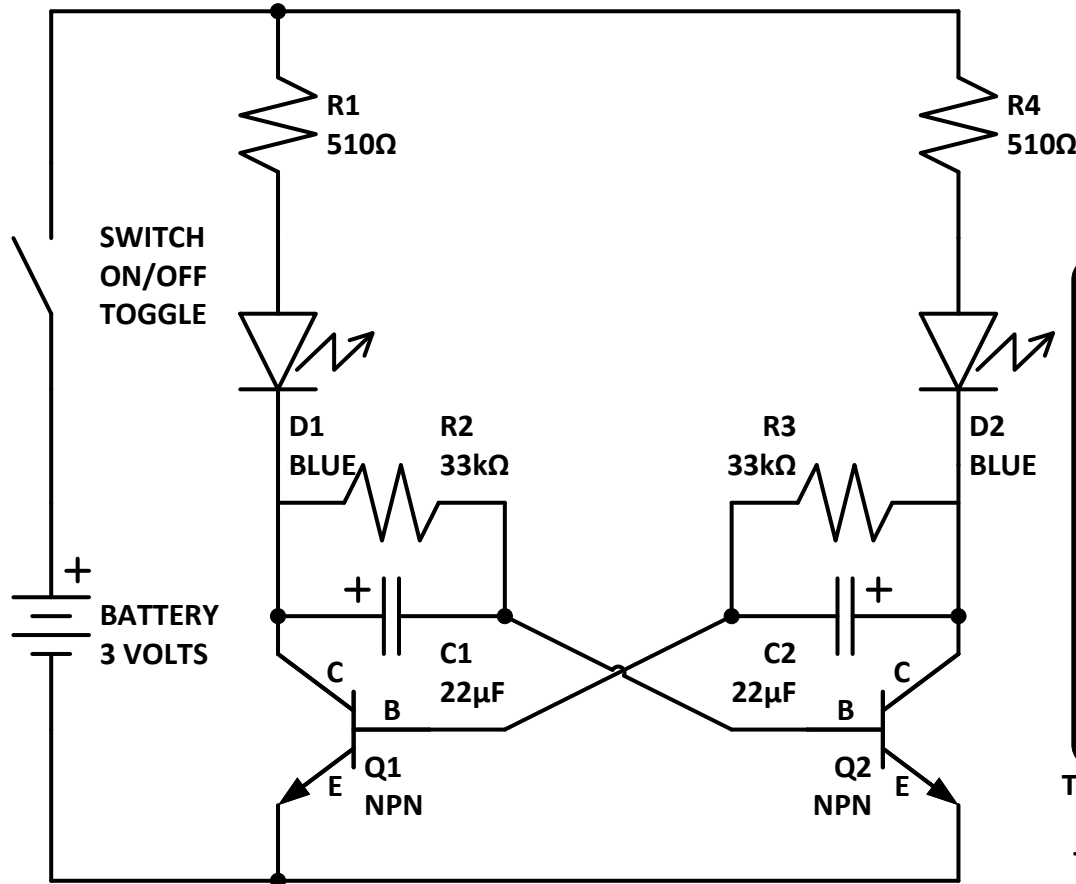
TOGGLE SWITCH

HOW IT WORKS

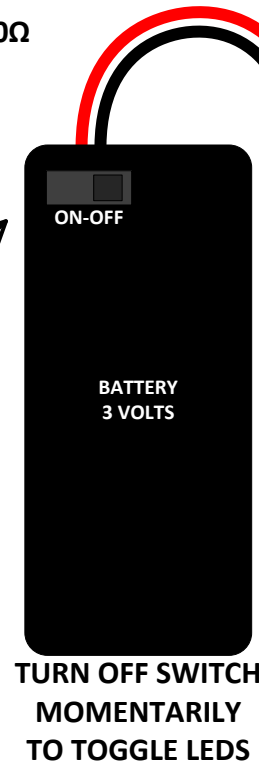
CURRENT FLOWS INTO THE CIRCUIT WHEN THE SWITCH IS ON. IT IS INITIALLY A RACE CONDITION TO SEE IF Q1 OR Q2 TURN ON DUE TO THE SMALL CURRENT FLOWING INTO THEIR BASES VIA R2 AND R3. SUPPOSE Q1 WINS AND TURNS D1 ON. CAPACITOR C1 WILL BE DISCHARGED AND CAPACITOR C2 WILL BE CHARGED. NOW IF THE SWITCH IS TURNED OFF, BRIEFLY, AND THEN TURNED BACK ON AGAIN, THE STATE OF C1 AND C2 CHANGES THE INITIAL CONDITIONS. BECAUSE C2 IS CHARGED IT GUARANTEES THAT Q1 WILL TURN OFF AND BECAUSE C1 IS DISCHARGED IT GUARANTEES THAT Q2 WILL TURN ON. SO THIS TIME Q2 AND D2 TURN ON. OF COURSE, IF THE SWITCH IS CYCLED AGAIN, THE INITIAL CONDITIONS WILL AGAIN FAVOUR Q1 AND D1 TURNING ON. SO EACH TIME THE SWITCH IS MOMENTARILY TURNED OFF, THE ALTERNATE LED IS ILLUMINATED. UNFORTUNATELY THIS CIRCUIT IS QUITE FINELY BALANCED AND SMALL VARIATIONS IN COMPONENT TOLLERANCES MIGHT FAVOUR ONE SIDE OR THE OTHER. YOUR CIRCUIT MAY NOT TOGGLE EACH TIME OR EVEN AT ALL. IF SO, TRY TURNING YOUR CIRCUIT OFF FOR DIFFERENT PERIODS OF TIME OR SWAPPING YOUR COMPONENTS AROUND WITH OTHERS. DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

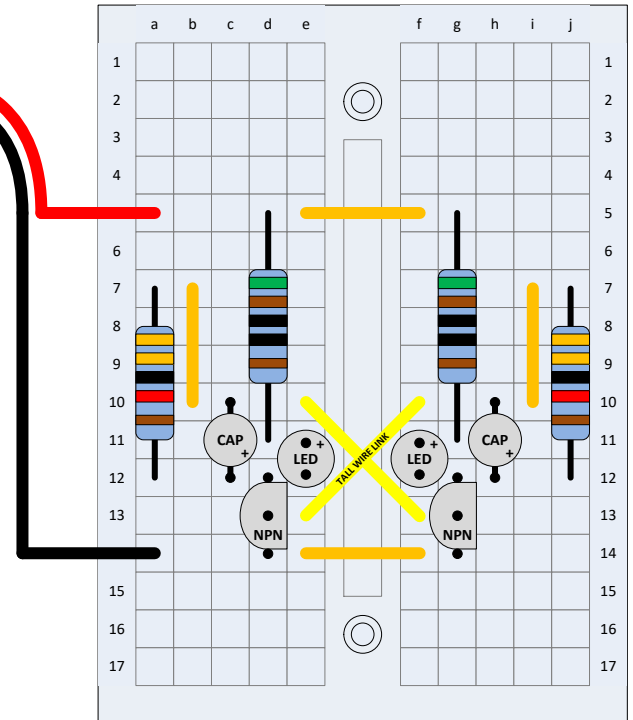
- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 2 - GENERAL PURPOSE NPN TRANSISTOR
- 2 - LIGHT EMITTING DIODE (BLUE)
- 2 - 510Ω 1/4W RESISTOR
- 2 - 33kΩ 1/4W RESISTOR
- 2 - 0.3" WIRE LINK
- 1 - 0.4" WIRE LINK
- 1 - 0.4" WIRE LINK (TALL)



CIRCUIT DIAGRAM



TURN OFF SWITCH
MOMENTARILY
TO TOGGLE LEDS



RESISTOR COLOUR CODE									
BAND 1	BAND 2	BAND 3	BAND 4	BAND 5	# ZEROS		TOL %		VALUE
5	1	0	0	1	510 OHM		1%		510 OHM 1%
3	3	0	2	1	33000 OHM		1%		33000 OHM 1%

PROTOTYPE BOARD LAYOUT



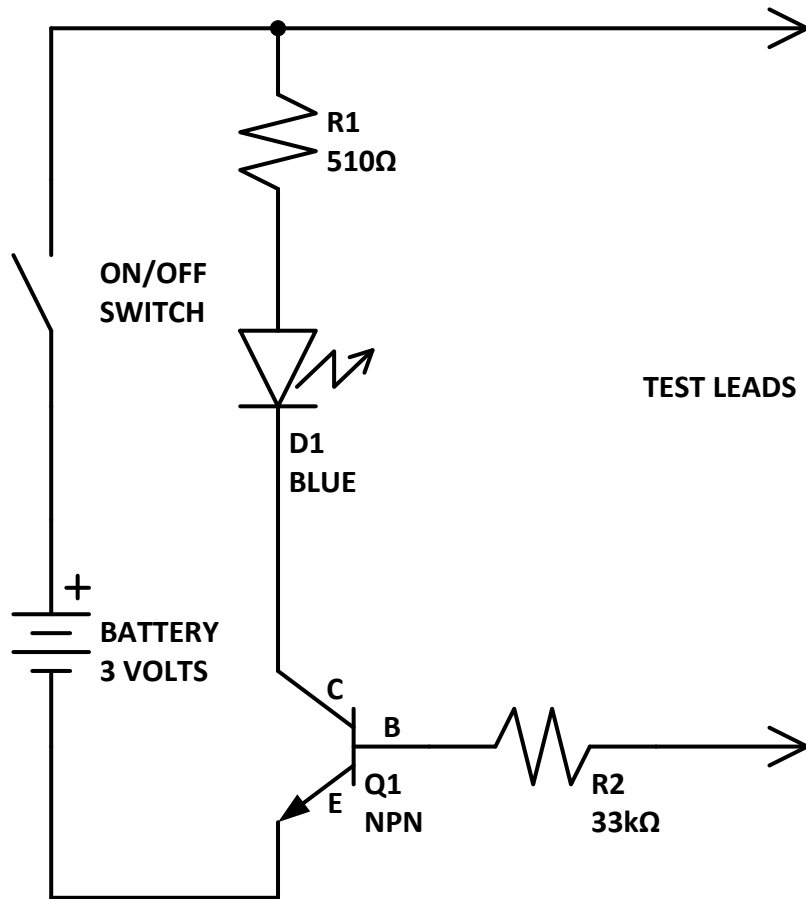
TESTER

HOW IT WORKS

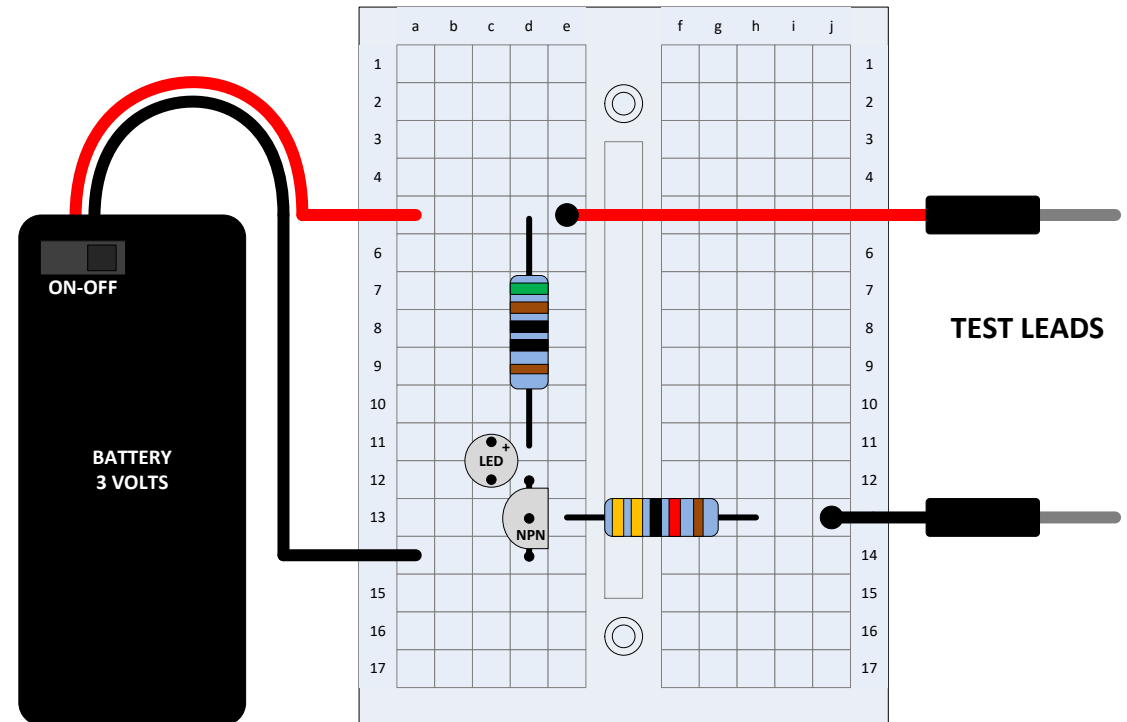
THERE ARE TWO 1.5 VOLT AA BATTERIES IN THE BATTERY HOLDER. CONNECTED IN SERIES, THEY CAN PRODUCE 3 VOLTS. WHEN THE SWITCH IS OFF, NO CURRENT FLOWS IN THE CIRCUIT AND THE LED IS OFF. WHEN THE SWITCH IS TURNED ON, NO CURRENT FLOWS UNTIL THE TEST LEADS ARE CONNECTED TOGETHER. THEN, A VERY SMALL CURRENT FLOWS FROM THE BATTERY, THROUGH THE 30kΩ RESISTOR INTO THE BASE (B) OF THE NPN TRANSISTOR Q1. THE TRANSISTOR "TURNS ON" AND IT PERMITS A MUCH LARGER CURRENT TO FLOW FROM THE BATTERY, THROUGH THE 510Ω RESISTOR INTO THE COLLECTOR (C) AND OUT OF THE EMITTER (E). THE LED ILLUMINATES. RESISTOR R1 LIMITS THE CURRENT FLOWING THROUGH THE LED TO A SAFE LEVEL – ABOUT 2 MILLIAMPS. THE RESISTOR R2 LIMITS THE CURRENT INTO THE BASE (B) OF THE TRANSISTOR TO ABOUT 75 MICROAMPS. THE CIRCUIT IS SO SENSITIVE THAT THE LED WILL TURN ON JUST BY HOLDING THE TEST LEADS BETWEEN YOUR FINGERS OR DIPPING THEM INTO TAP WATER. YOU CAN USE THE CIRCUIT AS A CONTINUITY TESTER TO SEE IF ELECTRIC CURRENT CAN FLOW BETWEEN ANY TWO POINTS. TRY IT ON DIFFERENT MATERIALS. DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 1 - GENERAL PURPOSE NPN TRANSISTOR
- 1 - LIGHT EMITTING DIODE (BLUE)
- 1 - 510Ω 1/4W RESISTOR
- 1 - 30kΩ 1/4W RESISTOR
- 2 - TEST LEADS



CIRCUIT DIAGRAM



RESISTOR COLOUR CODE									
BAND 1	BAND 2	BAND 3	BAND 4	BAND 5	TOL %		VALUE		
DIGIT 1	DIGIT 2	DIGIT 3	# ZEROS						
5	1	0	0	1			510 OHM 1%		
3	3	0	2	1			33000 OHM 1%		

PROTOTYPE BOARD LAYOUT



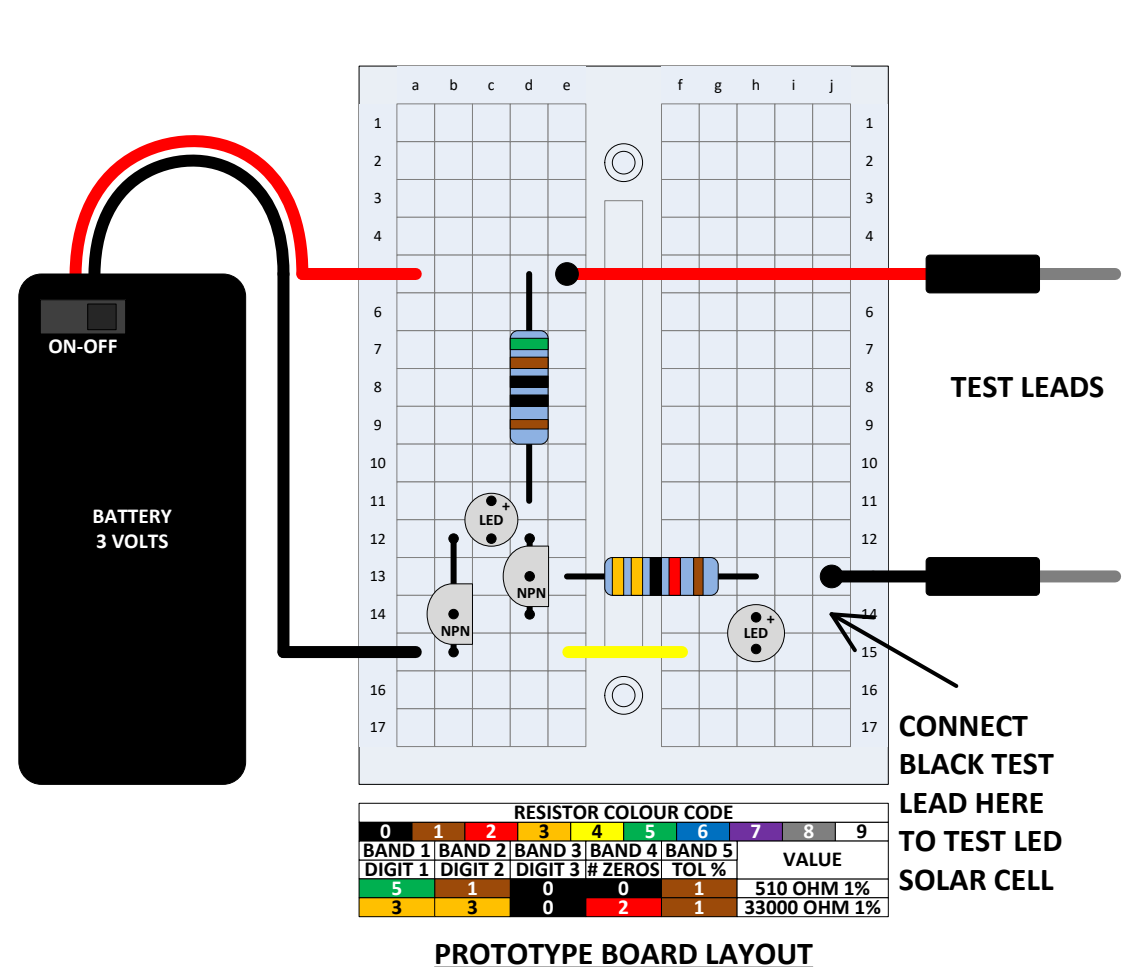
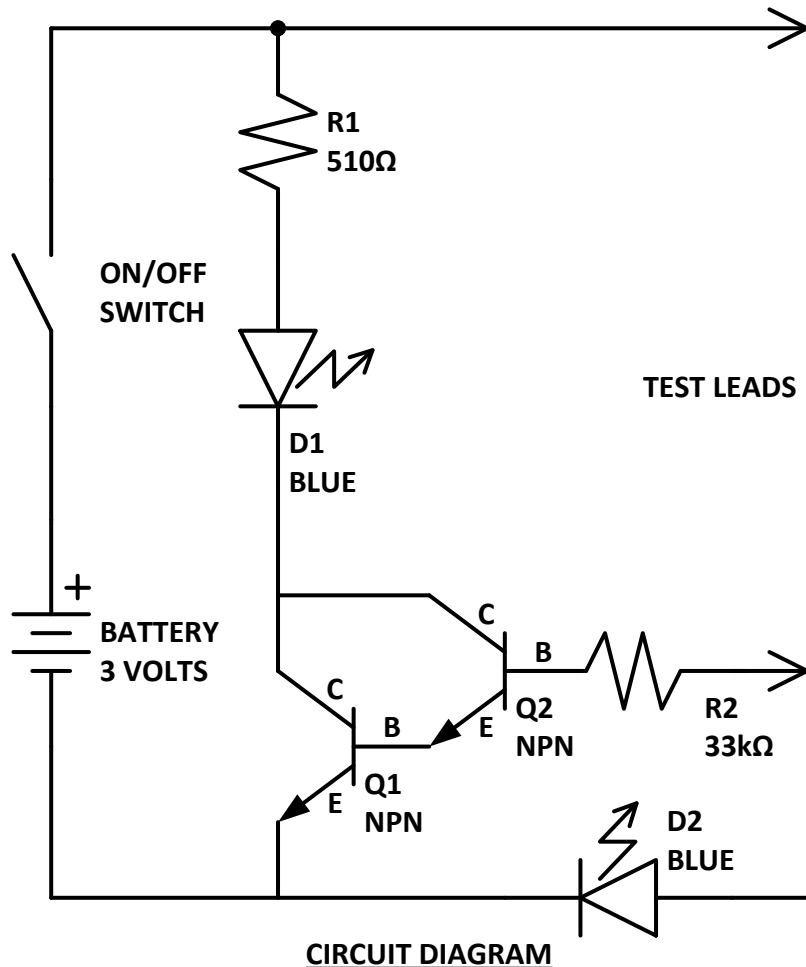
SUPER TESTER

HOW IT WORKS

TWO 1.5 VOLT AA BATTERIES CONNECTED IN SERIES IN THE BATTERY HOLDER CAN PRODUCE 3 VOLTS. NO CURRENT FLOWS WHEN THE SWITCH IS OFF. WHEN THE SWITCH IS ON AND THE TEST LEADS ARE CONNECTED TOGETHER, A VERY SMALL CURRENT FLOWS FROM THE BATTERY, THROUGH RESISTOR R2 INTO THE BASE (B) OF THE NPN TRANSISTOR Q2. AS A RESULT Q2 TURNS ON. CURRENT FLOWS FROM THE BATTERY, THROUGH R1 AND LED D1 INTO THE COLLECTOR (C) AND OUT OF THE EMMITER (E) OF Q2 AND THEN INTO THE BASE OF Q1. SO Q1 TURNS ON AS WELL. THE COMBINED EFFECT OF Q1 AND Q2 CONNECTED IN THIS WAY IS THAT AN EXTREMELY SMALL CURRENT FROM THE TEST LEADS WILL TURN ON THE LED. R1 LIMITS THE CURRENT IN THE LED. R2 LIMITS THE CURRENT INTO THE BASE OF THE Q2. THE LED MAY EVEN GLOW BY JUST TOUCHING THE BLACK TEST LEAD. THIS IS CAUSED BY THE PRESENCE OF HOUSEHOLD AC MAINS WIRING IN YOUR ROOM OR STRONG RADIO STATIONS IN YOUR AREA. BY TOUCHING THE TEST LEAD YOU ARE ACTING AS AN ANTENNA! THIS FAMOUS CASCADED CONNECTION OF TWO TRANSISTORS IS CALLED A "DARLINGTON PAIR". THE CIRCUIT IS SO SENSITIVE THAT IT CAN DETECT THE TINY PHOTOELECTRIC CURRENT FROM LIGHT FALLING ONTO THE LED. WHEN CURRENT PASSES THROUGH A LED IT IS CONVERTED DIRECTLY INTO LIGHT. IT IS NOT COMMONLY KNOWN THAT THE REVERSE IS ALSO TRUE: LIGHT SHINING ON AN LED WILL PRODUCE CURRENT LIKE A SOLAR CELL. CONNECT THE BLACK TEST LEAD TO D2 AND ILLUMINATE IT WITH A TORCH. D1 WILL LIGHT UP ALSO! THE CIRCUIT CAN ALSO DETECT STATIC ELECTRICITY PRESENT ON THE SURFACE OF SOME INSULATORS: TRY RUBBING A PLASTIC PEN WITH WOOL AND THEN TOUCHING IT TO THE BLACK TEST LEAD. DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 2 - GENERAL PURPOSE NPN TRANSISTORS
- 2 - LIGHT EMITTING DIODES (BLUE)
- 1 - 510Ω 1/4W RESISTOR
- 1 - 30KΩ 1/4W RESISTOR
- 1 - 0.4" WIRE LINK
- 2 - TEST LEADS





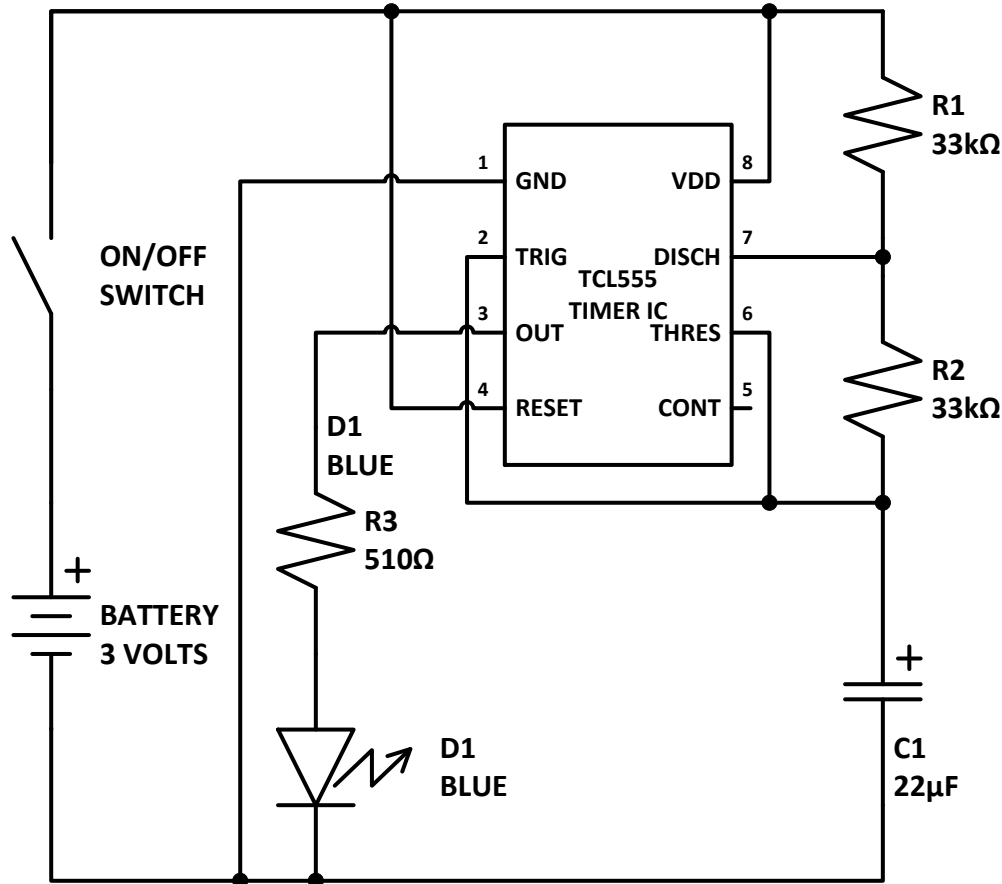
INTEGRATED CIRCUIT TIMER

HOW IT WORKS

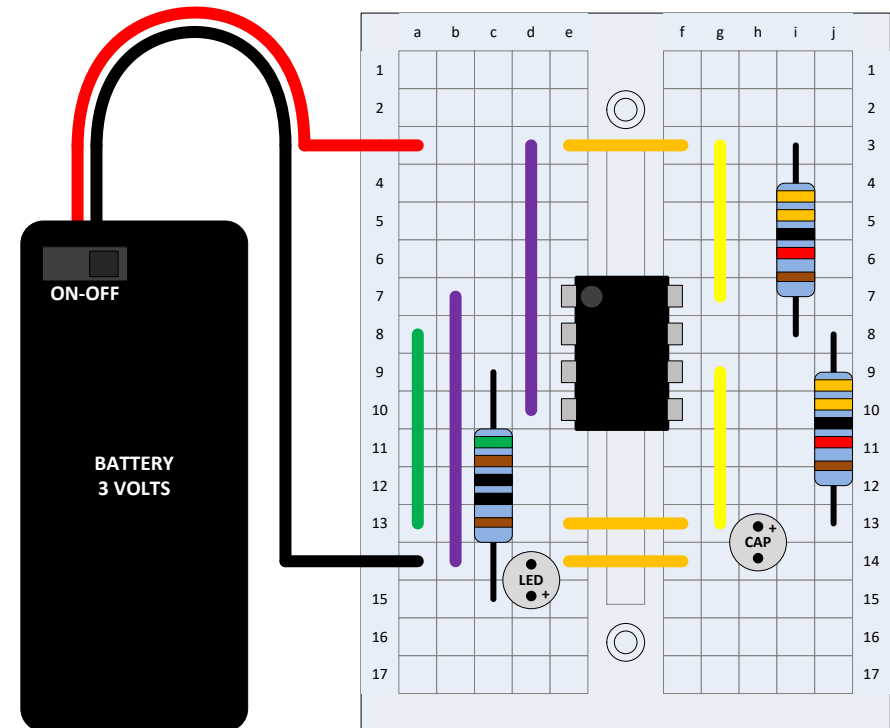
IN THIS ACTIVITY WE INTRODUCE AN INTEGRATED CIRCUIT OR IC. AN IC IS A PACKAGE OF ELECTRONIC DEVICES DESIGNED TO PERFORM A SPECIAL FUNCTION. SOME ICs CAN CONTAIN THOUSANDS OF ELECTRONIC DEVICES. THE IC USED HERE CONTAINS 39 TRANSISTORS AND 5 RESISTORS AND IS DESIGNED TO TURN A DEVICE ON AND OFF FOR A PRECISE PERIOD OF TIME. WE CAN USE IT TO FLASH AN LED. IT WORKS BY LETTING THE CAPACITOR C1 CHARGE UP TO 2 VOLTS THROUGH RESISTORS R1 AND R2. THEN IT DISCHARGES THE CAPACITOR TO 1 VOLT THROUGH RESISTOR R2. THE CYCLE REPEATS CAUSING THE LED D1 TO FLASH ON AND OFF. THE VALUES OF R1, R2 AND C1 CAN BE CHANGED TO CONTROL EXACTLY HOW LONG THE LED IS ON AND OFF FOR. YOU CAN USE A CALCULATOR TO WORK OUT HOW MANY TIMES THE LED FLASHES IN ONE MINUTE. THE FORMULA IS $86,400 \div (R1 + 2 \times R2) \times C1 = 86,400 \div (33 + 2 \times 33) \times 22 = 39$ TIMES A MINUTE. HOW MANY TIMES DOES YOUR LED FLASH PER MINUTE? THE IC IS ENCLOSED IN A PLASTIC PACKAGE WITH TWO ROWS OF FOUR PINS ON EACH SIDE. EACH PIN HAS A NUMBER AND A NAME, BUT ALL YOU CAN SEE ON THE PACKAGE IS A CIRCLE NEXT TO PIN 1. EACH PIN OF AN IC HAS A SPECIAL FUNCTION: PIN 1 GND IS CONNECTED TO THE BATTERY NEGATIVE TERMINAL. PIN 2 TRIG IS USED TO TRIGGER EACH CYCLE OF THE TIMER. PIN 3 OUT IS THE TIMER OUTPUT FOR CONNECTION TO THE LED. PIN 4 RESET IS USED TO STOP THE TIMER (IT IS NOT USED). PIN 5 CONT IS USED TO CONTROL THE TIME INTERVAL (IT IS ALSO NOT USED). PIN 6 THRES MEASURES WHEN THE CAPACITOR VOLTAGE HITS A 1 VOLT OR 2 VOLT THRESHOLD. PIN 7 DISCH IS USED TO DISCHARGE THE CAPACITOR. PIN 8 VDD IS CONNECTED TO THE BATTERY POSITIVE TERMINAL. THE TIMER RUNS CONTINUOUSLY BECAUSE THE TRIG PIN IS CONNECTED TO THE THRES PIN. DOWNLOAD MORE WORKSHOP NOTES AT WWW.SARCNET.ORG/WORKSHOPS.HTML.

PARTS LIST

- 1 - 3V BATTERY HOLDER WITH SWITCH
- 1 - PROTOTYPING BOARD - 170 TIE POINTS
- 1 - TLC555 TIMER IC
- 1 - LIGHT EMITTING DIODE (BLUE)
- 1 - 510Ω 1/4W RESISTOR
- 2 - 33kΩ 1/4W RESISTORS
- 1 - 10μF ELECTROLYTIC CAPACITOR
- 3 - 0.3" WIRE LINKS
- 2 - 0.4" WIRE LINKS
- 1 - 0.5" WIRE LINK
- 2 - 0.7" WIRE LINKS



CIRCUIT DIAGRAM



RESISTOR COLOUR CODE									
BAND 1	BAND 2	BAND 3	BAND 4	BAND 5					
DIGIT 1	DIGIT 2	DIGIT 3	# ZEROS	TOL %	VALUE				
5	1	0	0	1	510 OHM 1%				
3	3	0	2	1	33000 OHM 1%				

PROTOTYPE BOARD LAYOUT