T.C.

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DEPARTMENT OF

ELECTRICAL & ELCTRONICS ENGINEERING

INDUSTRIAL INSTRUMENTATION AND DESIGN

MIDTERM PROJECT REPORT

GROUP 4

BJT: FAULTY COMPONENT TESTER CIRCUIT

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Introduction

We have designed a easy to use general faulty BTJ tester circuit.

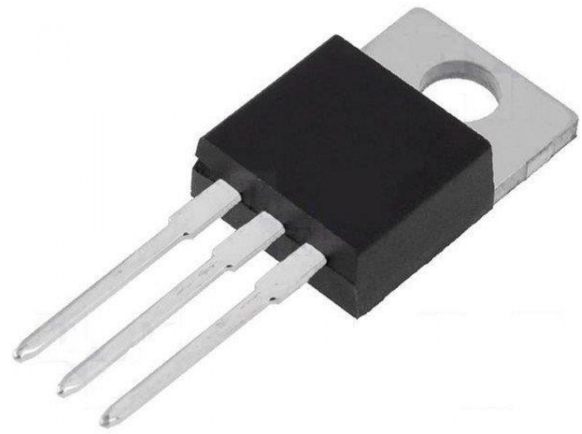
Reader should see the first three chapter as general pre-project research. Actual Project starts at Chapter 4.

Table of Content

1)HOW DO A TRANSISTOR WORK

Transistors are electronic components that can do two different works. It can function as an amplifier or a switch. There are so many types of transistors used in electronics according to their characteristics and applications.

Transistors like BJT(Bipolar Junction Transistor), FET(Field Effect Transistor) are used in electronics. Junction Transistor can be of two types PNP transistor and NPN transistor and there are two types of Field Effect Transistor - Junction Field Effect Transistor(JFET) and Metal-Oxide Field Effect Transistor(MOSFET). WE will br talking about how Bipolar Junction Transistor(BJT) work since our task is to find when they are faulty.



How do a BJT transistor works?

With transistor, a larger supply of electricity can be controlled by using a small amount of electricity, It's much like to control a supply of water by turning a valve.

Transistor has it's three legs -

1. Base

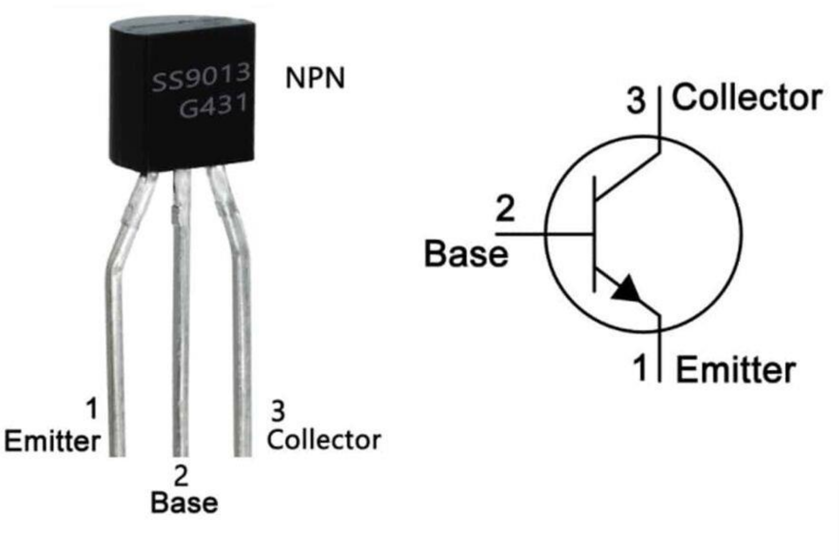
2. Emitter

3. Collector

In the transistor, the base is used as a gate to control the larger electrical supply. The collector is used as a larger electrical supply and emitter is works as the outlet for this supply.

By applying different levels of electric current from the base, the amount of flowing current through the gate from the collector can be regulated. In this way, a very small amount of current may be used to control a large amount of current, as in an amplifier.

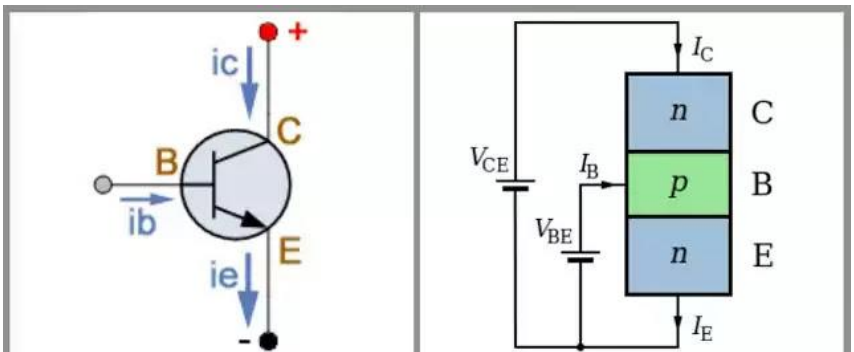
How NPN transistor works?



Basically, Transistors are made of semiconductor materials. Depending on this materials there are two types of Biopolar Junction Transistor - NPN transistor and PNP transistor.

NPN transistor has three legs - Base, Emitter, and the Collector. In the NPN transistor, the collector and emitter regions are made up of N-type material, which is mainly composed of electrons. The base region is made up of P-type material, which is mainly composed of holes.

In the NPN transistor current flows from collector to the emitter. for this type of flowing the biasing must be followed in this way –



NPN transistor symbol

NPN transistor biasing

If you understand the law of charges then we can easily figure out how a transistor works. it is a very simple concept. It is the concept where the same charges repel each other and opposite charges attract each other.

This means two positive charges will repel each other and two negative charges will repel each other, while the opposite charges will attract each other. This is all you need to know to understand transistors.

As we know before, In NPN transistor the emitter regions that made up of N-type material, where majority carriers are electrons that are negative charges.

Now we want to flow current from the collector to the emitter region. So, we place a positive voltage on the emitter region. As a result, the electrons in the collector terminal are repelled by this voltage and current will flow toward the emitter.

Now we apply a voltage in the base region which is made up of P-type material. It is the most important region for controlling the on/off capability of the transistor.

If there is no current is going into the base region of the transistor then it offers strong resistance to the flow of current. So the current does not flow from collector to emitter.

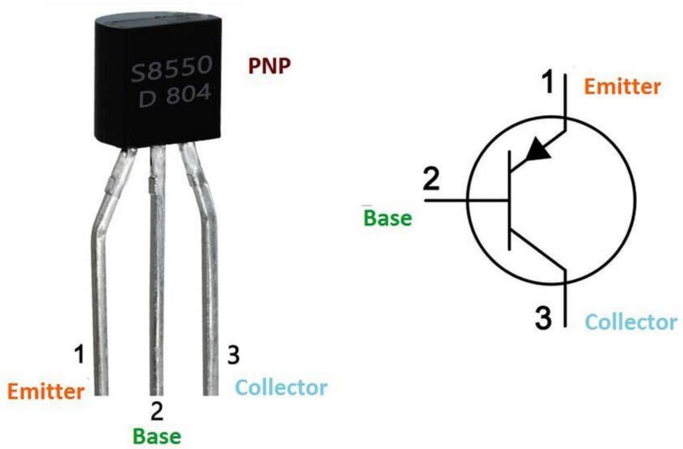
This is why the P material comprising the base region, made up of holes, provides a strong barrier that separates the collector and emitter regions.

However, when current flows into the base, the electrons start to flow into the P material and depleting the number of holes in the base region.

The base region barrier becomes depleted, becoming smaller until there are enough electrons filling it to completely break down the barrier. When this occurs, the current can easily flow from collector to emitter.

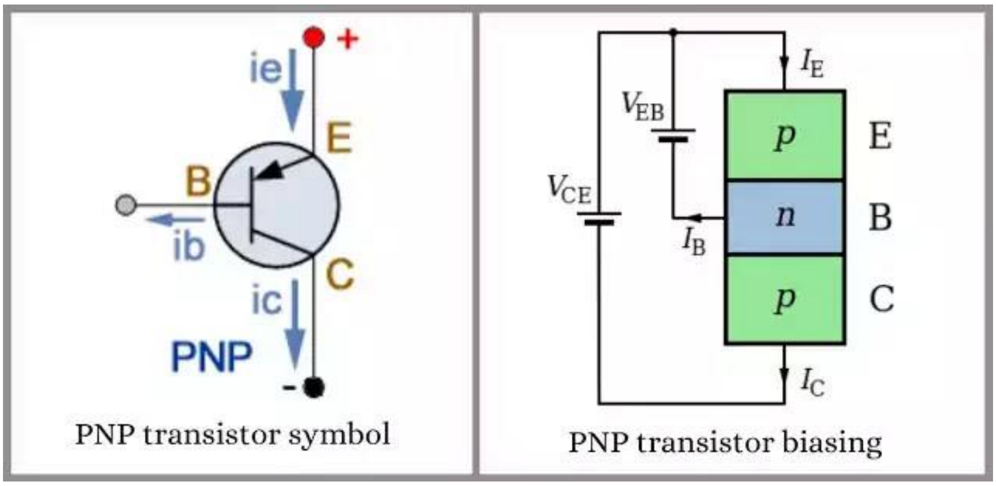
Now connect the transistor as the biasing given above. After connecting the circuit if you apply a sufficient current into the base then you will see the transistor becomes on. And if you remove this current from the base then it becomes off.

How PNP transistor works?



PNP transistor also has three legs - Base, Emitter, and the Collector. The collector and emitter regions are made up of P-type material, which is mainly composed of holes. The base region is made up of N-type material, which is mainly composed of electrons.

In the PNP transistor current flows from emitter to the collector. for this type of flowing the biasing must be followed in this way –



As we know before, In PNP transistor the emitter regions that made up of P-type material, where majority carriers are holes that are positive charges. Now we want to flow current from the emitter to the collector region. So, we place a positive voltage on the emitter region. As a result, the holes in the emitter terminal are repelled by this voltage and current will flow toward the collector.

Now we apply a voltage in the base region which is made up of N-type material. It is the most important region for controlling the on/off capability of the transistor. If there is no current is going into the base region of the transistor then it offers no resistance to the flow of current. So the current can easily flow from emitter to collector.

This is why the N material comprising the base region, made up of electrons. Now If we give more electrons, by applying current then the thickness of the base region is increased and it blocked the flow of current from the emitter to the collector.

This is why when we give current to the base of a PNP transistor then it blocks the flow of current from the emitter to the collector. And when there is no current flowing from the base then current can easily flow from emitter to collector.

Now connect the transistor as the biasing given above. After connecting the circuit if you apply a sufficient current into the base then will see the transistor becomes off. And if you remove this current from the base then it becomes on.

WE NEED TO REMEMBER THIS: What will happen if I bias the collector and emitter of an NPN Transistor inversely?

When the NPN transistor is ON, its BE junction is biased in the forward direction. This means now holes from the basis cross the junction, become minority carriers in the emitter, and diffuse to the emitter contact.Likewise, electrons from the emitter cross the BE junction, and become minority carriers in the basis region of the transistor.

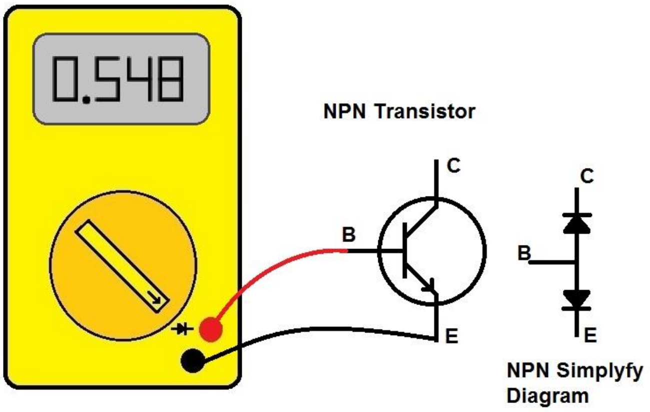
Now, it becomes interesting. There happen mainly 2 things in the basis region of the transistor: The minority carrier electrons recombine in the basis region or they get attracted by the CB junction, which is biased in reverse direction. However, the minority carrier electrons cross the CB region, become majority carriers in the collector, and form the collector current.

Now, there are basically 3 current components associated with the forward biased BE junction: The current of holes crossing the BE junction, and getting into the emitter.The current of the electrons crossing the BE junction, and recombining in the basis.The current of electrons crossing the BE junction and also crossing the CB junction. Now, the transistor is constructed to have high beta (high gain). Now, if you use the transistor in reverse, the emitter becomes the collector and the collector becomes the emitter, and its quite simple to see what happens:

As the collector doping is less than the emitter doping, the hole current in the collector (now the emitter) increases, leading to lower beta. The voltage withstand capability goes down, as now the BE junction is reverse biased, and the emitter is not constructed for high withstand voltage. The effect of the thin basis remains. For that reason, if the forward beta is high, then the reverse beta will also be higher.

2)TESTING BJTS

METHOD 1: Using multimeter with NPN Transistor



(A)

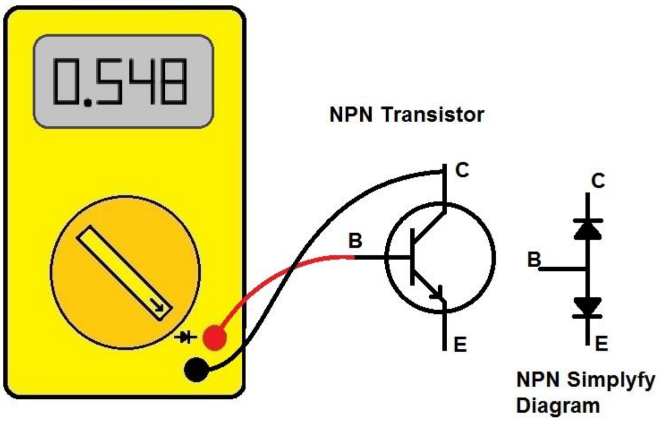
First turn ON digital multimeter and select **diode mode**.

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(A)** connection.

Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is from 0 above 150, the **transistor is good**.

Displayed multimeter value is 0 or .0L, the **transistor is bad**.

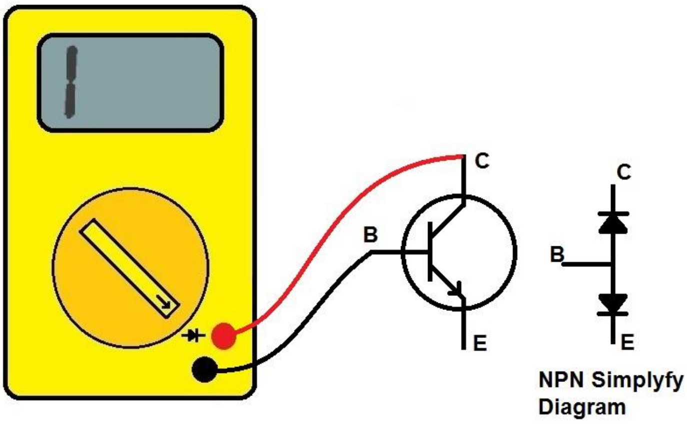


(B)

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(B)** connection.

Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is from 0 above 150, the **transistor is good**.Displayed multimeter value is 0 or .0L, the **transistor is bad**

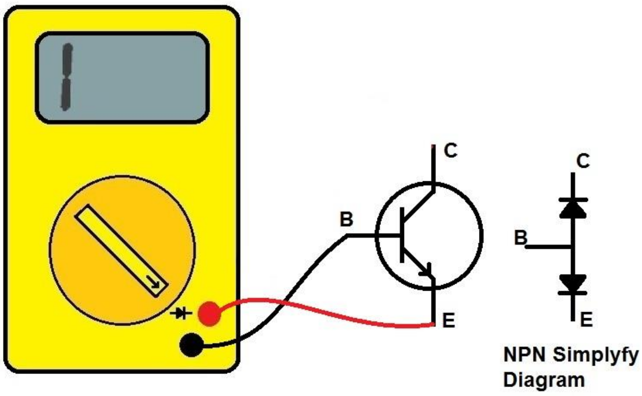


(C)

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(C)** connection.

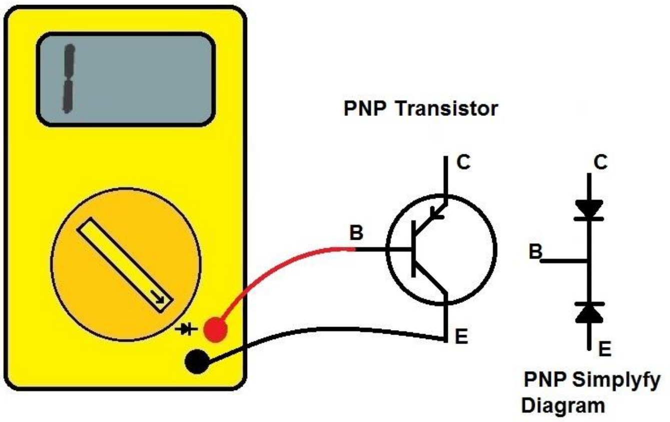
Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is 1, the **transistor is good**.



(D)

METHOD 2: Using multimeter with PNP Transistor

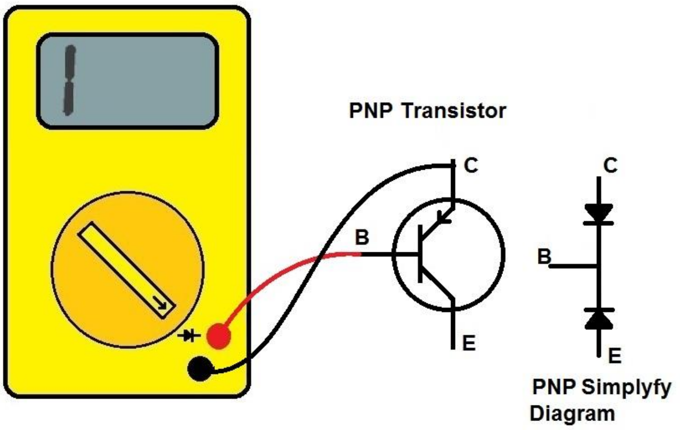


(E)

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(E)** connection.

Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is 1, the **transistor is good**.

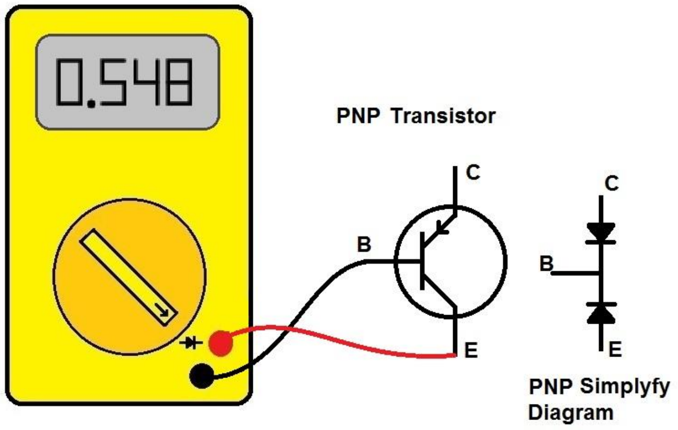


(F)

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(F)** connection.

Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is 1, the **transistor is good**.



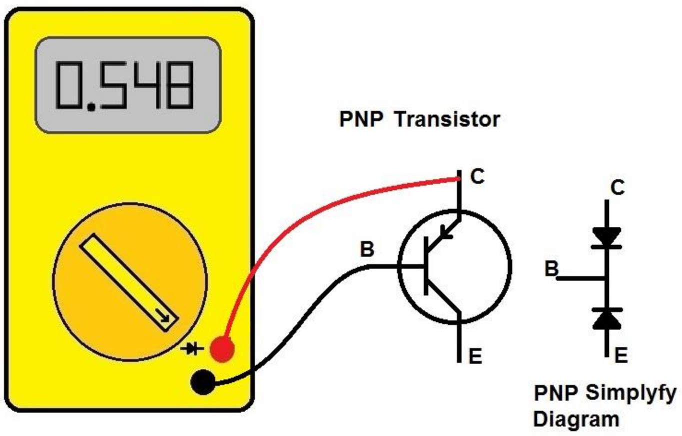
(G)

Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(G)** connection.

Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is from 0 above 150, the **transistor is good**.

Displayed multimeter value is 0 or .0L, the **transistor is bad**.



(H)

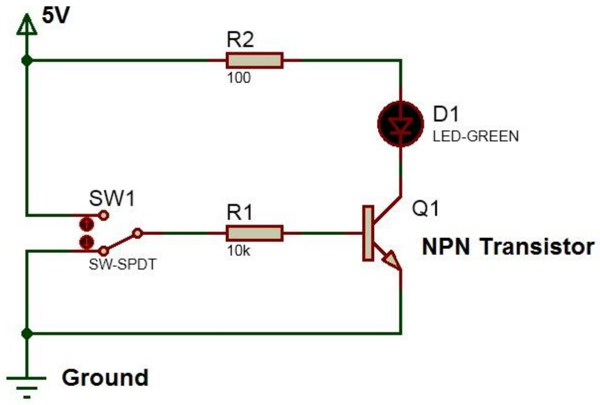
Connect the test leads to the transistor terminals. Keep test leads connected for a few seconds at like this **(H)** connection.

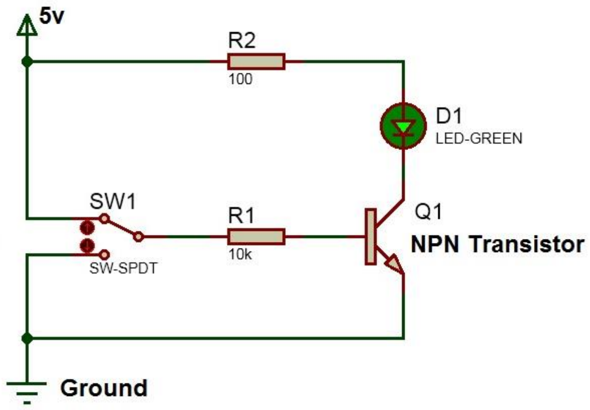
Read the measurement displayed. If the transistor value is within the measurement range, the multimeter will display the transistor value.

Displayed multimeter value is from 0 above 150, the **transistor is good**.

Displayed multimeter value is 0 or .0L, the **transistor is bad**.

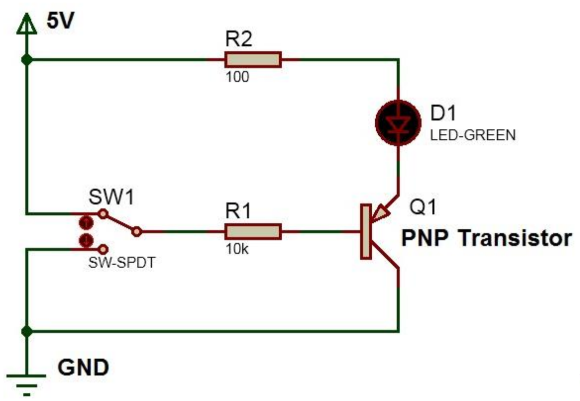
METHOD 3: Using power supply with NPN Transistor

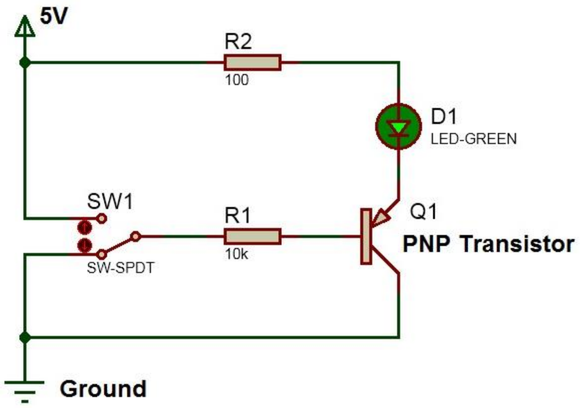




If push button is pressed **supply side**, the transistor will **turn ON** and the LED will **ON**. else button is pressed ground side, the transistor will **turn OFF** and the LED will **OFF**. its working properly, the **transistor is good**. its not working, the **transistor is bad**.

METHOD 4: Using power supply with PNP Transistor





If push button is pressed **supply side**, the transistor will **turn OFF** and the LED will **OFF**. else button is pressed ground side, the transistor will **turn ON** and the LED will **ON**. its working properly, the **transistor is good**. its not working, the **transistor is bad**.

3)555 TIMER

The basic **555 timer** gets its name from the fact that there are three internally connected 5kΩ resistors which it uses to generate the two comparators reference voltages. The 555 timer IC is a very cheap, popular and useful precision timing device which can act as either a simple timer to generate single pulses or long time delays, or as a relaxation oscillator producing a string of stabilised waveforms of varying duty cycles from 50 to 100%.

The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate Monostable, Bistable or Astable Multivibrator to produce a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division, power supplies and converters etc, in fact any circuit that requires some form of time control as the list is endless.

The single 555 Timer chip in its basic form is a Bipolar 8-pin mini Dual-in-line Package (DIP) device consisting of some 25 transistors, 2 diodes and about 16 resistors arranged to form two comparators, a flip-flop and a high current output stage as shown below. As well as the 555 Timer there is also available the NE556 Timer Oscillator which combines TWO individual 555's within a single 14-pin DIP package and low power CMOS versions of the single 555 timer such as the 7555 and LMC555 which use MOSFET transistors instead.

A simplified "block diagram" representing the internal circuitry of the **555 timer** is given below with a brief explanation of each of its connecting pins to help provide a clearer understanding of how it works.

555 Timer Block Diagram

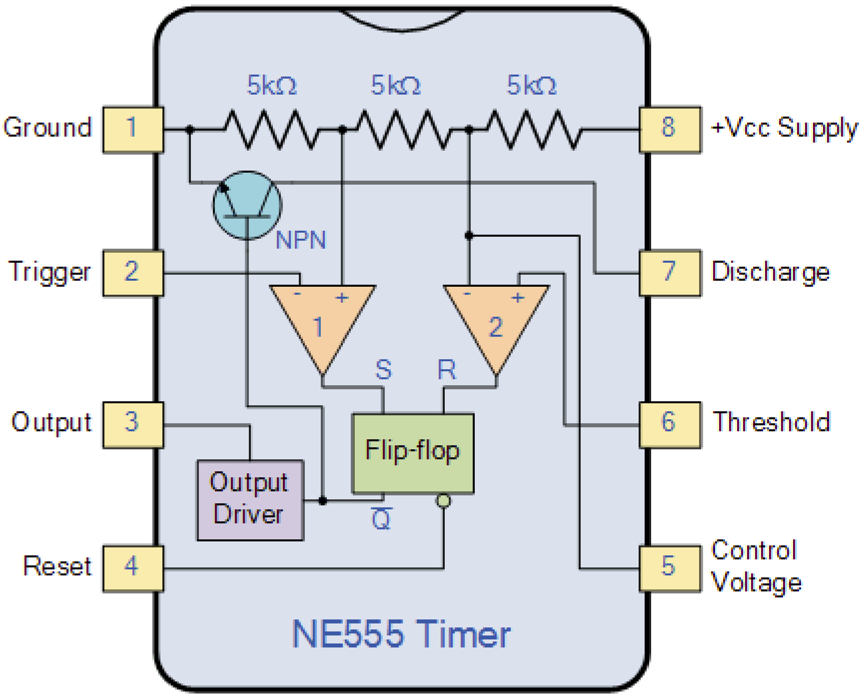


Figure 1: Pinout of 555 Timer

Pin 1 - Ground (GND) This pin is connected to circuit ground.

Pin 2 - Trigger (TRI)
A low voltage (less than 1/3 the supply voltage) applied momentarily to the Trigger input causes the output (pin 3) to go high. The output will remain high until a high voltage is applied to the Threshold input (pin 6).

Pin 3 – Output (OUT)
In output low state the voltage will be close to 0V. In output high state the voltage will be 1.7V lower than the supply voltage. For example, if the supply voltage is 5V output high voltage will be 3.3 volts. The output can source or sink up to 200 mA (maximum depends on supply voltage).

Pin 4 – Reset (RES)
A low voltage (less than 0.7V) applied to the reset pin will cause the output (pin 3) to go low. This input should remain connected to Vcc when not used.

Pin 5 – Control voltage (CON)
You can control the threshold voltage (pin 6) through the control input (which is internally set to 2/3 the supply voltage). You can vary it from 45% to 90% of the supply voltage. This enables you to vary the length of the output pulse in monostable mode or the output frequency in astable mode. When not in use it is recommended that this input be connected to circuit ground via a 0.01uF capacitor.

Pin 6 – Threshold (TRE)
In both astable and monostable mode the voltage across the timing capacitor is monitored through the Threshold input. When the voltage at this input rises above the threshold value the output will go from high to low.

Pin 7 – Discharge (DIS)
when the voltage across the timing capacitor exceeds the threshold value. The timing capacitor is discharged through this input

Pin 8 – Supply voltage (VCC)
This is is the positive supply voltage terminal. The supply voltage range is usually between +5V and +15V. The RC timing interval will not vary much over the supply voltage range (approximately 0.1%) in either astable or monostable mode.

Monostable Circuit

Figure 2 shows the basic 555 timer monostable circuit.

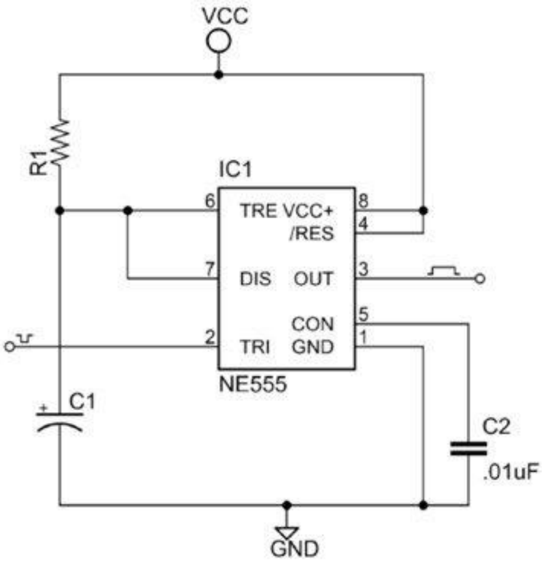


Figure 2: Basic 555 monostable multivibrator circuit.

Referring to the timing diagram in figure 3, a low voltage pulse applied to the trigger input (pin 2) causes the output voltage at pin 3 to go from low to high. The values of R1 and C1 determine how long the output will remain high.

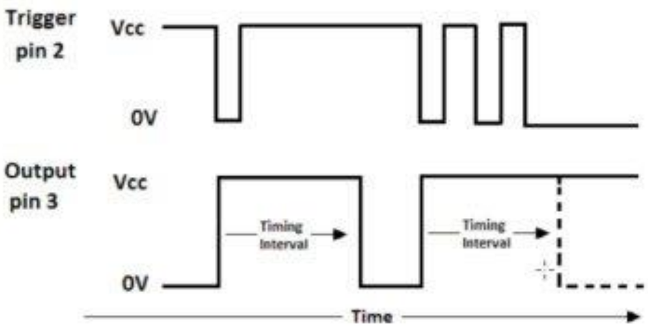


Figure 3: Timing diagram for 555 in monostable mode.

During the timing interval, the state of the trigger input has no effect on the output. However, as indicated in figure 3, if the trigger input is still low at the end of the timing interval the output will remain high. Make sure that the trigger pulse is shorter than the desired timing interval. The circuit in figure 4 shows one way to accomplish this electronically. It produces a short duration low going pulse when S1 is closed. R1 and C1 are chosen to produce a trigger pulse that is much shorter than the timing interval.

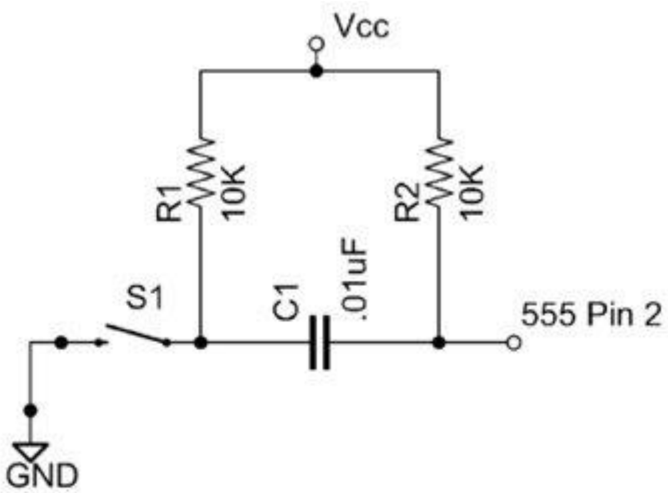


Figure 4: Edge triggering circuit.

As shown in figure 5, setting pin 4 (Reset) to low before the end of the timing interval will stop the timer.

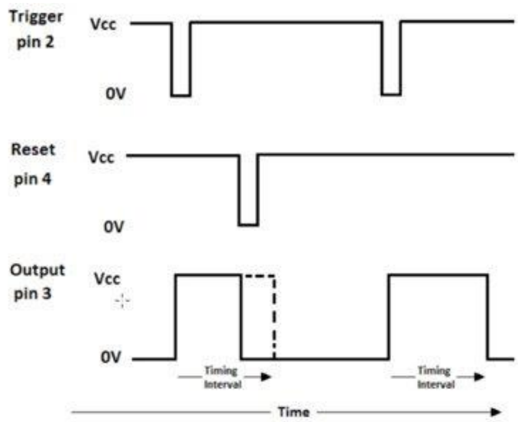


Figure 5: Resetting the timer before the end of the timing interval.

Reset must return to high before another timing interval can be triggered.

Calculating the timing interval

Use the following formula to calculate the timing interval for a monostable circuit:

T = 1.1 * R1 * C1

Where R1 is the resistance in ohms, C1 is the capacitance in farads, and T is the time interval. For example, if you use a 1M ohm resistor with a 1 micro Farad (.000001 F) capacitor the timing interval will be 1 second:

T = 1.1 * 1000000 * 0.000001 = 1.1

Astable Circuit

Figure 7 shows the basic 555 astable circuit.

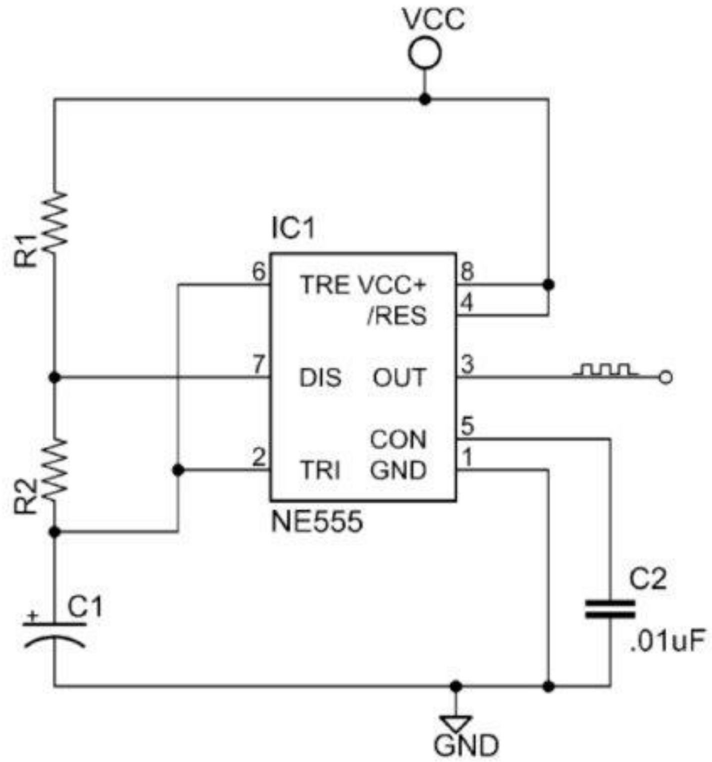


Figure 7: Basic 555 astable multivibrator circuit.

In astable mode, capacitor C1 charges through resistors R1 and R2. While the capacitor is charging, the output is high. When the voltage across C1 reaches 2/3 of the supply voltage C1 discharges through resistor R2 and the output goes low. When the voltage across C1 drops below 1/3 of the supply voltage C1 resumes charging, the output goes high again and the cycle repeats.

The timing diagram in figure 8 shows the 555 timer output in astable mode.

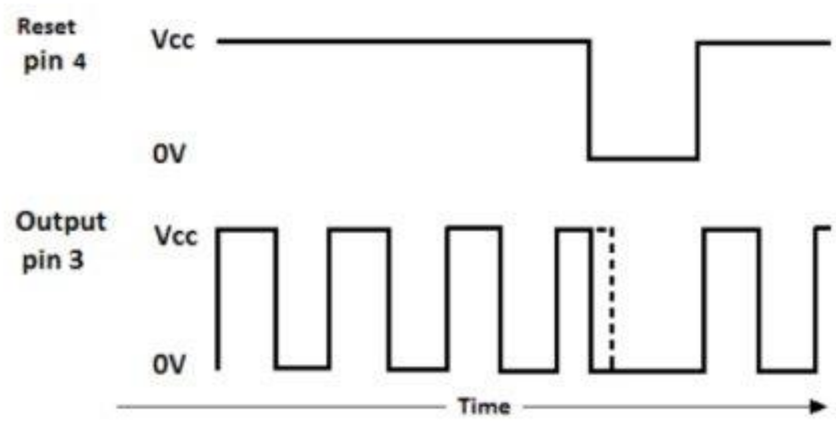


Figure 8: 555 timer in Astable mode.

As shown in figure 8, grounding the Reset pin (4) stops the oscillator and sets the output to low. Returning the Reset pin to high restarts the oscillator.

Calculating the period, frequency and duty cycle Figure 9 shows 1 complete cycle of a square wave generated by a 555 astable circuit.

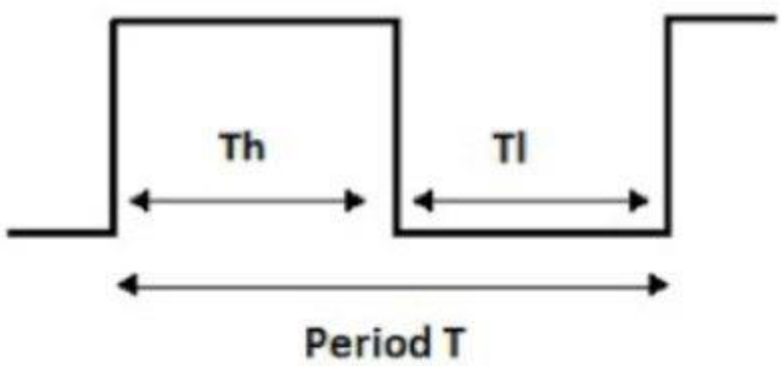


Figure 9: Astable square wave one complete cycle.

The period (time to complete one cycle) of the square wave is the sum of the output high (Th) and low (Tl) times. That is:

T = Th + Tl

where T is the period, in seconds.

You can calculate the output high and low times (in seconds) using the following formulas:

$Th = 0.7 * (R1 + R2) * C1$
$Tl = 0.7 * R2 * C1$

or, using the formula below, you can calculate the period directly.

$$T = 0.7 * (R1 + 2*R2) * C1$$

To find the frequency, just take the reciprocal of the period or use the following formula:

$$f = \frac{1}{T} = \frac{1.44}{(R1 + 2*R2) * C1}$$

Where f is in cycles per second or hertz (Hz).

The duty cycle is the percentage of time that the output is high during one complete cycle. For example, if the output is high for Th seconds and low for Tl seconds then the duty cycle (D) is:

$$D = \frac{Th}{Th + Tl} * 100$$

However, you really just need to know the values of R1 and R2 to calculate the duty cycle.

$$D = \frac{R1 + R2}{R1 + 2*R2} * 100$$

C1 charges through R1 and R2 but discharges through R2 alone so duty cycle will be greater than 50 percent. However, you can obtain a duty cycle very close to 50% by choosing a resistor combination for the desired frequency such that R1 is much smaller than R2.

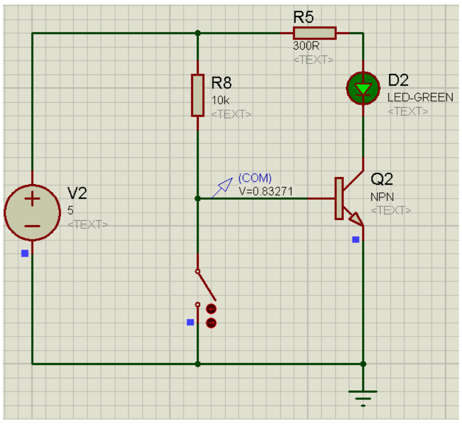
The smaller R1 is compared to R2 the closer the duty cycle will be to 50%.
To obtain a duty cycle that is less than 50% connect a diode in parallel with R2.

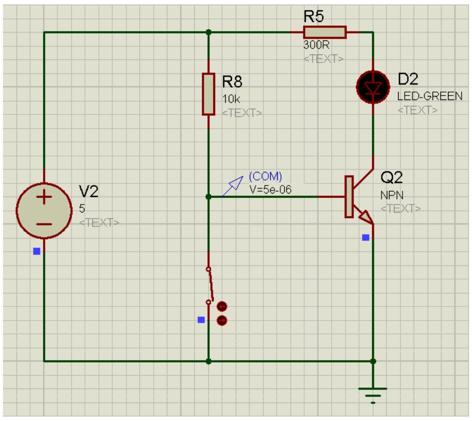
4)FIRST PROTOTYPE: OUR TESTING IDEA

We have done our researchs and decided to move on with our circuit.

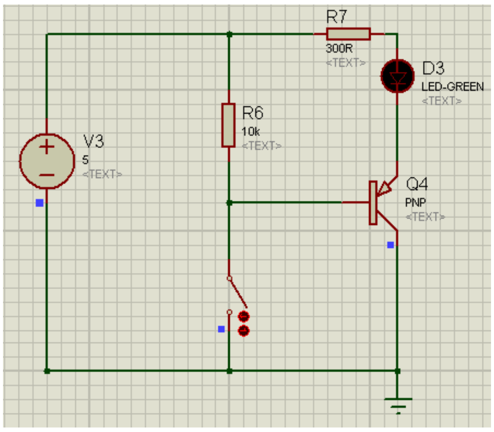
Our task is to test “any” BJT transistor and see if it is faulty or not. We know that PNP and NPN behave differently and we can test both of them in two different circuits.

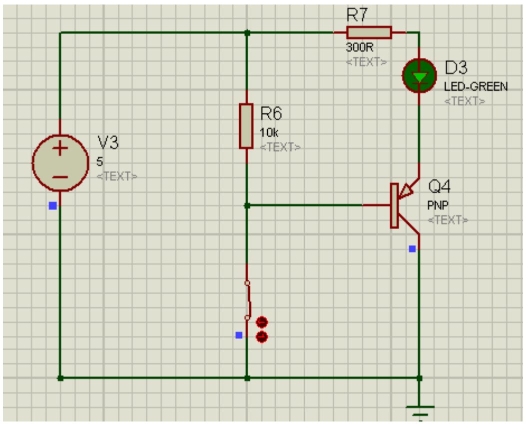
Firstly, to test a NPN we came up with the simplest circuit with reasonable resistor values which makes it on-state therefore lighting up the LED. Then we added a switch that connects the base pin to the ground so when the switch is on base pin voltage will be ground level.





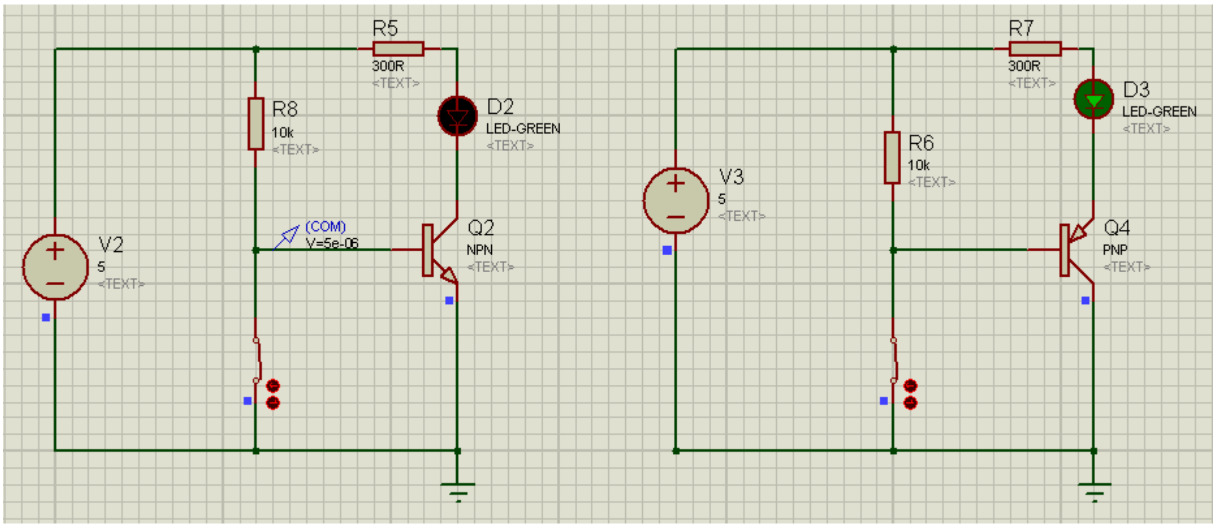
After finding a way to observe the switching of the NPN we then continued on with building a similar circuit for PNP. We realized that replacing the NPN and puting a PNP with Emitter pin to high side and Collector to ground our circuit will behave in inverse manner.





The reason being that the VBE voltage that is needed to activate the transistors are provided to them this way. Connecting the circuit vice versa will circuit to behave differently which we will talk about in a later part.

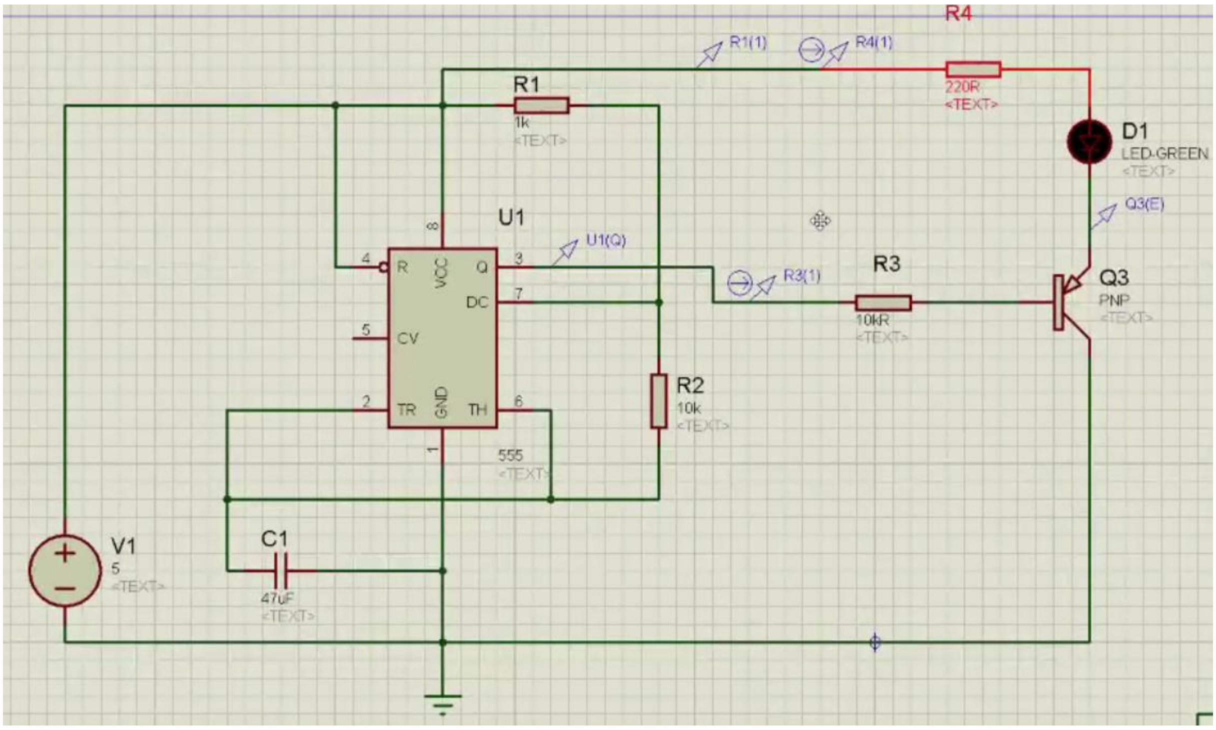
So we have built a circuit that can test the switching capabilities of both types of BJT transistors.



While this circuit can stay here as a “Proof of Concept” we will be fine tuning it to ease the users experience by making the switch automatically using a extra components. We had many options for oscilations but we eventually decided to use 555 timer.

We have experimented with 555 before and our teammate Okan had one 555 one laying around so we decided to not only make a simulation but make a prototype of the circuit in real life. We then proceeded to learn more about 555 timer. And We have used

5)555 Timer on Our Circuit



555 Timer on our circuit is in astable mode

Frequency

$$f = \frac{1}{T} = \frac{1.44}{(R1 + 2*R2) * C1}$$

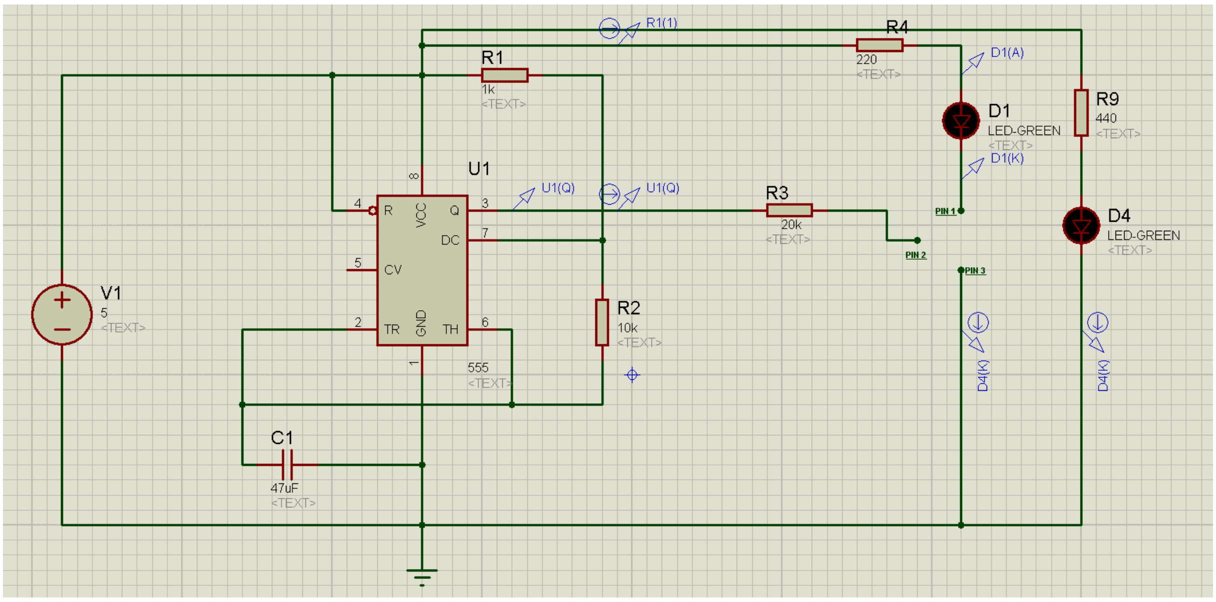
$$\rightarrow f = \frac{1}{T} = \frac{1.44}{(1k+2*10k)*47uF} = 1.45Hz$$

Duty Cycle

$$D = \frac{R1 + R2}{R1 + 2*R2} * 100$$

$$\rightarrow D = \frac{1k+10k}{1k+2*10k} * 100 = \%52$$

6) FINAL CIRCUIT



After deciding on the resistor and capacitor values of the 555 in order to get a reasonable frequency output , we integrated the 555 to our “Proof of Concept” circuit. Now only thing the user needs to do is to connect the transistor correctly.

DECISIONS

We have decided to use 5V to power the circuit so that it can be powered from computers USB port. We care about the enviroment. R3 resistor value has changed so that it protects the 555 reverse current while testing PNP and also providing enough base current for the circuit to operate.

Another thing we have added is a Power LED (D4). It is there to indicate that the circuit is ready to test any transistor and it serves a second purpose of being brightness reference. It has a constant current flow of 6mA and when the D1 LED blink healthily it is around that level of brightness. When the user connects the BJT in wrong order it blinks very lightly. We will talk about this later.

Finaly we named the pins and prepared a block schematic as a user manual for connections and observations.

TESTING THE CIRCUIT

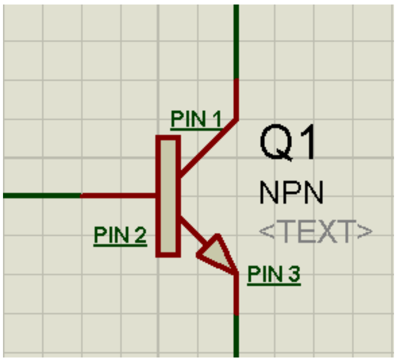
We know that the LED should blink very clearly if our transistor is healty. We have tested the conditions for it to fail by creating shorts and open circuits in proteus and noted our test values.

One thing to note : I_B is always under 0.2mA in both direction and it is negligible.

<u>Simulation Results</u>

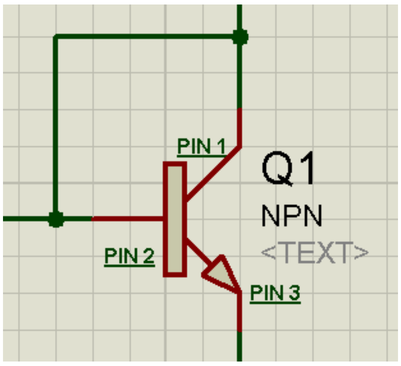
NPN

1)Healty NPN



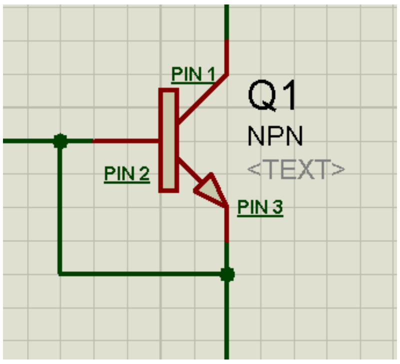
LED BLINKS AT AROUND 1HZ!

2)C-B SHORT



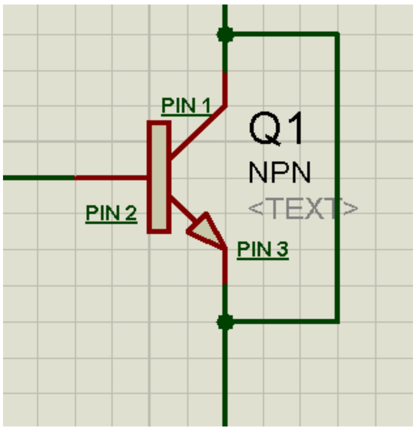
LED ALWAYS ON!!

3)E-B SHORT



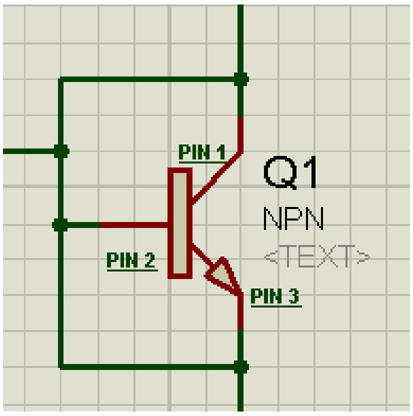
LED ALWAYS OFF!!

4)C-E SHORT



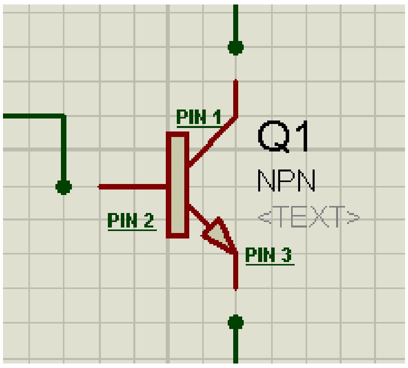
LED ALWAYS ON!!

5) C-B-E SHORT



LED ALWAYS ON!!

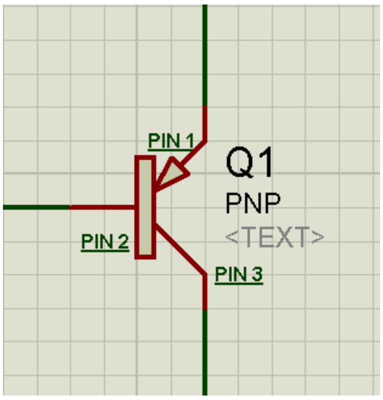
6)ANY OPEN CIRCUIT



LED ALWAYS OFF!!

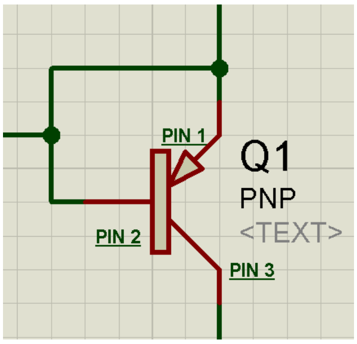
PNP

1)Healty PNP



LED BLINKS AROUND 1HZ!!!

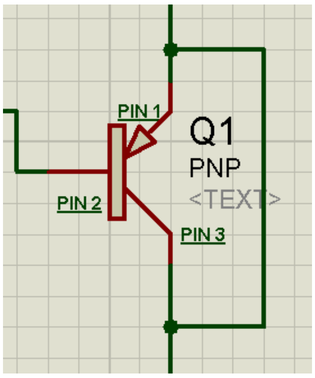
2)E-B SHORT



LED ALWAYS OFF(ish)!!

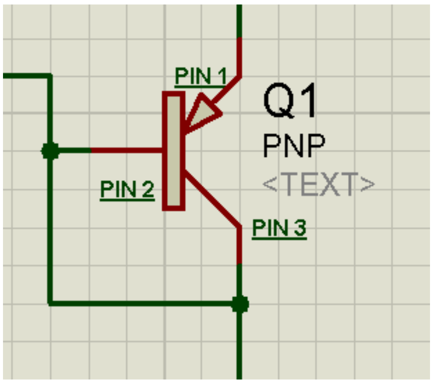
Circuit completes itself through 20kR and 0.1mA pass through LED making it blink very dimly. We can assume it is ALWAYS OFF!

3)C-E SHORT



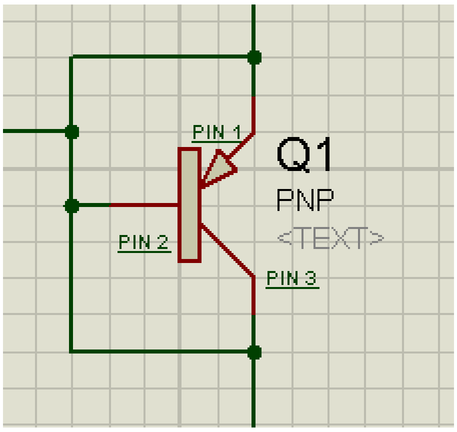
LED ALWAYS ON!!!

4)B-C SHORT



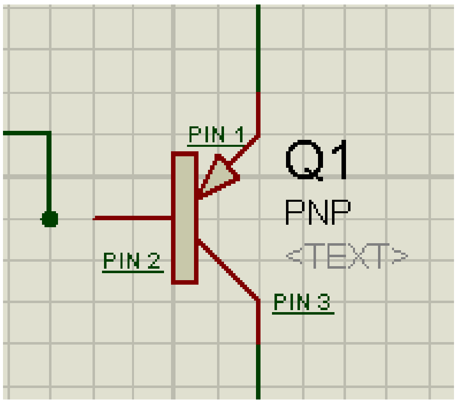
LED ALWAYS ON!!

5)C-B-E SHORT



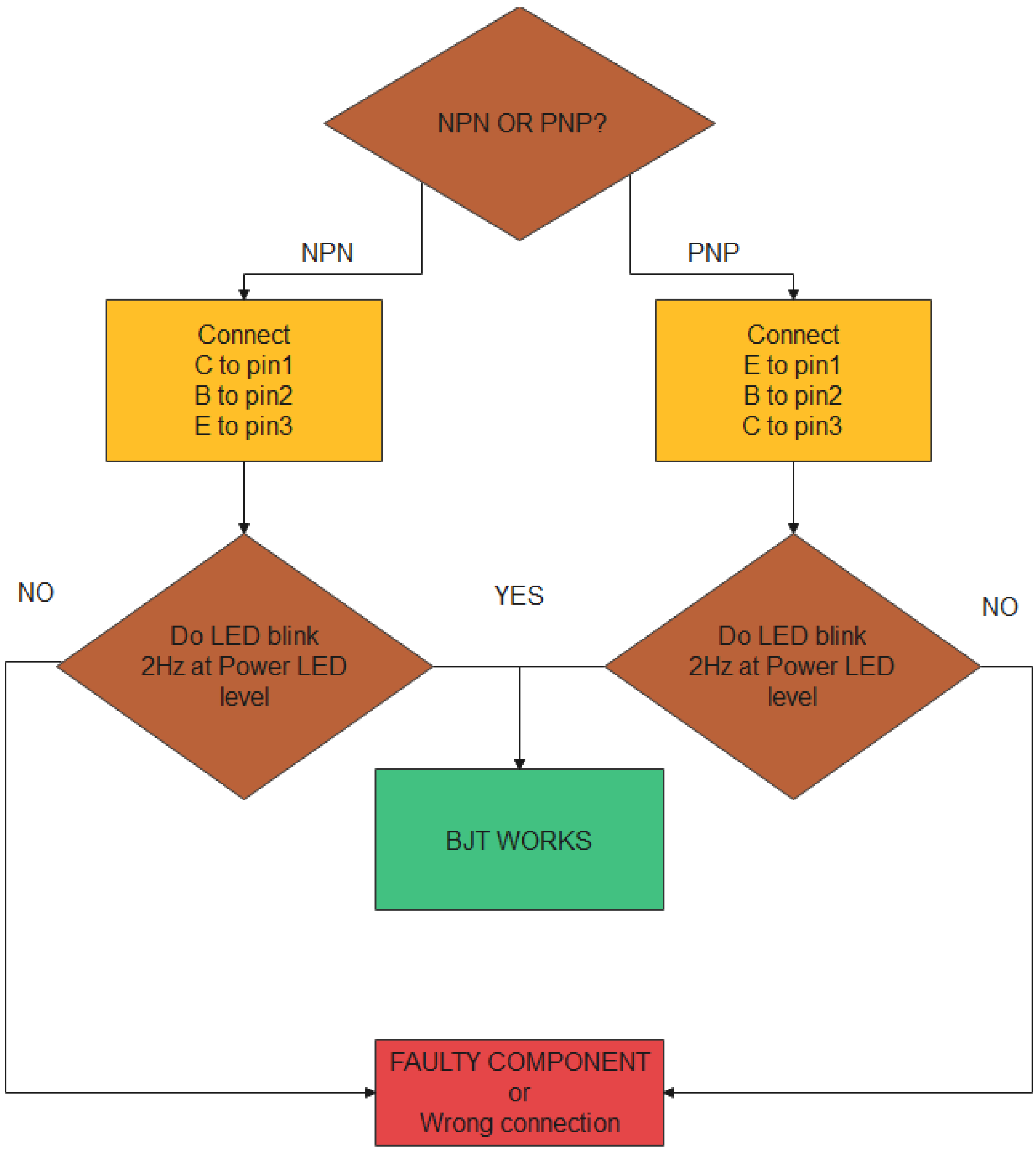
LED ALWAYS ON!!

6)ANY OPEN CIRCUIT



LED ALWAYS OFF!!

7)BLOCK SCHEMATIC & USER MANUAL



If the user wants to know what the fault may be, he/she can always look at our testing results here.

PROBLEM TO SOLVE: WHAT HAPPENS IF USER CONNECTS THE BTJ IN WRONG ORDER?

When we were testing the real life prototype of the circuit we occasionally misplaced the transistor. We noticed that the transistors when placed in wrong order (exp. C-B-E to E-B-C pins) behave like an ordinary transistor but with extremely low gain blinking with extremely low level of current. We have also mentioned this phenomenon in a previous chapter. LEDs have no minimum current for them to run.

Our schematic condition used to be that if it blinks it is healty which was no longer fully correct. We thought about a solution for a night and ended up with a solution which was also extremely inexpensive. Solution was to add a power on LED which can also be used as a healty connection reference. And We modified the block schematic to its final version.

This problem would not occur if the user connects the circuit as we inform it on the schematic But we are humans and it is natural for us to make mistakes it is good to have a fail-safe.

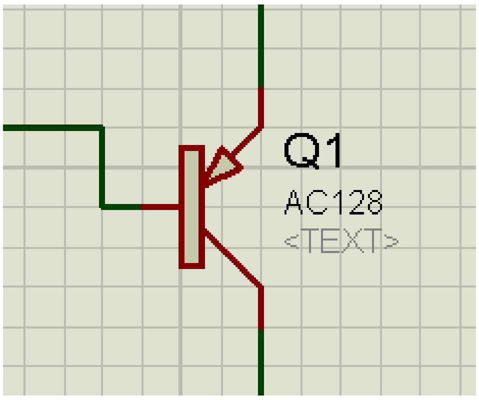
8) TESTED BTJ TYPES

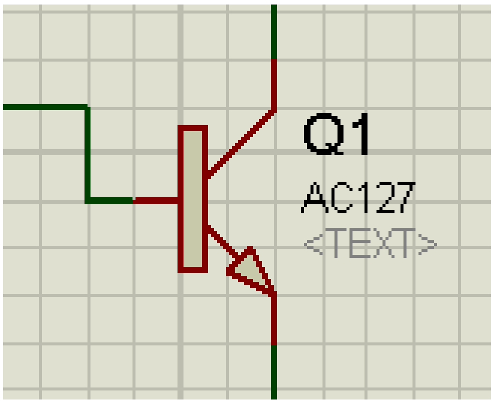
1-2)AC12X GERMANIUM SMALL SIGNAL TRANSISTOR

GERMANIUM SMALL SIGNAL TRANSISTORS

PRO ELECTRON TYPES

Type	Polarity	V_{CBO} V Max	V_{EBO} V Max	V_{CE} V Max		I_{CBO} @V_{CB} V	I_{CBO} µA Max	h_{FE} Min Max	@I_C mA	Cob pf Max	fab MHZ Min	Pack Outline	Power Dissipation @25°C MW
AC126	P	32	10	12		10	10	65-	2	50	1.7	TO-1	500
AC127	N	32	10	12				50-	500	70[2]	2.5	TO-1	340
AC128	P	32	10	16		10	10	55-175	50	100	1.0	TO-1	1,000
AC128K	P	32	10	16		10	10	55-175	50	100	1.0	NS257	1,000





AC127 10mA through LED (reverse connection 0.2mA)

AC128 6mA through LED (reverse connection0.4mA)

Faulty component results are as expected.

Test is a success

3) ZTX958 HIGH VOLTAGE PNP

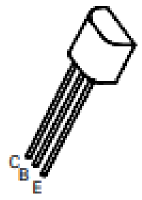
PNP SILICON PLANAR MEDIUM POWER HIGH CURRENT TRANSISTOR

ZTX958

ISSUE 3 – JUNE 94

FEATURES

* 0.5 Amp continuous current
* Up to 1.5 Amps peak current
* Very low saturation voltage
* Excellent gain characteristics up to 1 Amp
* Spice model available

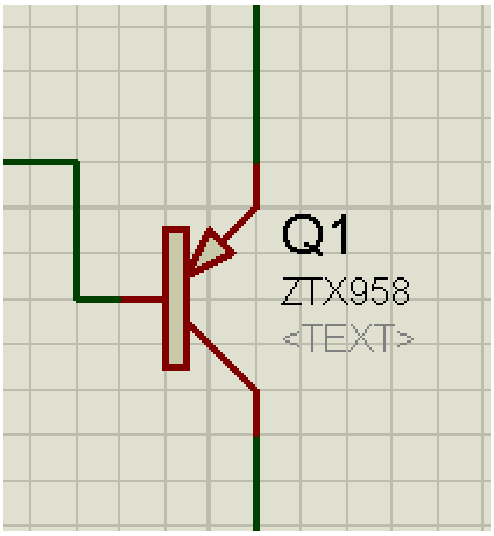


E-Line
TO92 Compatible

ABSOLUTE MAXIMUM RATINGS.

PARAMETER	SYMBOL	VALUE	UNIT
Collector-Base Voltage	V_{CBO}	-400	V
Collector-Emitter Voltage	V_{CEO}	-400	V
Emitter-Base Voltage	V_{EBO}	-6	V
Peak Pulse Current	I_{CM}	-1.5	A
Continuous Collector Current	I_C	-0.5	A
Practical Power Dissipation*	P_{totp}	1.58	W
Power Dissipation at T_{amb}=25°C	P_{tot}	1.2	W
Operating and Storage Temperature Range	T_j:T_{stg}	-55 to +200	°C

*The power which can be dissipated assuming the device is mounted in a typical manner on a P.C.B. with copper equal to 1 inch square minimum



6mA through LED(reverse connection 0.4mA)

Faulty component results are as expected.

Test is a success.

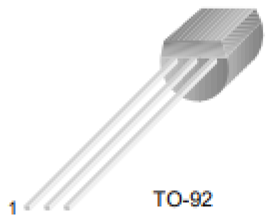
4)PN930 FAIRCHILD GENERAL PURPOSE AMPILIFIER

FAIRCHILD
SEMICONDUCTOR®

PN930

NPN General Purpose Amplifier

- This device is designed for low noise, high gain, general purpose applications at collector currents from 1μA to 50mA.



1

TO-92

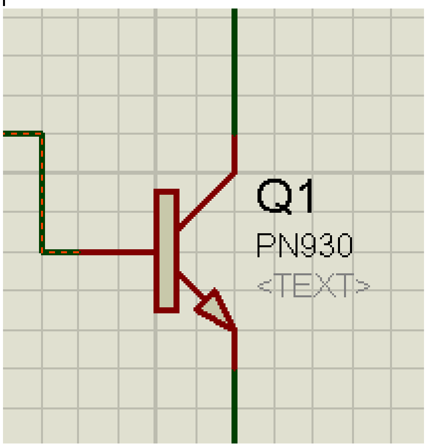
1. Emitter 2. Base 3. Collector

Absolute Maximum Ratings* T_A=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CEO}	Collector-Emitter Voltage	45	V
V_{CBO}	Collector-Base Voltage	45	V
V_{EBO}	Emitter-Base Voltage	5.0	V
I_C	Collector Current - Continuous	100	mA
T_J, T_{STG}	Operating and Storage Junction Temperature Range	- 55 ~ 150	°C

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaird.

NOTES:
1. These ratings are based on a maximum junction temperature of 150 degrees C.
2. These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations



11mA through LED (REVERSE 0.2mA)

Faulty component results are as expected.

Test is a success.

5)ZXTN25020DFH SOT23 MEDIUM POWER 20V

ZETEX SEMICONDUCTORS

ZXTN25020DFH
20V SOT23 NPN medium power transistor

Summary

BV_{CEX} > 100V; $BV_{(BR)CEO}$ > 20V

BV_{ECO} > 5V;

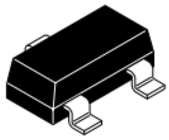
$I_{C(CONT)}$ = 4.5A

$R_{CE(sat)}$ = 28 mΩ typical

$V_{CE(sat)}$ < 43 mV @ 1A;

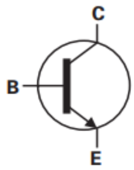
P_D = 1.25W

Complementary part number ZXTP25020DFH



Description

Advanced process capability and package design have been used to maximize the power handling and performance of this small outline transistor. The compact size and ratings of this device make it ideally suited to applications where space is at a premium.

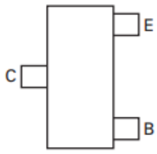


Features

- Higher power dissipation SOT23 package
- High peak current
- Low saturation voltage
- 100V forward blocking voltage
- 5V reverse blocking voltage

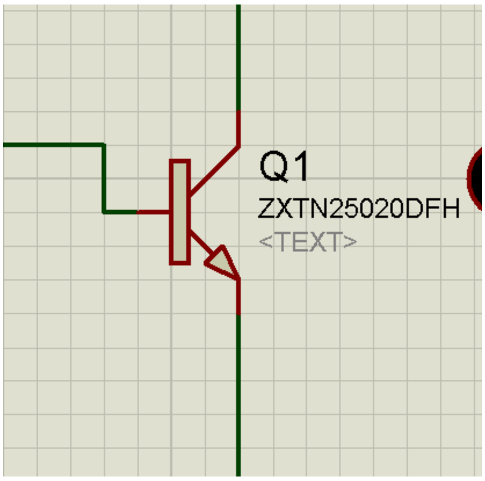
Applications

- DC - DC converters
- MOSFET and IGBT gate driving
- LED driver
- Motor drive
- Relay, lamp and solenoid drive



Pinout - top view

Ordering information



12.5mA through LED(reverse connection **also 12.4mA**)

Faulty component results are as expected.

Test is a success.

<u>OUTCOME OF THE SIMULATION TEST RESULTS</u>

A NPN transistor basically is a stack of three differently doped areas of a semiconductor. The first is N-doped, the middle P-doped and the last N-doped.

We can swap collector and emitter, and the transistor might still work. A real transistor is optimized to fulfill its specs when connected correctly in other words the **interior is not symmetric.**

If you swap C and E, you get a **new transistor with completely different specs**, which you don't know. It's also easy to overload and destroy the transistor by swapping C and E.

So it is better for the user to connect the BJT as it is intended.

9) PROTOTYPING THE CIRCUIT

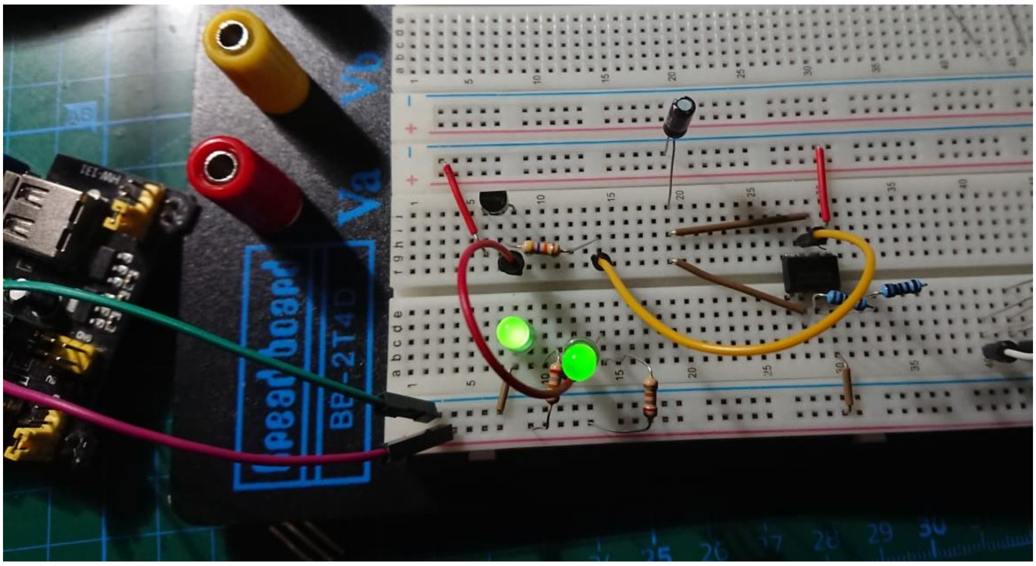


Figure 9.1 Prototype of Circuit

After the circuit has been created, it is time to implement the circuit. For this, the necessary connections were made on the breadboard and the circuit was run and it was successful. With the equivalent leds used in the circuit, it can be checked whether the direction of the transistor connected to the circuit is correct.

1. 2SD882 (NPN Transistor)

Description : The 2SD882 is NPN silicon transistor suited for the output stage of 3 watts auido amplifier, voltage regulator, DC-DC converter and relay driver.

Features :

- **Low saturation voltage.**

  $V_{CE(SAT)} < 0.5V$ (@ $I_C = 2A$, $I_B = 0.2A$)

- **Excellent h_{FE} linearity and high h_{FE}.**

  h_{FE} : 60 to 400((@ $V_{CE} = 2V$, $I_C = 1A$)

- Less cramping space required due to small and thin pacjage and reducing the trouble for attachment to radiator.

Maximum Voltages and Currents		
V_{cbo}	Collector to Base Voltage	**40V**
Vceo	Collector to Emitter Voltage	**30V**
Vebo	Emmiter to Base Voltage	**5.0V**
IC(dc)	Collector Current (DC)	**3.0A**
IC(pulse)	Collector Current (Pulse)	**7.0A**

Table 9.1 Maximum and voltages

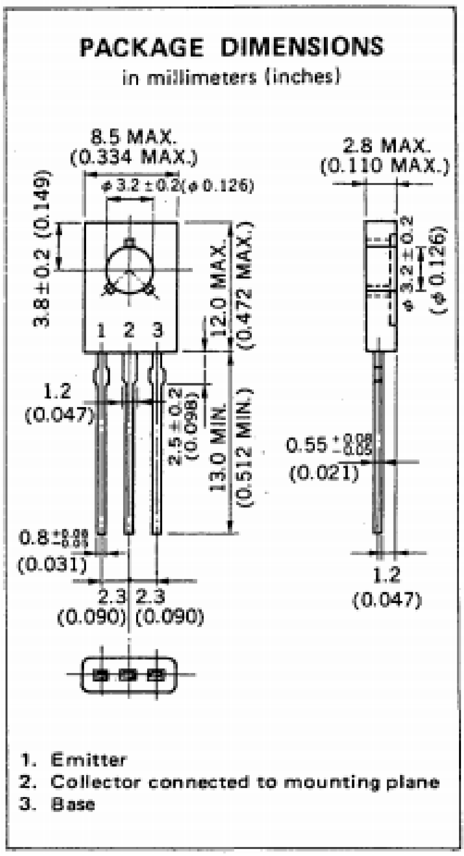


Figure 9.1 2SD882 Dimensions

Test Results: In the test, the 2SD882 transistor blinked as expected. Since pin connections are different from conventional transistors, pin connections are made in the form of 231.

2. 2N5401 (PNP Transistor)

Description: PNP high-voltage transistor in a TO-92 ; SOT54 plastic package. NPN complement 2N5551.

Features :

- **Low current (max: 300mA)**
- **High Voltage (max.150V)**
- **General Purpose switching and amplification**
- **Telephony applications**

PINNING

PIN	DESCRIPTION
1	collector
2	base
3	emitter

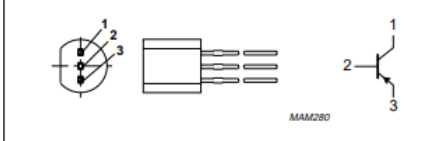


Fig.1 Simplified outline (TO-92; SOT54) and symbol.

Figure 9.2 2N5401 Dimensions

Maximum Voltages and Currents		
V_{cbo}	Collector to Base Voltage	**160V**
Vceo	Collector to Emitter Voltage	**150V**
Vebo	Emmiter to Base Voltage	**5.0V**
IC(dc)	Collector Current (DC)	**600mA**

Table 9.2 Maximum and voltages

Test Results: In the test, the transistor blinked as expected. Due to the structure of the PNP transistor, the led turns off when it is inserted reverse.

3. BC546(NPN Transistor)

Description: NPN high-voltage transistor in a TO-92 ; SOT54 plastic package. PNP complement BC556.

Features :

- **Low Noise**
- **High Voltage (max.65V)**

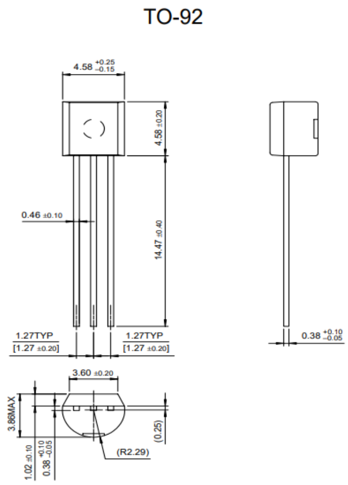


Figure 9.2 BC546 Dimensions

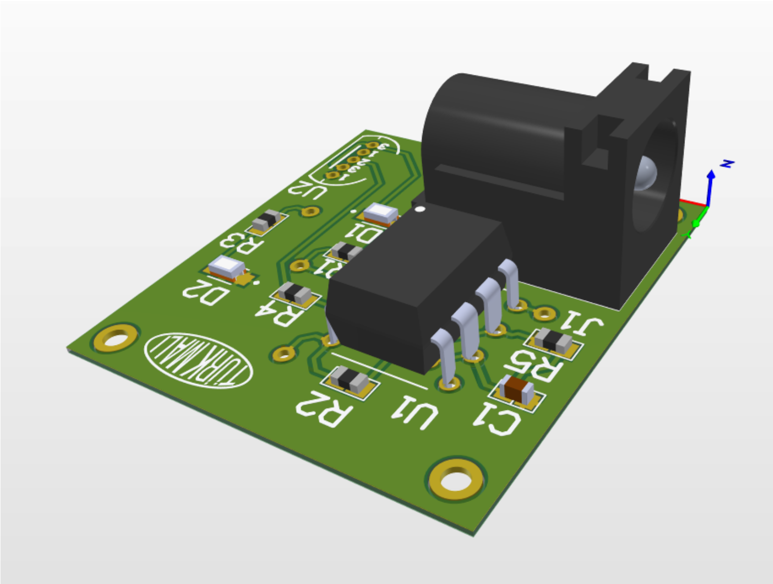
Maximum Voltages and Currents		
V_{cbo}	Collector to Base Voltage	**80V**
Vceo	Collector to Emitter Voltage	**65V**
Vebo	Emmiter to Base Voltage	**6V**
IC(dc)	Collector Current (DC)	**100mA**

Table 9.2 Maximum and voltages

Test Results:

In the test, the transistor blinked as expected. The control led remained on in the test performed with a defective version of which the connection between CE was short-circuited.

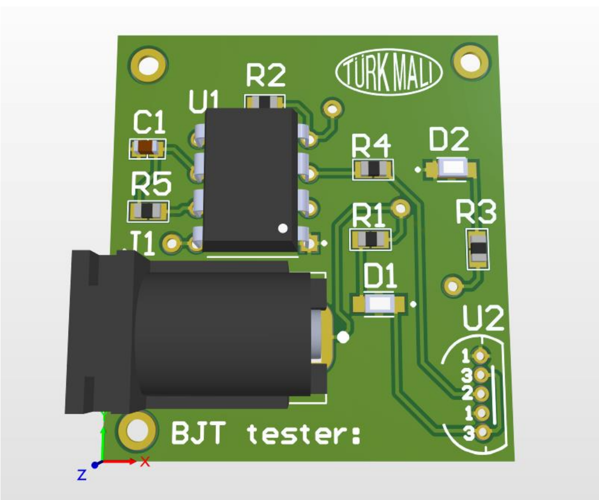
10) OUR CIRCUIT ON A PCB

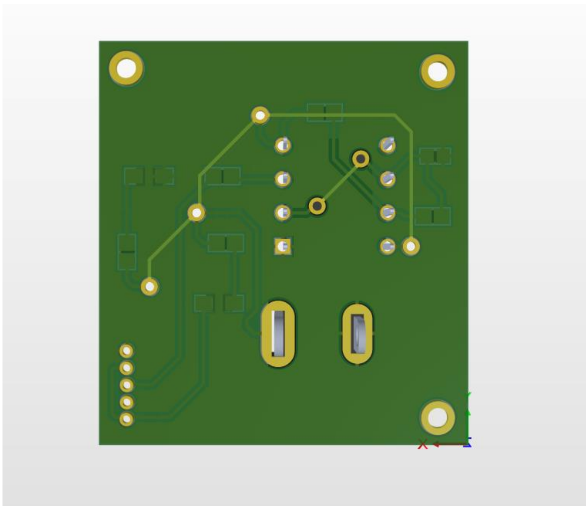


After our physical prototype being successful, we decided to make a PCB design for it on Altium.

Steps of PCB Production

1. For each component we created a library of its own.
2. After that we designed the schematic using those libraries. We uploaded the schematic to a PCB file.
3. We placed the components on board and drew the lines accordingly.
4. We have placed extra input pins (1-3-2-1-3) in order to test any kind of transistor since their packaging and pin-out order may differ.
5. Final board dimensions are 3cm x 2.8m making it very compact about the size of one souvenir coin and is ready to be produced.





BOM LIST

COMPONENT	QUANTITY
555 TIMER(8-DIP)	x1
Resistor(0805) (20kR,10kR,1kR,440R,220R)	x5
Capacitor(0805) (47uF)	x1
Green LED(0805)	x2
Barrel Connector	x1

REFERENCES

https://diyot.net/transistor-saglamlik-kontrolu/#:~:text=Transist%C3%B6rde

https://www.reddit.com/r/electronics/comments/7rj8sk/using_transistors_backwards/

https://www.researchgate.net/post/What_will_happen_if_I_bias_the_collector_and_emitter_of_an_NPN_Transistor_inversely

https://leetsacademy.blogspot.com/2017/03/how-to-test-npn-pnp-transistor.html

https://www.electronics-tutorials.ws/waveforms/555_timer.html

https://www.atlearner.com/2019/08/how-transistor-work.html