ANALOG PROJECT

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LOW BATTERY INDIACTOR CIRCUIT:

AIM

To study low battery indicator circuit.

MATERIAL REQUIRED

1. Power source
2. 4 resistors
   a. 3k3
   b. 22k
   c. 4k7
   d. Rx=1kohm
3. 2 NPN transistors(BC 547)
4. 1 Zener diode
5. 1 red LED
6. Connecting wires

THEORY:

ADVANTAGE OVER CONVENTIONAL ICs

The main advantage of the proposed two transistor low battery indicator circuit is its very low current consumption compared to the IC counterparts which consume relatively higher currents.

A IC 555 would consume around 5mA, a IC741 around 3 mA, while the present circuit would just consume around 1.5mA current.

Thus the present circuit becomes more efficient especially in cases where stand by current consumption tend to become an issue, example suppose in units which depend on low current battery supplies such as a 9V PP3 battery.

Another advantage of this circuit is it's ability to work even at voltages around 1.5V which gives it a clear edge over the IC based circuits.

the two transistors are configured as voltage sensor and inverter.

The first transistor on the left senses the threshold voltage level as per the setting of the 47K preset. As long as this transistor conducts, the second transistor on the right is held switched OFF, which also keeps the LED switched OFF.

As soon as the battery voltage falls below the set threshold level, the left transistor is no longer able to conduct.

This situation instantly triggers the right hand side transistor, switching ON the LED.

The LED switches ON and provides the required indications of a low battery warning.

WHY NPN TRANSISTORS ARE USED INSTEAD OF PNP

1. **NPN** transistors have **electron** as majority **carrier** and so NPN is preferred because of **faster mobility of electrons**.
2. NPN is most **suitable for negative ground system.**
3. **Common Emitter configuration** is most widely used transistor configuration.
   a. with **PNP** transistor, **+ve supply line becomes common point** (circuit ground) of input & output signal, which is **not** so **convenient for design, testing and maintenance.**
   b. with **NPN** transistors, **-ve supply becomes common point** and resulting in **-ve ground, which is convenient for design, testing & maintenance.**
4. The mass processing of Si based components are most economically manufactured using large N type silicon wafers while **PNP transistor requires 3 times more Si chip surface**, so it gets **uneconomical** when the chip costs are a big part of the component.

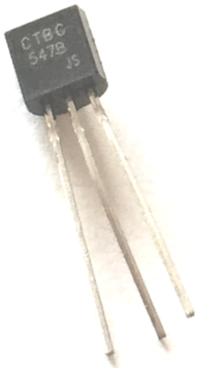
<u>WHAT IS HFE AND BETA</u>

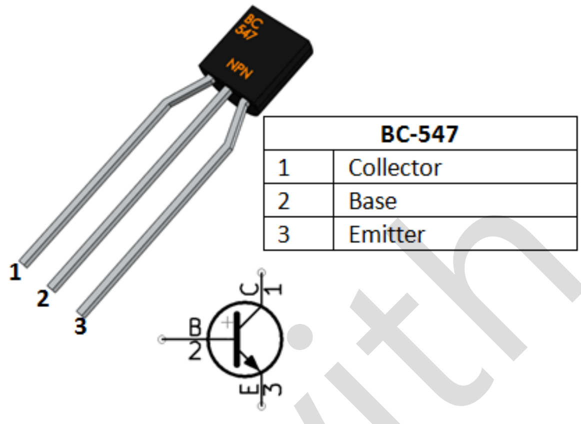
HFE is an abbreviation that stands for **HYBRID parameter FORWARD current gain, common EMITTER,** and is a measure of DC gain of a junction transistor.

For some transistors **HFE** readings may be done at several crucial frequencies as well as DC. **BETA** is a better term for common-base designs, or just a general statement about DC and/or AC current gain in a known circuit.

DESCRIPTION OF COMPONENTS:

BC 547 NPN TRANSISTOR





BC547 is a **NPN transistor** hence the collector and emitter will be left open (Reverse biased) when the base pin is held at ground and will be closed (Forward biased) when a signal is provided to base pin. BC547 has a gain value of 110 to 800, this value determines the amplification capacity of the transistor. The maximum amount of current that could flow through the Collector pin is 100mA, hence we cannot connect loads that consume more than 100mA using this transistor. To bias a transistor we have to supply current to base pin, this current (IB) should be limited to 5mA.

When this transistor is fully biased then it can allow a maximum of 100mA to flow across the collector and emitter. This stage is called **Saturation Region** and the typical voltage allowed across the Collector-Emitter (VCE) or Base-Emitter (VBE) could be 200 and 900 mV respectively. When base current is removed the transistor becomes fully off, this stage is called as the **Cut-off Region** and the Base Emitter voltage could be around 660 mV.

BC547 Equivalent Transistors

BC549, BC636, BC639, 2N2222 TO-92, 2N2222 TO-18, 2N2369, 2N3055, 2N3904, 2N3906, 2SC5200

BC547 Transistor Features

- Bi-Polar NPN Transistor
- DC Current Gain (HFE) is 800 maximum
- Continuous Collector current (IC) is 100mA
- Emitter Base Voltage (VBE) is 6V
- Base Current(IB) is 5mA maximum
- Available in To-92 Package

ACTIVE MODE OF LED:

Voltage across Led comes out to be 0.7V.

A red led to be active requires about 1.8V to be active with a few milliamperes of current.Using simulations and practical experiments it can be found out that the red led does not light when the current is below a few milliamperes.In such a situation the led does not light hence indicating that either the voltage is above a certain threshold voltage I.e. there is enough voltage provided to the circuit for it to fall below the threshold value of voltage to be indicated or the voltage is so low that the diode is not functional.In practical applications the device switches off in case the voltage falls below the minimum voltage required for the diode to operate.

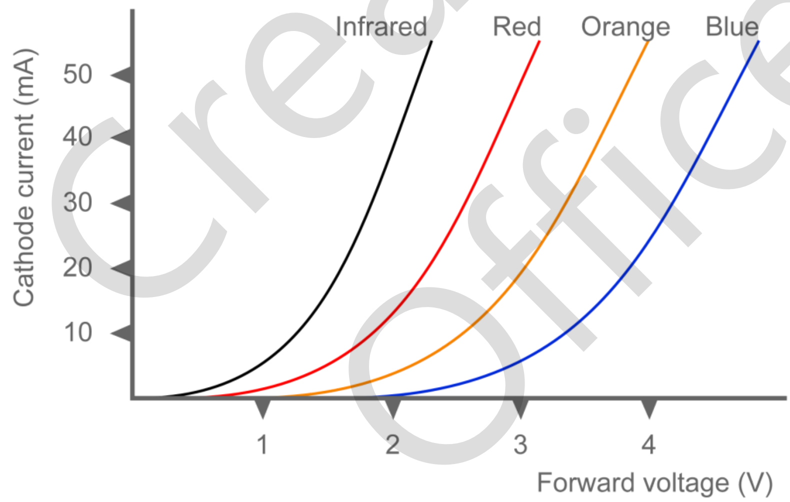
The question which arises here is why does the voltage across diode practically comes out to be 0.7V when the required voltage for a diode is 1.8V.This is because of the fact that the LED acts as a normal diode when it is active and hence provides a voltage of 0.6-0.7V across itself as any ideal diode would provide.However it requires a minimum of 1.8-2.0V to be active and hence a resistor is provided along with the diode to help save the diode from damage.

The 1.8V is a given for the LED; if current flows through a LED it will show a more or less constant voltage across it, just like a common silicon diode will drop about 0.7V at low currents. The anode will always be 1.8V higher than the cathode for your type of LED (the actual voltage mainly depends on the LED's color). The fact that this voltage is constant allows you to calculate the appropriate current limiting series resistor:

R=V+−VLED/ILEDR=V+−VLED/ILED

or the current for a given resistor value(when V+=V):

RLED=V+−VLED/ILED=9.6V−1.8V/8.79mA=939ohm=1kohm(app.)



USE OF ZENER AND BJTs IN THE CIRCUIT:

A)Zener diode

The zener diode is used in the circuit to regulate voltage so that the voltage across the led does not cross a particular voltage.This helps in preventing any damage to the diode.If the voltage in the diode crosses a particular threshold there are chances that the diode might get damaged.Hence a zener is used so as to prevent the damage to the diode.

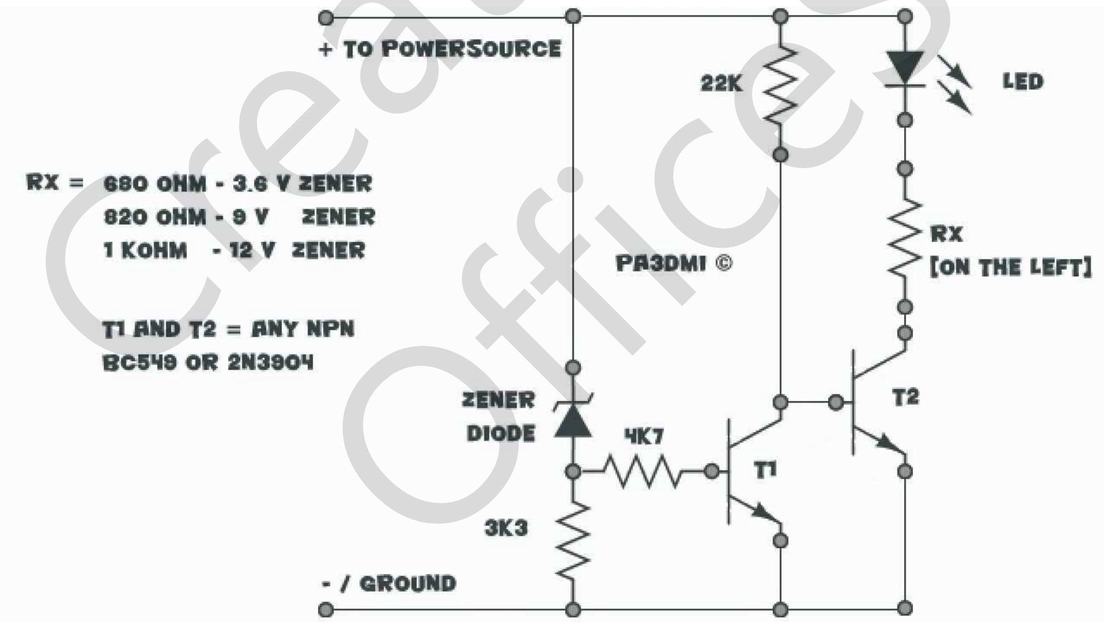
The voltage of the diode also controls the resistances in the circuit.The led can be used for different ranges of input voltages.This can be done with a few tweaks here and there of the zener diode and the resistances.

This is aptly explained in the diagram attached.

B) BI-Junction Transistor:

The use of a BJT in this circuit is very pivotal in providing the current amplification.The beta factor of the npn transistor used here(BC547/BC549) varies between 100-800 depending on the diode model A,B or C.

This provides an amplification to the current.Otherwise the current through the led would have been low due to the high resistances in the circuit.Also the resistance values could not have been lowered otherwise the led might get damaged due to very high current flowing through the LED.Hence a proper balance is required to be maintained between the resistances and the zener diode.



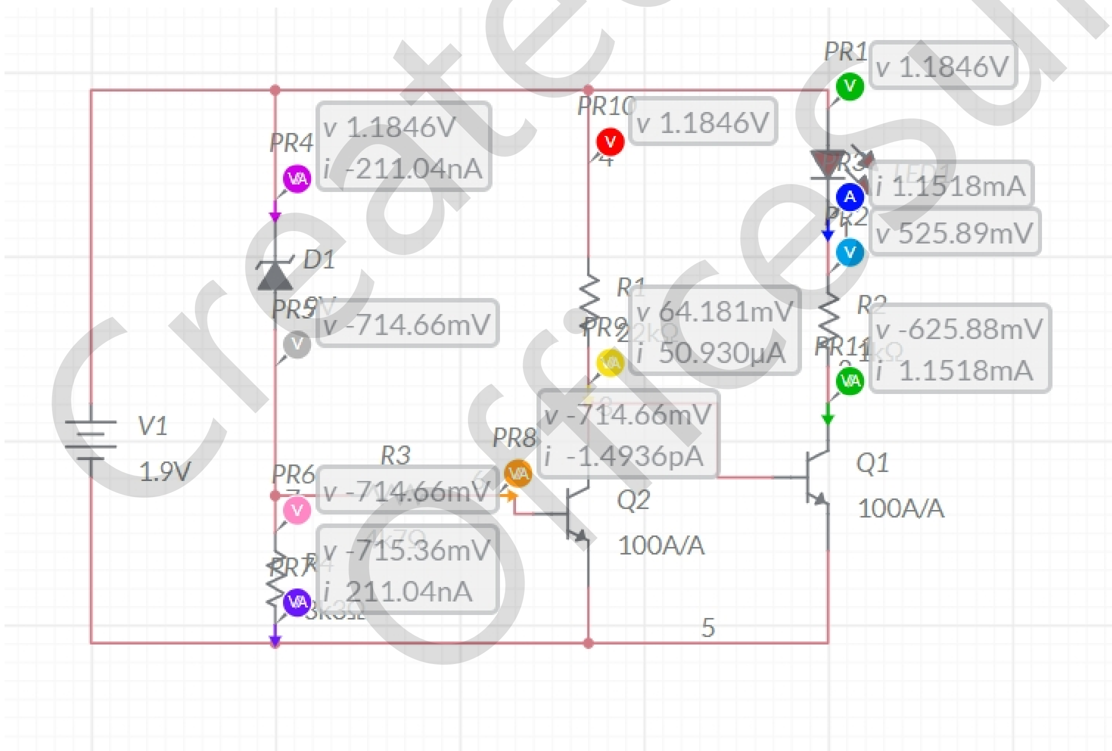
Range of operation of the low power/battery indicator:

This discussion basically discusses why the following components were used and forms the basis of the circuit diagram.

Assuming that the circuit operates in the range of (V-,V+) where V- is the lowest voltage for which the circuit operates and V+ is the highest voltage for which the circuit is operational.

One important point to note here is that circuit has used BJTs as well as zener diode and not just a circuit with a single zener diode to indicate low power .This is because when we use a single zener diode we get a lower voltage point as 0v whereas in case of such a complicated circuit we can actually increase the lower voltage from 0v to some V- point.This point in case of a simulated circuit with beta amplification of 100(ideal beta amplification) comes to be around 1.9V.

One more thing to note is that this circuit is a low power circuit hence the current requirements for the diode are very low.The power dissipated as well as required for the circuit is very low.



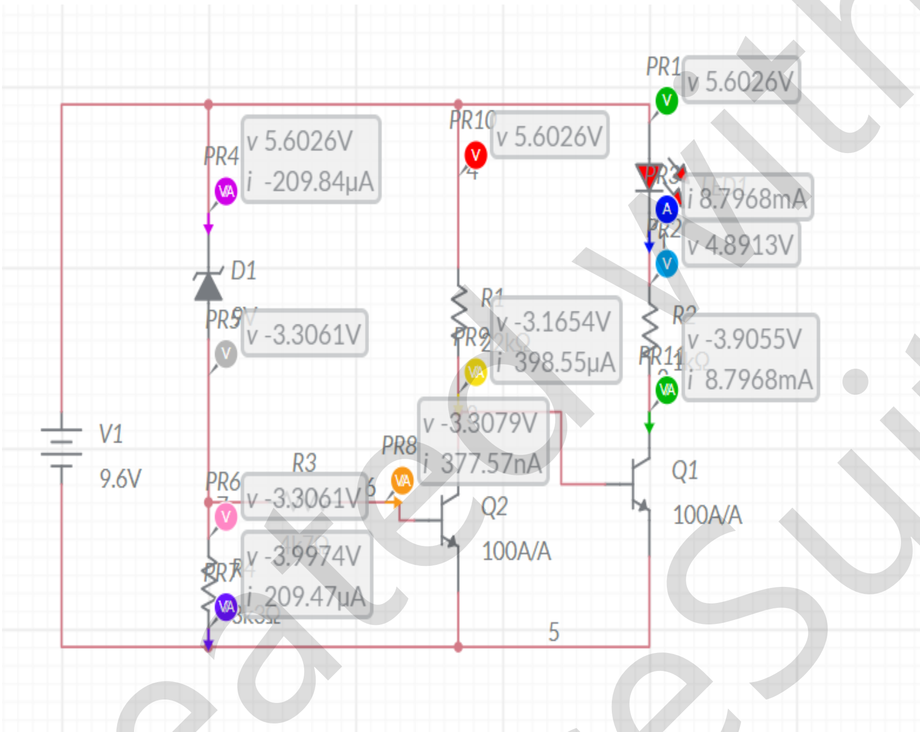
For V-=1.9V

You want the LED to turn on at about 1.9V. I am going to make the assumption you want it to work in the range of 1.9V to 9.6V, so we'll use those two as the extremes of our calculation. Further, for ease of the example I am going to assume a hfe of the BC547 of 100. a BC547C type may go up to 500 in the right circumstances.

First off, you mention a low-power LED. This again drives an assumption, as no specifications are made, I will assume the LED current is 1-10mA(a few mAs) and that the red LED adheres to commonalities, needing about 1.8V at that current. Here we go!:

Lowest V+ = 1.9V, I(led) = 0.001A, V(led) = 1.8V, means: R(led) = (1.9V - 0.7) / 0.001A =1.1 k Ohm.

LED current at 9.6V: I(led-9.6) = (9.6V - 1.9V) / 1kOhm =8mA



The current into the base of the LED's transistor then becomes 80uA at 9.6V and 10uA at 1.9V (divided by hfe, which is assumed 100). Which means:

Bias Resistor value, maximum: Rbias = (V+ - Vbase) / I(base) = (9.6V - 0.7V) / 80uA = 1271kOhm; or (1.8V - 0.7V)/10uA = 110kOhm   (1.8v assuming lowest v for led to light) , meaning 1000kOhm is our upper limit.However we have used a resistor of 22kohm which is well inside the safe range.

The transitor T1 is used just to amplify current to the second transistor.A currrent with values in nanoAmperes are amplified from T1 to microAmperes and finally to milliAmperes from T2 in the given circuit.

The rest is determined by your choice of Zener and Resistor to determine the initial trip voltage. The rest of the "waste" will be determined by your zener. Once the battery is at the trip level, the zener will start to cut off, so its loss will slowly minimize, but then, of course your LED will be draining 2mA.

For a reliable operation you want Iz not to be too far from its optimum, i.e. not a factor of 100. But there are probably types that can give decent effects with a bias current of 0.5mA.

OBSERVATIONS:

The volatge range for which the simulation works properly is:

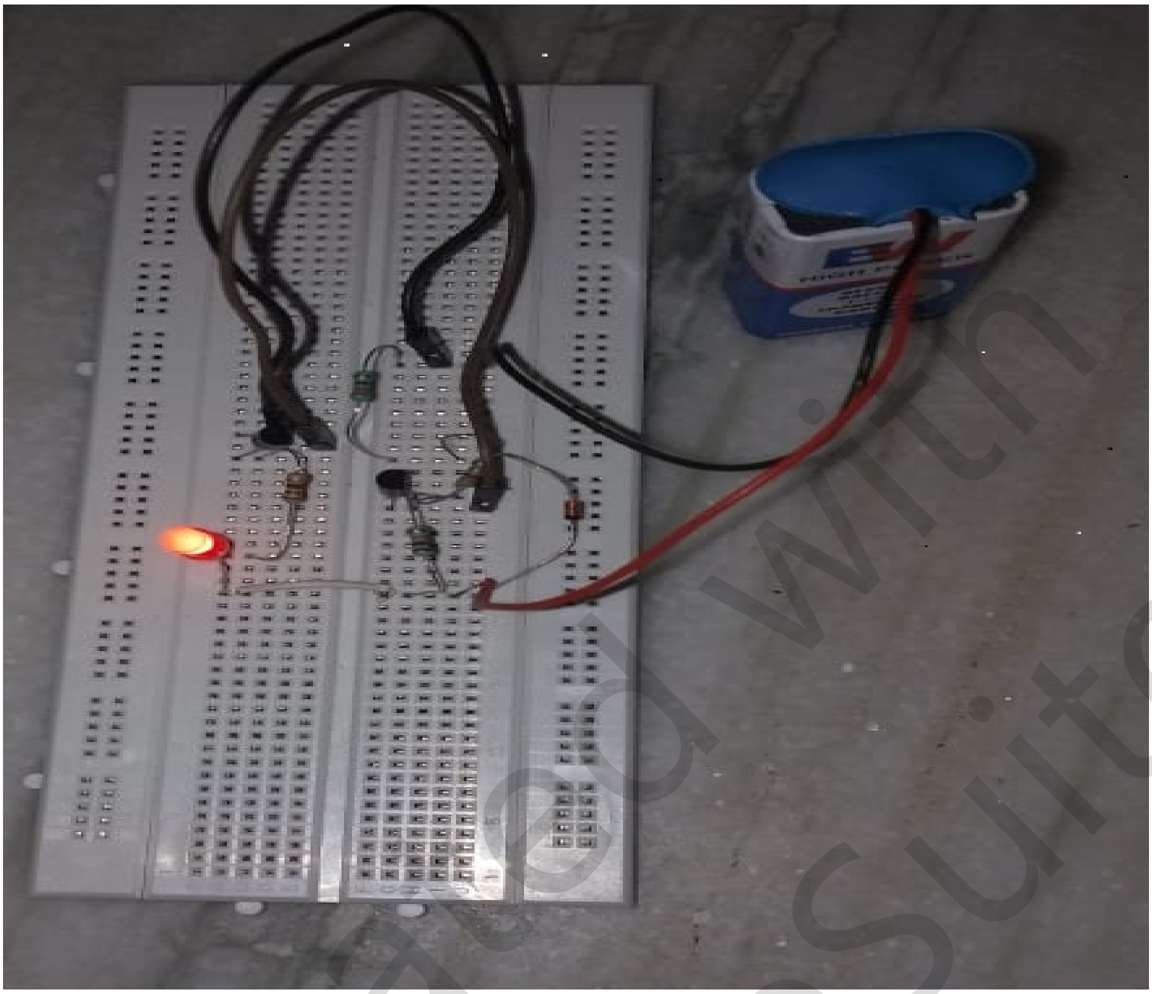
V+(highest voltage)=9.6V

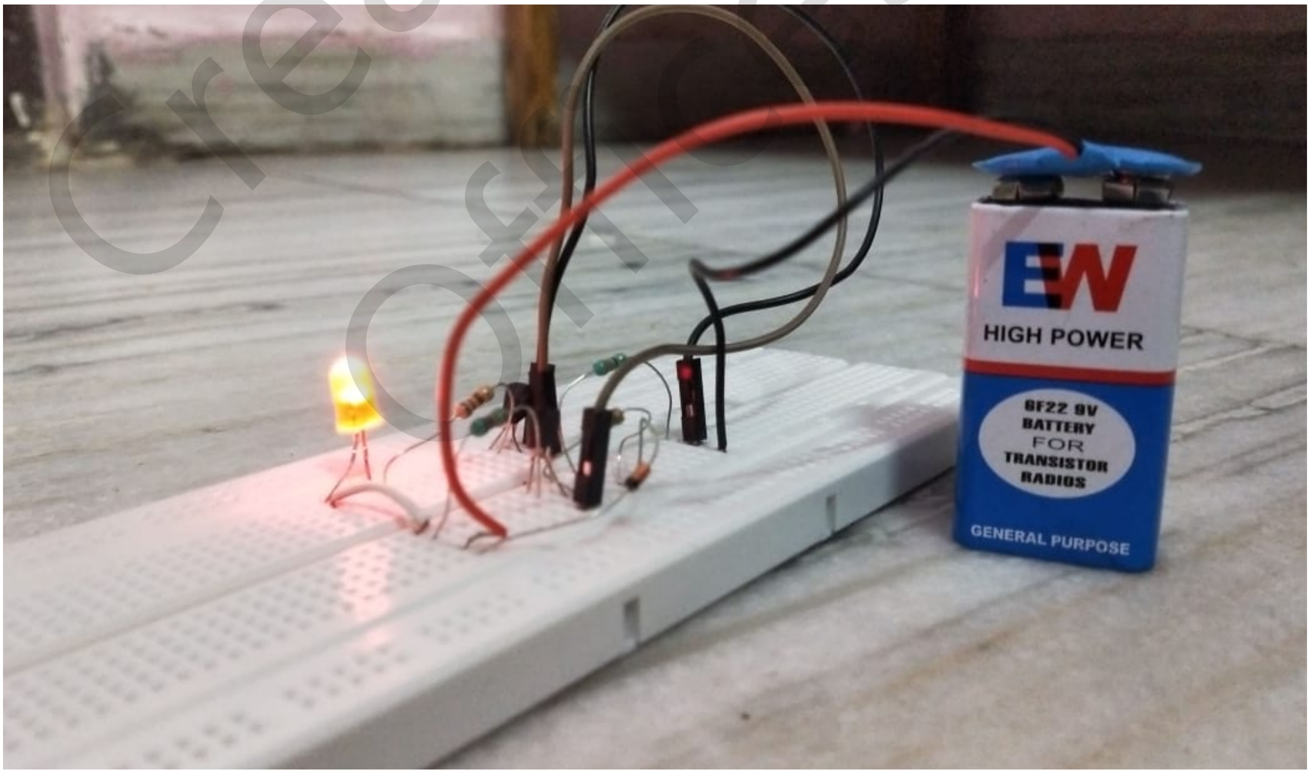
V-(lowest voltage)=1.9V

The actual range of values are approximately equal.

RESULT:

The low battery indicator is successfully tested with range of 1.9-9.6V.




EW
HIGH POWER
6F22 9V
BATTERY
FOR
TRANSISTOR
RADIOS
GENERAL PURPOSE