Abstract

Water level indicator alarm employs a mechanism to indicate the level of water in a tank. It displays information of water level in the tank by using led lights and buzzer alarm. Four leds are used in the circuit. The first LED indicates whether the system (circuit) is on. The second LED indicates low level of water in the tank. The third LED indicates half water level in the tank and the forth indicates when the tank is full plus the buzzer is triggered to sound an alarm. This system uses BC5748B Transistors as the heart of the circuit.

Acknowledgements

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Contents

Introduction

Nowadays everybody has an overhead tank at their homes. But everyone who has a water tank above knows the kind of problems that they face:

- Firstly, there is no system to track the water in the tank.

- Secondly, When the water pump is started they have no idea when it gets filled up and sometimes there are situations whereby the pump keeps on pumping water to the tank until water spills out from the tank.

Water tank overflow is a common problem which leads to the wastage of **water** as well as wastage of **energy**. Though there are many solutions to it like ball valves which automatically stop the water flow once the tank gets full. But us being electronic enthusiastic we wanted an electronic solution for it, as discussed in this report, whereby we are designing a circuit which will detect the water level and will raise an alarm upon getting the water tank full or at a preset level.

This project that we had taken up is the result of long hours of research of work at the internet as well as long hours of thinking. We had made various versions of the projects earlier but at last we came up with this final product. We bet this has been tested and we can firmly say that the model will work flawlessly without any complain for years.

Background Information

Our school has an overhead tank which is about 70 feet from the ground level. We thought how boring it was for the workers going to the rooftop to check whether the tank has filled or the water level was below to start the pump. Given that situations then they'll have to do this again and again. We sought for a solution, any possibility of tackling this problem in an electronic way. After days of thinking and trial and error, we found one and we wanted to put whatever we have done out here, so that it may be helpful to places with overhead water tank

The Working Principle

Basically the unit is made up of various **sensors** acting as a switch. In simple terms: What happens when you turn on the water pump, the water starts to get pumped from the underground reservoir or from the underground water supply from the pipes to the water tank. In the tank there are a set of sensors (to be precise there are 4 sensors) in the water tank, these act as switch, as the work of the sensor will be to connect the circuit. So the water starts to get filled in the tank and when the water level in the tank starts to rise up, what happens is that the sensors that are installed in the tank starts to get activated one by one indicating the water level in the tank. And finally when it reaches to its top most sensor, there will be a visual display(Led) as well as a sound from the unit indicating that the water has filled in the tank and one can be alerted that the tank has been filled up and the water pump has to be switched off thus saving the electricity bill as well as prevent overflow of water *from the tank.*

There are Four Parts in this Circuit System:

I. The Sensor part
It is generally a fixed support inside the tank having some nuts and bolt with wires coming out.

II. The Circuit part
It comprises the brain of the module, where in all the various inputs from the sensors are fed. It is the unit from where you will get all the information of how much of water is in the tank.

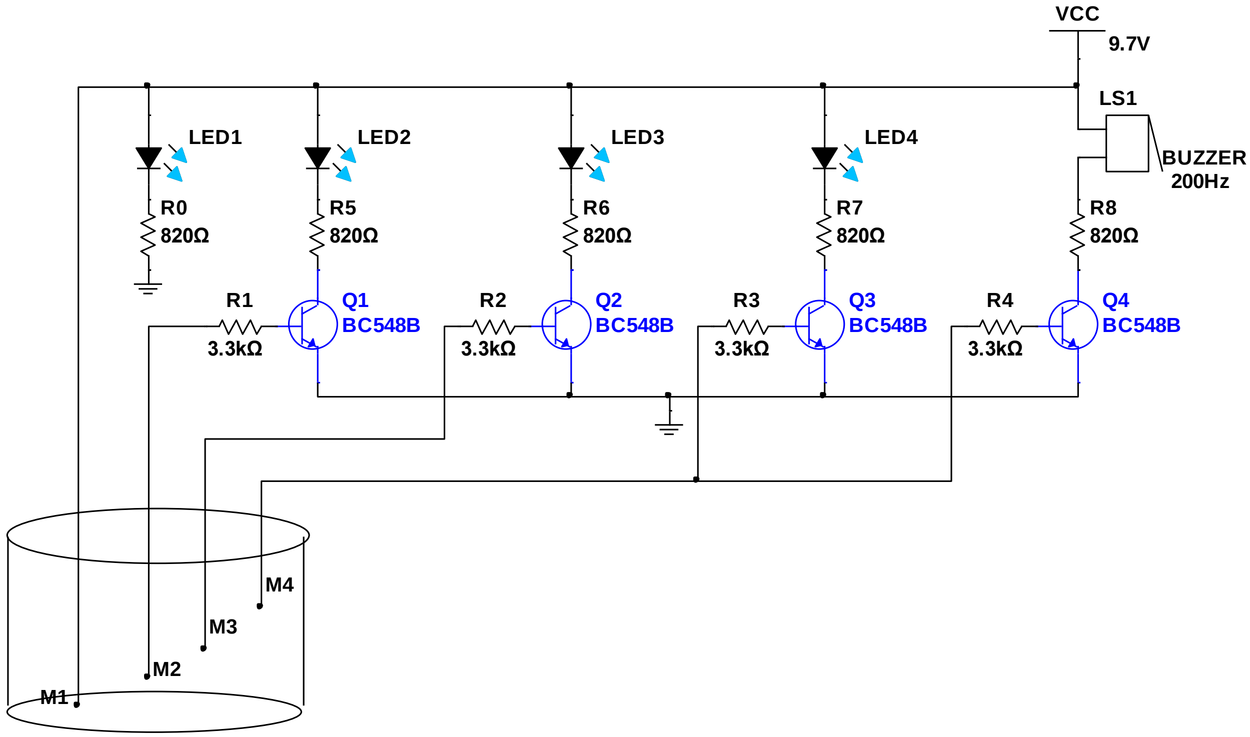
III. The Buzzer Part
It is responsible for bringing up the sound when the water level fills up in the tank. It will also be having a speaker or a buzzer to alert.

The Circuits Components

COMPONENTS	**RATINGS**	**Quantity**
Transistors	BC548B	4
Resistors	820Ω 3.3kΩ	5 4
Led Bulbs(green)	Vf = 2.13V @ 20mA	4
Buzzer/speaker	24V	1
DC Power Supply	10V	1

The General Circuit

The connections and arrangements are made as shown in the figure below. The +9.7V is supplied to water using a metal contact (Contact M1). In this circuit, all the transistors are working as switches. When the water touches the metal contact in which base of each transistor is connected, a small current flows and turns on the transistor. When a transistor turns on, LED connected to it glows. Thus leds will be turned on depending up on the **level** of water!



How the Circuit Works

The circuit has numerous *transistors acting as a switch* and the switch gets activated when the sensors tell them to, that is, when water touches the corresponding sensor connected to the transistor base.

The heart of the circuit is the **transistors BC548**. There are total 4 transistors in the circuit and each one will be sensing the level of water present in the overhead water tank.

There is one extra power *LED without a transistor* and that is because this (LED 1) will be telling us two things. Firstly, when you power the unit it will be monitoring the power present in the unit and secondly it is also the indicator telling us that there is no water at all present in the tank. As because the water level is below the M2 (as shown in the circuit) sensor, no LED's will be lighting up, but only for the LED 1. Therefore, when we switch on our unit and if we see only one LED lighting up, then you know that there is no water present in the tank and therefore water pump should be put on.

From the circuit diagram above, LEDs Starting from the beginning are

1. **LED 1** Indicating no water in the tank as none of the sensors are getting in contact with the water)

2. **LED 2** (Level *1*, indication low water in the tank)
3. **LED 3** (*Level 2*, indication of half of water in the tank)
4. **LED 4** *(Level 3*, Full water indication in tank and buzzer comes on)

If water is filled in the tank, water acts as a conducting medium, connecting the VCC coming from M1, with the other base contacts. This causes the base voltage to increase over the emitter voltage causing the transistors to become more switched until it's in a fully ON state, i.e saturated state. Hence the transistor becomes forward biased. Here the base terminals act as inputs and the collector emitter region of the transistor act as output. In between the transistors and the LEDs there is a current limiting resistor (820Ω), the job of the resistor is to check that the LEDs do not get destroyed by an over voltage.

Initially when the circuit is powered up, the first LED (LED1) lights up to indicate there is power in the circuit. As water rises, and reaches M2, the contacts M1 and M2 get shorted as water acts as a conducting medium between M1 and M2. This will turn on the transistor Q1 and the second LED starts to glow. As the water level continues to rise and reaches half the tank, M3 will come into contact with water and receives a small voltage from M1. As a result, Q2 is turned on and third LED will glow. When the water in the tank rises to full tank, M4 is also shorted with M1 and both Q3 and Q4 will turn on. Therefore, the forth LED glows and also an alarm is made by the buzzer as an indication that the tank is full.

Circuit Features

- Easy installation.
- Low maintenance.
- Compact elegant design.
- The Automatic water level controller ensures no overflows or dry running of pump there by saves electricity and water.
- Avoid seepage of roofs and walls due to overflowing tanks.
- Fully automatic, saves man power.
- Consume very little energy, ideal for continuous operation.
- Automatic water level controller provides you the flexibility to decide for yourself the water levels for operations of pump set.
- Shows clear indication of water levels in the overhead tank.

The BC548B Transistor Working

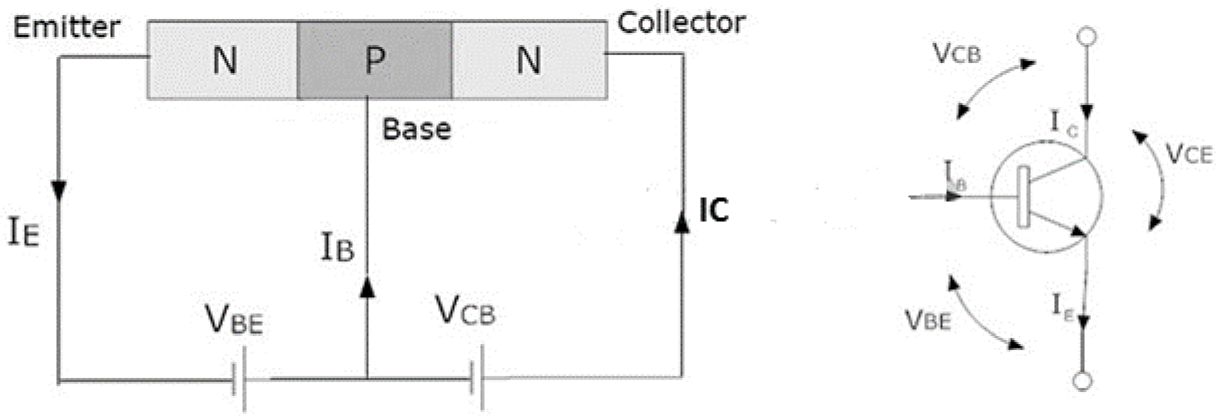
BC548 is an NPN Bipolar Junction Transistor (BJT). The NPN transistor consists of two n-type semiconductor materials and they are separated by a thin layer of p-type semiconductor. Here the majority charge carriers are the electrons. The flowing of these electrons from emitter to collector forms the current flow in the transistor.

We generally preferred using an NPN rather than PNP transistor because:

- The mobility of electrons is higher than the mobility of holes. The NPN transistor has three terminals – emitter, base and collector.

The BC548 NPN transistor can be used for amplifying but here were are mostly using it as an as an on/off switch (Switching the voltage signal from high to low and vice versa), that is, an inverter.

BC548 NPN transistor symbol and structure



The above figure shows the symbol and structure of BC548 NPN transistor used in the circuit. In this structure we can observe the three terminals of transistor, circuit currents and voltage value representations.

The collector terminal always connected to the positive voltage, the emitter terminal connected to the negative supply and the base terminal controls the ON/OFF states of transistor depending on the voltage applied to it.

When there is no water in the tank, the base contacts of the 4 transistors are grounded, therefore this causes the transistors to be in **Cut-off Mode:** In this mode, also the transistor acts like a switch but there is no current flow from collector to emitter (it's like an open circuit). There is no current flow through both emitter and collector terminals. The loads Here R1 R2, R3, and R4 limit the current flowing through the base terminals while the loads R5, R6, R7, and R8 are used to limit the current flowing through the collector terminal. Being no water in the tank, the base is grounded (thus the base voltage equals the emitter voltage), and where else the collector assumes the VCC, this causes the transistor to be in the OFF state, i.e cut-off state.

Operation Modes of the Transistor

There are four modes of operations they are saturation, cutoff, active and reverse active.

Saturation Mode: In this mode transistor acts as a switch. From collector to emitter the current will flow unconditionally (short circuit). Both diodes are in state of forward biased.

Cut-off Mode: In this mode also transistor acts like a switch but there is no current flow from collector to emitter (open circuit). There is no current flow through both emitter and collector terminals.

Active Mode: In this mode the transistor acts like an amplifier that is the current from the collector terminal to emitter terminal is corresponding to the current through the base terminal. Base will amplify the current moving into the collector terminal and outgoing from the emitter terminal.

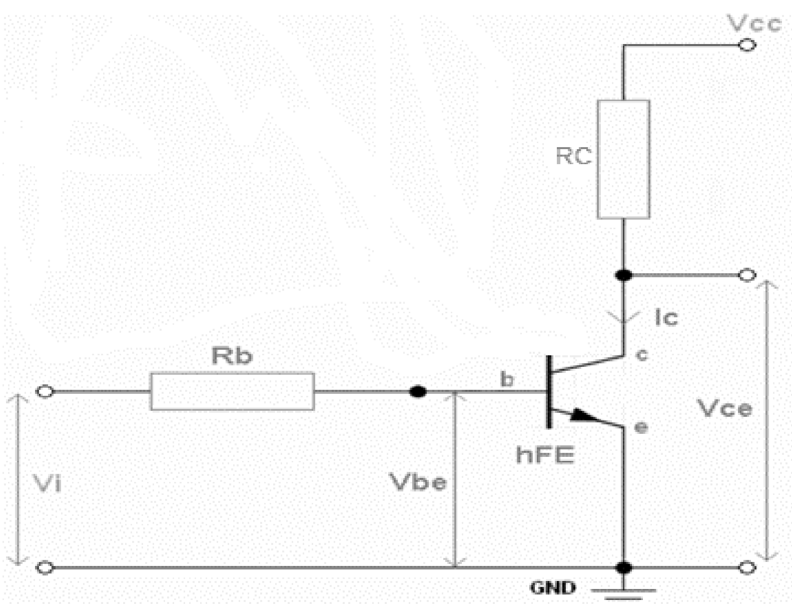
Reverse active Mode: The current from the collector terminal to emitter terminal is corresponding to the current through the base terminal but this flow is in reverse direction.

The Buzzer Part

Here we decided to use the normal buzzers that are readily available in the market and we realized that we could make one on our own using a simple 555 IC but because of time we decided not to.

Calculating The Base Resistor (Rb) formula

Taking a part of the circuit we see that:



The base resistor ("Rb"):

- Provides the necessary resistance to bias the base junction of a bipolar junction transistor (BJT)

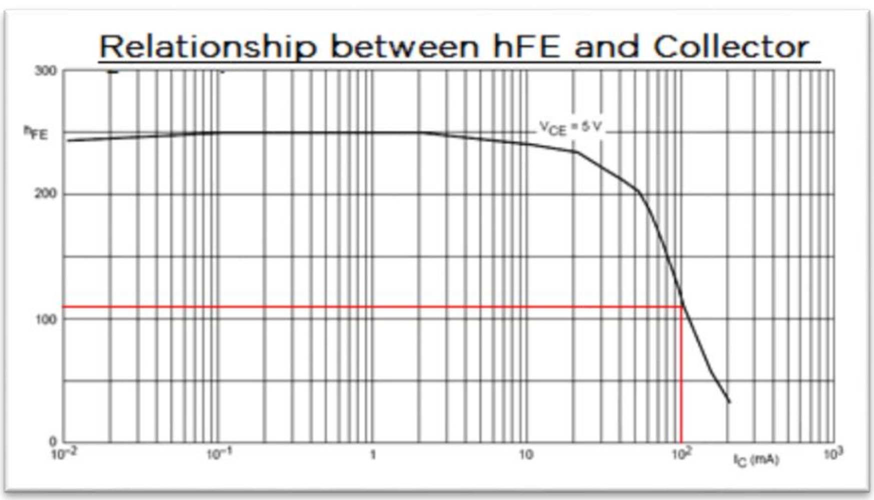
- Controls the amount of current "Ib" flowing into the base, which controls the amount of current flowing through the collector "Ic"
- Since the NPN transistor is required to behave as a switch and conduct fully known as *saturation,* then a proper value of base resistance is required for conduction in the saturation region. The value of this resistance is different for different input voltages.

The gain parameter (hFE):

We use DC gain parameter hFE when the transistor is being used as a switch. "hFE" parameter is used for switching loads.

From the BC548 Transistor datasheet, the value of hFE ranges from 110 (min) to 800 (max). In our experiment, we have chosen to use the minimum rating (that is, 110) as the worst case because we want the transistor to conduct in the saturation region.

In order to achieve the maximum collector current of 100mA, a minimum hFE value of around 110 is required, as it can be seen from the graph:



The graph above shows hFE on the y-axis and collector current on the x-axis for a BC548B transistor. As the collector current increases, hFE decreases.

As it can be seen from the line, in order to achieve the maximum collector current of 100 mA, a *minimum* hFE value of around 110 is required. That is why we've used the minimum hFE value.

Base Resistor Theory

In a bipolar transistor a small amount of current "Ib" through the base is used to control a larger amount of current "Ic" flowing through its collector. How large the current flow is depending upon a gain factor known as "hFE", also sometimes called the DC current gain, and beta (β).

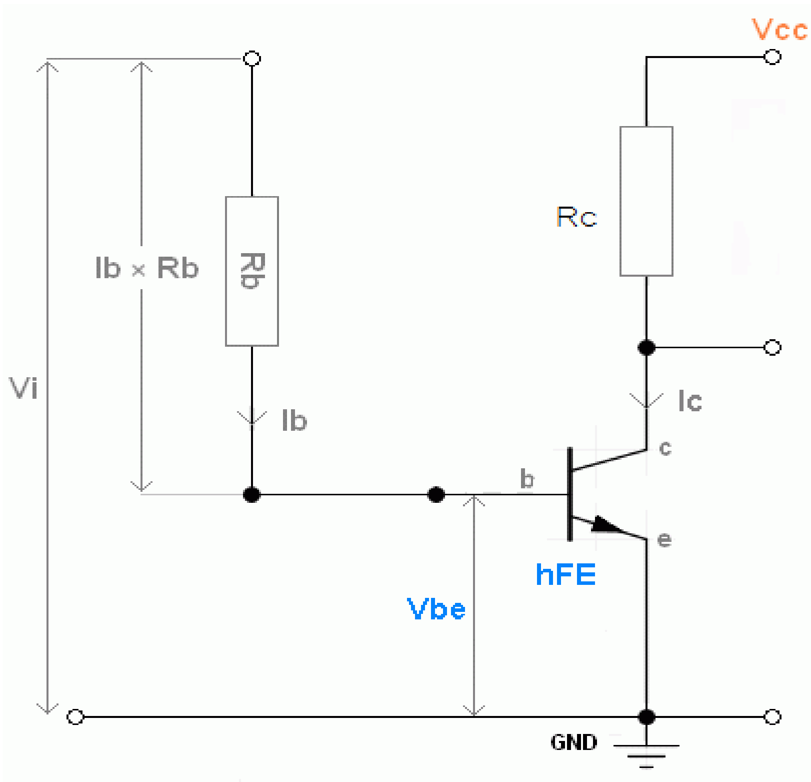
Hence, the current flowing through the collector is proportional to the base current multiplied by gain, as shown by the formula:

$$Ic = Ib \times hFE$$

whereby for a BC548, hFE we've chose 110 hence Ib, will be

$$Ib=Ic/hFE$$

Calculating the resistor values Rb and Rc



In the above diagram we've inverted the base resistance in order to ease up calculation of the resistor value (so as to make more sense).

From the circuit diagram the input voltage Vi is equal to the VCC (neglecting the resistance of the water). We will be supplying a VCC of 10V which will also be equivalent to the input voltage.

As it can be seen in the above circuit, the input voltage Vi, is equal to the sum of the voltage across resistor Rb and the base-emitter junctions Vbe. The voltage across the base resistor Ib*Rb as in accordance to Ohm's Law. From the transistor reference sheet Vbe=0.7V. Hence:

$$Vi=(Ib_{x}Rb)+Vbe$$

transpositioning the above formula gives:

$$Rb = (Vi - Vbe) / Ib$$

To guarantee that the transistor operates in the saturation region, we multiply the base current by a factor of three.

$$Rb = (Vi - Vbe) / (3 \times Ib)$$

The base-emitter junctions of the bipolar transistor typically behave as a forward-biased diode with a 0.7 V drop across it.

$$Vb - Ve \approx 0.7$$

Therefor Ib is calculated as follows:

$$Ib = Ic / hFE$$

where by:

hFE(min)=110 and Ic=100mA=0.1A

Thus:

$$Ib=0.1/110$$

$$=0.91mA$$

Vbe(sat)=0.77 and Vi=10V hence Rb:

$$Rb = (Vi - Vbe) / (3 \times Ib)$$

$$Rb= (10-0.77)/ (3\times 0.9091 \times 10^{-3})$$

$$=3384\Omega$$

Finding Rc in transistors with LEDs

Since from the circuit diagram each Rc is in series with a LED, where by the LED specifications are:

$$V_f = 2.13V \text{ and } I=2.5mA$$

Finding the resistance of each LED (ohms law),

$$R_{LED}=2.13/(2.5\times10^{-3})$$

$$=852\Omega$$

And the Rc is,

$$Rc+R_{LED}=(VCC-Vce)/Ic$$

From the datasheet Vce of a BC548 transistor is=0.25V, thus

$$Rc+852= (10-0.25)/0.1$$

$$0.1Rc+85.2=10-0.25$$

$$0.1Rc=-75.45$$

$$Rc=754.5\Omega$$

But since we are implementing the circuit in hardware, we will have to use the Standard Resistor Values chart to find the nearest standard resistor value. For Rb which we calculated as 3384Ω, standard value picked was=3.3kΩ and for Rc whose value was found out to be=754.5, the value we picked was 820Ω as it was the one available at the lab

Having Rb=3.3kΩ, finding the VCC, then

$$Rb = (Vi - Vbe) / (3 \times Ib)$$

$$Vi=VCC=?$$

$$Vbe=0.77$$

$$Ib=0.1/110$$

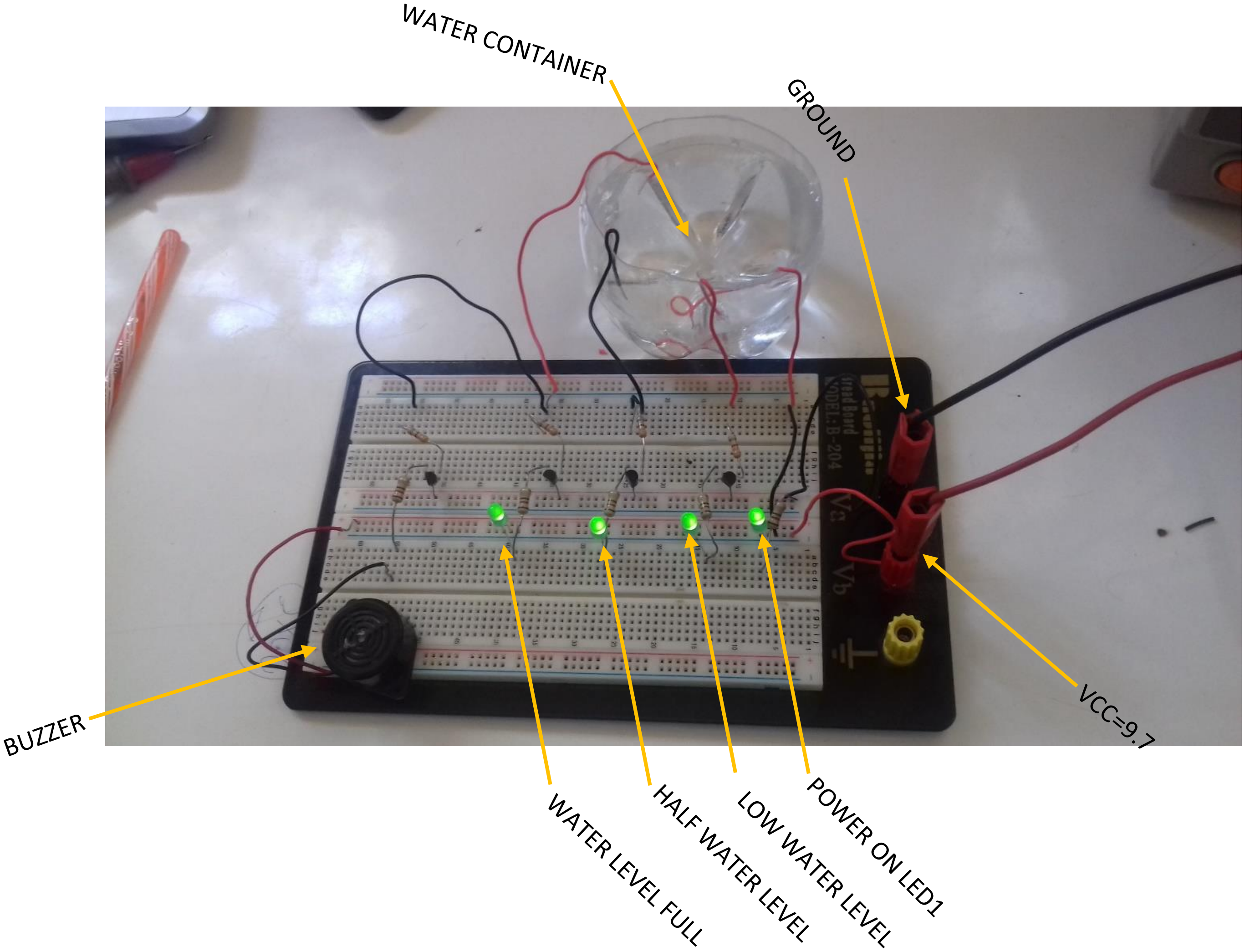
thus

$$3300\Omega=(VCC-0.7)/2.73mA$$

whereby

$$VCC=9.7V$$

Hence Final Circuit Diagram:



From The Circuit Voltages in the individual Components Were Observed as follows:

LED1=2.07V

LED2=2.07V

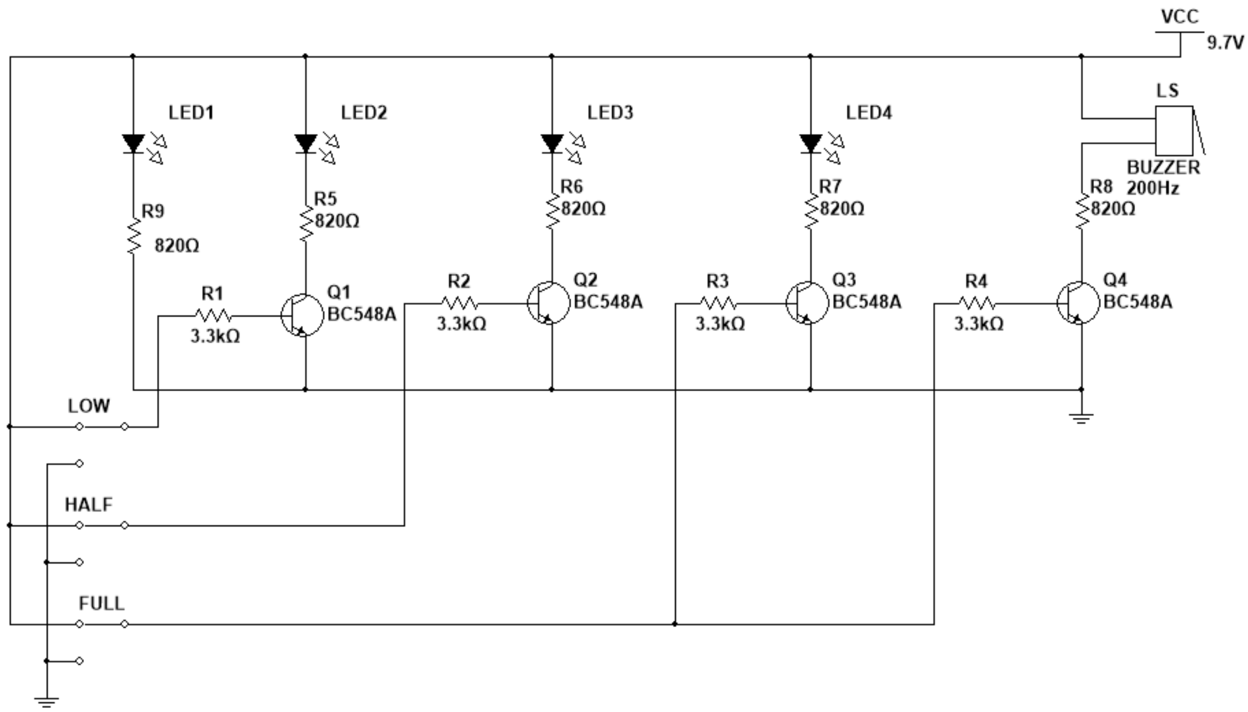
LED3=2.07V

LED4=2.07V

For The Collector Resistances RO=7.611, R5=7.611, R6=7.611, R7=7.611, R8=2.2V

For The Base Resistances RO=0.021V, R5=0.021V, R6=0.021V, R7=0.021V, R8=0.021V

The Simulation Circuit Diagram Is:



<u>Demerits of our project plus the solution</u>

The sensors are more prone to rusting due to Ionization which leads to deposits on the terminals inserted in water. This can be adamant in areas which have creek water/ well i.e hard water it causes corrosion in the copper wire

This has a simple solution:

- Clean the terminals frequently, which is rather a tedious operation:
- Or we can use stainless steel screws as terminal. Stainless steel will never get corroded, but the disadvantage of using stainless steel for the sensors is it's a poor conductor of electricity
- We can use ac sensing- ac voltage sensing avoids corrosion.
- We can reduce current –reducing current helps to reduce corrosion
- We can use float sensors- using float or tilt sensor in order to avoid corrosion, that is, float that is sealed and designed to be in water. It basically acts as a switch.
- Alternatively, we can use a 'carbon brush' as sensors we can remove the metal rusting.

Deposition of oxide layer over the probe(ionization) can significantly decreasing the conductivity drastically hence it's important we use any of the measures described above to avoid this problem.

To change the sensitivity of the sensors, we can either increase or decrease the value of the base resistor.

Summary

The circuit consisting of 4 sensing probes (M1, M2, M3, M4) which is dipped in water to sense the level of water. The probe M1 is connected as common to other three, which should be at the bottom most part of the water tank, also it acts as a reference level. The probes M2, M3, and M4 are set as minimum, middle and maximum level respectively. A short length three, 18 SWG copper wires can be used as sensing probes and for common sensor Probe M1, a bare copper wire can be used.

When water in the tank touches the probe M1 and M2 both, a small current flows from M1 to M2 through water and to the base of transistor Q1 via an 3.3KΩ resistor. As a result, the transistor conducts causing the LED1 to glow. Similarly, when water touches sensor C, LED2 glow and indicates that the tank is half-filled. Finally, when the water touches sensor D, LED3 glows and indicates the tank is completely filled.

Looking at the circuit diagram it seems like the circuit can work without resistors and capacitors, this is actually not the case because pure water has lower conductivity and this makes the inefficient.

conclusion

The circuit above is best suited for overhead water tanks to display the amount of water. The circuit consisting of 3 LED’s (ignoring the first LED) used to indicate minimum, medium and maximum levels. It is possible to increase the count of indicator LED’s and make it more convenient, but this will demand the increase in the numbers of components hence increasing the complexity. The circuit is powered by a 9.7V DC power supply and it consumes only very less current.

Bibliography

Electronics Hub Website