Design of Low Cost and Efficient Water Level Controller

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Abstract**—** This work presents the minimization of water wastage at the overhead tank due to overflow and prevents the motor from running continuously and consumes power unnecessarily. Two conditions are always necessary for the motor to run. The overhead tank to be filled with water should be dirt free and there should be enough water at the source from which water is to be drawn. When this two condition are satisfied the motor will run and start filling up the tank. After the water touch a certain level at the top of the overhead tank, the motor will stop running automatically and prevent the overflow of water. Water level will decrease due to the utilization of water but the motor will still be in off mode state. When the level reached down a certain level at the bottom than the motor will run again and start filling up the overhead tank. Water level indicator is also incorporated along with the work. This work is designed, implemented and simulated as shown in section III. This can be use in any organization, educational institute or domestic house. The main objective of this paper is cost minimization to build the circuit and making it work efficiently.

Keywords— 555 timer, comparators, LDR, sensor, relay, flip flop, simulation.

I. INTRODUCTION

Wastage of water due to overflow from the overhead tank which is operated manually is a common problem. If this wastage can be saved by proper monitoring with a simple circuit then scarcity and shortage of water can be prevented to some extent. The circuit will continuously check the two water level i.e the top level and the bottom level of the overhead tank. When the water level reach the top level the motor will stop filling the water from the source and prevent the overflow of water from the tank. The motor will remain in off state condition until it comes down to the bottom level. When the water level goes below the predetermine bottom level the motor will run again and start filling up the overhead tank. With simple display devices the level of water can also be check. The overall algorithm of the operation of the design circuit is shown as below in Fig. 1

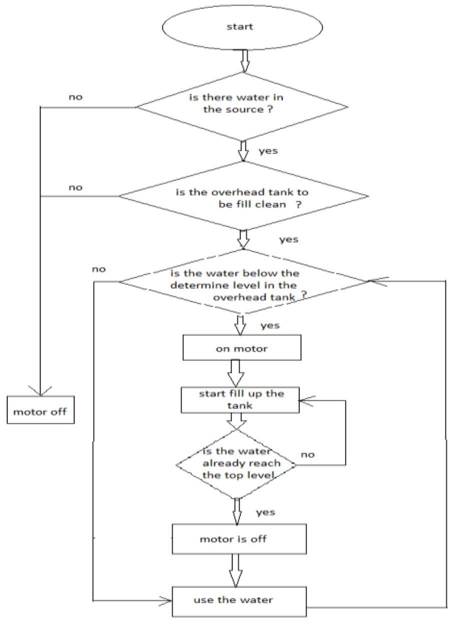

Fig. 1 Algorithm of water level controller

Two conditions are always necessary for the motor to put on. If either of them is not satisfied the motor will remain off. Different researchers have already presented the similar work based on microcontroller and GSM network [1], [2]. Others have also reported for water level controller Using Multisim and 555 timer [3]. The objective of this paper is to add additional features and minimizing the cost for its implementation. Common transistors, LEDs and timer can be use instead of logical gates, 7 segment display and microcontroller for its implementations and this will eventually minimize the cost of production.

II. CIRCUIT OPERATION

Fig.2 shows the complete over view of the controller with LEDs level indicator. The LEDs from L1 to L5 will glow progressively as the water level rises. The same function can be also implemented with 7segment dislay, encoder and decoder but the cost will go high. So with simple transistors, resistors and LEDs the display section is implemented. 555 timer is the controller and the heart of this circuit. After a prolong use of the tank, dirt or mud particles will gradually accumulated in course of time at the bottom of the tank. This need to be monitor and check for safety use of water. If such particles are present than the tank is needed to be clean. So, to check the dirt level the detector section will be placed at the bottom of overhead tank to be fill to detect any presence of dirt. If it is dirt free it will give high output and the dirt indicator will be in off state. But when numerous amount of mud particles are present the indicator will glow and the circuit will give a low output. Source detector is another section of the circuit which will determine whether the water pump motor should be in off mode or on mode. The motor will turn on only when there is water at the source else it will remain in off condition. From the flow chart in Fig.1 the two condition for the motor to run are, there should always be water at the source and the overhead tank should be free of dirt or mud particles. When these two conditions are met, than only the motor will run or stop depending upon the level of water at the tank. The motor will continue to run till it fill up the water upto the top demarcation level. When it reach that level it will stop running automatically and prevent the overflow of water. It will again turn on only when the water level is down below the bottom demarcation level.

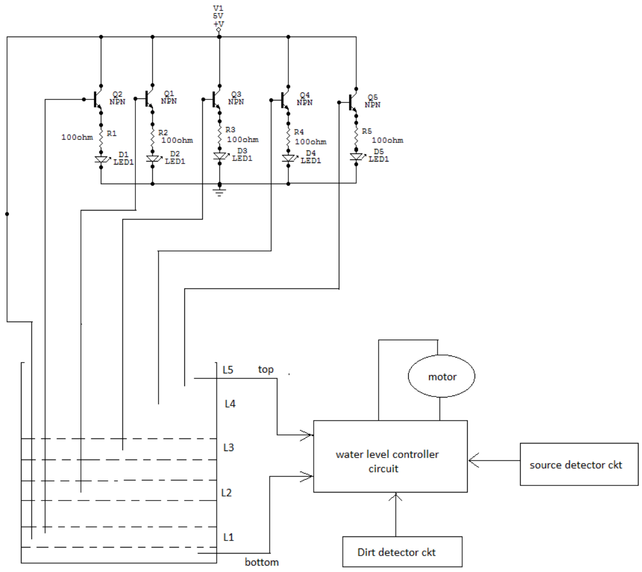

Fig.2 Water level controller at block level

III. CIRCUIT IMPLEMENTATION & SIMUTATION

This controller circuit will work with 9V supply. The complete circuit connection is shown in Fig.3. The properties of two comparators and flip flop inside the 555 timer is used to controled the state of output.The relay will connect the motor to AC line only when both transistors Q_a and Q_b are in saturation mode. Both the transistors are used as switch which will be either in cut off mode or saturation mode depending upon the signal level which is applied at the base of the transistor. Q_b will turn on only when both dirt detector and source detector give high output. If this condition is not satisfied than the relay will not energised and keep the motor in off state.

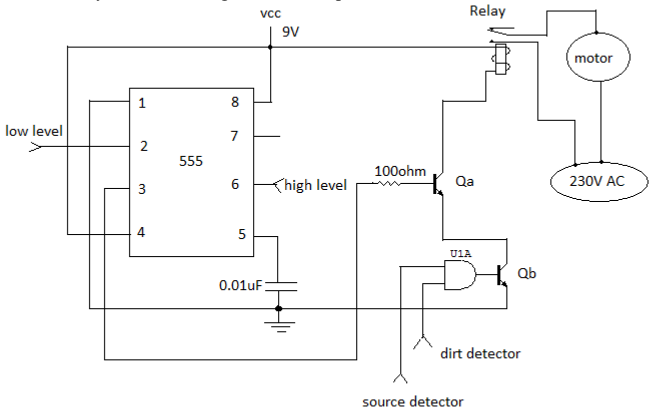

Fig. 3 wtaer level controller at circuit level

Fig.4 shows the implementation of source detector, dirt detector and AND gate implementing with two transistor. The source detector and dirt detector wil be place at different location with a common ground but in Fig.4 it is showing as one circuit for simulation purpose. In dirt detector, LDR is used as sensor which will change its value from low value to high value depending upon the intensity of light falling to it. If there is no dirt particles between LED(D3) and LDR, light from the LED(D3) will fall on the LDR and it will exhibits a very low resistance and will bypass almost all current i.e current I and this will turn off the transistor Q4. LED(D2) will remain off indicating the tank is free from mud particles and the collector of Q4 will give high output. But when accumulated dirt particles block the path of light rays of LED(D3) towards LDR, the LDR will exhibits a very high resistance so maximum amount of current I will flow towards the base of transistor Q4 and turn it on and eventually the indicator LED(D2) will glow. Under this condition the output of Q4 will be low, so transistor Q1 will also be in off mode. In source detector circuit Vcc is dipped into the source. When the base of transistor Q3 comes into contact with the water then only Q3 will turn on and the output across emitter will go high else it will give low output. Both the output of the detectors goes to the base of Qb in Fig. 3. Only when Qb is on the relay will connect or disconnect the water pump motor to AC supply according to the output of 555 timer.

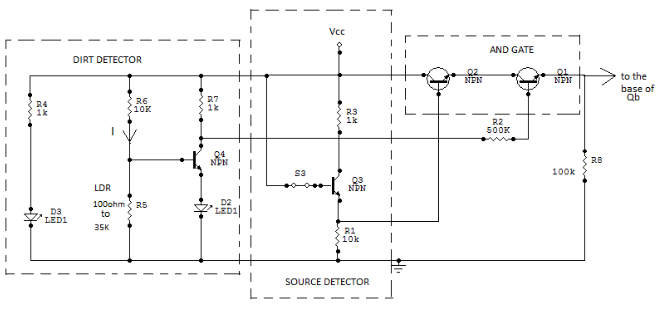

Fig. 4 AND gate implemented with transistor

For simulation purpose LDR is varied from 100Ω to 35KΩ by connecting the source detector switch to Vcc assuming that the base of source detector touches the water in which Vcc is already dropped into the water. When light rays from LED(D3) of Fig. 5 fall on LDR, the LRD will possess a very low resistance and this will turn off the transistor Q4. Under this condition both transistors Q1 and Q2 will turn on and give a high logic state at the output. From the simulation result the output is 5.51V. When light is blocked by dirt particles LDR will possess a very high resistance. Now LED(D2) will turn on as transistor Q4 is in saturation state. During this condition, transistor Q1 will be in cut off mode and the output voltage obtain from simulation result is 752.7mV as shown in Fig. 6.

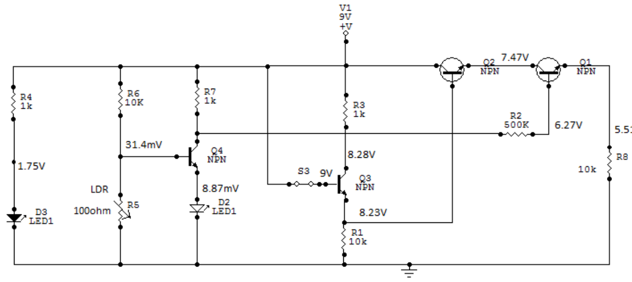

Fig. 5 simulation result of high output

The other condition for the output to go low is when the switch S3 is disconnected from the Vcc supply. This is when there is not enough water in the source. When the LDR value is 100Ω and 35KΩ the simulation output (o/p) result obtained by disconnecting the swith S3 is 162mV and 23mV respectively which is logically low and this will not drive the transistor Qb. The motor will be on only when the relay energise the ciol ie when both transistors Qa and Qb are in hard saturation region.

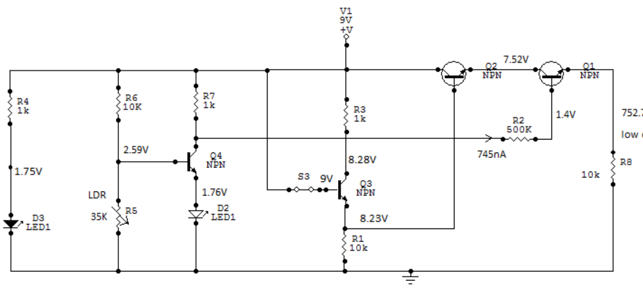

Fig. 6 simulation result of low output

Level detector of the overhead tank is implemented with transistors, resistors and LEDs as shown in the Fig .7 below. Here transistor works as an open switch or closed switch i.e in hard saturation or cut off mode region depending upon the voltage applied at the base. The closing of switch S1corresponds to the condition when the lead of the base touches the water carrying Vcc. Under this condition the transistor will saturate and the LED connected to its emitter will glow. Under cut off mode and saturation mode the emitter voltage is 170mV and 4.2V respectively and the emitter current is 452pA and 2.55mA respectively as shown in the simulation result in Fig. 7. When the transistor is in cut off mode LED will not glow and under saturation the LED will glow. So as the water level rises progressively with the arrangement shown in Fig. 2 the LEDs will be on pregressively from LED D1 till LED D6.

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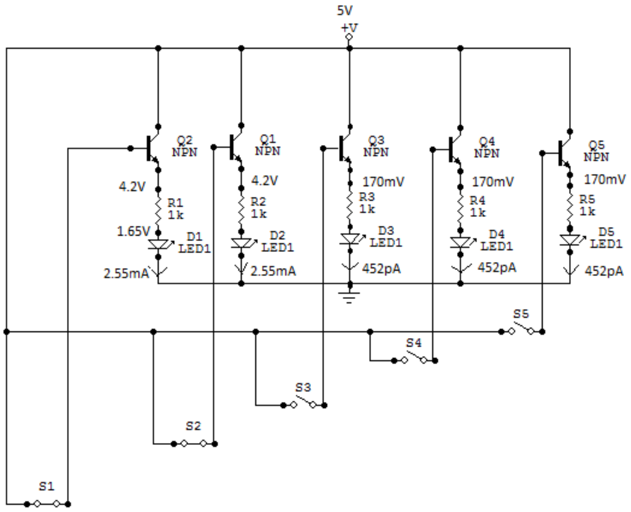

Fig. 7 simulation result showing node voltages and current of level detector

The main controlling unit is the 555 timer. Internally two comparators and a flip flop is present inside the timer as shown in Fig. 8[4]. Pin 2 is kept at high level of the overhead tank and pin 6 to the bottom of the tank. Water is a good conductor of electricity. So when Vcc is dipped into the water, water carries the value of Vcc.

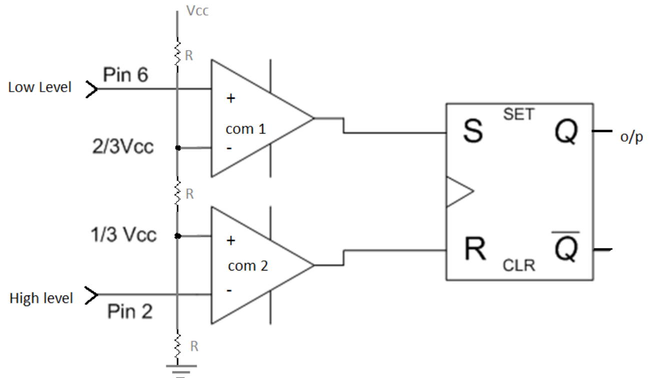

Fig. 8 internal structure of 555 timer

Table 1 in Fig. 9 shows the process of filling up the water and the corresponding outputs of the controller. Initially when both pin 6 and 2 are not in contact with water comparator 2 will give high output and comporator 1 will give low output. These outputs are inputed to R and S such that R=1 and S=0. This will set the flip flop and give a high output at Q. As water level rises pin 6 will comes in contact with the water letting comparator 1 output high i.e S=1 and R=1, under this state the output Q will retain its present state i.e output is still high. Finally both pin 2 and pin 6 are high, S= 1 and R=0 it will reset the flip flop and the output Q will be low.[6]

Table 1

pin 6	pin 2	output
low	low	high
high	low	present state
high	high	low

Fig. 9 Operation table of input and output

Again when the water level is receding away from the top level, pin 2 will be low and pin 6 will be still high. This will make the output hold the present state low as R=1 and S=1. Finally when both pins go low the flip flop will set and the output will give high logic state. The RS flip flop is NAND gate base flip flop.

Table 2

Water filling up

	S	R	o/p	
top level ⇧	1	0	0	motor off
⇧	1	1	1	motor on
bottom level ⇧	0	1	1	motor on

water receding from top

	S	R	o/p	
top level ⇩	1	0	0	motor off
⇩	1	1	0	motor off
bottom level ⇩	0	1	1	motor on

Fig. 10 summary of motor action

Table 2 in Fig 10 shows the operation of motor depending upon the output of the controller. The up arrow indicates the upward direction of water and the down arrow indicates the downward direction of water. Here the unique property of the flipflop to hold the present state[5],[6] is used to control the motor action in both upward and downward direction of water level. Fig. 11shows the simulation output of 555 timer depending upon the different input states at pin 6 and pin 2. When both the pins are at logic 0 in Fig. 11 (a) the output is high and from simulation result the output is 8.9 V. This high output will drive the transistor Q_a which in turn will drive the relay coil and put on the motor by connecting to the AC line. Again when pin 6 is high and pin 2 is low as shown in Fig. 11(b) the output will still be high and the motor will be at the present state i.e on. But finally when both the pin is high, the output will switch to low state and the motor will be off. From Fig. 11(c) simulation result the output obtain is 29.32 mV. As this low voltage cannot drive the transistor Q_a the motor will be turn off.

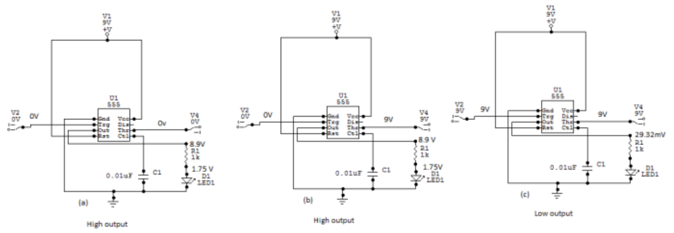

Fig. 11 different input states and the corresponding output of 555 timer

When pin no. 2 becomes low and still pin 6 is high, the output of the timer will be still in present state ie low state as R=1 and S=1. But finally when both the pins becomes low, R is logic1 and S is logic 0, so the 555 timer will give high output and drive the relay which in turn will put on the motor again. The motor action for both upward and downward direction of the water level is shown in Fig. 10. All the components for the implementation of the complete circuit is list down in Fig.12. All resistors are in ¼ watt except the 500KΩ which is a pot resistor.

List of components

components	quantity
555 Timer	1
9 V Mechanical Relay	1
LEDs (RED)	7
LDR 100Ω-35KΩ	1
Transistors BC 547	11
1 KΩ resistors	8
10 KΩ resistors	3
100 Ω resistors	1
500 KΩ resistors	1
capacitor 0.01uF	1

Fig. 12 component list

IV . CONCLUSION

As water is a basic necessity for all living being, shortage of water can be controlled by proper monitering and preventing the wastage of water unnecessarily. This work main objective is to prevent and check the wastage of water and to prevent the power consumption by motor continuously if there is no water at the source. Other aim of this work is the cost minimization for its design and implementation. By using 555 timer, transistors, LEDs, resistors, LDR which is a common and cheap components, this work is implemented without the use of microcontroller, seven segment display, decoder, logic gate and encoder. Each of the section i.e the level detector, source detector, 555 timer output and dirth detector are simulated with circuit maker and the result is also shown in the simulation section. The circuit work best with 9V Vcc supply. Efficient management of power consumption and water resources can be made possible from this research work.

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