DESIGN AND CONSTRUCTION OF AN AUTOMATIC BOREHOLE SWITCH CONTROLLED BY A GSM NETWORK

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ABSTRACT

The importance of having running water taps at homes cannot be over emphasized, hence pumping of water from the borehole using a controlled system is very important.This project encompasses the design and construction of an automatic borehole switch controlled by a GSM network that uses communication signals linked by two cell phones. The system was design, constructedwith high precision and tested. Test results showed that users located far away can get signals and feedback from the cell phone attached to the borehole switching system as commands are being issued. The result of this work confirmed the earlier work of Jack et al, (2016) and equally met its key objective. However, it recommended that future work should consider alternative means of sending feedback to save cost and ensure steady communication. It is also recommended that an internal charging circuit be provided for the attached cell phone to avoid device shutting down.

Key Words:Borehole, Switch, GSM, Automatic Switch, Circuit, Current, Network.

INTRODUCTION

Global technological advancements have achieved huge milestones in the 21st Century due to man's demand for security, comfort and efficient energy usage (Linstone, H. 2002). Today, many family members have very busy schedules, making the manual control of domestic water pumping switch and home appliances difficult. Therefore, to make the control of pump switch easier, the application of an automated controlsystem that can perform surveillance remotely is necessary.This systematic process can be made possible by using the GSM automated switching system.

A plethora of study have been conducted on the GSM automatedswitching system(Das et al 2009, Oghemwen 2011, Anthony 2012, Ana and Ritu 2014,Enalume et al 2017). For instance, Oghemwem (2011) designed and produced a GSM based home/office appliance control unit which uses Dual Tone Multi-frequency principle. The project successfully eliminated the need for users to always be physically present to operate their electrical device, however the system could not remotely detect power supply.

Furthermore, Anthony (2012) designed and constructed a GSM water alert system which detected when water in a storage tank becomes full or empty. The design was achieved with the help of a micro-controller which receives signals from the water level sensor and initiates a text message to the user.

Consequently, the goal of this project is to design and implement a smart home system for controlling electrical water pumps remotely with the help of a mobile device. The system uses GSM network to power and shutdown the switch remotely at any time. The motive behind this project is to enable home owners living in places of epileptic power supply to turn on their water pumping system when power supply is restored, especially when the users are not at home.

Project Aim

The aim of this work is to design and construct an automatic control circuit for a borehole pump using the GSM network.

DESIGN

The G.S.M controlled decoder borehole switch project is divided into nine major sub-circuit which are

Power supply unit/ battery charger unit; PHCN status unit; GSM transmitter unit; GSM Receiver unit; Borehole control unit; Alarm circuit unit; Voltage unit

Power Supply Sub-Circuit

This circuit performs rectification process by converting 220V AC input to 5V DCoutput. It removes the ripples from the ACvoltage and converts it to uni-directional DCvoltage, which it sends to other sub circuits. It performs this action because most electronic components require smooth DCvoltage for operation. We shall discuss and justify each component used in this circuit.

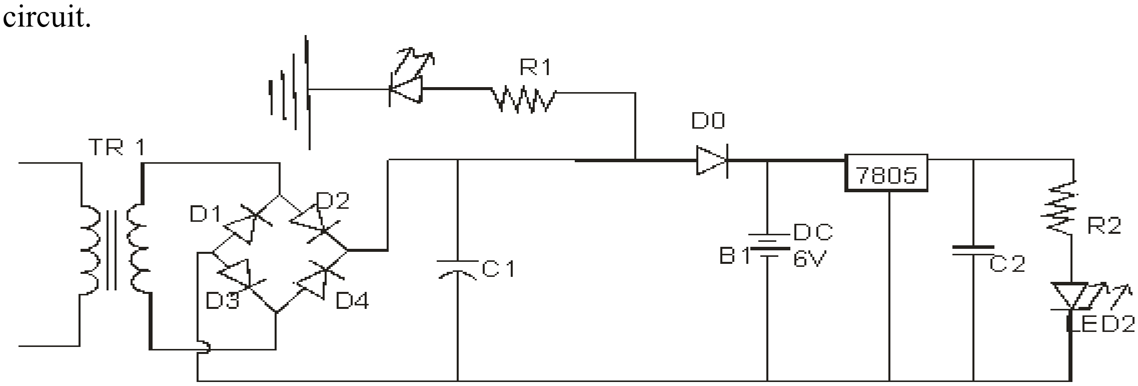

Figure 1: Block Diagram Showing Power supply unit/ battery charger unit

Power Status Indicator Sub-Circuit

This sub circuit detects the presence of 220V AC, and sends signal to the micro controller that there is public power supply available. Its main component is an opto coupler that does the actual power detection.

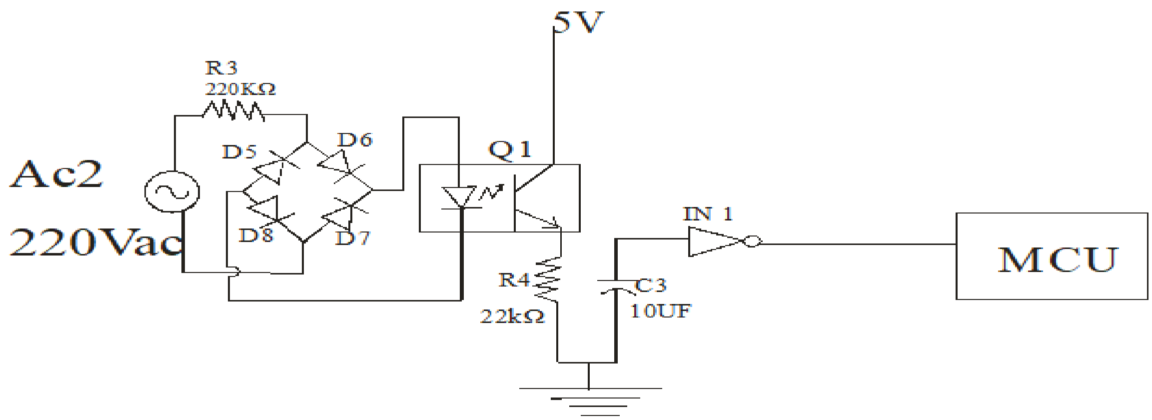

Figure 2:Block Diagram showing PHCN status unit

GSM Receiver Sub-Circuit

This is the sub-circuit that receives input commands in form of keypad tones sent from the user. The user calls the receiving phone and presses the assigned keys to detect the availability of power. Each individual keypad pressed produces its own distinctive sound tone. The sound tone signals are transmitted through the GSM network to the receiver cell phone. The receiver cell phone sends this command signal to the micro controller that perform appropriate actions depending on the command received. The keypads 1,2,3 and 4 were chosen randomly for assignment.

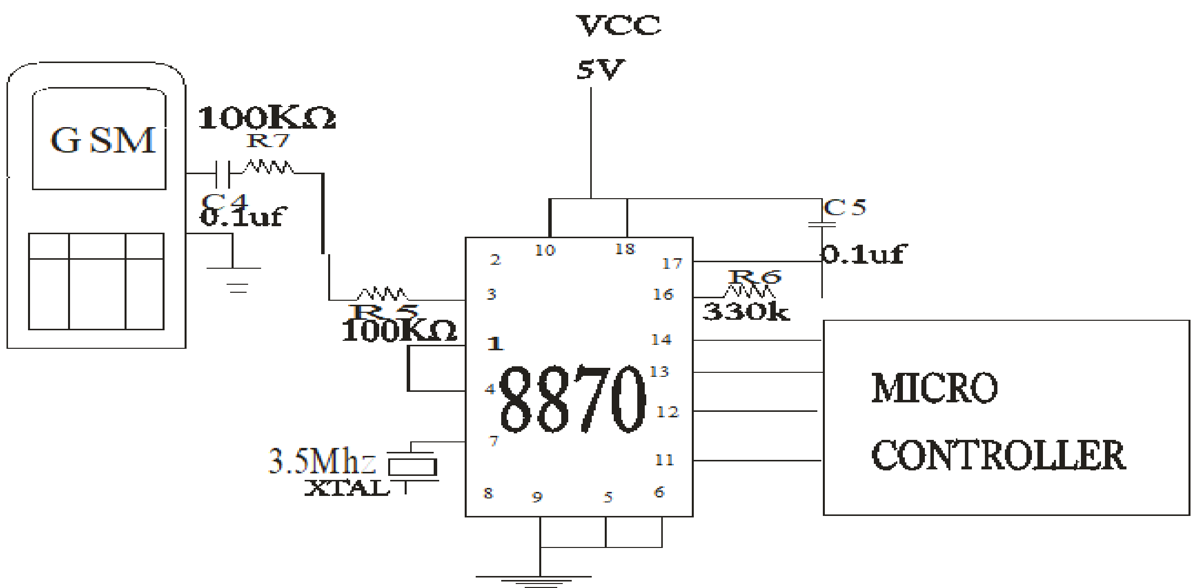

Figure 3: Block Diagram Showing Gsm Receiver Sub-Circuit

Alarm Sub-Circuit

This sub circuit is a programmed circuit that sounds when power supply is available and when the tank is full.

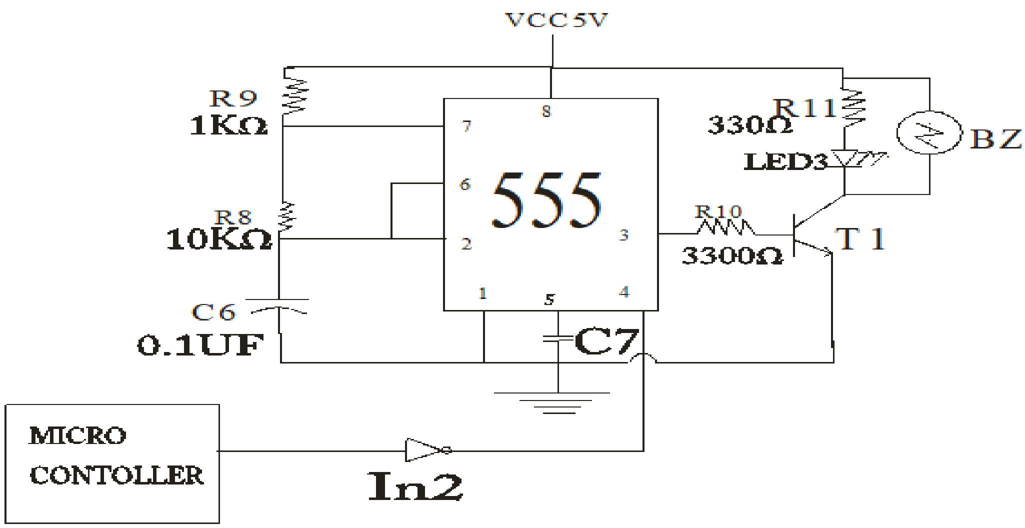

Figure 4: Block Diagram Showing Alarm sub-circuit

Voltage Monitoring Sub-Circuit

This sub circuit determines the adequacy of input voltage for turning on the borehole machine. A minimum voltage of 150V is set as a standard. If the input voltage is below 150V, the relay contactor will not close its switch hence, the borehole does not receive power to start pumping

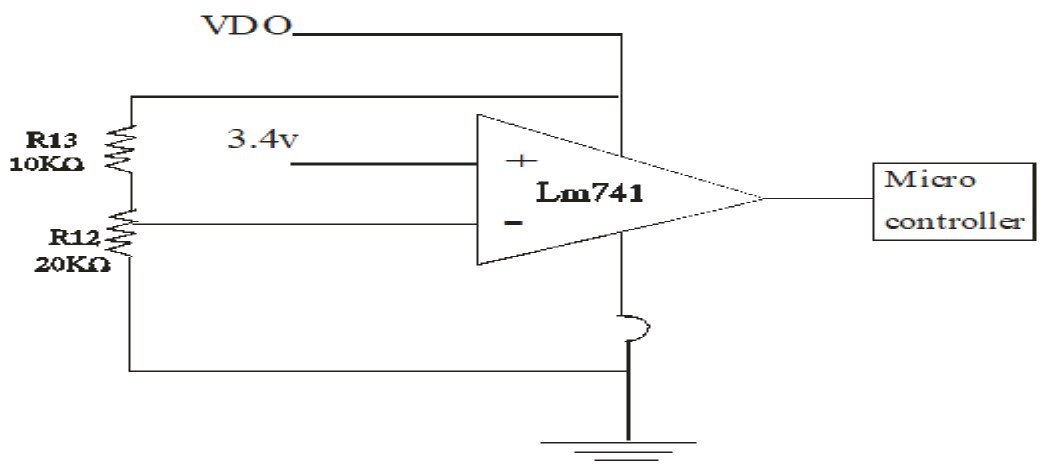

Figure 5: Block Diagram Showing Voltage Monitoring Sub-Circuit

The Feedback Sub-Circuit

This circuit produces two pairs of probing wire terminals from the micro controller to the borehole tank to determine if the borehole is actually pumping and if the tank is full

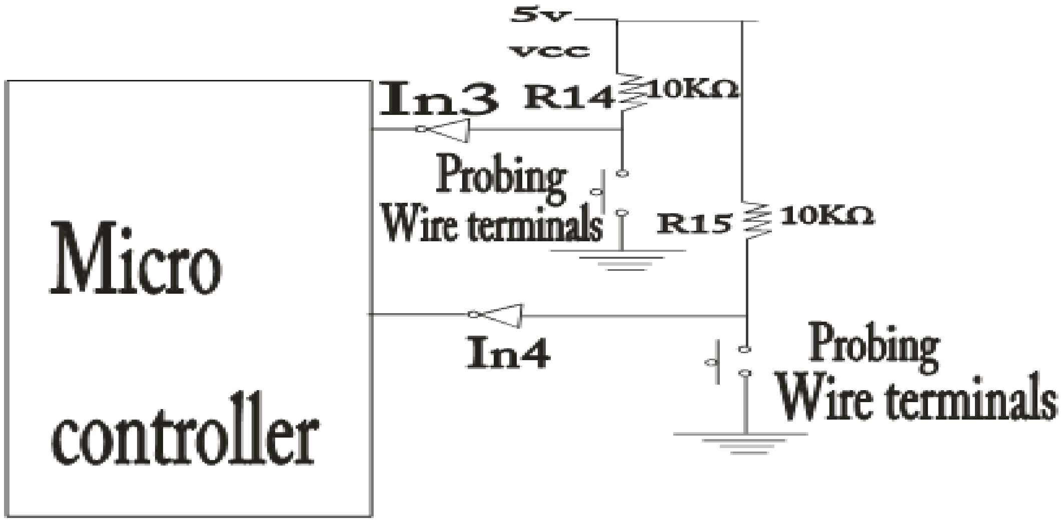

Figure 6: Block Diagram Showing the Feedback Sub-Circuit

Borehole Control Sub-Circuit

This is a sub circuit that controls the relay coils of the contactors. This circuit receives input current signal from the micro controller, this input current signal energizes the relay coil to close the contactor switch. When the contactor switch closes, it enables current to flow along the life wire to the borehole switch

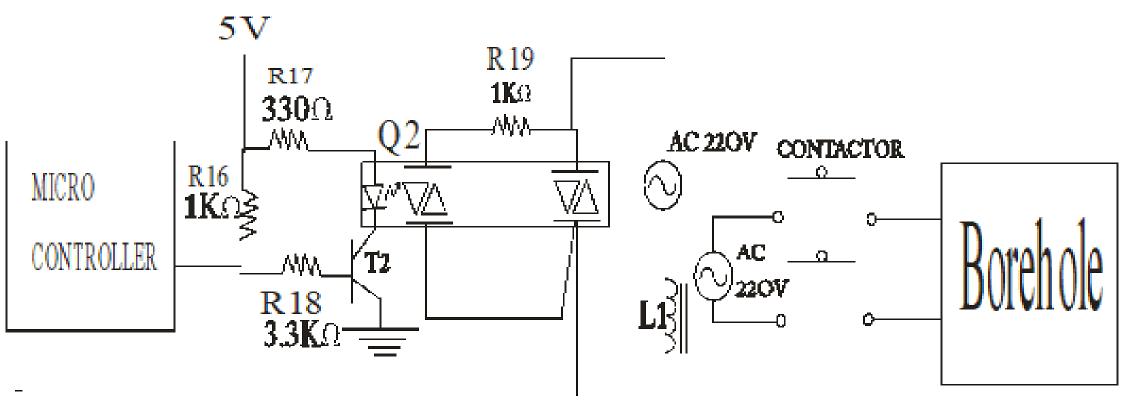

Figure 7:Block Diagram Showing Borehole Control Sub-Circuit

GSM Transmitter Sub-Circuit

This sub-circuit is used to transmit the current signals from the micro controller to the phone. This current signals are the command actions that control the operation of the phone.They specify the text messages that are sent for different results.

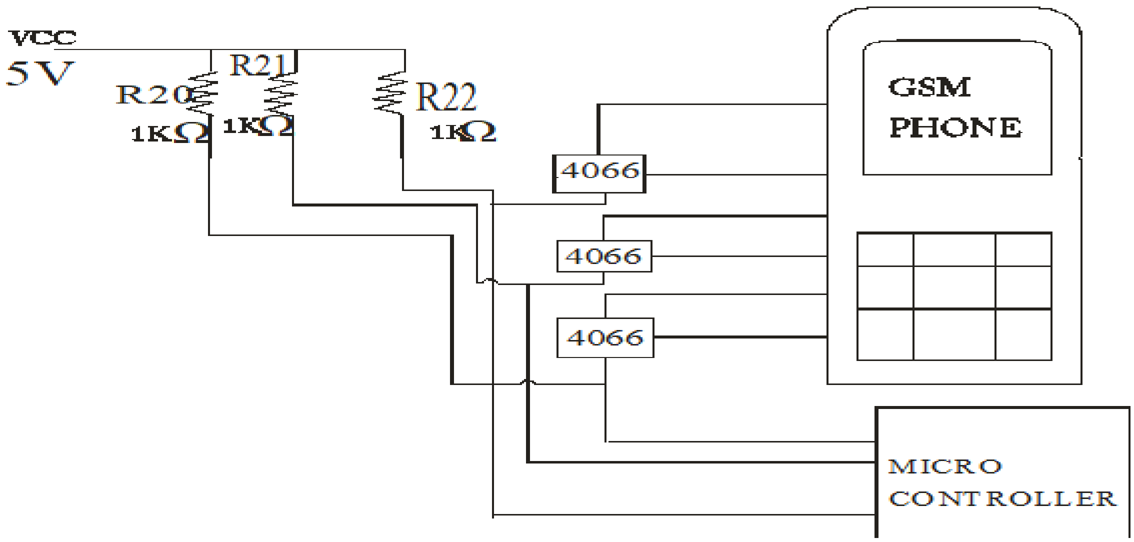

Figure 8: Block Diagram showing Gsm Transmitter Sub-Circuit

Micro Controller Sub-Circuit (MCU)

The micro controller used is an Atmel micro controller AT89C52.The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM). The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer.

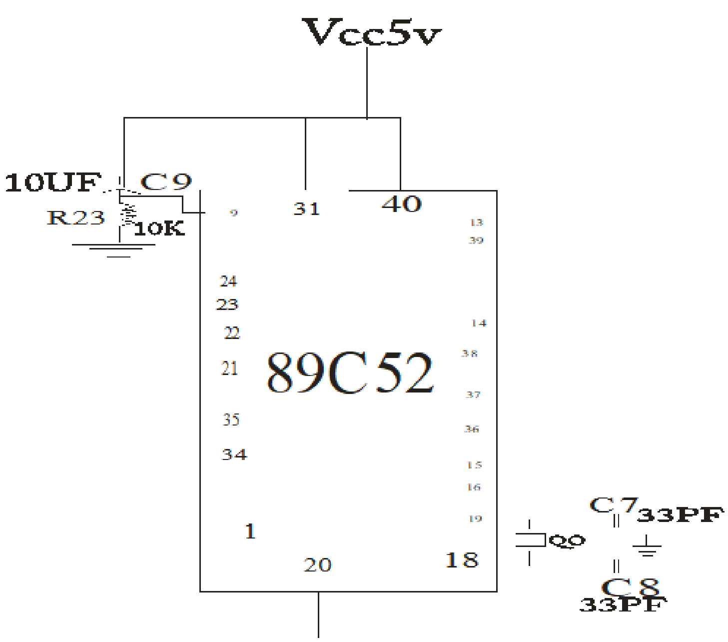

Figure 9:Block Diagram showing Micro Controller Sub-Circuit

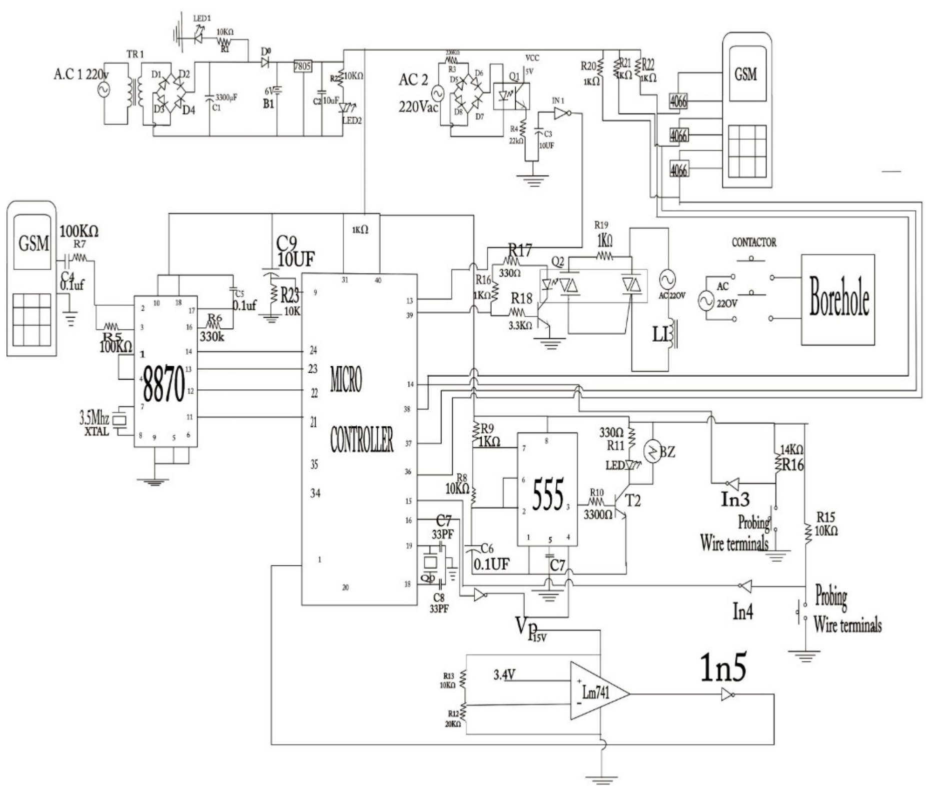

Figure 10: Block Diagram Showing Complete Circuit of the Project

CONSTRUCTION AND TESTING

The entire project is divided into nine major sub-circuits with each of these sub- circuits performing their various individual functions such as:

- Checking for availability of power supply.
- Ability to receive incoming phone calls and send text message automatically.
- Turning on the borehole automatically using the GSM network or manually using a manual push button switch.
- Ability to shut down the system when the tank is full

After accurate mathematical design of components, careful electrical construction and assembling of components in each sub-circuit was done and the project was tested.

Components used for the project

Table 2:Table Showing Components Used for the Project

Battery	Sim card	Earpiece	Turnkey
Resistors	Mobile Phone	Battery clip	Adaptable box

Capacitors	Metal probe	Solder iron	Switch
Transformer	I.C socket	Solder lead	Buzzer
MOC 3021	Miscellaneous	Solder sucker	Diode
4N35	Connector	AC wires	Microcontroller
Variable resistor	Connecting wire	AC plug	L.E.D
4069	Contactor	Multimeter	Buzzer
Crystal oscillator	Connecting wire	Screws	Vero board
4066	Voltage regulator (7805)	Ply board	BT 136
MT 8870	Voltage regulator (7805)	555timer	Transistor
LM 324			

Figure 11a&b: Diagram Showing Internal Circuit of the project & Mobile Phone Connected to the System

Testing

S/N	TEST	COMMAND	RESULT
1	Checking for power supply	Dial circuit number and press 1 and 4 at 3 seconds interval	Alarm sounds 5 times at user's end when power is available. Alarm sounds 2 times when power is not available
2	Powering the Borehole	Dial circuit number and press 1 and 3 at 3 seconds interval	The circuit checks for voltage level and power availability. If all these are in place, then it switches on the borehole and sends a confirmatory text message to the user. If the voltage level is low or power is not

			available, the circuit automatically send a text message that the borehole cannot be switched on
3	Pumping of water	On powering the borehole via test 2, the circuit wait for 3 minutes	Text message stating pumping status is sent to user.
4	Power Failure	Shut down of power	The circuit shuts down the borehole automatically and sends a text message to the user stating that there is power failure and that the borehole has been switched off automatically
5	Full Tank	At full tank during pumping	The circuit shuts down the borehole automatically and sends a text message to the user informing that the tank is full
6	Switching Off Borehole	Dial the circuit's phone number, and press 1 and 2 at 3 seconds interval while still pumping.	This system shuts down the borehole and send a confirmatory message to that effect.
7	Manual Start-up	Press the manual power button on the circuit.	The circuit shuts down the borehole automatically and sends a text message to the user informing that the tank is full

Casing

For proper presentation, the whole project was enclosed in a plastic casing. We choose plastic because it is cheap and availably and so that our components do not bridge and handlers do not get electrocuted. The device was mounted on a wooden base. The Vero board was screwed gently after verifying that I did not short circuit any leads, the transformer screwed onto the wooden base, and then the project was placed in the plastic casing.

Check for Short Circuit

Short circuit was checked by using a multi-meter set to the continuity range and also by visual inspection. Strips observed to be very close to each other due to the soldering were separated by reducing the quantity of the lead deposited on the broad with circuit components.

Construction

To ensure quality assurance, initial vetting was conducted to prove the functionality of the design and various modules. All the components were bought from the Benin electronics market. The resistance of the resistors, the capacitance of the capacitors, and the workability of all the other discreet components were verified before they were all used in the project.

The complete project was first simulated with electronic workbench and found to be working satisfactorily, before the actual components were then assembled on a bread board. It was only after the testing of the project has been done and its workability verified that the components were then transferred to a Vero board and soldered carefully.

The resistors, capacitor, the integrated circuits, diodes, transistors and other components were placed and soldered carefully. Finally, the transformer was introduced.

Positioning and Soldering

Before actual positioning, the surface of the Vero broad was cleared with sand paper to remove traces of dirt and oxide deposits. The components were then laid appropriately. Actual soldering was now done ensuring that excess lead does not short circuit two copper conductors.

Connection of Other Components on the Vero Board.

Short wire leads and earth continuity conductors were used to interconnect various components and soldering was done as usual. Excess or protruding lead of wire and components were cut off and removed. Component leads were joined by ensuring that copper string connecting them was continuous. The cutting and removal were done with a razor blade.

Checking Connections

Checking connections on the Vero board with the circuit diagram at this stage was to ensure that the connections made in the Vero board were exactly as specified in the circuit diagram and also that the correct components were at the correct positions. Selected defects like reverse of polarity of the capacitor filter were corrected and loose soldering was adjusted. Dry joint or improper soldering was checked using the multi meter set to the continuity range.

Working Mechanism of the GSM-Borehole Switch System

When a “number key” is pressed over an outgoing call, the corresponding DTMF tone is sent to the receiving phone which is connected to the input of the DTMF decoder circuit through its audio output. If a valid tone pair combination is given to the DTMF as programmed in the micro-controller is detected, the corresponding output is sent to the different devices.

As programmed in the software, when a correct key combination is received by the micro-controller, the corresponding output (each connected to a device switch) is triggered either on or off (depending on the key combination) to activate or de-activate the switch.

The device switch is designed with triac switching operation which allow electric signal to be fed from an opto-coupler to ensure electrical isolation of the DC portion of the circuit from the AC portion.

When the micro-controller output is high, the gate voltage of the triac rises. This turns on the triac and enables current to flow through it from the AC supply to the load. However, if the output of the micro-controller is low, the gate voltage goes low, thus turning off the triac and preventing current from flowing to the load.

Conclusion

The process of design and construction of each component and their assembly in their various sub-circuits was done with high precision and accuracy so as to avoid errors and electrical fault. The various sub-circuits were tested and able to perform their respective function. The various sub-circuits combined collectively, to achieve the general objective of the project. This work also confirmed the earlier work of Jack et al (2016).

From the various testing done on the project it was observedthat the user has to continuously recharge the receiving cell phone with airtime in order to receive feedback in form of text message. Secondly, it was also observed that the user must connect, disconnect and monitor the device battery to avoid shutdown and overcharging. Thirdly, only the registered mobile number can receive feedback irrespective of who gives the command.

Recommendation

To address the observed challenges, the following recommendations are made;

- The use of cheaper means for sending feedback instead of using airtime should be considered.
- The circuit can be made to provide point for charging the device.

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