THE DESIGN AND CONSTRUCTION OF AUTOMATIC FLUID PUMPING CONTROL SYSTEM

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ABSTRACT

The content of this article has to do with the design and construction of an automatic fluid pumping control system. The device operate independently without human assistance in triggering the fluid pumping machines whenever the fluid level inside a storage tank falls below a reference point. The device includes sensing unit to detect the presence of fluid and moisture. It also includes a logical unit that performs logical operation using what is received from the sensor and giving out appropriate signal to the actuator unit which triggers the machine pump.

INTRODUCTION

Water is without compromise a very important utility in the history of man and his development. Far back in ancient times, man made use of water flowing from streams and rivers. During this period man had to walk long distances in order to get water from these streams and this was a tedious operation which took time and energy. Later on, the advancement of man saw the utilization of water gotten from wells. These wells were usually cited close to living quarters, farms and industries. The inventions of wells tend to reduce the time and energy wasted in order to get water from streams and rivers.

Although the introduction of wells reduced the processes involved in getting water from its source close to its area of direct use, time and energy is still required in order to get water from wells. The invention of the wheel and axle which dates back to 3500BC (Griffin, 2007). helped to reduce this shortcoming in making use of wells. With the introduction of wells and the use of the wheel and axle, sources of water were still seen to be far from the area of direct use.

The invention of borehole and the use of lift pumps in the 3rd century BC ushered man into a new era of drawing water from its source. Soon centrifugal pumps were invented and the use of overhead storage tanks was introduced. Later in the 17th and early 18th century AD, British engineer Thomas Savery, and Denis Papin French physicist (1698) with some other friends contributed to the development of water pumps. The development of water pumps came as a high advantage and proof of man's technological advancement since the use of machine pumps to draw water is much more time and energy efficient in bringing water directly and close to its area of direct use.

In quest to make the process of operating machine pump more efficient, various electronic and mechanical automatic control system have been invented. These systems can detect water level in an overhead tank and trigger machine pumps automatically.

A related electronic circuit design that is capable of controlling a machine pump automatically is shown below.

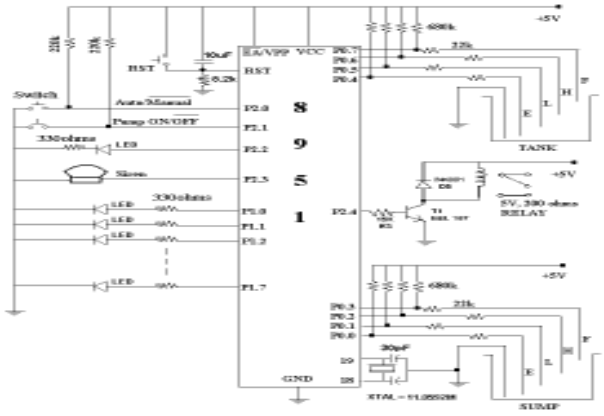

Fig. 1: Microcontroller based pump controller

This system is built around a microcontroller.

The sensor used is a probe which could be a thin stainless steel plate or a length of wire. The logical unit for this system is the microcontroller which is an 8951 microcontroller. (Microcontroller chip Technology, 2001)

The indicators for this design are LEDs and a siren, while the actuator is a 5v 200ohm relay. From the circuit diagram shown above, it is seen that this design requires a lot of components. In total it requires 25 resistors, 3 capacitors, 5 LED, 1 diode, 1 transistor, a relay, 2 switches and the microcontroller. The operation of this design will achieve its desired purpose, but knowledge in computer machine programming is a requirement when designing this circuit. This is to ensure that microcontroller is well programmed in order for it to carry out its automatic functions.(Balch, 2003)

DESIGN ANALYSIS

The major components that were used in the design of this device will be analyzed in respect to the various units in which they were incorporated and the functions they serve in order to achieve the single device unit. The circuit diagram for the automatic pump controller using latch principle is (Pedroni, 2008) shown below.

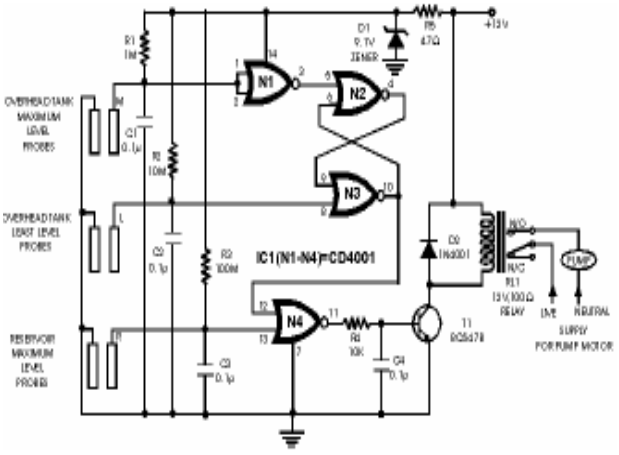

Fig:1.2 Automatic pump controller

The various units that make up the device are: The power supply, sensor, logic, actuator and indicator units. As shown in the block diagram below:

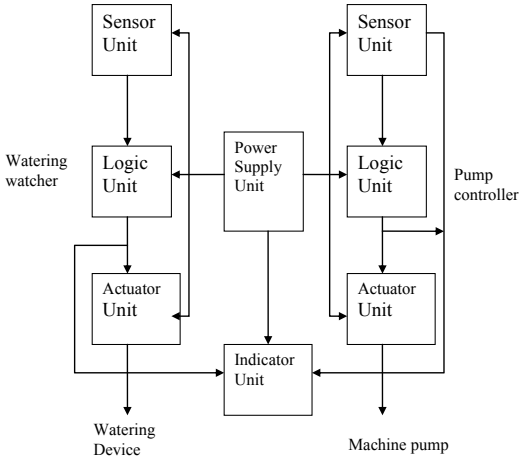

Fig1.3: The block diagram of the entire circuit design.

The design of the power supply unit is of paramount importance. It happens to be the building block of every electronic design in the sense that the overall functionality of the design depends on it. The required current and voltage of the system is supplied by the power supply. In other to achieve this required DC for the system design, the following are required. 240/12V Transformer, Bridge rectifier, Filter capacity, Voltage regulator (Theraja and Theraja, 2005).

The interconnections of the above elements give rise to what is called power supply as shown below:

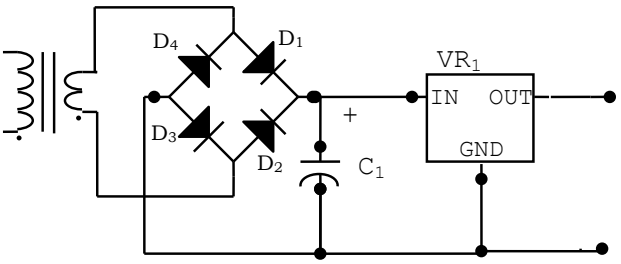

Fig. 1.4: Power Supply Unit

The Sensor units comprises of detectors that are incorporated to achieve desired result. The detectors used are metal probes and wires.

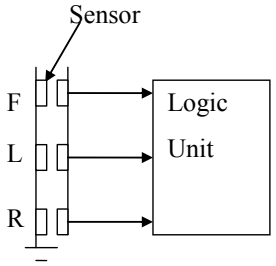

Fig1.5: Sensor unit design.

The sensor unit in the pump controller circuit provides the logic unit with appropriate signal it detects inside the overhead tank. The sensor unit of the pump controller detects water level by using the property of water and its conductivity. There are three level detections involved in this design; the full, the half, the low. The outputs of all three levels is delivered to the indicator unit; while only the full and the low level outputs are delivered to the logic unit. This is because the logic unit only requires the full and low level in order for the machine pump to be triggered (ON/OFF).

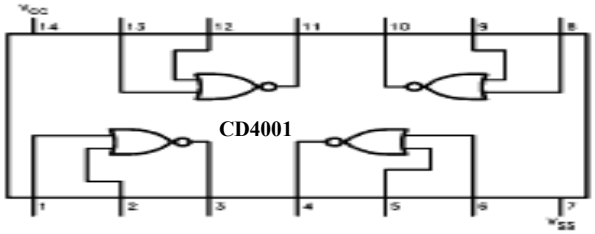

Fig 1.6: Pin notification of CD4001

The logic unit serves as the brain of the device. It is responsible for giving out appropriate signal that result in triggering the controlled devices. The logic unit comprises the IC CD4001 for the pump controller. The IC contains 4 logic gates integrated inside them. The IC CD4001 contains 4 NOR logic gates. It operates with a DC voltage of range 2v-6v. (Theraja and Theraja, 2005)

The actuator unit effects a response to the sensor unit under the command of the logical unit. It triggers the machine pump and plant watering device when appropriate signal is delivered to it from the logical unit. The actuator unit for this device is a 12v DC relay. Indicators are generally placed in electrical or electronic circuits to provide the operator a status of some function of the equipment. The indicator may be audible, visual, or both. For this device, the indicator is a visual one and hence the common LED is used. For the pump controller, 4 LEDs are used which provides the level of water in the overhead tank and the operation of the device.

In the course of this design, some components shown in the circuit diagram above were substituted with others of similar or near similar values.

For the pump controller, the R_3 100 Mega ohms resistor was replaced with 10 resistors of values 10 Mega ohms each connected in series. The effective resistance was deduced through the use of series resistance equation shown below.

$R_T = R_1 + R_2 + R_3 + \ldots + R_{10}$
But $R_1 = R_2 = R_3 = \ldots R_{10} = 10$ Mega ohms
Hence $R_T = 10 \times 10$ Mega ohms = 100 Mega ohms

The BC547 NPN transistor was substituted with a BC548 NPN transistor which has similar characteristics with the former.

RESULTS AND DISCUSSION

An important aspect of the design of this device is the assembly of the component parts. It is very important that the installed parts yield desired result. The circuit construction was first done on a breadboard to verify the work ability of the various components. After that, the components were transferred to a vero board and soldered in place. A test was carried out after assembling the component parts.

When connected to an AC voltage, the power indicator signaled 'ON'. Initially, water in the overhead tank was kept close to the low level so on draining the tank to the low level; the pump controller triggered the motor pump which pumped water into the overhead tank until it got to the full level before the motor pump was triggered 'OFF'. After the test was carried out to ascertain the operation of the device, the entire assembly was then encased using a plastic material.

A photograph of the complete assembled circuit components is shown below:

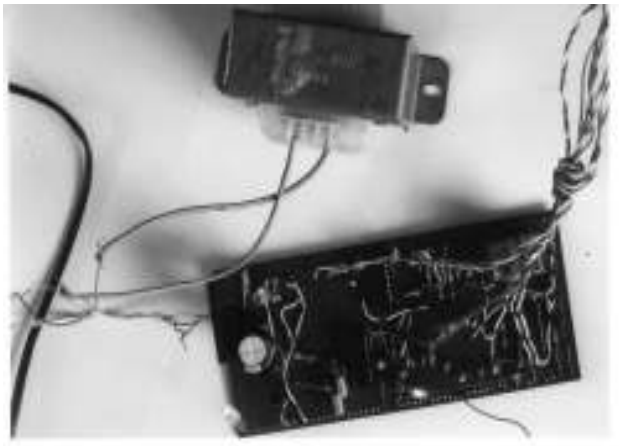

Fig1.7: Assembled circuit.

Several tests were carried out on the device to confirm the level of its performance and efficiency. In the power unit, test was conducted using the digital multi-meter to read the output voltage of the power supply. It was confirmed that the terminal output read the appropriate value. From the sensor unit, confirmation was made that the conducting wire used could deliver right information when it senses water. From the control unit, various testing was conducted to ensure that output is given in accordance to the input. This testing is the most important of the device because of its link to other units. The input section was tested using multi-meter and logic probe to ensure that no mistake was made in data transfer. After all these testing, I was convinced that the design work was successful in respect of software development and hardware assembly.

CONCLUSION

Modern technology has provided means of monitoring and controlling various systems. This is greatly enhanced by the use of ICs and other smaller electronic circuit components (Gibilisco, 2001)

This work presents the monitoring of water level, moisture content and controlling machine pumps with the use of an automatic pump controller and water watering watcher. The device is automated and works independently of human attention or devotion. The aim of the work was achieved by connecting the device powered with an AC source and observed to be carrying out its required purpose.

The device can also be used as a constant fluid level maintainer. For this purpose, the probes will be brought close to each other to ensure that the fluid level is maintained within the full and low level. The pump controller can be applied to tanks and reservoirs of any kind; hence it will be proper if it is employed for residential use, in farms, and also in rural water supply systems. It is to be noted that this device will be most useful in places with constant power supply.

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