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Research Article

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Development of a Microcontroller Programmable-Based Water Heater with Temperature Display

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Abstract A collection of sensors and transducers were used to create a microcontroller-based water level and temperature monitoring system. The device keeps an eye on and regulates the water level and temperature range. Water is heated using the heating element's arrangement while being pumped between tanks using a water pump. The equipment's output demonstrates that it operates with great precision and an accuracy of roughly ±5%. The developed instrument has the capability of retaining high temperature over a long period. An Arduino software-programmed multi-position control system mode is used by the apparatus.

Keywords Micro-controller, Water level, Temperature range, Arduino software, Heating element

1. Introduction

Water heating is part of energy utilization and is a process that is as old as man, with the mode of heating water changing from the use of sun to the modern day electricity [1]. Due to the importance of hot water to mankind, water-heating units are therefore indispensable and are found in homes, offices, factories, cafeterias, manufacturing processes, laundries, etc [1]. For customers to use energy efficiently for domestic or industrial utility when heating water in a system, there is a need to use a micro-controller based water heater [2,3]. The domestic water heater known as geyser accounts for 43% of the household's total power consumption which makes use of the fact that efficient control of temperature of geyser will reduce the overall domestic power consumption of the entire nation [2,3]. Micro-controller based water heater or geyser is a type of water heaters which makes it possible for consumers in the domestic premises and industrial areas to efficiently control water heating system [1]. Without this, consumers may find it difficult to make a daily routine of switching their geysers OFF or ON manually and keep setting thermostat to meet their requirements, for different periods of the day in a week.

Hardware and software designs are the controller which is interfaced with a real time digital watch, a temperature sensor and a keypad [5]. A real-time emulator driven by the software controls a water heater using a micro-controller. The configuration consists of micro-controller, the geyser, keypad, interface design and consumption. Mechanical device such as the thermostat is not meant for frequent adjustments and does not offer that accuracy and precisions required by a consumer to control temperature [6]. The technique used is very crude to determine hotness or coldness of water in a geyser. These devices have high cost, required higher maintenance due to wear and tear; depending on specifications of materials, the electronic controller is designed to control water heating from a remote point using a personal computer and an intelligent temperature sensor. It is user friendly, efficient, and has longer lifespan and is supported by a simple software designed to control the water heater and controls temperature accurately. It saves electrical energy if precisely programmed and is a mechatronics device.

In addition, heating elements are often the cause of many electrical fire outbreaks due to negligence. Hence there is a need to automate heating processes. In this paper, a simple automatic water-heating unit was designed and constructed.

2. Materials and Methods

Hardware Description

i. ARDUINO BOARD:

The circuit consists of an arduino board which is the brain of the project and any arduino board that is available can be used.

ii. LCD Display

A 16×2 LCD display is provided to display the user set value and the current temperature of the water. A 10K variable resistor is provided to adjust the contrast of the LCD display.

iii. DS_18B20 Digital Temperature Sensor

A water proof (digital) temperature sensor DS18B20 is utilized in the circuit to measure the current water temperature accurately. It comes in a metallic tube and the actual sensor inside it looks like a transistor as shown Fig.1. The sensor comes with 3 wires 5V, Data and GND and the sensor communicates with the microcontroller using "one wire" protocol. The data line must be connected with a 4.7K pull-up resistor.

iv. **Digital Temperature Sensor**

It can sense temperature from -55 to +125 degree Celsius and can measure temperature with the accuracy of +/- 0.5 degree Celsius (from -10 to +85 C). Since our application is about heating the water, the limited the working range from 0 to 110 degree Celsius / 32 to 230 F is required.

v. Relay Pin

A 9V/12V relay is utilized in the circuit to turn on and off the water heater. The relay coil is controlled by a NPN transistor BC548 and the input signal to the transistor is provided from pin #8 of Arduino. A current limiting resistor of 4.7K is connected to the base terminal to prevent over-biasing of the transistor. A diode is connected across the relay coil to arrest the high voltage spikes that could arise while energizing and de-energizing the relay coil.

vi. Heater to Relay Wiring

It was ensured that relay contacts could handle the current water heater demands. A 10A 250V relay can handle 1KW / 1000W heater, above which a higher ampere rated relay.

vii. Buzzer

A 5V buzzer is provided to notify when the water reaches the temperature set by you, this feature is helpful when you just want to attain certain temperature and you would remove the heater from water. The buzzer could be switched off buzzer using the switch provided in the circuit when the temperature of the water wants to be maintained for long time. For example, sterilizing medical tools where the tools need to be placed in hot water several minutes to hours. and you don't want to get notified when the temperature reaches the set value.

viii. Power input:

The circuit is powered by a wall adapter with 9V (if you are using a 9V relay) or with 12V.It should provide a minimum current of 500mA.

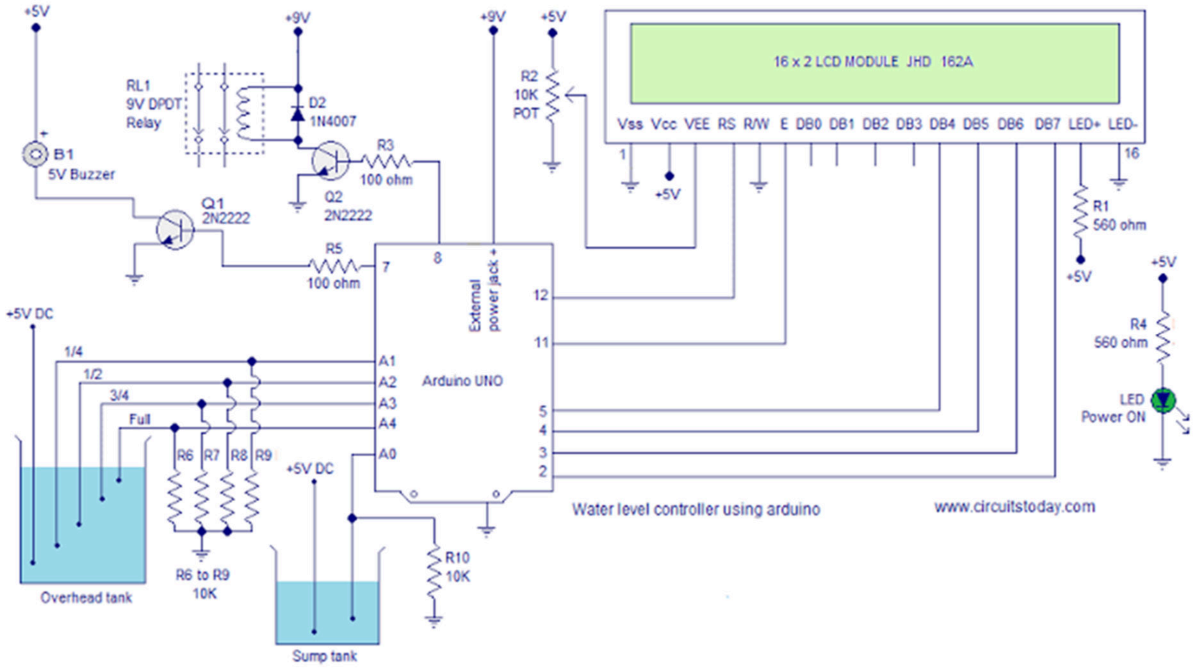

Figure 1: Working circuit diagram

3. Results and Discussion

3.1 Testing

After the programs was written, it was tested, this involves executing the programs with selected input known as test cases, to check whether the program is functioning as desired. This involves detecting out and removing errors in the program.

3.2 Program Entry and Editing

After the design of the software, a text editor is employed to enter the source into the disk file. As noted earlier, the text editor also functions as error correcting in the program. The text editor use is the CRIMSON text editor.

3.3 Compiling and Linking

The small device C "compiler" comes with a lot of modules. It doses the task of compilation, linking binary to hexadecimal conversion once the compilation command is issued an object file, a hexadecimal and a binary file.

3.4 Principle of Operation

All microcontroller embedded system runs on an internal firmware burnt into the chip or outside the chip in a ROM. The design uses the ever familiar MCU "Microcontroller Unit" from Atmel semiconductors owing to the fact that its brand of MCU that has a wider data I/O lines for the job. The firmware "program" was written in assembly language and compiled using the ASEMW brand of macro cross assembler to finally get the machine executable file. Once the exec file is gotten, we downloaded it into the MCU internal flash memory from where it was executed using a gadget called a "programmer". Programmers are device used to get the executable file that resides in the computer down to the microcontroller for final execution of the program.

The modes of operation of the system outlined in a special manner in order to aid quick understanding of how the project works are outlined as follows:

i. At power "ON" the microcontroller immediately initializes the state of the visual display unit to a known state and also resets its self to a defined status that conforms to the preloaded program.

ii. The first instruction is called upon to gate out command that will initialize the ADC unit to a value of zero

iii. Here the controller enables conversion by gate out command signals to the ADC (analog to digital converter), the ADC quickly responds by converting the voltage fed to it by the sensor or current to voltage converter. The output from ADC is a digital representation of the analog quantity which is in power.
iv. Once conversion is complete, the ADC transfers the digitalized analog quantity to MCU for further processing via its data bus.
v. The MCU at this stage carries out mathematical and logical operations on the data passed to it via its bus; the after math is a digital quantity that is equal to the measured power output on the visual display unit as decimal values. At this stage, the controller jumps back to step 2 so long power is still turned ON.
Experimental result is shown in Table 1

Table 1: Experimented Result Vs Actual Result

Component	Experimented Value	Actual Value	Tolerances
Buzzer	5.00V	5.02V	
Relay	9v	9v	
Temperature Sensor Transistor Type	5V	5V	
Resistor	4.7K	4.7K	
	4.7K	4.7K	5%
	100	100	
	100	100	
Diode	1N4007	1N4007	
Potentiometer	10K	10K	

The system was powered and operated upon using several possibilities they include making sure that the pump only started when the water level has gone below the mark, and stops when the water level has reach maximum. The seven segment display was also tested to make sure correct level was display on the seven segment display screen. The result in Table 1 shows that range between the expected value and the actual could be tolerated. As a result of this the drift in expected value has no critical effect on the system design since the result current range was also exceeded, also the operational voltage was not exceeded.

4. Conclusion

In essence, the research was done successfully to reach the goals established at the start of the project activity. Even if there is always a chance of a constraint of some kind, it was a success to a greater level. Overall, the research has been a fruitful endeavor. The researcher has been given the chance to accurately assess the situation on the ground and to identify potential improvement areas for the research project.

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