MICROCONTROLLER BASED SNOW DEPTH SENSOR FOR MEASURING DEPTH OF SNOW AVALANCHE

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Abstract: An avalanche is a rapid flow of snow down a slope, from either natural triggers or human activity. At present snow gauge and direct measurements are the most commonly used techniques adopted for measuring snow depth. This paper deals with total design and implementation of microcontroller based snow depth sensor using ultrasonic pulses.

1. INTRODUCTION

Precipitation is mainly in the form of rain and snow. In the universe 5% of annual precipitation is in the form of snow. Snow avalanches occur in higher mountains as a result of heavy snow accumulations on steep slope. Avalanches are strong snowy storms which is often reaches upto 200 miles an hour and can exert forces great enough to destroy structures, traffic blocking, disruption of human life etc.[1]

A need is felt to devise technique which help in measuring depth of snow to forecast the volume of the snow avalanche for understanding preventive measures to minimize the damages. At present snow gauge and direct measurements are the most commonly used techniques adopted for measuring snow depth. Both these techniques are not precise enough to record such frequent measurements of changes in snow depth as snow quickly settles down and undergoes metamorphosis.To overcome these limitations, this paper deals with total design and implementation of microcontroller based snow depth sensor which has been prepared for measuring depth of snow in the range of 0.5 to 4 meters. This model works using ultrasonic pulses. In this system sensors used send a 40KHz sound pulse and measure the time it takes to return to the sensors. This help in recording the frequent measurements of changes which may be occurring due to quick settling of snow and its metamorphosis. [2]

2. MICROCONTROLLER BASED SNOW DEPTH SENSOR

The block diagram proposed in this research project is shown in Figure 2.1.This whole system works into six sections. They are:

- Transmitter Section
- Receiver section
- Temperature Sensing Section
- Regulated Power Supply
- Microcontroller
- LCD Display [3]

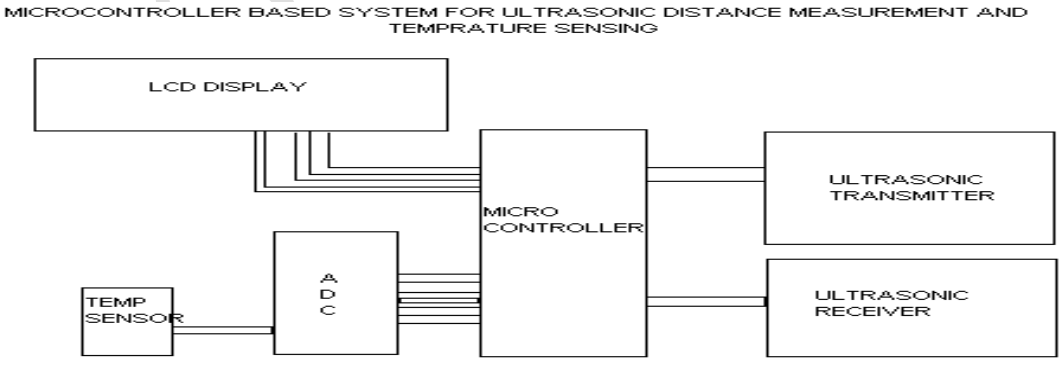

Figure 2.1. Block Diagram of Microcontroller based Snow Depth Sensor

2.1 Transmitter Section

Transmitter is used to transmit ultrasonic sound wave to the target through a suitable media such as sensor. Transmitter need to give a frequency of 40 KHz for which receiver is tuned at. In order to generate such frequency 555 timer is used. The timer basically operates in one of two modes either as monostable or as an astable multivibrator.

An astable 555 timer is used in transmitter circuit as shown in Figure 2.2 .It also consists of two transistor model BC547 i.e. Q2 and Q3.These are NPN general purpose transistor. Transistor Q2 gives the supply and transistor Q3 is provided to make Q2 in active state because one cannot give so much of current to transistor from the microcontroller. This is how transmitter sensor gives out an ultrasonic sound pulses at a frequency of 40 KHz.[4]

Frequency of output waveform is given by:

F= 40 KHz

T=1/F=1/40KHz=25µsec

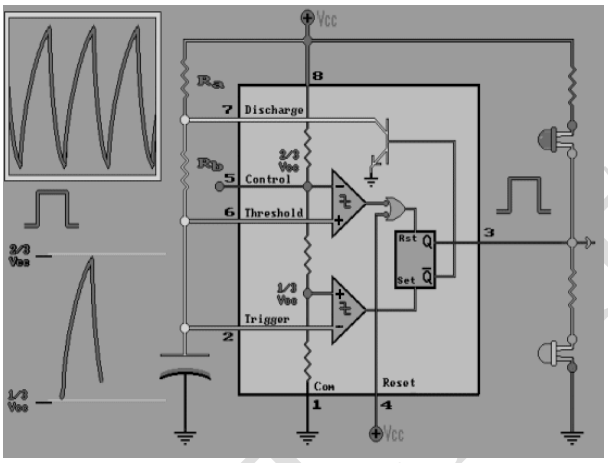

Figure 2.2 Transmitter Section

Thus the output waveform of 555 Timer has a time period of 25µsec as shown in Figure 2.3.

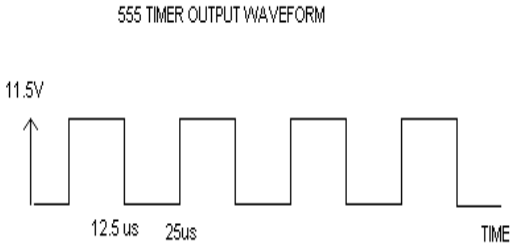

Figure 2.3. 555 Timer Output Waveform.

2.2 Receiver Scetion

The ultrasonic pulses generated by transmitter reaches the target.From the target,they retreat back and are received by the receiver tuned at 40 KHz frequency. The circuit for the receiver is shown in Figure 2.4. It consists if a dual amplifier NJM4558D.This dual amplifier amplifies the signal twice that it undergoes two stage amplification. In the receiver circuit prefiltering capacitors are provided before the amplification is done at both times. The capacitor filter out the environmental disturbances left in received signal and send it for amplification. It is amplified at two stages and a distortion free voltage is obtained.

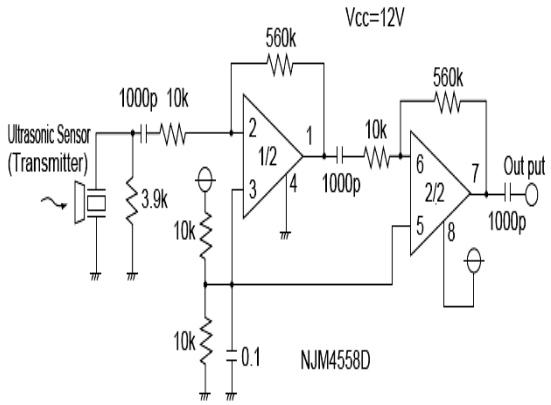

Figure 2.4. Receiver Section

The receiver circuit is taking an input voltage of 12 V and it gives an output waveform as shown in Figure 2.5.

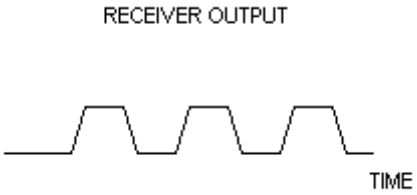

Figure 2.5. Receiver Output Waveform

In order to display the distance, it is interfaced with the microcontroller. Microcontroller takes the voltage from 0 to 5V. Hence, a BC 547 transistor is used to convert the output of receiver and makes it between 0-5V so as to give it to the microcontroller.[3]

2.3 Temperature Sensing Section

Speed of sound in air varies with the temperature, an independent temperature measurement is required to compensate the distance reading. Hence, the temperature measurement is done. It is interfaced with the microcontroller so that the temperature of the surrounding is measured where the depth of snow is calculated. The circuit for the LM35 temperature sensing section is shown in Figure 2.6.

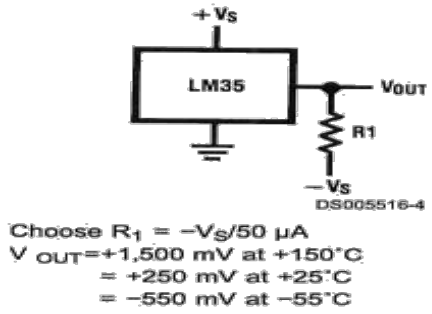

Figure 2.6. LM35 Temperature Sensing Section

The output is given according to the temperature. The output is then given to ADC 0804. This is because the output of temperature sensors is analog. Using ADC, the analog is converted to the digital output. This digital output is given to the microcontroller which gives the required temperature of the surroundings.[5]

2.4 Regulated Power Supply

The power supply is a vital part of all electronic system. Most digital IC's including microprocessor and microcontroller operate on ±5V and ±12V supply. This system work on both these supplies

2.5 Microcontroller

In this system 89C51 microcontroller has been used. It is a low power, high performance CMOS 8 bit microcomputer with 4Kbyte flash programmable and erasable read only memory (EPROM). By combining a versatile 8-bit CPU with Flash on a monolithic chip, the 89C51 is a powerful microcomputer, which provides a highly flexible and cost-effective solution to many embedded control applications.

In this system microcontroller is programmed using Keil software. It is the software which has both assembler and compiler. It will directly convert the C language into hexadecimal code. It is the IDE for microcontrollers. It means full development environment for controller i.e assembler,compiler,debugger and simulator.

2.6 LCD Display

In this system, HD44780U controller chip has been used which receives the data from an 8051controller and communicates directly with the LCD. The 44780 standard requires 3 control lines(EN,RS & RW) as well as either 4 or 8 I/O lines for the data bus.

Figure 2.7 and 2.8 shows the layout and photograph of hardware design of the system respectively.

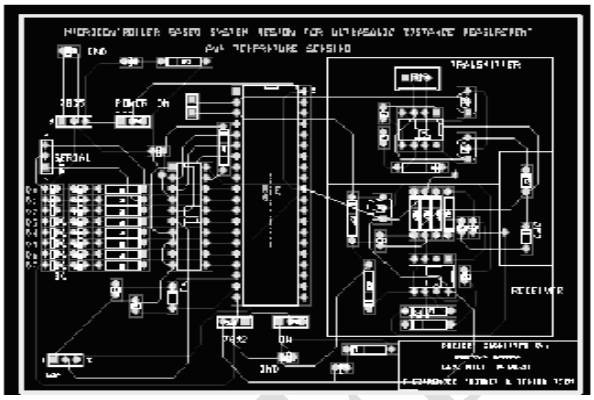

Figure 2.7. Layout of system hardware Design.

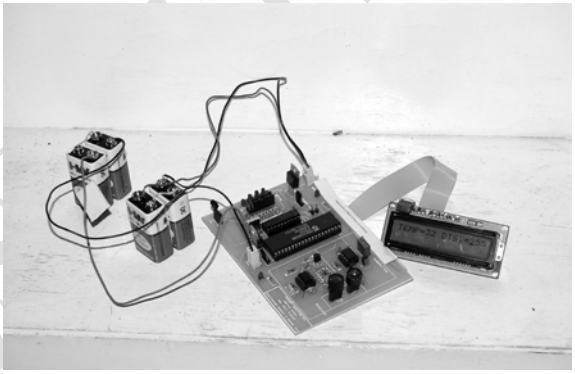

Figure 2.8 Photograph of system design

3. EXPERIMENTAL RESULTS

This system has been tested using cold environmental chambers. It is like a refrigerator in which the temperature is maintained using a thermostat. It is set according to the requirement. Place the model on cold environmental chamber of height 3 meters. It display the count=t

The measurement of the depth of snow is done by using the simple distance formula.

Distance = Speed * Time

Therefore it was calculated, using

Speed of sound = 332 m / s = 331.4 m / s

Time= Count displayed on the LCD.

Therefore d = 3 meters calculated.

The measurement of the depth of snow depends upon the temperature of the surrounding. The system also has the provision to record the temperature of that particular area. Since the speed of sound in air is different from the speed of sound in snow, therefore, temperature compensation has been provided.

The temperature compensation can be calculated as (1)

$$Distance = Reading\{Sensor\}\sqrt{Tdegree Kelvin/273.15} \quad (1)$$

If temperature compensation is not applied, distance values will not be accurate for temperature other than zero degree centigrade. By using the temperature compensation formula depth of snow has been recorded at different temperature during the day as shown in Table3.1[7]

Table3.1 Recording of the depth of snow at different temperatures during the day

Date	**Time**	**Temperature**	**Reading**	**Actual reading**	**%Error**
28th April	2.00 PM	25 Degrees	3.08 Meters	3 Meters	2.6 %
28th April	3.00 PM	10 Degrees	3.05 Meters	3 Meters	1.66 %
28th April	4.00PM	-10 Degrees	2.94 Meters	3 Meters	2 %
28th April	4.30PM	-5 Degrees	2.97 Meters	3 Meters	1 %

4. CONCLUSION AND FUTURE SCOPE

This model can help us in measuring depth of snow in the range of 0.5 to 4 meters. The distance are measured at different temperature during different part of time and shows an accuracy level of 96%.

This circuit is designed to measure the depth upto range of 0.5 to 4 meters.Future work is to design this model for greater depths. This can be done by using more efficient sensors.

5. REFERENCES

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[7] Campbell Scientific Inc., 2005: Campbell ScientificOnline SR-50 Manual.