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Microcontroller Based Low Cost Earthquake Monitoring Using Lab-View

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Abstract: ***Earthquake cause thousands of deaths and property is lost throughout the world, most all earthquakes are preceded physical vibration processes, which are commonly known as earthquake precursors. Earthquakes and tsunamis resulting from large vibration between two plates surface as earthquakes canter under the sea are of particular concern. They generally occur with very little without advance warning. An instrumentation system is demonstrated here for the detection of the surface variations in pressure and vibration which gives all warning before the disaster. It consists of a sensor coupled smart embedded system; precise detected the variation in physical-electrical pressure and vibration parameters. This will interface with the microcontroller through embedded software and send an alarm in the audio and visual form when the parameters exceed beyond certain critical threshold. The measurements of the dynamic variations of the parameters indicate a departure from the routine values. This alarm enables us to put in place the preventive safety measures. The instrumentation includes the vibration, pressure sensor as the predominant sensor for detecting the relative parameters. The instrumentation system monitoring of such parameters with standards along with an alarm system to trigger off during exceptional variations.***

Keywords: surface wave, embedded system, vibration parameter, analysis using Lab-VIEW

1. Introduction

In the resent year numerous developments in VLSI give new era to the development of microcontroller based system call as smart system. This development is being coupled with numerous applications and continued with development changes compared with traditional philosophy of data acquisition. Traditional scheme based on simple ADC interface have been replaced in many situation where there is the need to collect information faster than a human, data loggers can possibly collect the information and in cases where accuracy is essential.

The environmental variations in physical parameters such as temperature, pressure, relative humidity, conductivity of Ionosphere, earth's magnetic field, gravitational field etc. either natural has led to calamities such as earthquakes generating Tsunamis or volcano [2]. Several types of pressured process continuously occur in the earth's environment results sudden change in energy and associated action, leads to earthquakes. Earthquakes occur along the weak plate boundaries of two surfaces [2]. The seismic wave's energy travel away from the epicentre of the earthquake. Seismology is the branch of earthquakes study. The seismometer is measure earthquakes in the form of intensity of the arrival of the waves, will generate different types of waves that travel through the earth and along its surface [1].Geophone is an instrument for measuring ground motion. It is designed for earthquakes, machine vibrations, oil exploration, mining etc [4].

A signal conditioner can vary in complexity from a simple resistive network or impedance matching network to a Complex multistage high gain amplifier with or without detectors, demodulators and filters [5]. Alternately they are termed assigned processors. The output is analog but can be converted into digital using the analog to digital converter for processing in digital world. The output of signal conditioning circuit with high gain and amplitude is interfaced as input to the microcontroller ATmega 16 having inbuilt ADC of 10 bit. The microcontroller on the other hand monitors and sends warning signal when the parameter exceeds the predefined critical value [6].

Almost all natural gives their significant slow impact well before massive destruction. This paper comes with through of this basic signal pick up as and when they occur, analyse them, crosscheck with the standard data and if the value exceeds a certain predetermined values; send an appropriate warning message and signal. However it is observed that variation in few physical parameters is common to many natural calamities. So it is necessary to study which 3 – 4 parameters changes predominantly and in case; any three of them exceeds a certain threshold then the alarm should be activated.

Monitoring many parameters at a time would avoid false alarming, for example the nature of wave in the earth's interior during earth quake and nuclear explosion is same, the sensor should not alarm for earthquake when there is nuclear explosion. The variation in the content of ions in the ionosphere as well as the variation in humidity, temperature, velocity of air and pressure takes place before earthquake as well as during thunder.

To summarize, if four dominating parameters are finalised and if any three of them cross the threshold; there should be a strong alarm. The occurrence of earthquake sends its signature well in advance through the Lithosphere, Atmosphere and Ionosphere [1].

- Emanation of Radom gas pressure, velocity changes
- Infrared radiations are emitted in the atmosphere,

- Change of E-flux takes place in the ionosphere and
- Variation of Humidity is experienced in the atmosphere.

2. Seismology

Seismology is the study of earthquakes. The principal tool to measure earthquakes is a seismometer which measures the arrival of earthquake waves. Sudden displacement along a fault will generate different types of waves that travel through the earth and along its surface [1].There are of two types of seismic waves i.e. body waves and surface waves. Body waves consist of Primary waves (P-waves) and Secondary waves (S-waves), and Surface waves consist of Love waves and Rayleigh waves [2].The velocity of P and S waves increases with depth in the earth which causes the waves to bend. The waves also reflect and refract off abrupt discontinuities such as the crust/mantle boundary. Fluid layers in the earth block S waves and create "shadow zones". P waves (or "longitudinal waves") travel through fluids, and solids.

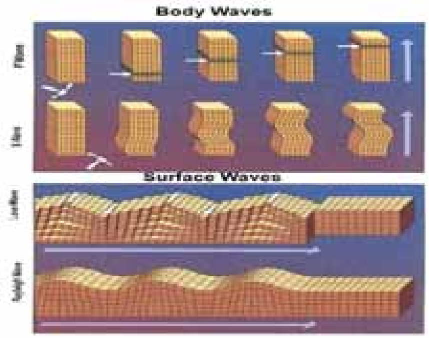

Fig1: wave nature of P and S wave

They are compression waves and rely on the compression strength and elasticity of the materials to propagate. They are known as body wave’s travel though the body of a material in all directions and not just at the surface, as water waves dose. For P waves, the motion of the material particles that transmit the energy move parallel to the direction of propagation. P waves travel the same way as sound waves in air and the fastest seismic waves and travel at roughly 6.0 km/s in the crust (much more than the speed of sound). S waves depend on the shear strength of the material and have a velocity of about 3.5 km/s in the crust. The velocity of the surface waves varies with their wavelength but always travel slower than P and S wave [2]. An earthquake will generate all of these waves and they will propagate over the surface of the earth and through the body of the earth.

2.1 EARTHQUAKE

Earthquakes produce all three types of seismic waves: P waves, S waves, and Surface waves travel at different velocities, the time it takes each wave to arrive depends on the distance to the earthquake (just like thunder and lightning; the farther away the lightning is, the longer it takes the thunder to arrive) [1].If we have are cording of the seismic waves made by a seismometer, we can measure the time between the P and S waves. From that time we can calculate the distance to the earthquake. It has been observed that before the actual occurrence of an earthquake, anomalous change in various environmental parameters of the Earth take place [2].These variations effect the thermosphere, ionosphere, atmosphere and lithosphere in space and time. Which changes geo-physical parameter E-flux(electron flux) which changes after the coronal mass ejection from the outer periphery of the sunspots. When the E-flux(electron flux) changes suddenly it affects the environment of the earth. This phenomenon changes the thermosphere, ionosphere atmosphere and lithosphere locally as well as globally [1]. The response of the magnetosphere to interplanetary shocks or pressure pulses can result in sudden injections of energetic particles into the inner magnetosphere. It has been recorded that 22-36 hours before the occurrence of the earthquake; the E-flux increases drastically.

3. Instrumentation

- The transducer/sensor which converts the physical parameter into usable electrical output [4].
- The signal conditioner converts the transducer output into an electrical quantity for control, recording and display [5].
- The display or read out devices which display the required information about the physical parameter in certain units [5].
- The power supply for the signal conditioners and display devices [7].

3.1 Transducers/Sensors

The study of control and monitoring of any physical parameter through an electronic instrumentation, called transducer/sensor. This converts the variation in the physical parameter to a variable electrical pulse signal. Transducers usually generate output signals in the mV range (spans of 10mV to250mV), often amplified to the voltage level (1 to 5V) and converted to current loops, usually 4-20mA dc [4].Quartz based Electrostatic Pressure Sensors are the most preferred sensors because these transducers are small and rugged. The force applied to the crystal longitudinally or transverse direction Voltage output proportional to the force applied. The crystal’s self-generated voltage signal is useful because providing power to the sensor is impractical or impossible. These sensors also provide high speed responses (30 kHz to 100kHz), which makes them ideal for measuring transient phenomena.

3.2 Amplifiers

The output voltage of almost all active sensors corresponding to the variation in a physical parameter is very small. Amplifier with very high input impedance and sufficient gain reused to pick up very small signals (approximately in Pico to mill volts) is necessary [5]. An amplifier with appropriate input/output impedance, sufficient gain and high CMMR is an important part of the signal conditioning circuit [5].The amplifier LM324 are used in the preamplifier section and CA3103 are integrated circuit operational amplifiers that combine the advantages of gate protected MOSFET (PMOS) transistors with bipolar transistors on a single monolithic chip. Bi-MOS operational amplifiers have PMOS transistors in the input circuit which provides very high input impedance, very low input current and high speed performance.

An amplifies sensor output is fed to the advance microcontroller ATmega 32/16. The advantage of selecting this controller due to the inbuilt ADC of 10 bit and bit resolution. As there is no interaction with the ADC sinking and sourcing current the bit resolution will be remain intact with change in the input level. The perfect decision making is also maintain with the utilisation of Lab-VIEW utility. The graphical representation with the Lab-VIEW recorded the data and shows the smallest change in the form of continue graphing.

4. Experimental Set Up

A block diagram shown in Fig. 2. Consists of application modules which are installed on back panel of card developed using ATmega- 16/32 microcontroller of the system. The physical address for the application module is set on mother board from 000 to 111. When system is switched ON, the application module read the physical address and saves in local register of microcontroller. While transferring command for Read / Write, the logical address is sent first with the interrupt status value. The microcontroller in application module compares logical address and physical address. The module program command sequence is executed in the application module whose logical address and physical address matches. All the commands are treated as either read or write considering as receive or send by PC. Data and commands are sending or receive by the PC to the application module via serial interface.

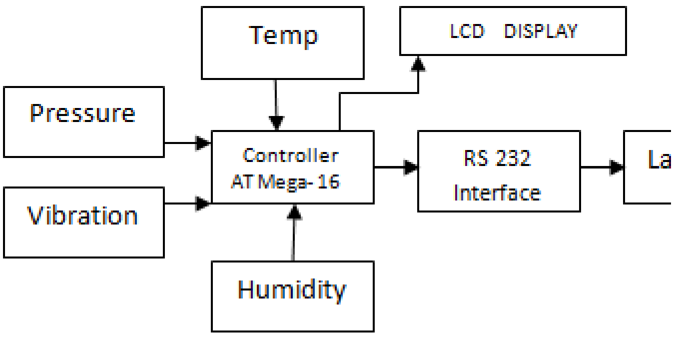

Fig2: Bock Diagram of system

4.1 Selection of Suitable Transducer

For measuring the temperature, the choice of sensor is of utmost importance[7]. The sensors are used in many fields includes Thermocouples, Resistive temperature devices and bimetallic devices. The factors for the selection of sensor that we take into account includes the inherent accuracy, durability, range of operation, susceptibility to external noise influences, ease of maintenance and installation, handling during installation (delicacy), ease of calibration, and type of environment it will be used in.

1) Criteria for choosing microcontroller

1) The first and foremost criterion for choosing a microcontroller is that it must meet the task at efficiently and cost effectively [7]. In analysing the needs of microcontroller-based project, it is seen whether an8-bit, 16-bit or 32-bitmicrocontroller can best handle the computing needs of the task most effectively. Among the other considerations in this category are:

(a)Speed–What is the highest speed that the microcontroller supports?

(b)Packaging –Doesitcomein40-pinDIP (dual in line package) or a QFP (quad flat package),or some other packaging format? This is important in terms of space, assembling, and prototyping the end product.

(c)Power consumption–This is especially critical for Battery-powered products.

(d)The number of I/O pins on the chip.

(g)Cost per unit–this is important in terms of the final cost of the product in which a microcontroller is used.

2) The criterion in choosing a microcontroller is how easy it is to develop products around it. Key considerations include the availability of an assembler, debugger, a code–efficient compiler, technical support.

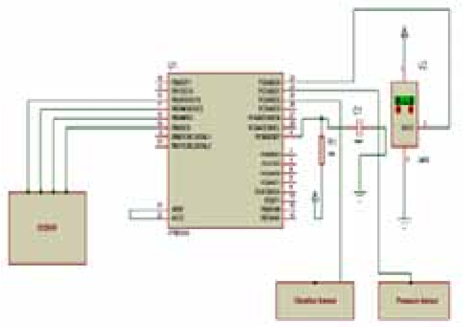

Figure 3: Schematic of designed prototype

The prototype is designed using the same schematic with the temperature, vibration, pressure sensor in the system. As LM-35, MXP10-40, LM393 and then it compares with the standard, and this analogue data is then given to the ADC which is already inbuilt in a AVR ATmega16 microcontroller. AT-Mega16 microcontroller is used to control the control action is done. The ATmega 16 microcontroller is programmed in embedded C language with Code Vision AVR IDE.

2) Pressure sensor

The MPX10 series silicon quartz-pizo resistive pressure sensor provides accurate and linear voltage output, directly proportional to the applied pressure. These standard, low cost, uncompensated sensor permits manufacturer to design and add their own external temperature compensation and signal conditioning network. In this project the compensation circuit along with the vibration scanning is carry forwarded in the ASCII format and converted the logical part in to the fixed digital environment.

Figure 4: Snapshot of pressure sensor

3) Vibration sensor

The vibration is the main source of disturbing the performance of the system and same data analysis so we observed the vibration of system. Also the in prospective application the vibration data give the information of the material characterization and status of material. The more vibration is shows the poor performance of the system and durability of the system is less. Here we used the capacitive vibration, which give the smallest vibration

Figure 5: Snapshot of vibration sensor *RF module*

4.2 Instrumentation

Microcontroller ATmega 8/16/32 based instrumentation involving interfacing hardware with software to connect the Sensor for parametric measurement of the precursors to the earthquakes[7]. The instrumentation can monitor four channels at a time [3].An arrangement is made to display the Sensor and the equivalent number corresponding to the voltage available at the channel. The basis of microcontroller control system is node intelligence module. The reliability and reliability of the whole system are strong, so it is mainly applied in automatic control system of industry. Most of its performance is the same as single sensor data acquisition system. We will go on learning control system by taking microcontrollerAT-MEGA16. Its over-all structure can be expressed as:

Human-machine interface↔ control centre ↔ front-end processor of the system ↔ node intelligence module ↔ controlled equipment. Of course,

The hardware in microcontroller control system is similar to that in data acquisition system, which is equipped with PC control, input and output port, conversion module, keyboard, display, timer, data acquisition system and hardware multiplying unit etc. Its operating principle is interlinked to the said system of over-all structure.

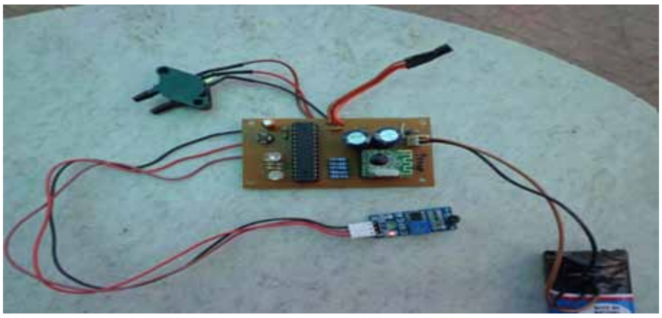

Figure 6: Sensor module with microcontroller

4.2.2 Software control system.

Software control system of single chip is also programmed by C programming language compiling. We will also take the workflow of single chipAT-MEGA16

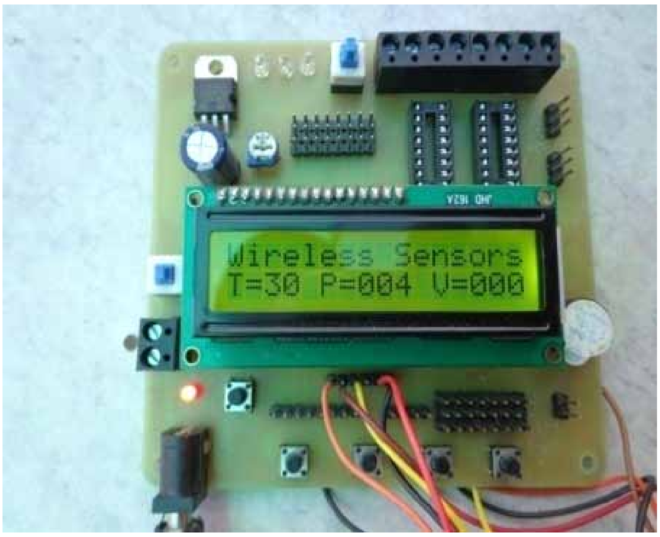

Figure 7: snapshot of prototype

The control systems of microcontroller can be expressed by picture. Here, we will describe a part of control software. According to comprehension of communication protocol and hardware principles, it is concluded that software communication module is controlled by register establishment, while USART controller include RX Control Register, TX Control Register and Adjustment Control Register. The clock source of software in initialization setting adopts sub-clock of system, the length of transmission characterise as 8-bit, Baud rate is 9600-bit, the circuit is free multi-machine protocol which can send, receive and interrupt enable. Serial communication adopts interrupt mechanism; RXD and TXD also adopt interrupt mechanism. If main program sends data, the interrupt signal can beset as assess to interrupt to send data. If there is RXD, a signal will be setup to inform main program that data is coming. If we want to receive data, while the service program is interrupted, we can read data we want to get at RXD register and put this data in to global variable buffer zone setting up a signal to inform main program there is data. The program checking and processing data is the main processor, which transfer correct data to main function of the system and calculate it, then responsive information will be sent to computer after packaging. If data is false, it will be sent to computer after packaging too, and data will be resent. A microcontroller includes data acquisition system and control system. The control system is to ensure data acquisition system works normally and give related instructions after analysing and processing received data. The two are in separable supplementing each other and promoting each other. The application module can be installed in one to eight locations while controller is placed on ninth position. The application module has no physical position limitation, i.e., any module can be installed in any position except the controller module.

5. Result and Conclusions

Result

The data capture by the microcontroller ATmega 16 is converted into string format using the standard library function and send through the serial port which is already defined in the code wizard.. The lab view and microcontroller is configured with the tool VISA available in library. The received string is stored at location and same string is used with string splitter tool with the common separate or symbol. The separate logic of string to numeric converter the string data is converted into the numeric floating point data. The data acquired by the microcontroller is shown on the LCD display attached with the microcontroller-developed board.

Conclusion

The instrumentation setup was intended to work on the basic principles of Physics and Electronics [5]. This is the first time that such instrumentation is set up using systems based on Microcontroller and interfaced with the circuitry developed for monitoring the output parameters [4].Incidentally these are the very parameters which are understood to develop weeks before the advent of the actual earthquake.

6. Future Scope

No part of the world is immune from earthquakes. Developing countries, in particular, are the most affected because response services may not be available even in less stressful times. Earthquake prediction research in the country should be taken seriously, of course, along with other necessary measures aimed at reducing damage and minimizing human suffering. Almost all earthquakes are preceded by physical processes which are commonly known as earthquake precursors [1].

7. Acknowledgement

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