

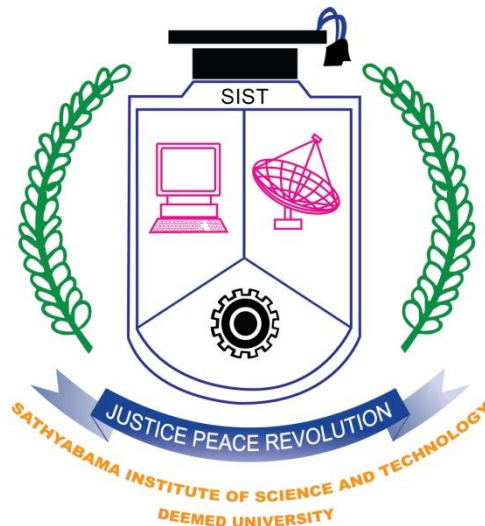
CONSRUCTION ALERT SYSTEM USING WIRELESS SENSOR NETWORK

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

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APRIL 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **KISHAN SANGO.S** (Reg. No. 37140044) and **JERSON.J** (Reg. No. 37140039) who carried out the project entitled "**CONSTRUCTION ALERT SYSTEM USING WIRELESS SENSOR NETWORK**" under our supervision from December 2020 to April 2021.

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Head of the Department

Submitted for Viva voce Examination held on _____

Name:

Signature:

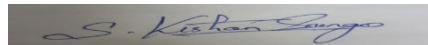
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DECLARATION

We **KISHAN SANGO.S** (Reg. No. 37140044) and **JERSON.J** (Reg. No. 37140039) hereby declare that the Project Report entitled “**CONSTRUCTION ALERT SYSTEM USING WIRELESS SENSOR NETWORK**” done by us under the guidance of **Dr.S.JAYAPRAKASH** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1.



2.



DATE: 09/04/2021

SIGNATURE OF THE CANDIDATES

PLACE: Kaniyakumari

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ABSTRACT

A wireless sensor network is proposed for monitoring buildings to assess earthquake damage. The sensor nodes use custom-developed piezoelectric sensor and 3-D acceleration sensors. The piezoelectric sensors are mounted at the base of the building to measure the settlement and plastic hinge activation of the building after an earthquake. They measure periodically or on-demand from the base station. The accelerometers are mounted at every floor of the building to measure the seismic response of the building during an earthquake. They record during an earthquake event using a combination of the local acceleration data and remote triggering from the base station based on the acceleration data from multiple sensors across the building. Low power network architecture was implemented over an 802.15.4. A custom patch antenna was designed in this frequency band to obtain robust links in real-world conditions. It consists of Arduino Microcontroller, Bluetooth communication, Atmel 89C52, ADC0809, Liquid crystal Display unit, Power supply etc.,

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CHAPTER 1

1.1 GENERAL INTRODUCTION

Buildings are a basic need for public infrastructure and many more reliable methods are needed to maintain those buildings to ensure that the building is reliable and efficient for people to use. People have huge investments in public infrastructure. There is a need for a proper building study of these infrastructure that analyzes the age of the building and whether it has been most effective in maintaining the above.

The development of monitoring structures seems to be a powerful motivator. Over the years more than a thousand people have lost their lives or been seriously injured by construction failures and, therefore, by monitoring the structure can help save millions of lives and save us financial and economic losses. Due to population growth, people are relying more heavily on the civil structures that are growing day by day including construction, bridges etc. even new processes are being introduced to build safe structures that can hold earthquakes etc.

In the present time there are multiple methods in order to monitor and secure the structure. Despite research work and development, a precise method is still not achieved to monitor the health of structure. In order to achieve a precise method, we used multiple parameters. The principal goal of the presented system is to know the condition of the Structure on an actual time basis that leads to features of safety protection, increasing the lifetime of structures. Shock and vibration are present in all areas of our daily lives. It may be transmitted and generated by machine-tools, turbines, motor, towers, bridges, and even by the human body. Vibration and shock also may be desirable, disturbing and even destructive. It depends on the place and what type of source of vibration that occurs. MEMS accelerometers are one of the simplest but also used micro-electro-mechanical systems. They have become indispensable in the automotive, space, telecommunication, audio-video, etc. industries. An accelerometer is an electromechanical device that measures acceleration; they may be static, such as gravitational force, or dynamic - caused by the movement or vibration of the accelerometer. There are several types of accelerometers developed and reported in

the literature; most are based on piezoelectric crystals, but they are quite large. People have tried to develop something smaller, which could increase applicability and have started searching in the field of microelectronics; so MEMS accelerometers have developed. Micro-processed accelerometers are an extremely permissive technology with a huge commercial potential.

1.2 BLOCK DIAGRAM

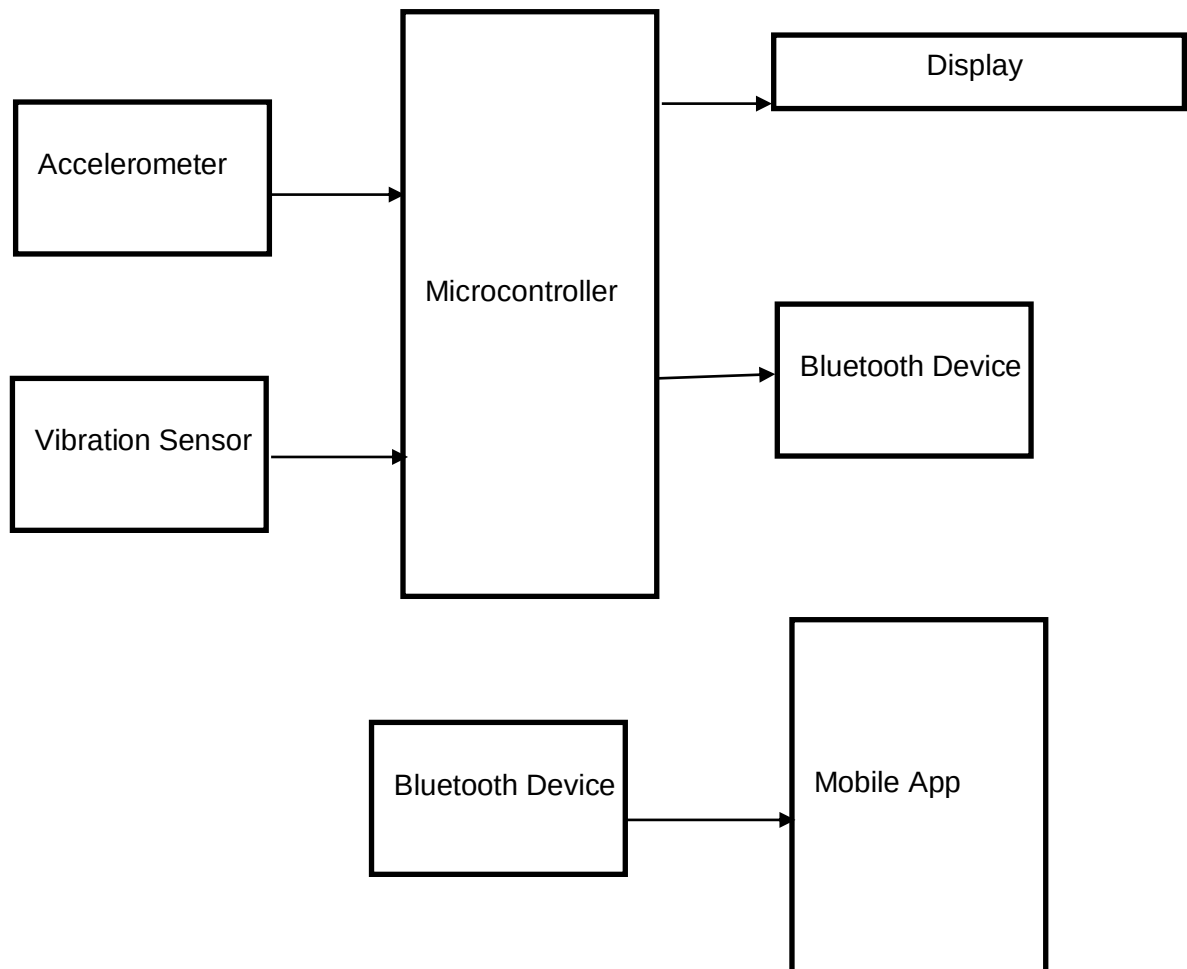


Fig 1.1 Block diagram for proposed system

1.2.1 BLOCK DESCRIPTION

VIBRATION SENSOR

Vibration sensor works on the basis of piezoelectric effect. Due to the force act on the locker it changes the resistance and generates electrical charge which is in the range of 4-20 mA. It will sense any offensive acts on the locker and provide the control signal to the Raspberry processor. Vibration sensor is relatively cheap and easily to use. A crystal generates a low voltage or charge when stressed as for example during compression .

Bluetooth module

The communication media between the user is provided by the Bluetooth module through the android phone and the system i.e. by giving voice command to the android phone. The user will send the command to the BT voice control for Arduino voice the software application installed in the android phone i.e. connected via BT module.

Display

16*2 alphanumeric display are used in this project, it is wide range of applications, including computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16*2 intelligent alphanumeric dot matrix displays is capable of displaying 224 different characters and symbols.

Microcontroller

Arduino is a simple integrated development environment (IDE) which runs on a pc and allows user to write programs for Arduino in c or c++ language. The entire programs are installed in Arduino controller.

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It

contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Differences with other boards: The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

1.3 HARDWARE REQUIREMENTS

1. Atmega 328p
2. 16 x 2 LCD Display
3. Accelerometer
4. Vibration sensor
5. Bluetooth Module

1.4 SOFTWARE REQUIREMENTS

1. Kiel compiler
2. MP LAB IDE
3. Proteus Software
4. IC program

CHAPTER 2

LITERATURE SURVEY

2.1 EXISTING SYSTEM

2.1.1 VIBRATION MEASUREMENT SYSTEM WITH MEMS ACCELEROMETERS BASED ON ARDUINO

This paper presents the design and construction of a mechanical vibration measurement system based on an Arduino platform and a series of MEMS accelerometers. The important element of the project is the three-dimensional accelerometer sensors (ADXL335/345- triple axis sensor x, y and z), supported by open source board (Arduino board).

The Arduino is a microcontroller board based on the ATmega328. It has 14 digital input and output pins which six of them can be used as pulse-width modulation (PWM) outputs, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains every-thing needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Keywords: vibration, accelerometer, sensors, ADXL335, Arduino

2.1.2 GSM BASED SYSTEMS FOR REAL TIME STRUCTURAL HEALTH MONITORING

Structural Health Monitoring helps us to ensure integrity and safety of infrastructures. It consists of methods that include detecting the damage, identification of the weaknesses and estimating performance deterioration within the structure due to aging, earthquake or any other reason, to make preemptive defense repairs.

In this project we have collected real time values of a set of parameters etc, temperature, vibration, humidity with the help of low cost and energy efficient sensors. The data of desired parameters is then transferred to a cloud data storage platform for universal availability and investigations by the civil structures experts.

2.1.3 Bridge Health Smart Monitoring System

Now a days, various types of disaster is happening mostly in all over the world. This is because of change in natural conditions. These types of disasters will destroy the many structure like bridges and this will damage the life. Hence to continuously verify and monitor the conditions on bridge we make the system called bridge monitoring system. Bridge monitoring system will help to know the current conditions on bridge like wind speed, temperature, weight etc. and inform us. According to the readings of different sensors we can compare it with fixed values and we will get alert before any disaster.

2.1.4 Measuring mechanical vibrations using an Arduino as a slave I/O to an EPICS control system

In this study we have assembled hardware and software to be used for measuring of mechanical vibrations in the FREIA-laboratory at Uppsala University. We have utilized an Arduino microcontroller as a slave I/O and equipped it with dual accelerometers to be used for vibration measurements and a serial adapter which was used to connect the hardware to an EPICS IOC for analysis. Data from the two accelerometers have then been cross correlated in order to find a transfer function. Our results where in good agreement with theory

2.1.5 Development of Smart Sensing Unit for Vibration Measurement by Embedding Accelerometer with the Arduino Microcontroller

In this paper, we have described a novel smart sensing unit for vibration measurement and machinery condition monitoring. Here we have embedded accelerometer with the arduino microcontroller board. Where microprocessor-based smart sensor shall collect 3-D vibrations; and these stored data in microcontroller can be sent to third party devices (Laptop, PC etc.) for further signal analysis. Analytical approaches have

demonstrated that vibration monitoring has tremendous potential in detecting localized defects in the machines. When mounted in proximity of a bearing housing (a general case), these module can collect the Stationary as well as non-stationary signature data of vibration of bearing housing reliably. Since, most vibration sensors are mounted in proximity of bearing housings (based on mechanical impedance considerations); bearing fault detection techniques can be implemented for online bearing condition monitoring. This module can be easily deployed for different rotating machines for vibration monitoring purposes. Arduino board is utilized for collecting data from sensor as data acquisition module; which consists of ATmega328P microcontroller having 16 MHz clock speed, hence enabling us to capture high frequency signals from accelerometer.

2.1.6 MONITORING OF STRENGTH OF A BRIDGE USING ACCELEROMETER

The main aim of the proposed work is to analyse the strength of bridge using accelerometers (ADXL345)/vibration sensors. The capability of this sensor system is to analyse the property of the bridge using the data's collected from the accelerators which are fixed on bridge piers. Accelerometer is a widely used device for application such as wrecking of bridges and damage of bridges for bridge monitoring. Health monitoring systems generally include information acquisition, analysis, diagnosis, evaluation, feedback and safety. It enables the timely realization of the function of data acquisition

CHAPTER 3

3.1 AIM

This system will monitor the minute vibrations and the slope of the building surface to avoid the disaster. Appropriate Sensors will transmit the health data via Wireless Network . We can monitor the vibration and any tiny movements occurrence inside the walls, floors and roofs etc. To sense the miniature movements MEMS based accelerometer is used. WSN can be implemented by using IEEE 802.15.1

BUILDINGS can progressively accumulate damage during their operational lifetime, due to seismic events, unforeseen foundation settlement, material aging, design error, etc. Periodic monitoring of the structure for such damage is therefore a key step in rationally planning the maintenance needed to guarantee an adequate level of safety and service ability. The capability of MEMS and wireless networking for monitoring civil structures is well documented. The presented work addresses all of the above requirements.

A wireless sensor network of spatially distributed autonomous sensor to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

3.2 SCOPE

To monitor the health of building structure. Minute earth vibrations can cause cracks over a period of time. Vibrations exerted on to building and slope change are measured by sensors. Sensors are connected to intelligent electronic module that can transmit the health parameters via wireless network for further monitoring centrally.

Monitor minute vibration. The sensors are the early warning system for the bridges providing the essential information that help the highways department to accurately monitor the general health conditions of the bridge.

It operates in low power. It provides high quality sensor data.

This project is more relevant today and is important to the society considering below facts

1. To monitor the high rise buildings.
2. Resident Buildings near industry and rail tracks are much affected by the vibrations. To monitor this vibration we are using this system.
3. To monitor the Earthquake damage.

SOFTWARE TOOLS

The software used in this project is given below

- IDE
- PROTEUS
- IC PROG
- KEIL Development Tool

3.3 IDE

Integrated Development Environment (IDE) is a comprehensive editor, project manager and design desktop for application development of embedded designs .

3.3.1 IDE EDITOR

The MPLAB Editor is an integrated part of the IDE Integrated Development Environment. The editor is always available when IDE is running.

3.3.2 IDE FEATURES

IDE provides the ability to:

- Create and edit source code using the built-in editor.
- Assemble, compile and link source code.
- Debug the executable logic by watching program flow with the built-in simulator or in real time with in-circuit emulators or in-circuit debuggers.
- Make timing measurements with the simulator or emulator.
- View variables in Watch windows

3.4 PROTEUS

Traditionally, circuit simulation has been a non-interactive affair. In the early days, netlists were prepared by hand, and output consisted of reams of numbers. A pseudo - graphical output plotted with asterisks to show the voltage and current waveforms. More recently, schematic capture and on screen graphing have become the norm, but the simulation process is still non-interactive - you draw the circuit, press go, and then study the results in some kind of post processor. This is fine if the circuit you are testing is essentially static in its behavior e.g. an oscillator which sits there and oscillates at 1MHz. However, if you are designing a burglar alarm, and want to find out what happens when a would-be burglar keys the wrong PIN into the keypad, the setting up required becomes quite impractical and one must resort to a physical prototype.

Only in educational circles has an attempt been made to present circuit simulation like real life electronics where it is possible to interact with the circuit whilst it is being simulated. The problem here has been that the animated component models have been hard coded into the program. In addition, the quality of circuit simulation has often left much to be desired. For example, one major product of this type has no timing information within its digital models.

Proteus Vsm brings you the best of both worlds. It combines a superb mixed mode circuit simulator based on the industry standard SPICE3F5 with animated component

models. And it provides an architecture in which additional animated models may be created by anyone, including end users. Indeed, many types of animated model can be produced without resort to coding. Consequently PROTEUS VSM allows professional engineers to run interactive simulations of real designs, and to reap the rewards of this approach to circuit simulation. And then, if that were not enough, we have created a range of simulator models for popular micro-controllers and a set of animated models for related peripheral devices such as LED and LCD displays, keypads, an RS232 terminal and more. Suddenly it is possible to simulate complete micro-controller systems and thus to develop the software for them without access to a physical prototype.

3.5 PROG

This software is used for downloading the program into PIC controller. IC programming is the process of transferring a computer program into an integrated computer circuit. The modern ICs are typically programmed in circuit through a serial protocol. Some even load the data serially from a separate flash or prom chip on every startup.

3.6 KEIL Development Tool

Keil software provides the ease of writing the code in either C or ASSEMBLY. U-VISION2, the new IDE from Keil Software combines Project management, Source Code Editing and Program debugging in one powerful environment. It acts as a CROSS-COMPILER. Keil software offers development tools for ARM.

Multisim Details

Multisim is the schematic capture and simulation application of National Instruments Circuit Design Suite, a suite of EDA (Electronics Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Multisim is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout.

Ultiboard is the PCB layout application of National Instruments Circuit Design Suite, a suite of EDA (Electronics Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Ultiboard is used to lay out and route printed circuit boards, perform certain basic mechanical CAD operations, and prepare them for manufacturing. It also provides automated parts placement and layout. Schematic capture is the first stage in developing your circuit.

In this stage you choose the components you want to use, place them on the circuit window in the desired position and orientation, wire them together, and otherwise prepare your design. Multisim lets you modify component properties, orient your circuit on a grid, add text and a title block, add sub circuits and buses, and control the colour of the circuit window background, components and wires

ATMEL STUDIO 7

Atmel Studio is an Integrated Development Environment (IDE) for writing and debugging applications for AVR/ARM platforms. Currently as a code writing environment, it supports the included AVR Assembler and any external AVRGCC/ARMGCC compiler in a complete IDE environment.

Using Atmel Studio as an IDE gives you several advantages:

1. Editing and debugging in the same application window allows for a faster error tracking.
2. Breakpoints are saved and restored between sessions, even if the code was edited in the meantime.
3. Project item management is made convenient and portable.

Programming for 328p

1. Go to the ATMEL website and download ATMEL studio 7. The download link is below and it can be download and install either the web installer or the offline installer.
2. The second step to program Arduino using ATMEL Studio 7 is to add AVRdude as an external tool. To do this, open ATMEL studio and go to Tool > External Tools. There you will see a form for specifying external tool. Here we have to setup the AVRdude.exe that Arduino uses as our external tool so that ATMEL studio can use it.
3. The final step to program Arduino using ATMEL Studio 7 is to write, compile and upload the program into the Microcontroller via USB. As we said we will use C program to write the code. Start a new GCC C Executable Project, provide some name and finally select the Atmega328P as your device. This also works if you want to use C++ programming language.
4. the External Tool Arduino UNO Programmer that we created in the earlier step. But before that you have to connect the Arduino to your PC.
5. To do this, go to Tools menu in the toolbar and select/click Arduino UNO Programmer. The hex code will be burned into the microcontroller and you should see a message "avrdude.exe done.

CHAPTER 4

4. HARDWARE MODULE

4.1 CIRCUIT DIAGRAM

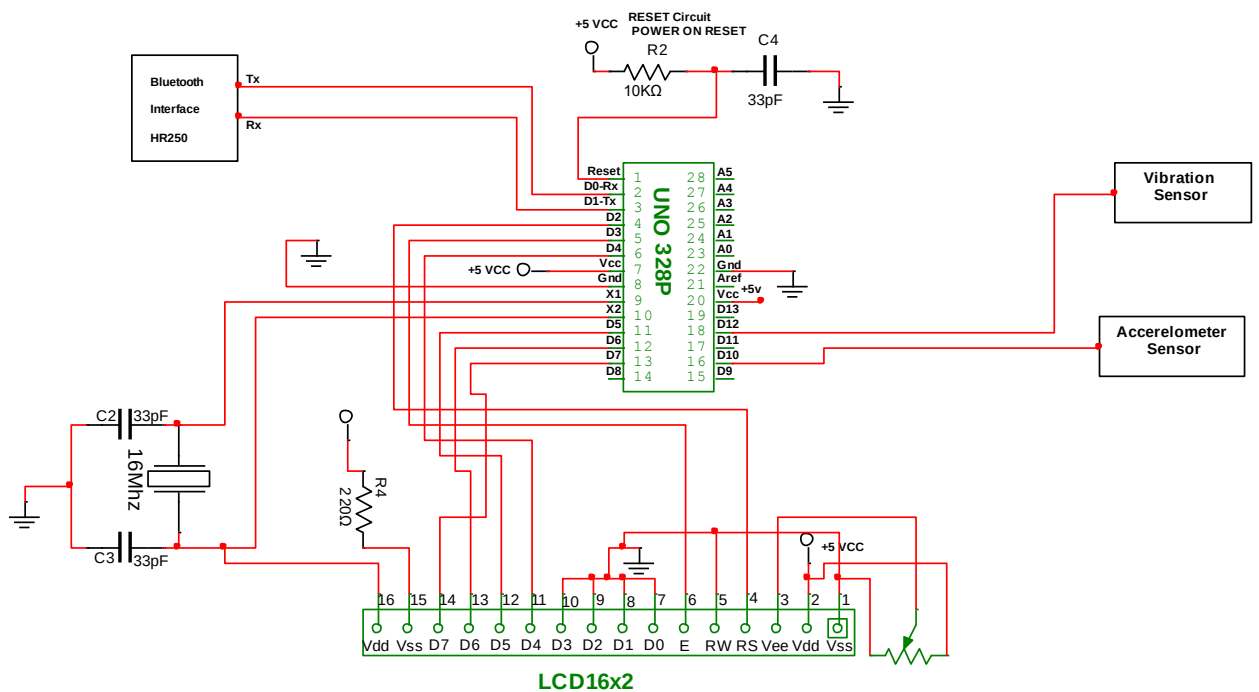


Fig.4.1 circuit diagram

4.1.1 WORKING PRINCIPLE

The entire system consists of an ATmega 328p microcontroller which controls the interface between the different components of the system i.e. sensors, motor driver, LCD Display, Wi-Fi Modem . The power supply is given to Arduino Board which is smaller in size and has a microcontroller.

The board is connected to the various Sensor, LCD Display and Bluetooth. Here we have used LCD 16x2. The microcontroller port is connected to the sensors like accelerometer and vibration .. Here for angle sensor we are using accelerometer. Thus, when the sensors sense some harm or detect values above the threshold value, it sends signals to the Microcontroller. The program installed in the Arduino will start to execute and according to the flow of the program it will send the signals to the respective components. Arduino Board sends data to Bluetooth module to transfer data to user end.

All sensors get the realtime value and send user through bluetooth The analyst is already logged in to the android device and analyze the data that was sent to the control room by the system. It sends the data to the user. User can see the data who has been already registered in the database and can see this data. This data will help the user to see the details of the bridge. These data can be helpful to avoid accident from happening and all that data will be display on the LCD so that the coming vehicles could see the information from not so far distance and inform the other passage vehicles.

4.1.2 Accelerometer

Accelerometers have multiple applications in industry and science. Highly sensitive accelerometers are used as inertial navigation systems for aircraft and missiles. Accelerometers work is to detect and monitor vibration with rotating machinery. Basic structure of accelerometer consists fixed plates and moving plates (mass). Acceleration deflects the moving mass and unbalances the differential capacitor which results in a sensor output voltage amplitude which is proportional to the acceleration. By the amount of sense of acceleration, users can come to know how the device is moving.

Accelerometers are available as digital devices and analog devices. Accelerometers are designed using different methods. Piezoelectric, piezoresistive and capacitive components are generally used to convert the mechanical motion caused in accelerometer into an electrical signal. Piezoelectric accelerometers are made up of single crystals. These use the piezoelectric effect to measure the acceleration. When applied to stress, these crystals generate a voltage which is interpreted to determine the velocity and orientation. Capacitive accelerometers use a silicon micro-machined

element. Here capacitance is generated when acceleration is sensed and this capacitance is translated into a voltage to measure the velocity values.

Modern accelerometers are the smallest MEMS, consisting of a cantilever beam with proof mass. Accelerometers are available as two-dimensional and three-dimensional forms to measure velocity along with orientation. When the upper-frequency range, high-temperature range, and low packaged weight are required, piezoelectric accelerometers are the best choice.

Applications

- The Applications of Accelerometer sensor are as follows:
- For inertial navigation systems, highly sensitive accelerometers are used.
- To detect and monitor vibrations in rotating machinery.
- To display images in an upright position on screens of digital cameras.
- For flight stabilization in drones.
- Accelerometers are used to sense orientation, coordinate acceleration, vibration, shock.
- Used to detect the position of the device in laptops and mobiles.
- High-frequency recording of biaxial and triaxial acceleration in biological applications for discrimination of behavioral patterns of animals.
- Machinery health monitoring.
- To detect faults in rotator machines.
- These are also used for building and structural monitoring to measure the motion and vibration of the structure when exposed to dynamic loads.
- To measure the depth of CPR chest compressions.
- Navigation systems make use of accelerometer sensors for knowing the direction.
- Remote sensing devices also use accelerometers to monitor active volcanoes.

4.2 VIBRATION SENSOR

Vibration sensor works on the basis of piezoelectric effect. Due to the force act on the locker it changes the resistance and generates electrical charge which is in the range of 4-20 mA. It will sense any offensive acts on the locker and provide the control signal to the Raspberry processor. Vibration sensor is relatively cheap and easily to use. A crystal generates a low voltage or charge when stressed as for example during compression .

Vibration sensors are sensors for measuring, displaying, and analyzing linear velocity, displacement and proximity, or acceleration.

Vibration — however subtle and unnoticed by human senses — is a telltale sign of machine condition. Abnormal vibration indicative of problems with an industrial machine can be detected early and repaired before the event of machine failure; because such a failure is potentially costly in terms of time, cost, and productivity, vibration measurement allows industrial plants to increase efficiency and save money. Therefore, vibration analysis is used as a tool to determine equipment condition as well as the specific location and type of problems.

The severity of machine vibration is standardized by the International Standards Organization (ISO) in the ISO 10816 publication. The standard describes acceptable vibration levels for four different classes of machines. This data, as laid out in the chart below, proves useful as a reference point when analyzing vibration measurements.

4.3 DIODE BRIDGE RECTIFIER:

4.3.1 Full Wave Bridge Rectifier

single phase rectifier uses four individual rectifying diodes connected in a closed loop “bridge” configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

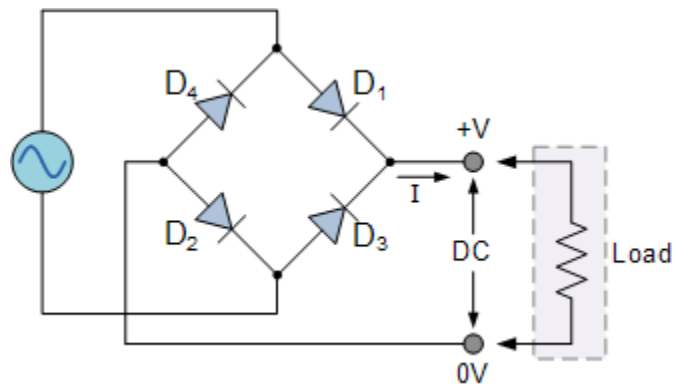


Fig no 4.2 Full wave Bridge Rectifier

The four diodes labelled D_1 to D_4 are arranged in “series pairs” with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D_1 and D_2 conduct in series while diodes D_3 and D_4 are reverse biased and the current flows through the load as shown below.

4.3.2 THE POSITIVE HALF-CYCLE

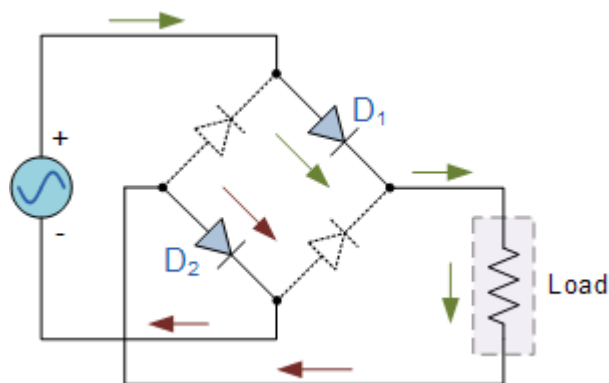


Fig no:4.3 positive half cycle

During the negative half cycle of the supply, diodes D_3 and D_4 conduct in series, but diodes D_1 and D_2 switch “OFF” as they are now reverse biased. The current flowing through the load is the same direction as before.

4.3.3 THE NEGATIVE HALF-CYCLE

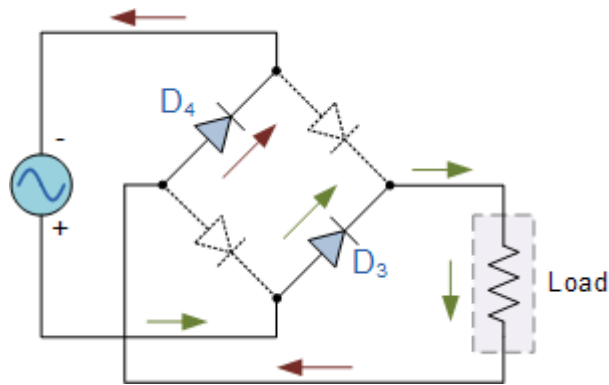


Fig no:4.4 negative half cycle

As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier, therefore the average DC voltage across the load is $0.637V_{\text{max}}$.

However in reality, during each half cycle the current flows through two diodes instead of just one so the amplitude of the output voltage is two voltage drops ($2 \times 0.7 = 1.4\text{V}$) less than the input V_{MAX} amplitude. The ripple frequency is now twice the supply frequency (e.g. 100Hz for a 50Hz supply or 120Hz for a 60Hz supply.)

Although we can use four individual power diodes to make a full wave bridge rectifier, pre-made bridge rectifier components are available “off-the-shelf” in a range of different voltage and current sizes that can be soldered directly into a PCB circuit board or be connected by spade connectors.

The image to the right shows a typical single phase bridge rectifier with one corner cut off. This cut-off corner indicates that the terminal nearest to the corner is the positive or +ve output terminal or lead with the opposite (diagonal) lead being the negative or -ve output lead. The other two connecting leads are for the input alternating voltage from a transformer secondary winding.

4.4 THE SMOOTHING CAPACITOR:

The smoothing capacitor converts the full-wave rippled output of the rectifier into a smooth DC output voltage. Generally for DC power supply circuits the smoothing capacitor is an Aluminum Electrolytic type that has a capacitance value of 100uF or more with repeated DC voltage pulses from the rectifier charging up the capacitor to peak voltage.

However, there are two important parameters to consider when choosing a suitable smoothing capacitor and these are its *Working Voltage*, which must be higher than the no-load output value of the rectifier and its *Capacitance Value*, which determines the amount of ripple that will appear superimposed on top of the DC voltage.

Too low a capacitance value and the capacitor has little effect on the output waveform. But if the smoothing capacitor is sufficiently large enough (parallel capacitors can be used) and the load current is not too large, the output voltage will be almost as smooth as pure DC.

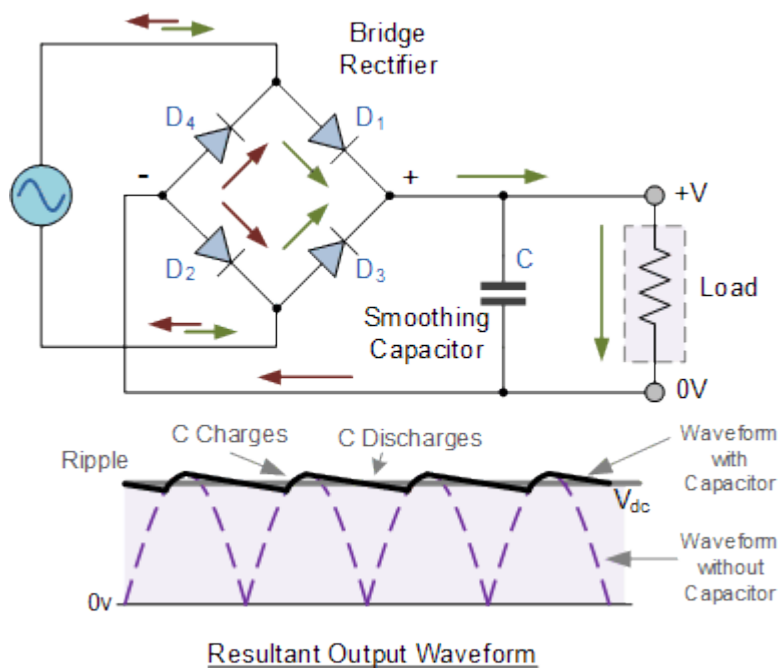


Fig no :4.5 smoothing capacitor

4.4.1 LINEAR REGULATOR:

The function of a linear voltage regulator is to convert a varying DC voltage to a constant, often specific, lower DC voltage. In addition, they often provide a current limiting function to protect the power supply and load from over current (excessive, potentially destructive current).

A constant output voltage is required in many power supply applications, but the voltage provided by many energy sources will vary with changes in load impedance.

Furthermore, when an unregulated DC power supply is the energy source, its output voltage will also vary with changing input voltage. To circumvent this, some power supplies use a linear voltage regulator to maintain the output voltage at a steady value,

independent of fluctuations in input voltage and load impedance. Linear regulators can also reduce the magnitude of ripple and noise present appearing on the output voltage.

Common solid-state series voltage regulators are the LM78xx (for positive voltages) and LM79xx (for negative voltages), and common fixed voltages are 5 V (for transistor-transistor logic circuits) and 12 V (for communications circuits and peripheral devices such as disk drives).

In fixed voltage regulators the reference pin is tied to ground, whereas in variable regulators the reference pin is connected to the centre point of a fixed or variable voltage divider fed by the regulator's output.

4.4.2 FIXED REGULATORS:

"Fixed" three-terminal linear regulators are commonly available to generate fixed voltages of plus 3 v, and plus or minus 5 v, 6v, 9 v, 12 v, or 15 v, when the load is less than 1.5 amperes.

The "78xx" series (7805, 7812, etc.) regulate positive voltages while the "79xx" series (7905, 7912, etc.) regulate negative voltages. Often, the last two digits of the device number are the output voltage; e.g., a 7805 is a +5 v regulator, while a 7915 is a -15 v regulator. There are variants on the 78xx series ICs, such as 78l and 78s, some of which can supply up to 1.5 amps.

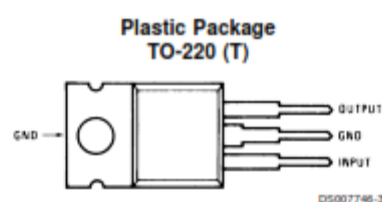


Fig no:4.6 fixed regulator

4.5 LCD DISPLAY:

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. In this project document, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit), programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your

application. LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

4.5.1 LCD Interface Circuit:

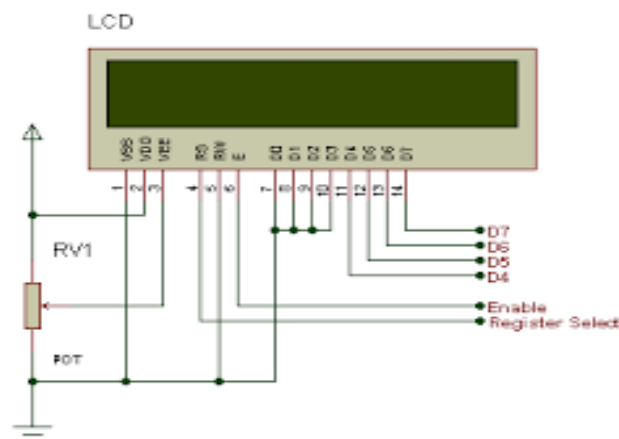


Fig no: 4.7 LCD interface circuit

Pin Details:

Table no:4.1 pin details

PIN NUMBER	SYMBOL	FUNCTION
1	V _{ss}	GND
2	V _{dd}	+ 3V or + 5V
3	V _o	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/W	H/L Read/Write Signal
6	E	H → L Enable Signal
7	DB0	H/L Data Bus Line
8	DB1	H/L Data Bus Line
9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/V _{ee}	+ 4.2V for LED/Negative Voltage Output
16	K	Power Supply for B/L (OV)

The LCD standard requires 3 control lines and 8 I/O lines for the data bus. Liquid Crystal Display is very important device in embedded system. It offers higher flexibility as the user can display any data on it. Copy and paste technique may not work when an embedded system engineer wants to apply LCD interfacing in real world projects. First thing to begin with is to know what LCD driver/controller is used LCD. LCD driver provides a link between microcontroller and LCD. In LCD initialization user has to send command bytes to LCD. Here the user sets the interface mode, display mode, address

counter increment direction, set contrast of LCD, horizontal or vertical addressing mode, color format. The command register stores the command instructions given to the LCD.

A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

The registers stores the data to be displayed on the LCD.

16 characters *2 lines display

4-bit or 8-bit MPU interfaces

Display mode and back light variations

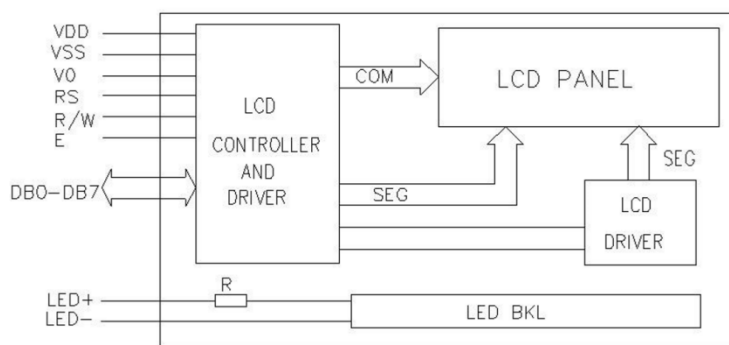


Fig no:4.8 LCD Pin Description

4.6 ATMEGA 328P

This circuit consists of ATMEGA 328 p which is used to collect the data from the sensor and post to main unit through wireless transceiver. It has 14 digital I/O pins, of which 6 can be used as PWM outputs and 6 analog input pins.

These I/O pins account for 20 of the pins. 2 of the pins are for the crystal oscillator. This is to provide a clock pulse for the Atmega chip. A clock pulse is needed for

synchronization so that communication can occur in synchrony between the Atmega chip and a device that it is connected to.

The chip needs power so 2 of the pins, Vcc and GND, provide it power so that it can operate. The Atmega328 is a low-power chip, so it only needs between 1.8-5.5V of power to operate.

The Atmega328 chip has an analog-to-digital converter (ADC) inside of it. This must be or else the Atmega328 wouldn't be capable of interpreting analog signals. Because there is an ADC, the chip can interpret analog input, which is why the chip has 6 pins for analog input.

The ADC has 3 pins set aside for it to function- AVCC, AREF, and GND. AVCC is the power supply, positive voltage, that for the ADC. The ADC needs its own power supply in order to work. GND is the power supply ground. AREF is the reference voltage that the ADC uses to convert an analog signal to its corresponding digital value.

Analog voltages higher than the reference voltage will be assigned to a digital value of 1, while analog voltages below the reference voltage will be assigned the digital value of 0. Since the ADC for the Atmega328 is a 10-bit ADC, meaning it produces a 10-bit digital value, it converts an analog signal to its digital value, with the AREF value being a reference for which digital values are high or low. Thus, a portrait of an analog signal is shown by this digital value; thus, it is its digital correspondent value.

The Atmega328 is one of the microcontroller chips that are used with the popular Arduino Duemilanove boards. The Arduino Duemilanove board comes with either 1 of 2 microcontroller chips, the Atmega168 or the Atmega328. Of these 2, the Atmega328 is the upgraded, more advanced chip.

Unlike the Atmega168 which has 16K of flash program memory and 512 bytes of internal SRAM, the Atmega328 has 32K of flash program memory and 2K of Internal SRAM.

Atmega328

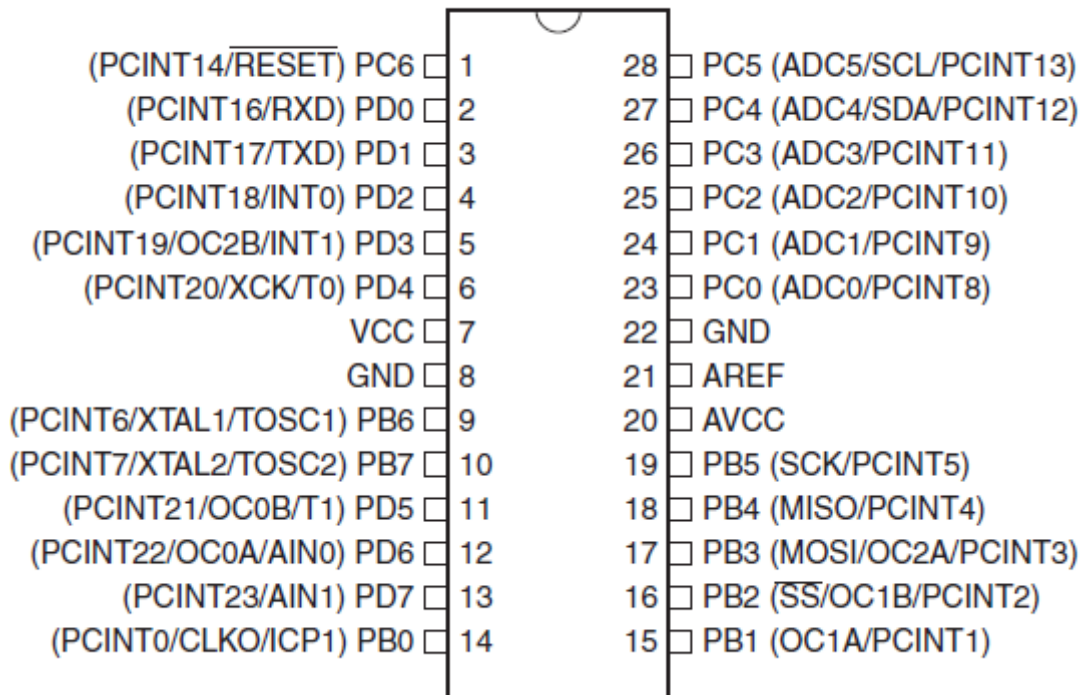


Fig no :4.9 Atmega328

Features

28-pin AVR Microcontroller

Flash Program Memory: 32 kbytes

EEPROM Data Memory: 1 kbytes

SRAM Data Memory: 2 kbytes

I/O Pins: 23

Timers: Two 8-bit / One 16-bit

A/D Converter: 10-bit Six Channel

PWM: Six Channels

RTC: Yes with Separate Oscillator

MSSP: SPI and I²C Master and Slave Support

USART: Yes

External Oscillator: up to 20MHz

An important aspect of the Arduino is its standard connectors, which let users connect the CPU board to a variety of interchangeable add-on modules termed shields. Arduino is used to communicate the input analog signals and given an output digital signals. Arduino is have a set of arrangements that should be in this system have an input from the Arduino UNO. That is ultrasonic sensor for the user of the application.

An Arduino board historically consists of an Atmel 8-, 16- or 32- bit AVR microcontroller with complementary components that facilitate programming and incorporation into other circuits. An important aspect of the Arduino is its standard connectors, which let users connect the CPU board to a variety of interchangeable add-on modules termed shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I2C serial bus, so many shields can be stacked and used in parallel.

Official Arduino's had used the Atmel megaAVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280 and ATmega2560. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards and other circuits.

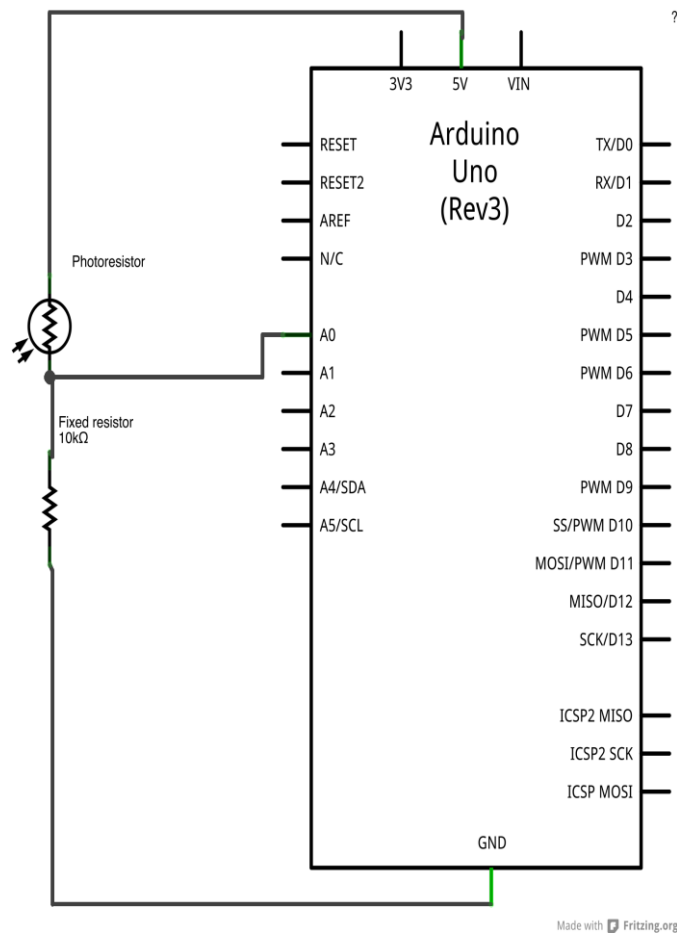


Fig no:4.10 Arduino uno

ATmega-328 is basically an Advanced Virtual RISC (AVR) micro-controller. It supports the data up to eight (8) bits. ATmega-328 has 32KB internal builtin memory. This micro-controller has a lot of other characteristics.

ATmega 328 has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. Moreover, ATmega-328 has 2KB Static Random Access Memory (SRAM). Other characteristics will be explained later. ATmega 328 has several different features which make it the most popular device in today's market. These features consist of advanced RISC architecture, good performance, low power consumption, real timer counter having separate oscillator, 6 PWM pins, programmable serial USART, programming lock for software security, throughput up to 20 MIPS etc. ATmega-328 is mostly used in Arduino.

ATmega328 is an eight (8) bit micro-controller. It can handle the data sized of up to eight (8) bits. It is an AVR based micro-controller. Its builtin internal memory is around 32KB. It operates ranging from 3.3V to 5V. It has an ability to store the data even when the electrical supply is removed from its biasing terminals. Its excellent features include the cost efficiency, low power dissipation, programming lock for security purposes, real timer counter with separate oscillator. ATmega-328 is an AVR micro-controller having twenty eight (28) pins in total. All of the pins in chronological order, are listed in the table shown in the figure given below

Table no:4.2 Atmega

ATmega328 Pins			
Pin Number	Pin Name	Pin Number	Pin Name
1	PC6	15	PB1
2	PD0	16	PB2
3	PD1	17	PB3
4	PD2	18	PB4
5	PD3	19	PB5
6	PD4	20	AVCC
7	V _{CC}	21	A _{REF}
8	GND	22	GND
9	PB6	23	PC0
10	PB7	24	PC1
11	PD5	25	PC2
12	PD6	26	PC3
13	PD7	27	PC4
14	PB0	28	PC5

VCC is a digital voltage supply.

AVCC is a supply voltage pin for analog to digital converter.

GND denotes Ground and it has a 0V.

Port A consists of the pins from PA0 to PA7. These pins serve as analog input to analog to digital converters. If analog to digital converter is not used, port A acts as an eight (8) bit bidirectional input/output port.

Port B consists of the pins from PB0 to PB7. This port is an 8 bit bidirectional port having an internal pull-up resistor.

Port C consists of the pins from PC0 to PC7. The output buffers of port C has symmetrical drive characteristics with source capability as well high sink.

Port D consists of the pins from PD0 to PD7. It is also an 8 bit input/output port having an internal pull-up resistor.

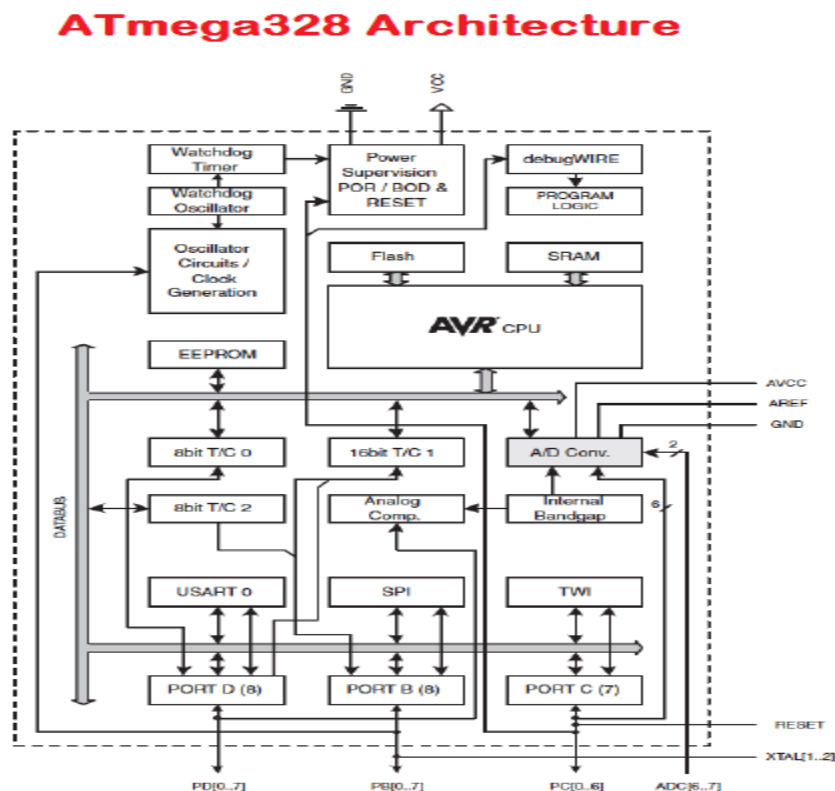


Fig no: 4.11 Atmega architecture

ATmega 328 has three types of memories e.g. EEPROM, SRAM etc.

The capacity of each memory is explained in detail below.

Flash Memory has 32KB capacity. It has an address of 15 bits. It is a Programmable Read Only Memory (ROM). It is non volatile memory.

SRAM stands for Static Random Access Memory. It is a volatile memory i.e. data will be removed after removing the power supply.

EEPROM stands for Electrically Erasable Programmable Read Only Memory. It has a long term data.

AVR Memory Spaces

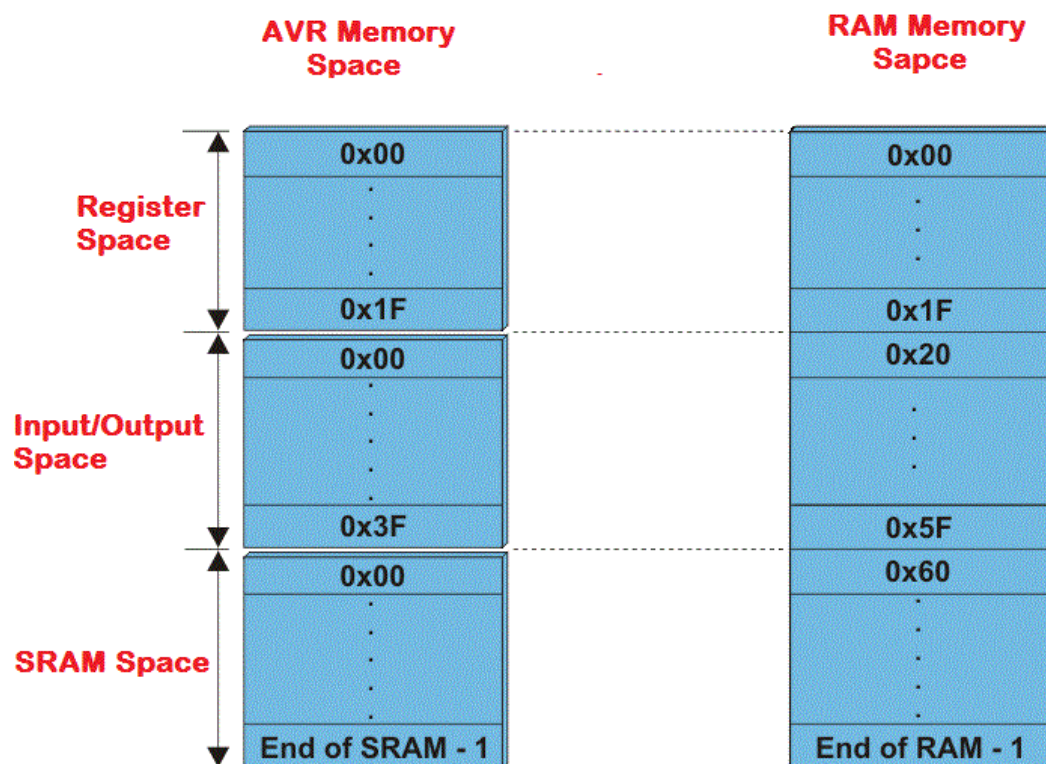


Fig no: 4.12 AVR memory space

ATmega-328 has thirty two (32) General Purpose (GP) registers.

These all of the registers are the part of Static Random Access Memory (SRAM). All the registers are given in the figure shown below.

AVR General Purpose Registers		
7	0	Addr.
R0		0x00
R1		0x01
R2		0x02
...		
R13		0x0D
R14		0x0E
R15		0x0F
R16		0x10
R17		0x11
...		
R26		0x1A
R27		0x1B
R28		0x1C
R29		0x1D
R30		0x1E
R31		0x1F

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Fig no :4.13 AVR general purpose register

The different versions of the same device are denoted by the different packages of that device.

Each package has different dimensions, in order to differentiate easily.

ATmega 328 packages are given in the table shown in the figure given below.

A complete package including ATmega 328 and Arduino can be used in several different real life applications.

It can be used in embedded systems projects.

It can also be used in robotics.

Quad-copter and even small aeroplanes can also be designed through it.

Power monitoring and management systems can also be prepared using this device.

ATmega328 Block Diagram

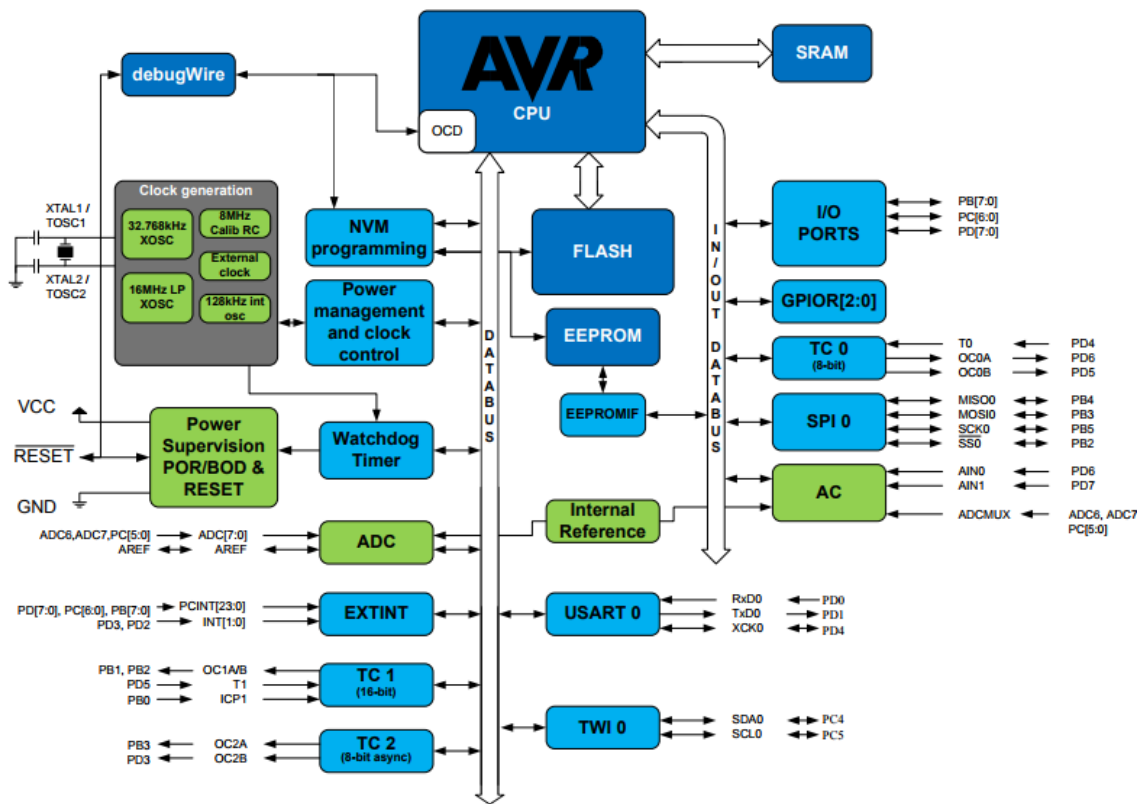


Fig no: 4.14 Atmega

4.7 Bluetooth

Bluetooth is a specification for a small form-factor, low cost radio solution providing links between mobile computers, mobile phones and other portable handheld devices, and connectivity to the Internet. It will enable users to connect a wide range of computing and telecommunications devices easily and simply, without the need to buy, carry, or connect cables. It is a wireless technology that operates on an unlicensed radio spectrum. There is no charge for communicating between two Bluetooth devices. Bluetooth is intended to get around the problems that come with both infrared and cable synchronizing systems. The hardware vendors, which include Siemens, Intel, Toshiba, Motorola and Ericsson, have developed a specification for a very small radio module to be built into computer, telephone and entertainment equipment. From the user's point of view, there are three important features to Bluetooth: 1. Its wireless. When you travel, you don't have to worry about keeping track of a briefcase full of cables to attach all of

your components, and you can design your office without wondering where all the wires will go. 2. It's inexpensive. 3. You don't have to think about it. Bluetooth doesn't require you to do anything special to make it work. The devices find one another and strike up a conversation without any user input at all. It is a wireless protocol that is used to communicate from one device to another in a small area usually less than 30 feet. Bluetooth communicates on a frequency of 2.45 gigahertz, which has been set aside by international agreement for the use of industrial, scientific and medical devices (ISM). Bluetooth's founding members include Ericsson, IBM, Intel, Nokia and Toshiba. Bluetooth was designed to allow low bandwidth wireless connections to become so simple to use that they seamlessly integrate into your daily life. A simple example of a Bluetooth application is updating the phone directory of your mobile phone. Today, you would have to either manually enter the names and phone numbers of all your contacts or use a cable or IR link between your phone and your PC and start an application to synchronize the contact information. With Bluetooth, this could all happen automatically and without any user involvement as soon as the phone comes within range of the PC! Of course, you can easily see this expanding to include your calendar, to do list, memos, email, etc. This is just one of many exciting applications for this new technology! Can you imagine walking into a store and having all the sale items automatically available on your cell phone or PDA? It is a definite possibility with Bluetooth

System Architecture Bluetooth communication occurs in the unlicensed ISM band at 2.4 GHz. This is an unlicensed band and, in most countries, includes the frequency range from 2400 to 2483.5 MHz. of course, as always when dealing with international standards, there are a few exceptions. The primary geographies with exceptions are France (2446.5 to 2483.5 MHz) and Spain (2445 to 2475 MHz). The transceiver utilizes frequency hopping to reduce interference and fading. A typical Bluetooth device has a range of about 10 meters. The communication channel can support both data (asynchronous) and voice (synchronous) communications with a total bandwidth of 1 Mb/sec. The supported channel configurations are as follows:

The synchronous voice channels are provided using circuit switching with a slot reservation at fixed intervals. A synchronous link is referred to as an SCO (synchronous connection-oriented) link. The asynchronous data channels are provided using packet switching utilizing a polling access scheme. An asynchronous link is referred to as an

ACL (asynchronous connection-less) link. A combined data-voice SCO packet is also defined. This can provide 64 kb/sec voice and 64 kb/sec data in each direction. Bluetooth devices can interact with one or more other Bluetooth devices in several different ways. The simplest scheme is when only two devices are involved. This is referred to as point-to-point. One of the devices acts as the master and the other as a slave. This ad-hoc network is referred to as a piconet. Specifications:

FCC Approved Class 1 Bluetooth® Radio Modem. Extremely small radio - 0.15x0.6x1.9". Very robust link both in integrity and transmission distance (100m) - no more buffer overruns! .Low power consumption : 25mA avg Hardy frequency hopping scheme - operates in harsh RF environments like WiFi, 802.11g, and Zigbee Encrypted connection. Frequency: 2.4~2.524 GHz Operating Voltage: 3.3V-6V Serial communications: 2400-115200bps Operating Temperature: -40 ~ +70C.

4.7.1 BLUETOOTH MODULE (HC-05):

Communication device:-over project is based on wireless communication between micro controller and mobile phone. But alone micro controller is not able to communicate directly to the android mobile phone. Bluetooth Serial module's operation doesn't need drive, and can communicate with the other Bluetooth device that has the serial. But communication between two Bluetooth modules requires at Least two conditions: (1) The communication must be between master and slave. (2) The password must be correct. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the Foot print as small as 12.7mmx27mm. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup.

Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband Bluetooth Wireless networks for short range communications have a wide spread usage of Bluetooth radio transmissions between 2400–2480 MHz Modern mobile devices

embed small, low-powered and cheap integrated chips functioning as short-range radio transceivers for Bluetooth radio communications.

Device pairing, authentication, encryption and authorization techniques have given recognition to Bluetooth technology due to its vital security mechanisms. Different types of Bluetooth applications can be developed using Android platform architecture using the Bluetooth profiles. The device manufacturers provide the services using the support of these profiles in their devices to maintain compatibility for the Bluetooth technology

Specifications Hardware features

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmits power.
- Low Power 1.8V Operation, 3.3 to 5 V I/O.
- PIO control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

Software features

- Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.
- PIO9 and PIO8 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto connects to the last device on power as default.
- Permit pairing device to connect as default.
- Auto pairing PINCODE:"1234" as default.
- Auto reconnect in 30 min when disconnected as a result of beyond the range of connection.

Pairing: After connect the Bluetooth module, scan for new devices from the Android phone and you will find the module with the device name "HC-05", after that, click to connect, if some message appears asking about "Pairing code" just put "1234" as default code.

BLUE LED = ACTIVE (Blinking 500ms period inactive connection, change 1seg with active connection) How to get to the standard communication mode 1. Leave free KEY, don't connect it to VDD neither GND. 2. Supply power to the module. Then the module will enter to communication mode. It can be used for pairing

The Bluetooth module HC-05 is used to receive & transmit data between Bluetooth device and MCU. It requires power supply from 3.3V to 5V. 2.2.6. SERIAL COMMUNICATION:- To transfer to a device located many meters away, the serial method is used. The data is sent one bit at a time. Here not 8bit data is send 2 extra bit are send along with it .this two bit are called start bit and stop bit. These two bit are used so synchronization can be done .

CHAPTER - 5

CONCLUSION

In order to keep the total costs low, low-level sensors were integrated due to which the accuracy of the data is compromised. The Building Health Monitoring module for designed with accelerometer and Vibration sensor configured with microcontroller Atmega 328p.

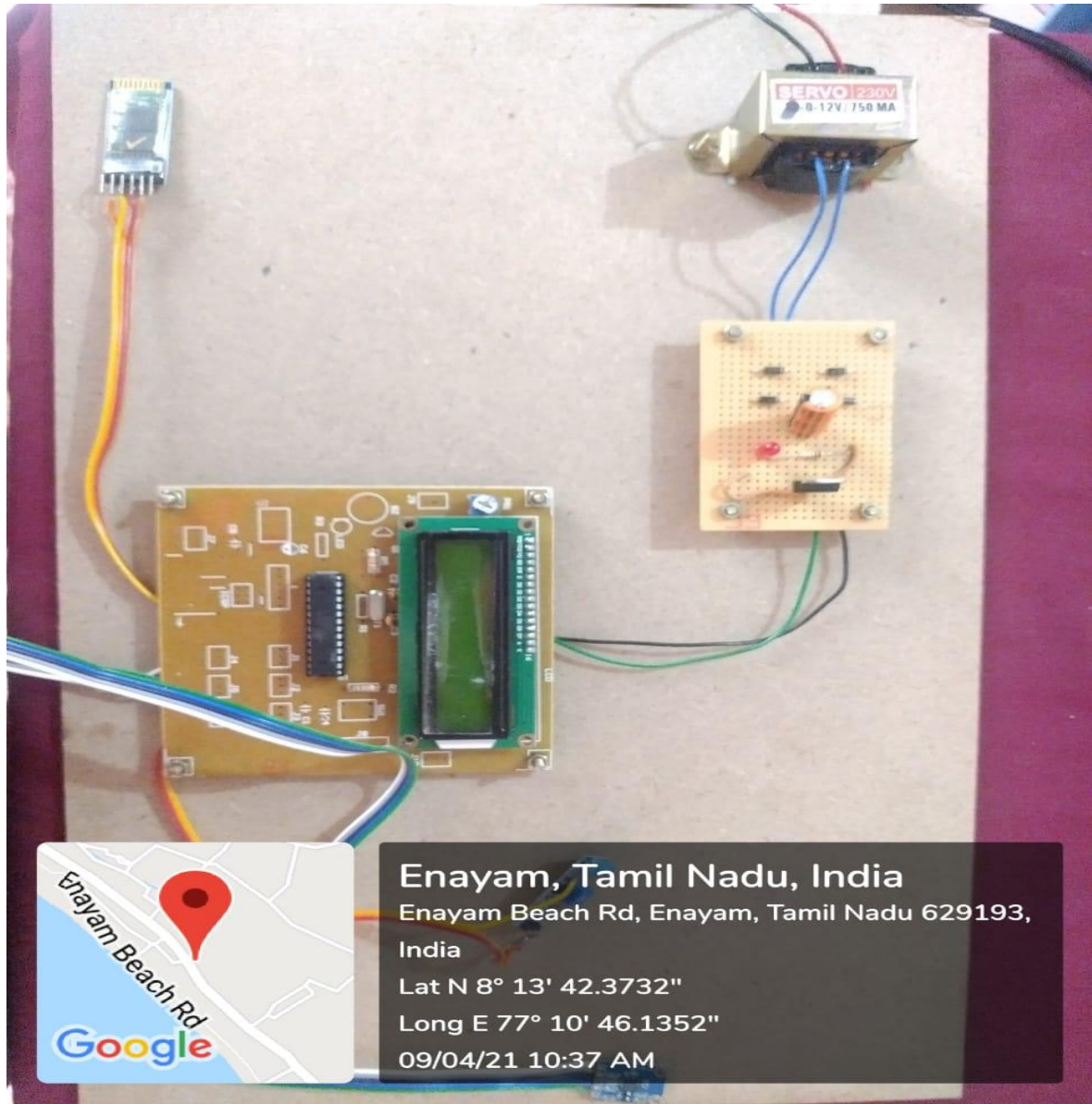
The equipment developed within this proposed manages to measure accelerations well enough and with a sampling rate high enough to even characterize phenomena that occur at high speeds (such as vibrations). The use of carcasses and connectors to preserve component integrity and the stability of connections is warranted, since even during the debugging of the operating programs some components have been subjected to situations in which they would have been decommissioned in the absence of protection.

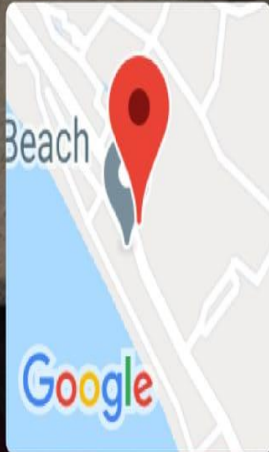
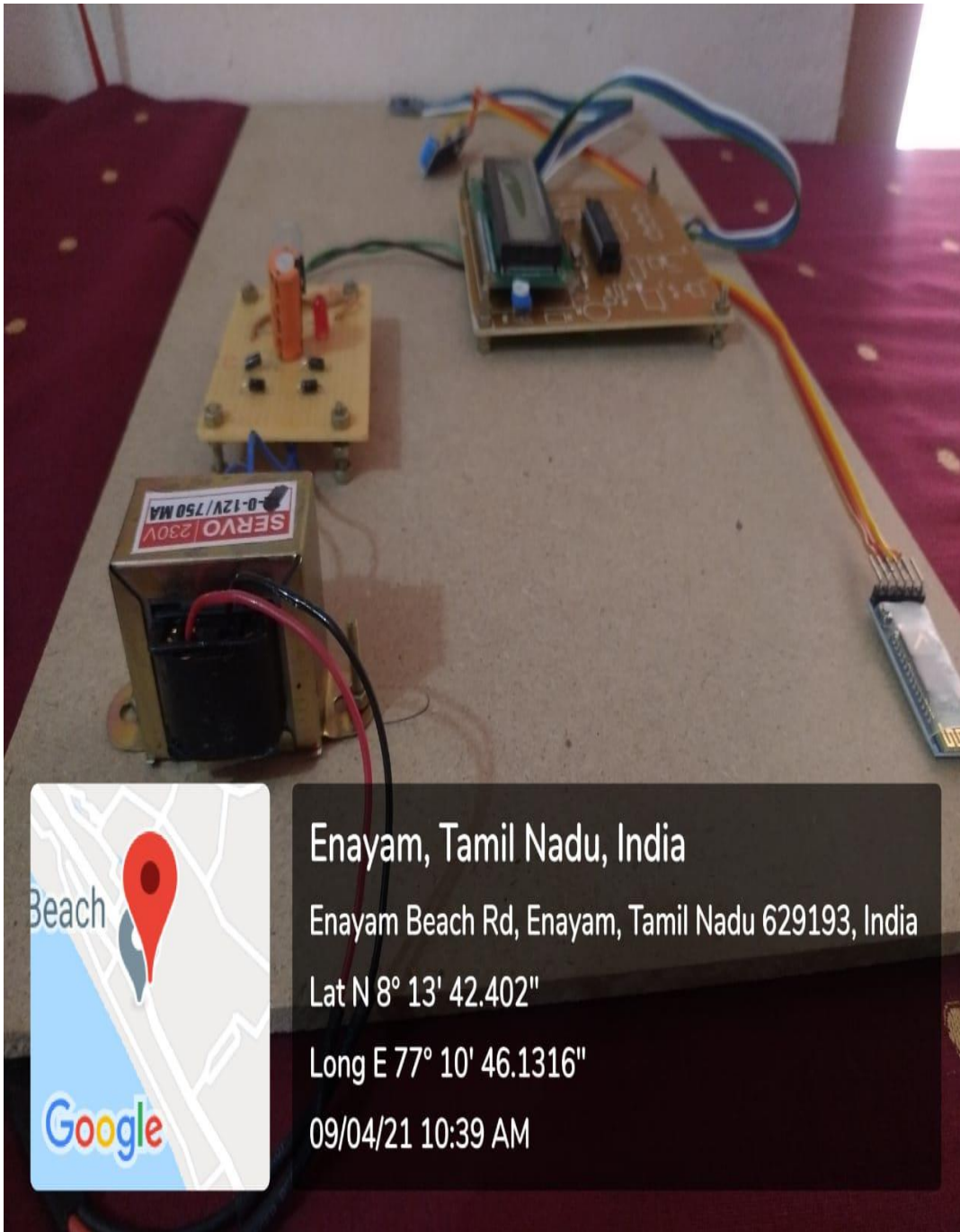
REFERENCES

1. A. Abdaoui, M. H. Ahmed, A. Badawy, T. Elfouly, A. B. Noel, S. Shehata, and M."Structural Health Monitoring Using Wireless Sensor Networks: A Comprehensive Survey," in IEEE Communications Surveys Tutorials, vol. 19, no. 3, pp. 1403-1423, third quarter 2017 ;
2. Aiello G., Catania P., Giada La Scalia,,Vallone M., Venticinque M., Real time assessment of hand–arm vibration system based on capacitive MEMS accelerometers, Computers and Electronics in Agriculture, vol. 85, 2012, pp 45-52;
3. Ms.Arohi. P. Chavande, Mr.Nitin. D. Sonawane, Mr.Shubham. Ms.Pooja. P. Vichare, S. Patil, and "Bridge Monitoring System Using IOT",Journal of Advances in Electrical Devices Volume 3, Issue 2, 2018 ;
4. Baritz, M.I., Balcu, I., Cotoros, D. and Evaluation of Comfort Degree for Pushing/Pulling Motions under the Influence of Controlled Induced Vibrations in the Fingers- Hand– Arm Assembly. Applied Mechanics and Materials, 658, pp.413-416, 2014.
5. Conway R., Godfrey A., Meagher D., Olaighin G., Direct measurement of human movement by accelerometry, Medical Engineering & Physics, 30(10):1364-86, 2008;
6. Cardador D., Fuks H., Milidiú R., Ugulino W., Vega K., Velloso E., Wearable Computing: Accelerometers' Data Classification of Body Postures and Movements. In: Barros L.N., Finger M., Pozo A.T., Giménez-Lugo G.A., Castilho M. (eds) Advances in Artificial Intelligence - SBIA 2012. Lecture Notes in Computer Science, vol 7589. Springer, Berlin, Heidelberg, 2012.

7. Druga C., Serban I., Experimental system for hip prosthesis vibration, Acta Technica Napocensis, vol. 60, nr.1, 2017;
8. Drugă, C. Repanovici, A., and Roșca, I.C., Micro-electro-mechanical systems-Laboratory Guide, Biomedical Engineering series, ed. Transylvania University of Brașov, ISBN 978-606-19-0562-1, 2015.
9. https://www.robofun.ro/accelerometru_adxl345. Accessed on 27.04.2017.
10. Jin-Lian Lee, Ming-Hui Wen¹, Yaw-YauanTyan, Yun- Wu Wu, "Development of an IoT-based Bridge Safety Monitoring System", IEEE, International Conference on Applied System Innovation, 2017.;
11. Y. R. Risodkar; A.S. Pawar,"A survey: Structural health monitoring of bridge using WSN"2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication, 2017 ;

Geotagged Photos





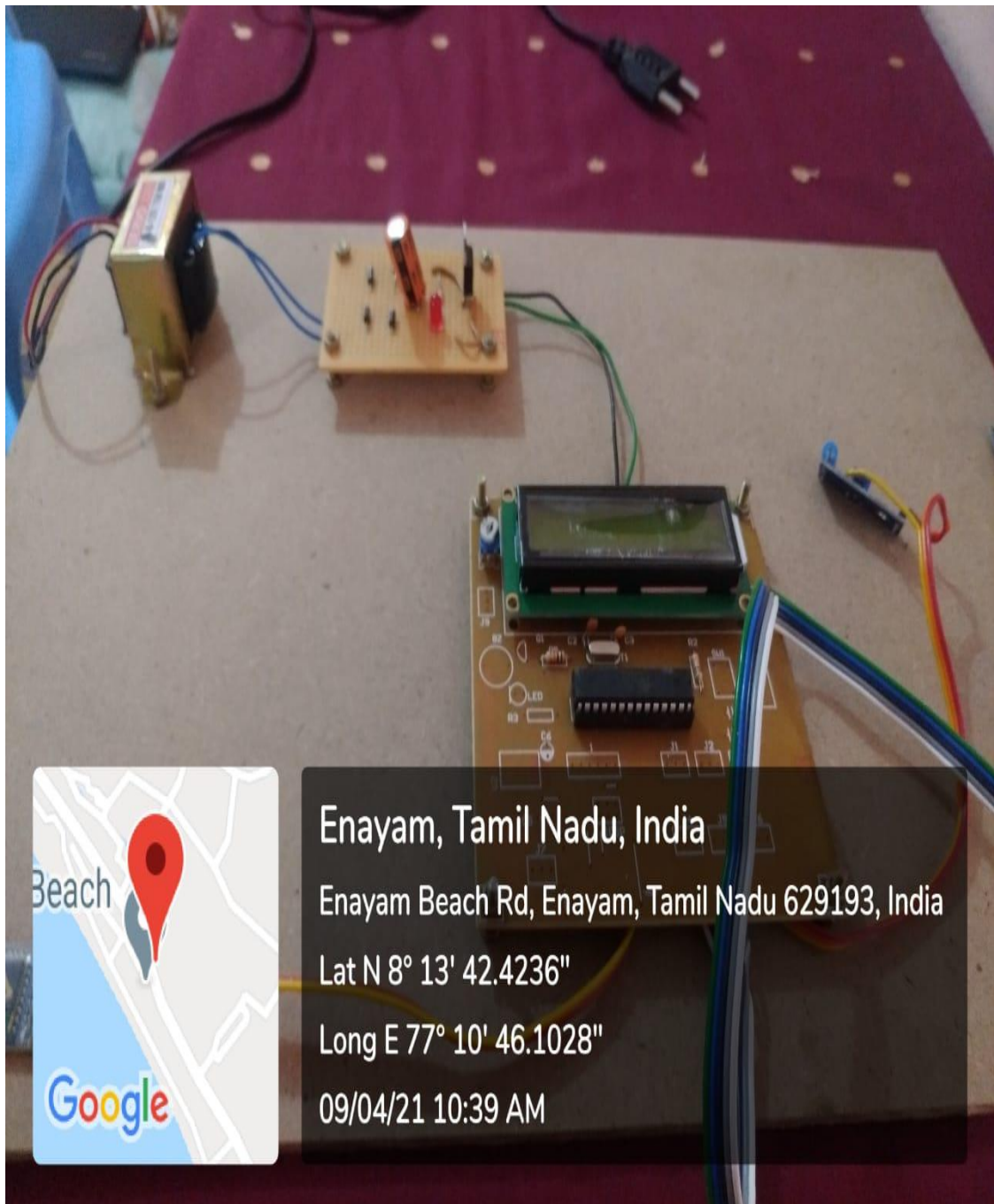
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