International Journal of Engineering Applied Sciences and Technology, 2020
Vol. 4, Issue 12, ISSN No. 2455-2143, Pages 683-690
Published Online April 2020 in IJEAST (http://www.ijeast.com)

A PORTABLE WEARABLE TELE ECG MONITORING SYSTEM

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Abstract: **This paper introduces a wearable Tele-ECG and heart rate (HR) monitoring system which has a novel architecture, ECG circuit. In addition, a Bluetooth low energy (BLE), a smartphone, a server, and a web page have been added to the system for remote monitoring. The TE can be attached to and removed from the singlet by a Velcro, which allows the user to dry-clean the TE easily for long-term use. A new ECG system has been designed to evaluate the TE-based ECG system and the average correlation between the recorded ECG signals is obtained as 99.23%. A filtered digital signal, with a high signal-to-noise ratio of 45.62 dB, is transmitted to the smartphone via BLE.ECG measuring is quite important to examine and monitor a patient with heart problems The ECG signal is plotted, the HR is calculated with 1.83% mean absolute percentage error, and displayed. The data are sent to the server, allowing the patient's physician to analyse the signals in real time through the web page or the smartphone. If HR reaches beyond the normal range or user presses the "HELP" button on the smartphone screen, the physician is informed automatically by a short message service (SMS) with a location pin on the map. The battery lasts approximately 14 days and when it needs replacement, the system automatically alerts the users by an SMS and a flashing LED. This fast and uninterrupted telemonitoring system has the potential to improve the patient's life quality by providing a psychological reassurance.**

I. INTRODUCTION

Patient care demands on hospitals are on the rise in parallel with the growth of the world population and the accompanying rise in chronic diseases. According to the mortality statistics recorded in 2015, 17.7 million people have lost their lives due to cardiovascular diseases in the world. This number corresponds to 31% of the total number of deaths. Instrumentation and measurement (I and M) are a keystone to diagnose each disease. ECG measuring is quite important to examine and monitor a patient with heart problems. In a conventional ECG measuring system, In a recent study, Mahmud et al. [6] have proposed to measure instant ECG with a smartphone accessory, Ag/AgCl electrodes are attached to the body, with conducive gel at the electrode–skin interface, for signal acquisition to derive certain ECG leads. The conductive gel may be toxic and cause skin irritation and the Ag/AgCl electrodes may cause allergic reactions of the skin. Despite their high conductance initially, after prolonged use, Ag/AgCl, lose their adherence resulting in signal loss and requiring replacement. Therefore, the use of Ag/AgCl electrodes for extended periods of patient monitoring is not appropriate. As alternatives, dry metal electrodes have been used and some studies have explored textile electrode (TE) that has a minimal effect on patient's normal lifestyle. The TE also has high contact conductivity that is essential for a reliable ECG acquisition. TE can be used to pick up ECG, EEG, and electromyogram (EMG) signals and they have been proven to be as reliable as Ag/AgCl electrodes. In normal conditions, the conductance of TE based ECG monitor is regarded as equivalent to Ag/AgCl. Humid conditions are advantageous rather than detrimental to TE-based monitor due to the electrolytic properties of sweat. The electrolyte includes molecules and ions. Therefore, it increases electrical conductivity. Nemati et al. [3] demonstrated a wireless ECG monitoring system which consisted of a belt stretched inside a T-shirt and equipped with three capacitive electrodes, Contactless ECG sensors provide the convenience of monitoring in nonhospital environments. Diverse ECG measurement systems have been reported including systems that can be fixed to chair bed or can be adapted to clothes. Nemati et al demonstrated a wireless ECG monitoring system which consisted of a belt stretched inside a T-shirt and equipped with three capacitive electrodes, where the ECG measuring is transmitted to a PC, requiring the user to own a PC. However, once this proposed system is preferred, the patients can use their existing cell phone for monitoring the vital signs collected ECG signals using two electric potential integrated circuit sensors fitted in a phone case and were able to transmit the signal with a microcontroller through Bluetooth low energy (BLE) and displayed the ECG signal on a cell phone. They also use smartphone memory to save ECG data, which is not appropriate for multiple usages due to limited data storage.

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II. LITERATURE SURVEY

1. TITLE: "A wireless wearable ECG sensor for long-term applications"

AUTHOR: E. Nemati, M. J. Deen, and T. Mondal

ECG measuring is quite important to examine and monitor a patient with heart problems. In a conventional ECG measuring system, Ag/AgCl electrodes are attached to the body, with conducive Manuscript received June 11, 2018; revised January 3, 2019; accepted January 5, 2019. This work was supported by the Republic of Turkey Ministry of Development, Istanbul Development Agency through the Innovative and Creative Istanbul Financial Support Program under Project TR10/16YNY/0136. Color versions of one or more of the figures in this paper are available online at Digital Object Identifier gel at the electrode–skin interface, for signal acquisition to derive certain ECG leads. The conductive gel may be toxic and cause skin irritation and the Ag/AgCl electrodes may cause allergic reactions of the skin. Despite their high conductance initially, after prolonged use, Ag/AgCl, lose their adherence resulting in signal loss and requiring replacement. Chamadiya et al. [8] performed ECG measurements with electrodes fitted on stretchers, wheelchairs, and patient beds Therefore, the use of Ag/AgCl electrodes for extended periods of patient monitoring is not appropriate. As alternatives, dry metal electrodes have been used and some studies have explored textile electrode (TE) that has a minimal effect on patient's normal lifestyle. The TE also has high contact conductivity that is essential for a reliable ECG acquisition. TE can be used to pick up ECG, EEG, and electromyogram (EMG) signals and they have been proven to be as reliable as Ag/AgCl electrodes. In normal conditions, the conductance of TEbased ECG monitor is regarded as equivalent to Ag/AgCl. Humid conditions are advantageous rather than detrimental to TE-based monitor due to the electrolytic properties of sweat. The electrolyte includes molecules and ions. Therefore, it increases electrical conductivity. Contactless ECG sensors provide the convenience of monitoring in nonhospital environments. Diverse ECG measurement systems have been reported including systems that can be fixed to chair, bed or can be adapted to clothes demonstrated a wireless ECG monitoring system which consisted of a belt stretched inside a T-shirt.

2. TITLE: "Unobtrusive Sensing of Psychophysical Parameters" AUTHORS: M. Ouwerkerk, F. Pasveer, and G. Langereis

One of the main goals of this project is to provide maximum convenience to the user or patient during ECG measurements, especially for prolonged use. Therefore, special consideration is taken regarding two interfaces: the patient-sensor and sensor-cardiologist interfaces. A convenient interface between the body and the sensor can be realized using a non-contact ECG sensing method. Alternatives for wet ECG that potentially provide comfortable patient-sensor interface are dry-electrode or capacitively-coupled ECG (CC-ECG) methods.

III. EXISTING SYSTEM

This system consists of Bluetooth module and it is used to transmit about the condition of patient's brief. It Can't able to transmit for a long range.

IV. PROPOSED SYSTEM

In proposed system we can send the data in IoT. Since the Bluetooth range is short, it can't be well utilized. This system has Bluetooth and IoT and it will inform about the brief condition. In addition it has pressure sensor which sense about tightness of the brief. Fast response, Easy to monitor patient's condition.,

Easy to use in Hospitals and in Homes. In order to overcome the drawbacks of existing system, our system ensures safety of the humans mainly the elderly people. Arteaga-Falconi et al. [28] utilized the benefits of smartphone and developed a mobile biometric authentication by using measured ECG signal, We proposed "A Portable Wearable Tele ECG Monitoring System". Our system includes temperature and humidity sensor to know the inside temperature and humidity conditions of the person, an ecg sensor and pressure sensor are present to monitor the blood pressure and the heart rate of the person and if it's below the values required then it is displayed in mobile will be given in the particular area.

V. HARDWARE DESCRIPTION

MICROCONTROLLER: PIC 16F877 is one of the most advanced microcontroller from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and so on. The PIC 16F877 features all the components which modern microcontrollers normally have. The figure of a PIC16F877 chip is shown below.

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Fig. 2.5: PIC Microcontroller

Features of PIC16F877

The PIC16FXX series has more advanced and developed features when compared to its previous series. The important features of PIC16F877 series is given below

General features

- High performance RISC CPU.
- ONLY 35 simple word instructions.
- All single cycle instructions except for program branches which are two cycles.
- Operating speed: clock input (200MHz), instruction cycle (200nS).
- Up to 368×8bit of RAM (data memory), 256×8 of EEPROM (data memory), 8k×14 of flash memory.
- Eight level deep hardware stack.
- Interrupt capability (up to 14 sources).
- Different types of addressing modes (direct, Indirect, relative addressing modes).
- Power on Reset (POR).
- Power-Up Timer (PWRT) and oscillator start-up timer.
- Low power- high speed CMOS flash/EEPROM.
- Fully static design.
- Wide operating voltage range (2.0 – 5.56) volts.
- High sink/source current (25mA).
- Commercial, industrial and extended temperature ranges.
- Low power consumption (<0.6mA typical @3v-4MHz, 20µA typical @3v-32MHz and <1 A typical standby).

Peripheral features

- Timer 0: 8 bit timer/counter with pre-scalar.
- Timer 1:16 bit timer/counter with pre-scalar.
- Timer 2: 8 bit timer/counter with 8 bit period registers with pre-scalar and post-scalar.
- Two Capture (16bit/12.5nS), Compare (16 bit/200nS), Pulse Width Modules (10bit).
- 10bit multi-channel A/D converter
- Synchronous Serial Port (SSP) with SPI (master code) and I2C (master/slave).
- Universal Synchronous Asynchronous Receiver Transmitter (USART) with 9 bit address detection.
- Parallel Slave Port (PSP) 8 bit wide with external RD, WR and CS controls (40/46pin).
- Brown Out circuitry for Brown-Out Reset (BOR).

Key features

- Maximum operating frequency is 20MHz.
- Flash program memory (14 bit words), 8KB.
- Data memory (bytes) is 368.
- EEPROM data memory (bytes) is 256.
- 5 input/output ports.
- 3 timers.
- 2 CCP modules.
- 2 serial communication ports (MSSP, USART).
- PSP parallel communication port
- 10bit A/D module (8 channels)

VI. LIQUID CRYSTAL DISPLAY

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.

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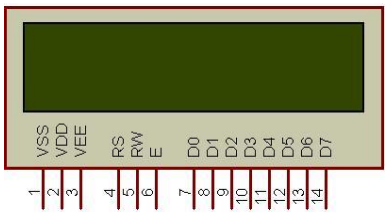

Fig: 16x2 LCD

VII. TEMPERATURE SENSOR

Temperature is the most-measured process variable in industrial automation. Most commonly, a temperature sensor is used to convert temperature value to an electrical value. Temperature Sensors are the key to read temperatures correctly and to control temperature in industrials applications. A large distinction can be made between temperature sensor types. Sensors differ a lot in properties such as contact-way, temperature range, calibrating method and sensing element. The temperature sensors contain a sensing element enclosed in housings of plastic or metal. With the help of conditioning circuits, the sensor will reflect the change of environmental temperature.

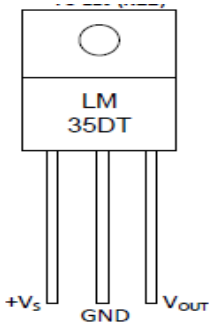

Fig: Temperature Sensor

VIII. HUMIDITY SENSOR

Humidity sensor is an instrument used for measuring the moisture content in the environment. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity. The measure of the amount of water vapor present in the air. Humidity is calculated as Relative humidity and Absolute humidity. For industrial and medical environments relative humidity becomes an important factor. A rise in the values of humidity, beyond threshold levels, can lead to malfunctioning of control systems, errors in weather prediction systems.

Fig: Humidity Sensor

IX. PRESSURE SENSOR

A pressure sensor is a device which senses pressure and converts it into an analog electric signal whose magnitude depends upon the pressure applied. Since they convert pressure into an electrical signal, they are also termed as pressure transducers. A pressure sensor is a device for pressure measurement of gasses or liquids. Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, waterlevel and altitude. The pressure sensor works on the principle of force applied will deflect the diaphragm inside the pressure transducer.

Fig. Pressure Sensor

X. BLUETOOTH

HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with controller or PC.

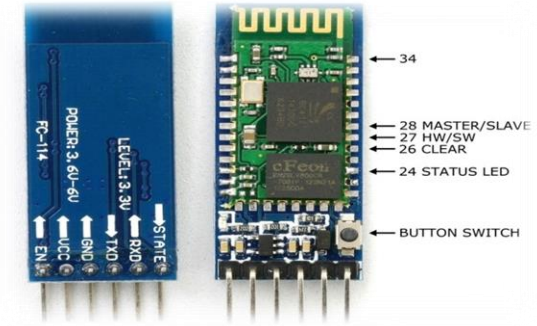

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Fig. 2.26: Bluetooth Module

HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neithereceiving nor transmitting data. GND: Ground: Connect to Ground TXD: UART_TXD, Bluetooth serial signal sending PIN: Connect with the MCU's (Microcontroller and etc.) RXD PIN: RXD UART_RXD, Bluetooth serial signal receiving PIN: Connect with the MCU's (Microcontroller and etc.) TXD PIN. KEY: Mode switch input: If it is input low level or connect to the air, the module is at paired or communication mode. If it's input high level, the module will enter to AT mode.

XI. ELECTRO CARDIOGRAM SENSOR

The heart functions as a pump for circulating blood to the body by repetition of contraction and enlargement. The cardiac electric potential is produced in the body during heart contraction. Electrocardiogram can be measured by leading these electrical signals to other body position and amplify.

Fig. ECG Sensor

Specifications

Range of ECG sensor
EKG - Range : 0~5㎷
Resolution : 5㎶
Pulse - Range : 47 ~ 250bpm
Resolution : 1bpm

Internet of things (IoT)

Internet of things (IoT), is another advance technology in IT sector, provides internetworking for numerous of devices such as sensors, actuators, PLCs and other electronic embedded smart devices and controls, and various software's' and provides systems network configuration and connectivity, which enables communication between these numerous devices for information exchanging.

Nowadays, IoT is one of the most advanced, efficient, and cost less technological solution which encompasses various hardware and software resources; and allows remotely connected sensing devices to sense with more capabilities, provides efficiency and can be monitored and controlled through deployed of existing systems or infrastructures, resulting the physical World integration with computer controllers (or systems). As IoT provides interconnectivity among various real-time sensing sensors and PLC and other intelligent devices, therefore this technology will be an entity indicated for the more advance cyber-systems encircling the significant developments, "such as smart grid, smart vehicle systems, smart medical systems, smart cities, and others smart systems."

Fig. Internet of Things

In early future, IoT has striven to provide advance or smart connectivity for variety of electronic and intelligent equipment's or devices, IT-based systems and the more advanced services through deploying of various traditional and real-time protocols, networks domains, and system software/hardware applications, which will be a work followed by machine-to-machine technological concept.

XII. SOFTWARE DESCRIPTION

MPLAB® X IDE is a software program that runs on a PC (Windows®, Mac OS®, Linux®) to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment (IDE), because it provides a single integrated "environment" to develop code for embedded microcontrollers. MPLAB® X Integrated Development Environment brings many changes to the PIC® microcontroller development tool chain. Unlike previous versions of MPLAB® which were developed completely in-house, MPLAB® X is based on the open source Ne tBeans IDE from Oracle. Taking this path has allowed us to add many frequently requested features very quickly and easily while also providing us with a much more extensible architecture to bring you even more new features in the future.

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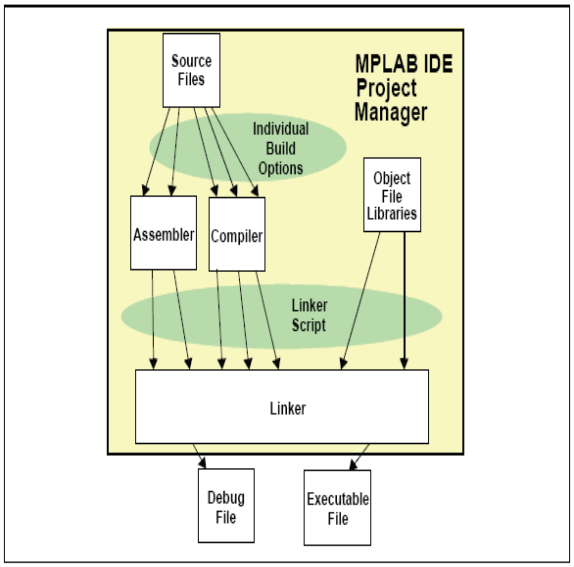

Fig. 3.2: MPLAB® X IDE Project Manager

Using MPLAB**:** This section details the installation and uninstall of MPLAB IDE. It is followed by a simple step-by-step tutorial that creates a project and explains the elementary debug capabilities of MPLAB IDE. Someone unfamiliar with MPLAB IDE will get a basic understanding of using the system to develop an application. No previous knowledge is assumed, and comprehensive technical details of MPLAB IDE and its components are omitted in order to present the basic framework for using MPLAB IDE.

These basic steps will be covered

- Features and installation
- Selecting the Device
- Creating the Project
- Setting Up Language Tools
- Naming the Project
- Adding Files to the Project
- Building the Project
- Creating Code
- Building the Project Again
- Testing Code with the Simulator

XIII. FLOWCHART

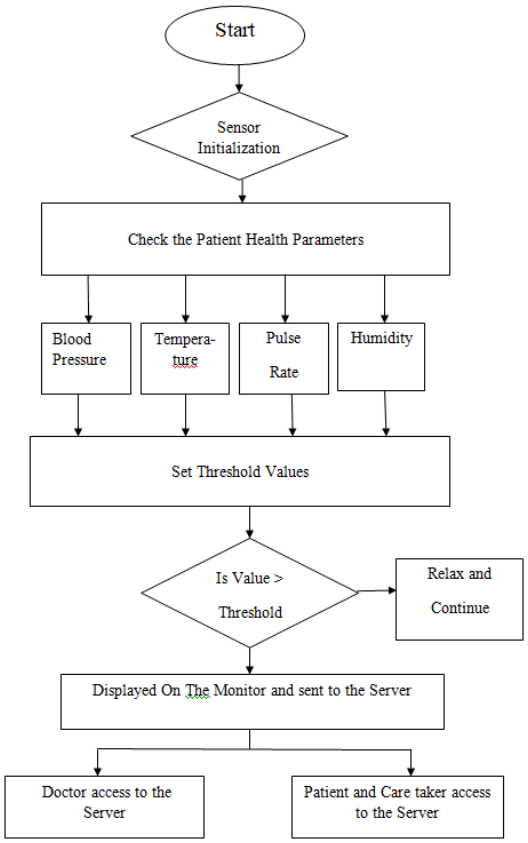

Fig. 4.10: Flow chart

XIV. CONCLUSION

In this paper, a wearable wireless Tele-ECG monitoring system is demonstrated. The system has a novel architecture which includes a singlet redesigned by attaching TE, textile thread, snap fasteners, Velcro, soft sponge, ECG front end, and MCU. The instruments on the singlet acquire the ECG signal and transmit it to a cell phone. The ECG signal along with the measured HR is depicted on the cell phone and then transmitted to a server, which allows the physician to observe the signals through the webpage and the smartphone. In addition, a holter-based ECG measuring system has been designed to compare TE-based system. Both systems have been evaluated with 30 volunteers in standing, walking, and going upstairs conditions. The highest SNR value of TE- and holter-based systems is 45.62 and 45.89 dB, respectively. The average correlation of ECG measurements of two systems in each condition is 99.23%. In addition, the HR is measured with both systems for each group and with fingertip pulse oximeter for all

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patients. The smallest MAE and MAPE are obtained as 1.1% and 1.83% between the TE-based system and the pulse oximeter. Spano et al. [36] and Wang et al. [38] have demonstrated the remote healthcare system by using dry electrode placing a belt and a medical vest with battery life approximately 7 and 2 days, respectively The wearable system merges the latest technologies such as TE, BLE, smartphone, server, and webpage to utilize and combine all the advantages into one telemonitor. The significant advantage and novelty of the proposed telemedicine technology is the combination of the best available technologies and the addition of few other features. No single reported device has all the features and benefits of the proposed device: comfort in daily life, easy to clean, high-quality ECG by TE, fast data transmission, long battery life with approximately 14 days, remote multiple-patient following by physicians, manual and automatic emergency requests, medical history, and geographical location tracking. The proposed system can potentially reduce congestion of hospitals and the cost of the medical examination since the patients can be monitored remotely for heart problems.

XV. FUTURESCOPE

In future the project can be upgraded in more ways such as Instead of body worn ECG electrodes one can use the capacitive electrodes which can be fitted in clothing instead of sticking to the body using gel. Ultra low power system can built with low power wireless protocol to save power and long battery life. Solar powered ECG electrodes can be used in future.

XVI. RESULT

As shown in fig LCD displaying the kit is connected to mobile using IOT.

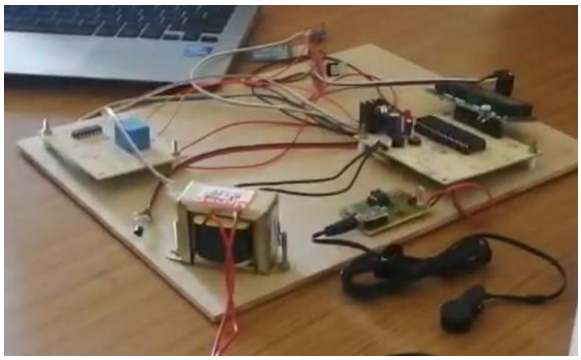

Fig: LCD Displaying The Temperature

As shown in figure if any abnormality in temperature is found then temperature sensor detects and it is displayed on LCD.

Thus we find out the health of the person and the heart rate through ECG acquisition sensor and pressure sensor through the Bluetooth and Internet of Things(Iot).

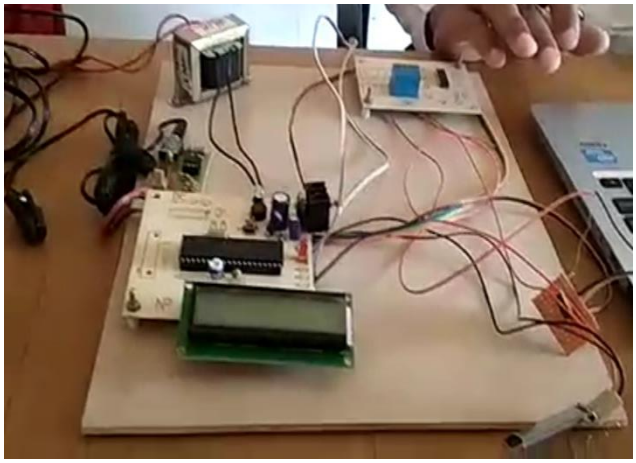

Fig: LCD Displaying The Humidity

As shown in figure if any changes occur in humidity then humidity sensor will detect and gives the information to mobile through IOT.

ACKNOWLEDGEMENT

The authors would like to thank Dr. B. Karagozoglu for his suggestions and comments, B. Gun for his official support, and Y. Arik and S. Kocakaplan for their SolidWorks program support and Aluminum test, training, and research center for 3-D printing.

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