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# Smart ECG Monitoring Wireless System

**Santosh Chede, Vyenktesh Girhepunje**

***Abstract*: Under advanced patient diagnostic approach, expensive wearable Holter Electrocardiography unit is used to record cardiac parameters for 24 or 48 hours. This may cause inconvenience to patient due to weight, dangling wires and taxing additional time to transfer data to the hospital from patient's location. IOT plays a crucial role to read and transfer ECG data from remote places effectively for individuals and more. In this paper low cost, low power, portable ECG monitoring system is designed and experimented. Hardware-software co-design realizes real-time, wireless, acquisition of cardiac parameters. AD8232 is used to capture cardiac signals and processing is realized using MSP432P401R microcontroller and IOT. Under the event driven approach, in case of specific abnormality, Electrocardiogram (ECG) signal is transmitted, otherwise no transmission is allowed in order to reduce power consumption.This approach increases battery life time and reduces complexity.***

***Keywords:Telemedicine, ECG transmission, ECG Instrumentation, MSP432P401R..***

## I. INTRODUCTION

Nowadays at global level health care monitoring issues had taken a great concern especially for aging population. Hence it is necessary to design portable, cheaper and smart device for health care of age related disease sufferers. Advanced technology based sensor, communication systemsand effective information technologies have enabled development of latest monitoringsystems to monitor and measure various crucial health parameters like body temperature electrocardiogram (ECG), heart rate, oxygen saturation, and blood pressure etc. Cardiovascular disease is a disease involving the heart and its vasculature, including heart rhythm abnormalities, coronary disease and myocardial infarctions and heart failure. Recently, patient with cardiovascular disease is reaching to younger stage. The range with high risk is between 40 to 60 years old. It is important to get the disease checked and detected at early stage as some of the heart diseases are asymptomatic. Electrocardiography (ECG) is a representation of the heart rhythms of a person in a graphical form. By reviewing the ECG of a patient, cardiologist is able to diagnose with a person having heart disease. When a patient is suspected of heart disease, the patient needs to record the ECG data for a minimum of 24 hours.Holter ECG is a portable ECG recorder that is used to record the patient's ECG during their daily activity.

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After record, patients have to visit clinic again to update their data which will be analyzed by cardiologist. Though,Holter is portable as compared to conventional ECG machine, it has still limitations in terms of convenience and user-friendliness. Therefore, this study needs to be done in order to reduce the burden of patient and to increase the possibility of public in getting their heart checked.

## II. LITERATURE REVIEW

Major cause of mortality today is cardiac failure and malfunctioning of heart. Various heart diseases are diagnosed by Electrocardiogram (ECG).Crucial conditions such as cardiac failure prediction, cardiovascular disease identification etc. is usually carried out by regular monitoring of heart and ECG signal analysis.In this work, cheaper wireless ECG data acquisition system for disease prediction and clinical analysis is designed and developed. System is developed usingArduino Uno microcontroller and Bluetooth serialcommunication to transmit ECG signal to the laptop or monitoring display. Bluetooth dongle is used in this system to interface in desktop computer. To store real time ECG data and to visualize results a system is developed. In order to diagnose cardiac diseases this application is developed. This application stores the ECG signal in text file, which can be used in MATLAB for analysis. This system can be used in Mac OS or Linux, Windows. To acquire ECG data continuously upto 22 hours battery powered portable system is developed[3]. Nowadays smart care of health is an important application enabled by Internet of Things (IoT). For verification and collection of appropriate data related with physical and mental health, to implantnetworked sensors on body in regular environment is an excellent approach. Monitoring and recording of data regularly and processing of data appropriately can develop effective health care strategy. Datacaptured at unpredicted scales and latest intelligent processing algorithms used (a) to develop innovative techniques forclinical analysiswith respect to prevention, cure, and overall management of health and (b) overall cost of health care with improved results is reduced. IOT is used to cope with the opportunities and challenges with respect to health care health care[4]. Hardware-software co-design approach is beneficial for design of remote acquisition system to capture patient's physiologic information in real time creating home environment. To detect changes in physiologic status with respect to heart rate variability (HRV)electrocardiogram (ECG),and acoustic information appropriately without any obstacle, advanced transducers can be implanted into patients clothing**.** 1 KHz is the sampling rateper channel for this system. Hardware-software co-design based system embedded in patients clothing performs signal conditioning and information captured is transmitted wirelessly to a central server located elsewhere in the home.

Dynamic frequency ranges of Heart Sound (HS) and ECG are 35-1350Hz and 0.05-160 Hz.Respectively.100+10 feet with direct line of sight to home server stationis the range of operation for the existing patientwearable physiologic data capture module.Home medical server with digital display is used to measure weight directly. Physiologic information such as, HRV, ECG, weight and HS are dynamically analyzed using a combination of various software like MATLAB, LABVIEW and other strategies.Abnormal and alarming patient conditions, critical information and weight as defined by health care provider will be monitored and predicted by software based algorithms. To monitor heart and for failure management, remotely captured data wirelessly can be utilized smartly by Health care professionals [5].

The main cause of mortality due to cardiac stroke at global level is cardiovascular disease (CVD) and will continue further.For sudden cardiac death common type of CVD i.e. cardiac arrhythmia is prominentlyresponsible.To diagnose a cardiac patient and to access risk of arrhythmia most widely authentic clinical tool is Electrocardiogram (ECG). ECG is used to monitor electrical activity of heart from the body surface. Arrhythmias may not be detected primarily during patients' hospital by standard Electrocardiograph as condition may be normal at the time of visit. In this situation Holter-based portable monitoring system can provide 24–48 hours ECG recording. This systemcannot provide real time feedback even after recording of thousands of heart beats and correct solution is possible after analyzing data tediously offline. The combination of various approaches like portability of Holter monitors and real-time processing capability of Eletrocardiographis used to provide appropriate diagnosis solution using smart phones. It is possible to have two Smartphonebased wearable CVD-detection platforms for real-time ECG acquisition and display, feature extraction, and beat classification [2].

Wireless telemetry system used in ambulance for monitoring of heart signals is very crucial diagnostic method for analysis and detection of cardiac arrhythmia. Main hurdles are overcoming motion artifacts, to deal with low power consumptionand to develop cheaper, low maintenance data acquisition instrumentation set up. In order to rectify motion artifacts with the help of digital signal processing techniques, to capture excellent quality ECG signal data a wireless Electrocardiograph monitoring is presented. A data acquisition system consisting three ECG lead and ultra-low power integrated is used to capturecardiac signals and measures electrode-tissue impedance for one lead. System also consists of imec's Cool Bio Digital Signal Processor, to perform Independent Component Analysis and Adaptive Filtering using electrode-tissue impedance. Both methodologies are used for motion artifact reduction and to reduce power consumption of system of approximately 7.6mW. Combination of low power DSP and wearable ECG module is an innovative approach to reduce power consumption of system as well as to reduce motion artifacts[6].

Fig.1 shows proposed Wireless ECG monitoring scheme consisting of various components. In a three lead ECG system, electrodesas shown in Fig.2 are placed on the patient's left arm, right arm and right leg.Overall magnitude of heart's electrical potential is measured and recorded for the period of 10 seconds by the three lead system. Magnitude and direction of heart's electrical depolarization activity iscaptured at each instant throughout the cardiac cycle. The non-invasive medical method to provide graph of voltage versus time is known as an Electrocardiogram.

## III. PROPOSED METHODOLOGY

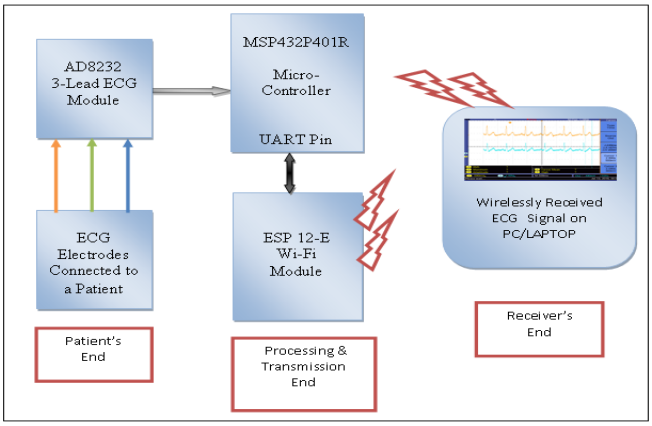


**Fig.1.Proposed ECG monitoring scheme.**

**Fig.2.ECG Electrodes**

## IV. AD8232 ECG MODULE

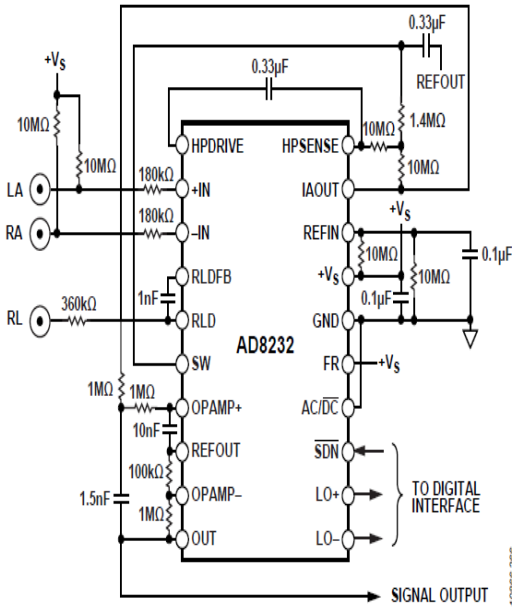


**Fig.3.Functional diagram of AD8232 ECG module.**

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Fig.3 shows AD8232, an integrated signal conditioning unit with 3-leads andbio-potential signals required for heart rate monitoring are captured. It consists of an operational amplifier, a RL drive amplifier,specialized instrumentation amplifier and a reference buffer. The lead status detection facility w.r.t. leads connection andto restore the ECG signal shortly after leads are reconnected is provided by ECG module. Shut down pin is especially available on module in order to develop power efficient telemedicine system. If it is not required to use system, this pin will make it off which increases battery lifetime.

## V. MSP 432P401R MICROCONTROLLER (MCU)

Fig.4 shows MSP432MCU module consisting high performance ARM Cortex-M4F core, with DSP extensions and an integrated floating-point engine. It is most power-efficient processor available today. MCU is especially designed for power and high performance optimization.MSP MCU product line now provides ultra-low power 16-bit flash and FRAM-based MCUs to high performance, low power 32-bit ARM Cortex-M4F units. The 48MHz core supports the full ARM instruction set.MSP432 MCUs consume 850nA in standby mode and 95 µA/ MHz in active mode.


**Fig.4.MSP 432P401 target board**

## VI. ESP12E WI-FI-MODULE

Fig.5 showsESP12 E, low cost Wi-Fi module with Wi-Fi functionality via a UART serial connection. Range of this Wi-Fi module is 32 meter long. Modulecan bereprogrammed as a standalone Wi-Fi connected device [5].

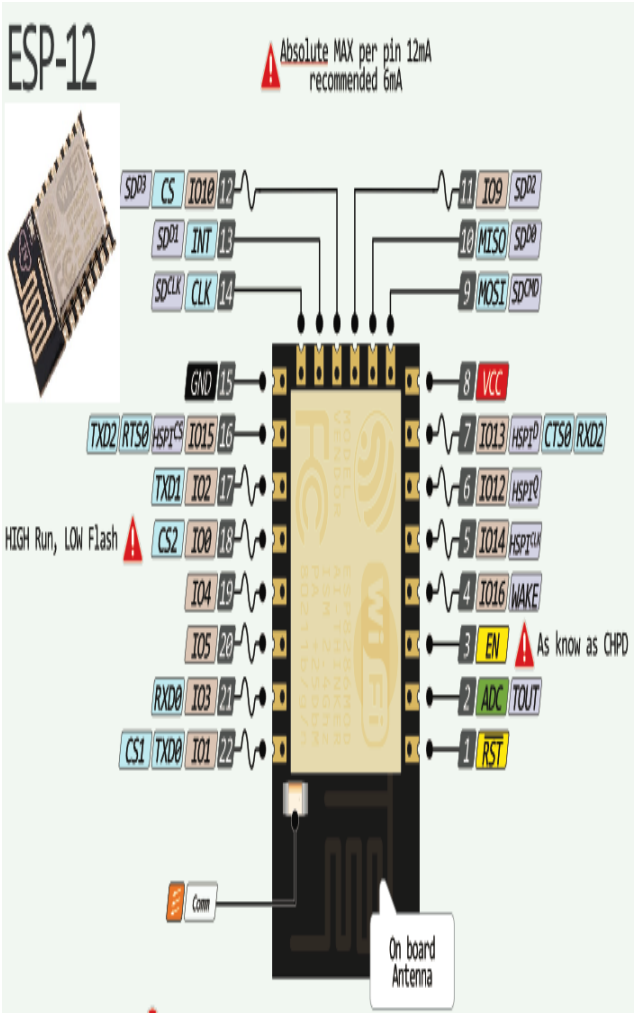


**Fig.5. ESP12E wi-fi module**

## VII. METHODOLOGY FLOW

Proposed system consist of electrodes, AD8232 ECG module, microcontroller MSP432P401R, ESP12E Wi-Fi module and receiver consist of laptop or personal computer. Three electrodes connected to left arm,right arm and left leg. Electrodes are used to capture ECG signal from human body and given to the AD8232 ECG module. AD8232 ECG module is basically used to measure electrical activity of heart. AD8232 amplify the ECG signal coming from the human body with the help of electrodes and give amplified analog signal. Output of AD8232 is given to the MSP432P401R microcontroller. Output of AD8232 is converted into digital signal with help of inbuilt analog to digital converter available in Microcontroller. Then with the help of programming some range of signal into the microcontroller is stored and with the help of comparator which is inbuilt in microcontroller compared the incoming signal with the predefined signal. If the incoming signal range is out of the predefined signal range then incoming signal passes towards the receiver.Otherwise signal will not be transmitted towards the receiver. Signal from the transmitter to receiver is transmitted with help of ESP12E Wi-Fi module and range of this Wi-Fi module is 32meter. Received signal is displayed on the cardiologist PC with the help of lab view software.

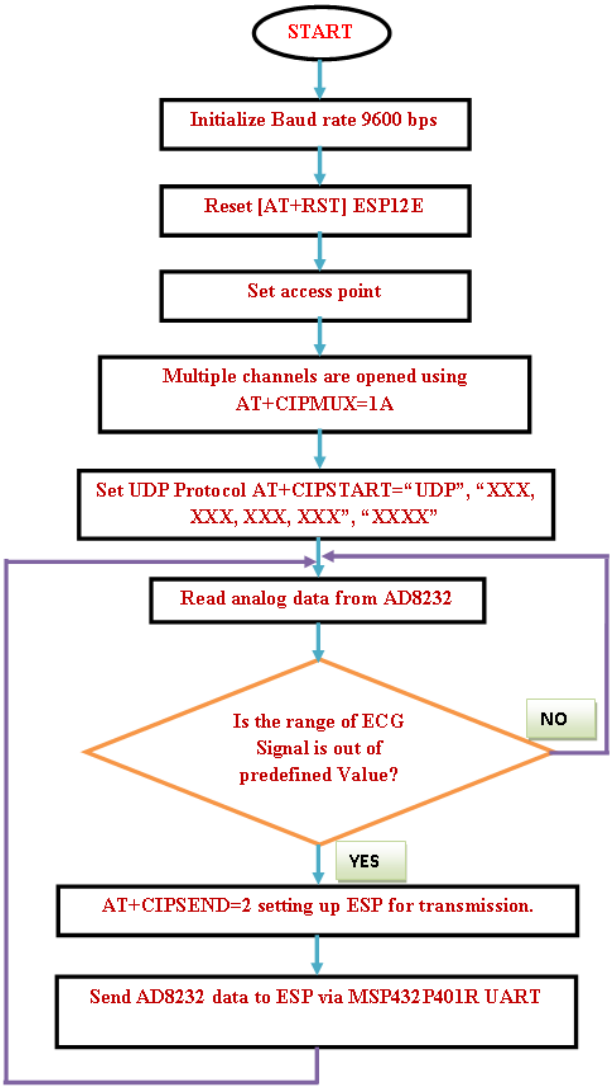


**Fig.6.Transmission Process flow**

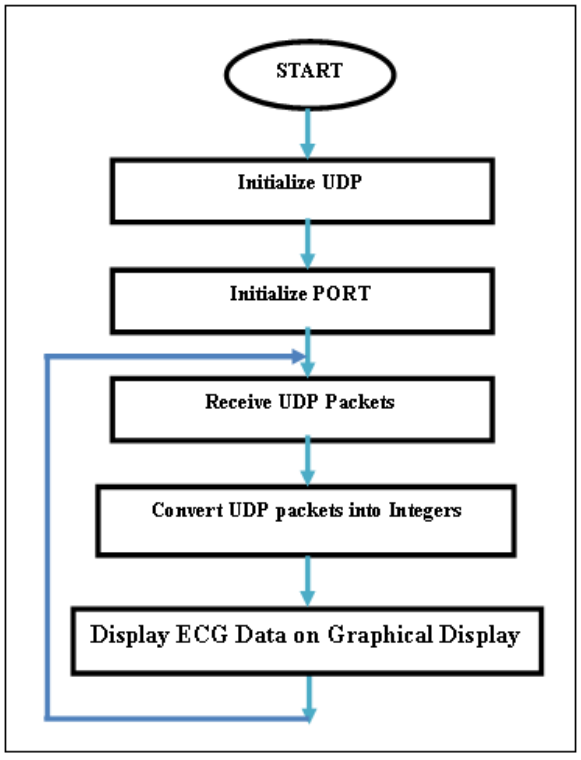


**Fig.7.Reception Process flow**

## VIII. RESULT

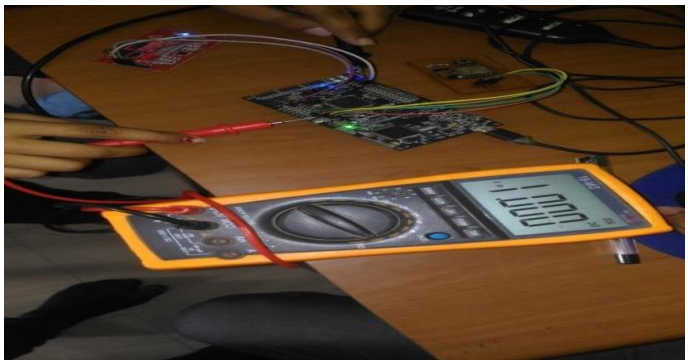

**Fig.8. Detection of normal ECG**

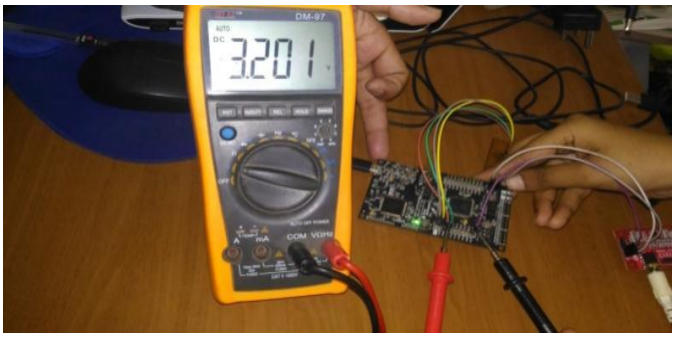

**Fig.9. Detection of abnormal ECG**

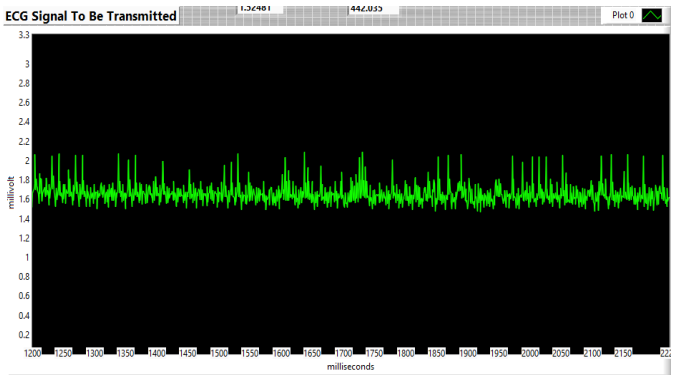


**Fig.10.Transmittedabnormal ECG signal**

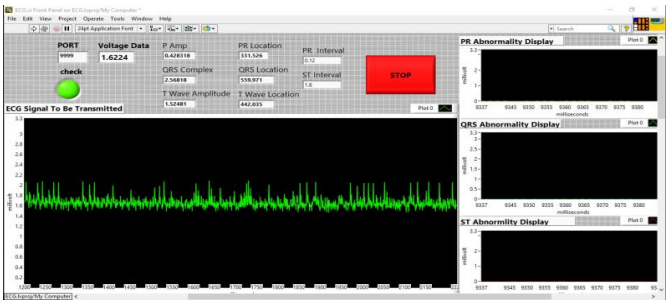


**Fig.11. Received abnormalECG signal**

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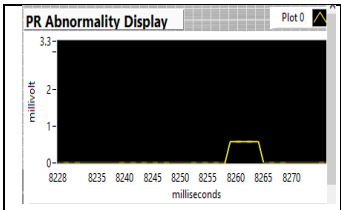
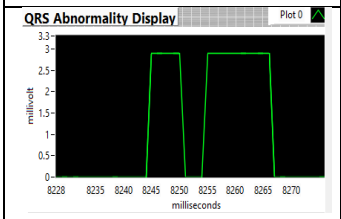
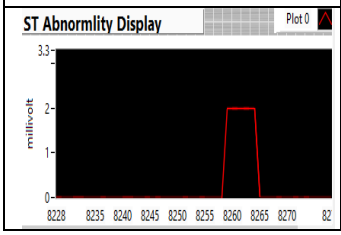
|   | 0.12 to 0.20 sec. is normal PR interval but if patient ECG is abnormal then the pulse is shown in corresponding window. |
|   | Normal QRS interval is 0.09 sec. but if patient ECG is abnormal then the pulse is shown in corresponding window. |
|   | Normal ST interval is 0.05 to 0.15 sec. but if patient ECG is abnormal then the pulse is shown in corresponding window. |

**Fig.12.PR, QRS, ST,Interval status for abnormal ECG**

Fig.8shows that when ECG is in predefined range then no transmission will takes place and displays 0.1V. Fig.9shows that when ECG is out of predefined range the signal is transmitted and displays 3.201 V at port P3.3.When ECG of patient is in normal condition as shown n i.e. the PR interval, QRS complex and ST interval are in the predefined range the ECG signal will not be transmitted. PR, QRS, ST abnormality displays, when these three intervals are out of predefined range the abnormal ECG and signal is transmitted via Wi-Fi module as shown in Fig.10 and Fig.11.Corresponding pulses with respect to abnormalities are shown in Fig.12.The predefined range of PR interval, QRS complex and ST interval is given in table I.

**Table- I: ECG interval details**

| *ECG Discrete Wave* | *Standard Amplitude* | *ECG Discrete Interval* | *Standard Duration* |
|---|---|---|---|
| P | 0.25 mV | P-R | 0.12 - 0.20 sec. |
| R | 1.60 mV | Q-R-S | 0.09 sec. |
| Q | 25% of R | S-T | 0.05 – 0.15 sec. |

## IX. CONCLUSION

A wireless ECG monitoring module is designed and tested with respect to power consumption. ECG is captured and measured and wirelessly transmits respective clinical data to Personal Computer (PC)via Wi-Fi module. PC is used as a primary receiving unit to display ECG records and information is storedasa database. It is observed that ECG monitoring module records abnormal ECGs and monitors related abnormalities useful for crucial cardiac clinical diagnosis.Three lead module designed is wireless, low cost, portable, power efficient and effective for in house use. Wi-Fi allows greater range and penetration through objects. Being an event driven approach, battery lifetime of a system will increase.

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## AUTHORS PROFILE

**Dr. Santosh D. Chede,**received Bachelor of Engineeringin Industrial Electronics and Master of Engineering in Electronics from SGB Amravati University in 1990 and 2000 resp. From IGNOU he has received MBA, PGDIM, PGDHRM, DIM. From Visvesvaraya National Institute of Technology (VNIT) Nagpur, he has been awarded PhD in 2010 under the guidance of Dr.K.D.Kulat. His topic of research was "Low power design aspects of Embedded System: A case study of Implantable pacemaker". He has served at various academic and administrative levels from Lecturer, Assistant Professor, Professor, H.O.D and Principal. He has teaching experience more than 27 years and taught many subjects from UG and PG .He also guided many UG and PG projects. He is recognized PhD supervisor in RTMNU Nagpur and SGB University Amravati.He has total 60 publications in Journals and Conferences and visited Hongkong for paper presentation.He was a chairman, Board of Studies (Electrical Engg.) at RTMNU, Nagpur. Currently he is working as a Professor and Head of Departmentof Electronics and TelecommunicationEngineering at VPKBIET, Baramati. He is a Life member ofISTE.

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