ECG analysis for detecting cardiovascular disease using LabVIEW

Mrs. Arti R.Wadhekar[1], Dr. Vandana B. Malode[2]

[1] Department of Electronics & Telecommunication Engineering, Deogiri Institute of Engineering and Management Studies, Aurangabad.

[2]Associate Professor, Department of Electronics, Jawaharlal Nehru Engineering College, Aurangabad.

Abstract: Cardiovascular diseases are the largest cause of death in world accounting for more than a third of all deaths. A research estimated that nearly 27% of total deaths in India happen with no medical attention at the time of death. Due to the high cost and inaccessibility of medical care in rural and hilly areas a large percentage of deaths happened without medical care. In this paper we propose a wearable heart disease monitoring system that can be cheaply made available to people. In the proposed system heart behavior of patient is monitored continuously and extracts the ECG feature making it easier to interpret the abnormality using LabVIEW Biomedical Toolkit 2013. Using feature extraction parameters such as P wave, T wave, PR interval, QT interval, QRS complex, ST segment are obtained to evaluate the different types of cardiac disorders.

Keywords: Cardiovascular disease, ECG, Feature extraction, Biomedical toolkit, cardiac disorders.

I. INTRODUCTION

In the biomedical field signal monitoring is one of the important tool to understand the physiological condition of the patient. ECG signal is very important and contains valuable information of patient [8]. Cardiovascular disease is the disease related to heart. Acute Myocardial Infarction (AMI) or commonly known as heart attack is one of the cardiovascular diseases. Because of the changing lifestyle the AMI rate is increasing day by day. AMI is a leading cause of death for both man and woman throughout the world. A heart attack happens if the flow of oxygen rich blood to a section of heart muscle suddenly becomes blocked and the heart cannot get oxygen. Early treatment for a heart attack can prevent or limit damage to a heart muscle otherwise it might further leads to arrhythmia. Acting fast at the first symptoms of heart attack, can save patient life.

So, there is a necessity of new inventions in the field of healthcare which can give the early warning about diseases observance of prevention in the area of health has a significant impact on economic productivity and most important on quality of life of the common people. For this purpose number of healthcare systems were developed which test the health conditions. The present medical devices are uneasy to wear during continuous monitoring period. Such systems are heavy and there are number of hampering wires from sensor to data acquirement system. Nowadays due to technical advances in the field of microelectronics, nanotechnology, miniature sensors are developed. These require low power during monitoring. The problems with conventional system are avoided using such type of sensors. Telemedicine and remote monitoring are areas which need new innovative ideas and modern unconventional methods of realization. The purpose of this research work is to develop a device that would replace the existing electrocardiograms and facilitate doctors to record both electrocardiographs and generate an alert to detect arrhythmia and heart attack simultaneously.

II. Electrocardiography (ECG) processing

Electrocardiography is the most commonly used diagnostic tool in cardiology, it will used for monitoring and recording the electric currents generated due to the alternating contraction of atria and ventricles of the heart [8]. ECG (electrocardiogram) is nothing but the device which is used to monitor and record these signals. Electrodes are applied to the skin in places where the heart's signal can be measured easily.

To diagnosis various heart conditions Electrocardiography is used. The ECG sensor is a signal conditioning block for measurement of ECG signal. ECG sensor module outputs analog ECG signals when connected to chest using ECG electrodes. It is specially design to remove, amplify and filter small bio-signal in the existence of noise and other motion artifacts. The design of sensor is such that it may be used by other microcontroller to capture the output signal easily. Following table 1 shows the normal ECG parameters. Figure 1 shows the processing steps of ECG signals. There are two main ECG stages i.e. preprocessing of signal (it contains Removing Baseline wandering and Removal of wideband noise) and feature extraction.

Table 1 Normal ECG Parameters [17, 18]

Phase	Duration	Amplitude
P wave	0.06-0.11sec	<0.25
PR interval	0.12-0.20sec	
PR Segment	0.08sec	
QRS complex	<0.12sec	0.8-1.2
ST segment	0.12sec	
QT interval	0.36-0.44sec	

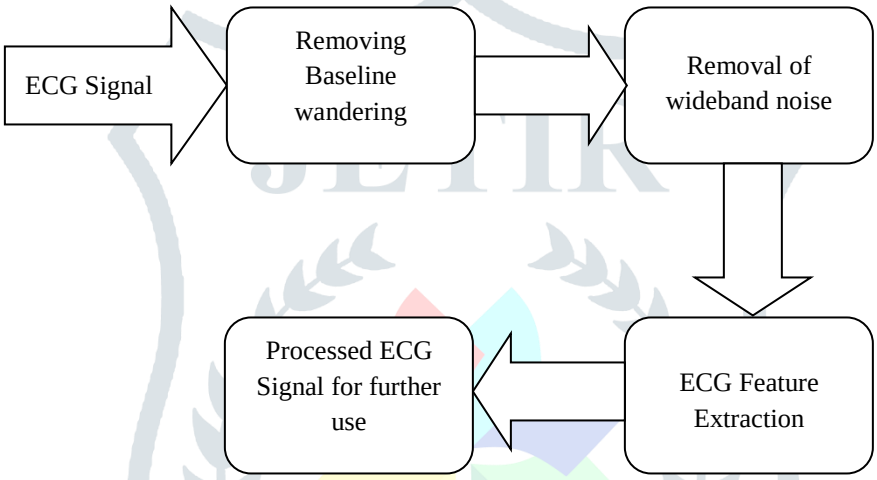

Figure 1 Processing steps of ECG signals.

a. Removing Baseline wandering

Baseline wandering usually comes from respiration at frequencies 0.15 to 0.3 Hz and different methods are used to remove baseline wandering like Butterworth high-pass filter, moving median and subtraction, spline approximation and subtraction wavelet-based baseline cancellation, and wavelet-based high-pass filtering [19]. Wavelet transform can be a best option to remove the baseline wandering. Baseline wandering can be suppressed by high pass digital filter and it is used to eliminate the trend of the ECG signal. Because of no latency and less distortion than the digital filter based approach the wavelet transform better than the digital filter based approach. Trend level specifies the number of levels of the wavelet decomposition which is approximately [16]. For the monitor mode Baseline Wandering in Respiratory signals lies between 0.15Hz and 0.5Hz frequencies because signals above the threshold are allowed to pass, also known as high-pass filter. Generally two types of digital Filters are considered for the Impulse Response i.e. Infinite Impulse response and Finite impulse Response. Figure 2 shows block diagram of signal processing using different methods and figure 3 shows the result of different methods of signal processing. Generalized discrete differential equation for Digital Filters is [20]:

$$\sum_{m=0}^{M} a_m y[n-m] = \sum_{K=0}^{N} b_K x[n-k]$$

Where,

a, b : filter coefficients,

x[n] : input signal,

y[n] : output signal,

M,N : filter order

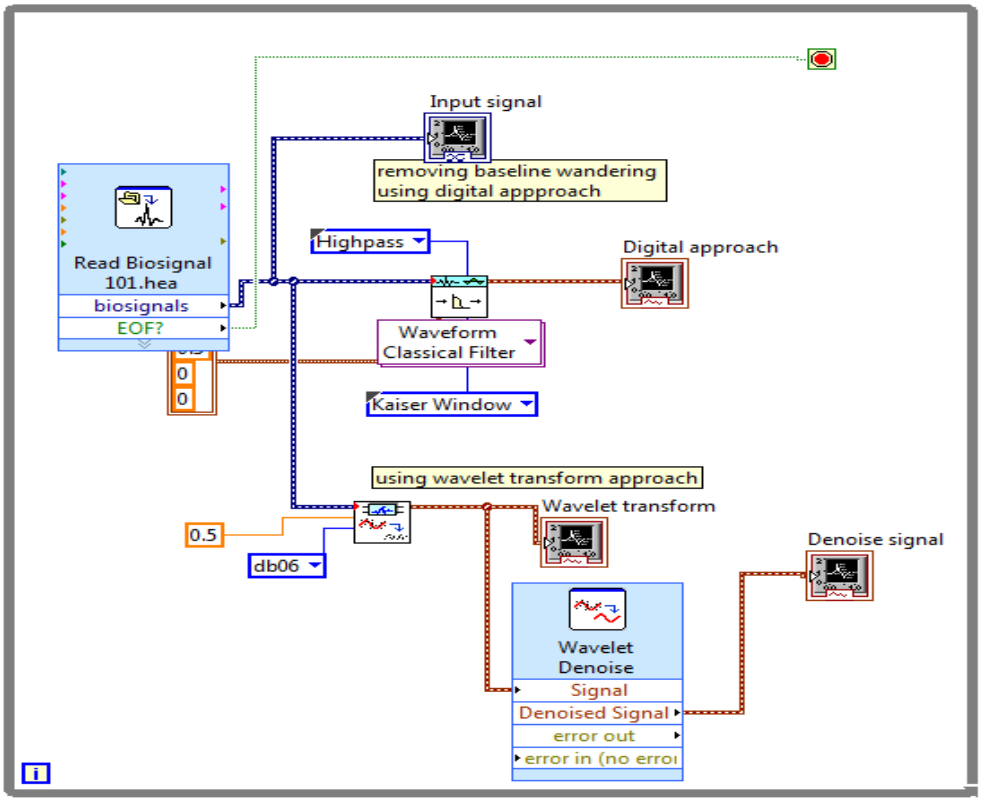

Figure 2 Block diagram of signal processing using different methods

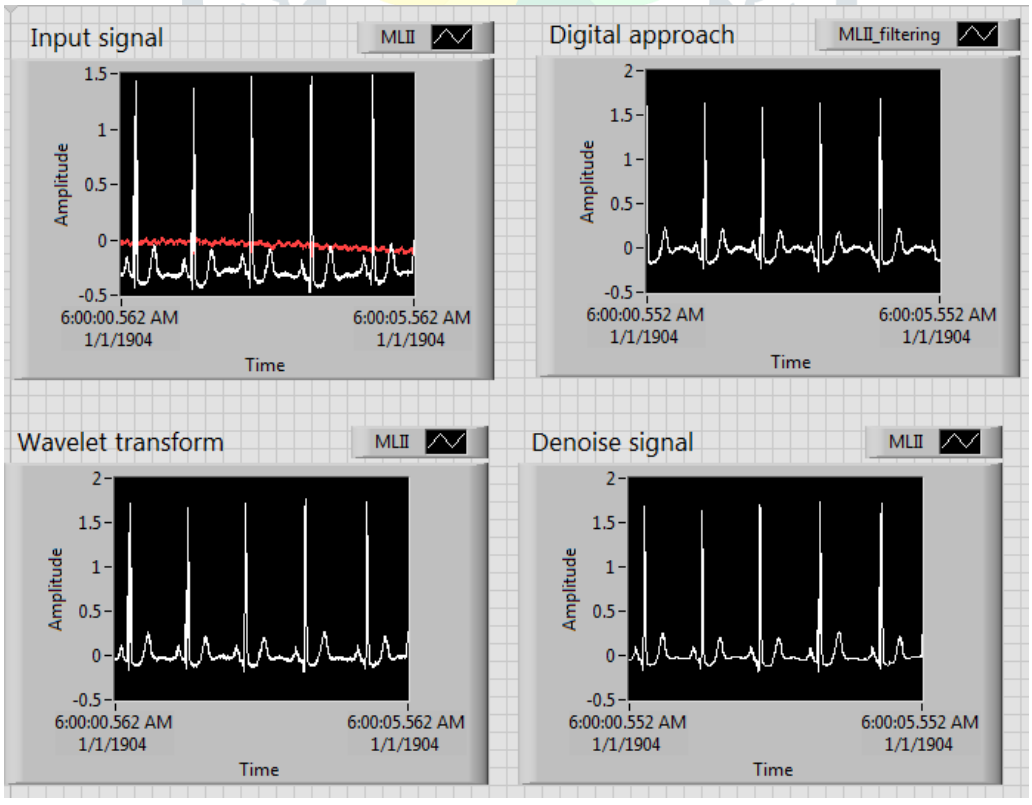

Figure 3 Front panel of signal processing using different methods.

b. Removal of wideband noise

After removing baseline wandering some other types of noise might still affect feature extraction of the ECG signal and we cannot remove them by using traditional digital filters [21]. ECG signal becomes more stationary and explicit than the original signal after removing baseline wander the resulting ECG signal. After feature extraction of ECG signal some other types of noise might still and noise may be complex stochastic processes within a wideband. the wavelet denoise express virtual instrument, decomposes the ECG signal into several sub bands by applying the wavelet transform, is used here to remove the wideband noises to reconstructs denoised signal. From the threshold setting options available soft Thresholding is selected and Thresholding rule selected is 'universal' and the virtual instrument, offers an option to select either discrete wavelet transform or undecimated wavelet transform to denoise the signal, sets the threshold to sqrt(2*log(N)). DWT having main drawback i.e. offers an option to select either discrete wavelet transform or undecimated wavelet transform to denoise the signal, to overcome this drawback UWT is used because it is redundant, linear and shift invariant, more robust and less sensitive to noise [16].

c. ECG Feature Extraction

Feature Extraction is diagnosis various features from preprocessed ECG data or we can say that it is the important process to detect the cardiac disorders. Feature Extraction provides information about heart rate, conduction velocity, and the conditions of tissues within the heart as well as various abnormalities [6]. For diagnosing many cardiac diseases ECG has been extensively used and it is nothing but direction and magnitude of the electrical commotion. These generated by depolarization and repolarization of the atria and ventricles of heart. ECG feature extraction provides fundamental features to the automated system and in the recent year a number of techniques have been proposed to detect these features [21]. LabVIEW is a biomedical toolkit provides ECG feature extractor where one can select whether to obtain QRS only or all parameters such as ST segment, QT segment, P onset, P offset, T onset, T offset etc. [8]. Table 2 and figure 5 shows the System output readings and Feature extracted output respectively.

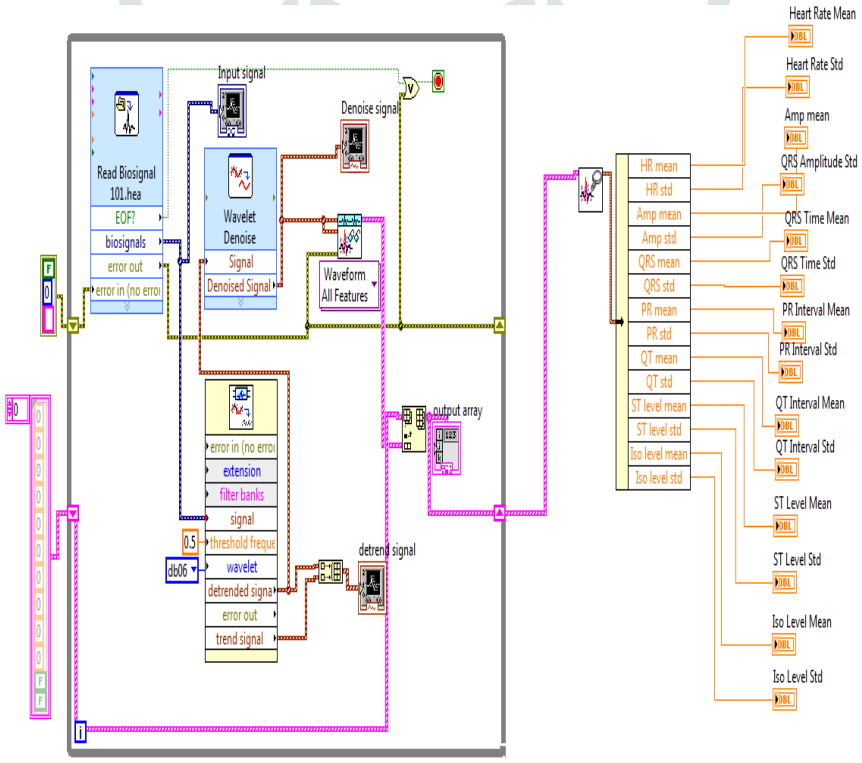

Fig. 4 Feature Extraction of ECG signal

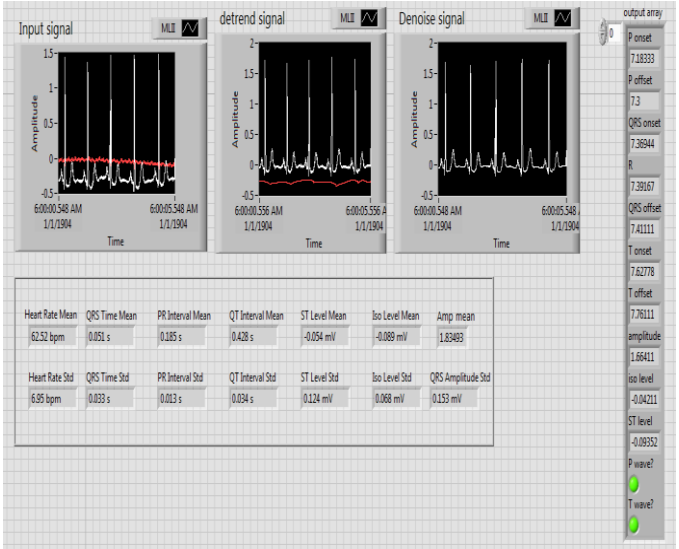

Figure 5 Feature extracted output

Table 2 System output readings.

Segments	100.hea	114.hea	117.hea
Heart rate mean	75.82bpm	114.04bpm	53.47bpm
Heart rate Std	5.07bpm	70.28bpm	18.58bpm
QRS time mean	0.047s	0.092s	0.075s
QRS time Std	0.009s	0.039s	0.02s
PR interval mean	0.151s	0.14s	0.222s
PR interval Std	0.005s	0.045s	0.015s
QT interval mean	0.342s	0.325s	0.484s
QT interval Std	0.019s	0.096s	0.051s
ST level mean	-0.016mv	-0.027mv	0.004mv
ST level Std	0.101mv	0.141mv	0.087mv
ISO level mean	-0.071mv	-0.016mv	-0.048mv
ISO level Std	0.04mv	0.098mv	0.065mv
QRS amp. Std	0.107mv	0.353mv	0.193mv

d. LabVIEW SOFTWARE

In 1986, LabVIEW was first launched as tool for scientists and engineers to facilitate automated measurements and it is uses a graphic interface that enables different elements to be joined together to provide the required flow. LabVIEW is a system-design platform and used for data acquisition, instrument control, and industrial automation in a variety of operating systems, like Microsoft Windows, various versions of UNIX, Linux, and Mac OS. LabVIEW is specifically designed to accelerate the productivity of engineers and scientists and that makes it simple to visualize, create, and code engineering systems [13]. It is designed to interoperate with other software. LabVIEW has its advantages like Graphical interface is flexible and simple to use, provides a universal platform for numerous applications in diverse fields, it can be interfaced with C/C++, VB, Fortran etc Easy to interface to many hardware items (like data acquisition and test equipment products), excellent customer support and a large active community forum, automating

Measurements and Processing Signal Data, Automating Test and Validation Systems, Designing Embedded Control and Monitoring Systems etc. LabVIEW provides different toolkit for the signal processing like Advanced Signal Processing Toolkit (ASPT: provides the WA Detrend VI which can remove the low frequency trend of a signal), Digital Filter Design Toolkit (DFDT: useful to design and implement finite impulse response (FIR) or infinite impulse response (IIR) filters), Wavelet Denoise Express VI etc. [23].

3. Conclusion

For ECG signal processing LabVIEW is more effective and ECG data we still can simulate and analyze it. We can simulate and analyze any ECG data by using the LabVIEW without having an ECG machine and useful for experimental/lab purpose.

Acknowledgment

At the successful completion of my project work I take this opportunity to express sincere gratitude to many who have made the completion of my project possible. I would like to express my profound thanks to ETC Department of Deogiri Institute of Engineering and Management Studies for the support, help and guidance throughout my project tenure. I extend my heartfelt thanks to my brother, sister and my parents, friends and well-wishers for their support and timely help.

References

[1] World Health Organisation (WHO), "The Atlas of Heart Disease and Stroke", 2002 http://www.who.int/cardiovascular_diseases/resources/atlas/en/index.html (Acessed: 28/02/2011)
[2] E.O. Thorp, "The Invention of the First Wearable Computer", Second International Symposium on Wearable Computers, 1998, pp:4-8
[3] Jianchu Yao, Schmitz R., Rarren S., "A wearable point-of care system for home use that incorporates plug-and-play and wireless standards," IEEE Transactions on Information Technology in Biomedicine, vol 9, issue 3, Sept. 2005, pp 363- 371 (2005)
[4] Chin-Chih Lin, Ming-Jang Chiu, Chun-Chieh Hsiao, Ren- Guey&Yuh-Show Tsai, "A Wireless Healthcare Service System for Elderly with Dementia", TITB-00146-2005.R,@2006 IEEE
[5] Yuan-Hsiang Lin, I-Chen Jan, Patrick Chow-in Ko, Yen-Yu Chen, Jau-Min Wong, and Gwo-jen Jan, "A wireless PDA-based physiological monitoring system for patient transport," IEEE Transaction on Information Technology in Biomedicine, vol 9, issue 4, Dec. 2004, pp 439-447 (2004)
[6] Shalin Savalia, Eder Acosta, Vahid Emamian, "Classification of Cardiovascular Disease Using Feature Extraction and Artificial Neural Networks", Journal of Biosciences and Medicines, vol. 5, 27 Nov 2017, pp. 64-79.
[7] J. Coosemans, B. Hermans, R. Puers, "Integrating wireless ECG monitoring in textiles", Sensors and Actuators A: Physical, Vol. 130-131, pp. 48–53, 2006.
[8] Anjali Deshmukh and Yogendra Gandole, "ECG Feature Extraction Using Ni Lab-View Biomedical Workbench", International Journal of Recent Scientific Research, Vol. 6, Issue, 8, pp.5603-5607, August, 2015.
[9] T. R. Hansen, J. M. Eklund, J. Sprinkle, R. Bajesy and S. Sastry, "Using Smart Sensor and a Camera Phone to Detect and Verify the Fall of The Elderly Person", European Medicine Biology and Engineering Conference, (2005).
[10] Bhagya Lakshmi. J. M. Hariharan.R, Udaya Sri. Nandhini Devi.P Sowmiya.N "Heart Beat Detector using Infrared Pulse Sensor", International Journal for Scientific Research & Development, Vol. 3, Issue 09, 2015.
[11] Embedded Lab" ARM 7 LPC 2148 measures heart beat rate from fingertip", Souvik Das "The Development of a Microcontroller Based Low-Cost Heart Rate Counter for Health Care Systems" International Journal of Engineering Trends and Technology- Volume4Issue2- 2013.
[12] LPC214x User manual
[13] http://www.startautomation.in/training/ni-labview-training-courses-fees.html
[14] ARM Architecture Reference Manual by David Seal Addison-Wesley ARM System-on-chip Architecture by Steve Furber M. A. Mazidi, J. C. Mazidi, R. D. Mckinaly, the Microcontroller and Embedded Systems, Pearson Education, 2006
[15] LM35 Temperature Sensor: Sourced from the web:www.alldatasheets.com
[16] Channappa Bhyri, Kalpana.V, S.T.Hamde, and L.M.Waghmare, "Estimation of ECG features using LabVIEW" TECHNIA – International Journal of Computing Science and Communication Technologies, Vol. 2, No. 1, July 2009.
[17] https://www.nottingham.ac.uk/nursing/practice/resources/cardiology/function/normal_duration.php
[18] https://ecg.utah.edu/lesson/3
[19] Gustavo Lenis, Nicolas Pilia, Axel Loewe, Walther H. W. Schulze, and Olaf Dösse, "Comparison of Baseline Wander Removal Techniques considering the Preservation of ST Changes in the Ischemic ECG: A Simulation Study", Computational and Mathematical Methods in Medicine, Volume 2017.
[20] Sonali and Payal Patial, "Different Techniques of Baseline Wandering Removal - A Review", International Journal of Enhanced Research in Science Technology & Engineering, Vol. 2 Issue 5, May-2013, pp. 37-43.

[21] S.Karpagachelvi, Dr.M.Arthanari and M.Sivakumar, "ECG Feature Extraction Techniques - A Survey Approach", International Journal of Computer Science and Information Security, Vol. 8, No. 1, April 2010.
[22] M. K. Islam, A. N. M. M. Haque, G. Tangim, T. Ahammad, and M. R. H. Khondoka. "tudy and Analysis of ECG Signal Using MATLAB & LABVIEW as Effective Tools", International Journal of Computer and Electrical Engineering, Vol. 4, No. 3, June 2012.
[23] M. K. Islam, A. N. M. M. Haque, G. Tangim, T. Ahammad, and M. R. H. Khondokar, "Study and Analysis of ECG Signal Using MATLAB & LABVIEW as Effective Tools", International Journal of Computer and Electrical Engineering, Vol. 4, No. 3, June 2012.

BIOGRAPHIES

Dr. Vandana B. Malode received M. Tech & Ph.D. in Electronics from Dr. BAMU Aurangabad, Maharashtra, India. She is presently working as Associate Professor in Department of Electronics at Jawaharlal Nehru Engineering College, Aurangabad. She has published around 42 papers in International and National Conference and journals. Her research area is Digital communication and OFDM technology and VLSI.
E-mail:vandana_malode@jnec.ac.in

Mrs. Arti R. Wadhekar Department of Electronics & Telecommunication Engineering, Deogiri Institute of Engineering and Management Studies, Aurangabad. Email Id: arti.wadhekar@gmail.com