© 2019 IJSRSET | Volume 6 | Issue 5 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET

HRV Analyzer based Driver Fatigue Detection Algorithm - LabView Simulation

Prashrita Kaushal,
M.Tech (Electronics Engineering)
University of Allahabad, Uttar Pradesh, India.

ABSTRACT

Driver fatigue is one of the key causes of car accidents in the world. Various causes for drowsiness or fatigue include increased stress levels, less sleep, irregular sleep pattern, drinking alcohol, long routes, etc. Driver fatigue can be detected by monitoring eyelid movement through image analysis, variation in speed, or through detecting head tilt or yawning of the driver. Driver fatigue can be detected more accurately by monitoring ECG signals. An intelligent sensor network integrated into the vehicle can be developed that utilizes a pulse sensor for ECG monitoring. This acquired ECG signal can be processed to determine heart rate and further analyzed to determine the drowsiness in the driver. This paper presents a software simulation developed using the LabView tool for analyzing ECG signals.

Introduction

As per the Ministry of Road Transport and Highways Report 2016, 1,50,785 people were killed and another 4,94,624 were injured in 4,80,652 road crashes [1]. Road crash deaths have increased by 31% from 2007 to 2017 and that fatal road crashes have increased by 25.6% within the same period. The responsibility of drivers is the top contributor to road crash deaths, accounting for 80.3% of deaths out of the total road crash fatalities in 2016. According to the Road Accident Report 2018 by the Ministry of Road Transport and Highways, 1,51,417 people were killed and another 4,69,418 were injured in 4,67,044 road crashes. As per the WHO Global Report on Road Safety 2018, India accounts for pretty much 11% of the accident-related deaths within the World [2]. This paper presents the HRV analyzer LabView simulation. Heart Rate Variability (HRV) in the time and time-frequency domains can be utilized to detect the sleep pattern [3,4]. ECG signals vary during sleep stages and thus HRV analysis can be developed to detect real-time change patterns preceding falling asleep while driving or if the driver is sleeping [5,6].Section 2 of the paper explains the theoretical base for designing the complete system including ECG Waveform features and section 3 gives the overview of the drowsiness detection system comprising HRV (Heart rate Variability) analyzer for processing of acquired ECG signals. Section 4 deals with the software simulation description and section 5 present the result of the simulation for different samples.

ECG Signal Features and HRV Analyzer

ECG signal during normal heartbeat comprises a P wave, a QRS complex, and a T wave as shown in Fig 1. The beginning of ventricular contraction is denoted by the peak of the R segment. The QRS wave and RR interval detection are considered most reliable for heart rate determination as the QRS wave is visibly distinct and least affected by noise. The time interval between QRS waves is considered as RR interval which can be further utilized for heart rate calculation.

Heart rate is the number of pulses per unit of time and is calculated in beats per minute (bpm). The heart rate of an active person is in the range of 60 to 100 bpm. Whenever, a person is tired, sleepy, or drunk, the heart rate reduces up to 40 bpm. A heart rate greater than 100 bpm is also considered abnormal and suggests a medical emergency. Thus, heart rate can be used as an accurate measure for detecting alertness and drowsiness in drivers while they are on road.

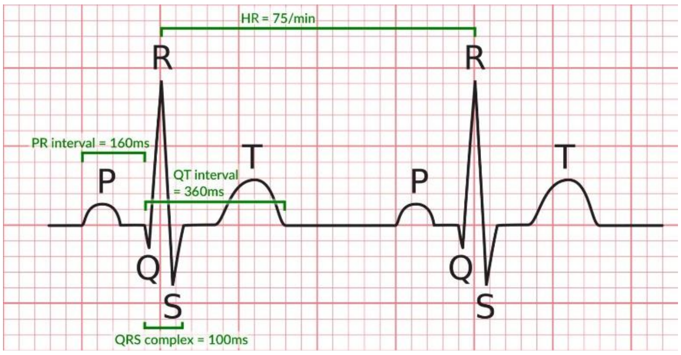

Fig 1. ECG Signal features [7]

HRV (Heart rate Variability) Analyzer - This analyzer can be used for processing measured ECG signals and is capable of detecting QRS complex and RR intervals. As stated, earlier heart rate can be calculated from extracted RR interval. HRV analysis comprises preprocessing and ECG feature extraction stages. The raw ECG signal is preprocessed by filtering and rectifying for removing noise and R peak detection. In Lab VIEW, the HRV FFT spectrum VI is utilized for QRS complex detection. The next stage of feature extraction is used for calculating heart rate from the RR interval. HRV analysis can be performed in the time domain, frequency domain, or other nonlinear methods. Variation in RR interval is analyzed during HRV analysis [8].

Proposed System Overview

The proposed system acquires a biosignal i.e., ECG signal which is pre-processed, and heart rate is determined. The heart rate is compared against the threshold to determine the state of driver alertness and accordingly, action is taken. The proposed system consists of the following modules:

1. Steering Wheel Network (pulse sensors and signal conditioning)
2. Sensor Data Storage
3. Data Analysis and Feedback (HRV Analyzer, Multilevel Alarm system, GPS GPRS module)
4. Remote Reporting Center

Steering Wheel Network- Pulse sensors are integrated into the steering wheel. Electrically conductive fabric is wrapped around the steering wheel as two ECG electrodes that help in non-intrusive monitoring of heart rate when the driver places hands on the wheel while driving. The ECG signal is acquired from the pulse sensors has a weak amplitude (0.0001 to 0.003 V) and is generally affected by noise. Therefore, signal conditioning is required for amplifying and filtering noise from the ECG signal. The frequency range of the acquired ECG signal is 0.05 to 100 Hertz and it's affected by noise from power line interference, electrode pop or contact noise, muscle noise, baseline wandering, etc. ECG signal analysis is mainly affected by baseline wandering and power line interference. Baseline wandering can be caused due to body movement, breathing, or sweating (changes electrode impedance). A high pass filter is used to eliminate this noise. The lowest heart rate is taken as 40 bpm that corresponds to 0.67 Hz and thus the lowest cut-off frequency of HPF is set to 0.5 Hz. Power line interference is due to power lines causing 50/60 Hz sinusoidal interference. Any one of the narrow bandpass filters, adaptive or notch filter could be used for removing this noise.

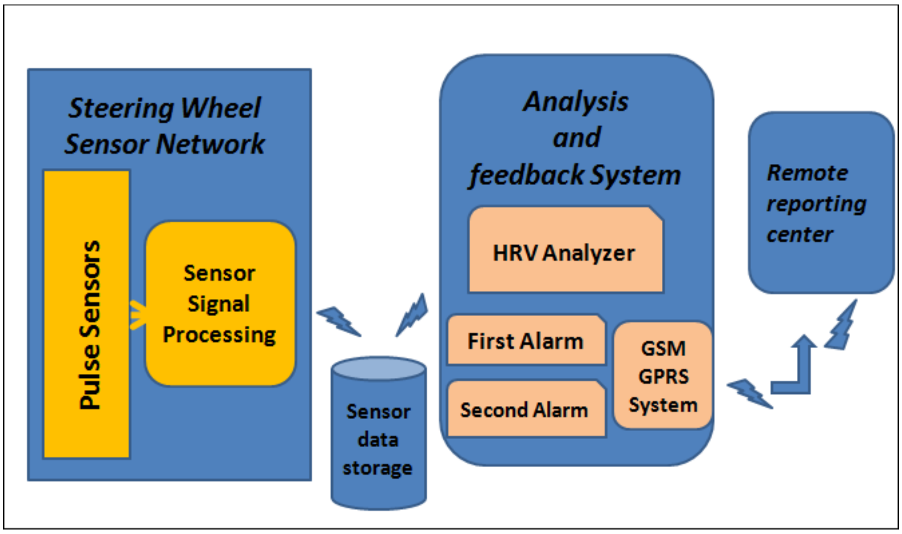

Fig 2. Block Diagram of Proposed System using Embedded systems and wireless network

Sensor Data Storage- Sensor data storage is a database that collects and stores the monitored ECG signals acquired from the pulse sensor. This database can be integrated as a memory chip in the steering wheel or onboard vehicle control system. It can also be implemented as cloud data storage and pulse sensors will transmit their data directly to the cloud server.

Analysis and feedback system- The data from the steering wheel network is given to an analysis and feedback system to check the driver drowsiness stage. The HRV Analyzer runs a Unique Heart Rate algorithm every time at the start of driving for normal heart rate calculation and sets the threshold for determining drowsiness in the driver. While driving, HRV Analyzer receives ECG signals from sensor data stored in real-time. HRV analyzer further extracts heart rate from the received ECG signal. The heart rate continuously traced through the sensors will be closely monitored in order to determine the variations in the pattern of pulse values. If any change in the HR against the dynamic normal heart rate value is noted and if HR deteriorates for a specific interval, it will invoke the multi-level alarm system. The Multi-level alarm system generates the first and second alarm based on different conditions. If the Heart rate is found to be below the threshold for a set period of time, then a first alarm is invoked which is a buzzer sound and vibrator installed in the driver's seat. After this, if no change in heart rate is observed for a specific time interval that means the driver might have slept or an accident occurred so a GPS module is used to send the coordinates of the location to the nearest rescue or reporting center for further action.

Remote Reporting Center- If the heart rate variation is found to be consistent, even after the first level warning, it implies that the driver has fallen asleep or having cardiac-related problems, or an accident has occurred and the driver has lost his consciousness, or the driver died due to an accident. Then the system will disseminate the second level warning constituting an emergency message that consists of vehicle identification number and GPS location to the rescue force, traffic control unit, and police. The emergency notification will be sent through GPRS or GSM module.

Lab VIEW Software Simulation

A LabVIEW simulation is developed for preprocessing and feature extraction of ECG signals. ECG sample data was taken from the Physionet database. The preprocessing of ECG sample data is performed to detect R waves. The ECG signals are filtered using a bandpass filter and then rectified for enhancing R waves detection. In the Feature extraction stage, ECG Feature Extractor VI, and an ECG Feature Extractor application are utilized for detecting QRS, and all other supported features.

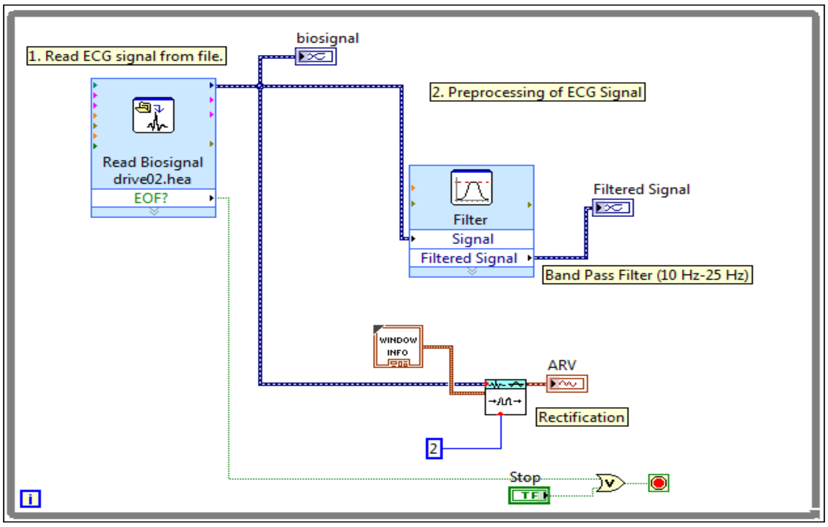

Fig 3. VI for Preprocessing of ECG signal

After preprocessing, the resultant ECG signal is utilized for QRS and RR Interval detection. Also, Lab VIEW Biomedical Workbench is used for extracting other features of ECG signals like RR interval, heart rate, QRS amplitude, QRS width, etc. which will be used in HRV (Heart Rate Variability) analysis. This module is used for peak detection and heart rate extraction. It also consists of a threshold detector that displays the state of heart rate. In this, if heart rate is labeled as-

1. Heart rate is less than 60 as “low”.
2. Heart rate between 61 and 90 as “normal”.
3. Heart rate between 91 and 200 as “high”.

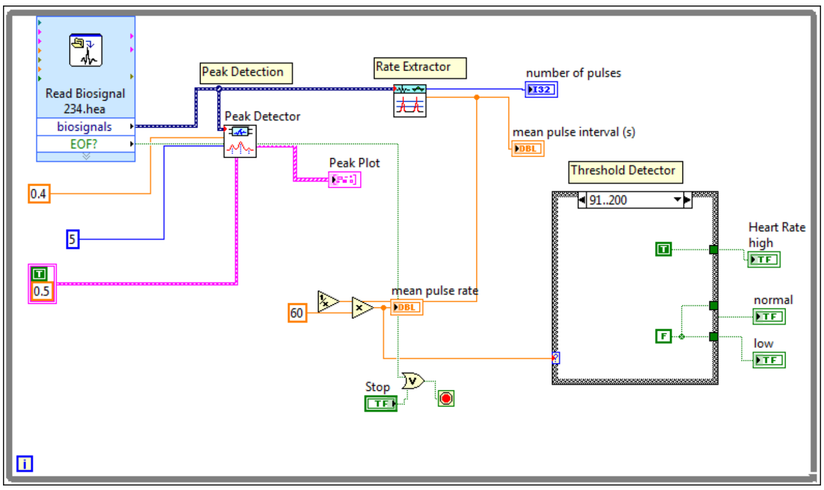

Fig 4. VI for Peak detection of ECG signal and threshold detector for extracted heart rate

Results

This section presents the pictorial results of the different stages of the simulation. Results for three different driver states are shown i.e., alert state, drowsy state, and abnormal state. For every case, the first graph shows an acquired signal without preprocessing, then the next three graphs depict the filtering, rectification stages, and R peak detection process. The next figure shows the ECG feature extractor result comprising peak plot, threshold indicator, heart rate, etc. In the last, HRV analysis graphs in time and frequency domain are attached that show different parameters including RR interval, heart rate, and different frequency components.

Case 1: Normal Heart Rate – "Normal State (Alert)"

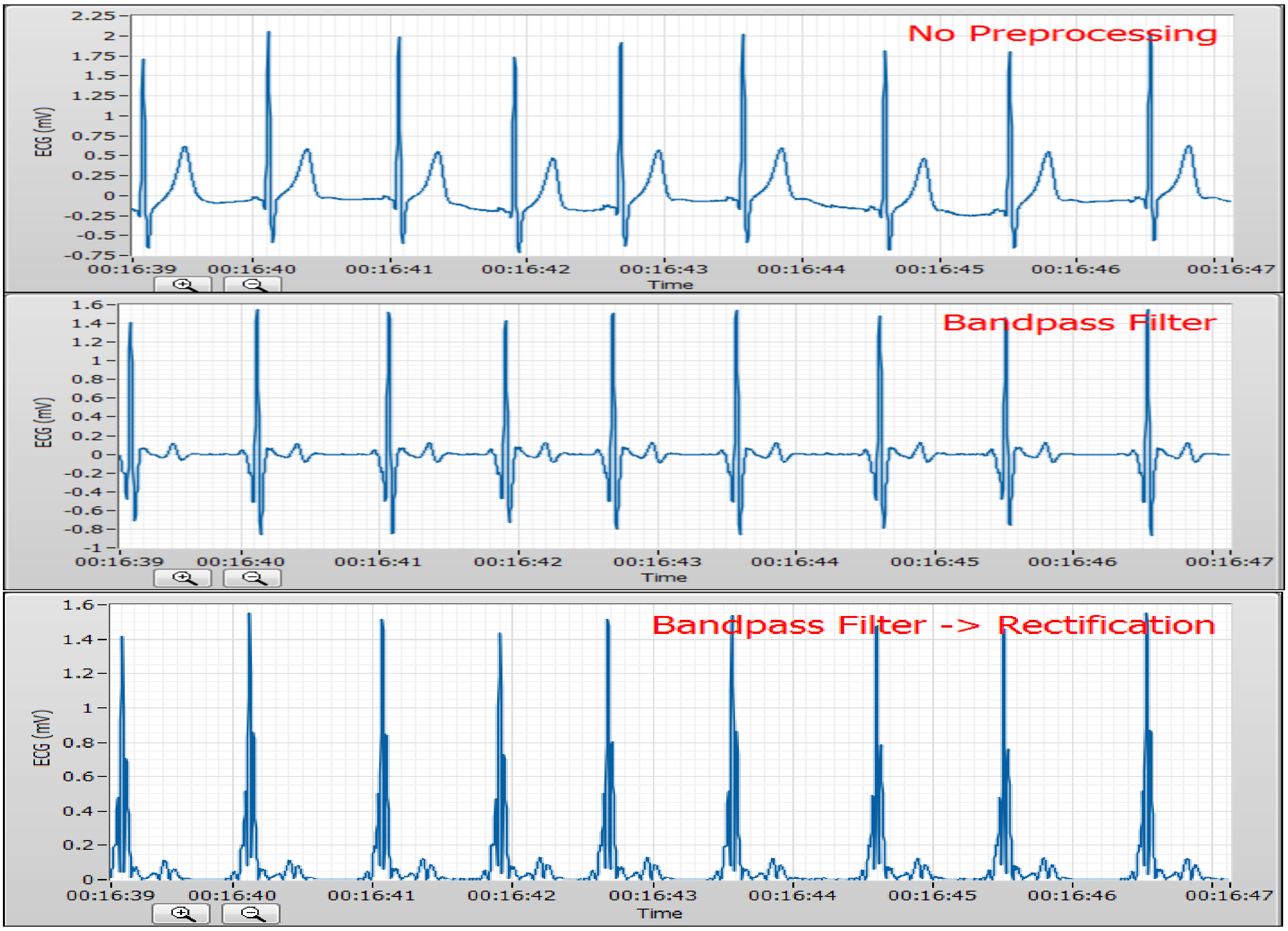

Fig 5. Original and preprocessed ECG signal , Case1.

Peak Detection

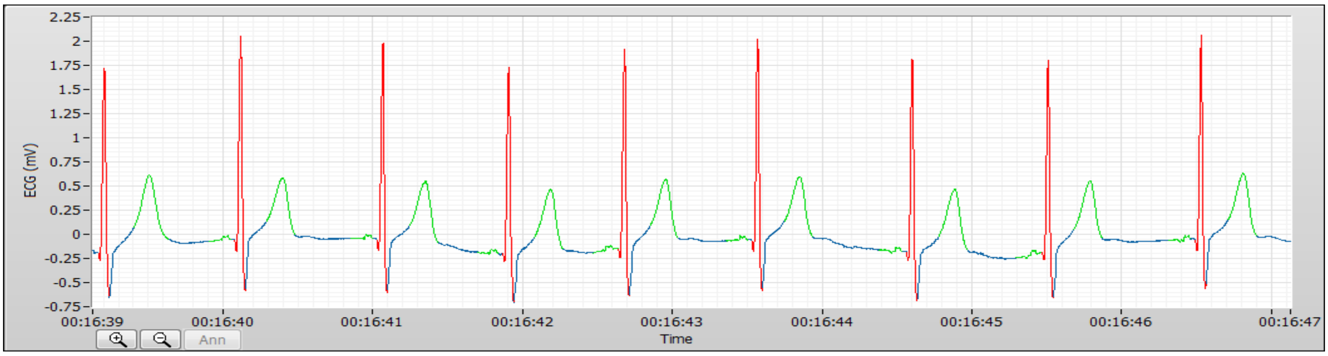

Fig 6. R wave detection, Case1.

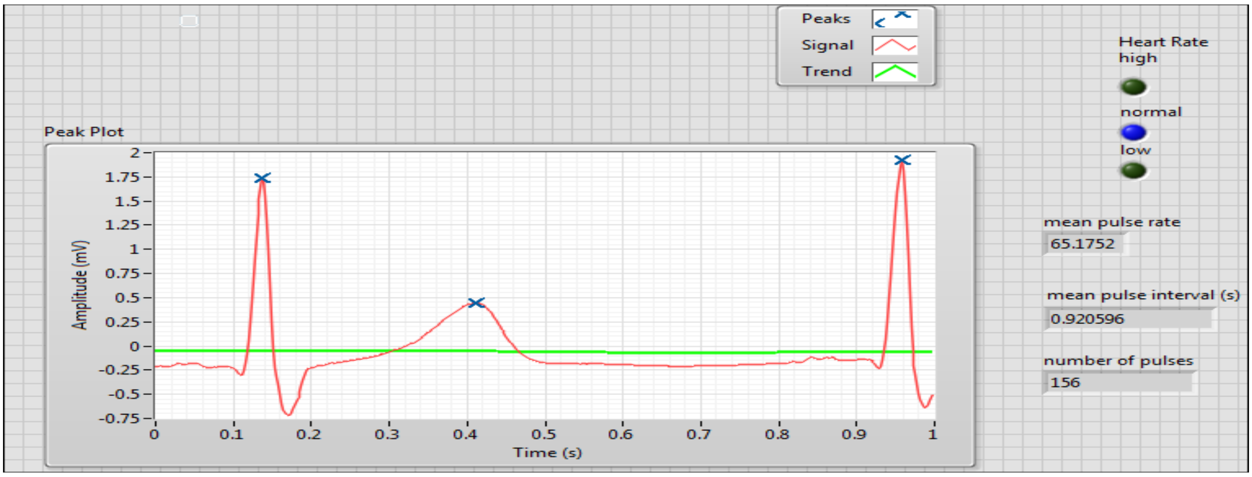

Fig 7. Peak detection and rate extraction with threshold detection, Case1.

HRV Analysis Results:

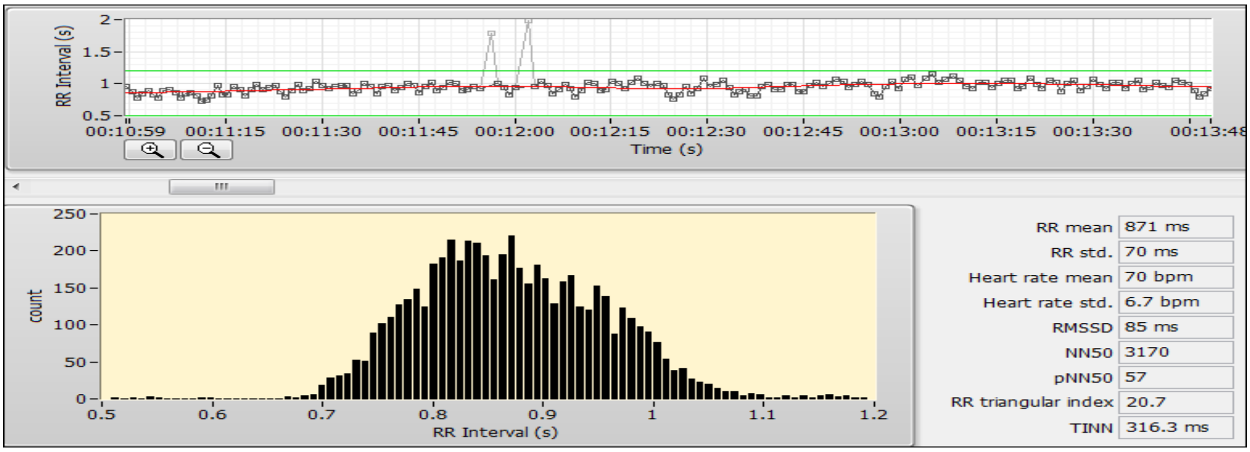

Fig 8.Time domain HRV Analysis , Case1.

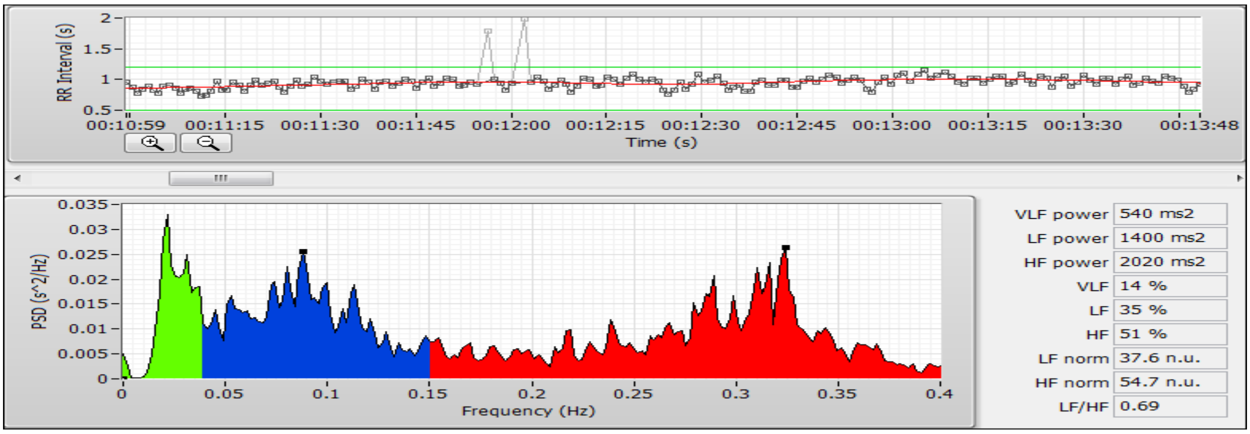

Fig 9.Freuency domain HRV Analysis , Case1.

Case 2: Low Heart Rate – "DROWSY STATE"

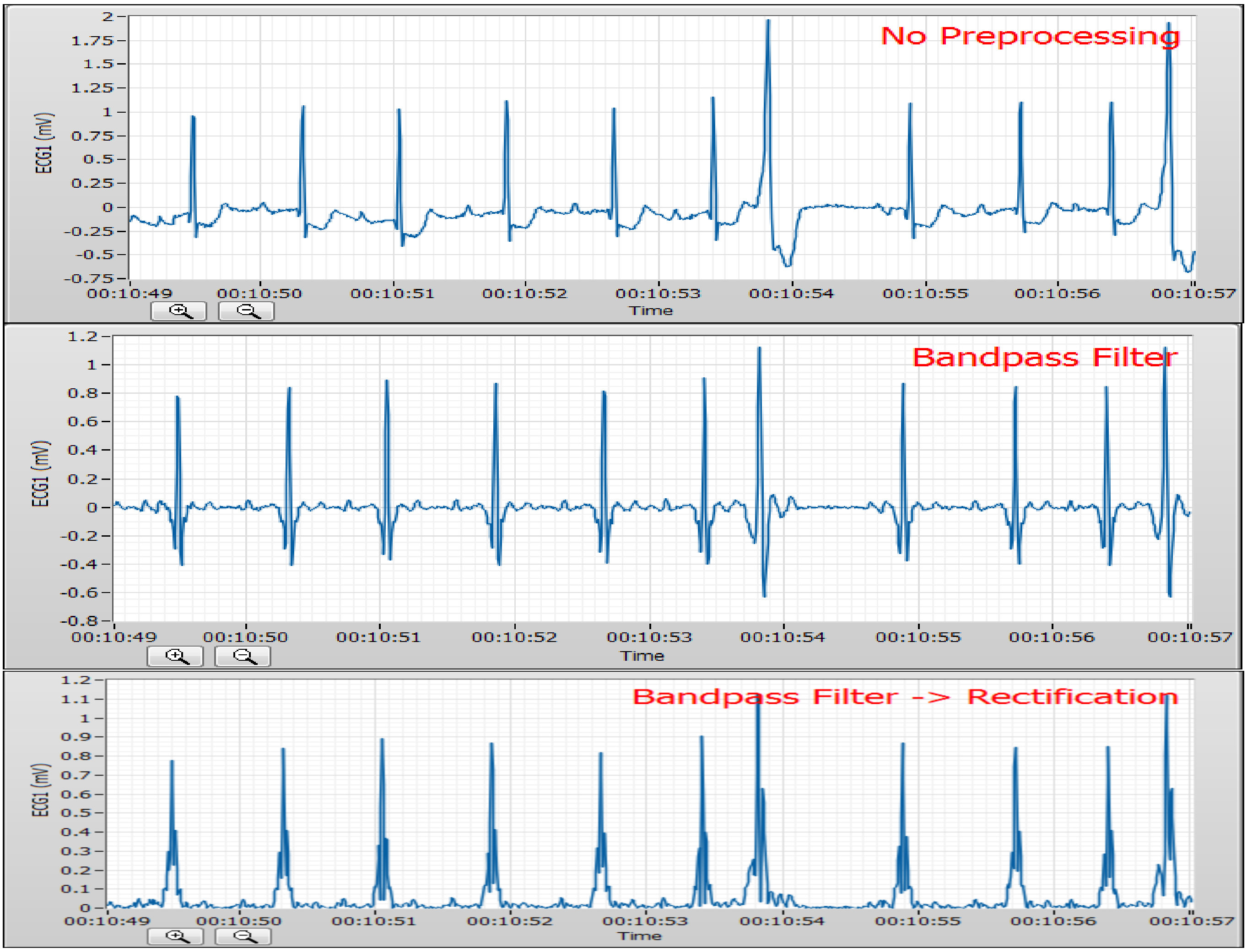

Fig 10.Original and preprocessed ECG signal ,Case2.

Peak Detection

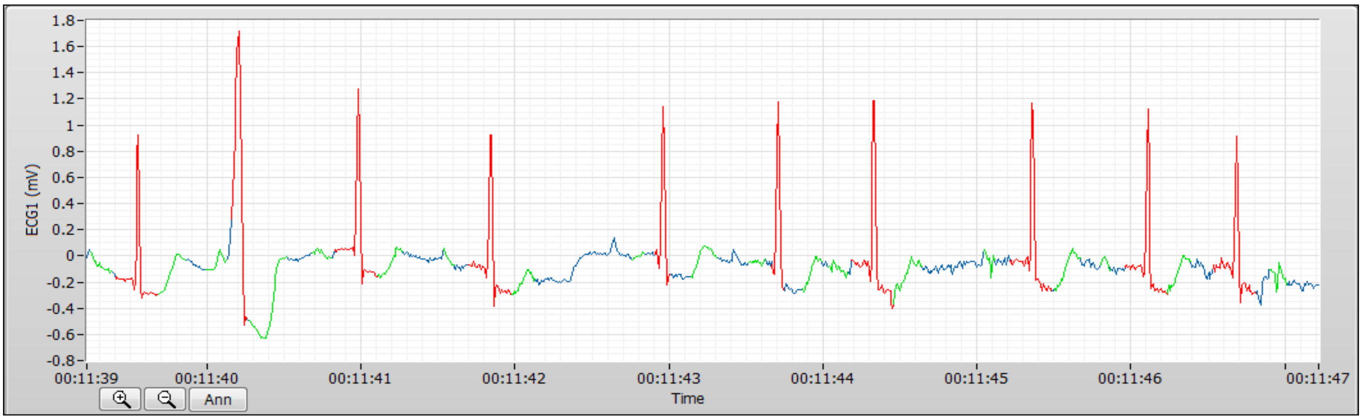

Fig 11. R wave detection ,Case2.

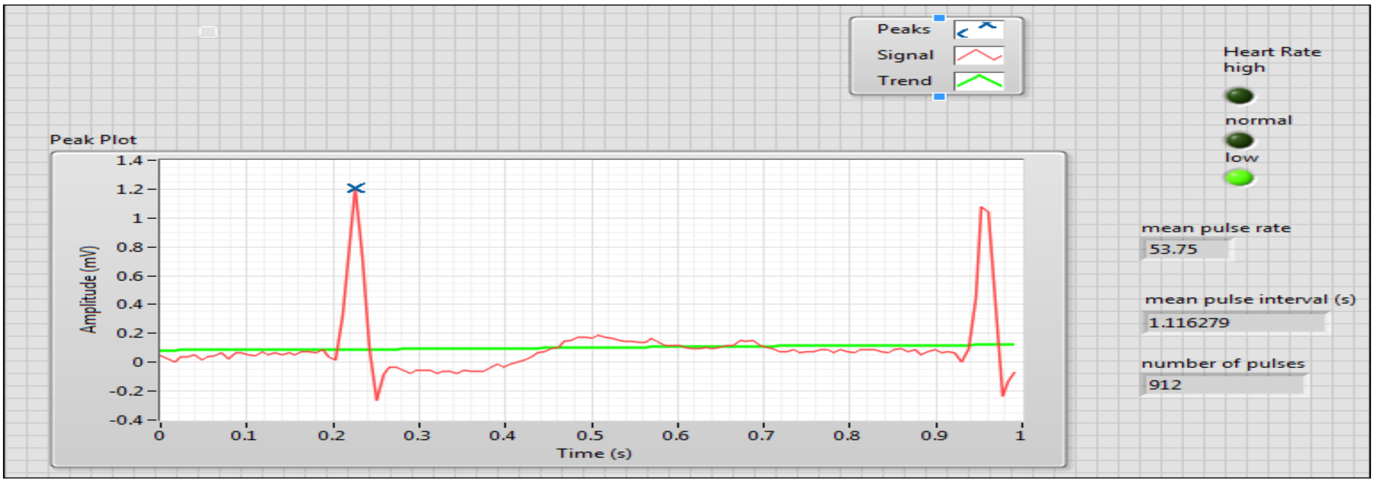

Fig 12.Peak detection and rate extraction with threshold detection, Case2.

HRV Analysis Results:

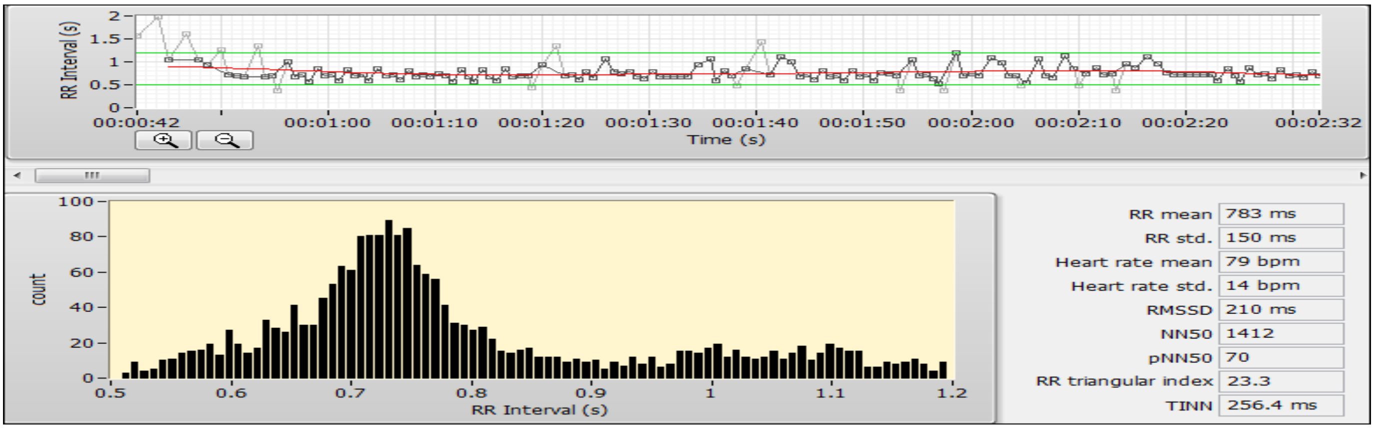

Fig 13.Time domain HRV Analysis , Case2.

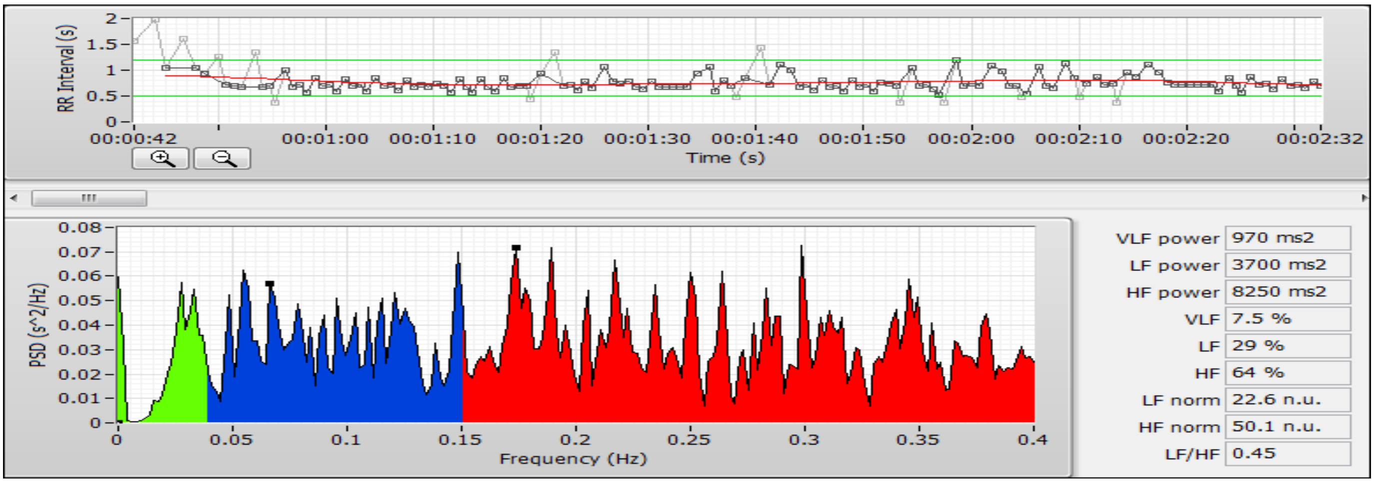

Fig 14.Freuency domain HRV Analysis , Case2.

Case 3: High Heart Rate- "Abnormal State"

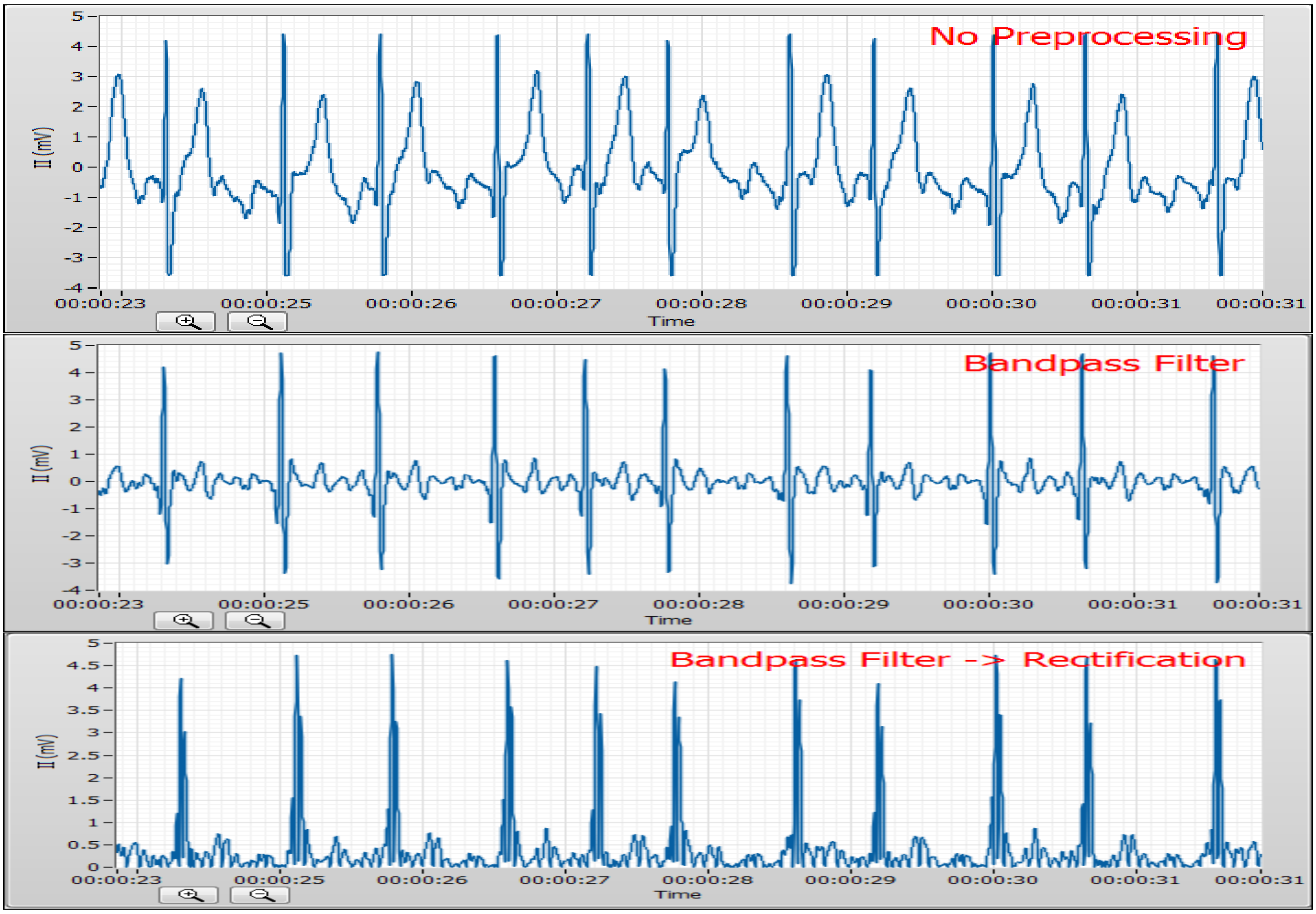

Fig 15. Original and preprocessed ECG signal ,Case3.

Peak Detection

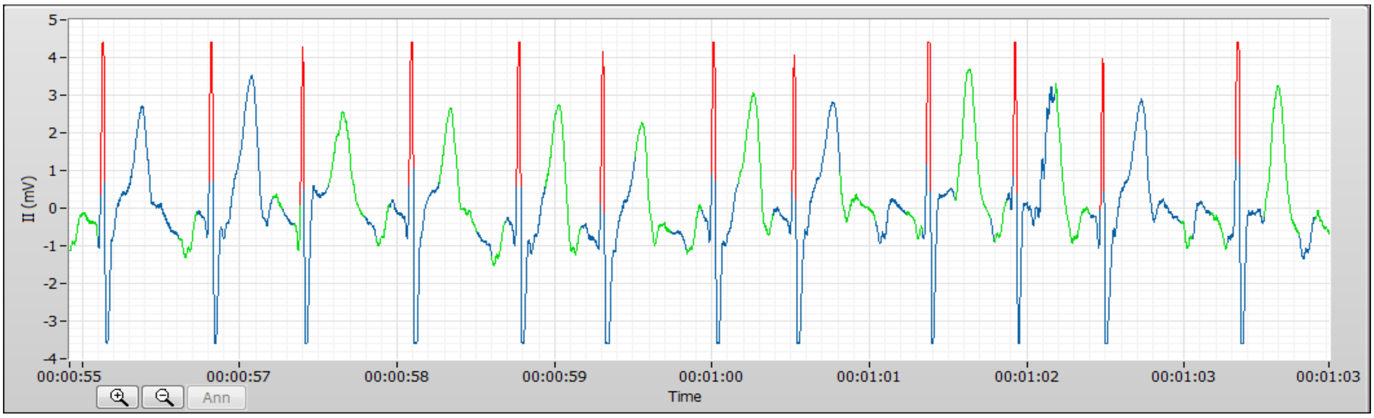

Fig 16. R wave detection ,Case3.

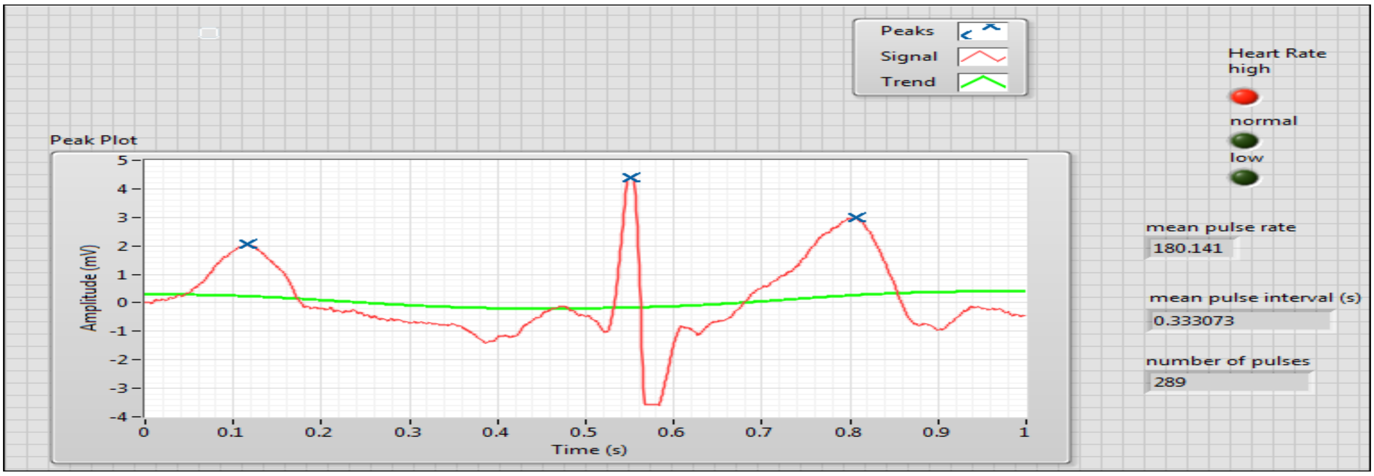

Fig 17.Peak detection and rate extraction with threshold detection, Case3.

HRV Analysis Results:

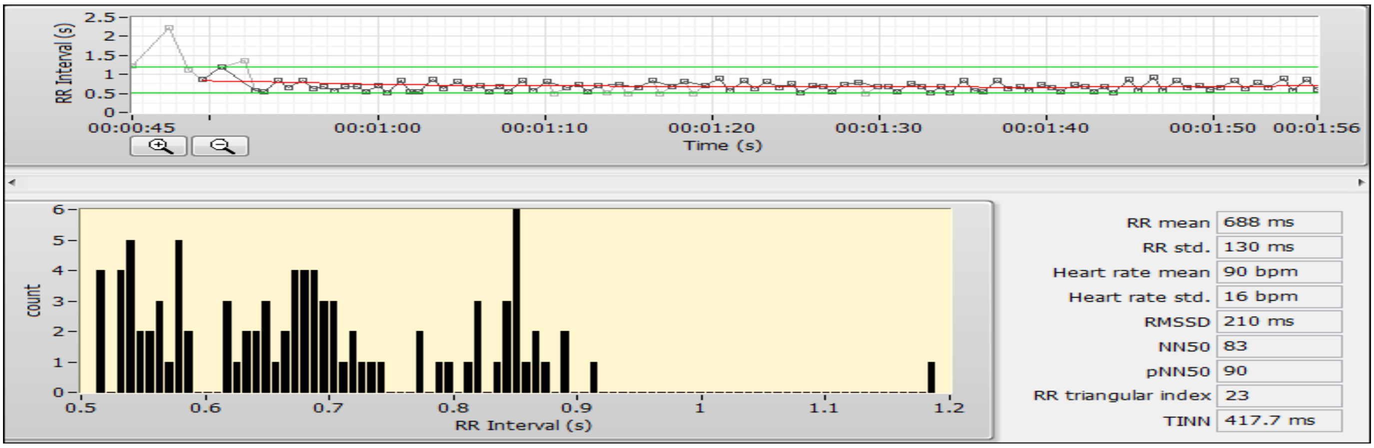

Fig 18.Time domain HRV Analysis , Case3.

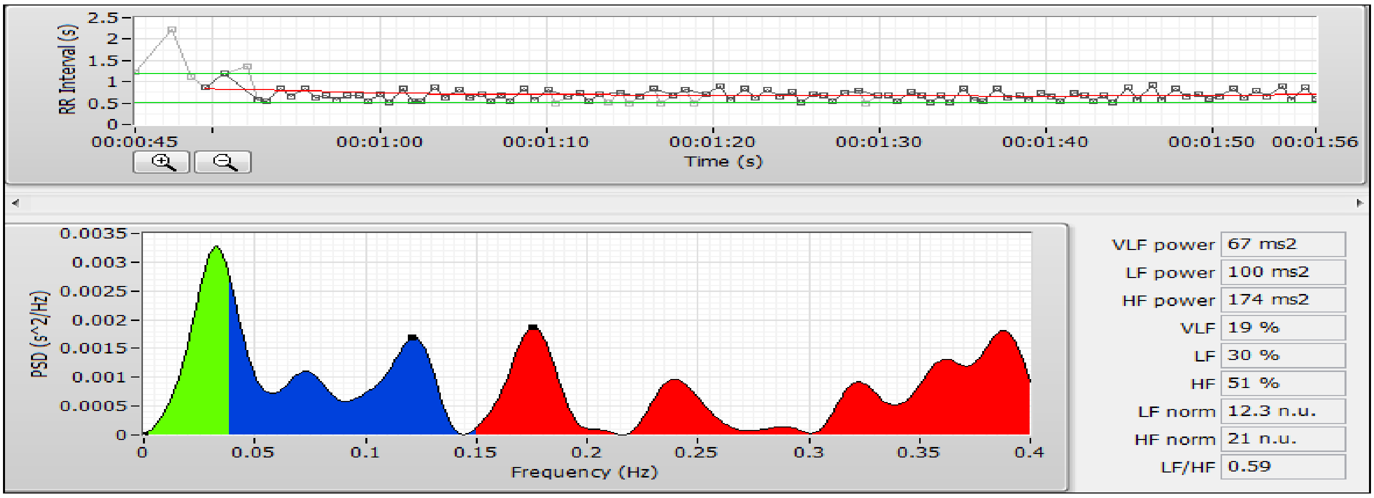

Fig 19.Freuency domain HRV Analysis , Case3.

Conclusion & Future Scope

This paper presents a Lab VIEW simulation of a heart rate-based driver alertness and drowsiness detection system. The detection system comprises pulse sensors integrated into the steering wheel, sensor data storage, HRV analyzer, GPS unit, multi-level alarm system, and remote reporting center. The relationship between heart rate and drowsiness detection system is being analyzed using Lab VIEW as a realizing tool. The results for different states of the driver such as alert, drowsy and abnormal are presented.

The efficiency of the system could be further improved by employing the sensors on the seat belt for achieving better accuracy. This system has a wide scope since the purpose of improving safety in vehicles is a highly focused issue.

I. REFERENCES

[1]. https://morth.nic.in/sites/default/files/Road_Accidednt.pdf

[2]. https://morth.nic.in/sites/default/files/Road_Accidents_in_India_2016.pdf

[3]. Shinar Z, Akselrod S, Dagan Y, Baharav A.Autonomic changes during wake-sleep transition: a heart rate variability based approach. Auton Neurosci2006 Dec30;130(1-2):17-27.

[4]. E. Vanoli, P. B. Adamson, B. Lin, G. D. Pinna, R. Lazzara, and W. C. Orr, "Heart Rate Variability During Specific Sleep Stages – A Comparison of Healthy Subjects With PatientsAfter Myocardial Infarction," Circulation, vol. 91, pp. 1918-1922, 1995.

[5]. G. Calcagnini, G. Biancalana, F. Giubilei, S.Strano, and S. Cerutti, "Spectral analusis of heart rate variability signal during sleep stages," Proceedings of the 16th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1994.,vol. 2, pp.1252-1253, 1994.

[6]. L. Toscani, P. F. Gangemi, A. Parigi, R.Silipo, P. Ragghianti, E. Sirabella, M.Morelli, L. Bagnoli, R. Vergassola, and G.Zaccara, "Human heart rate variability and sleep stages," TheItalian Journal of Neurological Sciences, vol. 17, pp. 437-439,1996.

[7]. https://www.amboss.com/us/knowledge/ECG/

[8]. S. Elsenbruch, M. Harnish, and W. C. Orr,"Heart rate variability during waking and sleepin healthy males and females," Sleep,vol. 22, pp.1067-1071, 1999.