IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Special Issue-18, May 2019 E-ISSN: 2347-2693

Design Methodology of a Sensor Based Robotic Wheelchair For Physically Disabled Community

Aditi Shriya[1*], A. Billaha[2], B. Roy[3], B. Mondal[4], K. Roy[5]

[1,3,4]Department of Applied Electronics & Instrumentation, Asansol Engineering College, Asansol, India
[2,5]Department of Electronics & Communication, Asansol Engineering College, Asansol, India

Corresponding Author: shriyaaditi@gmail.com,

Available online at: www.ijcseonline.org

Abstract— In this paper, an intelligent low cost wheelchair system is being developed which not only ponder on the mobility of the physically disabled persons, but also to change their daily life. By using this system they can control their home appliances by sitting in the wheelchair without any external remote control. A prototype mobile robot have been designed which is equipped with accelerometer, micro-electro-mechanical based sensor. To solve the problem of safe navigation an assistive obstacle avoidance method based on ultrasonic sensor has been incorporated. Additionally, dual tone multi-frequency signaling used for operating the wheelchair via mobile phone. For implementing hand gesture recognition for the physically challenged people this is a simple but efficient method. Using these gestures, it is possible to control the wheelchair in an efficient way. Besides controlling by a computer, which is a difficult task here all the methods used in this proposed system for controlling the wheelchair are natural and convenient by involving of micro-electromechanical sensors, micro-controllers and the wheelchair for the prototype. Based on the data from either the accelerometer, DTMF or the ultrasonic sensors, the movements of the wheelchair are controlled and this system will be highly efficient as compared to the other conventional methods as because it is not only controls the movement of a wheelchair but also detects the barrier coming in its path and take necessary action to overcome it.

Keywords— Wheelchair, Accelerometer, Ultrasonic Sensor, RF Data Transmission, Microcontroller

I. INTRODUCTION

Researchers have been made known to us about evolution in our day to day lives which talks about the era in which disabilities of the especially abled ones are to be abolished by the help of the development of various technologies that are brought into existence, it is a fact that these people remained devoid of normal well-being in spite of having normal abilities and sometimes more than abilities, the recreation aims for the provision of autonomy, more so over about their self-independence in the fields of life politically, socially, and economically. Intelligent wheelchairs are the noticeable application of the technical work developed in the last decades in this area [1-4]. Moreover, these assistive technologies still are the object of research and the interaction between them and the user, which remain is an open research problem. Human psychology and wheel chair system is dealt together for the betterment of life of differentially abled people. Many scientific organizations have been researching about these “intelligent” products and one of them is the intelligent wheelchair [5-6].

II. RELATED WORK

Felker et al. report on the newest version of the hands-free wheelchair control system which allows persons with severe disabilities to rely for locomotion using a power wheelchair by the need to use only the hands [7]. There are numerous methods which have the usage of different sequential functionalities as it uses different hardware. S. Yokota et al. focuses on the electric wheelchair controlled by human body motion interface [8]. Rosella Blatt gives some obstacle hindrance, low cost, autonomous wheel chair [9]. The solution proposed by T. Carlson and J. Millan represents the same where non-invasive brain-computer interfaces (BCIs) offer a promising solution to an interaction problem between user and wheelchair [10]. Intelligent adaptive user interface based on an adaptive shared control mechanism is proposed by T. McGinty et al. [11]. A. Milinkovic et al. introduces a smart wheelchair that utilizes a smart phone which has built-in sensors to capture and record physical attire of manually used wheelchair in both unstructured and structured ambience [12]. M. Bailey et al. explain the description of the structural development of robot wheelchair system and its vision-based navigation system [13]. N. Kawarazaki et al.

discussed the performance of the wheel chair [14]. G. DeSousa developed a system that allows a user to operate a wheelchair using only their heads [15]. All this research work described above either requires constant monitoring by the helper or requires a lot of effort to handle the wheelchair. Moreover, some of the existing traditional wheelchairs are connected with computers for the gesture recognition or voice recognition. But making use of the computers along with the chair includes more complexity. This complexity is reduced by using microprocessors and sensors based systems. They are very compact in size and can be placed on the fingertip of the patients. Some traditional wheelchair based on the same technique and use of similar kind of sensors are wired, which again increases the complexity of the system. They also limit the long range communication. In our proposed model, this complexity is removed by using the DTMF, it does not matter where you are as long as you have a mobile phone and you can control the wheelchair. Rest of the paper is described as follows. Section III contains the methodology of the proposed model. Results are described in section IV and the conclusion is given in section V.

III. METHODOLOGY OF THE MODEL

Aurdino is the pioneer building block unit of the system, which functions as the brain of the prototype wheel chair. There are three mode of the working of wheel chair and is described as follows

A. MODE 1 – THE GESTURE CONTROL

Gesture control screws for the use of accelerometer (ADXL335) mode which has micro electro mechanical type gesture sensing device. This is obliged by the movement of wrist, movement of carpels and Meta carpel's attached by ligaments and tendons. Further, ADXL335, has three sensing axes for the abscissa axis, ordinate axis and z-coordinate axis which is governed by stepper motor for the bidirectional movement fixed at an angle, accelerometer has low profile package, with less amount of consumption of power, excellent temperature stability, and strong shock absorption capacity.

B. MODE 2-THE TOUCH TONE CONTROL

The instantaneous portable controlling ability of the prototype is depicted under this section; the circuit which deals with dual tone multi frequency (DTMF). The decoder is basically used for the production of tone, when the buttons are pressed subsequently the tones are produced, the tones identify specific unit they are supposed to connect to and then function upon, thereafter the generated signals are sent to a Arduino and further wheels function desirably according to the instruction given.

C. MODE 3-THE AUTO PILOT MODE

The pre defined mode, which is self-adjusted and works on the principle of ultrasonic proximity sensor. Suppose the user is in an attenuated mood and is roaming about in the garden recklessly, the mode has the functioning in which the user moves unidirectional motion if any obstacle is observed in path the system will itself overcome the obstacle by help of installed programs in the system.

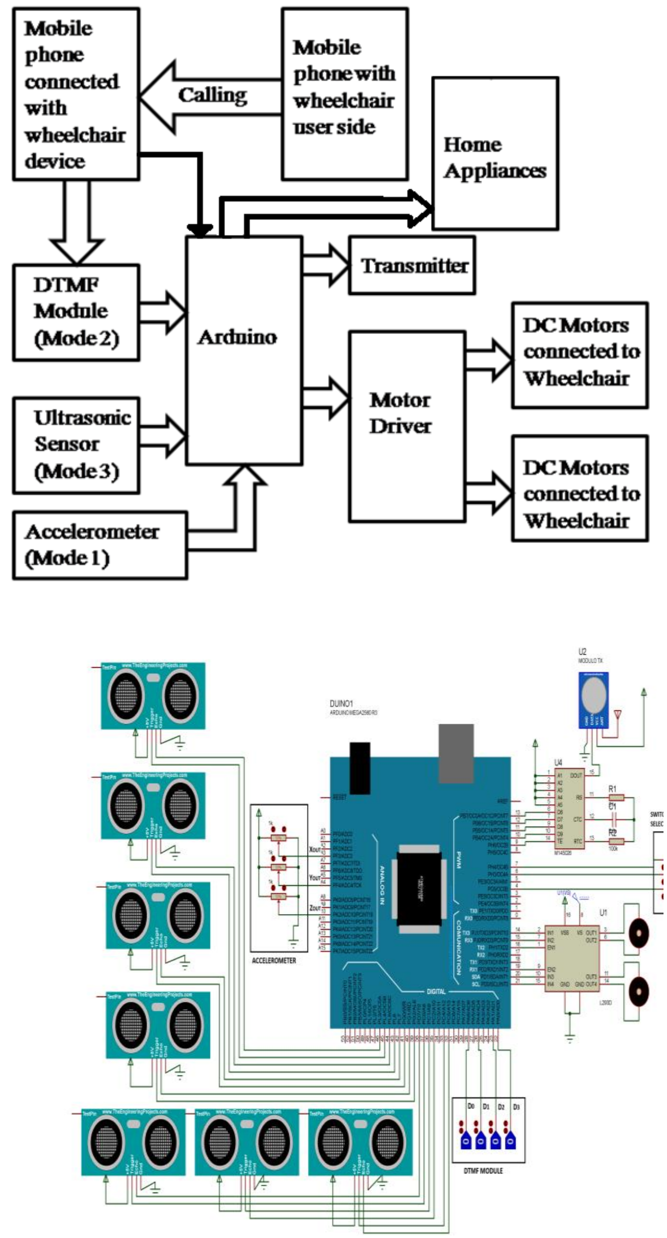

Figure 1:(a) Block diagram of proposed system (b) Simulation Circuit Diagram

D. MODE 4- OPERATION OF HOME APPLIANCES

The home appliances are also operated by Radio Frequency (RF) technology for this we need to use 434MHz RF transmitter and 434MHz RF receiver; thereafter the command is given to the device to function for the operation of the home appliances.

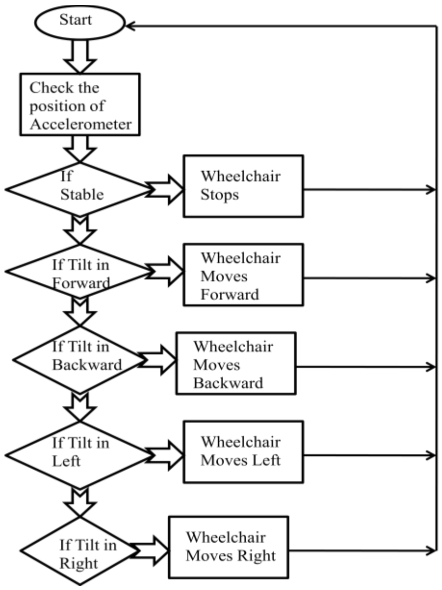

Figure 2: Flowchart of gesture control Mode (Mode 1)

Figure 1(a) explains that the accelerometer, which senses three axes, the sensed result is sent to the Arduino and then the processed data is forwarded to the wheel chair. Next, the signals are generated using mobile phone, the mobile phone has DTMF in it ,which forwards the data to the Arduino ,the Arduino has programming pre-loaded in it, which processes the instructions given to it ,the processed data is sent to the motor driver the motor driver leads to the motion of the wheels of the wheel chair. Next the ultrasonic sensors are the ones which have the ability of sensing the obstacle in the path ,the obstacle is sensed thereafter the signals are sent to the Arduino where the programming is pre-installed for the application , after this if there is a is requirement for the operation on the home appliances then the processed data is sent to the transmitter in digital form the digitalised data is then transferred to the receiver which receives the data and then the receiver sends the received data by converting it into the analogue, from the Arduino to home appliances for their functioning . The simulation circuit diagram of the proposed model is clearly shown in Figure 1(b). It is to be noted here, that some assumptions are made in order to complete the circuit diagram. The Proteus software is devoid of library function for DTMF decoder and accelerometer. Since the DTMF decoder has 4-bit binary output, so in place of DTMF decoder we have used 4 logic states which provide 1 or 0 as output. Accelerometer sensor provides three outputs for 3-axis. So, in place of accelerometer sensor, 3-potentiometer as X_{OUT}, Y_{OUT} and Z_{OUT} is used. Although both above mention assumptions are in complete support of the practical one. For three switches, three logic states of wheelchair are shown in the circuit diagram. The operation of each mode is described below.

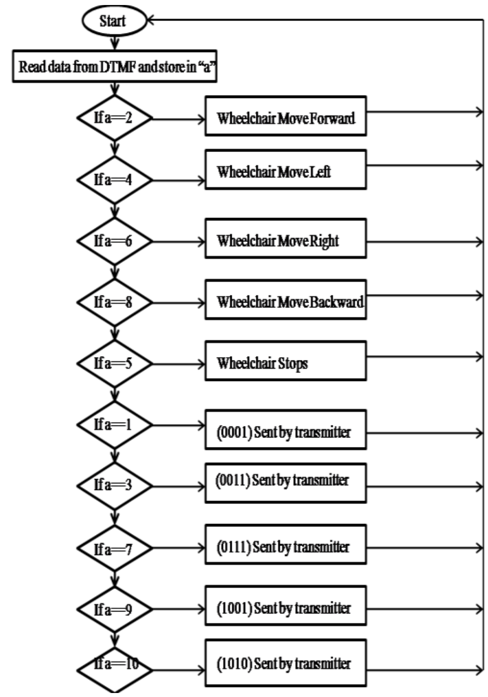

Figure 3: Flowchart of mobile phone control mode (Mode 2)

Accelerometer (ADXL335) is used for gesture mode (mode 1) where, three axial analog accelerometer reads X, Y and Z coordinate acceleration which is calibrated with analog voltages. The measurement of acceleration due to gravity is required for the measurement of the tilt of the angle with respect to the earth surface. It is equipped with on-board voltage regulator IC and signal conditioned analog voltage output. When the user gives some gesture input, an analog output X_{OUT}, Y_{OUT} and Z_{OUT} is observed. Microcontroller reads the analog input by using analog pins of the Arduino. Microcontroller takes verdicts of the directional movement by imposing conditions upon output X_{OUT}, Y_{OUT} and Z_{OUT} in which direction user wants to move the wheelchair. After deciding the direction, microcontroller provides some controlled signal to the motor driver through which user can control the movement of the wheelchair. After decision of the directional motion, microcontroller provides some controlled signal to the motor driver through which user can control the movement of the wheelchair. Figure 2 describes the operational algorithm of mode 1. It is observed that after checking the position of accelerometer, it takes a decision as programmed and continuously checks the position of the accelerometer. In touch tone control mode (mode 2), DTMF Module is used which convert the DTMF tones into 4-bit binary output available in pin D_0-D_3 (see Figure 1(b)). According to the output of DTMF decoder, microcontroller can precisely control the movement of the wheelchair. In this mode, there is no distance limitation as calls can be connected from anywhere on earth to anywhere on earth. The flowchart related to mode 2 is presented in Figure 3. It is observed that microcontroller extracts data from the DTMF decoder circuit and then depending upon the condition, Arduino sends control signal to the motor driver to control the wheelchair movement.

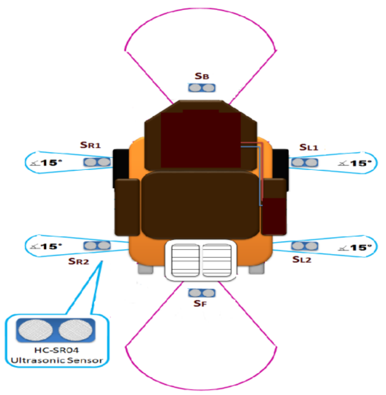

Figure 4: Configuration for mode 3

The obstacle avoidance system is designed to fit into the propose wheelchair. The system allows constant communicational control for monitoring the environment and detecting potential obstacles as such there lays no semantic gap between the sender and the receiver. The simulation circuit diagram of mode 3 is already shown in Figure 1(b), which is an autopilot mode by which the wheelchair can take some decisions by itself depending on surrounding ambience.

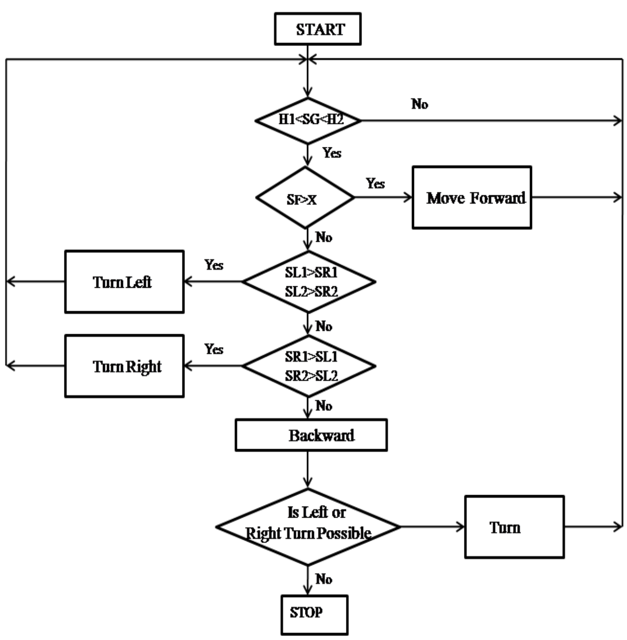

Figure 5: Flowchart of Mode3 where SL1 and SL2 are the data read from left ultrasonic sensor 1 and 2, SR1 and SR2 are the data read from right ultrasonic sensor 1 and 2, SF, SB and SG are data read from ultrasonic sensor which is directed towards Forward, Backward and Ground, H1, H2 and X are a constant distance.

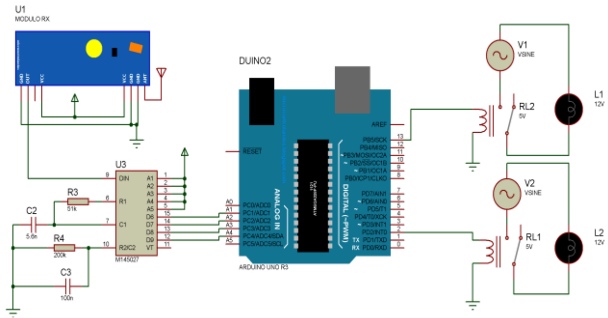

Figure 6: Simulation circuit diagram of home appliances control system.

Table 1: Result for Mode1

Gesture Orientation	**Wheelchair Movement**
+X	Forward
-X	Backward
+Y	Right
-Y	Left
STABLE	Stop

Seven ultrasonic sensors are connected on five different sides of the wheelchair. These are one in front, two in left, two in right, one in Backward and one towards the ground. The configuration and position of six sensors for obstacle detection and avoidance is depicted in Figure 4. Sensor faced towards the ground is not shown in the figure. By depending upon the data of this sensor, the wheelchair takes the decision on which direction it will go. For better understanding, the simplified operational algorithm of mode 3 is described in flowchart which is shown in Figure 5.

Figure 6 show the circuit diagram used for controlling home appliances and by that scheme, required results are obtained. M145026 encoder IC is used to convert the 4-bit parallel data given to pins D_0 - D_3 to serial data and will be available at D_{OUT}. This output serial data is connected to amplitude shift keying (ASK) RF transmitter. Address inputs A_0 - A_7 can be used to provide data security. The status of these address pins should match with status of address pins in the receiver for the proper transmission of the data. Data will be transmitted only when the transmit enable pin (TE) is low. ASK RF receiver section, receives the data which is transmitted using ASK RF transmitter. M145027 decoder will convert the received serial data to 4 bit parallel data D_0-D_3. The status of these address pins A_0–A_7 should match with status of address pin in the M145026 at the transmitter for the transmission of data. One of the most useful things that users can be able to control high voltage (240V) devices like fans, lights, heaters, cooler and other household appliances with this proposed system. To control these higher voltage devices directly through Arduino, a 5V relay is used to switch 240V home appliances since Arduino operates at 5V, so it can't control these higher voltage devices directly. The Arduino at the receiver side is programmed to turn on the relay when a certain event occurs. Since M145027 decoder converts the received serial data to 4 bit parallel data using this 4-bit data, one can control up to 2^4=16 devices.

Table 2: Result for Mode2

Control Keys	Wheelchair Direction
2	Forward
4	Left
6	Right
8	Backward
5	Stop
1,3,7,9,#,0,*	Can control home appliances

IV. Results and Discussion

The user control over this device is governed by gesture control by the tilt at a respective angle. The relation between gesture orientations and the wheelchair movement are shown in Table1. Table 2 demonstrates the result for the touch tone control mode. The control keys for the wheelchair are 2, 8, 4, 6 and 5 to drive the wheelchair in forward, backward, left, right direction and to stop it respectively and 1,3,7,9 send the decoded signals to the transmitter. By pressing different keys from both the mobile, user can drive the wheelchair as required. Since this wheelchair works on the principle of artificial intelligence device and so it is obliged to take some decision by itself. For that purpose four ultrasonic sensors are connected in 4-side of this wheelchair. By reading the output of different sensors, the wheelchair can take decision by itself and is well explained in Table 3

Table 3: Result for Mode3

Direction of Ultrasonic sensor	Task
Forward	Obstacle detect and avoid
Left	Detecting wall and follow it
Right	Detecting wall and follow it
Backward	Detecting pit

V. Conclusion

An efficient, low cost intelligence wheelchair for common people has been reported in this paper which has various advantages. According to all these advancements and progressions mentioned above, especially for the assistance of the disabled person, our project aims to be an innovative idea that not only improves the lifestyle of the differentially abled person, but also would smoothen their lives by allowing them to control their home appliances without any external help.

This modest invention is built to create connections between disable person and wheelchair to help the disabled become independent. Since, it is operating in three different modes of control which makes it user friendly. .Moreover, users can control his home appliances. This Wheelchair will be economical and can afford to common people.

References

[1] M.Fernandez-Carmona, J.M.Fernandez-Espejo, B.Peula, C.Urdiales and F.Sandoval, "*Efficiency based collaborative control modulated by biometrics for wheelchair assisted navigation*", In IEEE 11th Int. conf. Rehabil. Robot., **Japan**, pp. **737-742**, **2009.**

[2] Y.Ren,W.Zou, H.Fan,A.Ye, K.Yuan and Y.Ma " *A docking control method in narrow space for intelligent wheelchair*", In 2012 IEEE Int. conf. Mechatronics and Auto., **China**, pp. **1615-1620**,**2012.**

[3] A.V.Nguyen, L.B.Nguyen, S.Su and H.T.Nguyen , "*The advancement of an obstacle avoidance bayesian neural network for an intell wheelchair*",35th Annu. Int. conf. IEEE Eng. in Medicine and Biology Soc., Japan, pp. **3642-3645** ,**2013**.

[4] E.Takano, Y.Kobayashi, and Y.Kuno, "*Multiple robotic wheelchair system based on the observation of circumstance*", 18th Korea-Japan Joint Workshop Frontiers of Comput. Vision, pp. **222-226**,**2012.**

[5] J.S.Nguyen, S.W.Su, and H.T.Nguyen., "*Experimental study on a smart wheelchair system using a combination of stereoscopic and spherical vision*", 35th Annu. Int. conf. IEEE Eng. in Medicine and Biology Soc., **Japan**, pp. **4597–4600**, Jul. **2013.**

[6] T.Rofer, C.Mandel, and T.Laue. , *"Controlling an automated wheelchair via joystick/head-joystick supported by smart driving assistance*", In 2009 IEEE Int. Conf. Rehabil. Robot., **Japan**, pp. **743-748**, **2009.**

[7] T.Felzer, B.Strah, R.Nordmann, and S.Miglietta., "*Alternative wheelchair control involving intentional muscle contractions*", Int. J. Artificial Intell. Tools, vol. **18**, No. **3**, pp.**439-465**, **2009.**

[8] S.Yokota, H.Hashimoto, D.Chugo, and J.She Y Ohyama., "*Absorption of ambiguous human motion on human body motion interface*", IEEE Int. Symp. Ind. Electron., pp. **853-858**, **2011.**

[9] R.Blatt, S.Ceriani, B.D.Seno, Fontana, Giulio., M.Matteuci, and D.Migliore, "*Brain control of a smart wheelchair*", Intell. Auton. Syst., vol. **10**, pp. **221–228**, **2008.**

[10] T.Carlson and J.Millan,"*Brain controlled wheelchairs: A robotic architecture*", IEEE Robot. and Auto. Mag., vol. **20**, No. 1, pp. **65–73**, **2013.**

[11] V.Gandhi, G.Prasad, D.Coyle, L.Behera, and T.McGinnity, "*EEG-based mobile robot control through an adaptive brain-robot interface*",IEEE Trans. Syst., Man, and Cybern.: Syst., vol. **44**, No. **9**, pp. **1278–1285**, **2014.**

[12] A.Milenkovi, M.Mladen and E.Jovanov, "*Smartphones for smart wheelchairs"*, In IEEE Int. conf. Body Sensor Netw., **USA** pp. **1–6**, **2013.**
[13] M. Bailey, A. Chanler, B. Maxwell, M. Micire, K. Tsui, and H. Yanco, "*Development of vision-based navigation for a robotic wheelchair"*, In IEEE 10th Int. conf. Rehabil. Robot., **Netherlands**, pp. **951–957**, Jun. **2007.**
[14] N. Kawarazaki, D. Stefanov, B. Diaz, and A. Israel, *"Toward gesture controlled wheelchair: A proof of concept study"*, In IEEE Int. conf. Rehabil. Robot., **USA**, pp. **1–6**, **2013.**
[15] L. Rivera, and G. DeSouza, "*Control of a wheelchair using an adaptive k-means clustering of head poses*", In IEEE Symp. Comput. Intell. in Rehabil. and Assistive Technol, **Singapore**, pp. **24–31**, **2013**

Authors Profile

Aditi Shriya is currently pursuing Bachelor of Technology in the department of Applied Electronics & Instrumentation Engineering, Asansol Engineering College in the session of 2017-2021. She is attached with the student chapter of Institution of Engineers(India).

Md Aref Billaha received his PhD degree from Indian Institute of Technology (ISM), Dhanbad, India in the year of 2018. Prior that he obtained his M.E degree from BIT Mesra, Ranchi in 2010. Currently, he is working as an Assistant Professor, Dept. of ECE, Asansol Engineering College, Asansol, India. He has published more than 11 research papers in reputed international journals including Thomson Reuters (SCI & Web of Science) and conferences including IEEE and it's also available online. His main research area includes modelling of optoelectronics devices and their applications considering group III-V and IV based QWIP, QDIP etc.

Bhaskar Roy received his M.Tech. degree with specializtion in Electronics & Communication Engineering (VLSI Design & Microelectronics Technology) from Jadavpur University,Kolkata,India in 2010 and presently persuing his PhD in the field of semiconductor devices. He is currently working as an Assistant Professor in the Department of Applied Electronics and Instrumentation Engineering of Asansol Engineering College,Asansol,India.

Bikas Mondal received his M.Tech. degree with specialization in Instrumentation and Control from University of Calcutta in 2009. He is currently working as an Asst. Professor and teaching B.Tech. and M.Tech. students in Electronics and Instrumentation Engineering and Electrical Engineering, Asansol Engineering College.