Development of Low-Cost Robotic Arm for Welding

T. Vignesh, Manikandan N, Kannaki. S, Prasath C, Bhuvaneswari M, Vignesh S.

Abstract*: This paper work concentrated on the implementation of 5 Degrees of Freedom Robotic arm using servo motor. The servo motor is controlled by PIC16F877A controller. Controller has a PWM pulse module signals which used to achieve a specific rotation. The specific rotation used to stop the arm in the particular rotation so that welding in particular place is achieved. Robotic arm used for welding purpose. Now a day's robot replaces the humans it avoids the dangerous task and work faster with efficient. So, the low-cost welding robot fabricated in this project.

***Index Terms*: Robotic arm, Servo motor, PWM signal, Pic controller**

I. INTRODUCTION

The expansion of new technology, the requirement of latest Robotic devises grows consequently [1] use of Computers and programming languages with electronic devices used to raising the new technologies. There are many technologies affect the todays Engineers [2]. AI and robotics place a major role in nowadays this going to replace a many humans and machines. The robot is doing work accuracy and efficient than humans, humans cannot do a repeated work in efficient. Now a day's robot employed instead of human for doing repeated works [3]. The robot is not having any emotional feels and it is not tired at any tired so it can perform a task in many years. It is programmed by the humans so it can perform any task based on the programming. it can perform a many simulation and various types of works in a single program, the aim of fabricating robot it is perform the day by day task and regular and dangerous task. It is avoided many human deaths due dangerous task [4].

Now a day many tools, vehicles, electrical devices and cookery square measure engineered are ready with industrial robots. Square measure industrial automatic assembly lines that help to operate additional works and correct it automatically quicker than the humans. Now a day robot operates by the human with less operate time with the help of AI technologies the robot learned by its own by the environment which is help to human contrate on the other major works and programming. its help to develop the organization keep growing.[5].

Revised Manuscript Received on June 11, 2019

Vignesh T, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India

Manikandan N, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

Kannaki S, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

Prasath C, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India

Bhuvaneswari M, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

Vignesh S, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

Nowadays theirs is use of technologies and modification in technologies use to produce any product easy and less time. In the automobile industries now day a they need to competition the current scenario so they need to develop a product and many updates in the product, so that only they can sustain the market. Using a current technologies car manufactures develop and release a product in very short span of time. In the Computer aided modelling and manufacturing technologies in single model it can modified and fabricate a prototype is very simple so the fabrication and wastage cost is reduced. So, the utilization of equipment is very simple and less man power. After the protype of a model the original model is fabricated using the automated fabricated lines. The assembly lines run by the motors. The conveyor system used to transfer the material from one place to next place, which reduce the transport and manpower. The conveyor and motor system controlled by the PLC [6]. The robot can perform the many tasks painting, welding, assembling, packaging, pick and place, inspection, shorting. The robot is performed very faster and accurate. As package utilized in the golem is advanced the designation is additionally terribly straightforward and quicker. The robot programming is a part of experience. There are four coordinate system used in the robot s mainly. The transient description for every system is given below [7].

1.Joint
2. World
3. Base and Tool co-ordinate system

From the various literature the work is to fabricate a robot for welding operations. The robot arm is performing the welding. The Pic micro controller is used for control the working of the robotic arm.

II. BUILDING A ROBOTIC ARM

A. Kinematic Structure

The kinematics used to find out the length of the robotic arm. Forward kinematic used to find the length of the robot. The first step is to find the length of the robot and space configuration according to the requirement figure 1. Based on the length and weight of the links the actuator torque is calculated. The robot link is fabricated using the aluminium sheets. Weight of the arm is less compared to the other materials. Aluminium very robust enough to stay the weight and it hold the hole components [8]. The arm is connected to the base at the bottom part of arm it used to hold the heavy weight to in order to maintain the centre of gravity of the system near the base.

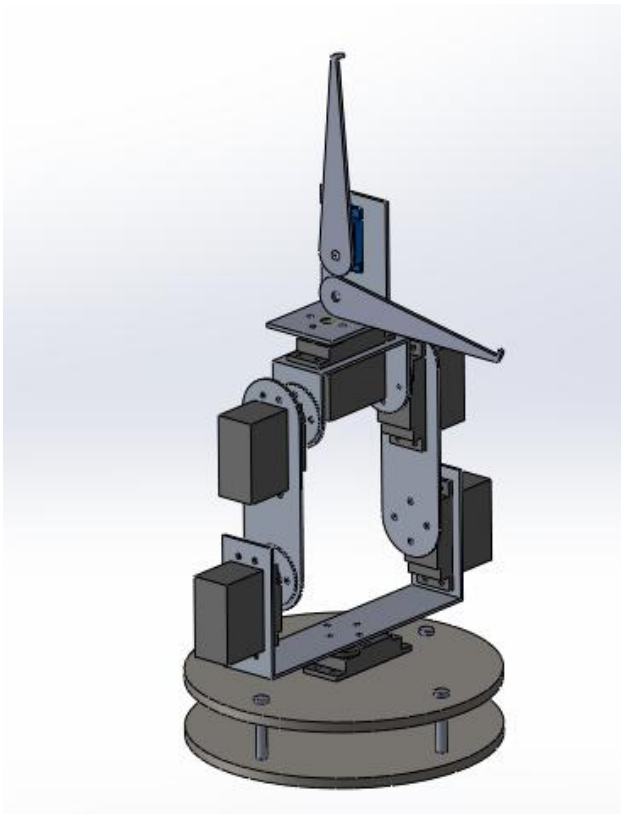


Figure 1. Isometric View of the Robotic Arm

DC and stepper motors can be considered as actuators for a robotic arm; however, the arm rotation controlled by the servo motor which is connected to the controller. Advantage of the servo motor is that they can the initial position (start point) can be programmed. Based on the controller output the servo motor is controller in a specific rotation. However, this characteristic of the servo motors is an obstacle, as a result of the possibility in case of receiving wrong signal the servomotor is not working properly. The robot has a gripper, spin, base shoulder it is attached with revolute joints. It has a five Degrees of freedom in the total arm.

Shoulder, elbow, gripper this are the components of the robotic arm, are cut accurately from aluminium sheets. Using Carpentry processes to make a hole and required cut in the desired place make the link of the robotic arm. There is special type of mechanism used for the gripper which is fabricated using the aluminium sheets with required cut and holes. After making a require cut and holes it fitted in the bold with one another. The gripper attached with special type motor used to actuate the gripper. Based on the servo motor rotation the gripper opening and closing operated.

The dimension of the robot arm is choose based on the study. The actuator torque is calculated based on the weight of the arm and other accessories. The torque places the major role on the robotic arm which main based on the dimension and weight of the robotic link. Based on the torque value calculated on the calculation the motor is closed otherwise the motor is not able to lift the joints.

B. Mathematical model of the kinematics

Mathematical modelling used to analyse the system with having a model. It used to reduce the fabrication and wastage cost. The mathematical modelling compares with the models developed by the modelling software's. The arm having a five axis in these three major axis respects to the base, shoulder and elbow. There are two minor axis respect to gripper spin and shank movement. The MATLAB software used to solve the mathematical equation and models [18].

The parameters and kinematic equations of the robotic arm can be written as follows

$L_0 \; to \; L_5$ – Six-unit frames

d_5– Gripper length, $q_1 to \; q_5$ – Joint variables (q = θ)

P – Gripper spin

d_1 – Height of shoulder from base

$x^0 \; to \; x^5$ – base, shoulder elbow, gripper pitch and spin in x direction motion

$y^0 \; to \; y^5$ – base, shoulder elbow, gripper pitch and spin in y direction

$z^0 \; to \; z^5$ – base, shoulder elbow, gripper pitch and spin in z direction

$1,2,\ldots..5$ – Rotary joints

a_2, a_3, a_4 – Link lengths

the above parameter used to write the mathematical equation of the robot.

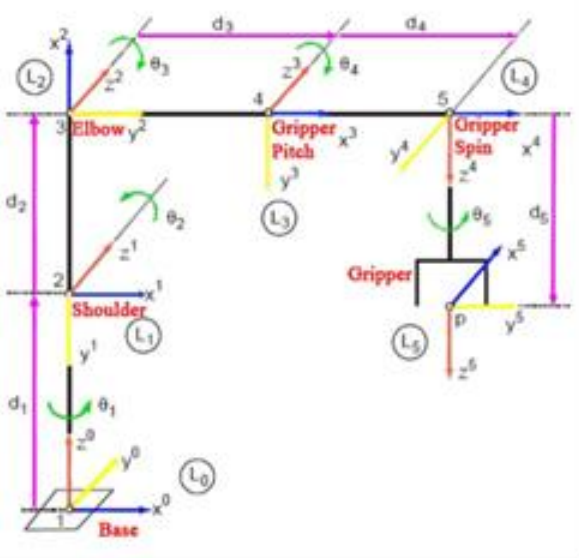


Figure 2. Link coordinates

$$Z_{shoulder} = Z^1 - D_1 \quad (1)$$

$$X_{shoulder} = X_{Shoulder} - D_2 \quad (2)$$

$h = \sqrt{(x_{shoulder})^2 - z_{shoulder})^2}$ (3)

where $\theta_2 = tan^{-1}\left(\frac{z_{shoulder}}{x_{shoulder}}\right) - cos^{-1}\left(\frac{l_1^2 + l_u^2 - h^2}{2 l_1 l_2}\right)$ (4)

and $[\frac{\pi}{6} \le \theta_2 \le \frac{2\pi}{3}]$ for (L_1= Lower Link, L_u= Upper Link, h = Height of base) rotation from 30° to 120°.

Two servos used to rotate the motion of the shoulder (Shoulder 2 and Shoulder 3) the motor connected to D.1 port in the controller.

Elbow:

$\theta_3 = cos^{-1}\left(\frac{l_1^2 + l_u^2 - h^2}{2 l_1 l_2}\right)$ (5)

where $[\frac{7\pi}{6} \le \theta_3 \le \frac{\pi}{3})]$, rotation from 60° to 210°.

The shoulder 4 servo motor connected to the port D.2 in the controller.

Gripper Pitch:

$\theta_4 = -\theta_2 - \theta_3$

where $[-\frac{\pi}{4} \le \theta_4 \le \frac{\pi}{4})]$ from -45° to 45°. (6)

The servo motor for the gripper pitch (S5) is connected to Port D.3.

Base:

q1 = θ1

where $\theta_1 = tan^{-1}\left(\frac{y^0}{x^0}\right)$ and $[-2\pi \le \theta 1 \le 2\pi]$ full counter and clockwise rotation.

The shoulder 1 servo motor is connected to the port D.0 in the micro controller.

Shoulder:

$x_{shoulder} = \sqrt{(x^1)^2 - (x^2)^2}$ (7)

Gripper Spin:

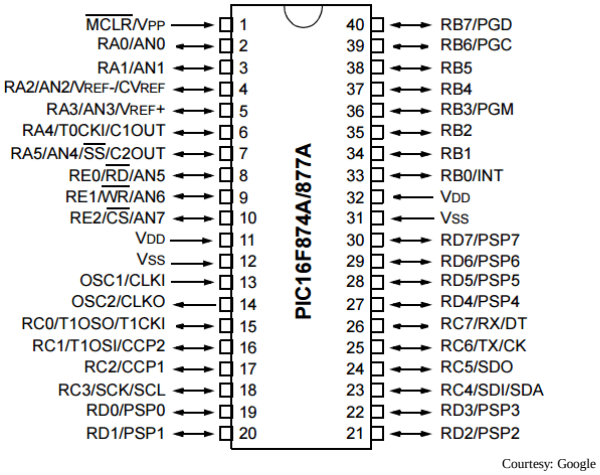
$\theta_3 = cos^{-1}\left(\frac{l_1^2 + l_u^2 - h^2}{2 l_1 l_2}\right)$ (8)

where $[-\frac{\pi}{4} \le \theta_4 \le \frac{\pi}{4}))]$ rotation -45° to 45°.

The servo motor for the gripper spin and gripper is connected to the Port D.4 and D.5. This used to perform the opening and closing of the end effector

III. HARDWARE IMPLEMENTATION

The pic micro used for the project. The pic micro controller has a pulse width modulation module which used to control the robot in the specific rotation. The controller has a many input and output module which used to interface many devices. The sensors used to acquire the signal from the environment based on the sensor signal the robotic arm performed is task [9]. The electronic equipment of the arm is initial designed and tested on a bread board and so the particular computer circuit board (PCB) is constructed within the final step and also the electronic devices area unit soldered on the PCB.



Courtesy: Google

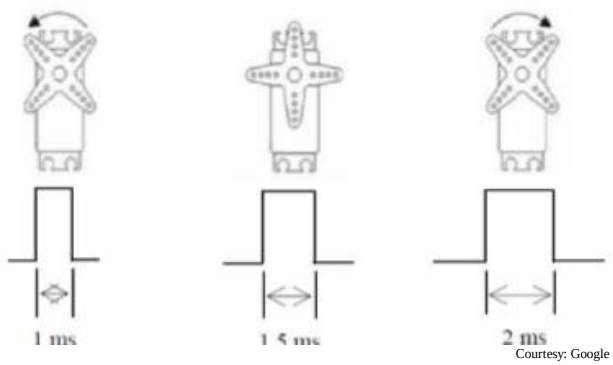
Figure 3. PIC 16F877A Microcontroller

A. PIC 16F877A Microcontroller

The microcontroller has a flash program memory and non-volatile EEPROM. It has 40 pins which used to interface many devices. out of 40 pin 33 used to input and output. Other 8 pin used to analogue and digital converters with 10-bit resolutions. It has a PWM generator with 3 timer circuits. It has a synchronous receiver transmitter, internal and external interrupt capabilities. the figure 3 shows the architecture of the pic microcontroller

B. *Microcontroller interface with motor*

Serov motor has Square measure exceptional properties. Using PWM the motor is controlled. The motor connected to the potentiometer this is feedback method used in this project. The feedback system indicates the current position of the servomotor with respective to the potentiometer voltage. The servo motor has rotation from zero to 180 degrees. In the base it has 360 degree. This motor controlled with signal sent from the controller. The PWM Signals sent from the controller. Servo motors are controlled with PWM signals. The PWM signals square measure generated with the microcontroller is discussed in this study. The direction of the motor based on the pulse width modulation is show in the figure 4. Based on the PWM pulse width the motor is rotated.



Courtesy: Google

Figure 4. Servo motor effect with PWM signal

The mathematical equation of the servo motor circuit is given below

$$V_a = R_a I + L_a\left(\frac{di}{dt}\right) + E_b \quad (9)$$

$$J\left(\frac{dw}{dt}\right) = T_e - T \quad (10)$$

$$Eb = K_w,\ T_e = K_e \quad (11)$$

Where i_a, V_a, R_a, L_a are armature current, voltage, resistance, inductance, K torque, w rotor angular speed, Te is electromagnetic torque, T total load torque and J rotor inertia. It is important to keep in mind that the built-in oscillator of microcontroller operates with 1MHz, therefore the oscillator should be adjusted accordingly.[12] Robot the oscillator is adjusted by connecting a 4MHz crystal and two 22µF capacitors to oscillator pins (OSC1 and OSC2) of the microcontroller in order to increase the process speed of the microcontroller, the servo motor operate properly with respect to the PWM signals.

C. *Implementation*

The control diagram derived from behaviour of the system and simulation of the models is shown in figure.[13] It ought to be mentioned that since the shoulder servos operate at the same time, Shoulder axis 2 and Shoulder axis 3 are connected with port D.1 controller to receive the PWM signal. As seen in below figure 5, shown the microcontroller connected with the servo motors. This motor is controlled by the PWM pulse.

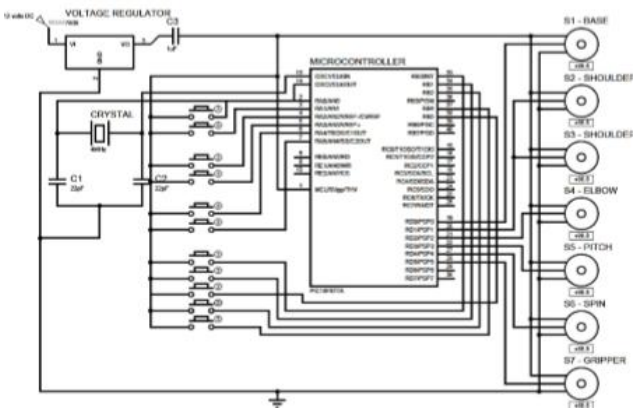


Figure5. Arm controller connected with servo motor

the figure 6 show the flowchart behaviour of the robotic arm in a generalized way. When a button is pressed, the corresponding PWM signal is received to the motor generated by the microcontroller. If the proximity sensor isn't activated, the robot is continuing to grasp and finish the job. Otherwise the corresponding servo motor stops and also the arm will continue and end the task once the device is deactivated.

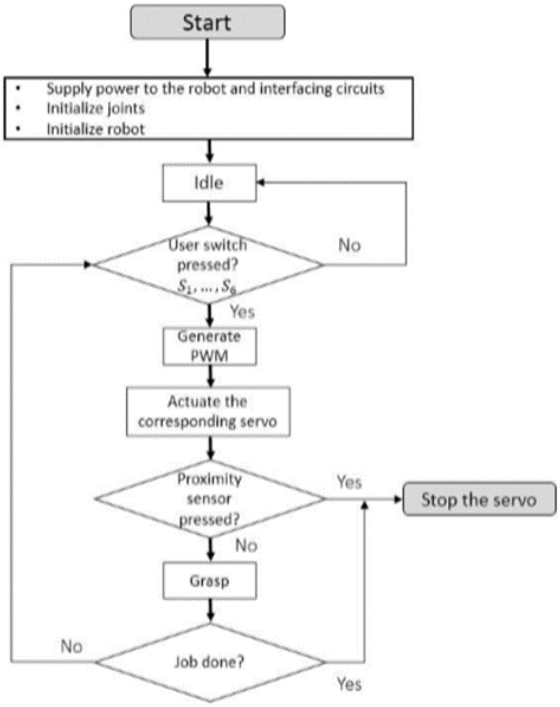


Figure 6. Flow chart of robotic arm

The procedure shown within the flow diagram in above picture 6 is processed with microcontroller. The micro controller is programmed based on the user requirement. it easy to use the user [16].

There are different approaches to program like C++ and embed program used in the robotic arm. The pic basic pro compiler used generate the hex files for the microcontroller. Then file is dumped into the controller.

When the HEX code is prepared, it dumped on the EPROM of the controller. PULSIN, PULOUT, are the most common commands of the PBP language. Commands primarily generate pulses as Associate in Nursing output or it store the pulse it used to ensure the input steps.

The controller is connected to computer via a coder. After microcontroller is programmed then it removed from the base and place in to the location. Then the power is switched on the micro controller is worked.

Once it is setup the arm is moved towards the desired location and once on reaching the spot the weld gun is supplied with power supply. Now the movable

shank is closed and this brings a contact between the metal surface and the tips of the weld gun. Due to this a closed circuit is formed and this leads to the flow of current from one shank to another through the sheet. Thus, a massive heat is generated due to the flow causing the spot welding. Using some Rocker Bogie mechanism, we can make moving robot [19]. This used to give mobility to the robot.

IV. RESULT AND DISCUSSION

The proposed model is a prototype of the industrial grade system used for welding. The structure is far more cost efficient and is comparatively weighs less. Each and every servo are iterated to produce the exact amount of output and the parts are selected only as per requirement. The weld gun parameter is met and the processing is efficient in order to achieve the cycle time as accurate as possible.

V. CONCLUSION

Thus, the spot welding is carried out with the robotic arm using the PIC16F877A microcontroller. Using the robots for welding is a good example of a cost-effective production process. It also improves the quality of the work compared to the manual welding and also increases the production rate the system is cost efficient and will have more advantages compared with the manual method. This is prototypes to process the given parameters.

REFERENCES

1. F. Olson, Lab. JP, Technol. CIo, Pasadena., “Probabilistic self-localization for mobile robots”,IEEE Transactions on Robotics and Automation, 2000.
2. Abhishek Bhambere., “Design of 6-Axis robotic arm” ,International Journal of Advance Research, 2015.
3. Ahuja, N., Sreedaran, R., "Computer Controlled Robotic Arm", IEEE Computer Society, Symposium on Computer-Based Medical Systems (CBMS), pp.361-366, 2003.
4. Hao, G. W., Leck, Y. Y., Hun, C. L., "6-DoF PC-Based Robotic Arm (Pc Robotarm) With Efficient Trajectory Planning And Speed Control", International Conference on Mechatronics (ICOM), pp.1-7, 2011.
5. Seki, K., Yokoi, H., Iwasaki, M., “Experimental Evaluations of Friction Behavior in Micro-Displacement Region Positioning for Servo Motor with Air Bearings” Proceeding of IEEE International Conference on Advanced Intelligent Mechatronics, pp.731-736, 2012.
6. R.B. Gillespie, J. E. Colgate, M. A. Peshkin., “A general framework for robot control”,IEEE Transactions on Robotics and Automation 2011
7. Kramer, A. K., Anderson, M., "A PIC18 Robot-Centered Microcontroller Systems Laboratory", IEEE Frontiers in Education Conference (FIE), pp.1-6, 2011.
8. Park, I. D., Park, C., Do, H., Choi, T., Kyung, J., "Design And Analysis of Dual Arm Robot Using Dynamic Simulation" IEEE 10th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), pp. 681-682, 2013 .
9. Puran Singh , Anil Kumar, Mahesh Vashisth ., “Design of a Robotic Arm with Gripper & End Effector for Spot Welding” ,Universal Journal of Mechanical Engineering 1(3): 92-97, 2013
10. Govil, V. K., Charuasia, Y., “Modeling and Simulation of PWM controlled Cycloconverter FED Split Phase Induction Motor” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Issue 3, Vol. 1, pp.126-133, 2012. [7]Lin, I. H., Liu, C. Y., Chen, L. C., "Evaluation of Human-Robot Arm Movement Imitation", Proceedings of 8th Asian Control Conference (ASCC), pp.287-292, 2011.
11. Muir, F. P., Neuman, P. C., "Pulsewidth Modulation Control of Brushless DC Motors for Robotic Applications", IEEE Transactions on Industrial Electronics, Issue 3, Vol. 32, pp.222-229, 1985.
12. Kabuka, R. M., Glaskowsky, N. P., Miranda, J., "Microcontroller-Based Architecture for Control of a Six Joints Robot Arm”, IEEE Transactions on Industrial Electronics, Issue 2, Vol. 35, pp.217-221, 1988.
13. Bejo, A., Pora, W., Kunieda, H., "Development of a 6-Axis Robotic Arm Controller Implemented on a Low-Cost Microcontroller", " IEEE 10th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), pp.328-331, 2009.
14. Haidari, A. M. A., Benachiba, C., Zahir, M., “Software Interfacing of Servo Motor with Microcontroller”, Journal of Electrical Systems (JES), pp.84-99, 2013.
15. Şahin, S., İşler, Y., "Microcontroller-Based Robotics and SCADA Experiments", IEEE Transactions on Education, Issue 4, Vol. 56, pp.424-429, 2013.
16. Hung, C. P., Liu, W. G., Su, H. J., Chen, J. W., Chiu, B. M., “PIC-Based Multichannel PWM Signal Generation Method and Application to Motion Control of Six Feet Robot Toy” International Journal Of Circuits, Systems And Signal Processing, Issue 2, Vol. 3, pp.73-81, 2009.
17. Alimul, Dr. Tofayel Ahmed., “Design, Analysis and Implementation of a Robotic Arm- The Animator“ ,American Journal of engineering research, 2011.
18. Vignesh T, Karthikeyan P, Sridevi ,”Modelling and Trajectory generation of bionic hand for dexterous task “,IEEE Explore.
19. S. Madhankumar, M. Jishnu, J. Karthick Prithiv, S. Gowrishankar, S. Rajesh R. Balamurugan,” Design and Modelling of Disaster Relief Vehicle using Rocker Bogie Mechanism “, International Journal of Innovative Technology and Exploring Engineering, 2019

AUTHORS PROFILE

Prof. T. Vignesh is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has obtained B.E, degree in Mechanical Engineering from Jeppiaar Engineering College, Chennai, India in 2015 and M.E., degree in Mechatronics Engineering from Madras Institute of Technology, Chennai, India in 2017. His research interests include Robotics and Automation. He has published a number of research papers in international journals and conferences and guided a number of UG Scholars**.**

Prof. N. Manikandan is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has obtained his B.E, degree in Mechatronics Engineering from Kumaraguru College of Technology, Tamilnadu, India in 2010 and M.E, degree in Computer Integrated Manufacturing from PSG College of Technology, Tamilnadu, India in 2013. His research areas include Robotics, Additive Manufacturing and Manufacturing Systems.

Prof. S. Kannaki is working as Assistant Professor in the Department of Mechatronics Engineering at Sri Krishna College of

Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. she has attained B.E, degree in Electrical and Electronics Engineering from PSNA College of Engineering and Technology, Dindigul, India in 2005 and M.E., degree in Power Electronics and Drives from PSNA College of Engineering and Technology, Dindigul, India in 2007. She is doing research in Advanced Meter Infrastructure in Smart Grids. She has published a number of research papers in international journals and conferences and guided a number UG Scholars.

Prof. C. Prasath is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has Obtained B.E, degree in Mechanical Engineering from Adhiparasakthi Engineering College, Melmaruvathur, India in 2009 and M.E., degree in Production Technology from Thiagarajar College of Engineering, Madurai, India in 2013. He has published a number of research papers in international journals and conferences and guided a number UG Scholars**.**