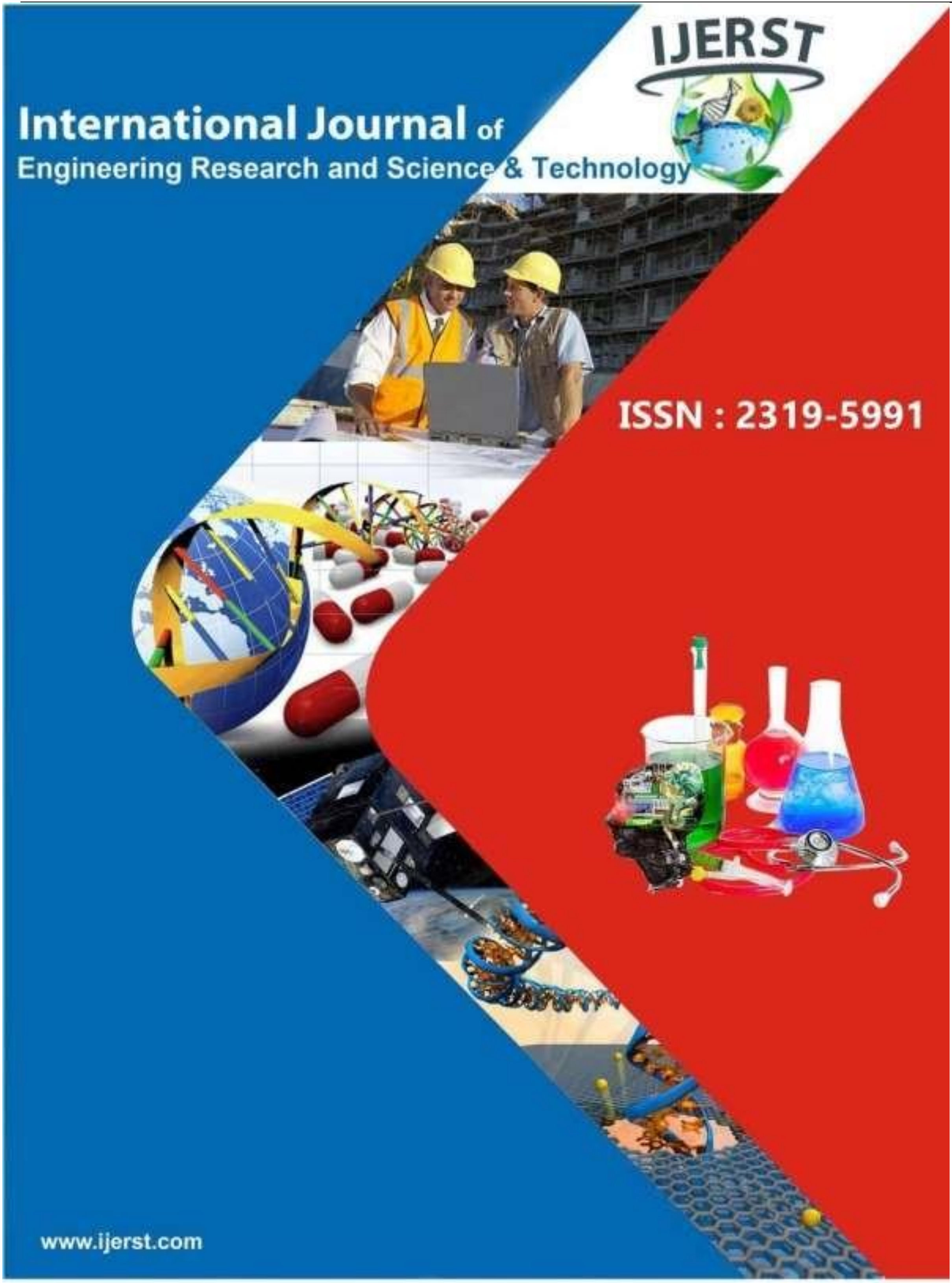

Email: editor@ijerst.com or editor.ijerst@gmail.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 19, Issuse.2,June 2023

EMF BASED SENSOR-LESS SPEED CONTROL OF BLDC MOTOR USING A TWO STAGE AC-DC CONVERTER

Dr. R. Durga Rao, Mr. Kumar Saliganti,

Article Info

Received: 24-01-2023 *Revised: 14-02-2023* *Accepted: 06-03-2023*

Abstract: This paper presents an AC-DC converter for speed control of a Brushless DC(BLDC) Motor. This model consists of two stages in which, the first stage is an AC-DC converter also known as a diode bridge rectifier and the second stage is the DC-DC buck converter. A dc-link capacitor couples the two stages which is used to eliminate the ripple present in the output of the rectifier. In order to control the speed of BLDC motor, it is important to know the rotor position. This paper illustrates the use of an emf-based sensor-less control technique for rotor position detection. A PWM based feedback control loop is used to regulate the output of buck- converter which controls the output of BLDC Motor. This technique has been implemented for the speed control of a brushed DC Motor but now-a-days there are a large number of applications for BLDC motor. So, an efficient speed control system is essential. Sensor-less speed control technique overcomes the drawbacks of sensor-based control technique such as temperature sensitivity and higher costs. Hence, this paper presents the implementation of sensor-less control to control the speed of BLDC motor using MATLAB/SIMULINK.

Keywords: *Bridge rectifier, Buck converter, Inverter, Feedback control, BLDC motor, Pulse Width Modulation.*

I. INTRODUCTION

Now-a-days, due to the raise in the utility of DC power ranging from 12V to 400V, the usage of single-phase AC-DC converter has raised. A large number of applications involve the use of brushless dc motors in that power range. Hence, it is necessary to have an efficient power conversion system.

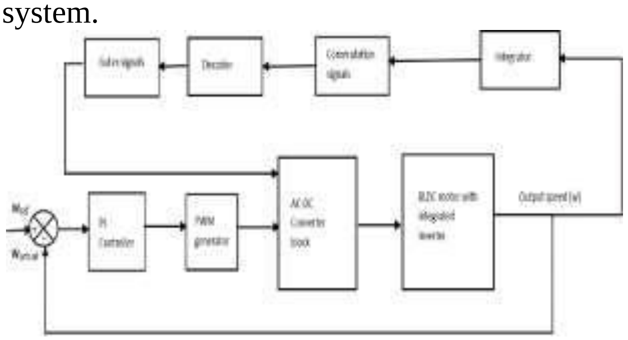

Fig-1: Block diagram of proposed system

The above two stage ac to dc converter is used to regulate the speed of a brushless dc motor. WE need to control the output voltage of the buck converter to regulate the speed of motor. This can be achieved by a good feedback control loop. However, it is important to consider that the designed feedback control loop must be able to overcome the disturbances. The disturbances inthe feedback loop are mainly due to variations in load, input voltage changes, and electromagnetic interference. The cause for these disturbances is the non-linearity of semiconductor devices such as IGBTs, transistors and diodes [1],[2].

Associate Professor & Head
Assistant Professor
Department of Electrical & Electronics Engineering,
JNTUH University College of Engineering Manthani

Hence, to get the output voltage as desired, the feedback control system must be able to reject the disturbances. Many control schemes such as predictive method of control [3], adaptive method ofcontrol [4], Sliding mode type control [5], control using fuzzy logic [6] have been proposed by researchers. This lead to better functionality of feedback control system. This paper presents the implementation of PWM control technique because of its less complexity. Also, in order to control the speed of brushless DC motor, it is necessary tolocate the position of the rotor so that the supply can be given to the respective phase according to the position of the rotor. For this, Hall sensors are used generally but because of the high sensitivity ofhall sensors to temperature, they may miss-behave at higher loads as temperature increases. Hence, this paper presents the implementation of a sensor-less control technique, which is based on the EMF induced in the motor [7][8]. In order to achieve high efficient conversion, the rectifier as well as dc-dc converter should be efficient. As BLDC motor is used in the paper, the noise obtained is very low compared to when a normal DC motor is used.

II. TOPOLOGY DESCRIPTION

A PI controller is used for the converter's closed loop operation, which is closer to the two stage AC-DC converter block. AC-DC converter, VSI, which is integrated to the BLDC motor that converts DC input to AC output and IGBTs, which are used as switches for the inverter of the Three-Phase BLDC motor. These are the components that are used inthe proposed model.

A. PI speed controller design

A PI controller is used in the proposed method. The 3-phase BLDC drive's swift and precise response characteristics can be obtained using this controller. The following is description of PI controller functions: The relative part reduces the aggravation from the plant while steady-state error in the system is reduced by the integral part. Error is proportional to the proportional part:

$$U = KPe(t)$$

The integral part will vary in proportion to the area under error curve:

$$U = KI * \int e(t)dt$$

Then, the PI controller can be represented as

$$U(t) = Kpe(t) + KI \int e(t)dt$$

Where,

e(t) = speed reference – actual speed

B. Front end AC-DC converter

The AC-DC conversion block described in this paper essentially consists of two stages. The first stage is an AC-DC converter which is a full bridge rectifier. Since the rectifier operates at the power frequency of 50 Hz, switching loss is not a problem.By attaching a capacitor to the rectifier's output, ripples in the rectifier's output are reduced to a minimum.

C. DC-DC Converter

The second stage is the DC-DC converter which converts fixed DC into variable DC, which is nothing but a buck converter [9]. It consists of an inductor (L), capacitor(C), switch, and a diode (D). The DC motor receives the converter's output. The converter can be operated in continuous conduction mode by proper selection of the diode with a proper switching frequency and a duty cycle of D. The size of the inductor can be found by using the formula given below:

$$L_{(buck\ converter)} \geq (DT/2L) * (V_{input} - V_{output})$$

D. The BLDC motor and speed control

The amount of error is obtained from its reference value and the actual speed of motor.

$$e(t) = \omega(ref) - \omega(actual)$$

Where,

e(t)= error obtained

(ref) = reference speed

(actual)= speed of the motor

The error obtained is given to the PI controller and it reduces the error and hence the speed of the motor is controlled.

E. Integrator

The output speed of the motor is integrated to find the rotational angle. Using this rotational angle, the position of the rotor can be found and according to that position the gate pulses will be given to the respective phases of the 3-phase inverter.

F. Commutation signals

The mechanical angle obtained from the integrator is converted into electrical angle inside this block and after finding the electrical angle, the phase to be fired will be known.

G. Decoder

In this block, the output from the commutation signals block is decoded. According to that output, the direction of the back EMF can be known.

H. Gates

Once the emf direction is known**,** according to the direction, the gate signals which will be given to the switches of the inverter are generated. According to the gate pulses the phase to which the input voltage to be given will be decided.

III. SIMULINK MODEL

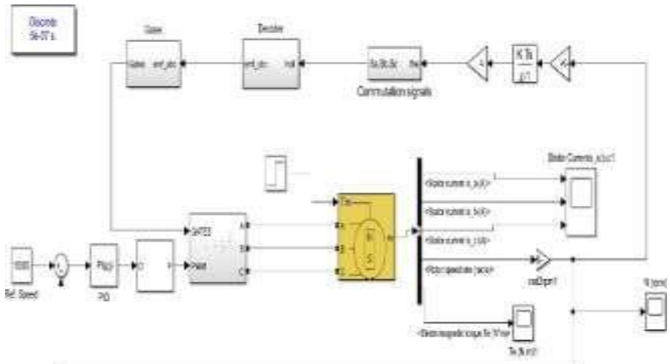

Fig-2: simulink model for the proposed system

Here, the actual speed is compared with the reference speed. By comparing the actual speed with the reference speed. An error is obtained if they are not equal. That error is reduced by the pi controller. The output of the PI controller is given to the input of the PWM generator. And from that it is given to the subsystem. Subsystem consists of 3- phase power supply, diode bridge rectifier, DC-DC buck converter and inverter. 400Vrms value is givento the 3- phase power source. That input is given to the rectifier which converts AC to DC. A DC link capacitor is connected to the rectifier to reduce the ripple content. That DC output is given to the buck converter which steps down the voltage with respect to speed. Next, there will be an inverter. Gate pulses coming from the sensor-less strategy are used for the switching of inverter. Sensor-less strategy contains of an integrator block, commutation signal and decoder and gate subsystems. Integrator is used to integrate the speed in sec to convert it into the mechanical angle. This angle is then converted into electrical angle. According to this angle, output from the commutation signals subsystem is obtained which resemble that of the output of hall sensors. Then, this output signals are decoded inside the decoder block to obtain the direction of back EMF induced. Then back EMF direction signals obtained from theprevious block are converted into 6 signals which will be the gate pulses that will be given to the switches of the inverter. In this way, the speed of the motor is controlled.

IV.RESULTS AND DISCUSSION

Input voltage given to the rectifier is 400 volts. When this voltage is given, the output of buck converter that is obtained is 145 volts.

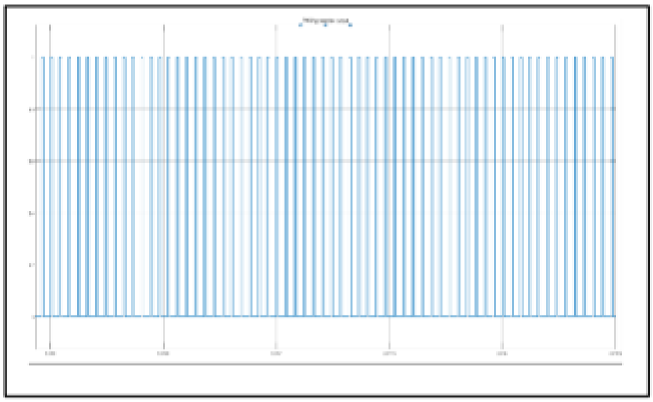

Fig-3: PWM Generator output

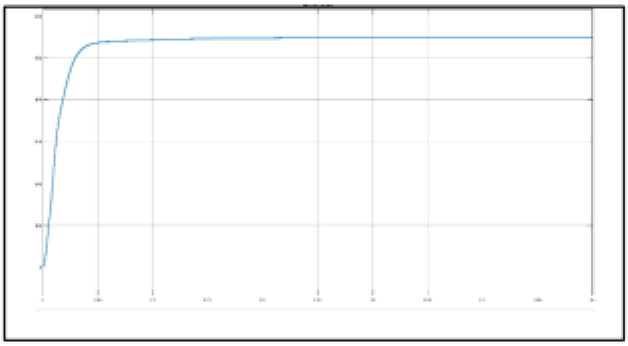

Fig-4: Voltage of rectifier

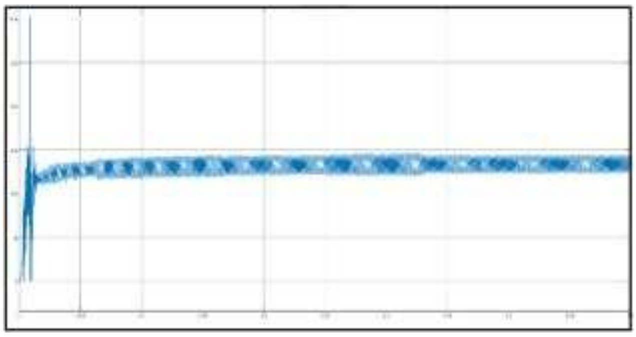

Fig-5: Buck converter output

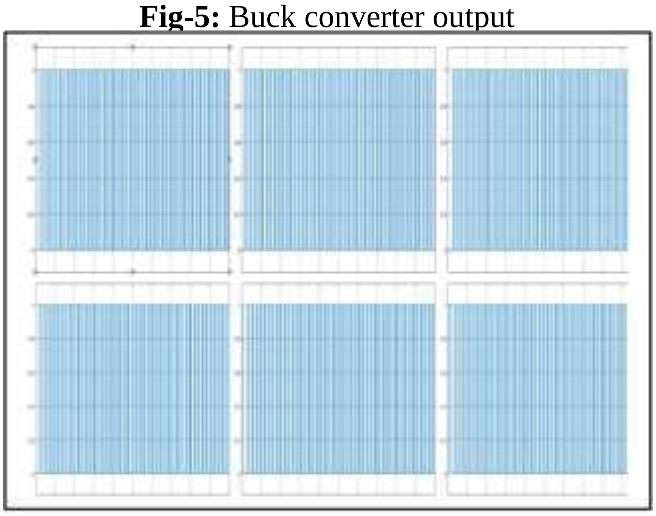

Fig-6: Gate pulses

IJERST International Journal of Engineering Research and Science & Technology

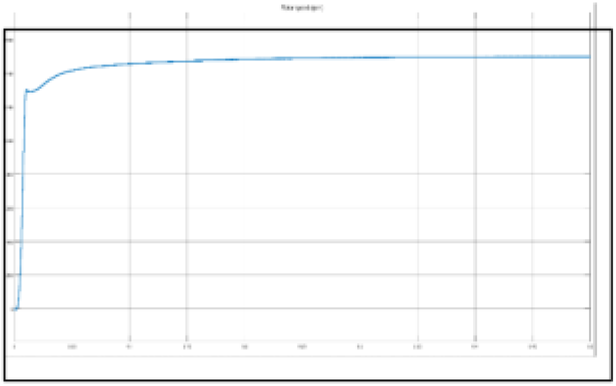

Fig-7: Speed of the motor

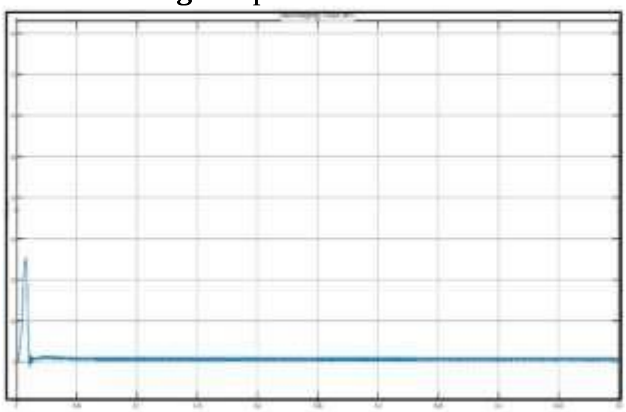

Fig-8: Torque of the motor

The ripple content obtained in the output of the buck converter is low. This shows the efficiency of the converter. BLDC motor gets input from the output of the buck converter. Initially, the obtained speed is 1300 rpm for a torque of 0.5 N-m and as the reference voltage that was given is 1500 rpm it took the motor 0.05 sec to reach the reference speed. As BLDC motor is used in place of the normal DC motor, noise in the motor will be reduced and the performance of the motor in terms of speed has been improved. And also, as sensor-less control is implemented instead of using hall sensors, the inefficiency of the motor at high temperatures due to high loads will be decreased and hence, the performance of the motor is increased.

V.CONCLUSION

In this paper, the performance of the BLDC motor is analyzed, when its speed is controlled using an EMF-based sensor-less control technique and a two stage AC-DC converter. In applications where high speed is desired, sensor-less control gives more efficient results than sensor control.

REFERENCES

[1] P. Karamanakos, T. Geyer, and S. Manias, "Direct voltage control of dc-dc boost converters using model predictive control based on enumeration," in 2012 15th International Power Electronics and Motion Control Conference (EPE/PEMC), Sept 2012, pp. DS2c.10–1–

DS2c.10–8.
[2] S. C. Tan, Y. M. Lai, and C. K. Tse, “General design issues of sliding- mode controllers in dc x2013;dc converters,” IEEE Transactions on Industrial Electronics, vol. 55, no. 3, pp. 1160–1174, March 2008.
[3] S. K. Kim, C. R. Park, J. S. Kim, and Y. I. Lee,“A stabilizing model predictive controller forvoltage regulation of a dc/dc boost converter,”IEEE Transactions on Control Systems Technology, vol. 22, no. 5, pp. 2016–2023, Sept2014.
[4] J. Linares-Flores, A. H. Mndez, C. Garca-Rodrguez, and H. Sira-Ramrez, “Robust nonlinear adaptive control of a x201c;boost x201d; converter via algebraic parameter identification,” IEEE Transactions on Industrial Electronics, vol. 61, no. 8, pp. 4105–4114, Aug 2014.
[5] H. Sira-Ramrez, “On the generalized pi sliding mode control of dc-to-dc power converters: A tutorial,” International Journal of Control, vol. 76, no. 9-10, pp. 1018–1033, 2003. [Online]. Available: http://dx.doi.org/10.1080/0020717031000099047
[6] C. Elmas, O. Deperlioglu, and H. H. Sayan, “Adaptive fuzzy logic controller for dc-dc converters,” Expert Syst. Appl., vol. 36, no. 2, pp. 1540–1548, Mar. 2009. [Online]. Available: http://dx.doi.org/10.1016/j.eswa.2007.11.029
[7] Gamazo-Real, J.C.; Vázquez-Sánchez, E.; and Gómez-Gil, J. (2010). Position and speed control of brushless DC motors using sensor-less techniques and application trends. Sensors, 10(7), 6901-6947.
[8] Johnson, J.P.; Ehsani, M.; and Giizelgiinler, Y. (1999). Review of sensorless methods for brushless DC. Conference Record of the 1999 IEEE Industry Applications Conference. Thirty-Fourth IAS Annual (Cat.No.99CH36370), Meeting Phoenix, AZ, USA, 0197- 2618.

Author’s Profile

Dr.R.Durga Rao, currently working as an Associate Professor & Head, Department of Electrical & Electronics Engineering, JNTUH University College of Engineering, Manthani. Obtained his Ph.D in Electrical Engineering (in High Voltage Engineering) from Jawaharlal

Nehru Technological University Hyderabad. He has 20 years of teaching Experience and established various Laboratories in Department of EEE. He has 15 years of administrative experience at various positions. He is technical expert member in various committees. He is a Fellow Member of the Institution of Engineers, LIFE Member of the Indian society for Technical Education & System Society of India. He has published more than 50 research papers in National & International Journals. He has attended and conducted several conferences, workshops, faculty development programs, orientation courses. He has done extensive research in the areas of Gas insulated Substations, High Voltage Engineering, Electrical Power Systems, Electrical Machines, Electrical Distribution Systems.

Mr. Kumar Saliganti, currently working as an Assistant Professor (C) & Department of Electrical & Electronics Engineering, JNTUH University College of Engineering Manthani. He is pursuing his Ph.D in Electrical Engineering (Power Quality) in University College of Engineering, Osmania University, Hyderabad. He received M.E in Power Systems from Osmania University, Hyderabad in 2009 and received his B.E EEE from Vasavi College of Engineering affiliated to Osmania University, Hyderabad, India in 2005. He has 12 years of teaching Experience in JNTUH University College of Engineering Manthani. He has published five papers in International Journals. He has attended several workshops, faculty induction & development programs and refresher courses.