International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Quadratic Boost Converter Fed Switched Reluctance Motor with Improved Dynamic Response.

Mohammad Aheraz Bin Muslim, Neeraj Prasad, Saugaat Gupta, K. Vijayalakshmi

Abstract- Quadratic boost converters in Switched reluctance motor will enhance the output of the motor in the ratio 1:2 thereby making it more efficient. SRM is generally used in heavy ships and aviation which will help to reduce the emission of CO2 through combustion engines. The proposed model will have reduced switching losses with increased output power.

In this paper the authors have proposed the idea of simulation of the existing circuit diagram of the SRM drive open loop system, QBC with SRM drive open loop system. Apart from this, the simulation of QBC with SRM drive closed loop PI controller and QBC with SRM drive closed loop FLC controller will be simulated and their voltage output, speed, torque and power will be compared.

The proposed system will help us to compare the output of the existing model and the proposed model in terms of rise time, peak time, settling time etc.

Keywords- Quadratic boost converter, switched reluctance motor, PI controller, FLC controller.

I. INTRODUCTION

Currently the use of combustion engines produce tremendous amount of greenhouse gases which are released in the air and deteriorate the quality of air[1].To deal with this problem we need efficient motors to replace the combustion engines[2]. SRM when fed with QBC converter with certain controllers such as PI and FLC produce good output. The speed of motor as well as the torque is increased to 1:2 ratios.

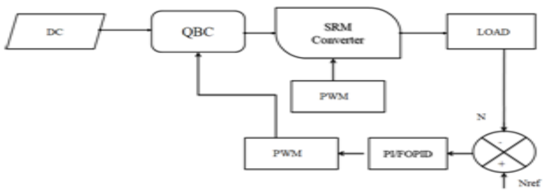

Fig 1. Block Diagram of the proposed model with QBC and PI, FLC controller.

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.

* Correspondence Author

Mohammad Aheraz Bin Muslim, Student, Bachelor of Technology in Electrical and Electronics Engineering from SRM Institute of Science and Technology

Neeraj Prasad, Student, Bachelor of Technology in Electrical and Electronics Engineering from SRM Institute of Science and Technology

Saugaat Gupta, Student, SRM Institute of Science and Technology pursuing Bachelor of Technology in Electrical and Electronics Engineering.

K Vijayalakshmi, Assistant Professor (Senior Grade) of the department of Electrical and Electronics Engineering in SRM Institute of Science and technology.

Switched reluctance motor is very costly [3] but if fed with correct controllers and boosters it can give a very satisfying output.

This proposed model can be used in various industries such as aviation [4] where combustion engines produce fatal gases and heavy ships which still use coal as a source of fuel. It adds an advantage to reduce noise pollution [5] from aviation and coal combustion engines.

Switched reluctance motor is getting much interest because of its industrial applications in the power electronics industry [6].

II. CONCEPT OF FEEDING THE QBC WITH SRM AND CONTROLLERS.

In this paper the SRM converter is fed with the QBC which helps to boost the output DC voltage to twice the input. Hence, the torque, speed, voltage output is increased. Firstly, the simulation of existing system of SRM drive system is simulated using MATLAB software and explained without any QBC converter or controller, and then the boost converter is used and the output is compared. In the existing method the input is 48V DC and the output is also 48V DC with a motor torque of 34 N-m, speed of 600 rpm and mechanical power of 2.1KW. When the QBC converter is fed to the SRM drive with an input of 48V DC it steps up the voltage output to 96V DC output. Moreover, the motor torque rises to 50 N-m, speed to 1100 rpm and the mechanical power to 5.1 KW. In the second part, the QBC fed SRM drive motor is fed with a Proportional integral controller which helps to reduce the dynamic response of the whole system. The PI controller helps to reduce the rise time to 4.29, peak time to 7.31, steady state time to 9.70 and steady state error to 4.9. However, if we use the Fuzzy logic controller instead of the proportional integral controller we get an improved dynamic response which is less than the values retrieved from the PI controller. The rise time, peak time, steady state time and steady state error for FLC controller are 3.52, 4.86, 5.20, and 2.5 respectively.

III. SIMULATION OF THE EXISTING CIRCUIT.

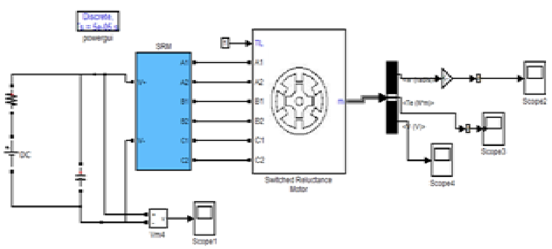

Fig 2. Simulation diagram of the existing circuit.

Here in the above Fig 2 the simulation diagram of the existing circuit is given which does not contain any boost converter nor any controllers.

IV. INPUT VOLTAGE OF THE EXISTING MODEL.

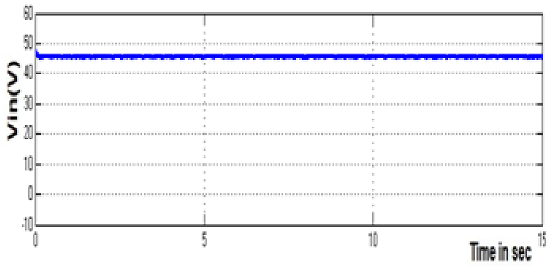

Fig 3. Input voltage of the existing model

In the above Fig 3 the input voltage of the existing model is shown which is 48 Volts DC.

V. OUTPUT VOLTAGE OF THE EXISTING MODEL.

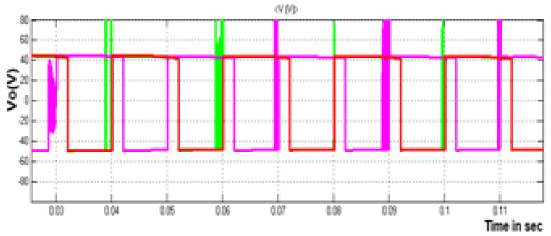

Fig 4. Output voltage of the existing model

In the above Fig 4 the output voltage of the existing model is shown which is 48 Volts DC.

VI. VI. MOTOR TORQUE OF THE EXISTING MODEL.

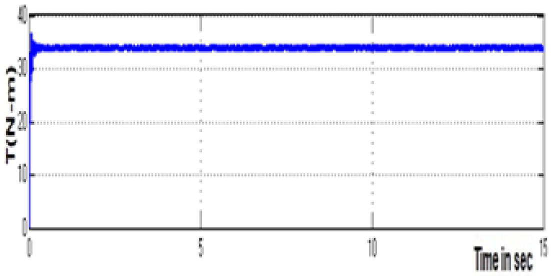

Fig 5. Motor torque of the existing model.

The above graph clearly shows us the motor torque of the existing model which is 34 N-m.

VII. . MOTOR SPEED OF THE EXISTING MODEL IN RPM.

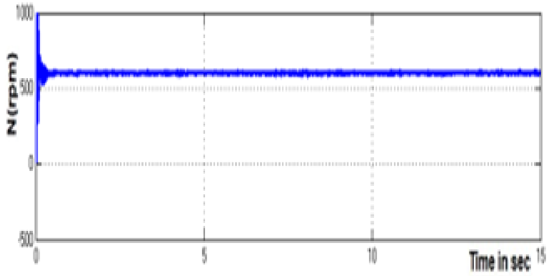

Fig6. Speed of the motor in RPM

In Fig6 the speed of the motor is shown which 600 RPM.

VIII. MECHANICAL OUTPUT POWER OF THE EXISTING SYSTEM.

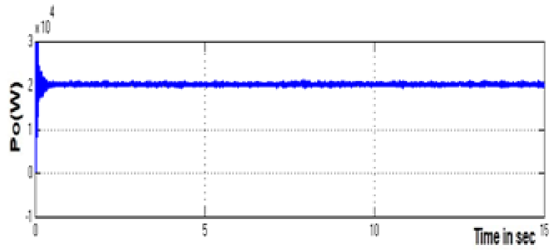

Fig 7. Mechanical output of the existing system.

The above shown graph clearly shows us the mechanical output power which is 2.1KW.

IX. SIMULATION OF THE PROPOSED MODEL (WITH QBC).

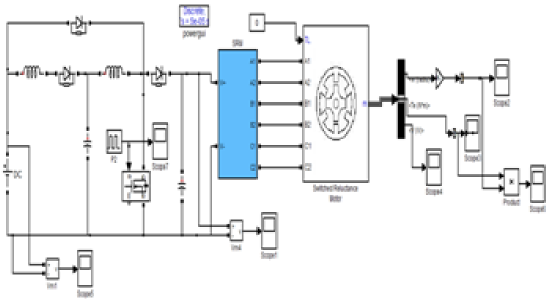

Fig 8. Simulation diagram of the proposed model.

The above given figure clearly illustrates the model which consist of a QBC converter fed to the SRM drive.

X. INPUT VOLTAGE OF THE PROPOSED MODEL (WITH QBC).

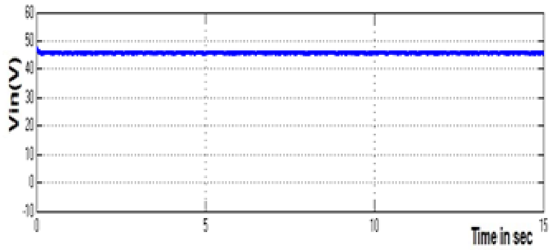

Fig 9. Graph of the input voltage of the proposed model.

The above graph shows the input power fed to the QBC converter which is 48 Volts DC.

XI. VOLTAGE ACROSS QBC (OUTPUT).

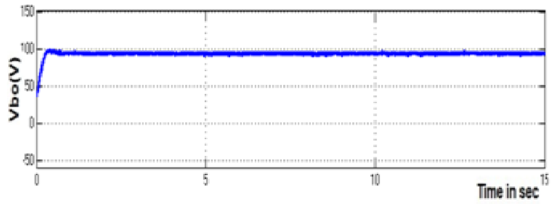

Fig10.Graph of the voltage across output.

The above graph shows us the output voltage across the QBC converter which is 96 volts DC.

XII. MOTOR TORQUE OF THE PROPOSED MODEL (WITH QBC).

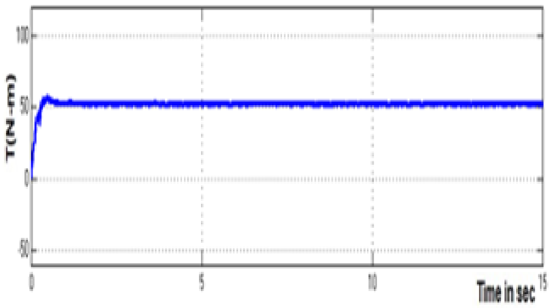

Fig 11. Graph of motor torque of the proposed model.

The graph of the motor torque is shown in Fig 11 which is 50 N-m.

XIII. MOTOR SPEED OF THE PROPOSED MODEL (WITH QBC).

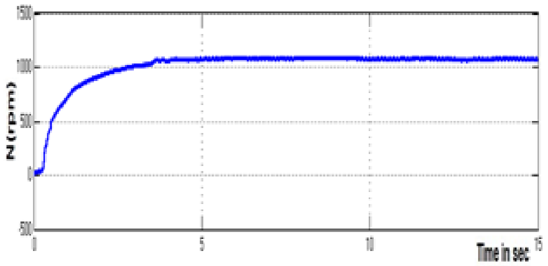

Fig 12. Graph of motor speed of the proposed model.

The above graph shows output of the motor speed of the proposed model which is 1100 RPM.

XIV. MECHANICAL OUTPUT OF THE PROPOSED MODEL (WITH QBC).

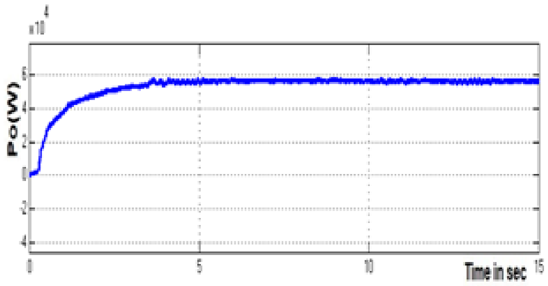

Fig 13. Graph of the mechanical output of the proposed system.

The above graph depicts the mechanical output power of the proposed system which is 5.5 KW.

XV. SIMULATION OF THE PROPOSED MODEL OF QBC& PI CONTROLLER.

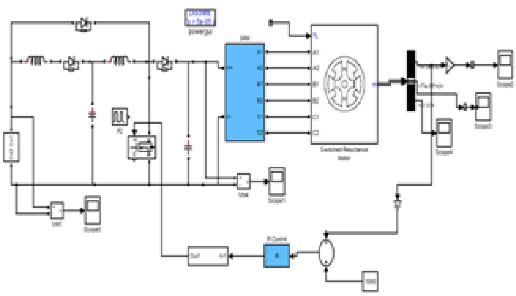

Fig 14. Simulation of the QBC with PI controller.

The above given figure clearly illustrates the diagram of QBC converter with PI controller in a closed loop. The previous section showed us the QBC implementation with existing system and open loop system.

PI controller is used to decrease the steady state error (Ess) without changing the stability of the system. Idea behind PI controller is to deal with nonlinearity.

XVI. MOTOR SPEED OF THE MODEL QBC WITH PI CONTROLLER.

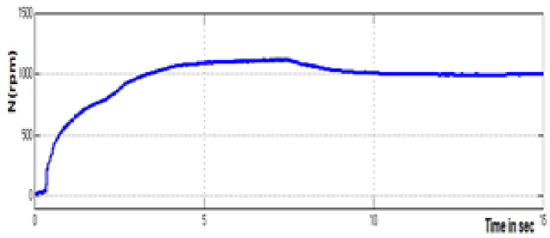

Fig 15. Motor speed of the QBC with PI controller.

The above graph clearly indicates the motor speed when fed with PI controller which is 1100 RPM

XVII. INPUT VOLTAGE OF THE MODEL OF QBC WITH PI CONTROLLER.

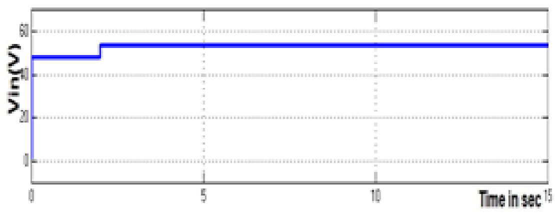

Fig 16. Input voltage of the QBC with PI controller.

The above figure depicts the input voltage of the controller which is around 55Volts DC.

XVIII. MOTOR TORQUE OF THE MODEL OF QBC WITH PI CONTROLLER.

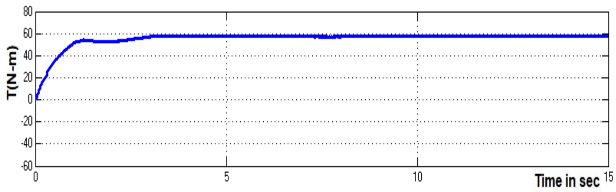

Fig 17. Graph of the motor torque of QBC with PI controller.

The given figure illustrates the motor torque value of QBC with PI controller which is nearly 52 N-m.

XIX. SIMULATION OF THE PROPOSED MODEL OF QBC & FUZZY LOGIC CONTROLLER.

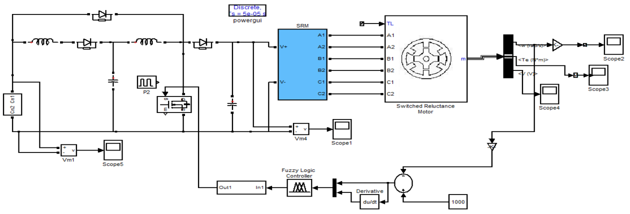

Fig 18. Simulation diagram of QBC with FL Controller.

The above diagram clearly depicts the simulation diagram of QBC and Fuzzy Logic controller in closed loop. The previous section showed us the QBC implementation with PI Controller. To improve the dynamic response of the system we are using fuzzy logic controller. The controller will produce the feedback control.

XX. INPUT VOLTAGE OF THE MODEL OF QBC WITH FUZZY LOGIC CONTROLLER

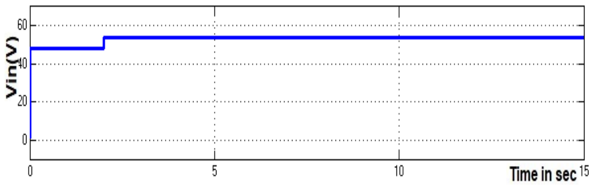

Fig19. Input voltage of the QBC with Fuzzy Logic controller.

The above figure clearly shows the simulation diagram of QBC and Fuzzy Logic controller. Input voltage which range 48 volts to 96 volts

XXI. MOTOR SPEED OF THE MODEL OF QBC WITH FUZZY LOGIC CONTROLLER

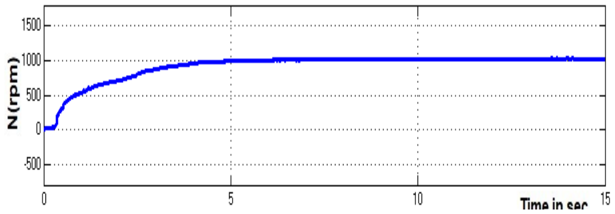

Fig20. Motor speed of the QBC with Fuzzy Logic controller

The above figure clearly shows the simulation diagram of QBC and Fuzzy Logic controller. The output speed of the 6/4 pole motor is 600 rpm to 1100 rpm.

XXII. MOTOR TORQUE OF THE MODEL OF QBC WITH FUZZY LOGIC CONTROLLER

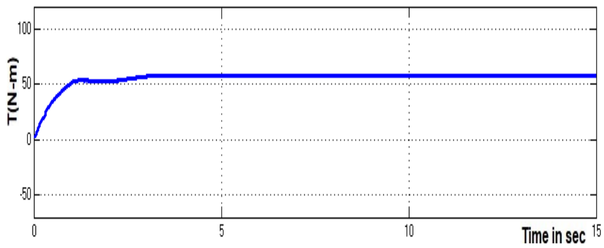

Fig21. Motor Torque of the QBC with Fuzzy Logic controller

The above figure clearly shows the simulation diagram of QBC and Fuzzy Logic controller. The motor torque graph been obtained in the range of 34 N-m to 50 N-m.

The dynamic response of the system has been obtained.

- Rise time
- Peak time
- Settling time
- Steady state error

XXIII. CONCEPT OF RISE TIME, PEAK TIME, STEADY STATE ERROR, STABLE TIME.

Rise time is the amount of time required to reach the final value from initial value with an under damped time response signal in its first cycle. Whereas, the time required by the response to reach its first peak is called the peak time. Stable time is the time required for the output values to get stable. Whereas, the difference between the input and output of the system is known as steady state error. According to the system if the rise time, peak time, stable time and steady state error is less the system has better dynamic response.

In the proposed model the dynamic response values of the QBC with fuzzy logic controller is lesser than the QBC with PI controller. Hence, we can say that the dynamic response of FLC controller is better than PI controller.

XXIV. COMPARISION OF DYNAMIC RESPSONSE OF QBC WITH PI & FLC CONTROLLERS RESPECTIVELY.

Comparison of time domain parameters

Types of controller	Tr	Tp	Ts	Ess
PI	4.29	7.31	9.70	4.9
FLC	3.52	4.86	5.20	2.5

Fig 19. The above table indicates the value of rise time (Tr), standby time (Ts), peak time (Tp) and steady state error values of PI and FLC controllers.

XXV. BAR CHART OF PI AND FLC CONTROLLER DYNAMIC RESPONSE VALUES.

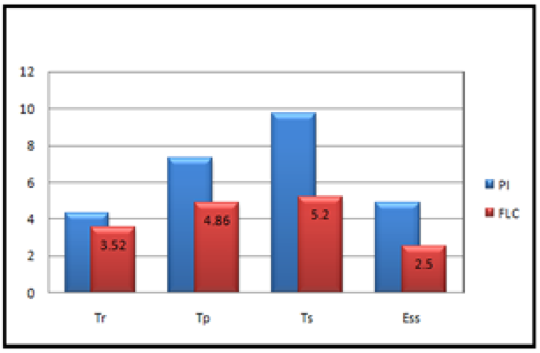

Fig 20. The above bar chart clearly indicates the values of the dynamic response of the proposed model

XXVI. CONCLUSION

From the above research paper, it can be concluded that the Switched Reluctance motor can give better output in terms of Speed, Mechanical Power, Output voltage & torque if a quadratic boost converter is connected in the drive compared to no boost converter. Moreover, after simulation it can also be concluded that using fuzzy logic controller over proportional integral controller gives better output in terms of rise time, peak time, standby time and steady state error.

REFERENCES

1. According to India pollution levels air Delhi health report. [Online available] https://www.vox.com /2018/5/ 8/17316978/India-pollution-levels-air-Delhi health.
2. Vehicular Pollution in India (2118 Words) Article shared by Smriti [online available] Chand. http: //www. yourarticlelibrary.com/pollution/vehicular-pollution-in india-2118-words/19796.
3. According to the Indian markets the Switched reluctance motor is very costly [online available] https://www.switched_reluctance_motor_price.
4. 4.https://www.researchgate.net/publication/308574766__switchedreluctance_motor_for_aerospace_application_Design_analysis_and_results.
5. According to the noise pollution index of Kolhapur [onlineavailable]https:/www.sciencedirect.com/science/article/pii/S1877042812007896
6. Kai- Wei Hu, Pei- Hsun Yi, Chang – Ming Liaw (2015), 'An EV SRM drive powered by Battery/ Super capacitor with G2V and V2H/V2G Capabilities', IEEE Transactions on Industrial Electronics.
7. A review of single-phase improved power quality ac–dc converters,' IEEE Trans. Ind. Electron., vol. 50, no. 5, pp. 962–981.
8. Muthulakshmi. S and Dhannasekaran. R (2015). 'A new switched reluctance motor drive using passive network for marine propulsion' Indian Journal of Geo- Marine Science., Volume 44(11), pp 1807-1814.
9. Hari Prastowo, Francisco Pinto and Semin, (2016)' Advanced Ship Propulsion Technology: A Review', Asian Journal of Applied Sciences (ISSN: 2321 – 089) Volume 04 – Issue 03.
10. Academia publications {online available http://www.academia.edu/Documents/in/Fuzzy_Logic_Controller
11. Hu. Y, Song. X, Cao. W, and Ji. B, (2014) "New SR drive with integrated charging capacity for plug-in hybrid electric vehicles (PHEVs)," IEEE Trans. Ind. Electron., vol. 61, no. 10, pp. 5722–5731.
12. Sundaram Maruthachalam, (2011)," Determination of Flux linkage Characteristics and Inductance of a Submersible Switched Reluctance Motor using Software Tools" Journal of Computer Science 7, ISSN 1549-3636.
13. Jing Bao, Konstantin Boynov, Johannes Paulides, and Elena Lomonova, (2016), "Usage of the Inductive Energy Storage in the Field Winding for Driving the Variable Reluctance Motor", IEEE TRANSACTIONS ON MAGNETICS, VOL. 52, NO. 7.
14. Avoki M. Omekanda et al, (1997)," Calculation of the Electromagnetic Parameters of a Switched Reluctance Motor Using an Improved FEM–BIEM—Application to Different Models for the Torque Calculation", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 33, NO. 4.

AUTHORS PROFILE

(**Mohammad Aheraz Bin Muslim**) student of Bachelor of Technology in Electrical and Electronics Engineering from SRM Institute of Science and Technology with a Grade of First class with distinction.
Published Two research papers, in the field of DC-DC converters in JETIR & in the field of Electric Vehicles hybrid systems in IRJTE journal. (https://www.ijrte.org/wpcontent/uploads/papers/v8i1s4/A108806815419.pdf)&(http://www.jetir.org/papers/JETIR1904386.pdf). Served as the vice president in the IEEE Student branch of the college from (2018-2019) and also served as Historian officer in IEEE Student Branch from (2017-2018).

(**Neeraj Prasad**) student of Bachelor of Technology in Electrical and Electronics Engineering from SRM Institute of Science and Technology and achieved a performance-based scholarship.
Successfully completed the NPTEL certification in Introduction to Probability and Statistics.

(**Saugaat Gupta**) student of SRM Institute of Science and Technology pursuing Bachelor of Technology in Electrical and Electronics Engineering.
Published two papers in the JETIR journal (http://www.jetir.org/papers/JETIR1904386.pdf)&(http://www.jetir.org/papers/JETIR1904676.pdf).Served as the technical head of the IEEE student branch of college from (2018-2019).

(**K Vijayalakshmi**) B. E (Electrical and Electronics Engg) M. E (Embedded System Technologies). Assistant Professor (Senior Grade) of the department of Electrical and Electronics Engineering in SRM Institute of Science and technology.
1. Published a journal on "review of network layer attacks" in iosr journal."performance of dvr and idvr for voltage sag compensation in power distribution network" in international Journal of Pure and Applied Mathematics, volume 118 no. 24 2018.
2."AUTOMATIC PATH FINDER CO-RELATED WITH CO &CH4 DETECTOR" In International Journal of Pure and Applied Mathematics, Volume 118 No. 24 2018.
Membership: International Society for Research and Development (Isrd), Member Id: Sm3140905114