International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 4 Issue: 2

ISSN: 2454-4248
265 – 269

Designing of Solar PV Module with MPPT Controller

Rinku Kumar
Dept. of Electrical Engg.
DCR University of Science & Technology, Murthal, India

Lokendra Kumar
Rajkiya Engineering College
Bijnor, Uttar Pradesh, India

Vijay Kumar
Senior Engineer Electrical
GE India Ltd., Noida, UP, India

Rohit Saini
Dept. of ECE
Hindu College of Eng. Sonepat, India
Corresponding author email ID: rohitsaini2010@gmail.com

Abstract**—**Solar Photovoltaic (PV) systems are having increasing importance in present time of electrical power system due to its non-polluting nature, less maintenance, and free fuel characteristics. The efficiency of the Solar PV system is limited to design constraints that are as follows-Surface Reflection, Carrier Collection, Recombination and Parasitic Resistances. Hence, attaining higher efficiency and achieving maximum power from PV system is the major concern for all utilities which involves the solar PV systems. MPPT is one of the technique by which we can achieve maximum power from the PV module or array.

***Keywords* -** *MPPT; MATLAB (Simulink);Solar PV module*

*****

I. INTRODUCTION

For human lives, energy is the basic requirement. So, its supply should be secure and sustainable. It should be eco-friendly, economic and socially acceptable. The regular hike of fuel prices together with increasing carbon footprints threatens our energy supply. Among all the non-conventional energy resources like as wind, geothermal, solar, ocean etc. solar is abundant. In recent years, various research work have been done on the application of PV as a alternate energy source. PV energy is one of the energy resources as a clean, inexhaustible and can be easily harvested. Several applications employing Solar PV technology have been developed for satellite power systems, solar power generation etc.

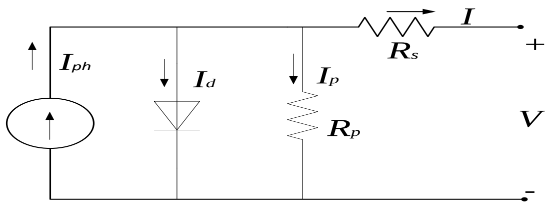


Fig. 1. Practical single diode model with R_s and R_p

The solar cells are represented as the single diode model fig no.A. The equivalent single diode model consists of a controlled current source, a diode, Rs and Rv shunt resistance. The controlled current source depends upon the solar irradiance.

At higher solar irradiance it gives greater value of current. Solar cells are connected in combination of series and according to the voltage, current and power rating is required. The model of solar module is configured by using SIMULINK blocks. Boost converter is used for regulating the voltage of the solar PV system [1-14]. The gate signal of dc-dc converter is given from the MPPT algorithm. The algorithm takes voltage and current signal from the solar PV module and after optimizing voltage value a referenced duty cycle is generated which is given to dc-dc boost converter.

II. BLOCK DIAGRAM OF MODEL

In dc-dc boost converter IGBT is used as switching device. Pulse width modulation technique is used for varying the output voltage of the boost converter. Perturb and observe method is easy to implement and also it tracks Maximum power point accurately.

The generalized block diagram of PV System is shown in figure 2. The input voltage and current of PV System is measured and using these data calculate the instantaneous power. Maximum power point is identified and MPPT algorithm is used to vary the duty ratio of DC-DC Converter accordingly. The duty ratio is varied in such a way that the power delivered from input side to the converter will almost be equal to the power delivered to the load.

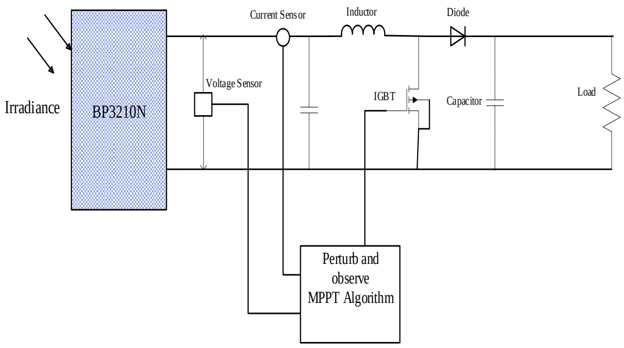


Fig.2. Block diagram of proposed PV system

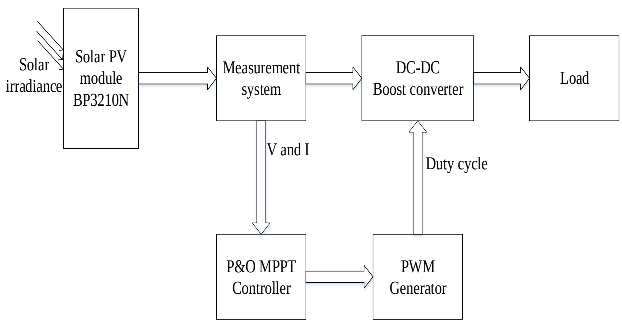


Fig.3 PV System Modeling

ISSN: 2454-4248
265 – 269

Diode current is proportional to the saturation current and is given by the equation:

$$I_d = I_o\left[\exp\left(\frac{V}{A.N_s.V_T}\right) - 1\right] \qquad 2$$

$$V_T = k.\frac{T_c}{q} \qquad 3$$

Where V = voltage imposed on the diode

I_o = reverse saturation current or leakage current of the diode in ampere

T_c = actual cell temperature (K)

k = Boltzmann constant = 1.381×10^{-23}J/K

q = electron charge = 1.602×10^{-19} Coulombs

V_T= thermal voltage (exclusively depend on temperature)

N_s= number of PV cells connected in series

A = ideality factor

III. Implementation of PV Module with MPPT and Boost Converter

Figure 4 shows the implementation of the proposed research work. The Perturb and Observe MPPT algorithm is implemented in this model. This method is used here to perform maximum power point tracking for PV module due to its easiness and ease of execution [15-66]. The boundary and initial value of the duty cycle is specified in MPPT parameters block. The initial value of input duty cycle of P&O algorithm is 0.5, the maximum value of input duty cycle is 0.8 and the minimum value is 0.3.

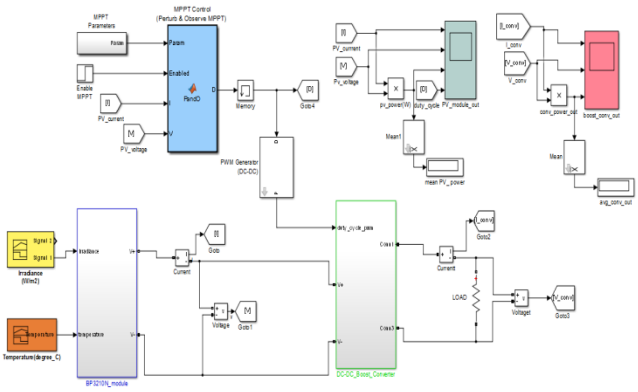


Fig.4 PV Module with MPPT and boost converter

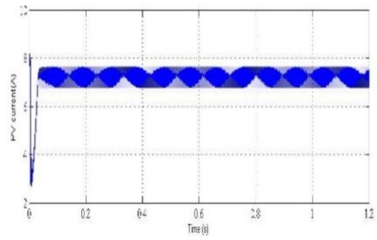
The incremental value of duty cycle is chosen as 0.001 for increase or decrease in duty cycle according to the environmental condition. If the greater incremental change of duty cycle it gives fast response but produces higher oscillation at MPP. If a lower value of incremental change in duty cycle is chosen to increase or decrease duty cycle it gives slower tracking response but it gives minimum oscillation.

The operation of Perturb and Observe starts by measuring the voltage and current at two sampling intervals. By using voltage and current instantaneous power is calculated and compared. By checking these two operating voltage and output power of the PV module at two sampling intervals, the algorithm decides the direction of tracking process, shifting the voltage either to a smaller value or to a larger value. P&O algorithm operates continuously and finding maximum power point at which module operates at maximum power point.

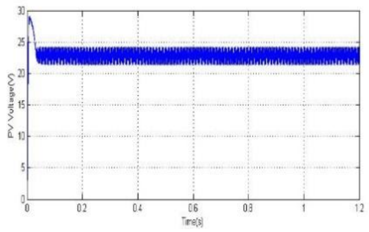
IV. Result Analysis

A. *Simulation at G = 1000w/m² & cell temperature = 45°C*

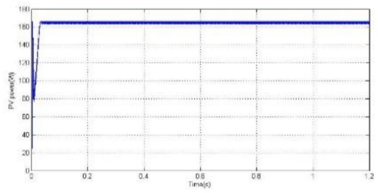
At irradiance level and PV cell temperature of PV Module is 1000W/m2 and respectively, the average power achieved by the PV module is 165.2 Watt. The average value of power at STC is 194.5. Hence, the maximum power point ratio calculated at this condition is 84.95 %. Hence, the boost converter shows the efficiency of 92.7%. The various waveforms are shown at this environmental condition is in figure 5.1.



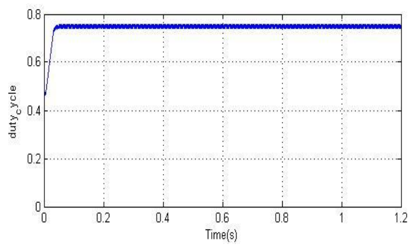
(a) PV module output current



(b) PV module output voltage



(c) PV module output power

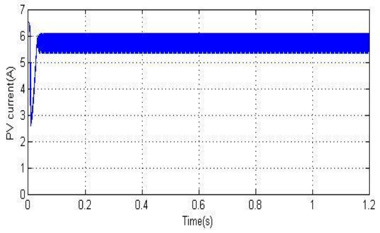


(d) Duty cycle

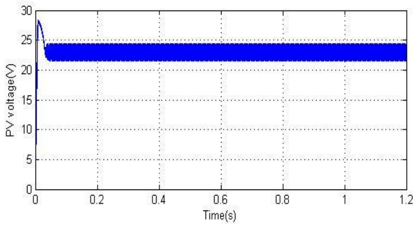
Fig 5.1 Output waveform of PV module at G=1000 W/m² & 45°C

B. *Simulation at G = 800w/m² & cell temperature = 45°C*

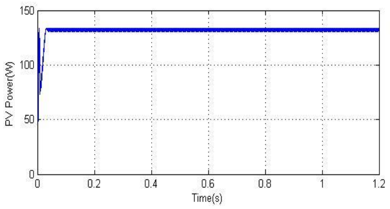
At irradiance level and PV cell temperature of PV Module is 800W/m² and $45^0 C$ respectively the average power achieved by the PV module is 132.4 Watt. The average value of power at STC is 156.7. Hence, the MPP ratio calculated at this condition is 84.49 %. The average output power of the boost converter is 122.7Watt. The various waveforms are shown at this environmental condition is in figure 5.2



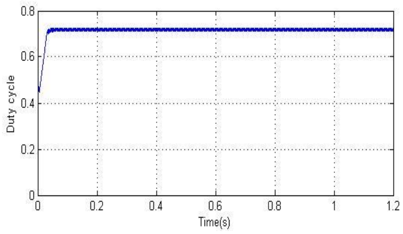
(a) PV module output current



(b) PV module output voltage



(c) PV module output power



(d) Duty cycle

Figure 5.2 Output waveform of PV module at G=800 W/m^2 and 45°C

REFERENCES

[1] R. Singh, Satpal and S. Saini, "Power Sector Development in Haryana," International Journal of Science, Technology and Management, vol. 5, no. 3, pp. 278-285, 2016.

[2] S. Saini, "Evolution of Indian Power Sector at a Glance," National Journal of multidisciplinary research and development, vol. 3, no. 1, pp. 275-278, 2018.

[3] S. Saini, "Rationale behind developing awareness among electricity consumers", International Journal of Research in Engineering Application & Management, vol. 3, no. 11, pp. 1-5, 2018.

[4] S. Saini, "Social and behavioral aspects of electricity theft: An explorative review," International Journal of Research in Economics and Social Sciences, vol. 7, no. 6, pp. 26-37, 2017.

[5] S. Saini, "Scenario of Distribution Losses – A Case Study From Haryana", International Journal of Research in Economics and Social Science, vol. 8, no. 1, pp. 163-175, 2018.

[6] S. Saini, "Malpractice of Electricity Theft: A major cause of distribution losses in Haryana," International Research Journal of Management and Commerce, vol. 5, no. 1, pp. 284-313, 2018.

[7] S. Saini, "Electricity Theft – A primary cause of high distribution losses in Indian State", International Research Journal of Management and Commerce, vol. 8, no. 1, pp. 163-175, 2018.

[8] S. Saini, "Expectancy-disconfirmation based assessment of customer Satisfaction with electric utility in Haryana," International Research Journal of Human Resources and Social Sciences, vol. 5, no. 1, pp. 320-335, 2018.

[9] S. Saini, "Service quality of electric utilities in Haryana – A comparison of south and north Haryana", International Journal of Research in Engineering Application & Management, vol. 3, no. 11, pp. 1-8, 2018.

[10] S. Saini, "Analysis of service quality of power utilities", International Journal of Research in Engineering Application & Management, vol. 3, no. 11, pp. 1-8, 2018.

[11] S. Saini, "Difference in Customer Expectations and Perceptions towards Electric Utility Company," National Journal of multidisciplinary research and development, vol. 3, no. 1, pp. 264-269, 2018.

[12] S. Saini, "Appraisal of Service Quality in Power Sector of NCR," National Journal of multidisciplinary research and development, vol. 3, no. 1, pp. 270-274, 2018.

[13] S. Saini, R. Singh and Satpal, "Service quality assessment of utility company in Haryana using SERVQUAL model," Asian Journal of Management, vol. 9, no. 1, pp. 212-224, 2018.

[14] S. Saini, "Influence of gender on service quality perceptions", International Journal of Economics, Commerce & Business Management - A Peer Review Quarterly Journal, vol. 5, no. 1, pp. 169-179, 2018.

[15] R. K. Beniwal, A. Aggarwal, R. Saini and S. Saini, "Analysis of electricity supply in the distribution network of power sector," International Journal of Engineering Sciences & Research Technology, vol. 7, no. 2, pp. 404-411, 2018.

[16] R. Kumar, A. Aggarwal, R. K. Beniwal, Sumit, R. Paul and S. Saini, "Review of voltage management in local power generation network," International Journal of Engineering Sciences & Research Technology, vol. 7, no. 2, pp. 391-403, 2018.

[17] Sumit, R. K. Beniwal, R. Kumar, R. Paul and S. Saini, "Modelling for improved cyber security in Smart distribution system," International Journal on Future Revolution in Computer Science & Communication Engineering, vol. 4, no. 2, pp. 56-59, 2018.

[18] R. Kumar, Sumit, A. Aggarwal, R. Paul, R. Saini and S. Saini, "Complete management of smart distribution system," International Journal of Engineering Sciences & Research Technology, vol. 7, no. 2, pp. 385-390, 2018.

[19] R. K. Beniwal, A. Aggarwal, R. Saini and S. Saini, "Detection of anomalies in the quality of electricity supply," International Journal on Future Revolution in Computer Science & Communication Engineering, vol. 4, no. 2, pp. 6-10, 2018.

[20] M. K. Saini, R. Dhiman, A. N. Prasad, R. Kumar and S. Saini, "Frequency management strategies for local power generation network," International Journal on Future Revolution in Computer Science & Communication Engineering, vol. 4, no. 2, pp. 49-55, 2018.

[21] M. K. Saini, N. K. Yadav and N. Mehra, "Transient Stability Analysis of Multi machine Power System with FACT Devices using MATLAB/Simulink Environment," International Journal of Computational Engineering & Management, vol. 16, no. 1, pp. 46-50, 2013.

[22] R. Kapoor and M. K. Saini, "Detection and tracking of short duration variations of power system disturbances using modified potential function," International Journal of Electrical power & Energy Systems, vol. 47, pp. 394-401, 2013.

[23] S. Dahiya, A. Kumar, R. Kapoor and M. Kumar, "Detection and Classification of power quality events using multiwavelets," International Journal of Energy Technology and Policy, vol. 5, no. 6, pp. 673-683, 2007.

[24] M. K. Saini and R. K. Beniwal, "Optimum fractionally delayed wavelet design for PQ event detection and classification," International Transaction of Electrical Energy Systems, vol. 27, no. 10, pp. 1-15, 2017.

[25] M. K. Saini and K. Dhamija, "Application of Hilbert-Huang Transform in the Field of Power Quality Events Analysis," Proc. of Int. Conf. on Advances in Signal Processing and Communication, 2013.

[26] M. K. Saini, R. Kapoor and B. B. Sharma, "PQ event classification using fuzzy classifier," Advanced Materials Research, vol. 403, pp. 3854-3858, 2012.

[27] R. Kapoor, M. K. Saini and P. Pramod, "Detection of PQ events using demodulation concepts: A case study," International Journal of Nonlinear Science, vol. 13, no. 1, pp. 64-77, 2012.

[28] M. K. Saini, R. K. Beniwal and Y. Goswami, "Signal Processing Tool & Artificial Intelligence for Detection & Classification of Voltage Sag," Proceedings of the 2016 Sixth Int. Conf. on Advanced Computing and Communication Technologies, pp. 331-337, 2016.

[29] M. K. Saini, R. K. Beniwal and S. Khanna, "Recognition of Power Quality Disturbances in Wind-Grid Integration by using TT-transform," Proceedings of the 2016 Sixth Int. Conf. on Advanced Computing and Communication Technologies, pp. 323-330, 2016.

[30] M. K. Saini, R. K. Beniwal and Y. Goswami, "Detection of voltage sag causes by using Legendre Wavelet Transform," Proceedings of the 2016 Sixth Int. Conf. on Advanced Computing and Communication Technologies, pp. 308-314, 2016.

[31] M. K. Saini, R. K. Beniwal and S. Khanna, "Critical Analysis of Power Quality Issues in Wind-Grid Integration," Proceedings of the 2016 Sixth Int. Conf. on Advanced Computing and Communication Technologies, pp. 315-322, 2016.

[32] R. Kumar, S. Saini. R. Saini "Scenario of Power Sector in Delhi," National Journal of multidisciplinary research and development, vol. 3, no. 1, pp. 313-320, 2018.

[33] A. Aggarwal, R. Kumar, "Examination of service quality dimensions in power distribution sector," International Journal on Future Revolution in Computer Science & Communication Engineering, vol. 4, no. 2, pp. 207-212, 2018.

[34] M. K. Saini, R. Kapoor, "Classification of power quality events- a review," International Journal of Electrical Power & Energy Systems, vol. 43, no. 1, pp. 11-19, 2012.

[35] R. Kapoor, M. K. Saini, "Hybrid demodulation concept and harmonic analysis for single/multiple power quality events detection and classification," International Journal of Electrical Power & Energy Systems, vol. 33, no. 10, pp. 1608-1622, 2011.

[36] R. Kapoor, M. K. Saini, "Multiwavelet transform based classification of PQ events," International Transactions on Electrical Energy Systems, vol. 22, no. 4, pp. 518-532, 2012.

[37] M. K. Saini, R. Kapoor, T. Goel, "Vector quantization based on self-adaptive particle swarm optimization," International Journal of Nonlinear Sciences, vol. 9, no. 3, pp. 311-319, 2011.

[38] R. Nagal, M. K. Saini, R. jain, "Optimal real time DSP implementation of Extended Adaptive Multirate Wide Band (AMR-WB+) Speech Codec," TENCON 2008-2008 IEEE Region 10 Conference, pp. 1-6, 2008.

[39] M. K Saini, J. S. Saini, S. Sharma, "Moment based wavelet filter design for fingerprint classification," International Conference on Signal Processing and Communication (ICSC), 2013.

[40] M. K. Saini, D. Sandhu, "Directional approach and modified self-adaptive ant colony optimization for edge detection," International Conference on Signal Processing and Communication (ICSC), 2013.

[41] M. K. Saini, D. Narang, "Cuckoo Optimization Algorithm based Image Enhancement," Proc. of Int. Conf. on Advances in Signal Processing and Communication, Elsevier, 2013.

[42] M. K. Saini, Deepak, "Review on Image Enhancement in Spatial Domain," Proc. of Int. Conf. on Advances in Signal Processing and Communication, Elsevier, 2013.

[43] M. K. Saini, R. Kapoor, "Image compression using APSO," International Journal of Artificial Intelligence and Soft Computing, vol. 3, no. 1, pp. 70-80, 2012.

[44] M. K. Saini, R. K. Beniwal, "Design of modified matched wavelet design using Lagrange Interpolation," Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH), pp. 244-248, 2016.

[45] M. K. Saini, S. Jain, "Designing of speaker based wavelet filter," International Conference on Signal Processing and Communication (ICSC), 2013.

[46] M. K. Saini, J. S. Saini, "Performance analysis of wavelet transform for unspoken words," International Conference on Signal Processing and Communication (ICSC), 2013.

[47] M. K. Saini, S. Saini, "Analysis of Licence Plate using MWT," 4th International Conference on Innovations in Information, Embedded and Communication Systems, 2017.

[48] M. K. Saini, S. Saini, "Multiwavelet Transform Based Number Plate Detection," Journal of Visual Communication and Image Representation, 2017.

[49] M. K. Saini, J. S. Saini, Sakshi, "Design of Wavelet Using Ring-Projection Technique for Ear," Proceedings of the Sixth Int. Conf. on Advanced Computing and Communication Technologies (ACCT 2016), 2016.

[50] M. K. Saini, R. K. Beniwal, S. Khanna, "Critical Analysis of Power Quality Issues in Wind- Grid Integration," Proceedings of the Sixth Int. Conf. on Advanced Computing and Communication Technologies (ACCT 2016), 2016.

[51] M. K. Saini, A. Aggarwal, "Condition Monitoring of Induction Motor using Multiwavelet Transform in LabVIEW Environment," Proceedings of the Sixth Int. Conf. on Advanced Computing and Communication Technologies (ACCT 2016), 2016.

[52] M. K. Saini, J. S. Saini, Sakshi, "Comprehensive Analysis of Ear Recognition Techniques," Proceedings of the Sixth Int. Conf. on Advanced Computing and Communication Technologies (ACCT 2016), 2016.

[53] M. K. Saini, A. Aggarwal, "A Critical Analysis of Condition Monitoring Methods," Proceedings of the Sixth Int. Conf. on Advanced Computing and Communication Technologies (ACCT 2016), 2016.

[54] R. Kapoor, S. Garg, R. Singh, M. K. Saini, "Intelligent Collision Avoidance and Navigation System for Watercraft," IE Patent 16/2, 015, 2015.

[55] M. K. Saini, S. Dhingra, R. Singh, "Mathematical Modeling and Signal Processing Technique In Automatic Number Plate Recognition," International Journal of Electronics, Electrical and Computational System (IJEECS), vol. 4, pp. 67-79, 2015.

[56] M. K. Saini, J. S. Saini, S. Sharma, "Various Mathematical and Geometrical Models for Fingerprints: A Survey," Proc. of Int. Conf. on Advances in Signal Processing and Communication, pp. 59-62, 2013.

[57] M. K. Saini, Neeraj, "Unspoken Words Recognition: A Review," Proc. of Int. Conf. on Advances in Signal Processing and Communication, pp. 84-87, 2013.

[58] M. K. Saini, Deepak, "Signal Processing, Statistical and Learning Machine Techniques for Edge Detection," Proc. of Int. Conf. on Advances in Signal Processing and Communication, pp. 88-91, 2013.

[59] M. K. Saini, J. S. Saini, Ravinder, "Signal Processing Tool for Emotion Recognition," Proc. of Int. Conf. on Advances in Signal Processing and Communication, pp. 92-95, 2013.

[60] M. K. Saini, Priyanka, "Signal Processing and Soft Computing Techniques for Single and Multiple Power Quality Events Classification," ," Proc. of Int. Conf. on

Advances in Signal Processing and Communication, pp. 104-107, 2013.

[61] M. K. Saini, R. Kapoor, S. Saini, “Object Tracking Using Particle Filter,” International Conference On Communication Languages And Signal Processing, 2012.

[62] M. K. Saini, R. Kapoor, “Power Quality Events Classification using MWT and MLP,” Advanced Materials Research, vol. 403, pp. 4266-4271, 2012.

[63] M. K. Saini, R. Kapoor, A. K. Singh, “Performance Comparison between Orthogonal, Bi-Orthogonal and Semi-Orthogonal Wavelets,” Advanced Materials Research, vol. 433, pp. 6521-6526, 2012.

[64] M. K. Saini, R. Kapoor, Jyoti, “Selection of Best Wavelet Bases For compression of ECG Data,” NEEC-2011.

[65] M. K. Saini, R. Kapoor, N. Mittal, “Nonlinear analysis of power quality events,” International Conference on Sustainable Energy and Intelligent Systems (SEISCON 2011), pp. 58-62, 2011.

[66] L. Singh, M. K. Saini, J. Shivnani, “Real Time Traffic Signal Control Strategy Using Genetic Algorithm,” International Journal of Recent Trends in Engineering, vol 2, no. 2, pp. 4-6, 2009.