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ECONOMICAL TECHNIQUE FOR VOLTAGE STABILIZATION IN WIND-DIESEL HYBRID MICROGRID

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Abstract

Electricity is the major ingredient in the development of modern society, which reflects the living standard of the people. However, everyone is not lucky to have the access of electricity. This is may be due to the remote location, non-availability of sufficient power and cost of electricity to make it available at that location. The most common way to supply electricity at such locations is by installing a diesel power plant. The main advantage of diesel engine that it can be located anywhere and can supply small/huge isolated Loads, such a system of its own will produce high cost electricity to the consumers. To reduce the cost of the electricity, renewable energy sources base generation can be used in coordination with the diesel generator. Most of the renewable sources are intermittent in nature and causes the imbalance between the demand and the generation. Absence of control mechanism even can damage the system especially in autonomous operation. The main parameters that are to be controlled are voltage and frequency which determines the stability and quality of the power supplied. By controlling the fuel input to the different generating units the frequency management of output power can be achieved easily while to control the voltage, the reactive power must be balanced. In this paper voltage and frequency of the hybrid wind Diesel system are controlled by static VAR compensator (SVC), which has excellent characteristics to control the terminal voltage of the system. The different type of SVC systems are designed and compared to show the performance of each type of compensator.

Keywords: Voltage regulation, static VAR compensator, microgrid, energy balance.

Introduction:

To meet the power requirement of the remotely located areas sometimes decentralized, standalone, autonomous or isolated system may be employed. These standalone systems are also known as microgrids. The microgrids are capable to supply electricity to local loads even in the bad weather/grid fault conditions or remotely located areas where is where there is no possibility to provide electricity by the utility power grid. Microgrid generation may be based upon the renewable energy sources but the main disadvantage of the renewable energy sources that the electricity generated through the renewable sources is highly intermittent in nature. These disadvantages can be compensated by the coordinated operation of the renewable base generation with diesel generators or any other fossil fuel based conventional method of electricity generation. This produces a hybrid combination of electricity generation. Renewable and nonrenewable sources coordinate with each other to provide electricity to the remote locations and balance the power demand. In power system frequency divisions are mainly due to the real power mismatch whereas the voltage imbalance is a result of improper reactive power generation by the source. So, by controlling the fuel, active power can be managed and hence the frequency while the reactive power can be obtained by installing a variable reactive power device that can provide or absorb reactive power as per the requirement of the system. In this paper, a hybrid wind diesel power generation plant is considered for supplying a common load. Wind system among the renewable sources of energy is of relatively low cost and requires very small installation time. The wind turbines ranging from very small to high capability of electricity generation are available in the market. At present about 4% of the total words electricity is generated through the wind generation. With the advancement in the design of wind energy conversion system, the efficiency of wind energy system has increased a lot. The energy stored or the total wind power available to wind turbine is given:

$$P_w = (kC_p\rho AV^3)/2 \qquad (1)$$

Where, Pw – is Power output in kW, Cp- Maxi. power coefficient (0.25 to 0.45), ρ – Air density in lb/ft3, A- rotor area in m2, V- wind speed in mph, k- constant (0.000133).

The power which can be extracted through the wind generation system is 30- 45% of the total wind power. There are a number of ways to classify the wind turbines say, according to the size, rotational orientation etc. In horizontal turbine axis of rotation is parallel to the direction of wind whereas in the vertical axis machines the axis of rotation is perpendicular to the direction of wind, these machines are also called as crosswind axis machine. Turbine extracts kinetic energy from the wind and converts it into the mechanical energy which is fed to the generator coupled to it through mechanical system and provides angular rotation to the shaft of the generator, where electricity is generated. In diesel engine generator set, diesel engine converts fuel into mechanical energy which is supplied to the generator through the mechanical coupling between the engine and the generator. Diesel engines may be of two types 2 stroke or 4 strokes. The speed of diesel engines related to its size, a large engine operates usually at lower speed approximately 900 rpms whereas; a small size engine can operate at higher speeds such as 3030/600 rpms. Engine governor controls the engine speed, which regulate the frequency of the generator depending upon the load. Advantage of hybrid wind-diesel system is that the wind is intermittent source of energy and power generation almost costs nothing as it completely depends on wind energy. The coordinated operation reduces the overall cost of the power generation while maintaining continuity of supply to the load every time.

Reactive power control and its requirement:

Electrical appliances operate satisfactory only and only if the specified input is provided to them, it may be in terms of voltage or frequency. The system voltage can be maintained within desired limits by providing adequate reactive power compensation [1]. The reactive power control stabilizes the system voltage by supplying/absorbing the reactive power. By controlling the generator excitation the voltage at the terminals of the generator can be controlled easily. But after a certain level of excitation/maximum current limit of the field winding, no further increase in excitation can be done otherwise it will overload and heat up the generator. The reactive power can be supplied externally by means of VAR compensating devices such as capacitor banks, series-shunt reactors, power electronics controlled devices i.e., SVC, STATCOM, D-STATCOM, TSC etc. Reactive power demand is a measure of the current flowing through the lines which can be sensed and switching of the thyristors used in automatic voltage regulators, can be varied accordingly[2-3]. Distributed system approach for installation of SVC and STATCOM at medium voltage level is much more beneficial as compared to the placing them at high voltage level. It further reduces the transformer cost required at low voltage level distribution buses [4-6]. Distributed compensator are advantageous over lumped compensation and provide better voltage regulation at load centers, enhanced reliability but calculation for the injected compensator current is not presented. The control technique offered in [20], only considers the power flow in one direction only i.e., from generation to the consumer and while in today's environment, the power flow can be either side and hence the voltage control must be determined by the both generation as well as load when multiple distributed generating units are connected to the grid [7]. In [8], it is sated that the bidirectional power flow can significantly change the voltage control mechanism in the distribution network where multiple DGs are operating together to support the grid. The distributed generation can be considered as PV or PQ nodes, the goal of this approach is to minimize the overall losses. The author in [9] used genetic algorithm to maintain the system requirement and DGs are operated at their maximum power rating to reduce the overall operating cost. When DG unit is connected to the main grid, it has to maintain the grid standards. Sometime it's quite difficult to regulate the voltage at the point of common coupling, this is due to the variable nature of the renewable sources. It can be eliminated by the use of fast responding D-STATCOM. Mathematical modeling of the overall system for voltage management and calculation of reactive power to be supplied to the system is very important in designing the control strategy [10]. In [11], the author has developed a cooperative control strategy of DG with STATCOM to maintain the system voltage and voltage arise in the presence of one DG did not result in over voltage with energized capacitors. [12] used a passive solution approach to reduce the impact on the transmission system voltage and overcome the distribution voltage arise barrier such that more DGs can be connected to it without affecting the system performance and keeping the power flow at maximum level. This method was tested on the simple radial distribution network. Wind generation stability improvement was investigated by [13], where adequate models were represented to study the transient stability of the DFGI. As compared to the cage induction generator DFGIs are more robust and are able to keep that equilibrium while maintaining the necessary transient stability margin in the electrical system. The power sharing among the different DGs units participating in the power generation is controlled by the central controller [14-21]. [22] proposed a method for the voltage control that can avoid typical under/overvoltage occurring in the distributed generation based in network. In [23], author investigated the control strategy in both coordinated and uncoordinated environment.

Frequency control:

Frequency control of wind-diesel hybrid system is important issue because in the generated power frequency variation threats the system stability. To provide good quality service to the consumers it is important to keep the frequency within the tolerable limits. The function of the load control controller is to manage the frequency as per the requirements. In the wind energy conversion system, the frequency controller controls the frequency by varying the speed of the mechanical system through the coupling gear system connected to the induction generator while in diesel generator the mechanical power is automatically adjusted by the engine through regulating the fuel input to keep the power [24-30] according to the demand. Further if a wind turbine is not capable to generate enough power due to low wind energy the diesel generator shares maximum load to serve the consumer. This automatic control is known as load frequency control.

Static VAR Compensator:

Reactive power control is required to manage the system voltage and to increase the study state as well as dynamic stability of the power system. The receiving and terminal voltage varies if the reactive power of the system is not balanced for example if a capacitive load is connected to the line then reactive power must be absorbed otherwise the voltage at the receiving and will be higher than the nominal voltage and in other case if inductive load connected, the terminal voltage becomes lesser than the nominal voltage, in this case reactive power must be supplied to the load so that the voltage at the receiving end remains within specified limits [31-40]. VAR compensator is a device that either absorbs or generates reactive power to keep the system voltage within limits. With the advancement in the semiconducting technologies the VAR compensators become are automatic in nature and the reactance can be varied in steps by the thyristor switching. This type of power compensation do not have any moving part so, are very quick in nature [41-49]. By controlling the firing angle of the thyristor, the provided compensation may be either inductive or capacitive. Three different types of SVC models are used in this paper to show the effectiveness in reactive power control in autonomous hybrid power system.

Some advantages of SVC:

1. SVC reduces the harmonics in the supply hence a high quality power is delivered to the consumer.
2. By the use of SVC the power transfer capability of the transmission line can be increased up to the maximum limit.
3. This utilizes the maximum transmission capability of the system and increases the efficiency.
4. SVC stabilizes the system voltage as voltage imbalances causes’ inefficiency, overheating, torque and speed pulsation and noisy operation of the motors.
5. Reduction in the flickers is achieved by balancing the voltage through the static VAR compensators.

System Modeling:

Frequency variations due to wind fluctuations and variation in demand can be mitigated by the extra power supplied by the diesel generator. Figure shows the power delivered to the consumers from a hybrid microgrid at the point of common coupling. An induction generator is used in wind generation system, where field excitation is supplied from the line itself. An induction generator

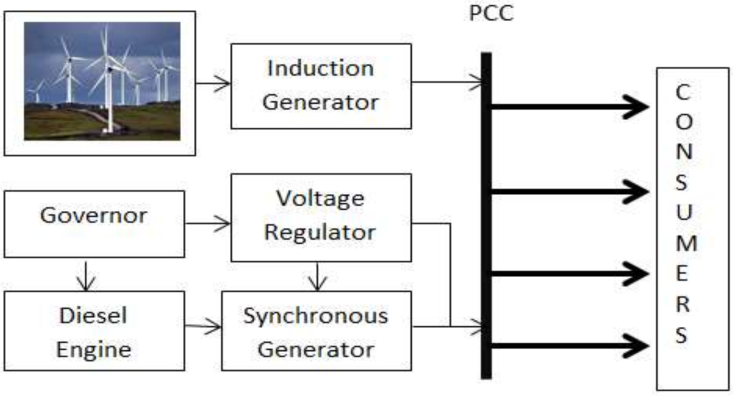

Fig. 1 Hybrid wind-diesel generation

generates electricity at power frequency while rotates at a speed higher than the synchronous speed.

In diesel engine based generation, a synchronous generator is used to generate electricity. It runs at fixed speed and hence generates a fixed frequency. The required reactive power can be balanced by controlling the excitation of the generator within its limits. Figure 2 shows generator and load connected to it. Power from generator (Sb) to load (Rb) calculated as:

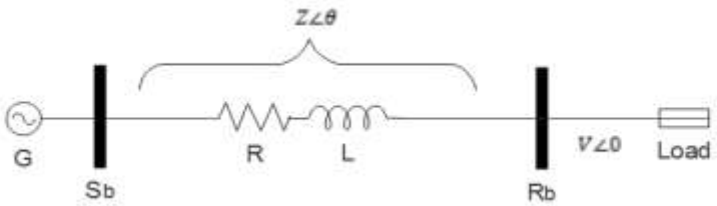

Fig. 2 Power transfer to load

Total power at load is given by

$S_R = (V\angle 0)\mathrm{I}^*$ (2)

$I = \frac{E\angle\delta - V\angle 0}{Z\angle\theta}$ (3)

$(V\angle 0)\mathrm{I}^* = V\angle 0\left(\frac{E\angle -\delta+\theta - V\angle\theta}{Z}\right)$ (4)

Equation (3) yields

$S_R = \frac{VE\angle -\delta+\theta - V^2\angle\theta}{Z}$ (5)

Real and Reactive power can be calculated as

$P_R = \frac{VE\cos(-\delta+\theta)}{Z} - \frac{V^2\cos\theta}{Z}$ (6)

$Q_R = \frac{VE\sin(-\delta+\theta)}{Z} - \frac{V^2\sin\theta}{Z}$ (7)

The active and reactive power transmitted over inductive transmission line (θ ≈ 90°), given by equations 7' and 8'.

$$P_R = \frac{VE\sin\delta}{Z} \qquad (8)$$

$$Q_R = \frac{VE\cos\delta}{Z} - \frac{V^2}{Z} \qquad (9)$$

For small value of Power angle (δ), equation 8 and 9 may be written as

$$P_R = \frac{VE\delta}{Z} \qquad (8')$$

$$Q_R = \frac{V(E-V)}{Z} \qquad (9')$$

As seen from the equation (9'), the change in voltage causes change in reactive power and vice-versa. In other words if adequate reactive power is supplied to the system the voltage at load terminals can be controlled. The required reactive power is supplied through SVC. There are three types of SVC. 1) Amplifier type, 2) Lead- lag compensator type and 3) Proportional and integral type.

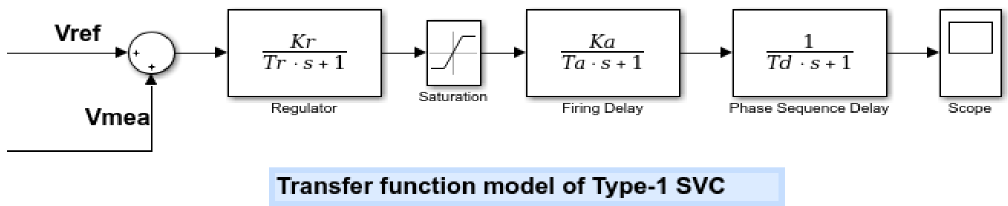

Fig.3 Transfer function model of type-1 SVC

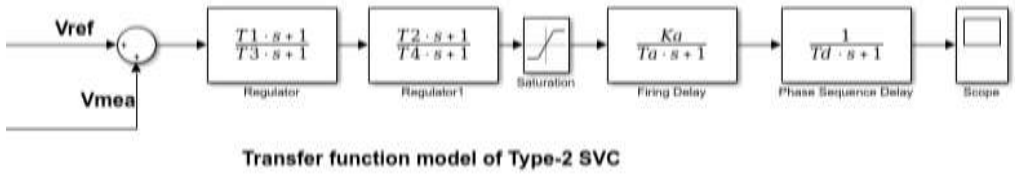

Fig. 4 Transfer function model of type-1 SVC

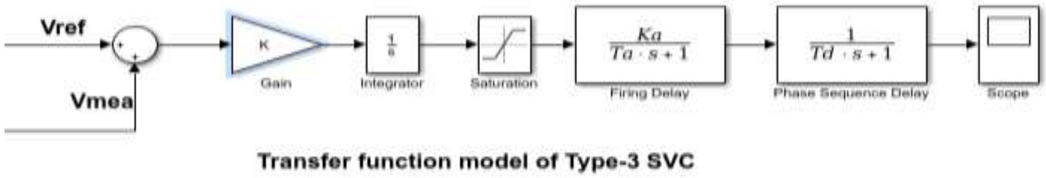

Fig. 5 Transfer function model of type-1 SVC

Results:

The thyristor controlled automatic voltage regulators offers great flexibility to control the reactive power flow, which in turn manage the system voltage within limits. By controlling the firing angle of the thyristors, the reactive power can be controlled. The model is prepared with the equivalent transfer function of the all components. From the figures 6, 7, and 8, it is clear that type-2 SVC produce much better results as compare to type-1 and type-3. Time taken by the controller to stabilize the voltage in type-2 is 0.2 sec. which is very less as compare to type-1 (0.7 se.) and type-3 (0.4 sec) controllers.

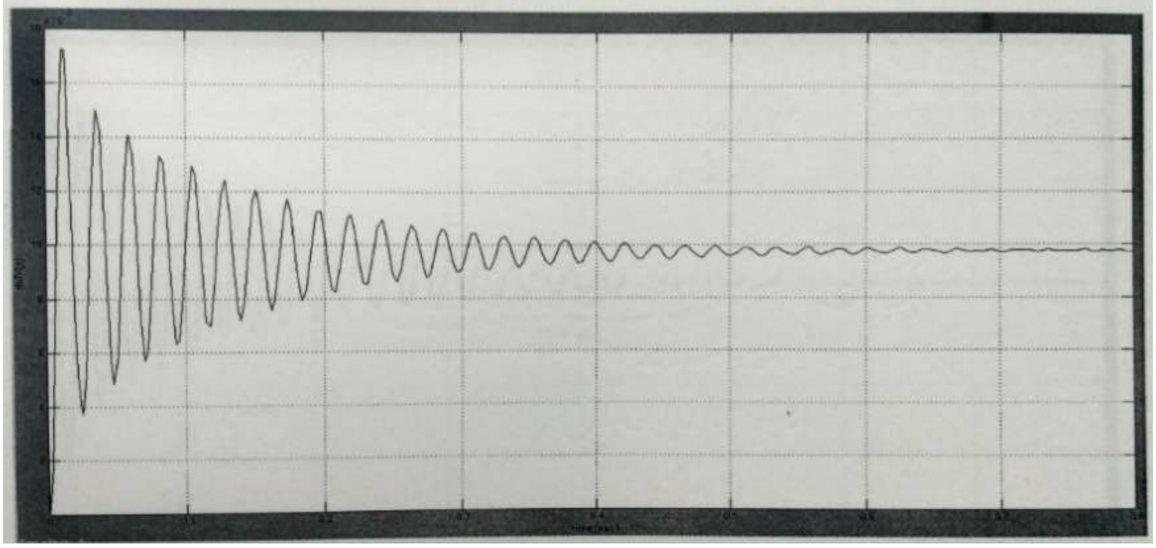

Fig. 6 Terminal Voltage control with SVC type-1

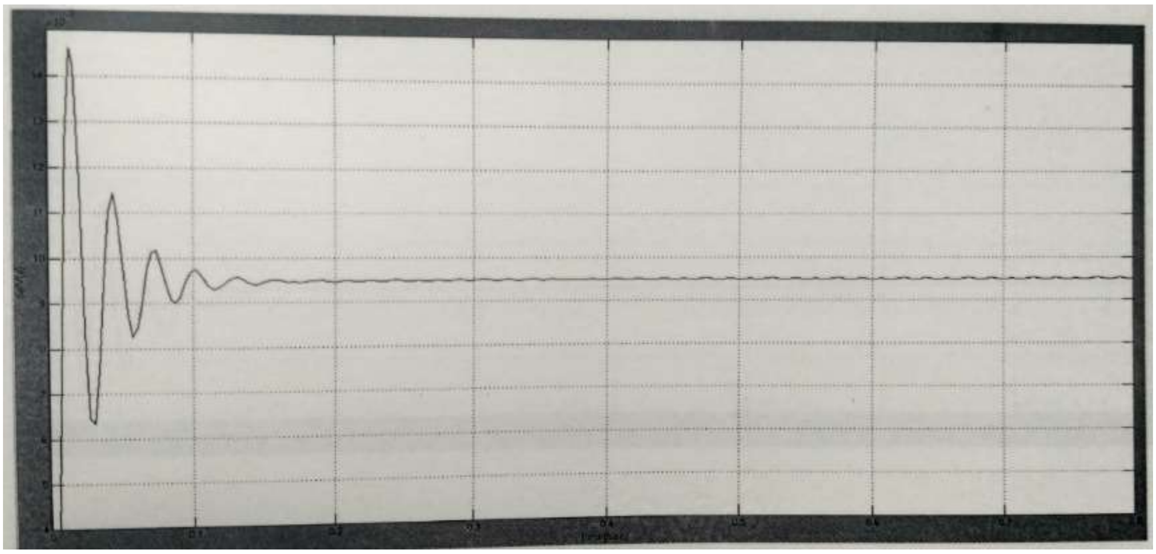

Fig. 7 Terminal Voltage control with SVC type-2

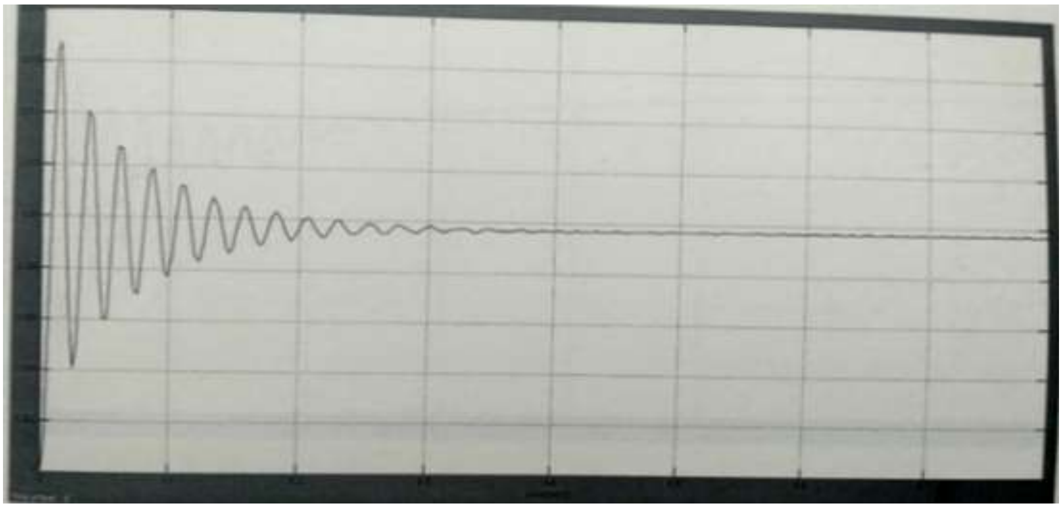

Fig. 8 Terminal Voltage control with SVC type-3

Conclusion:

This paper compares the results for voltage regulation by static VAR compensator. The complete model is prepared by considering the transfer function of each component. From the results it is clear that SVC type-2 produces better results as compare to type-1 and type-3 SVC. Small signal analysis for the hybrid microgrid consisting wind generation and diesel generator is done to compensate the reactive power requirement in standalone operation. Voltage regulation strategy adopted in this paper can be implemented using STATCOM, UPFC, DVR or UPQ.

Reference:

1. R. Hunter, G. Elliot, "Wind diesel systems: A guide to the technology and its implementation," Cambridge university press, New York, USA, 2004.
2. H. Nacfair, "Wind diesel and wind autonomous energy systems," Elsevier Applied science, London UK, 1989.
3. J. W. Twidel, A. D. Weir, "Renewable Energy Sources," 2nd Edition, Taylor and Francis, New York, USA, 2006.
4. M. R. Patel, "Wind and solar power system: Design analysis and operation," 2nd Edition CRC Press, Boca Raton, FL, USA, 2005.
5. G. M. Masters, "Renewable and electric power systems," John Wiley & Sons, New Jersey, USA, 2004.
6. T. Ackermann, "Wind power systems," John Wiley & Sons, USA, 2005.
7. E. D. Aries, "On a grand scale: World's largest wind commercial prototype," Renewable Energy World, vol. 5, no. 5, pp. 70-75, 2002.
8. M. A. Pai, D. P. S. Gupt, K. R. Padiyar, "Small signal analysis of power systems," Narosa Publishing House, New Delhi, India, 2004.
9. T. S. Bhatti, N. K. Bansal, "Load frequency control of isolated wind diesel hybrid power systems," Energy Conversion and Management, vol. 38, no. 9, pp. 829-837, 1997.
10. K. Uhlen, B. A. Foss, "Robust control and analysis of wind-diesel hybrid power plant," IEEE Trans. Energy Conversion, vol. 9, no. 4, pp. 113-132, 2006.
11. S. A. Papathanassiou, M. P. Papadopoulous, "Dynamic characteristics of isolated wind-diesel system," Renewable Energy, vol. 23, pp. 293-311, 2001.
12. E. D. Besant, F. M. Potter, "Capacitor excitation for Induction motors," IEEE Trans.,
13. R. C. Bansal, T. S. Bhatti, D. P. Kothari, "A bibliography survey on induction generators for application of non-conventional energy systems," IEEE Trans. On Energy Conversion, vol. 18, no. 3, pp. 540-545, 1935.
14. 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.
15. 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.
16. 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.
17. 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.
18. 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.
19. 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.

20. 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.
21. 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.
22. 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.
23. 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.
24. 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.
25. 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.
26. 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.
27. 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.
28. 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.
29. 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.
30. 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.
31. 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.
32. 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.
33. 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.
34. 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.
35. 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.
36. 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.
37. 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.

38. 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.
39. M. K. Saini, R. Kapoor and B. B. Sharma, "PQ event classification using fuzzy classifier," Advanced Materials Research, vol. 403, pp. 3854-3858, 2012.
40. 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.
41. 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.
42. 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.
43. 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.
44. 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.
45. 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.
46. 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.
47. 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.
48. 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.
49. 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.
50. 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.
51. 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.
52. 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.
53. 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.
54. M. K. Saini, D. Narang, "Cuckoo Optimization Algorithm based Image Enhancement," Proc. of Int. Conf. on Advances in Signal Processing and Communication, Elsevier, 2013.
55. M. K. Saini, Deepak, "Review on Image Enhancement in Spatial Domain," Proc. of Int. Conf. on Advances in Signal Processing and Communication, Elsevier, 2013.
56. 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.

57. 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.
58. M. K. Saini, S. Jain, “Designing of speaker based wavelet filter,” International Conference on Signal Processing and Communication (ICSC), 2013.
59. M. K. Saini, J. S. Saini, “Performance analysis of wavelet transform for unspoken words,” International Conference on Signal Processing and Communication (ICSC), 2013.
60. M. K. Saini, S. Saini, “Analysis of Licence Plate using MWT,” 4th International Conference on Innovations in Information, Embedded and Communication Systems, 2017.
61. M. K. Saini, S. Saini, “Multiwavelet Transform Based Number Plate Detection,” Journal of Visual Communication and Image Representation, 2017.
62. 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.
63. 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.
64. 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.
65. 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.
66. 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.
67. R. Kapoor, S. Garg, R. Singh, M. K. Saini, “Intelligent Collision Avoidance and Navigation System for Watercraft,” IE Patent 16/2, 015, 2015.
68. 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.
69. 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.
70. M. K. Saini, Neeraj, “Unspoken Words Recognition: A Review,” Proc. of Int. Conf. on Advances in Signal Processing and Communication, pp. 84-87, 2013.
71. 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.
72. 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.
73. 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.
74. M. K. Saini, R. Kapoor, S. Saini, “Object Tracking Using Particle Filter,” International Conference On Communication Languages And Signal Processing, 2012.
75. M. K. Saini, R. Kapoor, “Power Quality Events Classification using MWT and MLP,” Advanced Materials Research, vol. 403, pp. 4266-4271, 2012.
76. 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.

77. M. K. Saini, R. Kapoor, Jyoti, "Selection of Best Wavelet Bases For compression of ECG Data," NEEC-2011.
78. 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.
79. 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.
80. R. Nagal, M. K. Saini, N. Sindhwani, "Pitch Estimation Using Autocorrelation AICTE Sponsored National Seminar on Emerging Trends in Software Engineering, 2008.
81. M. K. Saini, R. Nagal, S. Tripathi, N. Sindhwani, A. Rudra, "PC Interfaced Wireless Robotic Moving Arm," AICTE Sponsored National Seminar on Emerging Trends in Software Engineering, 50, 2008.
82. L. Singh, M. K. Saini, S. Tripathi, Nidhi, N. Chugh, "An Intelligent Control System For Real-Time Traffic Signal Using Genetic Algorithm," AICTE Sponsored National Seminar on Emerging Trends in Software Engineering, 50, 2008.
83. R. Nagal, M. K. Saini, S. Tripathi, R. Chabra, R. Anand, "DSK 6713 Used Through MATLAB for Pitch Estimation," 3rd International Conf. On advanced Computing and communication Technologies, 2008.
84. R. Nagal, M. K. Saini, G. Kaur, R. Jain, "Optimization of AMR-WB+ Speech Codec (Decoder) Using TMS320C6713," 3rd International Conf. On advanced Computing and communication Technologies, 2008.
85. L. Singh, M. K. Saini, S. Tripathi, "Performance Optimization Of Neural Networks Based Face Localization," 3rd International Conf. On advanced Computing and Communication Technologies, 2008.
86. S. Tripathi, R. Agrawal, M. K. Saini, A. K. Jain, S. Basu, R. Ramchandani, "An Application Module Using Eigen Faces For Face Recognition," Inter. Conf. MS'07, pp. 1-6, 2007.
87. S. Dahiya, D. K. Jain, M. Kumar, A. Kumar, R. Kapoor, "Automatic Classification of Power Quality Events Using Multiwavelets," International Conference on Power Electronics, Drives and Energy Systems, New Delhi, pp. 1-5, 2006.
88. R. Kapoor, M. K. Saini, Umesh, "Complementary CNTFET Based a Novel Ternary and Quaternary Logic Generator on 32NM Technology," IN Patent