# Performance Analysis of SVC and STATCOM to Enhance Power System Stability

**P Suguna Ratnamala, M Ramjee Sakpal, M John Sreenivasa Rao**

***Abstract:*** ***In a similar feeder, it will decay the power nature of intensity supply when the quality is poor at burden side which can cause different types of gear glitch even harm gadgets. Consequently, a responsive power remuneration technique is recommended to enhance the power nature of the electric curve heater in an appropriation control framework. Both the static var compensator (SVC) and Statcom can adjust control factor and parity three stage flows at the same time. The statcom can take care of the issue of immediate condition of a SVC. And after that, a SVC can lessen control amount of the dynamic channel. At last, field estimation information in a metal processing plant were examined. Recreation results affirmed the plausibility of amending the power factor and adjusting load flows all the while utilizing the proposed technique.***

***Index Terms*****: *Power Quality, Reactive Power, Static Var Compensator, STATCOM, Current.***

## I. INTRODUCTION

Many metal businesses produce steel by utilizing electric circular segment heaters (EAFs). It is essential to research their impacts on the power quality [1]-[3]. By and large, there are three periods, exhausting down, softening down, and refining, amid the EAF working procedure. After preheated with burners, the terminals are brought down and empowered [4]. Amid exhausting down and dissolving down periods, the circular segment current changes significantly on the grounds that the piece is constantly softened and unpredictably falls among the graphite anodes. Thus, the status of an EAF haphazardly differs among short out, open circuit, and nonlinear bend demonstrate [5].

The actual unsettling influences from an EAF are voltage flash, load unbalance, and sounds [l]-[6]. An unreasonable dimension of intensity unbalance and poor arrangement contemporary are delivered about by the disappointment of bend re-start [7]. An uneven burden ought to prompt produce undesired bad succession present day in a three-stage three-wire framework. This terrible grouping contemporary will reason extra misfortunes of generators, transmission lines, and transformers. There are severa improvements to adjust the static var compensator (SVC) in three-stage frameworks that have been represented in written works [8, 9]. The susceptance of every duration of the SVC can be received from root imply rectangular (RMS) estimations of voltage and modern-day of three-stage loads. The pay calculation of the SVC can alter the three stage stacks and decorate the energy issue to unity of important section [8, 10].

Shockingly, the strategy for symmetrical directions is challenging to display any energy and go with the flow deterioration and their physical ideas [11]. In this manner, speedy dynamic responsive electricity and current in the time place can no longer be talked about. One lookup proposes a pay calculation which can adjust the three-stage flows by way of the dynamic depth of last cycle and beautify the energy aspect to be near harmony with the aid of the rapid estimation of three-stage flows [12]. The instantaneous estimations of three-stage flows can be exchanged to a vector on polar directions, which can be disintegrated the instantaneous dynamic present and momentary responsive current. Despite the reality that the strength thing can be altered by way of changing the instant receptive current , however the three-stage flows can no longer be adjusted in a similar time. The motive is that dynamic energy has un-symmetry parts. This examination proposes the dynamic strength is a steady which is received via using a heap guaging model. At lengthy last, it joins these two methods to get the on the spot three-stage pay flows which can alternate the electricity element and parity three-stage flows all the while .

The susceptance of every length of the SVC can be obtained from RMS estimations of voltage and contemporary of three-stage loads, therefore, non permanent dynamic receptive electricity and current in the time area can no longer be talked about. The rapid compensator can handle this difficulty [12], be that as it may, the remuneration cutting-edge is provided with the aid of an self sufficient energy source which reasons the fee getting to be costly. In this way, it is indispensable for diminishing the limit of the free electricity source. An examination joins a SVC and the short-term compensator together [13]. A SVC is used with the short-term compensator to reduce the restrict of the free power.

Moreover, better execution is acquired by using finding the shunt capacitance nearer to the low energy factor masses [14]. Along these lines, it regular that the SVC and the speedy compensator are brought at burden terminal.

## II. CHARACTERISTICS OF COMPENSATORS

The power factor for the most part is a fundamental punishment element in the earnings of strength clients. The affects of burden unbalance and symphonious mutilation ought to be considered. To take care of these issues, the innovation of alteration manage aspect with the SVC in three-stage three-wire has been utilized [15, 16]. The

**Revised Manuscript Received on May 06, 2019.**

**P Suguna Ratnamala**, Electrical and Electronics Engineering Department, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

**M Ramjee Sakpal**, Electrical and Electronics Engineering Department, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

**M John Sreenivasa Rao**, Electrical and Electronics Engineering Department, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

susceptance of every duration of the SVC can be gotten from voltage and present day signs of burdens. The receptive power remuneration innovation can regulate the power component and parity stacks at the same time [17].

To boost the electricity best all the extra proficiently on encouraging uneven burdens, a plan of on the spot modern pay that can compute the remuneration current to alter the energy thing and parity the three-stage flows at the identical time is proposed [12]. The approach for momentary area vectors can remunerate the receptive strength adequately, yet the troubles of lopsided burden flows remains. Hence, it recommends a method that can alleviate the uneven burden flows via putting the dynamic energy as a consistent for each cycle. In addition, the non permanent compensator requires a free energy source, whose restriction can be lessen with the aid of making use of a SVC. The SVC does not meddle with the capability of the momentary compensator. In this way, it is proposed for joining a SVC with the short-term compensator [13].

Retrieval Number: C6205058919/19©BEIESP

The momentary compensator and a SVC are introduced at the heap terminal, in this way the line opposition and reactance between the heap and compensators could be overlooked. It sets the dynamic power as a consistent for each cycle to handle the issue of unblancing three-stage load. The dynamic energy can be gotten after the voltage and modern-day data are estimated internal a energy cycle. Since the dynamic power would no longer alternate considerably amid two electricity cycles, accordingly, we in many instances expected the dynamic strength that is indistinguishable incentive from the ultimate strength cycle. In this exploration, it units the dynamic energy for each strength cycle through utilising load guaging innovation. The process of remember couldn't be extraordinarily perplexing in light of the truth that the immediate compensator desires a ordinary esteem each energy cycle . This examination consolidates a instant compensator with the innovation of burden forcasting and a SVC, as regarded in Fig. 1, to midify the strength component and parity three-stage load at the equal time [19-21].

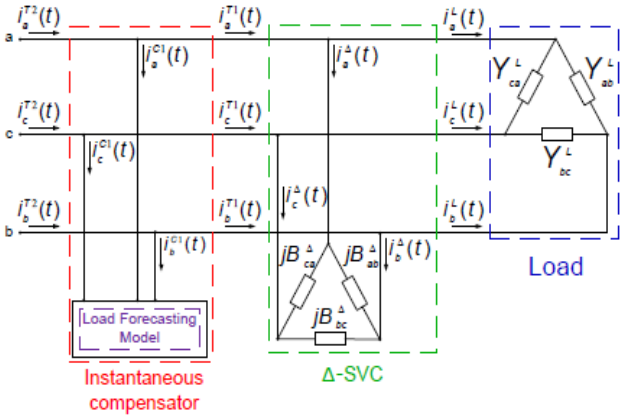



Fig. 1. A 3-phase three-wire system withcompensators and loadforecasting technology

## III. STATIC VAR COMPENSATER

In a three stage three wire framework, the pay susceptances of a SVC can be determined by utilizing load flows and voltage. The chart is appeared in Fig.1, where is an unequal burden through a three stage three wire dissemination framework. The superscripts L and Δ speak to the heap and Δ-associated SVC, individually. It expected that the three stage voltages are in positive stage grouping. The major segment of the three stage line flows as

$$\begin{aligned}\bar{I}^L_{a1} &= \bar{I}^L_{ab1} - \bar{I}^L_{ca1} = [Y^L_{ab}(1-a^2) - Y^L_{ca}(a-1)]V^L_{a1}\\ \bar{I}^L_{b1} &= \bar{I}^L_{bc1} - \bar{I}^L_{ab1} = [Y^L_{bc}(a^2-a) - Y^L_{ab}(1-a^2)]V^L_{a1}\\ \bar{I}^L_{c1} &= \bar{I}^L_{ca1} - \bar{I}^L_{bc1} = [Y^L_{ca}(a-1) - Y^L_{bc}(a^2-a)]V^L_{a1}\end{aligned} \quad (1)$$

$$\begin{bmatrix}\bar{I}^L_0\\ \bar{I}^L_1\\ \bar{I}^L_2\end{bmatrix} = \frac{1}{3}\begin{bmatrix}1 & 1 & 1\\ 1 & a & a^2\\ 1 & a^2 & a\end{bmatrix}\begin{bmatrix}\bar{I}^L_{a1}\\ \bar{I}^L_{b1}\\ \bar{I}^L_{c1}\end{bmatrix} \quad (2)$$

Substituting (1) into (2), we have

$$\begin{aligned}\bar{I}^L_0 &= 0\\ \bar{I}^L_1 &= \bar{V}^L_{a1}(Y^L_{ab} + Y^L_{bc} + Y^L_{ca})\\ \bar{I}^L_2 &= \bar{V}^L_{a1}(-a^2 Y^L_{ab} - Y^L_{bc} - aY^L_{ca})\end{aligned} \quad (3)$$

Therefore, the symmetric components of current of the SVC are

$$\begin{aligned}\bar{I}^\Delta_0 &= 0\\ \bar{I}^\Delta_1 &= j(B^\Delta_{ab} + B^\Delta_{bc} + B^\Delta_{ca})V^L_{a1}\\ \bar{I}^\Delta_2 &= -j(a^2 B^\Delta_{ab} + B^\Delta_{bc} + aB^\Delta_{ca})V^L_{a1}\end{aligned} \quad (4)$$

In order to reduce the negative sequence current and to improve the power factor, results of the loadcurrents and the SVCcurrents can be expressed as

$$\bar{I}^L_2 + \bar{I}^\Delta_2 = 0 \quad (5)$$

$$\mathrm{Im}[\bar{I}^L_1 + \bar{I}^\Delta_1] = 0 \quad (6)$$

Substituting eq (3) and(4) into (5) and(6), the compensation susceptancesof the SVC canbe expressed interms of symmetrical componentsof the load currents.

$$\begin{aligned}B^\Delta_{ab} &= -\frac{1}{3V^L_{a1}}\left[\mathrm{Im}(\bar{I}^L_{a1}) + \mathrm{Im}(a\bar{I}^L_{b1}) - \mathrm{Im}(a^2\bar{I}^L_{c1})\right]\\ B^\Delta_{bc} &= -\frac{1}{3V^L_{a1}}\left[\mathrm{Im}(a\bar{I}^L_{b1}) + \mathrm{Im}(a^2\bar{I}^L_{c1}) - \mathrm{Im}(\bar{I}^L_{a1})\right]\\ B^\Delta_{ca} &= -\frac{1}{3V^L_{a1}}\left[\mathrm{Im}(a^2\bar{I}^L_{c1}) + \mathrm{Im}(\bar{I}^L_{a1}) - \mathrm{Im}(a\bar{I}^L_{b1})\right]\end{aligned} \quad (7)$$

By observing Figure . 1, the resistor which isbetween loads andthe compensator is ignored. Whenthe compensationcurrent is inductive, the instantaneous current of eachphase for the SVC canbe obtained by

$$\begin{aligned}i^\Delta_{ab}(t) &= \frac{1}{L^\Delta_{ab}}\int v^L_{ab}(t)dt\\ i^\Delta_{bc}(t) &= \frac{1}{L^\Delta_{bc}}\int v^L_{bc}(t)dt\\ i^\Delta_{ca}(t) &= \frac{1}{L^\Delta_{ca}}\int v^L_{ca}(t)dt\end{aligned} \quad (8)$$



Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

If the compensatio current iscapacitative, the instantaneouscurrent of each phase forthe SVC can be expressed as

$$i_{ab}^{\Delta}(t) = C_{ab}^{\Delta}\frac{dv_{ab}^{L}(t)}{dt}$$
$$i_{bc}^{\Delta}(t) = C_{bc}^{\Delta}\frac{dv_{bc}^{L}(t)}{dt} \quad (9)$$
$$i_{ca}^{\Delta}(t) = C_{ca}^{\Delta}\frac{dv_{ca}^{L}(t)}{dt}$$

## IV. DESCRIPTION OF D-STATCOM OPERATION

A D-STATCOM consists of a 2-level VSC, a dc power storagedevice, controller and a coupling transformerrelated in shunt to the distribution network. Figure 2 shows the schematicgraph of D-STATCOM.

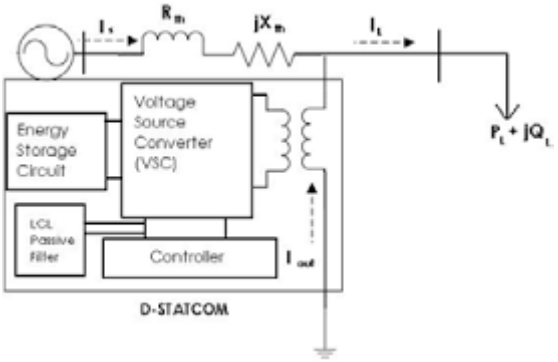



Figure: 2 Schematic diagram of a DSTATCOM

### 4.1 Overview of D-STATCOM

The DistributionStatic Compensator (DSTATCOM) is a voltagesupply inverter based totally static compensator that is utilized for the rectification of line flows [7]. Association (shunt) to the dispersion organize is by means of means of a preferred electricity circulation transformer [8]. The DSTATCOM is in shape for developing regularly element inductive or capacitive shunt pay at a dimension up its most severe MVA rating. The DSTATCOM constantly checks the line waveform concerning a reference air conditioning signal, and in this way, it can supply the ncorrect measure of driving or slacking responsive present day remuneration to decrease the measure of voltage variances. The huge segments of a DSTATCOMmare appeared in Fig.2.1 [9]. It comprises of a dc capacitor, at least one inverter modules, an air conditioner channel, a transformer to coordinate the inverter yield to the line voltage, and a PWM control system. In this DSTATCOM usage, a voltage-source inverter changes over a dc voltage into a three-stage air conditioning present day that is synchronized with, and associated with, the air conditioner line through a little tie reactor and capacitor (air conditioning channel) .

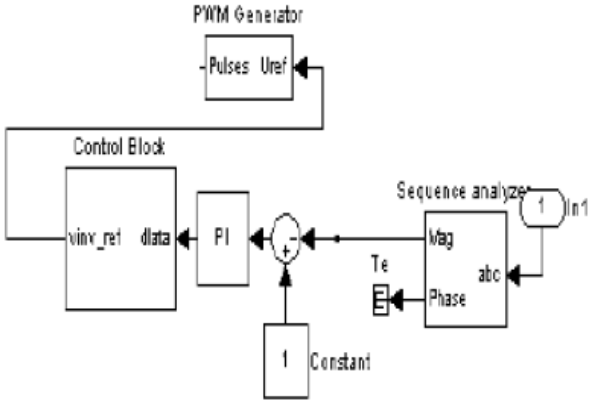



Figure: 3 Block diagram of Controller System

Figure 3 demonstrates the rectangular chart of Controller sytem.The controller framework is incompletely segment of circulation framework. Corresponding necessary controller (PI Controller) is an input controller, which drives the framework to be controlled with a weighted whole of the mistake flag (distinction between the yield and wanted set point) and the necessary of that esteem. For this situation, PI controller will manner the mistake flag to zero. The heap r.m.s voltage is taken once more to them reference voltage by way of contrasting the reference voltage and the r.m.s voltages that had been estimated at the heap point. It likewise is utilized to manipulate the pass of receptive energy from the DC capacitor stockpiling circuit.PWM generator is the system that creates the Sinusoidal PWM waveform or flag. To work PWM generator, the point is summed with the stage aspect of the parity grant voltages in a similar way at a hundred and twenty degrees. In this way, it can provide the ideal synchronizing signal that required. PWM generator in addition bought the mistake flag point from PI controller. The regulated flag is analyzed towards a triangle action so as to create the changing warning signs for VSC valves.

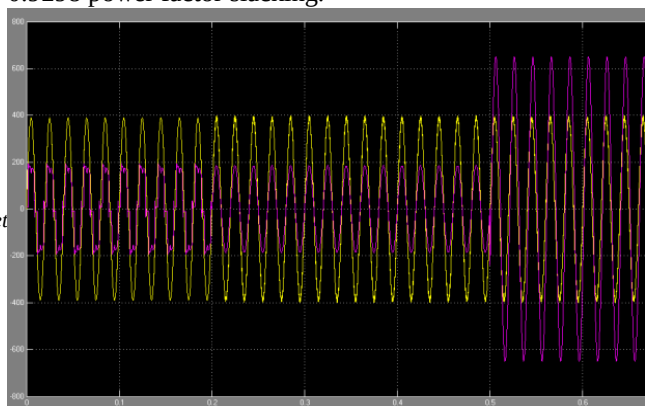
## V. SIMULATION RESULTS

So as to verify the modification of depth factor and remunerate the symphonious current, a 22-kV manipulate conveyance feeder with three-stage rectifier stacking was utilized. The take a look at was remoted into two cases. The most important case was once utilized the manipulate plot by [1]. Though, the second case was once the proposed control plot given in this paper. Both experiments were allotted to be labored with a comparable guidance. The check framework was once begun from zero beginning conditions with just the rectifier load. At t = 0.2 s, the DSTATCOM used to be associated with the framework by using skill of the cause of coupling association . At t = 0.5 s, the RL load was once changed on to increase the framework stacking.

With the control methodology proposed by [1], the framework response besides D-STACOM in the time meantime 0 – 0.2 s used to be regarded in Fig. 7. At t = 0.2 – 0.5s, the D-STATCOM used to be related with repay the non-direct burden as reactions. It tends to be

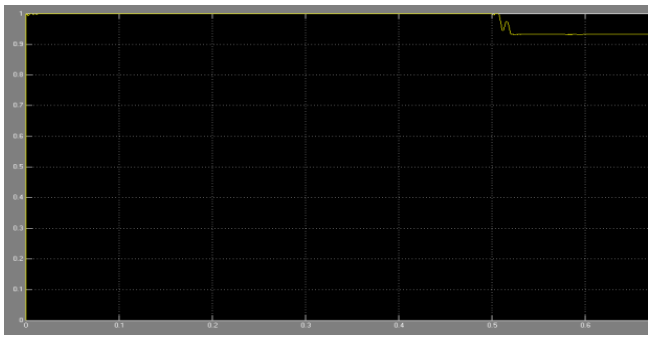
considered that the supply cutting-edge was molded to be nearly sinusoidal.

Be that as it may, because of the PWM activity of the DSTATCOM, higher-request symphonious segments were definitely experienced. At t ≥ 0.5 s when the RL load exchanged, the source current was slacked the voltage at the purpose of coupling association by 21.6 degree relating to 0.9298 power factor slacking.

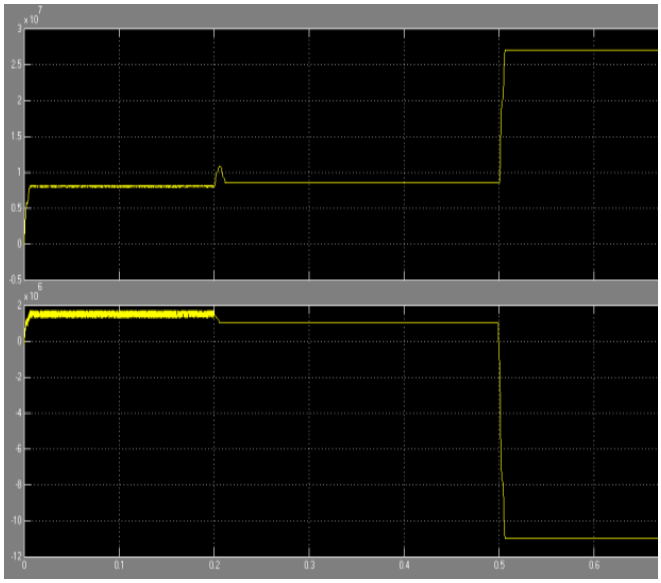


Ret

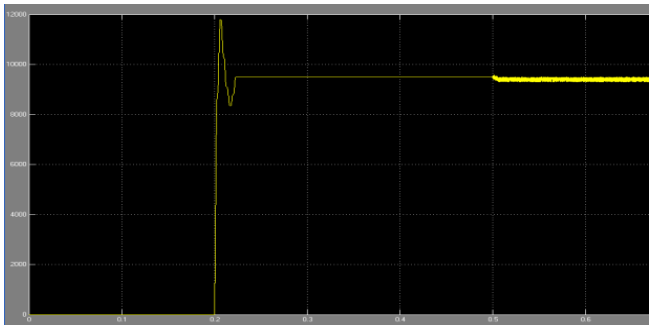
Source voltage and current



Power factor



Three phase active and reactive power



DC Voltage

## VI. Conclusion

The prompt compensator needs a free power source to supply the pay current, subsequently, the prime expense relies upon limit of the autonomous power source. This investigation recommends that a SVC is used to diminish the limit of the autonomous power. At the point when the momentary compensator is joined with a SVC, the two types of gear would not meddle with one another. Indeed, even it has mistake between the consequence of burden determining and estimation information, the recommendation technique can in any case keep up the power factor amendment and diminish the current of the quick compensator. At long last, it utilizes the proposed technique to dissect estimated information from an electric bend heater in a metal industry processing plant. The investigation results affirm the attainability of the pay technique that is proposed in this examination.

## REFERENCES


1. J. C. Gu, C. J. Wu, and J. C. Chiang, “Effects of high voltage side voltage flicker sources on low voltage side customers,” Power Research Institute, Taiwan Power Company, 1994.
2. G. Wiczynski, “Analysis of voltage fluctuation in power networks,” *IEEE Trans. Instrumentation and Measurement*, vol. 57, no. 11, pp. 2655–2664, 2008.
3. M. Joorabian, D. Mirabbasi, and A. Sina, “Voltage flicker compensation using STATCOM,” in Proceeding of the 4th IEEE Conference on Industrial Electronics Applications, Xi'an, China, pp. 2273-2278, 2009.
4. Y. J. Hsu, K. H. Chen, P. Y. Huang, and C. N. Lu, “Electric arc furnace voltage flicker analysis and prediction,” *IEEE Trans. Instrumentation and Measurement*, vol. 60, no. 10, pp.3360-3368, 2011.
5. C. J. Wu, C. P. Huang, T. H. Fu, T. C. Zhao, and H. S. Kuo, “Investigation of DC electric arc furnace average power factor calculation using ieee standard 1459,” in Proceeding of IEEE PES Transmission and Distribution Conference and Exposition, Dallas, USA, pp. 611-615, 2003.
6. A. D. Kolagar, A. Shoulaie, “Reduction of undesired harmonic components in a steel industrial plant with DC electric arc furnaces,” in Proceeding of 2011 2nd Power Electronics , Drive System Technologies Conference, Tehran, Iran, pp. 522-528, 2011.
7. Y. Suh, H. Park, Y. Lee, and P. K. Steimer, “A power conversion system for AC furnace with enhanced arc stability,” *IEEE Trans. Industry Application*, vol. 46, no. 6, pp. 2526-2534, 2010.
8. T. J. E. Miller, Reactive Power Control in Electric Systems, New York, USA: John Wiley and Sons., 1982.
9. S. Xu, J. F. Zhao and G. Q. Tang, “A new SVC control strategy for voltage flicker mitigation and integrated compensation to electric arc furnace,” Proceedings of the Third International Conference on Electric Utility Deregulation and Restructuring and Power Technologies, Nanjing, China, pp. 1972-1976, 2008.
10. M. Mokhtari, S. Golshannavaz, D. Nazarpour, and M. Farsadi, “Control of an SVC for the load balancing and power factor correction with a new algorithm based on the power analysis,” in Proceeding of Power Quality Conference, Tehran, Iran, pp. 1-5, 2010.




*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

11. A. Nabae and T. Tanaka, "A new definition of instantaneous active-reactive current and power based on instantaneous space vectors on polar coordinates in three-phase circuits," *IEEE Trans. Power Delivery*, vol. 11, no. 3, pp.1238-1243, 1996.
12. C. J. Wu and Y. W. Liu, "Reactive power compensation for unbalanced fluctuating loads by using two-dimensional instantaneous space vector approach," *Periodical of Advanced Materials Research*, vol. 732-733, pp. 1444-1449, 2013.
13. C. J. Wu and Y. W. Liu, "Reactive power compensation for unbalanced fluctuating loads by using two-dimensional space vector and a static var compensator," *Applied Mechanics and Materials*, vol. 533, pp. 397-400, 2014.
14. T. L. Baldwin, T. J. Hogans, S. D. Henry, F. J. Renovich, P. T. Latkovic, "Reactive-power compensation for voltage control at resistance welders," *IEEE Trans. Industry Application*, vol. 41, no. 6, pp. 1485-1492, 2005.
15. K. M. Son, K. S. Moon, S. K. Lee, and J. K. Park, "Coordination of an SVC with a ULTC reserving compensation margin for emergency control," *IEEE Trans. Power Delivery*, vol. 15, no. 4, pp. 1193-1198, 2000.
16. S. Y. Lee and C. J. Wu, "Reactive power compensation and load balancing for unbalanced three-phase four-wire system by a combined system of an SVC and a series active filter," *IEE Proceeding of Electric Power Applications*, vol. 147, no. 6, pp. 563-578, 2000.
17. Y. W. Liu, S. H. Ran, C. J. Wu, and W. J. Lee, "Improvement of power quality by using advanced reactive power compensation," Proceeding of 2016 IEEE/IAS 52nd Industrial and Commercial Power Systems Technical Conference, Detroit, MI, USA, pp.1-6, 2016.
18. X. Tang, C. Yang, and J. Zhou, "Stock price forecasting by combining news mining and time series analysis," Proceedings of the IEEE/WIC/ACM International Joint Conferences on Web Intelligence and Intelligent Agent Technologies, Milan, Italy, pp. 279-282, 2009.
19. VM Jyothi, TV Muni, SVNL Lalitha, "An optimal energy management system for pv/battery standalone system*," International journal of Electrical and Computer Engineering*, 2016.
20. T. Vijay Muni, D. Priyanka, S V N L Lalitha, "Fast Acting MPPT Algorithm for Soft Switching Interleaved Boost Converter for Solar Photovoltaic System", Journal of Advanced Research in Dynamical & Control Systems, Vol. 10, 09-Special Issue, 2018
21. T Vijay Muni, SVNL Lalitha, B Krishna Suma, B Venkateswaramma, "A new approach to achieve a fast acting MPPT technique for solar photovoltaic system under fast varying solar radiation", International Journal of Engineering & Technology, Volume7, Issue 2.20, pp-131-135.

## AUTHORS PROFILE

**P.Suguna Ratnamala** currently working as Assistant professor in Department of Electrical & Electronics Engineering, Godavari Institute of Engineering & Technology, Rajahmundry. I studied B.Tech at Godavari Institute of Engineering & Technology, Rajahmundry and M.Tech at Shri Vishnu college of engineering for women.

**Ramjee Sakpal Mortha** currently works at the Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology. Ramjee sakpal does research in Electronic Engineering and Electrical Engineering. I studied B. tech at JNTUK college of engineering Vizianagaram and M. tech from NIT Calicut. I am having membership in IAENG.

**M.John Sreenivasa Rao**, currently works at the Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology. John Sreenivasa rao does research in Electronic Engineering and Electrical Engineering. I studied by B. tech at Godavari Institute of Engineering & Technology,Rajahmundry and M. tech from Godavari Institute of Engineering & Technology,Rajahmundry. I am having membership in IAENG