ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Reactive Power Control of Three Phase Micro Grid with 5- Level D-STATCOM

Venkaiah Kokollu
PG Scholar,
Department of EEE,
MJR College of Engineering and Technology, Piler,
Chittoor(Dist), A.P, India.

Sri V.Veera Nagi Reddy
HOD,
Department of EEE,
MJR College of Engineering and Technology, Piler,
Chittoor(Dist), A.P, India.

ABSTRACT:

This paper proposes 5- level D-STATCOM gadget for Micro grid applications. This gadget is utilized to enhance the reliability and power nature of the general small scale lattice loads. Keeping in mind the end goal to get speedier computational time for substantial force frameworks, by determining the consistent state and the transient control issues independently, a novel control configuration utilized as a part of this new model of control calculation. To exhibit the capacity of the proposed adaptable ac dissemination framework gadget this design idea is checked through diverse experiment situations and the outcomes acquired are examined.

Index Terms:

Distribution static compensator (DSTATCOM), microgrid, voltage source converter (VSC), Micro Grid .

I.INTRODUCTION:

The ever increasing energy demand, along with the necessity of cost reduction and higher reliability requirements, are driving the modern power systems towards distributed generation (DG) as an alternative to the expansion of the current energy distribution systems [1]. In particular, small DG systems, typically with power levels ranging from 1 kW to 10 MW, located near the loads are gaining popularity due to their higher operating efficiencies. Fuel cells (FC), Photovoltaic cells (PV), Batteries, micro turbines, etc. are nowadays the most available DGs for generation of power mostly in peak times or in rural areas [2]. A diesel generator set (genset) consists of an internal combustion engine, exciter and a synchronous generator coupled on the same shaft. Such systems are widely used as backup or emergency power in commercial as well as industrial installations. Diesel gensets are also extensively used in remote locations where no utility supply exists [3]. Over the last few decades, there is a growing interest in FC System for power generation and it has been identified as a suitable solution for distributed generation [4]. Other than FC, the use of new efficient PVs has emerged as an alternative measure of renewable green power, energy conservation and demand side management [5].Microgrids are systems with clusters of loads and micro sources. To deliver high quality and reliable power, the microgrid should appear as a single controllable unit that responds to changes in the system [6]. The high penetration of DGs, along with different types of loads, always raises concern about coordinated control and power quality issues. In microgrid, parallel DGs are controlled to deliver the desired active and reactive power to the system while local signals are used as feedback to control the converters.The power sharing among the DGs can be achieved by controlling two independent quantities– frequency and fundamental voltage magnitude [7-9]. General introduction on microgrid basics, including the architecture, protection and power management is given in [10]. A review of on going research projects on microgrid in US, Canada, Europe and Japan is presented in [11]. Different Power management strategies and controlling algorithms for a microgrid is proposed in [12]. References [13-16] have evaluated the feasibility for the operation of the microgrids during islanding and synchronization. An algorithm was proposed in [17] and used for evaluation of dynamic analysis for grid connected and autonomous modes of the microgrid. In [18], it is shown that a proper control method of distributed resources can improve the power quality of the network.

There are still many issues which are needed to be addressed to improve the power quality in a microgrid. The power quality issues are important as the power electronic converters increase the harmonic levels in the network voltage and current. Unbalance loads can cause the current and hence the voltage of the network suffering from high values of negative sequence which can be a problem for all induction motor loads in the network.

Nonlinear loads (NL) can increase the harmonic level of the network current and voltage, which will increase the loss and reduce the efficiency of the network [19-20]. On the other hand, a power electronic converter can mitigate harmonic and unbalanced load or source problems. In [20] a series-shunt compensator is added in microgrid to achieve an enhancement of both the quality of power within the microgrid and the utility grid.

The compensator has a series element as well as a shunt element. The series elements can compensate for the unwanted positive, negative, and zero sequence voltage during any utility grid voltage unbalance, while the shunt element is controlled to ensure balanced voltages within the microgrid and to regulate power sharing among the parallel connected DG systems. The proposed method in [20] requires adding other converters, while the same power quality improvement objectives can be achieved by one of the existing converters in the microgrid as proposed and validated in this paper.

II. MICROGRID STRUCTURE:

The schematic diagram of the microgrid system under consideration is shown in Fig. 1. There are four DGs as shown; one of them is an inertial DG (diesel generator) while others are converter interfaced DGs (PV, FC and battery). There are four resistive heater loads and six induction motor loads. A nonlinear load, which is a combination of unbalance and harmonic load, is also connected to BUS 5 in the microgrid.

The FC will be used as the compensating DG for power quality improvement in this structure since it is the closest amongst all the converter interfaced DGs to the nonlinear load and connected to the same bus. If the nonlinear load was connected to BUS 3 or 4, the PV or battery should be used as the compensating DG.

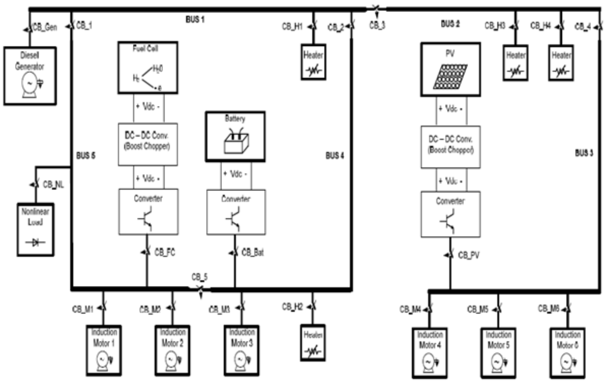


Fig.1 Schematic diagram of the microgrid structure under consideration.

II.MULTILEVEL CONVERTERS:

Multilevel converters (or inverters) have been utilized for air conditioning to-dc, air conditioning to-dc-to-air conditioning, dc-to-air conditioning, and dc-to-dc power change in high-control applications, for example, utility and substantial engine drive applications. Multilevel inverters give more than two voltage levels. A wanted yield voltage waveform can be incorporated from the numerous voltage levels with less contortion, less exchanging recurrence, higher effectiveness, and lower voltage gadgets.There are three noteworthy multilevel topologies: fell, diode braced, and capacitor clipped. For the quantity of levels ( ) no more noteworthy than three (i.e.,), or a few applications, for example, responsive and symphonious remuneration in force frameworks, these multilevel converters don’t oblige a different dc force source to keep up every voltage level Natural concern and nonstop consumption of fossil fuel stores have prodded critical enthusiasm for renewable vitality sources. The vitality stockpiling turned into a predominant figure financial improvement with the across the board presentation of renewable sources A Seven-level inverter was outlined and actualized to work as a battery adjusted release framework, which expands the capacity of a put away vitality use of a renewable vitality sources.

A. Cascaded Multilevel Inverter :

Cascaded Multilevel Inverter (CMLI) is a standout amongst the most essential topology in the group of multilevel and multi- beat inverters. It obliges slightest number of parts with contrast with diode-cinched and flying capacitors sort multilevel inverters and no uncommonly planned transformer is required when contrasted with multi heartbeat inverter.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

It has secluded structure with basic exchanging system and involves less space [1], [3]. The CMLI comprises of various H-span inverter units with particular dc hotspot for every unit and is associated in course or arrangement as indicated in Fig. 2. Every H- Bridge can create three distinctive voltage levels: +Vdc, 0, and –Vdc by joining the dc source to air conditioning yield side by diverse mixes of the four switches S1, S2, S3, and S4.

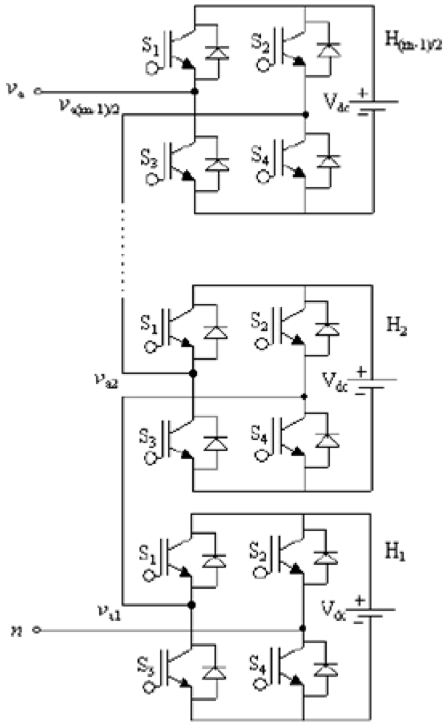


Figure. 2. Multilevel cascaded H-bridges inverter

The ac yield of every H-extension is associated in arrangement such that the combined yield voltage waveform is the total of the greater part of the individual H-scaffold yields. By joining the adequate number of H-scaffolds in course and utilizing legitimate balance conspire, an about sinusoidal yield voltage waveform can be integrated. The quantity of levels in the yield stage voltage is 2s+1, where s is the quantity of H scaffolds utilized per stage. Fig. 3 demonstrates a 7-level yield stage voltage waveform utilizing four H-spans. The size of the air conditioner yield stage voltage is given by van =va1+va2+va3+va4 [2].

III.CONVERTER CONTROL FOR DGS AND DSTATCOM:

In this section, the converter structure and control (for DG and DSTATCOM) is described. First similar to dq transformation in three phase, a transformation technique for single phase is explained.

The same technique is used for voltage and current transformation in DG and DSTATCOM. The implementation of the transformation is shown in Fig. 4. First, a low-pass filter eliminates the switching frequency harmonics; then, a product by sin(wt) and another by cos(wt), and finally, a notch filter tuned at twice the line frequency is used (in order to cancel the terms of this frequency that appeared due to the previous stage). A precise synchronization is achieved by a phase-locked loop

$V(t) = VmSin(wt - \Phi)$
$V(t) = VdSin(wt) - VqSin(wt)$
where, $Vd(t) = VmCos(\Phi)$and $Vq(t) = VmSin(\Phi)$.

A. DG:

All the DG converter structure and control are similar. Only DG-1 converter structure and control are described here. The converter structure for DG-1 is shown in Fig. 5. The singlephase converter is made of four IGBT switches, and the converter ac side output voltage e is connected through the transformer to the output filter capacitor (Cf) as shown in Fig. 5. Transformer loss and inductance are represented by Rtr and Ltr, respectively. The DG is connected to the PCC through output inductance Lf . Converter data are given in Table II. The converter control scheme for DG-1 is shown in Fig. 6. The voltage reference generation with frequency control is shown in Fig. 6.The generation of real and reactive power based on converter current limit is shown in Fig. 7, while Fig. 8 shows the current control loop. It is to be noted that the voltage and frequency regulation (last block in Fig. 6) is only active in islanded mode of operation. The voltage magnitude is regulated with reactive power [as shown in (1)], while the voltage angle controlled by the active power output [25]. In grid-connected mode, the voltage reference calculated by Voltage Reference Calculation block is directly fed to the converter.The measured power and voltage are communicated to DSTATCOM through the communication network as shown. In converter control, the power reference generation (Fig. 7) block calculates the real and reactive power reference based on current limit and available power. Both the real and reactive powers are limited to the corresponding real and reactive power limits. The current reference is generated from the reference power and measured power as shown in Fig. 8. The error in real power is used to calculate the d axis current reference, and the error in reactive power is used to calculate the q axis current reference.

Fig. 9 shows the converter reference voltage generation. The current errors are passed through the PI controller and added to the d-q axis voltage reference as shown in Fig. 9.

B. DSTATCOM:

The converter structure of the DSTATCOM is shown in Fig. 10. DSTATCOM parameters are given in Table IV. The capacitor in the dc side is connected to the H bridge. The ac side voltage estat is connected through the transformer to output filter capacitor. The DSTATCOM output current and voltage is shown as iSTAT and vstat, respectively.The converter control scheme for DSTATCOM is shown in Fig. 11. The DSTATCOM output voltage reference vstatref is calculated as (9). The dc voltage is held to a fixed value Vcref . The reference current generation is shown in Fig. 12. The error in dc capacitor voltage is passed through a PI controller to generate the d axis current reference, while the error in DSTATCOM output voltage is used to generate the q axis current reference as shown in Fig. 12. The control methods of the DGs and DSTATCOM are shown in Fig. 13. It can be seen that in grid-connected mode, the DG supplies maximum available power. The voltage and frequency regulations with droop are activated in islanded mode. In case the DG reaches the reactive power limit, the active power reference is modified based on (10). The DSTATCOM operates as described in (9) using both local and communicated measurement. The overview diagram of the control strategy is shown in Fig. 14. The control of the other DGs is same as DG-1. The power flow and voltage of the DG buses are communicated to the DSTATCOM through the communication network as shown.Usually, a single DSTATCOM is used in a feeder close to the far end for reactive compensation. However, depending on DG penetration, power flow, and voltage control in the microgrid, it may be necessary to install multiple DSTATCOM. The control should be modified for the multiple DSTATCOM scenarios. One way could be dividing the feeder in different zones where each DSTATCOM takes care of its own zone for the reactive compensation.

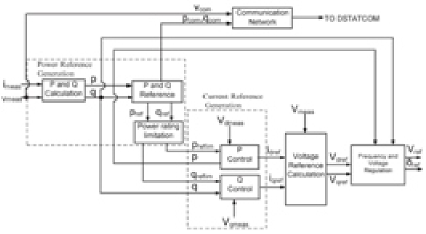


Fig. 6. Converter control of DG-1.

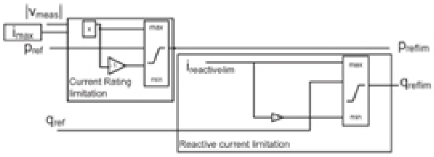


Fig. 7. Reference power generation.

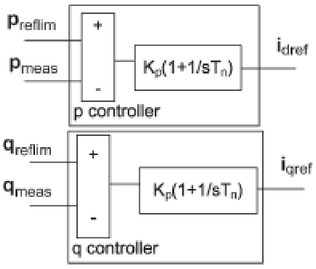


Fig. 8. Reference current generation.

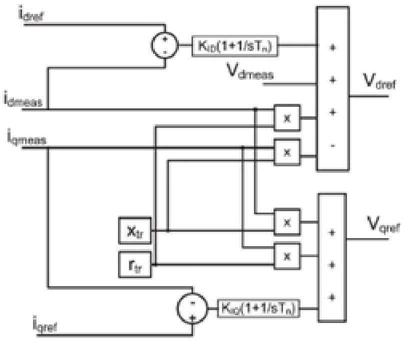


Fig. 9. Reference voltage generation.

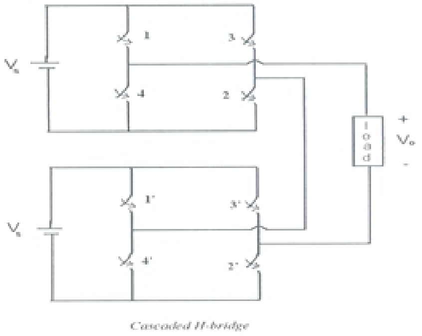


Fig. 10. Converter structure of DSTATCOM.

The DGs in that zone communicate with the DSTATCOM. Moreover, the DSTATCOMs can communicate with each other for an improved voltage profile along the line and to ensure that the control in one zone does not fight with the other.

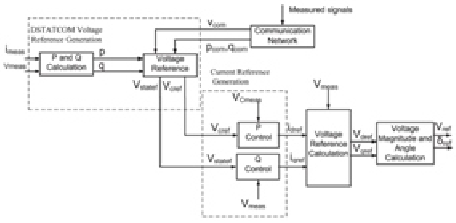


Fig. 11. Converter control scheme for DSTATCOM.

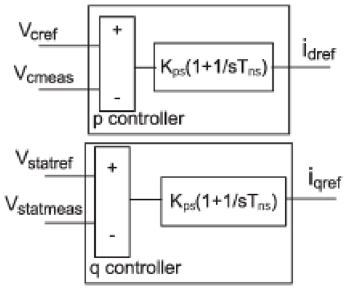


Fig. 12. Converter reference current generation.

V. SIMULATION RESULTS:

Simulation is performed using MATLAB/SIMULINK software. Simulink liabrary files include inbuilt models of many electrical and electronics components and devices such as diodes, MOSFETS, capacitors, inductors, motors, power supplies and so on. The circuit components are connected as per design without error, parameters of all components are configured as per requirement and simulation is performed

SIMULATION PARAMETES

DG isolation Transformer
100KVA, 50Hz
DG side filter ratings
C=440mF
L=1uH
Line parameters
R=10Ohm
L=1mH
Load ratings
415V 50Hz 3-Ph
4KW
Five level inverter switching frequency= 2.5KHz

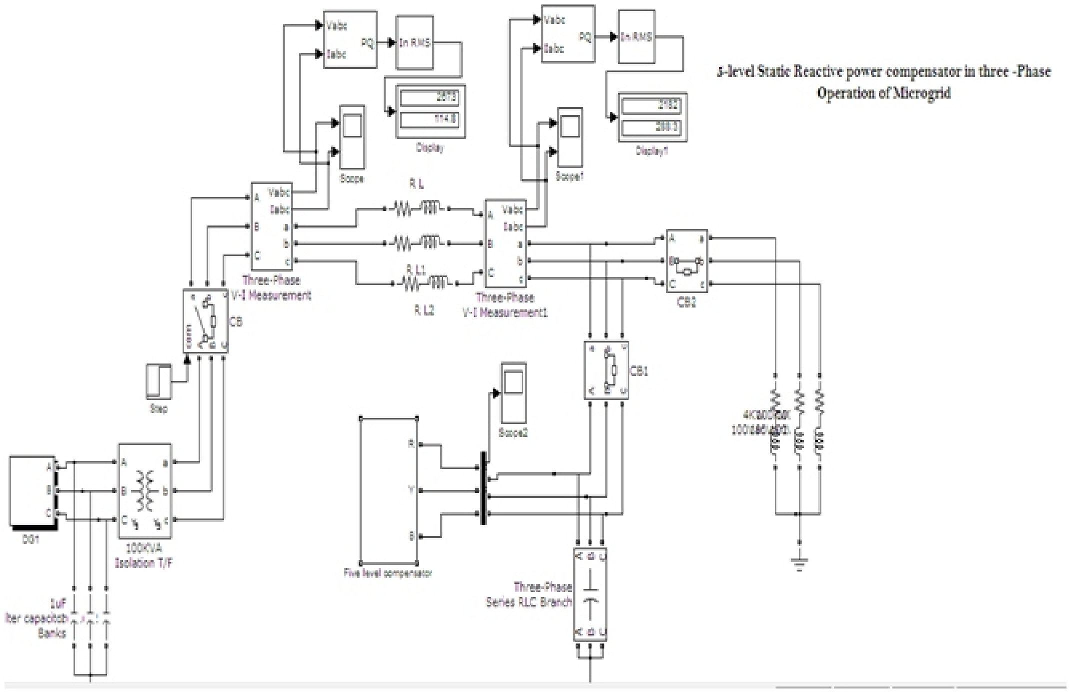
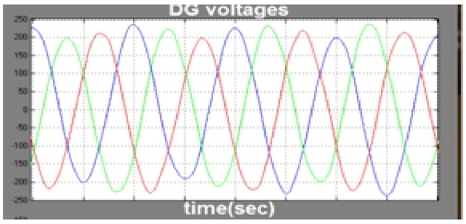


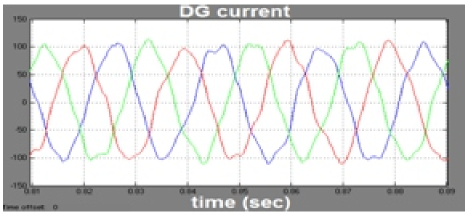
Fig.12: Simulation circuit

WAVEFORMS

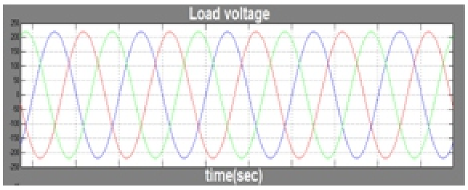
a)DG output voltage

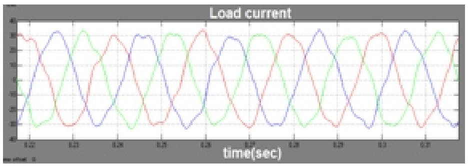


b)DG output current



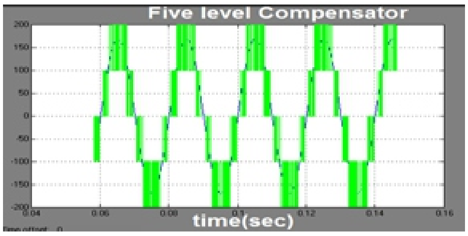
c)Load side voltages and currents





In the absence of compensator there is mismatch in reactive powers generated and reactive power demandIn the presence of compensator this difference is made less.

d)Five level inverter output



V. CONCLUSION

Hence in this paper a five level D-statcom is presented for reactive power compensation. In the absence of this compensation there wont be reactive power balance, this mismatch is reduced by injecting Statcom in to the network.

REFERENCES:

[1] X. Yoasuo, C. Liuchen, B. K. Soren, B. Josep, and S. Toshihisa, “Topologies of single-phase inverters for small distributed power generators: An overview,” IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1305–1314, Sep. 2004.

[2] T. E. McDermott and R. C. Dugan, “Distributed generation impact on reliability and power quality indices,” in Proc. IEEE Rural Elect. Power Conf., 2002, pp. D3_1–D3_7.

[3] National Energy Technology Laboratory, U.S. Department of Energy, Provides Power Quality for 21st Century Needs, Jan. 2007.

[4] 978-1-84800-317-0R. Strezelecki and G. Benysek, “Active power quality controllers,” in Power Electronic in Smart Electrical Energy Network. New York: Springer-Verlag, 2011.

[5] R. Majumder, A. Ghosh, G. Ledwich, and F. Zare, “Operation and control of single phase micro-sources in a utility connected grid,” in Proc. IEEE PES, Jul. 26–30, 2009, pp. 1–7.

[6] F. Shahnia, R. Majumder, A. Ghosh, G. Ledwich, and F. Zare, “Sensitivity analysis of voltage imbalance in distribution networks with rooftop PVs,” in Proc. IEEE Power Energy Soc. Gen. Meeting, Jul. 25–29, 2010, pp. 1–8.

[7] Z. Tao and B. Francois, “Energy management and power control of ahybrid active wind generator for distributed power generation and grid integration,” IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 95–104,Jan. 2011.

[8] Z. Qing-Chang and G.Weiss, “Synchronverters: Inverters that mimic synchronous generators,” IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1259–1267, Apr. 2011.

[9] Y. Shuitao, L. Qin, F. Z. Peng, and Q. Zhaoming, “A robust control scheme for grid-connected voltage-source inverters,” IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 202–212, Jan. 2011.

[10] I. J. Balaguer, L. Qin Lei, Y. Shuitao, U. Supatti, and P. Fang Zheng, “Control for grid-connected and intention

al islanding operations of distributed power generation," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 147–157, Jan. 2011.

[11] J. M. Guerrero, J. Matas, L. G. de Vicuna, M. Castilla, and J. Miret, "Decentralized control for parallel operation of distributed generation inverters using resistive output impedance," IEEE Trans. Ind. Electron.,vol. 54, no. 2, pp. 994–1004, Apr. 2007.

[12] J. M. Guerrero, J. C. Vasquez, J. Matas, M. Castilla, and L. G. de Vicuna, "Control strategy for flexible microgrid based on parallel line-interactive UPS systems," IEEE Trans. Ind. Electron., vol. 56, no. 3, pp. 726–736, Mar. 2009.

[13] A. Vaccaro, G. Velotto, and A. F. Zobaa, "A decentralized and cooperativearchitecture for optimal voltage regulation in smart grids," IEEE Trans. Ind. Electron., vol. 58, no. 10, pp. 4593–4602, Oct. 2011.

[14] T. Sauter and M. Lobashov, "End-to-end communication architecture forsmart grids," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1218–1228,Apr. 2011.

Author's Profile:

Venkaiah Kokollu Studying M.tech(EPS) branch at MJR College of Engineering and Technology (MJRCET), Piler, Chittoor(dt) A.P, India.

Sri V.Veera Nagi Reddy He obtained masters degree from JNTU,Anantapur, India. Currently, he is working as HOD in electrical and electronics engineering department at MJR College of Engineering and Technology (MJRCET), Piler, Chittoor(dt) A.P, India.. His research interests include Robotics, smart grids, distributed generation systems and renewable energy sources, power system operation and control.