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Adaptive Current -Voltage Control Scheme for Variable Pulse Load in a Hybrid DC Micro Grid

Mule. Pala Prasad Reddy[1]
Assistant Professor, Dept. Of EEE, AITS, Rajampet,

T.Pavan Kumar[2]
Assistant Professor, Dept. Of EEE, AITS, Rajampet,

Chakali. Shekshavali[3]
PG Student, Dept. Of EEE, AITS, Rajampet,

Abstract

In this paper, the proposed controlled technique is PhotoVoltaic−Maximum Power Point Tracking burp charging technique. By applying charging technique V_{dc} ripples are minimized. Better voltage regulation at load side even in presence of pulsed loads Battery life improvement with tickle charging-more reliable. The another technique is an adaptive current-voltage control (ACVC) scheme based on the moving average measurement technique and an adaptive proportional compensator. This technique can be controlling both voltage and current of the system while keeping the output current of the power converter at a relatively constant value. ACVC technique can be improves the dynamic performance of the hybrid dc microgrid. Although the ACVC technique causes slightly increases the bus voltage variation, it effectively eliminates the high current and power pulsation of the power converters. Using the experimental results comparing between ACVC and Burp charging technique.
ACVC technique increases the grid efficiency and reduces the voltage drops in the system.

Keywords: Hybrid dc microgrid, energy control system,pulse load, supercapacitor, and active hybrid power source, Burp charging technique.

I. INTRODUCTION

DC microgrid power frameworks with multiple sources and reconfiguration qualities of the dc microgrid on these system develop the efficiency and reliability of the system. The micro grid power systems are significant interest in spacecraft, shipboards and data centers applications. In these applications pulsed loads in- clude high-power radars, electromagnetic launch and recovery systems. It is often the case in such loads that a load specific energy storage element is charged over a finite in- terval of time, and then rapidly discharged. The charging of the energy storage device is an intermittent load which disturbs the power system [1], [4]. The power requirements of such loads can range from kilowatts to megawatts with a charge interval on the order of seconds to minutes. Adaptive control is the control method used by a controller which must adapt to a controlled system with parameters which vary, or are initially uncertain. The control system coordinates the operation of converters, sources, and switches used in the dc microgrid.

New designs may include much larger local generation, storage elements, hybrid dc distribution systems and more extensive involvement of power electronic converters and pulsed loads. Hybrid dc microgrids involving sustainable energy and hybrid energy storage. This hybrid storage system consists of super capacitors (SC) for ultra-fast load matching beside lithium-ion batteries for relatively long term load buffering. The energy management algorithm aims mainly at managing the en- ergy within the system such that the effect of pulsed (short duration) loads on the power system stability is minimized.

Loads based on hourly average variations can be considered as low-frequency variations, whereas power transients that sustain for minutes, seconds, or milliseconds come under the high- frequency segment. To buffer out the low frequency oscillations and to compensate for the intermittency of the renewable energy sources, energy storage elements with high energy density is required. To provide the high-frequency component of power and also to supply or absorb the high power transients, energy storage with high power density is required. Recently, high- power capability of super capacitors and high energy capability of batteries or fuel cells are exploited in pulse operating modes for portable power systems.

Supercapacitors are a relatively recent technology that has the potential to improve the performance of a power system. The force thickness of the supercapacitors is up to 10-20 times more than cutting edge batteries. A two fold layer capacitors, supercapacitors have a powerful thickness, low inside resistance and high cycle life. The analytical analysis presented in shows that a battery-supercapacitor hybrid power source can supply a pulsed load with considerably smaller internal losses and greater discharge time than that of a battery- powered system can be used for the beat power load applications. A battery-supercapacitor cross breed power source can supply a beat load with significantly littler inside misfortunes and more noteworthy release time than that of a battery-controlled framework alone.

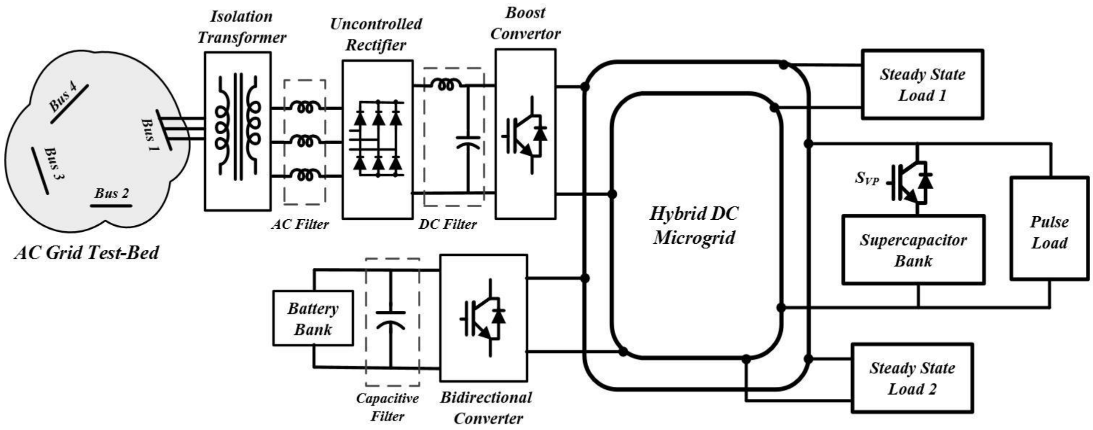


Fig.1: Schematic diagram of the hybrid dc microgrid under study.

In an active hybrid configuration, the battery and/or other energy resources are connected to the supercapacitor and pulse load through a power electronic converter to completely regulate the power injection.
power misfortunes and ease because of the non appearance of extra influence electronic converters. Despite what might be expected, in a dynamic half and half setup, the battery and/or other vitality assets are associated with the supercapacitor and heartbeat load through a force electronic converter to totally control the force infusion.
For heartbeat load moderation, the vitality control plan is imperative as it to a great extent administers the cooperation of the beat load with the air conditioner/dc power framework. In area III, diverse vitality control plans proposed in literary works are portrayed in subtle element. Not at all like traditional strategies, the proposed approach as the benefit of controlling both voltage and current of the dc microgrid. The created ACVC technique can legitimately cushion the converters from the high heartbeat streams while keeping up the transport voltage varieties inside an adequate extent.
The simulation results by PV-MPPT(PhotoVoltaic−Maximum Power Point Tracking burp charging technique demonstrate that the proposed methodology successfully decreases the problematic impacts of the beat power load and very upgrades the dynamic execution of the mixture dc microgrid and the interconnected air conditioning network. The proposed ACVC methodology and to contrast and the other traditional vitality control techniques, a lab scale crossover dc microgrid was produced.

I. SYSTEM DESCRIPTION

The notional hybrid DC microgrid considered for this study is depicted in Fig. 1. This microgrid consists of several types of loads and hybrid energy sources which are connected to a common dc bus.The ac gridis the microgrid while the battery bank provides extra power when the grid is highly loaded. This framework incorporates producing stations, and programmable burdens in a research facility size of up to 35 kW. Four air conditioning generators are associated in a ring blend through line/link models. One of the generators (associated with transport 1) keeps running at a consistent recurrence of 60 Hz and goes about as the slack transport. The other three creating stations are torque controlled, which takes into consideration steady yield power.

The cross breed dc microgrid under study is associated with the air conditioner matrix through the uncontrolled rectifier and help converter for force transformation and control. An inductive air conditioning channel is situated between the transformer and the uncontrolled rectifier to sift through the sounds to the AC lattice. A three stage Y/Δ transformer was actualized to galvanically detach the AC lattice from the dc microgrid. An inductive-capacitive dc channel is associated between the help converter and the uncontrolled rectifier to diminish the air conditioner matrix music AND enhance the execution of the converter. The nifty gritty parameters of the segments are condensed in table I.

TABLE I
HYBRID DC MICROGRID SYSTEM PARAMETERS

Component	Parameter	Specification
Transformer	*Connection*	*YD*
	S_N	*3 kVA (1 p.u.)*
	V_N	*208 V (1 p.u.)*
	Req , Xeq	*0.72 Ω (0.05 p.u.), 0.86 Ω (0.06 p.u.)*
	R_M , X_M	*4820 Ω (334 p.u.), 16.45 Ω (430 p.u.)*
Boost Converter	*power rating*	*2500 W*
	IGBT module	*SKM100GAL12T4*
	switching frequency	*5 kHz*
	LBC	*6 mH*
AC Filter	*L AF (XLAC)*	*12 mH (4.52 Ω, 0.31p.u)*
DC Filter	*LDF*	*2.7 mH*
	CDF	*680 μF*

As shown in Fig. 1, the battery bank is connected through the bidirectional converter to the common coupling dc bus. The supercapacitor bank is 2.9-F, and as an energy buffer, delivers high instantaneous power to the pulse load. The battery bank is composed of twelve lead-Acid battery cells rated 120-V, 110-Ah. This bank is composed of 20 Maxwell's 16-V modules. The passive balancing is a 640-Ω resistor that is connected in parallel to each 16-V module. If the voltage on any of the supercapacitor arrays exceeds the preset limit, the analog control circuit will open the output of the IGBT switch S_{vp}, shown in Fig. 1. The charging path remains open until the supercapacitor is discharged through the bypass diode to the point that its voltage is reduced to a transformer used to transfer electrical power from a source of alternating current (AC) power to some equipment or device while isolating the powered device from the power source, usually for safety reasons. Isolation transformers provide galvanic isolation and are used to protect against electric shock, to suppress electrical noise in sensitive devices, or to transfer power between two circuits which must not be connected. A transformer sold for isolation is often built with special insulation between primary and secondary, and is specified to withstand a high voltage between windings. Isolation transformers block transmission of the DC component in signals from one circuit to the other, but allow AC(alternating current) components in signals to pass. Transformers that have a ratio of 1 to 1 between the primary and secondary windings are often used to protect secondary circuits and individuals from electrical shocks between energized conductors and earth ground.

TABLE II
ENERGY STORAGE AND BIDIRECTIONAL CONVERTER PARAMETERS

Component	**Parameter**	**Specification**
Battery Bank	*Type*	*Universal (UB121100)* *Lead Acid*
	Number of Cells	*12*
	Rated Capacity	*110 Ah*
	Bank nominal Voltage	*120 V*
	Internal Resistance	*4 m* Ω
Supercapacitor Bank	*Type*	*Maxwell (BMOD0058)*
	Number of Cells	*20*
	Rated Capacity	*2.9 F*
	Rated Voltage	*320 V*
	Maximum Voltage	*340 V*

	Maximum Continuous Current	*12 A (∆T= 15˚C)*
	Leakage Current	*25 mA (Passive Balancing)*
	power rating	*1800 W*
Bidirectional Converter	*IGBT module*	*SK45GB063*
	switching frequency	*5 kHz*
	LBD	*6 mH*

Control Description

Fig. 2 shows the control of the hybrid dc microgrid which consists of three layers. The first layer is the energy control system. This control layer utilizes the dc grid bus voltage and the load current to set the total current command, i_c^*. The next layer is the formulation of the reference current of the boost converter, i_{c1}^* and the reference current of the bidirectional converter, i_{c2}^* based on the converters availability and their power limitation. The bidirectional converter is utilized in the case that an outage occurs in the AC grid or if the power requirement of the dc microgrid is higher than the boost converter power limitation. If both converters are available, the priority is given to the boost converter to supply the microgrid through the AC grid.

The third layer is the converter controllers that regulate the output current of the converters. The converter controllers are proportional-integral (PI) with anti-windup that improve the control loop responses during transients and saturation. . The switching signals PWM1 and PWM2 shown in Fig.2 are assigned to the boost converter and the bidirectional converter, respectively. The controller adjusts the duty ratio of the IGBT switching at 5-kHz fixed frequency using pulse

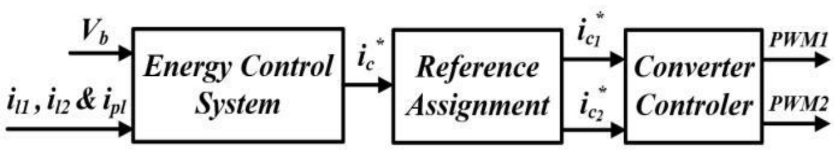


Fig. 2: Block diagram of the DC microgrid three layer control system.

III. ADAPTIVE CURRENT-VOLTAGECONTROL

A new adaptive current-voltage control (ACVC) technique is to improve the dynamic performance of the grid and to buffer the battery bank and AC grid from high pulse currents.

Fig. 3 shows the schematic diagram of this controller.

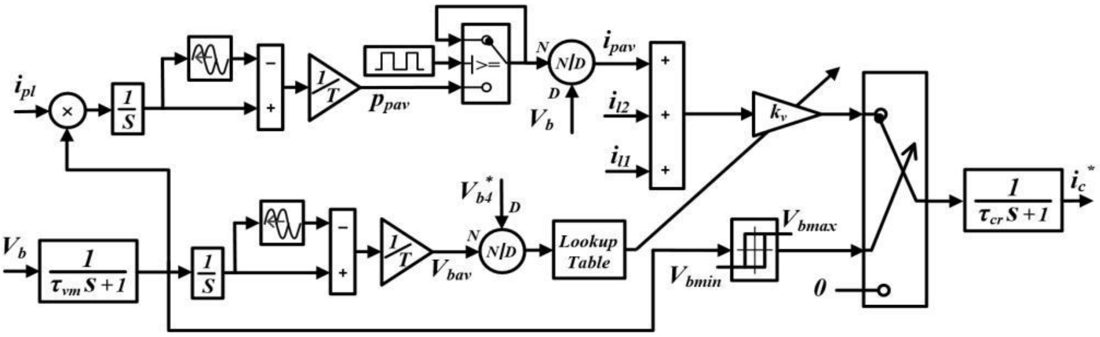


Fig.3: Block diagram of adaptive current-voltage control.

The ACVC is designed based on the moving average current and voltage measurement and an adaptive gain compensator. The input ports of the controller are the pulse load power, the steady state load currents and the bus voltage while the output port is the reference current command I_c^*.The integrated power is subtracted from the delayed value to calculate the accumulated power. To calculate the average power during the last T period, P_{pav} the accumulated power is divided by the time period T.

The average of the bus voltage, V_{bav} is calculated and then normalized with respect to the desired voltage. Thus, the p_{pav} is calculated per T period and is updated every T cycle, while the V_{bav} is continuously updated.

To set the reference current commandI_c^*, the updated P_{pav} is divided by the V_b to form the i_{pav} and then is added to the steady state load's currents. This current is fed to the gain k_v which is an adaptive proportional voltage controller. The k_v is continuously updated based on the normalized average bus voltage to adjustI_c^*.

IV.EXPERIMENTAL RESULTS

In this section, the performance of the developed ACVC technique is experimentally validated.

ACVC Technique:

Fig.4 shows the analysis of the hybrid dc microgrid performance when the ACVC technique employed. The energy control system adjusted the boost converter to a relatively constant 4.5-A which is equal to the sum of the steady state load current and the pulse load time-averaged current. During the pulse on- time, the supercapacitor bank was discharged to 314.7-V and was charged during the pulse off-time and the voltage increased to 322.6-V. Since the generated and consumed power were equal, the average voltage was always 320-V and the loads were continuously supplied.

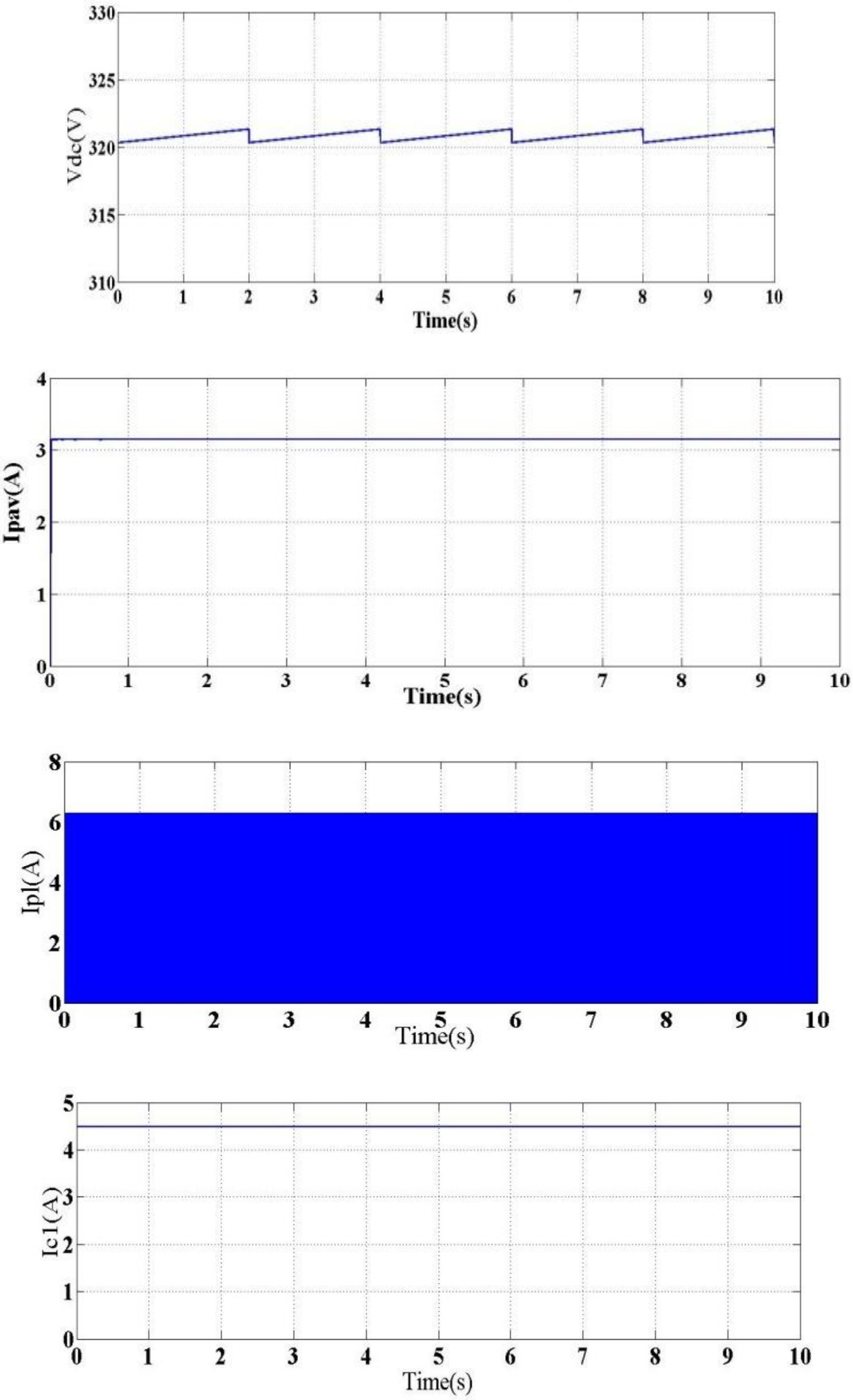


Fig 4: ACVC RESULTS

PV-MPPT BURP CHARGING TECHNIQUE:
Burp charging also called Reflex or Negative Pulse Charging Used in conjunction with pulse charging, it applies a very short discharge pulse, typically 2 to 3 times the charging current for 5 milliseconds, during the charging rest period to depolarize the cell.
These pulses dislodge any gas bubbles which have built up on the electrodes during fast charging, speeding up the stabilization process and hence the overall charging process. The release and diffusion of the gas bubbles is known as "burping".
Controversial claims have been made for the improvements in both the charge rate and the battery lifetime as well as for the removal of dendrites made possible by this technique. The least that can be said is that "it does not damage the battery".

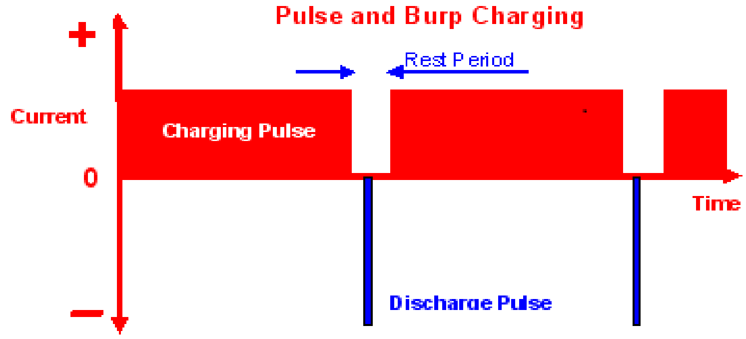
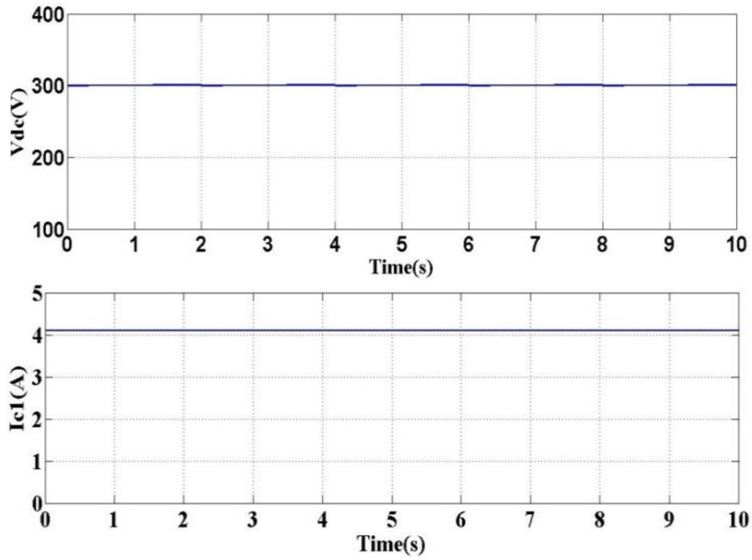


Fig.5: PV-MPPT burp charging

By applying charging technique V_{dc} ripples are minimized. Better voltage regulation at load side even in presence of pulsed loads Battery life improvement with tickle charging-more reliable. The Vdc value in this technique is 300V and also maintain the constant current in converters.



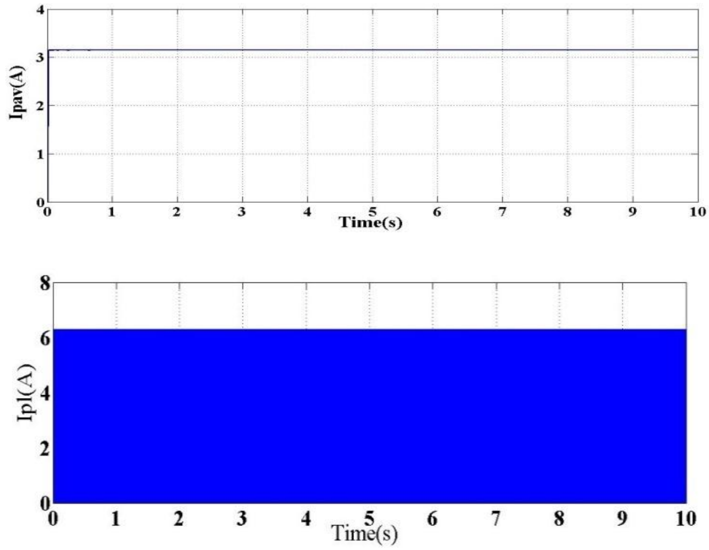


Fig.6: Simulated results with PV-MPPT burp charging technique

CONCLUSION

In this concept, a new energy control scheme was developed to reduce the adverse impact of pulsed power loads. The proposed energy control was an adaptive current-voltage control (ACVC) scheme based on the moving average current and voltage measurement and a proportional voltage compensator by PV-MPPT(PhotoVoltaic−Maximum Power Point Tracking)burp charging technique. The performance of the developed ACVC technique was evaluated and it was compared to the other common energy control methods. However, the transient response of the ACVC technique during pulse load variation was effectively improved and it prevented any steady state voltage error or dangerous over voltage. The developed ACVC method effectively eliminated the power pulsation of the slack bus generator and frequency fluctuation of the interconnected AC grid while the ac bus voltage drop was well reduced. Additionally, the efficiency analysis for different pulse duty ratios showed that the developed ACVC method considerably improved the efficiency of the system since the maximum current of the converter was reduced and the converter was operating at a relatively constant value.

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AUTHOR’S PROFILE

1) **Mule. Pala Prasad Reddy,**Assistant Professor, Dept. Of EEE, AITS, Rajampet.A.P
2) **T.Pavan Kumar,** Assistant Professor, Dept. Of EEE, AITS, Rajampet.A.P
3) **C.SHEKSHAVALI**: He was born in 1993. He obtained his Bachelor degree in Electrical and Electronics Engineering in 2014 from SVCET, CHITTOOR. Currently Pursuing his Post Graduation in Electrical Power Engineering in AITS, Rajampet, Kadapa (dist.).