

# Adaptive current -voltage control scheme for variable Pulse load in a hybrid DC micro grid by PV-MPPT burp charging Technique

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**Abstract** - In this paper, the proposed controlled technique is PV-MPPT 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.

**Key words** - 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. 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. For example, as an aircraft flies, its mass will slowly decrease as a result of fuel consumption; a control law is needed that adapts itself to such changing conditions.

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Battery vitality stockpiling frameworks are generally used in beat power load applications to meet the necessities of the heap. For the beat load framework, the vitality stockpiling parts are of key significance as an interface between the heap and the lattice. In spite of their high vitality thickness, the volumetric force thickness of the batteries is moderately low and they have huge trouble giving high control over a brief span period.

Supercapacitors are a moderately late innovation that can possibly enhance the execution of a force framework. The force thickness of the supercapacitors is up to 10-20 times more than cutting edge batteries. A twofold layer capacitors, supercapacitors have a powerful thickness, low inside resistance and high cycle life. In this way, keeping in mind the end goal to hold the advantages of high particular force and vitality, a half breed battery-supercapacitor capacity framework 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.

Distinctive half and half arrangements are workable for heartbeat load applications. Detached setup is the immediate parallel association of the supercapacitor with other vitality assets and is viewed as the least difficult half and half design. Focal points of this strategy incorporate simplicity of execution, lower power misfortunes and ease because of the nonappearance 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 burp charging technique demonstrate that the proposed methodology successfully decreases the problematic

impacts of the beat power load and very upgrades the

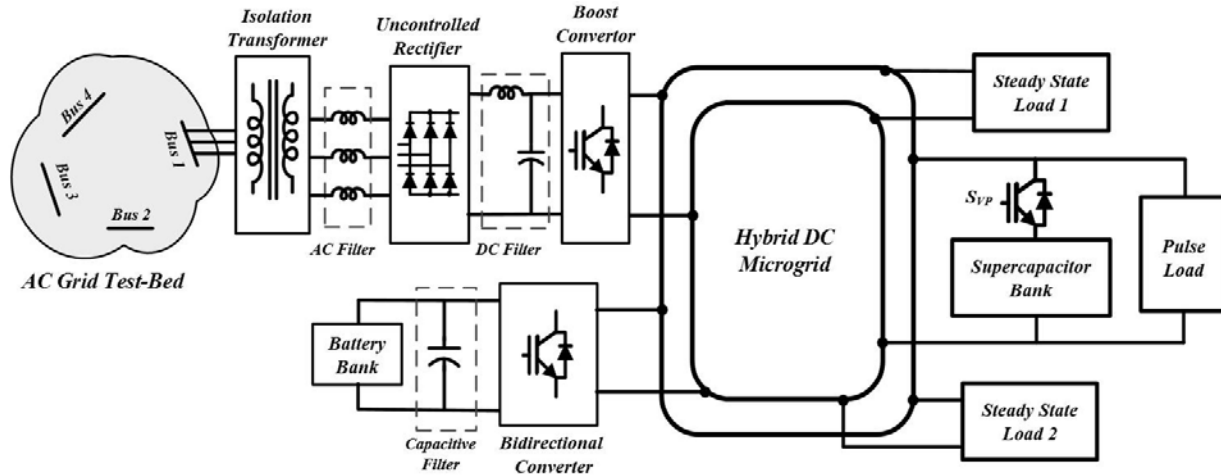


Fig. 1: Schematic diagram of the hybrid dc microgrid under study.

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.

Additionally, the nifty gritty portrayal of the created ACVC procedure is exhibited in segment IV. Area V examines the exhibitions of the ACVC methodology in contrast with other vitality control strategies. Taking after the framework portrayal, ordinary vitality control systems changed and adjusted for our mixture dc microgrid are clarified.

## II. 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 grid is 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/ $\Delta$  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
	Connection	YD
Transformer	$S_N$	3 kVA (1 p.u.)
	$V_N$	208 V (1 p.u.)
	$R_{eq}, X_{eq}$	0.72 $\Omega$ (0.05 p.u.), 0.86 $\Omega$ (0.06 p.u.)
	$R_M, X_M$	4820 $\Omega$ (334 p.u.), 16.45 $\Omega$ (430 p.u.)
Boost Converter	power rating	2500 W
	IGBT module	SKM100GAL12T4
	switching frequency	5 kHz
	$L_{BC}$	6 mH
AC Filter	$L_{AF} (X_{LAC})$	12 mH (4.52 $\Omega$ , 0.31 p.u.)
	$L_{DF}$	2.7 mH
DC Filter	$C_{DF}$	680 $\mu F$

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- $\Omega$  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 the 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 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.

predefined safe threshold. An isolation transformer is 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

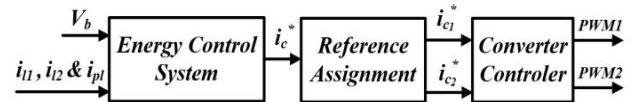


Fig. 2: Block diagram of the DC microgrid three layer control system.

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 $\Omega$
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 ( $\Delta T=15^\circ C$ )
Bidirectional Converter	Leakage Current	25 mA (Passive Balancing)
	power rating	1800 W
	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

### III. ADAPTIVE CURRENT-VOLTAGE CONTROL

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. 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 command  $I_c^*$ , 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 adjust  $I_c^*$ .

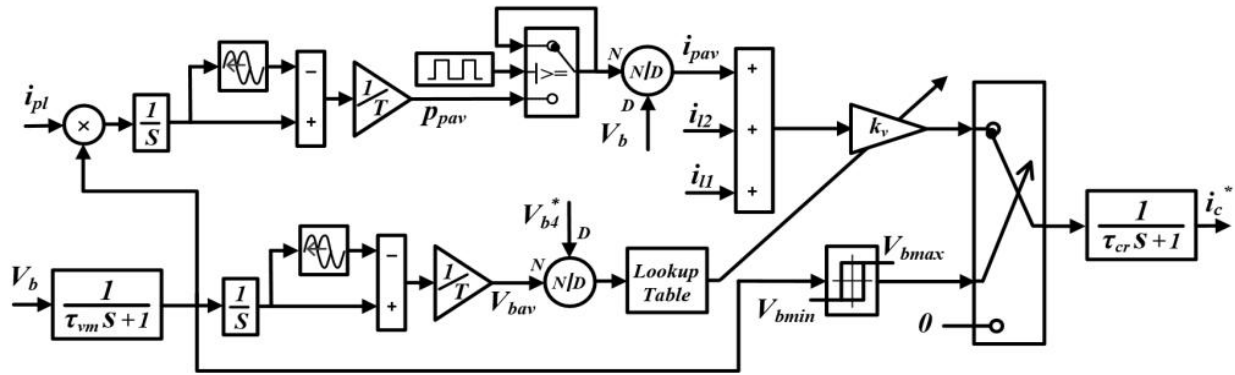


Fig.3: Block diagram of adaptive current-voltage control.

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.

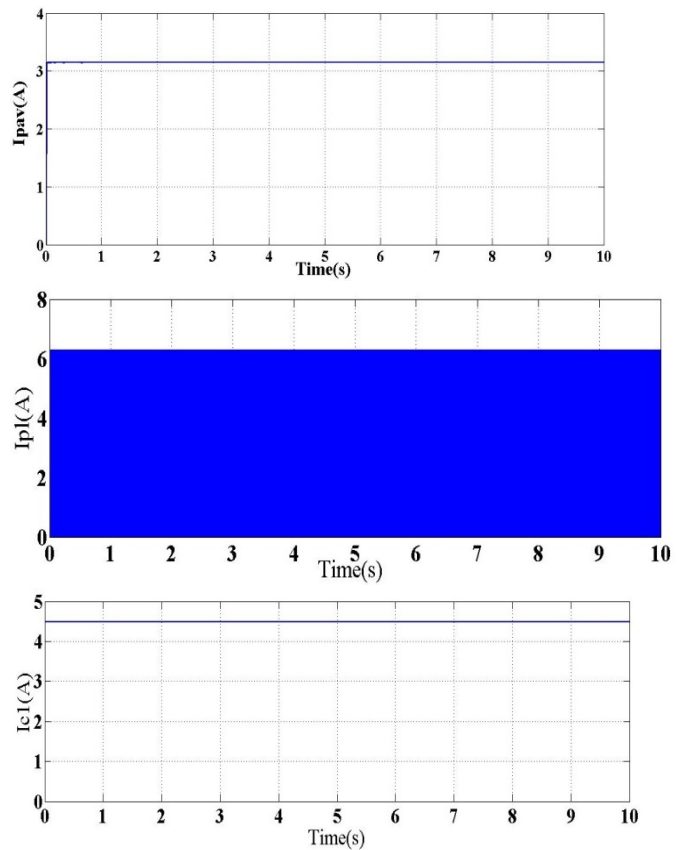
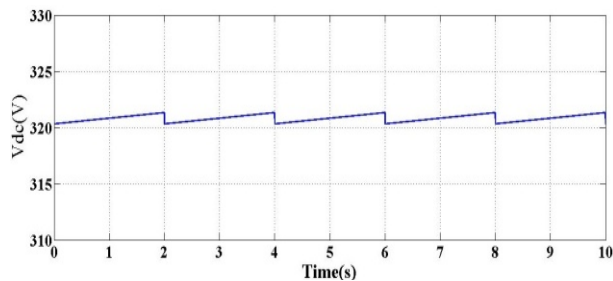


Fig 4: ACVC RESULTS

V. PV-MPPT BURP CHARGING TECHNIQUE

Burp charging also called Reflex or Negative PulseCharging 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".

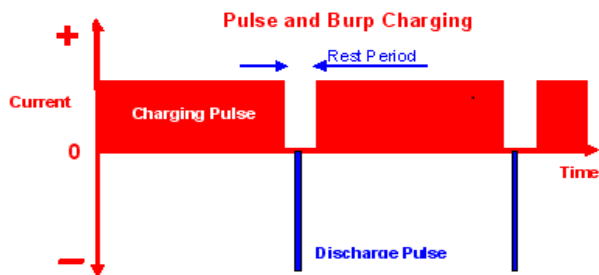


Fig. 5: PV-MPPT burp charging

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.

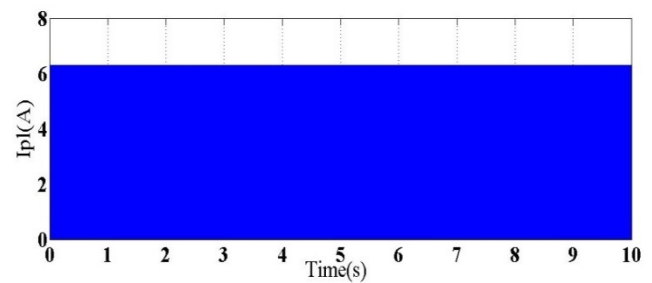
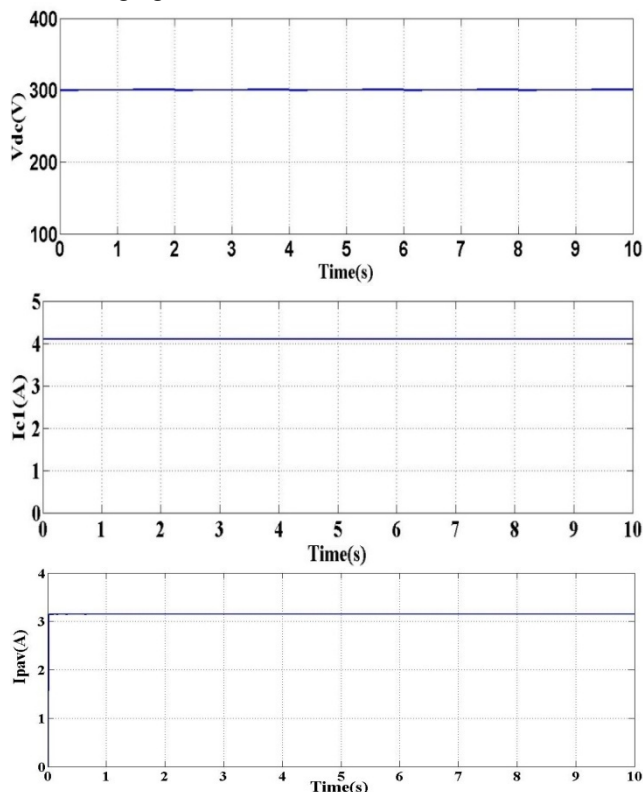


Fig.6: Simulated results with PV-MPPT burp charging technique

## VI. 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 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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