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PV MPPT based Burp Charge Technique for Battery Storage Control in Hybrid DC Microgrid

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Abstract:
In this paper, a brand new energy management theme is planned for actively controlled hybrid dc microgrid to cut back the adverse impact of periodical power hundreds. The planned energy management is associate degree adjective current-voltage management (ACVC) theme supported the moving average measuring technique associate degreed an adjective proportional compensator. Not like typical energy management strategies, the planned ACVC approach has the advantage of dominant each voltage and current of the system whereas keeping the output current of the ability device at a comparatively constant worth. For this study, a laboratory scale hybrid dc microgrid is developed to judge the performance of the ACVC strategy and to match its performance with the opposite Conventional energy management strategies. Exploitation experimental takes a look at results; it's shown that the planned strategy extremely improves the dynamic performance of the hybrid dc microgrid. Though the ACVC technique causes slightly additional bus voltage variation, it effectively eliminates the high current and power pulsation of the ability converters. The power/cost trade-offs usually end in a non-optimal battery energy storage system. Moreover, unequal current sharing between battery cells is problematic and may cause thermal problems at intervals the system. It had been continually but 4 wheel drives that were in an appropriate vary.

Keywords: Hybrid dc microgrid, energy control system, pulse load, super capacitor, active hybrid power source.

I. INTRODUCTION:

In order to unravel this drawback and to extend the ability capability of electric battery energy storage system, multiple cells ought to be place in parallel and series. However, the power/cost trade-offs usually lead to a non-optimal battery energy storage system. Moreover, unequal current sharing between battery cells is problematic and may cause thermal problems at intervals the system. DC microgrid power systems with hybrid energy resources are of serious interest in telecommunication, sea and orbiter applications. Multiple sources and reconfiguration characteristics of the dc microgrid on these systems extremely improve the potency and responsibility of the system. In these applications, there are some varieties of masses with a typical profile that need comparatively high pulse power however with a comparatively low average power demand. Such a high level of short time current behavior needs the next power rating of the elements and will probably cause a big disturbance to the whole grid. Periodical masses not solely cut back the potency of the dc microgrid and cause dip within the common coupling dc bus. However there are extra riotous impacts within the interconnected ac grid. Since in such a system there's no Infinite bus within the ac grid, the existence of enormous periodical masses cause wide dip and frequency fluctuation. Different hybrid configurations area unit potential for pulse load applications. Benefits of this technique embrace easy implementation, lower power losses and low value owing to the absence of further power electronic converters. However, since the sources area unit perpetually paralleled, the facility sharing between them is extremely restricted and it's determined by their several resistances and voltage-current characteristics.

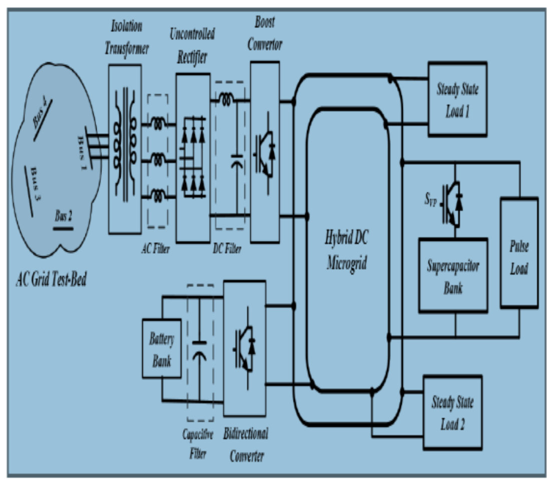


Figure.1. Schematic diagram of the hybrid dc microgrid under study.

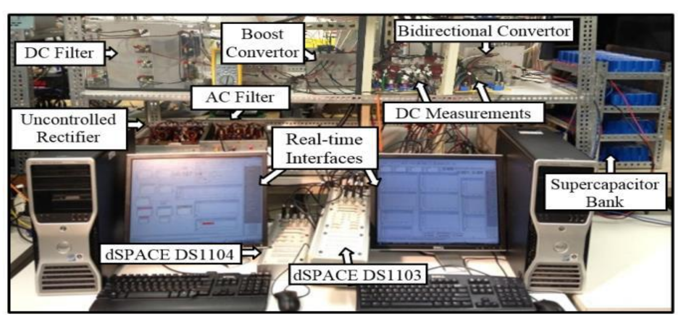


Figure. 2: General view of the dc microgrid and its control desk.

Moreover, the active hybrid combinations have advantages of lower weight and volume, low current ripple of the main source, and better output voltage regulation.

II. DC BUS AND DC MICROGRID:

The laboratory-based smart power system presented in this paper is a hybrid ac/dc power system. The ac side of the system has all ac alternators and loads connected. The dc side of the grid is used to connect the various renewable energy sources in addition to the battery storage system and other dc loads. The energy available from renewable sources on the dc side of the network should not only serve local loads on the dc grid, but also has to serve loads on the ac side. Power sharing can be used to mitigate fast load fluctuations and maintain high power and voltage stability levels on the ac side. Therefore, a bidirectional ac-dc/dc-ac converter was used to allow bidirectional power flow between the ac and dc sides.

A. Photovoltaic (PV) Emulator :

A 5-kW programmable dc power supply was used to emulate a typical I-V characteristics curve. The programmable power supply allows emulating different I-V characteristic curves in the form of lookup tables. Moreover, it allows including the effect of other parameters such as environmental conditions i.e., ambient temperature and solar insulation.

B. Fuel Cell (FC) Emulator :

A programmable dc power supply is programmed to emulate solid oxide fuel cells (SOFC) characteristics. The dc power supply can be programmed with a lookup tables representing the relation between the voltage and current or voltage versus time. For instance, in order to examine the robustness of the dc-dc boost converter interfacing fuel cells energy into the grid. The purpose of sharp and sudden changes in the voltage value is to examine the system and its components under severe conditions.

C. Controlled DC-DC Boost Converter

The system contains two controlled dc-dc boost converters operating as interfaces between different renewable energy sources and the dc grid. The first dc-dc boost converter is used to integrate the power generated by the PV emulator to the system. This converter is operating in the maximum power point tracking (MPPT) mode. The other converter is used to integrate the FC energy to the system and is operating in a current control mode. These converters are designed to receive a variable input voltage ranging from 70 to 140-V and integrate its power into the dc bus at 300-V. The power rating of each is 3 kW. The PV can be equivalent to a current source in parallel with a resistor.

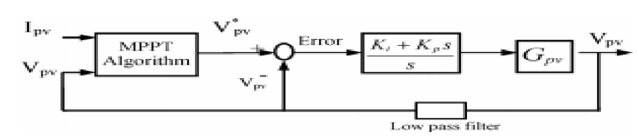


Figure.3. a block diagram of the dc-dc boost converter controller

In this paper, a new energy control technique based on adaptive current-voltage control (ACVC) for hybrid dc microgrid is developed. Unlike conventional methods, the proposed approach has the advantage of controlling both voltage and current of the dc microgrid. In order to improve the dynamic operation of the grid, the moving average current and voltage measurement is utilized for this method.

III. 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 hardware setup and the control structure for this system and the interconnected ac grid are explained in the following sections.

A. Description

The energy sources of the dc microgrid are the ac grid, the battery bank and the super-capacitor bank. The ac grid is mainly supplying the microgrid while the battery bank provides extra power when the grid is highly loaded or if the dc microgrid grid is islanded. The interconnected ac grid is a hardware/software based ac grid test-bed power system. This system includes generating stations, and programmable loads in a laboratory scale of up to 35 kW. Four ac generators are connected in a ring combination through line/cable models. One of the generators (connected to bus 1) runs at a constant frequency of 60 Hz and acts as the slack bus. This system also includes supervisory control and data acquisition (SCADA) system to monitor the entire system. More details about the ac grid test-bed configuration and control can be found. Moreover, an inductive-capacitive dc filter is connected between the boost converter and the uncontrolled rectifier to improve the performance of the converter and reduce the ac grid harmonics. The detailed parameters of the components are summarized in table. The battery bank is connected through the bidirectional converter to the common coupling dc bus. The battery bank is composed of twelve lead-Acid battery cells rated 120-V, 110-Ah. Also, the super-capacitor bank is 2.9-F, and as an energy buffer, delivers high instantaneous power to the pulse load. This bank is composed of 20 Maxwell's 16-V module

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.)*
	R_{eq} , X_{eq}	*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*
	L_{BC}	*6 mH*
AC Filter	L_{AF} (X_{LAC})	*12 mH (4.52 Ω, 0.31p.u)*
DC Filter	L_{DF}	*2.7 mH*
	C_{DF}	*680 µF*

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 (ΔT= 15°C)*
	Leakage Current	*25 mA (Passive Balancing)*
Bidirectional Converter	*power rating*	*1800 W*
	IGBT module	*SK45GB063*
	switching frequency	*5 kHz*
	L_{BD}	*6 mH*

B. Control Description

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, $ic*$. The next layer is the formulation of the reference current of the boost converter, $ic1*$ and the reference current of the bidirectional converter, $ic2*$ based on the converters availability and their power limitation. If both converters are available, the priority is given to the boost converter to supply the microgrid through the AC grid. 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.

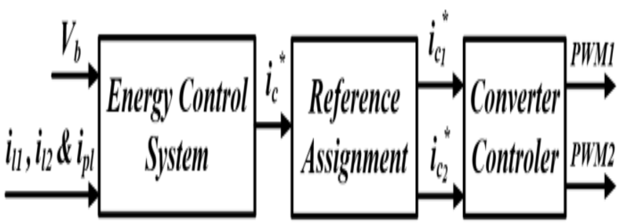


Figure.3: Block diagram of the DC microgrid three layer control system.

The energy control system largely governs the interaction of the pulse load with the dc microgrid and the ac power system. In the following sections, different energy control schemes including the developed ACVC technique are described.

IV. ENERGY CONTROL SCHEMES FOR HYBRID DC MICROGRID:

Various energy control methods for pulse load mitigation suggested in literatures are adapted for our hybrid dc microgrid and are explained here. These methods differ from each other for the measurement data required and the performance level achieved.

A. Instantaneous Power Control

Instantaneous power control (IPC) is the simplest control technique of a hybrid dc power system .the schematic diagram of this controller which is modified and adapted for our hybrid dc microgrid. This controller is equipped with hysteresis voltage protection that monitors the entire super-capacitor bank. Once the voltage of the dc bus exceeds the preset maximum limit *Vbmax* , the controller will set $ic*$ to zero until the bus voltage drops to the preset minimum bus voltage threshold Vbmin .

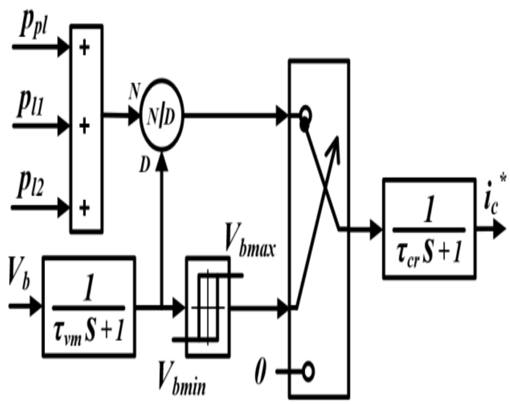


Figure.5: Block diagram of the instantaneous power control.

B. Limit-Based Voltage Control

voltage control (LBVC) is to charge the super-capacitor bank and control the dc bus voltage as rapidly as possible subject to the available power of the sources and the converter power limit.

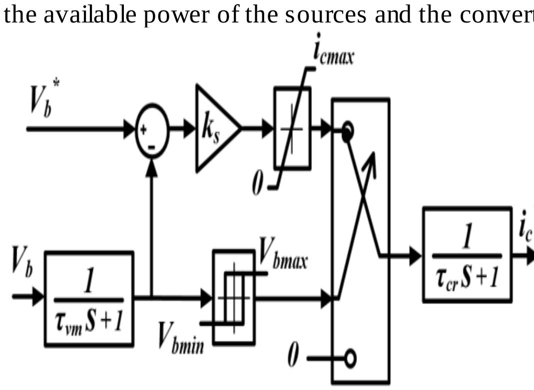


Figure.6: Block diagram of the limit-base voltage control.

The two input ports are the target bus voltage $Vb*$ and the measured bus voltage *Vb* and the output port is the reference current command $ic*$. The gain ks need to be large enough so that the limit *icmax* be in effect until the point where the bus voltage becomes very close to $Vb*$ and then approaches it asymptotically. It should be noted that the $Vb*$ is larger than the *Vbmin* and smaller than the *Vbmax*. If the bus voltage is less than the *Vbmax*, the output of the current limiter goes through an output filter to form *ic*

C. Continuous Average Current Control

Heavy pulse loads lead to significant disturbance in a power system due to their power profile characteristics. To reduce the power pulsation of the converters and sources, the continuous average current control (CACC) technique is suggested

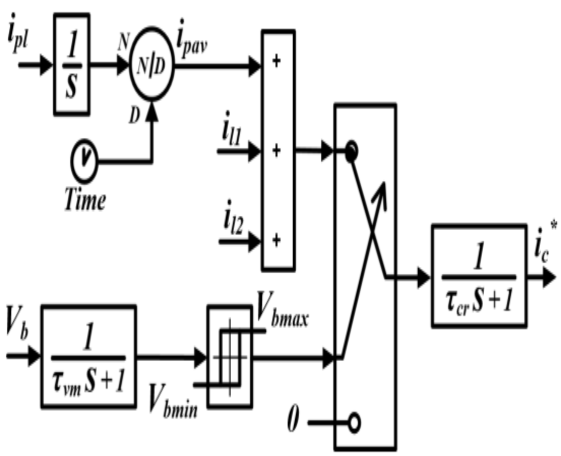


Figure.7. Block diagram of continues average current control.

The schematic diagram of the CACC method adapted for our hybrid dc microgrid. Inputs to this control are the bus voltage *Vb* and the load currents *ipl* , *il1* , and *il2* where the output is the reference current command *ic∗* .Then, the calculated continuous averaged current is added to the steady state load's currents. If the safe operation of the system is ensured, the calculated current is then fed to the output filter to form *ic∗*.

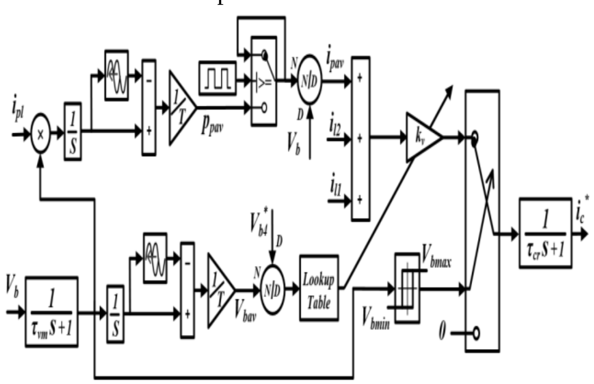


Figure.8. Block diagram of adaptive current-voltage control.

V. ADAPTIVE CURRENT-VOLTAGE CONTROL:

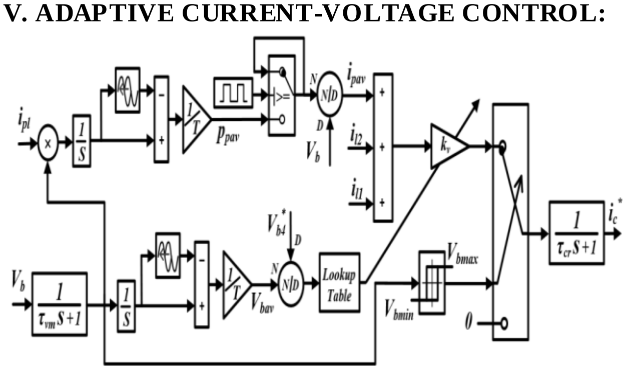


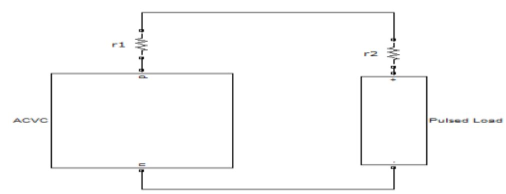
Figure.9. Current-voltage control

An effective energy control scheme should be able to keep the converters at a relatively constant value to prevent converter power pulsation. Although the CACC method effectively reduces the system disturbance during a pulse load with constant duty ratio and constant amplitude, it fails during pulse load changes and transient grid operation. In order to improve the dynamic performance of the grid and to buffer the battery bank and AC grid from high pulse currents, a new adaptive current-voltage control (ACVC) technique is developed.

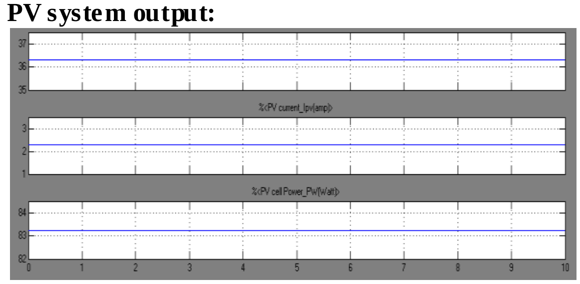
Extension:

Burp charge technique based storage control in hybrid DC micro grid

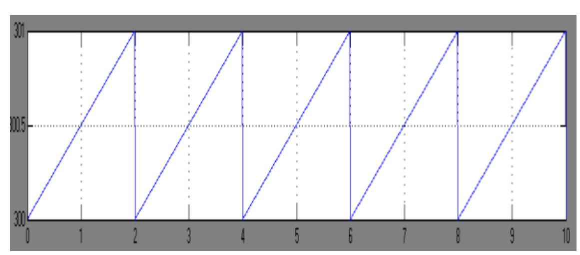
Green power dependent distributed generators (DGs) play a dominant part in production of electricity, with the rise in the global warming. Distributed generation depending on solar technology, wind, biomass, mini-hydro as well as utilization of fuel cells and micro turbines will offer significant momentum in near future. A microgrid is made of group of loads and distributed generators that will work as an individual controllable system. The actual microgrid principal introduces the lowering multiple number of reverse conversions in a single AC as well as DC grid and also make it possible for to variable AC and DC sources as well as loads. The proposed energy control is an adaptive current-voltage control (ACVC) scheme along with a burp charging control method applied for the storage systems involved in the grid.



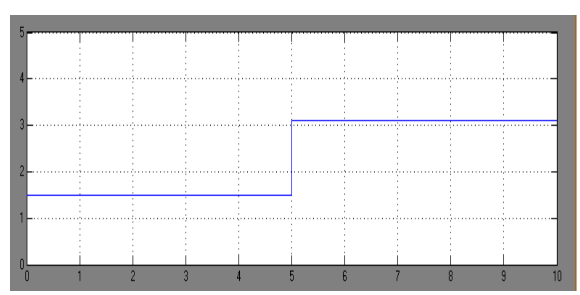
PV system output:



Simulation results Vdc :

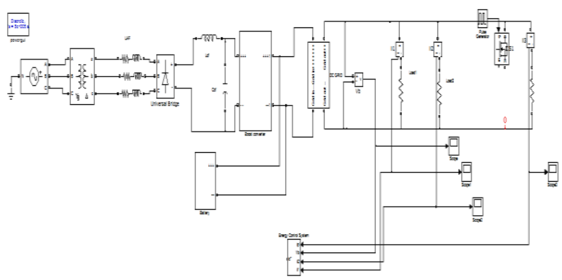


Pulse Load Current :

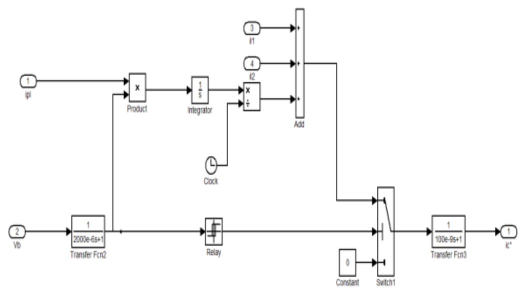


VI. SIMULATION REULTS

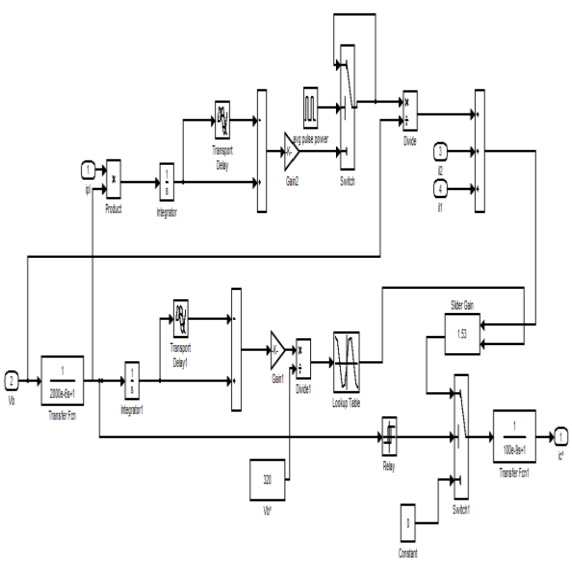
Simulink Circuit without Hybrid Filter



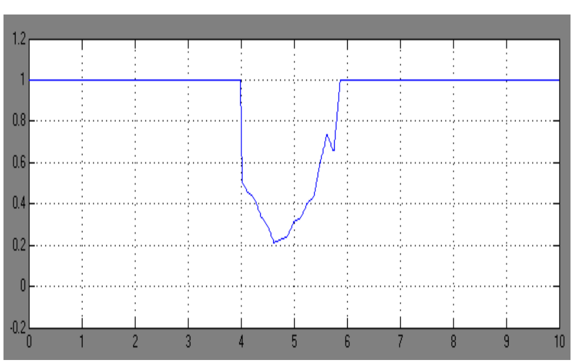
Simulink circuit of adaptive current-voltage control:



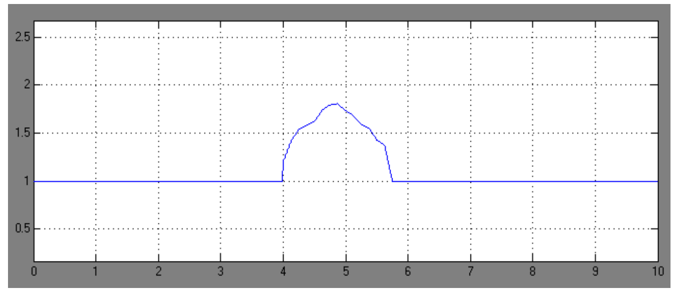
Simulink circuit of adaptive current-voltage control



Vbav :

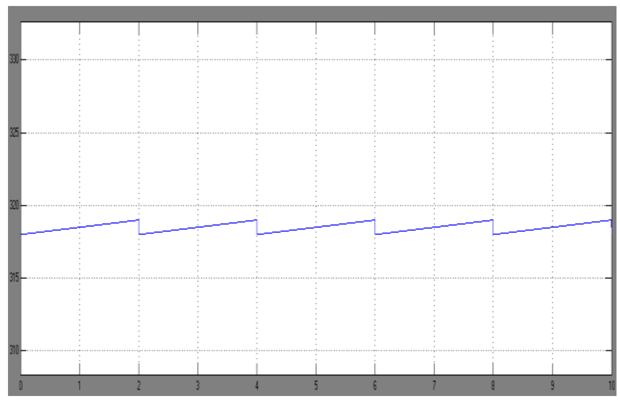


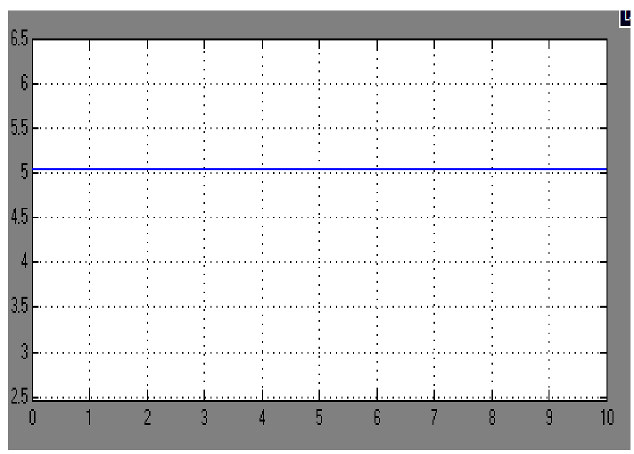
Kv :

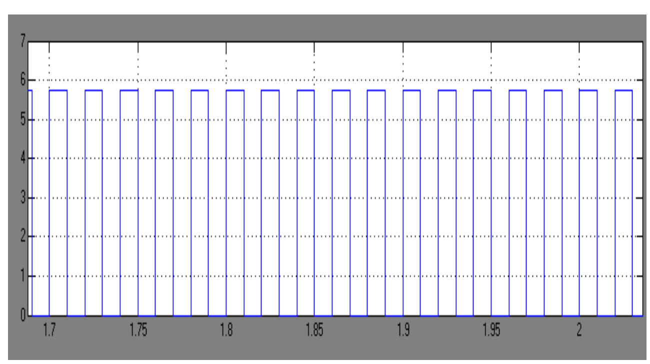


Vdc when pulsed load freequency changes :

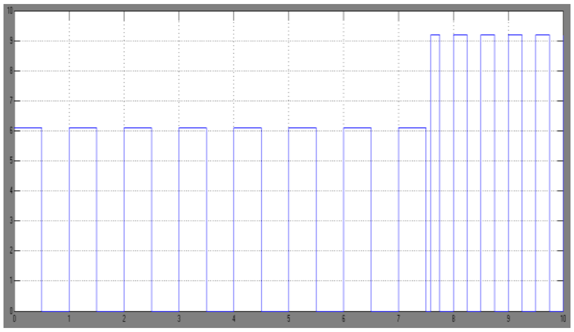
Experimental test results of ACVC and CACC technique during constant pulse load operation







Ipl when pulsed load increases :



Experimental test results of CACC method and ACVC technique when pulse load frequency changes from 0.1-Hz to 0.2-Hz and its duty ratio increased from 20% to 40%.

VII. CONCLUSION:

In this paper, 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. The performance of the developed ACVC technique was experimentally evaluated and it was compared to the other common energy control methods. The test results showed that the ACVC scheme has a similar performance with the continuous average current control (CACC) method during a constant pulsed power load operation. 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.

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