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Hybrid Energy Reposition Scheme Microgrids Integration for Enhancement of Power Quality Using Four Leg Three Level Nnc Elctrical Inverter and Second Order Sliding Mode Management

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ABSTRACT

A dedicated energy reposition scheme might contribute to an improved integration of RES into the microgrid by smoothing the renewable resource's irregularity, up the standard of the injected power and sanctioning extra services like voltage and frequency regulation. However, due to energy/power technological limitations, it's typically necessary to use Hybrid Energy reposition or Storage Schemes (HESS). During this paper, a second order slippery mode management is planned for the ability of power flow of a HESS, employing a Four Leg 3 Level Neutral purpose Clamped (4-Leg 3LNPC) electrical converter because the solely interface between the RES/HESS and therefore the microgrid. A three-dimensional house vector modulation and a sequence decomposition primarily based AC facet management permits the electrica l converter to figure in unbalanced load conditions whereas maintaining a balanced AC voltage at the Point of common coupling. DC current harmonics caused by unbalanced load and therefore the NPC floating middle purpose voltage, at the side of the ability division limits square measure fastidiously self-addressed during this paper. The effectiveness of the planned technique for the HESS power flow management is compared to a classical PI management theme and is well-tried through simulations and through an experiment employing a four Leg 3LNPC.

Key terms: *RES, HESS, Converter,*

I.INTRODUCTION

The utilization of associate degree ESS integrates constraints like admittable information measure, most ratings, current/power most gradient and therefore the variety of cycles. If these constraints don't seem to be revered it will result in a dramatic time period reduction of the ESS, or in sure cases, to its destruction. The utilization of a Hybrid Energy reposition or Storage or repostion Scheme (HESS) offers the required trade-off for increasing the time period of ESS where as additionally increasing the world specific energy and power of the entire system. Fig. 1 shows the main structures presently found within the literature to integrate a HESS into a grid. The passive topology a) shows a scarcity of management of the ability flow moreover because the ESSs State of Charge (SOC).The floating b) and parallel c) topologies are square measure active topologies that use

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DC/DC converters to manage energy flows directly.

Finally, despite a lower flexibility compared to the parallel topology, the 3L-NPC topology d) will be used as one power convertor ready to manage the ability flow of a HESS, acting as associate degree interface between the RES and therefore the grid. As a result of the reduced voltage applied on the switches associate degreed a multiplied variety of voltage levels, the 3L-NPC topology becomes a lot of economical whereas showing a lower current Total Harmonic Distortion (THD) It's shown that, on the far side the boundaries of the 3L-NPC topology,

the potency and doctorate improvement build this topology appropriate for ESS sexual union.

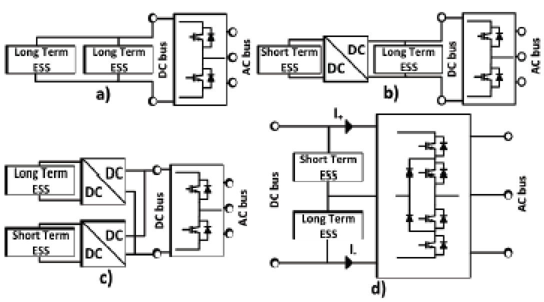

Fig. 1 Power converter topologies for microgrid ESS hybridization(a) Passive (b) floating (c) parallel (d) 3L-NPC topology

Another quality of this topology is that the floating DC link middle point voltage which involves voltage ripples at 3time the basic frequency (i.e. 150 Hz).

Converter used each as an influence filter and a HESS interface for RES integration into the grid isn't self-addressed within

the literature. During this paper, the ability flow management of a HESS composed of a Li-Ion battery and an atomic number 23 oxido reduction Battery (VRB) is investigated during a microgrid context. The foreleg 3LNPC electrical converter has been chosen to interface the HESS with the microgrid as a result of its low doctorate, the target of the paper is to prove that by adding the fourth leg to a 3L-NPC convertor and employing a new DC facet management strategy it's doable to succeed in each quick and economical DC power sharing between the 2 ESSs and therefore the RES, and at the same time improve the AC facet power quality.

II.HESS AND 4-LEG 3L-NPC MODELING

Modelling of the ESSs

The investigated HESS is made of a Li-Ion battery and a VRB. The VRB technology edges from the decoupled specific power (which depends on the stack characteristics) and its specific energy (which depends on volume of solution tanks). Along side the pliability offered by this specificity, the technology is additionally suited to long run energy storage as there's nearly no self-discharge with a decent trip potency of 78%-88%. The Li-Ion battery edges from a high specific power and moderate self-discharge (1-5% per day).

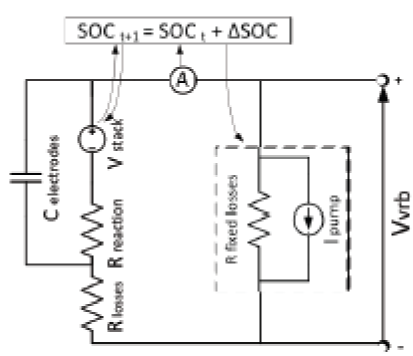

Fig. 2. Model of the VRB

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VRB model

The scheme of the VRB relies on the dynamic model introduced and has been valid on a 1.25kW experimental device. As solely the transient behavior is beneath investigation, for the sake of simplicity solely the capacitance of the conductor is taken into consideration. Fig. 2 a pair of shows the equivalent circuit of VRB whose parameters square measure is summed up in Table I.

TABLE I
VRB UNIT PARAMETERS

Parameter	Value
Cells in series	322
Vequilibrium (V)	1.4
Rreaction (Ω)	0.81
Rresistive (Ω)	0.54
Rfixed (Ω)	295.2
Celectrode (F)	0.0186

Li-Ion model

The Li-Ion model employed in this work is relies on the module given. This model is already enforced in MATLAB/Simulink inside the SimPowerSystems library. The battery is complete with strings of series modules connected in parallel to create associate degree ESS of 825 V/ 30Ah (at 80% of SOC and open circuit). Each charge and discharge voltages square measure given in (1) and (2) severally. The parameters of the Li-Ion battery square measure summed up in Table II.

$$E_{Li-ion}^{charge} = E_0 - K \frac{Q}{Q-it} . i_{LP} - K . \frac{Q}{Q-it} + A \exp(-B.it) \quad (1)$$

$$E_{Li-ion}^{dischare} = E_0 - K \frac{Q}{it+0.1.Q} . i_{LP} - K . \frac{Q}{Q-it} + A \exp(-B.it) \quad (2)$$

TABLE II
LI-ION UNIT PARAMETERS

Parameter	Value
Cells in parallel	20
Cells in series	550
E_0 (V)	3.73
K (V)	0.00876
A (V)	0.468
B $(Ah)^{-1}$	3.53
R_s (Ω)	0.09

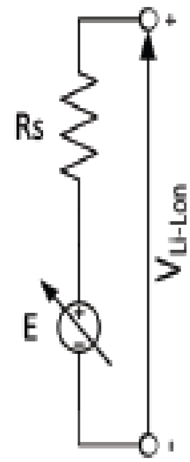

Fig. 3. Model of a Li-Ion cell

III. MODELLING OF THE 4-LEG 3L-NPC

Fig. 4 shows the schematic illustration of the 4-Leg 3LNPC electrical converter used as a HESS interface for RES and HESS integration to a microgrid. This topology needs the RES to be a current supply and especially, might betailored if placed either once a most wall plug following (MPPT) converter for a solar plant, or rather than the grid-side converter of a back to back started for wind turbines. For this study the RES is taken into account as a current supply injecting into the DC bus.

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$$\vec{V_s} = \sqrt{\frac{2}{3}}\,[V_{an} + \vec{a}V_{bn} + \vec{a}^2V_{cn}] \text{ with } \vec{a} = e^{\frac{j2\pi}{3}} \quad (3)$$

The strategy adopted for the 4th leg modulation signal generation relies on the Three Dimension Space Vector Modulation (3D-SVM) in ABC fundamentals coordinates and therefore the sensible development of this theme. The 3D-SVM scheme is employed to work a rework from three to four phase and solely generates the modulation signal for the fourth leg of the electrical converter however isn't careful any because it is out of the scope of this paper.

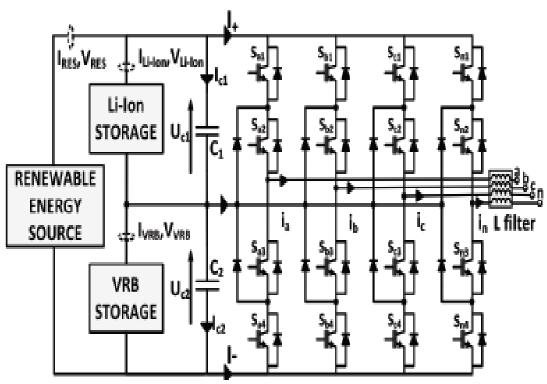

Fig. 4. 4-Leg 3L-NPC topology used as a HESS/RES interface

IV.CONTROL DESIGN

The planned DC facet management strategy is relies on the Second Order Slippery Mode management for its accuracy and hardness concerning some specific uncertainties. It aims to regulate the power flow of the HESS in step with to grid desires. So as to focus on its skills, the planned management strategy is compared to the classical PI controller approach. This comparison is going to be careful during this section and can be later compared through simulation results. Fig 5. Shows the block illustration of the modulation scheme

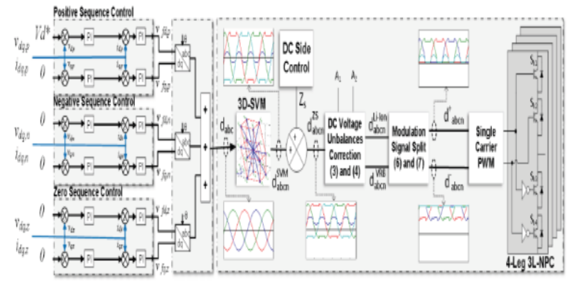

Fig. 5. Illustration of the modulation scheme

A) AC FACET MANAGEMENT

In a microgrid, the world load is usually unbalanced. As a consequence AC voltages might be considerably tormented by a zero sequence part, particularly in islanded mode. The investigated 4-Leg 3L-NPC electrical converter is ready to require care of such issues and keep AC voltages balanced, even in unbalanced load conditions, by using an adapted AC control. It employs Fortescue's decomposition in positive, negative and zero sequences, coupled with the 3D-SVM scheme to generate the 4th leg modulating signal. Every sequence is converted to the *d-q* rotating frame exploitation the Park and Clark transforms and severally employing a classical double-loop PI scheme (Fig. 6).

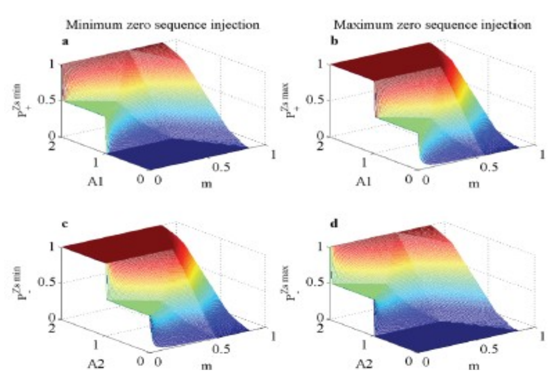

Fig. 6. Power division limits for a), c)lower limit and b), d) upper limit Zero sequence injection whereas DC voltage unbalances

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B) DC facet power flow management

For this work the zero sequence injection within the modulating signals is employed to regulate the ability to power flow of the HESS. This last principle is wide used for neutral purpose voltage Ripple compensation and DC link electrical device voltage reconciliation in construction inverters. The zero-sequence injection technique has been tailored to the present work, however with a distinct objective.

C) Classical PI scheme

A classic PI scheme is intended so as to match the dynamic performance of the second order SMC to regulate the power flow of the HESS. The differential equation is obtained.

$$Z_s f_2 + f_1 = i_{vrb} + R_{vrb} C_2 \frac{d i_{vrb}}{dt}$$

From this equation, the management of the zero sequence is chosen as wherever subscript 'FF' will be though about as a disturbance injected in the direct chain as defined. The term with the subscript 'PI' corresponds to a classic PI scheme in its parallel kind and is defined in the Laplace Domain.

$$Z_s = \frac{Z_{sPI}}{f_2} + Z_{sFF}$$

$$Z_{sFF} = \frac{f_1}{f_2}$$

$$Z_{sPI} = K_p + \frac{1}{T_i p}$$

Considering the identical approximation within the sliding mode control where the max value $f6$ is taken on top of equations the transfer function is obtained

$$T_f = \frac{I_{vrb}}{Z_{sPI}} = \frac{\hat{f}_1}{1 + R_{vrb} C_2 p}$$

The pole placement technique is then accustomed to get a primary order target error of settling time at 2% τ and result in to the PI gains.

$$K_p = \frac{R_{vrb} C_2}{\tau \hat{f}_1} \; ; \; T_i = \tau \hat{f}_1$$

V.SIMULATION RESULTS

The simulations are meted out for associate degree electrical converter rated power of 100kW using Matlab/Simulink and therefore the SimPowerSystems library. As a result of laboratory limitations, the experiments have been carried out on a real scale prototype of 20kW rated power operating at few kW.

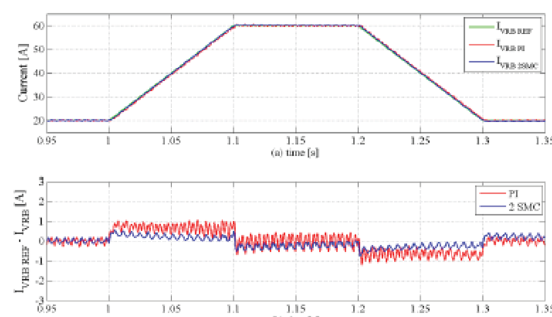

Fig. 7. Dynamic performance comparison (a) currents (b) errors

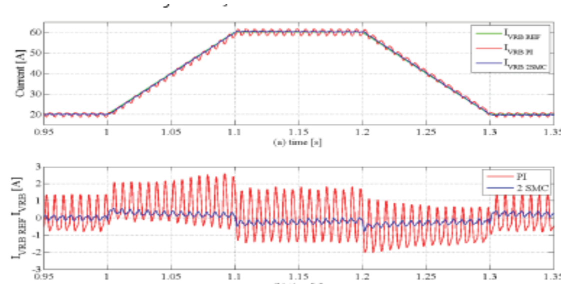

Fig.8. Dynamic performance comparison whereas constant quality uncertainties (a) Currents, (b) errors

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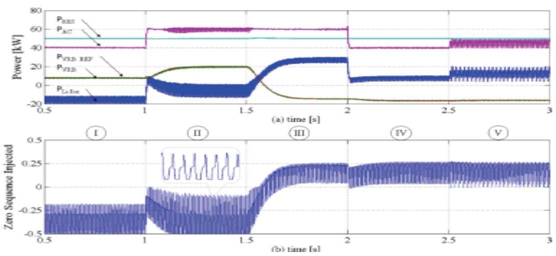

Fig.9. PI management scheme for the state of affairs of Table V (a) AC and DC Power (b) Zero sequence injection

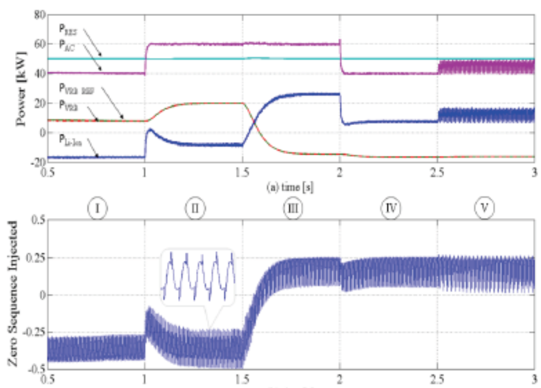

Fig. 10. 2-SMC scheme for the state of affairs of Table V (a) AC and DC Power (b) Zero sequence injection

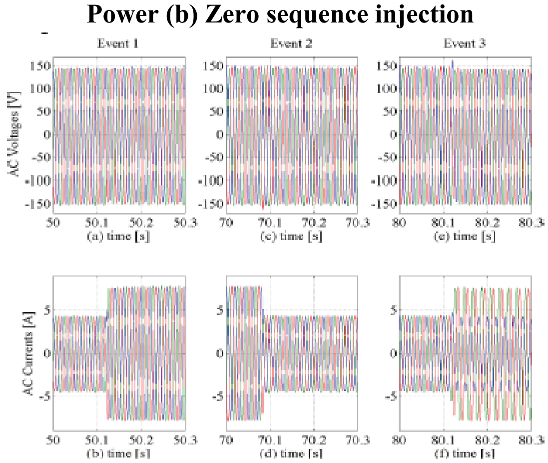

Fig. 11.AC voltages and currents for a) b) Event 1 c) d) Event 2 and e) f) Event 3

CONCLUSION

In this project the utilization of a 4-Leg 3L-NPC power converter topology to interface a RES with a HESS (formed by a VRBand a Li-Ion battery) during a microgrid context has been investigated. A brand new model of the structural limits is given and enforced to use the whole capability of the 4-Leg 3L-NPC converter to insure a maximum power division between the two ESS. A non-linear 2-SMC scheme has been designed and tuned to regulate the zero sequence injection in the modulating signals so as to regulate the ability of power flow of the HESS. Furthermore, the fourth leg of the converter permits the unbalanced load issue to be self-addressed, and therefore change active power filter capabilities. The HESS. Simulation results verified the capability of the planned management strategy to manage a HESS so as to boost the power quality and stability moreover on management renewable energy injected into a microgrid.

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