Electric Springs with Management of Battery in Order to Reduce Voltage Fluctuations

S.Geethanjali, S.Shanmugapriya, Niket, Harsh Kumar, Manish Anand

***Abstract*—Power electronics based electric springs have been discussed for the stabilization off the grid which are fed by conventional sources of energy an occasional basis. The proposed system can accommodate for compensation of both reactive and active power. Through this project we empower new method and enhanced method develop electric spring Technology which will not be constrained by the battery constraints such as state of charge. The electric Spring 3 is a converter which is grid connected and provides bidirectional conversion. The existing technology prioritizes injecting renewable energy into the system what the proposed scheme put the stability of the grid as its top most priority while still maintaining regular bidirectional flow of power. The developed technology has been tested beta prototype and simulation on Matlab.**

***Keywords*—Voltage control, Bidirectional power flow, Electric springs, Battery management system.**

I. INTRODUCTION

The augmented use of conventional sources of energy has been the instigator of new problems about stability of power system. the upcoming Power Grid mast accommodate for the availability of a control resign for wind and solar and other conventional sources of energy. There has been many methods proposed to counter this problem such as scheduling of delay-tolerant power demand storage of energy to compensate for peak demand real time pricing on control of loads etc.

Energy storage is only to tackle the power crisis issue of power generation and load demand in respect to the emergence of micro grids with intermittent renewable energy sources. In , a micro grid formed of parallel line-interactive uninterruptible power supplies (UPS) has been studied. Battery- based uninterruptible power supply have been infused to provide the voltage source when the micro grid enters the islanding mode. The state of charge (SOC) range from 35% to 95% of the battery should be used in the operation of the UPS inverters which also provide initail inertia through the droop method. This SOC model is also used in in which a decentralized control of a two-area storage-based power system (with diesel generators and batteries to provide long-term and short-term power demand) is studied. The SOC model considered in and is linear in nature. In a study of using a hybrid storage , a simple and linear battery model is used to study the effects of smoothing out the transients of load pulses. Battery- based photo voltaic (PV) system and wind power system have also been considered. In , the battery is regarded as an ideal voltage source, while a simple equivalent circuit model is adopted in.

In order to tackle the possible voltage and stability issues arising from the increasing use of intermittent renewable energy in the distribution networks, researchers in this field of power electronics came up with the idea of the electric springs (ES). ES is regarded as dynamic suspension technology in the electrical world. Unlike traditional flexible alternating current transmission system devices that basically mitigates the reactive power , some versions of ES are linked with redundant equipment such as monitors and other non-critical loads, forming intelligent loads that use active power smartly according to the availability of power generation.

Features like this inherently plays a associative role in achieving the new control scheme of having the power demand met following power generation from smart grids. ES has been developed till three versions so far. The simplified control schematics of the first and third versions of ES are shown in Fig(a). The first generation of ES (ES-1) does not uses battery storage . It uses reactive power to make the local mains voltage stable and manages the on load critical power at that instant of time to balance the power demand. The version-two (ES-2) uses batteries as energy storage, which allows the ES to output/input both active/reactive power. In other words, the ES-2 is capable to regulate both voltage and frequency of the grid, and also participate in correction of power factor and load compensation . ES-3 is basically a bi directional AC/DC converter with battery storage and without connection to non-critical load ,.

All of the suggested solutions have a common thread which is the storage of energy to tackle the imbalance issues of power generation in respect to micro grids. In 3 a line interactive UPS (parallel connected) has been proposed. This type of technology acts as a voltage source when the grid recedes to is-landing mode. the state of charge ranging from

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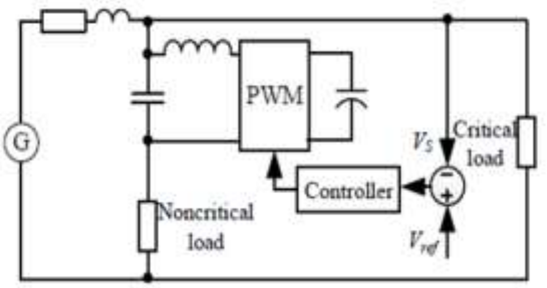
0.3 to 1 factor of the battery is used in the operation of uninterrupted power supply inverters. the model of state of charge which is considered in above case is a linear one and values are estimated on an experiment basis. wind power systems have been considered in the proposed system to evaluate the model. the battery has been considered as an ideal source of voltage.



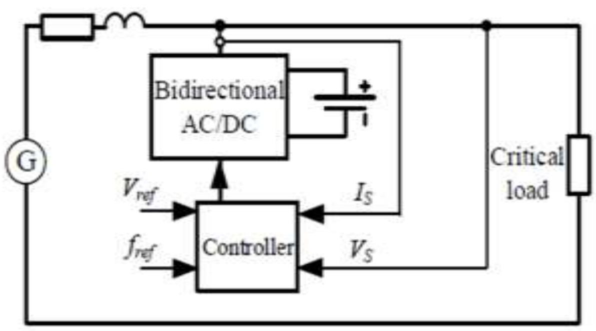
(a) ES-1

In route to counter the voltage stable issues which generates from the augmenting usage of renewable power injected into power system the researchers have come with a new founded approach known as electric springs. The system accounts for active power modulation and can also be used for non critical loads which by default acts as a constructive factor in achieving a new method for power system stabilization in micro grids. up until now there has been three versions of electric Springs.

ES 1 does not uses an active storage instead it utilizes reactive power for stabilization of voltage mains. ES 2, unlike the first uses battery storage and can provide compensation of both active and reactive power.

ES 3 is basically a bi-directional AC to DC Converter which incorporates inactive battery storage and no association two non critical loads

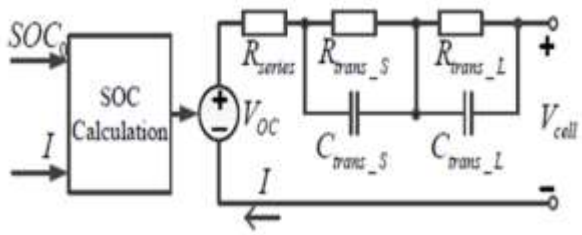
In the following paper new method for the compensation of active power using ES-3 is described and evaluated. Section 2 of the paper discusses a battery model which is used for the extrapolation. Section 3 of the paper discusses battery management system for electric Springs. Finally Section 4 discusses simulation and practical outcomes. Battery models can be bifurcated into two types which are equivalent circuit model and electrochemical model. Electrical engineers find equivalent circuit model easy to understand and apply in the circuit because this model is approximately and roughly based on Thevenins theorem using a dependent voltage source and first order RC network but many of the references paper discussed have ignored the nonlinear parameter off the battery and have rather focused on changing V-I performance.



(b) ES-3

II. BATTERY MODEL

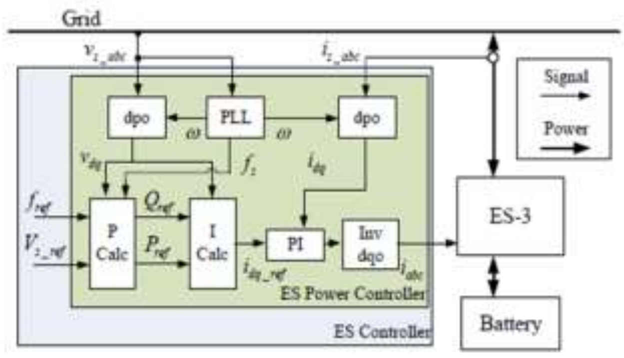
Out of all the references chosen to develop this battery model hybrid model in the paper is used. this model amalgamate both the battery models discussed above. it retains the dynamic response of the battery and also account for the nonlinear recovery character. therefore in retrospect state of charge acts as a feedback for both the control of electric Springs and the battery as well which ultimate live results in better precision than equivalent circuit and leads



(c) Hybrid model of battery

to performance augmentation in electric Springs. In this paper the parameters of the battery which are taken from the experimental data have been feeded into DSP controller and matlab simulink system for simulation.

The power inverter which are connected grids inject active power into the supply and does not assist with voltage and frequency fluctuations but the electric spring technology is basically designed for compensating voltage fluctuations as well as frequency but due to the constraint of SOC off the battery it is imperative to design the circuit so that the battery does not charge above threshold. Original is a control scheme was done in such a way that and the voltage regulation was done by reference of active and reactive power separately.



(d) Original scheme for BMS

III. SCHEMES OF BMS

The original control scheme of electric Springs is shown below. as we can see from obtained from the original control scheme we observe that the power of load at the consumer side is augmented by point 0.12 p.u. at t= 4s, which means that will have to compensate for the active power till 0.037 p.u. Using this method we constantly find yourself running out of battery capacity and does the system would not work efficiently let alone be efficient which calls for a modified control scheme for electric spring. In the new discuss control scheme an instantaneous state of charge signal. The SOC reference is set at 0.5 to to keep the battery at 0.5 fraction of the entire state of charge capacity and still deliver the active power that is that is needed for compensation. The new control scheme operates in two ways. An active power mode and a reset mode, regulate the voltage fluctuation we use the system and reset mode during the reset mode the state of charge is always maintained at 0.5, so that the power is present to deliver all take in the active power for the compensation of grids. there are mainly two factors which measure the power reference of the third version of electric spring which are namely Pf and Ps. Pf is the input signal which manipulates the quantum of active power which is delivered to the power grid for compensation whilePs is a signal which manipulates and maintains the state of charge of the battery. there is a link between the two parameters and can be observed in the equation.

$$P_{ref} = aP_{SOC} + (1-a)P_f$$

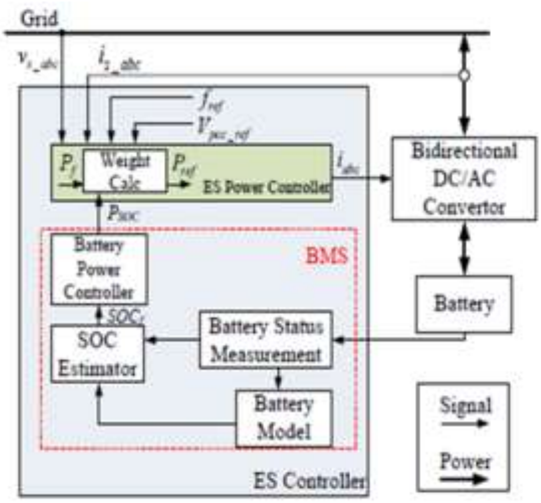
where a is a constant. The value of a is zero when the battery management system is not activated therefore the two signal are equal in magnitude and the new scheme is same as the original power scheme of electric springs. The overall efficiency and adaptability of the system depends on the value of this constant a which is a way to harmonize

between the BMS and the voltage regulation compensatory process. The constant a is a function of the error of state of

$$a = f(k, |SOC_e|) = \frac{e^{2k|SOC_e|-k} - e^{-k}}{1-e^{-k}}$$

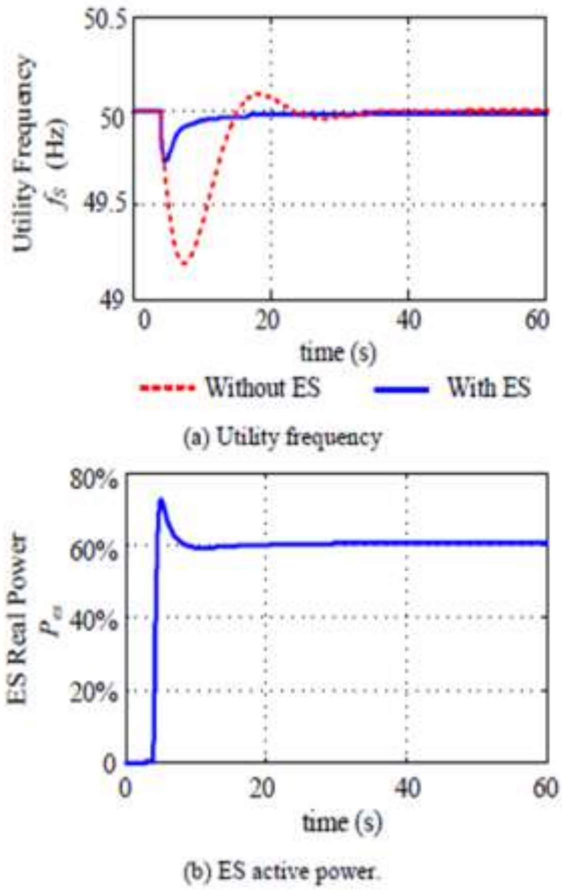
charge signal. it can be expressed as

New control scheme with weighted factor a necessitates that the discharging and charging of the battery is comparatively quick compared to when SOC error is of very high magnitude and it also compensates that the



(e) Proposed control scheme

initial condition of state of charge is close to the reference value the new control scheme as opposed to the original one is very adaptive between the assuaging the fluctuating voltage and also maintaining healthy state of charge of battery or the simulation of this project we used a single phase AC generation source like windmill whose output torque rotates a permanent magnet synchronous machine that generate the desired AC output that we require but for laboratory purposes we use a regular AC power supply



(f) System performance with and without ES

which can be controlled simulink model via 488 bus of IEEE which generally is the emulation of a generator machine. the characteristic of this particular generator is based on the very popular swing equation which is as follows

$$P_m - P_g = J\omega_r \frac{d\omega_r}{dt}$$

where w, J, Pg and Pm are the angular velocity, rotational inertia, electrical power and mechanical power. Any imbalance between the motor power and generator power could cause the generator frequency to vary. The new proposed control scheme is applied to this formulation of generator model what do you do the hardware limitation the sample time of this model is 1 second only.

IV. EXPERIMENT RESULTS

An inductor connected with a power resistoe in seires has been used as an emulator for the distribution line. A constant resistive load and a changing AC load controlled by the simulink model are introduced in the system ab bi directional AC to DC Converter which is basically are electric sprint Technology is is connected to a battery (lead acid). For the reasons of safety of instruments and personnel the capacity of the battery is high and for this experiment only a small capacity is used show that the battery operation is stable and safe at all point of time.

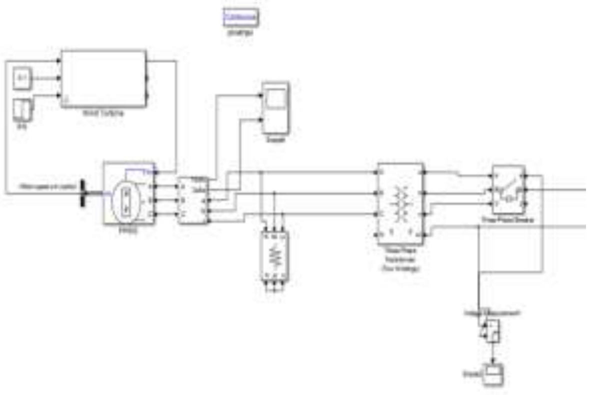
The main motive of the experiment was too analyse the compensation of voltage fluctuation why electric Springs. and to verify that the new proposed scheme of battery management is effective safe. The simulation result was perfect as expected and the hardware setup was also tested for practical evaluation.

A 12 volt 8 ampere hour lead acid battery is used in the emulation of a project. in order to determine the available capacity of the battery the battery was discharged to the threshold voltage at a very large current. we observe that the battery could discharge at 7.2 ampere for half an hour, show the available capacity of the battery was calculated which was 12960 seconds what according to the data sheet the capacity should have been 13284s, so the state of charge of the battery was calculated and it came out to be 78% which was within the limits in which the experiment was to be conducted which means that the state of charge was neither very less nor hundred percent which is considered to be optimum for the operation of the new proposed control scheme for electric spring.

In the first test the initial injected Power capacity of 650 watt only 450 watt was used and then suddenly at time t = 10 second an additional 140 watt was introduced in the system. the test was first without introducing the electric spring into the circuit why during the second time ES was introduced. the varying voltage versus time graph is shown below. as we can see from the graph the sudden load change caused a substantial drop in the mains voltage and it is perceivable that the fluctuation was very high when electric spring was not introduced in the circuit, with the use of electric spring the voltage was restored spontaneously and the magnitude of the fluctuations were substantially reduced.

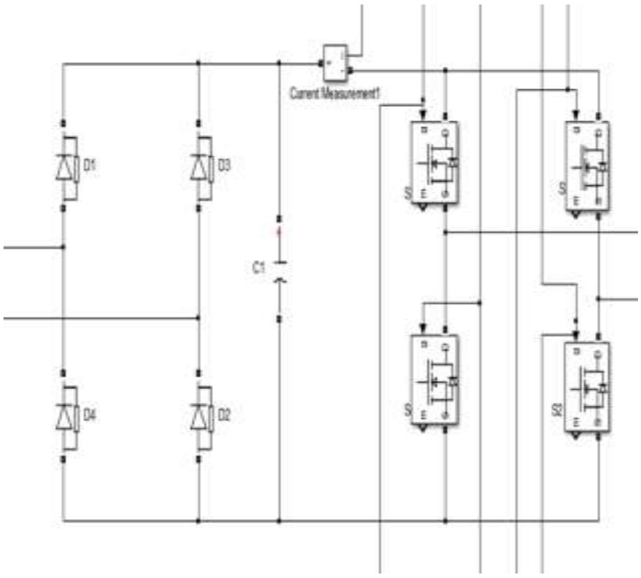
V. SIMULINK SIMULATION STUDY

To validate the new proposed control scheme of the electric Springs at a power level much higher than which was used in the emulation experiment assembling study was conducted on the model as shown in the figure below. The AC source power is a wind turbine whose output torque rotates the shaft of a permanent magnet synchronous machine which is connected to a 3 phase load to close the circuit on the load side and which also acts as a variable load Bank which represents the load off the grid. on the other side electric print technology is attached to it. There are two modes of operation and we obtain the graph for both of these. When the ES is not attached to the circuit as shown in the figure below the graph of obtained shows a significant reduction in the output voltage from the wind



(g)Simulation part of AC generation

turbine. the reduction is due to the fluctuations of the system. The Other graph is obtained when the electric spring was connected to the circuit in the graph obtained we can clearly see the output voltage which is supposed to come when the fluctuations are removed. the total run time of the simulation was one second in which about 5-7 cycles are obtained which is sufficient to validate the performance of electric Springs.



(h) Simulation diagram of ES

In figure (g) we see that the AC source used in the system is a wind trubine which has three constants as wind speed, generator speed and pitch angle. The three phase breaker in the circuit has two modes of operation namely open and close which connects and disconnects the ES from the system. In figure (h) given below we see the simulation diagram of the electric springs.

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VI. CONCLUSION

In this project the third version of which is basically based on the connection bidirectional AC to DC Converter with a battery is is operated with a battery management system. a novel an innovative approach of a new new control scheme was discussed and developed. the proposed method was tested and validated both hardware models. the result showed the working of the system within the constraint of the state of charge of battery while still mitigating the fluctuations of voltage. simulation and experimental results demonstrated that the new scheme is efficient and realizable. circuit both charging and discharging strategy could be implemented therefore many bidirectional converters can use this technology and equipped it with the current Technology. this will play an important role in providing compensation of active and reactive power for stability off the grid.

REFERENCES

1. A.H.Mohsenian-Rad,V.W.S.Wong,J.Jatskevich, R.Schober,and A.Leon-Garcia,"Autonomous demand-side management based on game-theoretic energy consumption scheduling for the future smart grid,"IEEETrans.SmartGrid,vol.1,no.3,pp.320–331,Dec.2010.
2. F.Kienzle,P.Ahcin,andG.Andersson,"Valuinginvestments inmulti-energyconversion,storage,anddemand-sidemanagementsystems underuncertainty,"IEEETrans.Sustain.Energy,vol.2,no.2, pp 194–202, Apr.2011.
3. A.J.Conejo,J.M.MoralesandL.Baringo,"Real-timedemandresponsemodel,"IEEETrans.SmartGrid,vol.1,no.3,pp.236–242, Dec.2010.
4. S.C.Lee,S.J.Kim, and S.H.Kim,"Demand side management with air conditioner loads based on the queuing system model,"IEEE Trans. Power Syst.,vol.26,no.2,pp.661–668,May2011.
5. J.M.Guerrero, J.C.Vasquez, J.Matas, M.Castilla and L.Garcia deVicuna,"Control strategy for flexible micro grid based on parallel line-interactive UPS systems",IEEE Transactionson Industrial Electronics, Vol.56,No.3,March 2009,pp: 726-735
6. P.Khayyerand U.Ozguner,"Decentralized control of large-scale storage- based renewable energy systems", IEEE Transactions on Smart Grid,Vol.5,No.3,May2014,pp:1300-1307.
7. A.Mohamed,V.SalehiandO.Mohammed,"Real-timeenergy management algorithm for mitigation of pulse loads in hybrid microgrids",IEEE Transactionson Smart Grid,Vol.3,No.4, December 2012,pp:1911-1922.
8. N.Tummuru,M.MishraandS.Srinivas,"Integration of PV/battery hybrid energy conversion system to the grid with power quality improvement features", IEEE International Conference on Industrial Technology(ICIT)2013,CapeTown,25-28Feb.,2013,pp:1751-1756
9. A.Esmaili,B.Novakovic,A.NasiriandO.Abdel-Baqi,"Ahybrid system of Li-ion capacitor sand flow battery for dynamic wind energy support",IEEE Transactionson Industry Applications,Vol.49,No.4, July/August 2013,pp: 1649-1657
10. S.Y.R.Hui,C. K.Lee,andF.F. Wu, "Electric springs—anewsmart grid technology,"IEEE Trans.Smart Grid,vol.3,no.3,pp.1552–1561, Sep. 2012.
11. S.C.Tan,C.K.Lee,andS.Y.R.Hui,"Generalsteady-state analysis and control principle of electric springs with active and reactive power compensations,"IEEE Trans.Power Electron.,vol.28,no.8,pp.3958–3969, Aug. 2013.
12. S.Yan,S.C.Tan,C.K.Lee,andS.Y.R.Hui,"Electric spring for power quality improvement,"IEEE Applied Power Electronics Conference and Exposition (APEC),pp.2140–47,Mar.2014.
13. C.K.Lee andS.Y.R.Hui,"Input voltage control bidirectional power converters,"US patent application,US2013/0322139,filed31May2013.
14. Tianbo Yang, Kwan-TatMok, Siew-ChongT anand S.Y.RonHui, "Control of electric springs with coordinated battery management", IEEE Energy Conversion Congress and Exposition(ECCE),2015, pp:6740 – 6746.