# Design and Electric Spring for Power Quality Improvement in Pv-Based Dc Grid

**N.Pandiarajan, G.Emayavaramban, A.Amudha, M.Siva Ramkumar, IR.V.Mohamed Mansoor, K.Balachander, S.Divyapriya, M..Sivaram Krishnan**

***Abstract:*** ***Electric Spring (ES) is a new idea which is come into view based on the mechanical spring concept. This can be employed for demand side control in DC or AC grid and also it improves the energy control and energy great. ES is taken in the DC grid to maintain the constant voltage fluctuations acquired with the help of the RESs power changes jointly with Photo Voltaic system and Wind systems because the Renewable Energy Sources (RESs) are irregular in nature. The DC-ES is placed with DC grid in series, then non-critical loads structuring a smart load. In this project, an assessment between the series and shunt DC - ES is detained taking into consideration four quadrant operation modes. To provide the bi-directional strength of power flow, the 4-quadrant DC-DC converter is analyzed and designed. The impact of the collection is discovering ES at the non-vital load. The simulation results for each open and closed loop operations are demonstrated to validate the accessible approach by the use of Matlab / Simulink. Furthermore, experimental possessions are provided for a prototyped ES based PV and Wind System.***

***Keywords: Electric spring, RES, DC-DC*** **Converter**

## I. INTRODUCTION;

Hooke's law presented the mechanical spring principle in the year 1678, which became widely used for different applications [1].

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A development appeared in 2010 after centuries, foundation with the concept of mechanical spring launched by Hooke, named as Electric Spring (ES) [2].

Table I gives the uniqueness and function of both mechanical spring and Electric Spring. however, ES execute unlike jobs to make the voltage constant and improve the performance efficiency of the entire system. The resemblance among ES and mechanical spring is exposed in their working manners in Fig. 1. The compression and extension is a basic principle to operate the mechanical spring, whereas depending on the system, the ES voltage is boosted or stepped down. When the mechanical spring is extended, the voltage of the ES is stepped down and When compressing the mechanical spring, the same law occurs in the ES, voltage is enhanced [5], [6].

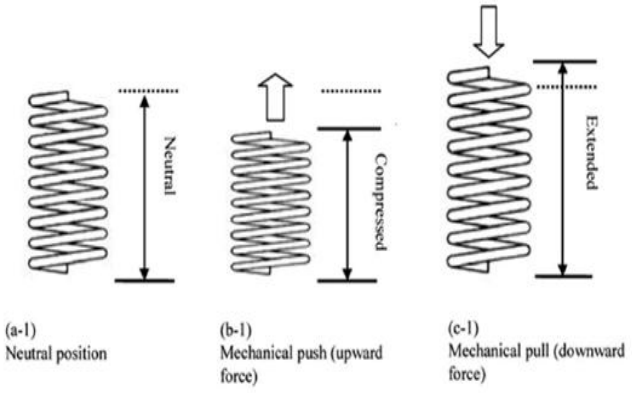


**Fig.1. Mechanical Spring Concept**

The voltage equivalence of electric spring is shown in fig. 2 which consists of three types.



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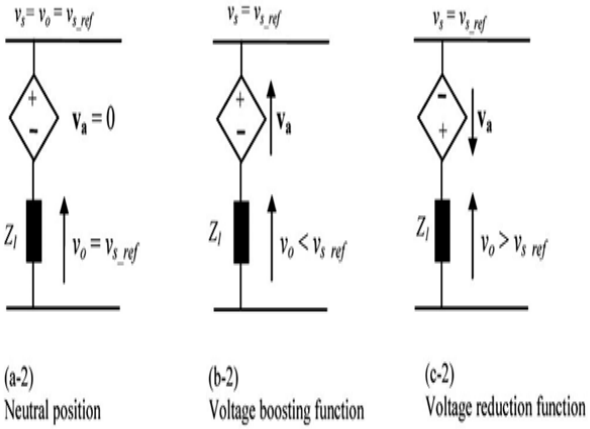


**Fig.2. Voltage Analog Dc electric spring;**

There is a growing interest in victimization DC micro grids for our electricity distribution and electricity power systems, especially for small-scale business and residential applications [7], [8], [37]. DC power distribution systems are projected, completely with various operating voltage ranges between 48V, 120 V, 230 V, 325 V, and 400V [8]-[9].

As a result, renewable distributed generations are increasing, like small scale photovoltaic systems, which connected to DC power networks [5]. The injection of irregular renewable energy sources into these power systems, will be the reason stability problem in the entire system [10] [38], [39].

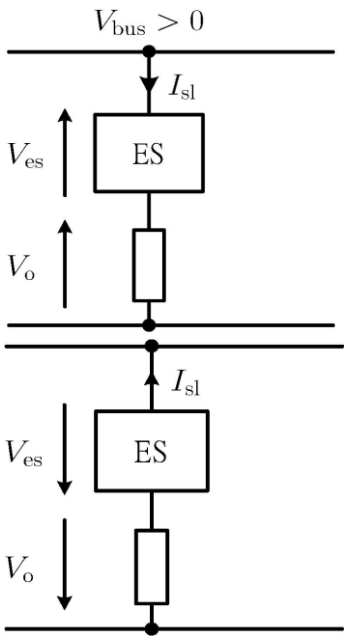


**Fig. 3.(a) DC-ES installed on positive**

**(b) DC-ES installed on negative DC bus.**

DC based electrical springs (DC-ES) is proposed for applications in DC power grid is proposed in this paper. This may be most probably, the first wear pattern connect in nursing metal to assist at regular intervals. Here, serially-connected to a non-critical load is measured by the DC-ES square measure, thereby forming a wise load then the non-voltage regulation level of the DC tiny grid conductor and presumably the DC transmission lines.

Hence, Inside the longer term DC power systems, a specific guideline of DC bus voltages is necessary. Selected voltage tolerance like AC mains, new provisions and regulations on governing the voltage tolerances of DC power grids are to be established. consequently, the DC-ES can be used in all probability for (i) load boosting and detaching functions to equal the ability expenditure of the DC a whole bunch to the renewable power generation connected to the DC grids and (ii) regulating the DC bus voltage at regular intervals the specified time limits, while enduring the intermittent fluctuations during power faults with energy sources or deep voltage sags. Associate in Fig. 3 as an example of a radial DC network is shown. Here, Rnc1 and Rnc2 are the non-critical a entire group linked in the network, Voc is side voltage, Rc1 to Rc4 are the essential a entire group, and It obtained to be prominent that the distributed line impedances (Rdl to Rd4) among any a pair of points in the DC network have to be considered.

### A. DC electric spring operating principle;

Detailed analysis on the Characteristics of the DC-ES in numerous regions is addressed here in this section. Fig. 3(a) and Fig. 3(b) shows the necessary configurations of series-connected DC-ES placed in positive and negative DC buses. Within the figures, the polarity of the Es voltage and noncritical voltage are shown. The positive track of the load current (i.e., the Es current and non-critical load current) is aimed towards the bottom (0V). Therefore the resistivity of the distribution lines isn't taken into consideration throughout this section. Here, it's assumed that the DC bus voltage Vbus is constant and up to so-called reference value Vbus official.



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## II. BLOCK DIAGRAM

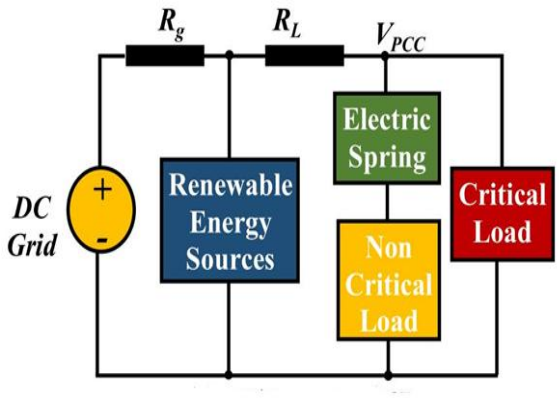


**Fig.4. Block diagram of proposed system**

Here, the DC-DC converter is implemented with electric spring for enhancing and restrain the power in the DC grid. series ES and shunt ES are the two types of Es. Where, series based electric spring based idea executed here. Series ES is coupled in series with the Non serious load. The proposed Series ES based DC-DC converter is used to resolve voltage fluctuation in PCC.

## III. SIMULATION RESULTS:

In every case, there are two different switches are plays an important role, among those one is always in on state and another one is switch conducting and the other set is always OFF. Four waveforms will be for each case which corresponds to the voltage of the ES, converter output waveform voltage and the inductor current. 50% with a switching frequency of 20 kHz is used as a duty cycle of the converter. As predictable after using second order LC filte the output voltage of the ES is a DC waveform. The DC-E diminishes, the voltage drop even with the attendance o renewable energy in open loop operation.

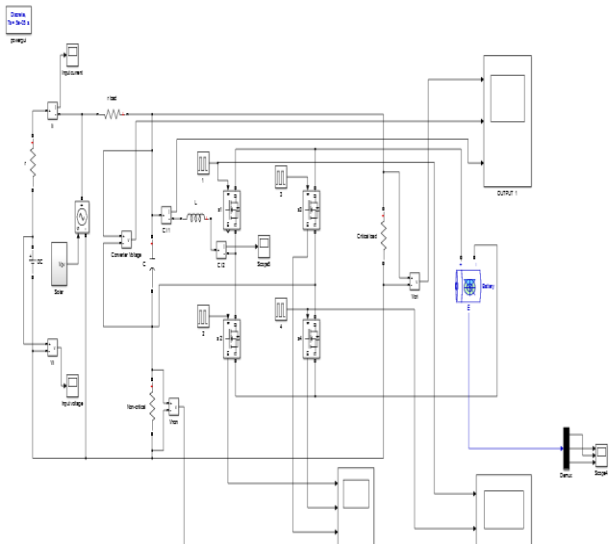

**Fig.5. (a) Simulink model of DC-ES with RES**

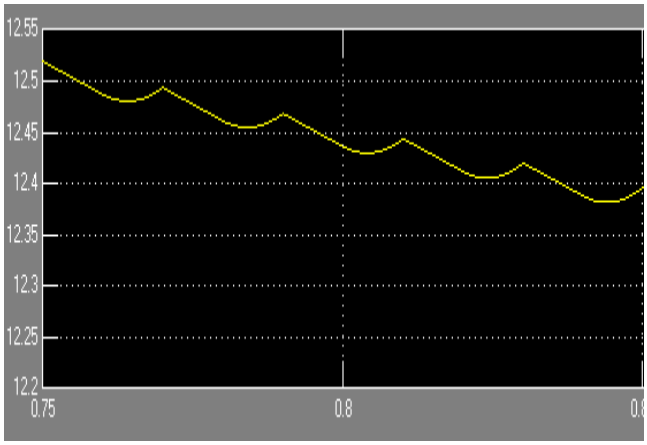


**Fig.5. (b) Voltage Waveform of Non-critical Load**

The Fig.5(a) shows Simulink model of DC grid based electric spring with RES. It consists of 4 units such as DC-DC converter, renewable energy sources, battery and loads. Fig5 (b) & 5(c) shows the output voltage waveforms measured across the terminals of non-critical load and the across the DC-DC converter.



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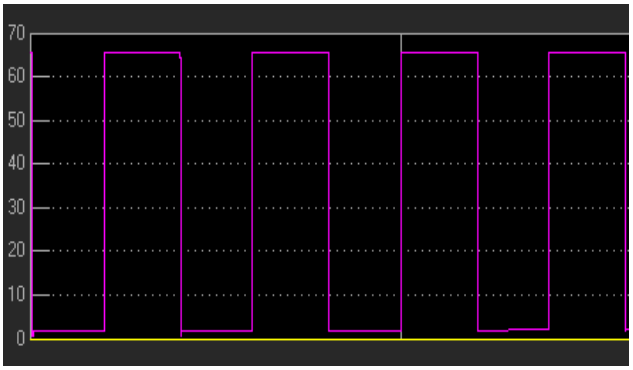


**Fig.5. (c) Converter Voltage Waveform**

## IV. CONCLUSION

For voltage stability problem and power quality improvement, DC-ES is an efficient solution in DC grid. The operating principle and various operating method of the DC-ES were also discussed, to provide the voltage regulation for DC bus and to maintain the PCC voltage constant. To control the voltage under the occurrence of fluctuations, the closed loop systems with PI controller have been presented. Simulation outcome of the open and closed loop system has been provided for the electric spring operation.

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