VOLTAGE STABILITY IMPROVEMENT USING ELECTRIC SPRING IN MICROGRID SYSTEM

S.Ganesh¹, N.Priya², D.Fathema Farzana³, G. V.Chidambarathanu⁴
¹Assistant Professor, Department of EEE, SRM TRP Engineering College, Tamilnadu, India.  
E-mail: gauti.ganesh@gmail.com
²,³Assistant Professor, Department of EEE, Easwari Engineering College, Tamilnadu, India.  
E-mail: priya13eee@gmail.com, farzana.reeha@gmail.com
⁴Assistant Professor, Department of EEE, Amrita College Of Engineering And Technology, Tamilnadu, India.  
E-mail: g.v.chidambarathanu@gmail.com

ABSTRACT

Electric Spring, a modern digital innovation, was previously used for a limit exposure source of energy driven grid to provide power system stabilization. It was suggested as a power output control of load management methodology. Roofs are a perfect place to put electric springs to good use. In this paper, a modern control strategy is proposed for the integration of electric springs in combination with non-critical house loads such as the heating and cooling system. Moreover to the regular functionality of electric spring of power output control stability, this proposed fuzzy controller will be able continue providing power factor improvement, and voltage control for critical loads, such as the house's protection system. Thus, by establishing voltage stability and improving power efficiency in solar and wind driven microgrids, the improved fuzzy control strategy provides possibilities for a better use of the electric spring.

Keywords: Micro-grid, Voltage Stability, Fuzzy Control, Electric Spring

I. INTRODUCTION

Wind and PV power are examples of alternative energy sources that are critical to a long-term future. Conversely, because of their erratic and unstable existence, reactive power compensation variability in the grid is a concern. To alleviate this intermittent renewables, various approaches have been suggested on both the source and demand sides. Load Side Management (LSM) was being widely used to reduce the impact of intermittent sustainable energy. LSM is implemented using a variety of approaches, including automatic load demand control, load scheduling, and power storage. They could, though, not be used in real-time, such as power scheduling, or they may be disruptive to customers, such as automatic load control.

Rui et al. [1, 2] implemented a new methodology to DSM called Electric Spring (ES), and can provide voltage and frequency stability. They only use reactive power support continue providing voltage support in real - time and variable in Non-critical loads are subject to load shedding. This is possible because ES is applied through an inverter, which has the ability to compensate for both active and reactive power [3]. Real power compensation has been used to boost power balance in a three-phase system [4] as well as power factor without voltage or power control [5].

In [6] and [7,8] introduce dynamic modelling for ESs to incorporate large-scale simulation analysis and a specific report on the steady-state behaviour of ESs, respectively. [9] describes the actual circuit and algorithm application of an ES to control the AC mains voltage through compensators. ESs may be used to minimise the usage of energy storage facilities in the smart grid system with significant alternative energy sources [10]. In this paper, we show how to use a Fuzzy control scheme to provide voltage stability in a renewable energy driven micro-grid, which is a previously unexplored aspect.
II. PROPOSED METHODOLOGY

In this article, a micro grid with loads, an energy storage system, and a solar system is used to realise the idea of electric spring. It is made up of a fluctuating A.C source connected to an AC/DC converter that feeds both critical and non-critical loads. A battery is also included in the micro grid system, which helps to sustain the loads when the AC source is unstable. As a result, the supply system (complete setup of source and storage system) should be able to provide required power to critical and noncritical loads even if the source is uncertain Fig.1.

\[ V_s = V_o + V_{es} \]  

(1)

As a consequence, non-critical voltage output fluctuate dynamically in response to weakly controlled grid problem by distributed generation power. The adjustment voltage, \( V_{es} \), must be analogous to the non-critical load current, \( I_o \), in order supply power compensation from the electric spring. The voltage value of an electric spring is determined by:

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(1)

When the system is over-voltage, the ES absorbs a mixture of capacitive and real power into the system to minimize the line voltage, \( V_s \), to the threshold value of 230 V and to control the line voltage, \( V_s \), and line current, \( I_m \), so that they stay in phase. In the event of an under voltage, the ES injects a mixture of actual and inductive power into the device to conduct identical line voltage control functions.

2.1 PV system and Energy Storage System

PV modules transform sunlight into electrical energy directly. Fitness trackers and clocks are often powered by solar cells. They're made of compound semiconductors used in electronic components. As these products absorb sunlight, the solar power loosens particles from their molecules, allowed to pass through into the product and generate power. The photovoltaic (PV) influence is the conversion of light (light energy) to electrical power (Watts). The term "Energy Storage System" (ESS) refers to a device which converts electrical power from power generation into a process which can be stored for future conversion through to electrical power.

2.2 Fuzzy Logic Controller

In the development of different types of fuzzy control (FC) is the most attractive research area. FLC is used in a variety of applications, including industrial applications, biomedical field, and security. FLC has performed better in dynamic ill-defined issues that can be regulated by an excellent work operator without knowledge of the actual dynamics, as compared to traditional control methods.

2.3 Electric Spring
An electric spring (ES) is a customized electrical system (Fig. 2), which is a voltage-controlled converter that can be 3 phase or 1 phase depending on the load requirement, and is series-connected with a non-critical load, with input feedback and voltage output control. A current-controlled voltage source can also be modelled as an electric spring. The source of DC voltage available at the DC bus can be used to classify electric springs, as follows:

![Fig. 2 Electric Spring in a circuit](image)

### III. SIMULATION RESULTS

A test system is considered, as shown in Fig. 1, with requirements as shown in Table I. A MATLAB-Simulink framework was used to simulate it. The voltage on the reference line, $V$, is set to 230 volts (rms). The device has a voltage instability due to its powerful resistive-inductive load. The proposed system with an invented fuzzy used electric spring that compensates for both actual and reactive power. A test system is pitted against one another in terms of complex voltage control, as well as power factor improvement.

<table>
<thead>
<tr>
<th>System Line Parameters</th>
<th>230 V</th>
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<tbody>
<tr>
<td>Voltage value of the line, V(rms)</td>
<td>230 V</td>
</tr>
<tr>
<td>Impedance value of the Line</td>
<td>0.1 Ohms. 3.5 mH</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Load Requirements</th>
<th>7.22+j0.55 Ohms</th>
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<tbody>
<tr>
<td>Non-Critical Load</td>
<td>7.22+j0.55 Ohms</td>
</tr>
<tr>
<td>Critical Load</td>
<td>12+j11 Ohms</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Electric Spring Topology</th>
<th>1 phase Full Bridge Network</th>
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</thead>
<tbody>
<tr>
<td>Inverter</td>
<td>1 phase Full Bridge Network</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>20 kHz</td>
</tr>
<tr>
<td>DC output voltage</td>
<td>415 V</td>
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<tr>
<th>Output Filter</th>
<th>2.88 Mh</th>
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<tbody>
<tr>
<td>Inductance</td>
<td>2.88 Mh</td>
</tr>
<tr>
<td>Capacitance</td>
<td>15.3 µf</td>
</tr>
</tbody>
</table>

The proposed work can provide variable voltage control, an Electric Spring (ES) with both active and reactive power injection technologies was used. The RMS line voltage is held at 230 v in an over-voltage situation, which is higher than the actual value.
The ES lowers and preserves the RMS line voltage at 230 volts by supplying inductive power into the device when switched on at t=0.5 seconds, as shown in Fig. 3 and an input current of the test system is shown in Fig. 4. The voltage around the non-critical load is also reduced to 215 V. As an outcome of ES injecting real power of 1500 W and reactive power of 2100 VAr into the system. As a result, the system's power output degrades.

The RMS line voltage is held at 245 volts in an over-voltage situation, which is above the threshold value. As shown in Fig. 5, ES is switched on at t=0.5 seconds and reduces the voltage output to 230 volts. The voltage increases to 145 volts over the non-critical load. The machine is injected with a 2300 capacitive VAr by ES. As a consequence, the power factor of an impedance device increases to 0.978 (leading) from 0.956 (leading). Even with the fact that the power factor has changed, there is static possibility for growth. The critical and non critical load voltage of the test system is shown in Fig. 6.
Although there is a 1.5 percent increase in the over-voltage case, the traditional ES absorbs only capacitive power while the improved ES absorbs both capacitive and real power into the device.

IV. CONCLUSION

Electric Spring (ES) has been shown to be an effective way to address the issue of power system instability associated with alternative sources driven grids in this article and previous research. In this study, it is illustrated that an ES a) preserves line voltage, b) provides power to the critical load, and c) increases power factor in the device using an Fuzzy control scheme. The proposed Fuzzy control scheme is often contrasted to the conventional pi controller. It has also been demonstrated that voltage control and power system enhancement can be accomplished with a separate entity. While only linear loads are included in this article, it will be expanded to include non-linear loads in the future. The current relation should be set such that the ES is the only source of harmonic distortion.

REFERENCES

