ADVANCED CONTROLLER FOR POWER FACTOR CORRECTION AND COMPARISON WITH CONVENTIONAL ES- ELECTRIC SPRING

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ABSTRACT: The utilization of DSM (Demand-Side Management) has demonstrated effectiveness in mitigating the consequences arising from the disruption of environmentally sustainable electricity supplies. To carry out DSM successfully, various strategies are employed, including direct burden management, load forecasting, energy stockpiling, among others. However, these strategies cannot be implemented in a progressive manner, such as load preparation, nor in an intrusive manner, like direct strain control. Both of these applications are incompatible with the intended use of DSM.

To address this limitation, an alternative approach called the Electric Spring (ES) has been previously proposed. The ES system is designed to continuously deliver voltage and power, providing consistent voltage support and shedding non-essential loads when necessary. This investigation aims to develop a hybrid algorithm to effectively manage the electric spring circuit and improve the efficiency of power factor correction.

By integrating the ES system into the DSM framework, this research seeks to enhance the overall performance of demand-side management strategies. The hybrid algorithm will optimize the power factor correction efficiency, ensuring a more sustainable and efficient use of electricity resources. By doing so, it will contribute to minimizing the environmental impact and maximizing the benefits derived from ecologically friendly electricity supplies.

Keywords- electric, spring, power quality, fuzzy, pi

Introduction-

Solar and wind power are only two examples of the types of renewable energy sources (RES) that are essential to the construction of a sustainable microgrid of the future. However, because of their sporadic and unexpected character, they provide a problem for the grid in the form of unstable power and voltage levels. Demand-side management,often known as DSM, is a strategy that has been actively adopted as a technique to mitigate the consequences of the intermittent nature of renewable energy sources. a number of different approaches, including load scheduling, direct load management, and energin and, each of which isable to offer voltage and power stability in real time. The DSM is implemented with the help of things like ys storage, etc. On the other hand, they cannot be utilised in real time like load scheduling and they could be obtrusive to the client like direct load control. Rui et al. presented a novel strategyfor DSM, which they referred to as the electricspring (ES) method. Only reactive power compensation was used by the authors in to offer voltage assistance in real time and load sheddingfor loads that were not important.

Unity power factor operation is desired in an ac system because it improves efficiency, reduces losses, increases active power delivery, and offers a number of other economic advantages on grid-side equipment, among other benefits. In a traditional grid, power factor correction (PFC) technologies such as passive capacitors and shunt condensers function flawlessly. Their locations are decided by the distribution system's reactive load as well as its losses. Devices such as DSTATCOM are being used more often in order to enhance power quality in response to the growing prevalence of nonlinear loads as well as developments in power electronics. It is hoped that we would look at PFC as a DSM problem in future microgrids that include significant amounts of renewable energy sourcesthat are spread across the grid. Buildings are going to be essential components of such future microgrids as they become more widespread. They have a lot of potential to put the idea of ES into practise, as shown in and via a variety of noncritical loads such electric heaters, air conditioners, and freezers. The idea of ES may be expanded even further in order to enhance the power factor of our brand-new microgrid that is fueled by renewable energy. Because the ES is implemented via an inverter, it is possible to accomplish this goal by making use of the inverter's capacity for both active and reactive power correction. Real power compensation has been applied to enhance power balance in a three- phase system and to increase the power factor without any voltage or power control being implemented. These improvements have been madepossible thanks to the utilisation of this technique. PFC may be included via a variety of control strategies, examples of which are the radial chordaldecomposition (RCD) control and the new -control. Electrical parameters of the system and grid voltage (input voltage) are necessary to apply the control scheme proposed in this paragraph, and the control strategy will not be a demand-side solution. The control approach in decouples the grid voltage regulation from the PFC of the smart load that is connected with ES. In this study and in, we show implementation of the ES using an improvised control scheme to offer the power and voltage stability and overall PFC. This is an area that has not previously been studied in the literature and is one of the contributions that we have made.

It was proved that the Electric Spring is an inventive solution to the issue of voltage and powerinstability that is connected with grids that are powered by renewable energy sources. Further onin this paper, by the implementation of the improvised control scheme, it was demonstrated that the improvised Electric Spring (a) maintained line voltage to a reference voltage of 230 Volts, (b) maintained constant power to the critical load, and
(c) improved the overall power factor of the system in comparison to the conventional ES. In addition, the 'input-voltage-input-current' control scheme and the traditional 'input-voltage' control are contrasted with one another. It was shown via modelling and simulation as well as hardware-in-the-loop emulation that voltage and power control as well as an increase in power quality can be accomplished with the use of a single device. In addition to this, it was shown that the improvised control scheme is superior than the traditional ES, which consists merely of reactive power injection. Additionally, it is possible that in the near future, household appliances may have electric springs. In a microgrid that is fueled by renewable energy sources, having a large number of non-critical loadsin the buildings that are equipped with ES might give a dependable and effective solution to voltage and power stability as well as in-situ power factor adjustment. It would be an innovative demand side management (DSM) system that did not rely in any way on information and communication technology to be put into action.

Literature Review-

[1] Jayantika Soni.et al., Electric spring (ES), a novel smart grid technology, has been employed in the past for the purpose of maintaining voltage and power stability in a renewable energy source powered system that was poorly regulated and operated on its own. a demand-side management strategy to offer voltage and power control. This article presents a novel control strategy for the application of the ES in combination with noncritical building loads such as electric heaters, refrigerators, and central air conditioning systems. The technique was developed for use in this particular publication. In addition to the already present characteristics of ESoft voltage and power stability, this control scheme would be able to provide power factor correction of the system, voltage support, and power balance for the critical loads such as the building's security system. Other characteristics of ESoft include stability in voltage and power. A comparison is made between this control system and the control scheme of the original ES, in which reactive power is the sole kind of power that is injected. The improved control system paves the way for the exploitation ofES to a larger degree by providing voltage and power stability and improving the power quality in microgrids that are fueled by renewable energy sources. This opens up new avenues for the utilisation of ES.

[2] Yan Shuo,et al., In this article, we will explain the fundamentals of using an electric spring (ES) as a power factor corrector and a reactive power compensator. In order to provide a broad notion on the operation of ES, the theory behind electric springs that use capacitors for voltage stabilisation is analysed and discussed. In the following discussion, we will concentrate on the fundamentals of ES with batteries, namely its eight distinct operational modes and the benefits that these modes bring to the table in terms of line current control. For the purpose of determining whether or not ES with batteries is capable of power factor adjustment, an input current control method has been developed. In order to test whether or not the theory behind ES can be implemented using batteries, a low-voltage, single- phase power system that includes a variety of various sorts of loads has been constructed. Experiments demonstrate that the ES is capable of performing all eight operating modes when the

power consumption of the non-critical load is altered. Furthermore, the experiments demonstrate that the ES is able to achieve power factor correction for both RL and RC loads when theinput current is controlled.

[3] According to E. F. Areed et al., In the realm of smart grids, a novel piece of technology known as the Electric Spring (ES) has only just emerged on the scene. This technique has a lot of promise for helping to stabilise the future smart grid bymanaging the main voltage in spite of the volatility in the amount of electricity that intermittent renewable energy sources provide. Expanding uses of electric spring are providing a fresh perspective on the functioning of the power system, one thathas less reliance on communication technologies. This study develops and proposes a novel methodof demand side management using electric springto adjust the main voltage and enable the smartload to follow the power production profile. The method is developed and proposed in this paper. Using genetic algorithms (GA), AC and DC PI voltage controllers may be developed to be as effective as possible, with the goal of reducing the amount of error in the voltage that is being monitored. In operating situations characterised by abrupt change and many disturbances, both the efficiency and efficacy of the controllers are subjected to investigation. The simulations demonstrate that the controllers are useful in improving the performance of the electric spring in terms of voltage regulation.

[4] Xile Wei et al., The purpose of this work is to present an analysis on the steady-state of electric spring (ES) for the purpose of stabilising the future smart grid with intermittent renewable energy sources. The disclosure of the operating principle of ES for the purpose of providing voltage support to the power grid and the provision of a theoretical foundation for the design of ES are the two primary goals of this body of work. The features of ES in its steady state are the primary focus of this paper. The effective operating range, change in power factor, and variation of phase angle used in control implement are all analysed in detail based on the vector diagram model of ES in relation to the phase angle of non-critical load current shifting from -90 degrees to 90 degrees. This change is considered in the context of the previous sentence. In conclusion, three investigations are carried out in order to evaluate the voltage boosting and reduction functions of ES in terms of stabilising the fluctuant voltage, in addition to validating the effective working range of ES. The investigation yields recommendations for the ES placements in the various distributed system configurations.

[5] Binita Sen,et al., New smart grid technology known as electric spring can control voltage fluctuations brought on by the integration of intermittent renewable energy sources. To until point, the majority of research on electric springs has been conducted using resistive loads that are always turned on. In this study, the functionality of an electric spring is evaluated in relation to a number of various forms of fluctuating loads. In the MATLAB/Simulink environment, an electric spring circuit was modelled with three distinct kinds of loads: resistive, resistive-inductive, and resistive-capacitive. Because of the modifications made to the circuit, some portions of the simulation willtake place with none of the loads being active. The impact of varying the load on the performance of the electric spring was found to be unaffected bythe kind of load being used. On the other hand, the kind of load that is linked to an electric springdetermines how the stress on the spring changes as the load changes. The report includes a comprehensive study that has been delivered in great depth.

[6] Shu Yuen (Ron) Hui, Fellow, et al., In the1660s, the British scientist Robert Hooke defined the scientific idea of "mechanical springs." Hooke was the inventor of the term "mechanical springs." Since that time, Hooke's law under the electric regime has not undergone any additional development in any way. The author of this article proposes a solution to this technical void by describing the creation of "electric springs." In this study, the fundamental basis behind electric springsas well as their working modes, limits, andpractical reality are discussed. It has come to our attention that such an innovative approach has a large potential for the purpose of stabilising future power networks that will include a significant proportion of variable renewable energy sources. This idea was successfully proved in a real power system setting that was fed by an alternating current power source as well as a variable wind energy source. The system was supplied by an ac power source. Despite the fluctuations in voltage that are brought on by the intermittent nature of wind power, it has been shown that the electricspring is an excellent means of controlling the mains voltage. Electric home appliances that already have electric springs have the potential tobe upgraded to the next generation of "smart loads." These loads have their power consumption patterned after the profile of the power production.

When dispersed throughout the power grid, it is anticipated that electric springs will provide a new kind of solution for the stability of the power system that is not reliant on information and communication technologies.

[7] Electric Spring (ES) is a notion that has arisen based on the mechanical spring idea. It was developed by Rana About Hashem, Yasmin Soliman, Sara Al-Sharm, Ahmed Massoud, and others. Demand side control, improvement ofpower quality, and better overall energy management are all possible applications for ES in either an AC or DC grid. The intermittent nature of Renewable Energy Sources (RES) necessitated the introduction of ES into the DC grid in order tostabilise the voltage variations that were caused by RES power changes caused by PV systems and the like. The DC ES is connected to the DC grid in series with the non-critical loads that make up the smart load (for example, thermostatically regulated loads such as air conditioning systems, electric water heaters, and refrigerators, or charging of charge of plug-in electric cars). Within the scope of this study, a contrast is drawn between the series and shunt DC ES, taking into account the four distinct modes of operation. An ES that is based on a four-quadrant DC-DC converter is examined and constructed in order to provide a power flow that can go in both directions. The use of MATLAB/ Simulink, in both open and closed loop operations, is shown to verify the technique that is being described here in order to validate the influencethat the series ES has on the non-critical load. provided for evaluation by an ES prototype.

[8] M.Tech Scholar Neethu S. Nair, along with Others, The electric spring is a relatively new idea that was developed to improve the reliability of the smart grid of the future by using renewable energy sources. Together with other types of non-critical loads, electric springs may combine to produce a "smart load," which has the ability to control the voltage at the point in the distribution system where it is attached. Within the scope of this study, Simulink serves as the platform for the electric spring implementation. The efficiency of electric spring in controlling the mains voltage may be tested by the comparison of the voltage waveforms obtained with and without the presence of electric spring.

[9] Nilanjan Ray Chaudhuri,et al., The utilisation of "Electric Springs" is an innovative technique for distributed voltage control that, at the same time, enables efficient demand-side management. This is accomplished through the modulation of noncritical loads in reaction to the fluctuations in intermittent renewable energy sources (e.g. wind). On some rather simple hardware for a 10 kVA testing system, the proof-of-concept has been successfully proven. However, in order to demonstrate the usefulness of such electric springs when installed inlarge numbers across the power system, it is necessary to develop simulation models for these electric springs that are both straightforward and accurate. These models should be able to be incorporated into large-scale simulation studies that are conducted on power systems. The dynamic modelling technique for electric springs is discussed in this study. This approach is suitable for voltage and frequency control investigations at the power system level. The strong resemblance between the simulation and this electric spring model provided us the confidence to apply this electric spring model for researching the efficiency of their collective operation when spread in a vast number throughout a power system. The efficiency of an electric spring is proven under a variety of load power factors, including unity and non-unity load power factors, as well as varying fractions of critical and non-critical loads.

[10] Congchong Zhang et al., Because loads in transmission networks are typically the aggregation of lower voltage networks, the control scheme needs to be granulated down to at least sub transmission networks in order to make the implementation of controllable loads for frequency regulation in transmission networks a practicable endeavour. Granularity at this level is necessarybecause of the nature of the controllable loads themselves. However, active power adjustments in sub transmission networks will have an effect not only on frequency but also on bus voltage since transmission lines have a greater R/X ratio. This is the case even if frequency is the more obvious of the two. Additionally, the expenses for loads that participate in frequency and voltage control must to be taken into consideration as well. A control strategy for electric spring (ES) aggregators is presented in this research. These aggregators comprise of back-to-back ESs and exponential types of noncritical loads in sub transmission networks. In order for ES aggregators to gain new active and reactive power setpoints by exchanging information with their neighbours, a distributed optimization has been used. This optimization seeks to reduce costs while simultaneously implementing frequency and voltage control. The power consumption of each ES aggregator is then

changed correspondingly in order to concurrently regulate frequency and voltage. The simulation demonstrates that ES aggregators have thecapability to provide the needed active power response, regulate frequency cooperatively, and maintain bus voltages within the permissible range while keeping costs to a minimum in accordance with the control scheme.

Implementation

In this work, for the control system, the fuzzy logic is used twice, the controller for voltage is onlyfuzzy logic controller and the PI controller is used to enhance work of ES for current controller.

The fuzzy rationale is applied with incredible achievement in the different control applications. Practically all the buyer items have fuzzy control. A portion of the models incorporates controlling your room temperature with the assistance of a climate control system, hostile to slowing mechanism utilized in vehicles, control on traffic signals, clothes washers, huge financial frameworks, and soforth.

A control framework is a plan of actual segments intended to adjust another actual framework with the goal that this framework shows certain ideal attributes. Following are a few reasons for utilizing Fuzzy Logic in Control Systems −

- While applying conventional control, one has to think about the model and the target work planned in exact terms. This makes it exceptionally hard to apply by and large.
- By applying fuzzy rationale for control we can use human skill and experience for planning a regulator.
- The fuzzy control rules, essentially the IF-THEN guidelines, can be best used in planning a regulator.

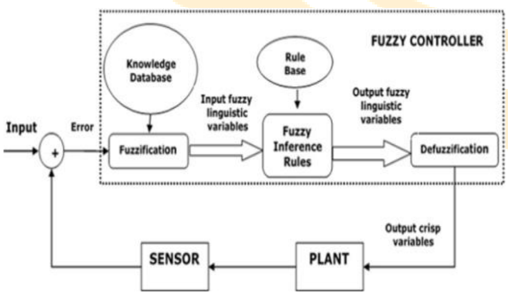


Figure 1: basic block diagram for advanced logic controller

Followings are the significant segments of the FLC as appeared in the above figure −

Fuzzifier − The job of a fuzzifier is to change over the fresh info esteems into fuzzy qualities.

Fuzzy Knowledge Base − It stores the information pretty much all the info yield fuzzy connections

Induction Engine − It goes about as a portion of any FLC. Fundamentally it reproduces human choices by performing rough thinking.

Defuzzifier − Part of defuzzifier is to change over fuzzy qualities into fresh qualities getting from the fuzzy derivation motor.

Advanced regulators are executed with discrete testing periods and a discrete type of the PI condition is expected to estimate the vital of the blunder. This adjustment replaces the ceaseless type of the essential with a summation of the blunderand uses Δt as the time between inspecting occurrences and nt as the quantity of examining cases. PI control is required for non-coordinating cycles, which means any cycle that in the end re- visitations of similar yield given similar arrangement of data sources and unsettling influences. A P-just regulator is most appropriate to incorporating measures. Necessary activity is utilized to eliminate counterbalance and can be ideaof as a customizable bias.

The circuit in is implemented on MATLAB Simulink. Figure 2 to figure 5 shows the existing implementation screens.

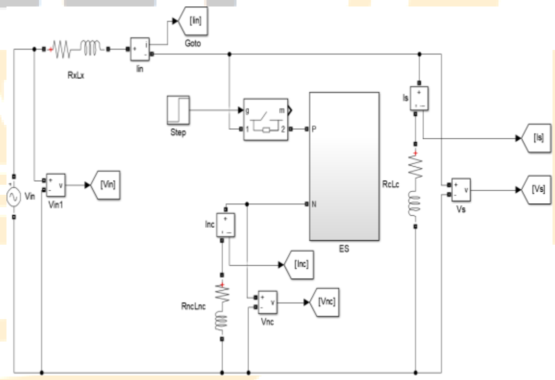


Figure 2: Electric Spring with loads Final Circuit

International Journal for Research in Engineering and Emerging Trends (IJREET), Volume 7, Issue 1, August, 2023
ISSN: 2545-4523 (Online)

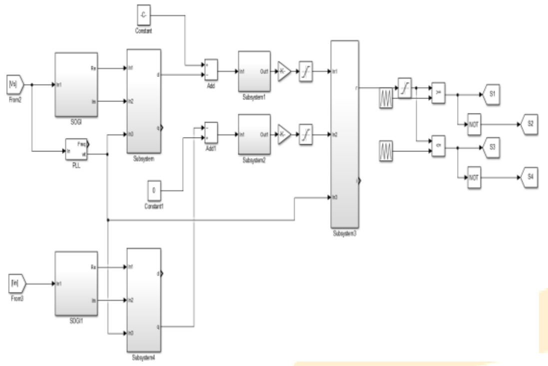


Figure 3: Control for ES

The circuit is taken as same in existing one to improve its performance using a suitable controller. Figure 6 to Figure 10 shows the proposed implementation with the controller.

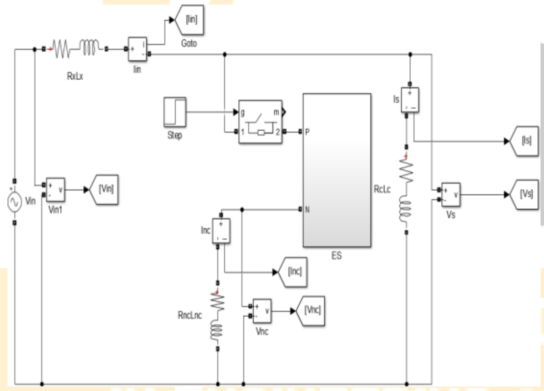


Figure 4: Electric Spring Load Circuit

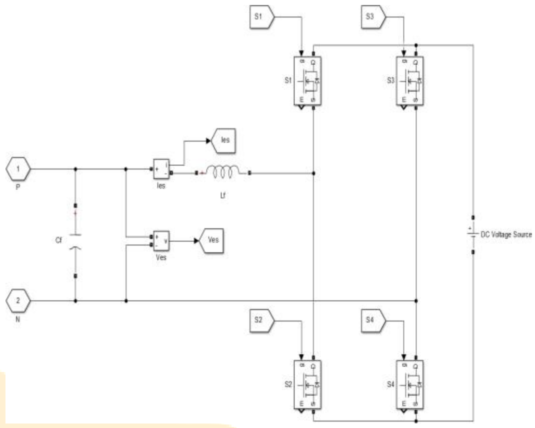


Figure 5: Electric Spring Circuit with Switches

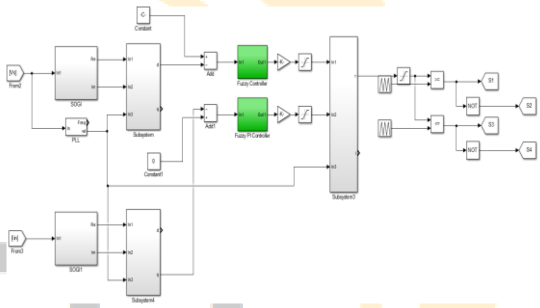


Figure 6: Advanced controller control system circuit

International Journal for Research in Engineering and Emerging Trends (IJREET), Volume 7, Issue 1, August, 2023
ISSN: 2545-4523 (Online)

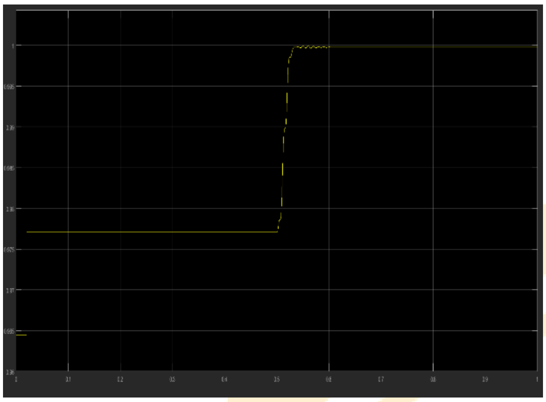
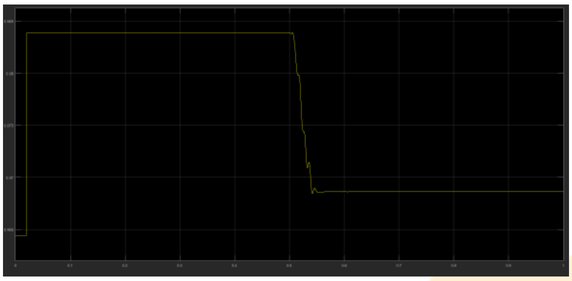


Fig:7 (Undervoltage)

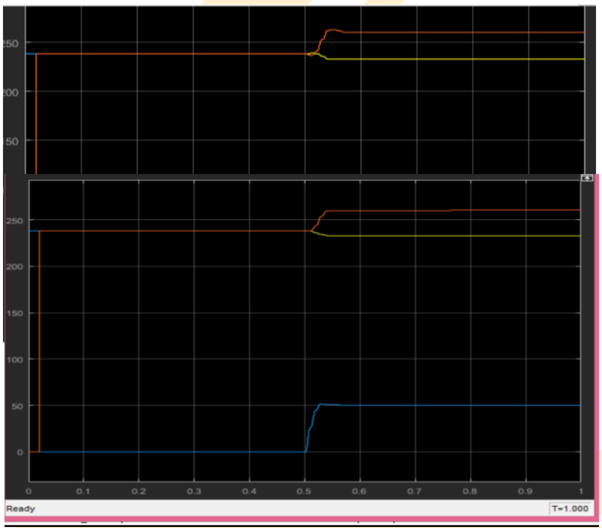
Fig 1 signifies the results of the power factor correction using the advanced controller.

However, the conventional ES results and the effects are shown in the next figure.
The results are of normal control. However, when the advanced controller is used, we can check that there is more smoothness in the curve and smooth regulation in the curve. The effect of advanced controller can be clearly seen with less distortion

Fig 8 Overvoltage pf results



The effect of advanced controller can also be seen with more smoothness in the regulation of voltage.



Conclusion

Demand-side management (DSM) and voltage monitoring in MV and LV appropriation organisations have, historically speaking, been treated with and controlled independently. The control devices that were explained in the part before this one are often used in order to accomplish the task of voltage regulation. On the other hand, the demand-side of the board is used in a more widespread method (often at the computer level), and it is predicated on the intuition or communication office that is present in the machine. Within the scope of this thesis, the effects of a number of different controllers were successfully applied and compared in order to arrive at the conclusion that the fuzzy pi-based hybrid controller offers superior power efficiencyas well as power factor correction as the powerfactor gets closer to one.

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