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FUZZY LOGIC CONTROLLER BASED DVR FED HYBRID SYSTEM TO ENHANCE SAG COMPENSATION CAPABILITY

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Keywords:

Energy Storage using Super Magnetic Field (SMES), FLC, DVR, and SAG.

ABSTRACT

To improve the ability of grid-connected hybrid power systems to compensate for voltage sags, we provide FLC-based DVR in this study. Renewable energy sources are typically considered to be the only viable green energy option due to their abundance in nature and lack of environmental impact. One of the main drawbacks of most renewable energy sources is the unpredictability of their output, which is especially true with wind and solar photovoltaics. In order to protect essential loads from power supply side changes and failures, dynamic voltage restorers (DVRs) are often utilised. This study's overarching goal is to safeguard the grid-connected hybrid PV-wind power gadget against the effects of voltage fluctuations. As a backup system, DVRs that rely on batteries and Super Magnetic Energy Storage (SMES) kick in when the power drops. To make up for disruptions, the pre-sag compensation technique locks the three phase magnitudes and angles in a normal condition at the instantaneous common coupling point (PCC).We use MATLAB/SIMULINK to solve symmetrical and asymmetric problems and determine compensation.

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I.INTRODUCTION: Global energy consumption increased 2.9% in the last year, which is roughly double the yearly average of the previous decade [1]. According to the 2018–2050 energy demand prediction, which is based on the research conducted by [2] for the three industrial subsectors (energy-intensive manufacturing, non-energies-intensive manufacturing, and non-manufacturing), the energy-intensive manufacturing industries will consume 50% more power compared to 2018. Nonrenewable energy sources are not ideal for supplying this market because of the pollution they cause, the fact that they are limited, and the instability of their prices. An optimal approach to meeting future electrical demand should centre on the efficient use of renewable energy sources (RES), including wind and solar photovoltaic (PV) capacity.
The energy transformation road plan for the year 2050 states that renewable energy sources, Using renewable energy sources, especially wind and solar power, would increase employment, decrease carbon dioxide emissions by 70%, and enhance GDP by 2.5% [3, 4]. It is anticipated that RESs will meet two-thirds of the energy demand[3,4,6] due to their size, lack of environmental impact, and economic acceptability in comparison to fossil fuels [5]. Countries want to maximise their demand for renewable energy due to the environmental impacts and problems linked with non-renewable power sources [7]. The results of the studies will inform a strategy for the year 2050 to be developed by the global agency for renewable energy. To alleviate the unpredictability of energy fluctuations, RESs provide a potential future for non-renewable energy sources [12]. Wind speed and sun irradiation are the main meteorological factors that determine this. The unpredictable Most industrial load forms, including those in the chemical and semi-driver manufacturing industries, are now susceptible to power fluctuations due to advancements in power electronics[14], [15]. In such instances, electronic companies and their customers should be considered to be within the defined limit for enduring power fluctuations. Using a custom power system (CPD) linked to the important load side and dynamic voltage restoration (DVR) is the most costly and extensively linked series CPD system [14][16][19]. A series CPD that is the most costly [14] [19]. To address important issues with PQ consistency, DVRs are employed to safeguard critical user loads against tilt and subsequent losses[16],[20],[21]. These losses are caused by sloppy voltage, swell, interruptions, harmonics, and flicker difficulties. The most typical voltage disruptions are things like starting large engines, significant loads shifting, power outages in distant buses, and transformer power outages. This is accompanied by a step angle jump [19]. Along with the aforementioned causes, sag may also develop in wind energy devices because of their intermittent sources.
Without the need for a storage component, the energy needed to power the DVR may be generated directly from sources such as self-storage condensers and external storage devices like battery energy storage (BES) and super-magnetic energy storage (SMES). The efficiency of wind power [16], photovoltaics [26], conventional electricity, and hybrids of PV and wind may all be enhanced by DVR. Storage and quick response make use of BES and SMES in conjunction with the conventional power source [18] [29]. When the primary power source is disconnected, the DVR will not be able to function properly under deep sag situations. When the DVR uses its own power storage, whether it's BES or SMES, the results are still subpar. This explains why SMES and BES units have strong strength but poor ability and medium power, respectively. As an example, using SMES as energy storage alone allows the DVR capabilities to be quickly used, but only for a short duration. On the other hand, using BES alone causes the reaction time to be slow, despite the fact that it is lengthy. In order to enhance the output capabilities of BES and SMES units, it is recommended that they be combined [18], [29].
Hybrid energy storage (HES) is a promising area of study, and theoretical work and device development in this area are moving forward at a rapid pace. One promising use is in micro-network

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photovoltaic power systems. Detailed descriptions of the DVR topologies, management approaches, and compensation plans can be found in [19]. Premature trips out from sensitive loads due to the inability to prevent jumping may occur as a result of compensating approaches relying on decreasing ratings of DVR and DC injection transformers. You can fix pre-sags with corrected step jumps since they lock the line voltage's phase angle and magnitude right away. Therefore, the optimal pre-sag compensation size for an injection converter and DC link condenser storage ability is narrowly desired.

PROPOSED SYSTEM:

PV and wind turbines are not reliable and cannot provide electricity with a firm capacity. The HES-based DVR device would play a key role in this study in the successful use of renewable energy sources as a micro-grid system and the improvementof the electricity to supply the linked critical load. The improvement of the voltage of the PV-wind hybrid power sys- tem linked with the grid is simulated. The variation is largelybecause of natural energy (wind and PV)and fault situations, which are unstable. In this analysis, the pay approach utilized ispre-sag compensation and is detailed with its supervisory and operating director. PSCAD simulation validates the accuracy of the proposed system. The rich nature of theenergy sources of solar and wind is exciting,and the cost of investments is steadily declining. Wind and Solar PV energy sources have been deployed globally with a capacity of over 539 GW and 405 GW respectively by 2017. Wind and PV power sources rely on the atmosphere andprimarily on wind speed and sunlight. The wind turbine power production (WTP) can be measured using wind speeds and windturbine companies' power curves as seen in Fig.3.1 and (1). In the interval of cut-in and rated wind speed values, the production capacity is non-linear and non-zero. The energy generated in that situation is not constant and can come under pressure to be coupled with another energy source toprovide end-users with continuous electricity. Calculation of PV cell productionon the basis of the seen I-V cellcharacteristics and Fig. 3.2 and Tab. 1 [5], [34], [35]. The solar and temperature of PV- cells, as stated in (3) and (4)[5],[35] are primarily dependent on Voc and Isc. As such, standalone photovoltaic plants with fluctuating power are not strictly desirable for critical loads that require continuous and sustainable power supply. As a general example, the maximum strength of the PV cell may be measured by (5) with an estimate of cell's temperature by

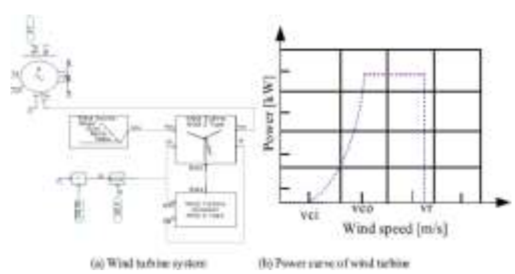

FIGURE 3.1. Wind turbine system and itspower curve.

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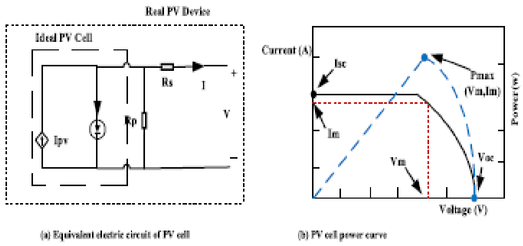


FIGURE 3.2. PV cell power circuit andcurve.

$$P_{WT}(v) = \begin{cases} 0, & 0 < v < v_{ci} \\ 0.5\rho A v^3 C_p, & v_{ci} \leq v < v_r \\ 0.5\rho A v_r^3 C_p, & v_r \leq v < v_{co} \\ 0, & v \geq v_{co} \end{cases} \quad (1)$$

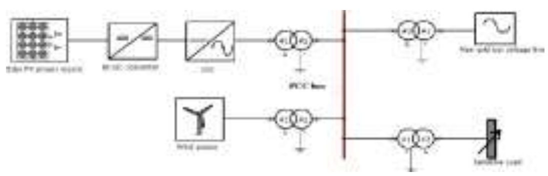
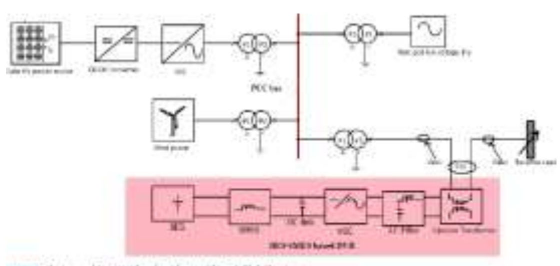


FIGURE 3.3. On grid PV-wind hybridsystem.



In an AC device it is impossible to store electricity electrically. Energy can, however, be stored using SMES and electrochemically by transforming AC and storing electricity like electromagnetically using BES. One potential use for improving the power efficiency is the integration ofthese energy storage technologies with CPDs for critical loads. In the case of

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In cases of voltage swell, SMES may be used to stabilise the load voltage by storing electric energy in a supra-conducting roller and then releasing it during a voltage sag. Running the superstructure coil at a very high current causes an inductive load, and discharging the coil reduces the available current. While SMES boasts a high power density and lightning-fast response time, BES excels at storing energy and dispersing it over a long duration. It takes some time for a combination of BES and SMES units to handle variations caused by sensitive loads, but the combination is effective for responding rapidly to such loads. If we have a look at Figure 3 and its parameters from Table 1, we can see that the BES-SMES dependent DVR is able to maximise voltage changes on the PV-wind hybrid power device. Figures 3.4 and 3.5 depict the overall design of this block. An injector, LC filter, two-way VSC, DC-link condenser, SMES unit, BES, and their corresponding equipped chopper make up the BES-SMES-based DVR, which is attached to the responsive load side of a distribution line. Detecting disturbances and determining the reference signal for voltage injection are the fundamental components of the DVR control system.

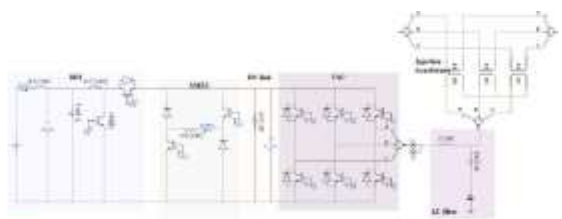

FIGURE 5. BES-SMES based DVR detail block diagram.

The tension detection is performed by calculating an instantaneous three phase- line real-time voltage at the point of typical

connection and analyzing the voltage disruption by calculation by the root average square (Vpu). Reference signal generation is based on the form of compensation system utilized for the most popular compensation systems, such as phase-in, pre-section, energy-reducing and hybrid compensation methods. The DVR injects and compensates for the lost voltage using HES and during excess value of the Vpu, which is the voltage swell, the DVR shall absorb the excess voltage to be deposited in the HES so the load voltage is stable and within the regular value. When it is injected at Vpu the DVR is in a natural (voltage sag condition). In both instances the DVR procedure is performed by correct BES, SMES and VSC controls in Fig. 3.6, Fig. 3.7, Fig. 3.9 depending on the criteria set out in Table 2. As shown in Fig. 3.5, the battery charges, discharges or stays in energy-storage states by looking at the voltage levels in the PCC and SOC.

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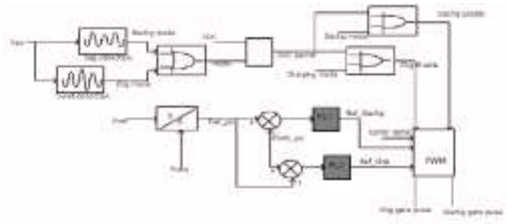

By matching its true power with its nominal capacity, the SOC of the battery is determined. When an insulated Gate bipolar (IGBT) transistor is switching called CS andDischarge (DS) ON, the BES would be charged and discharged. To ensure thebattery is not affected due to overload and discharge, its charge status (SOC) in addition to loading and discharge mode conditions is assumed to be between 5 and100 per cent. The SOC permit is the signal used to allow loading and unloading when the SOC is 100% and 5%, respectively. If the SOC is at the lowest level, charge is only allowed and only discharge is allowed wherethe SOC is close to the highest level. Whereas, if there is a SOC benefit, the battery can recharge or discharge as defined in figure 6, depending on the sag or swell detection. The CS and DS would be ONonly if the load enabled and the load enabled values rely on the SOC permit and mode. Based on a battery rank, the reference force is chosen for each unit value and the error is transmitted to the proportional integral (PI1) controller to produce the referral signal (Ref Dischg) for discharge in comparison to the battery per unit value. The reference value per unit is summed to the battery power per unit and converted by PI 2 toproduce the charge reference signal (Ref Chg). Compared with the carrier signal which contains 5 kHz, these reference signals produce pulses for charging the door and for discharge pulses. If the voltage is natural or even if it is dizzy or swelling, the BES would be in idle (storing condition),with SOC 5 or 100 percent. The SMES can charge, discharge or remain with energy storage states by observing the voltage level at the PCC and SOCs of the SMES as seenin Fig. 5 and Fig. 7. For the fee of the SMES, Sw1 and Sw2 switches should beswitched on and Sw1 and Sw2 should be switched off to discharge. Sw1 is switched off in the energy storage state and Sw2 is enabled. The reference energy is comparedto the energy contained in the SMES,supplies it to a PI 11 and is converted to the differentiator to generate energy by

multiplying the ON-OFF amount. Smes' power is then compared with the DC power (Pdc) from the DC connection condenser and multiplied with the ON-OFF value such that the reference signal is eventually passedto PI 12. Like the BES, if the SOC is below 100% and over 5% respectively, the SMES will fee and discharge it. By contrasting the real saved energy with full energy power, the SOC of the SMES is determined. The SMES is charged or downloaded when the SOC is between 5 and 100 percent and whenthe voltage swell or decrease occurs at the PCC, respectively. If the PCC voltage level is regular or swells but the SOC level of the SMES is in 100% or is in a sag state, but theSOC level of the SMES is 5%, so the SMESis at energy storage level. The total BESSMES DVR will run in these three countries, according to the status of the BESand SMES units.

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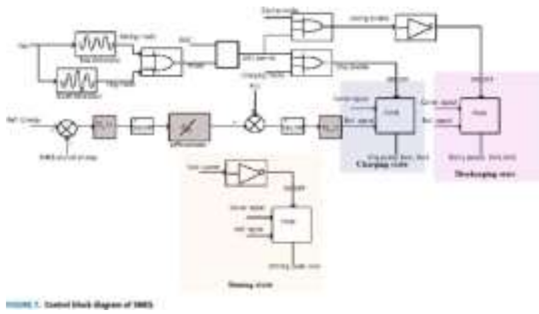
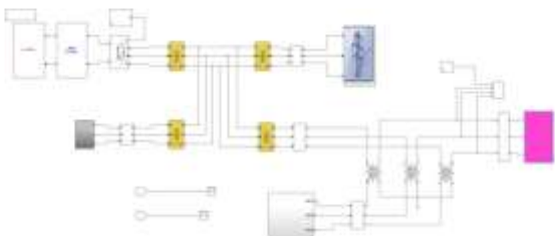
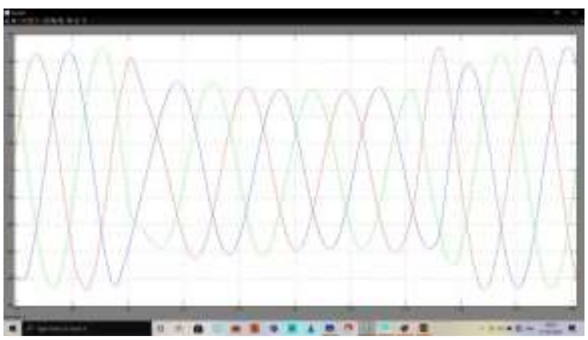


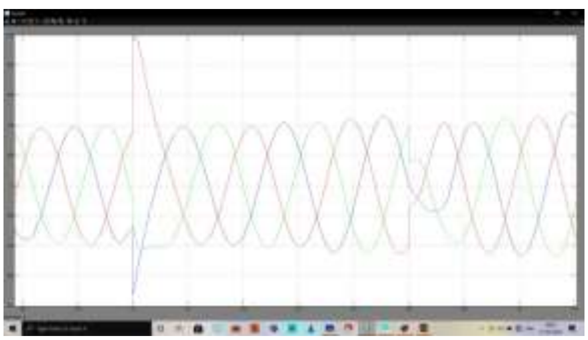
II. SIMULATION RESULTS



Symmetrical fault with 25% sag:



Without dvr



With dvr load voltage

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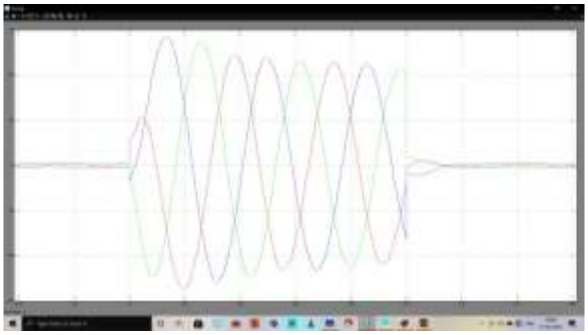

Dvr voltage Symmetrical fault with 12% sag:

Load voltage without dvr

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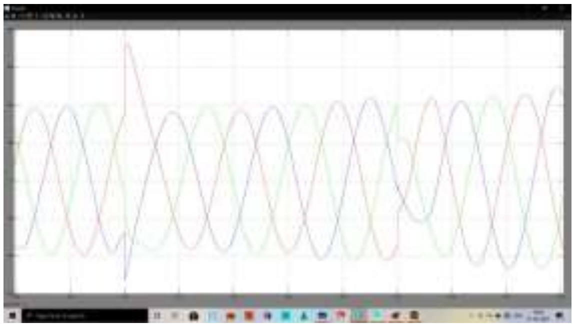
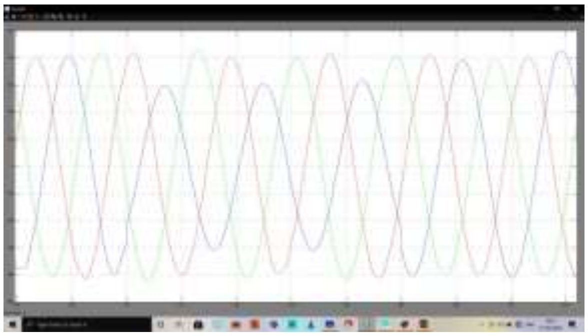
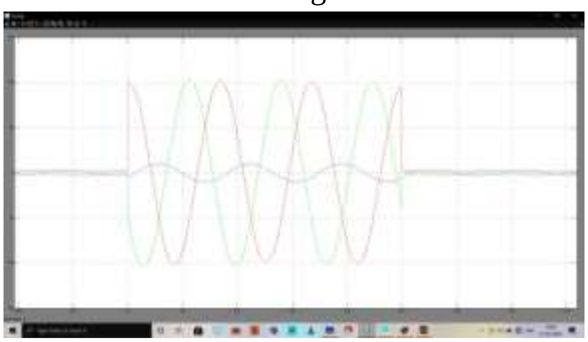
Dvr voltge



With dvr load voltage Asymmetrical with25% sag:

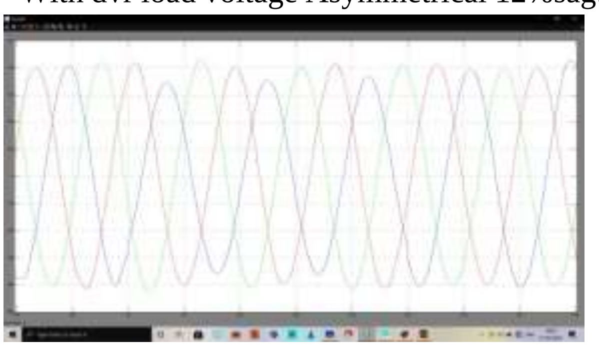


Without dvr load voltage

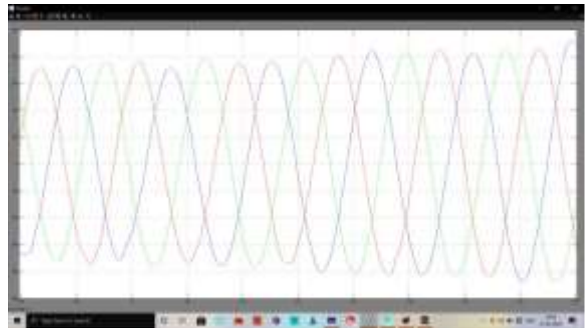


DVR voltage

With dvr load voltage Asymmetrical 12%sag:



Without dvr load voltage



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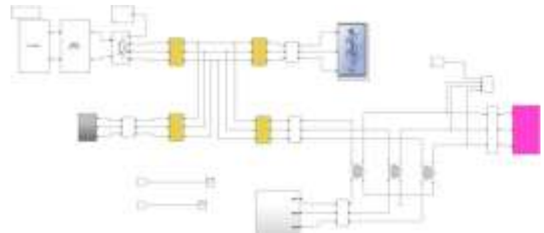
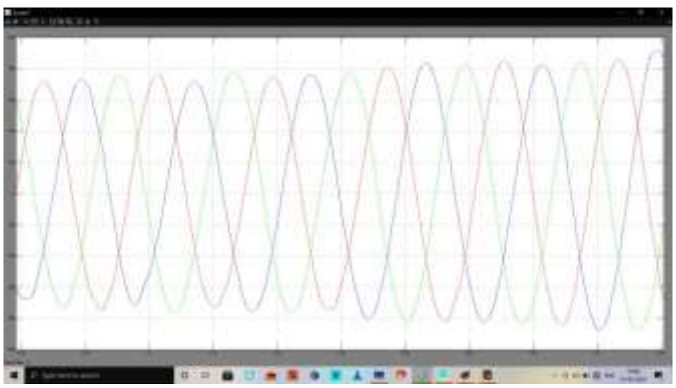


Dvr voltage



CONCLUSION

The proposed study describes how the PV-Wind connected grid may employ FLC with HES-based DVR to adjust voltage sag and boost the sensitive load. The sensitive load would be protected from voltage fluctuations caused by failure or unpredictable PV wind device output by the DVR. DVR suggested In order to monitor and operate the BES and SMES systems, data is analysed from the grid voltage at the PCC, as well as the speeds of the batteries and SMES SOC. In addition, checking the PCC voltage level establishes the VSC monitoring and application for the suggested DVR device's full implementation. We use the pre-sag compensation method because of its capacity for magnitude and leap phase. Regular (free), state of charge (SoC), and discharge-state are the three operating states of the HES-dependent DVR that are defined by the terminology. We have seen that the intended operational states are feasible in real-world contexts. The simulation accounts for various voltage sag depth situations, including symmetrical and asymmetrical imbalances. All three types of scenarios—tension sag, voltage swell, and harmonic—will be shown in subsequent works.

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