Power Quality Enhancement in Hybrid Wind-PV Grid-Connected Using DVR

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ABSTRACT: *This paper proposes the appliance of a dynamic voltage refinisher (DVR) to reinforce the facility quality and improve the low voltage ride through (LVRT) capability of a three-phase medium-voltage network connected to a hybrid distribution generation system. during this system, the electrical phenomenon (PV) plant and therefore the turbine generator (WTG) area unit connected to a similar purpose of common coupling (PCC) with a sensitive load. The WTG consists of a DFIG generator connected to the network via a transformer. The PV system is connected to the PCC via a two-stage energy conversion (dc–dc device and dc–ac inverter). This topology permits, first, the extraction of most power supported the progressive inductance technique. Second, it permits the association of the PV system to the general public grid through a transformer. additionally, the DVR supported symbolic logic controller is connected to a similar PCC. completely different fault condition situations area unit tested for rising the potency and therefore the quality of the facility offer and compliance with the necessities of the LVRT grid code. The results of the LVRT capability, voltage stability, active power, reactive power, injected current, and dc link voltage, speed of rotary engine, and power issue at the PCC area unit given with and while not the contribution of the DVR system .*

Keyword: *Active power, DC-link voltage DFIG, dynamic voltage restorer, LVRT, power factor, photovoltaic, voltage stability, reactive power.*

INTRODUCTION

Preamble

This renewable energy resources is characterized by factors limiting its use on an oversized scale, particularly intermittence thanks to variations within the uncontrollable primary supply of energy, and therefore the uncertainty of weather forecasts resulting in uncertainty regarding production. This challenge is additional pronounced for wind power as a result of wind speed forecasts ar less reliable than those of the sun irradiance. Another issue limiting the mixing of those energies is that the geographical location of the renewable energy production sites, that is usually situated in remote areas wherever each wind and surface conditions are favorable within the case of wind and alternative energy whereas the transmission systems are comparatively weak that causes new challenges for the management of the voltage and therefore the compensation of reactive power. The random nature of those renewable energy sources will have a bearing on the dynamic behavior of the grid and its stability throughout unforeseen and important variations within the power delivered by one or additional units of high power . Similarly, if a renewable energy powerhouse operative at full power is suddenly disconnected thanks to a fault within the internal grid of the installation, the grid ought to stay stable and therefore the voltage and frequency of the grid should be maintained among their admittible ranges. Another issue that negatively impacts the ability quality comes from the presence of recent power physical science technology because the output interface of power plants. These devices not solely manufacture harmonics within the system, however are terribly sensitive to distorted voltage signals. to beat these constraints and make sure the stability of the electrical installation connected to massive amounts of variable energy resources, the operators of energy systems have resorted to explore multiple technical solutions. The planned solutions have 2 components; one is regulative wherever the technical grid code, directives and conditions dedicated to the mixing of renewable energy sources into the grid needed by the grid operators and therefore the alternative solutions ar technical ones. one among the foremost vital grid code needs is that the Low Voltage Ride Through (LVRT) capability, which implies that the renewable energy conversion system should stay connected throughout grid faults and provide reactive power to support the grid. These needs are applied to wind turbines solely to date, however recently electrical phenomenon generators are needed to satisfy these grid codes. The DVR has the flexibility to attenuate voltage disturbances. it's typically put in between the load and therefore the supply within the distribution system to produce fast support of the voltage by injecting the desired voltage serial with the mains voltage through Associate in Nursing injection electrical device it's accepted that active power recovery and no excessive reactive power absorption ar essential for system security and sufficiently fast active power recovery is crucial for frequency stability within the overall grid whereas massive reactive power absorption might have a negative impact on voltage recovery or maybe drive the system into a neighborhood voltage collapse. This contribution is aimed to demonstrate that the DVR with the planned management theme is in a position to produce these options for the hybrid PV-Wind generators coupled to grid system.

Aim of paper

In this paper simulation study to demonstrate the effectiveness of the DVR to mitigate voltage disturbances, minimize their impact on the stability of the transmission and distribution network, and improve the LVRT capability once the network is connected to a hybrid PV-wind system. A DVR supported mathematical logic management and part compensation technique is intended and evaluated beneath varied fault conditions like short-circuits and voltage sags. Global demand for wattage is growing and increasing. it's fascinating to notice the sharp increase in energy consumption in China since 1973, by an element of eight.4 in 42 years, whereas the world's consumption inflated by a fac- tor of four and therefore the world's population doubled. however, in 2017, over one billion individuals still failed to have access to electricity. the 2 major sectors intense electricity ar the residential-tertiary sector and trade, however, this consumption includes a large impact on the setting thanks to the emission of carbonic acid gas Associate in Nursing consequently the worldwide warming and atmospheric phenomenon has forced many countries to sign an agreement to strengthen international action to take care of the worldwide rise in temperature throughout this century well below a pair of degrees Anders Celsius at the 2015 global climate change conference in Paris. during this context, the energy policy of most countries round the world tends towards the exploitation of renewable energies as clean, out there and cheaper supply of energy so as to achieve high levels of integration about to fifth part by 2020 [1]. However, this resource is characterized by factors limiting its use on an oversized scale, particularly intermittence thanks to variations within the uncontrollable primary supply of energy, and therefore the uncertainty of weather forecasts resulting in uncertainty regarding production [2]. This challenge is additional pronounced for wind power as a result of wind speed forecasts ar less reliable than those of the sun irradiance. Another issue limiting the integration of those energies is that the geographical location of the renewable energy production sites, that is usually situated in remote areas wherever each wind and surface conditions are favorable within the case of wind and alternative energy whereas the transmission systems are comparatively weak that causes new challenges for the management of the voltage and therefore the compensation of reactive power. The random nature of those renewable energy sources will have a bearing on the dynamic behavior of the grid and its stability throughout unforeseen and important variations within the power delivered by one or additional units of high power [2]. Similarly, if a renewable energy powerhouse operative at full power is suddenly disconnected thanks to a fault within the internal grid of the installation, the grid ought to stay stable and therefore the voltage and frequency of the grid should be maintained among their admittible ranges Another issue that negatively impacts the ability quality comes from the presence of recent power physical science technology because the output interface of power plants. These devices not solely manufacture harmonics within the system, however are terribly sensitive to distorted voltage signals. To overcome these constraints and make sure the stability of the electrical installation connected to massive amounts of variable energy resources, the operators of energy systems have resorted to explore multiple technical solutions.

The planned solutions have 2 components; one is regulative wherever the technical grid code, directives and conditions dedicated to the mixing of renewable energy sources into the grid needed by the grid operators and therefore the alternative solutions are technical ones.

One of the foremost vital grid code needs is that the Low Voltage Ride Through (LVRT) capability, which implies that the renewable energy conversion system should stay connected throughout grid faults and provide reactive power to support the grid [5]. These needs are applied to wind turbines solely to date, however recently electrical phenomenon generators are needed to satisfy these grid codes.

The prospects of power generation from hybrid energy systems ar proving to be terribly promising and reliable [6]. Muyeen [7] planned a static synchronous compensator (STATCOM) combined with a little series dynamic braking resistance (SDBR) to boost the soundness of a grid- connected powerhouse composed of a fixed-speed turbine generator system (WTGS). A DFIG and regulator energy storage system was studied in [8] and therefore the planned control theme was designed to make sure that the grid power is isolated from alternative energy output fluctuations.] analyzed a system consisting of a supercapacitor energy storage coupled to the DFIG for a grid integrated aerogenerator DFIG and studied the transient behavior and LVRT capability of the system with and while not energy storage system (ESS).

To enhance the LVRT capability of a grid-integrated DFIG-based powerhouse, a STATCOM and supercapacitor energy storage system are planned in [12]. In [13], a brand-new mechanical device damping resistance unit (SDRU) and rotor current management (RCC) for grid-connected DFIG-based turbine has been studied. alternative devices unremarkably utilized in distribution networks to safeguard crucial masses against voltage disturbances are called D-FACTS and include: D-STATCOM (Static Dispensing Compensator), DVR (Dynamic Voltage Restorer) and UPQC (Unified Power quality conditioner.)

II. PROPOSED SIMULATED SCENAROS AND SYSTEM DESCRIPTION

The choice of photovoltaic energy or wind turbine or both depends on the availability of the renewable resource over time and also is abundance at the site of installation. Currently, solar and wind are the most commonly adopted and most easily exploitable renewable energy sources. Several studies have shown that solar radiation and wind speed distributions often have complementary behavior, and consequently in many cases a hybrid configuration combining photovoltaic and wind generators is adopted [4].

Particularly, PV and wind energy technologies have enhanced their integration in hybrid power system con- figurations. This combination is considered as one of the most efficient configurations which can be used either in grid-connected or standalone modes. Solar and wind energies are complementary in nature [4], [15], [16] and therefore can be utilized to overcome the problem of intermittency and provide a more reliable power with better quality to the electricity grid and remote areas [17], [18].

In recent years, several research studies have been carried out on PV-wind hybrid systems [17]. This study summarizes several research articles in the literature on PV-wind hybrid power system. Among these, a few studies proposed the integration of PV and DFIG-based wind power in a hybrid configuration to supply sustainable power to remote load centers. This configuration has several advantages including simple design, decoupling control of the active and reactive powers, partially rated converters, and maximum wind energy extraction form the turbine [17]. systems, are becoming more popular than conventional PV systems, especially in European markets [20].

The simulation scenarios presented in this paper are carried out as follows:

1. The DVR is disconnected and no fault is applied.
2. The DVR is also disconnected but the fault is applied.
3. Same scenarios as above but with the DVR in operation. The PV farm is subjected to the solar irradiance described in Fig. 3 and the WTG is running with a wind speed of 12 m/s

The proposed topology is illustrated in Fig. 1. It consists of a 500 kW PV plant interconnected to a distribution system via a three phase PWM inverter with a three phase AC throttle filter and a step-up transformer.

The DFIG has a nominal output power of 500 kW and is connected to the grid at the PCC via a step-up transformer and supplying the load. Thus, the estimated total power delivered by the hybrid system is 1 MW.

This is a typical connection of a hybrid PV-WTG however there are other topologies of connections. The comparative study presented in [19] concludes that: (i) In terms of power efficiency, the single stage topology is better, (ii) For the DC link voltage stability and reduced total harmonic distortion in the AC side voltage, the two-stage topology is preferred, (iii) With regard to the maximum power tracking precision, within an acceptable error range of controller oscillation and power losses in the AC-side filter, both topologies can satisfy these requirements.

In [20], transformer-less inverters are employed to enhance the efficiency, reduce the size and lower the cost of the circuit. Because of their high efficiency, transformer-less PV A. PHOTOVOLTAIC PLANT

The PV plant array consists of 16 series modules and 102 parallel strings (type: SunPower SPR-305-WHT).

The PV model used in the paper is based on the two-diode equivalent circuit .

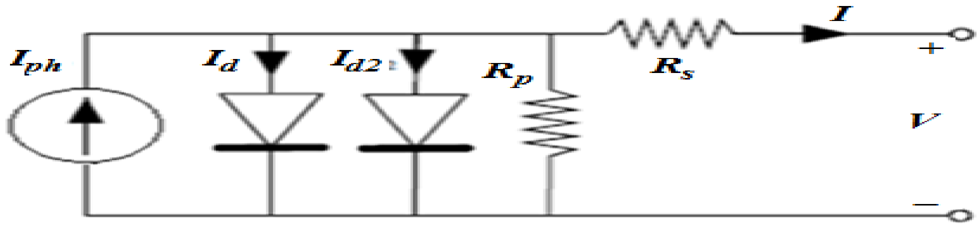

Fig.1 PV cell circuit model

B. MODELING OF THE WIND POWER PLANT

1) AERODYNAMIC MODELING OF THE WIND TURBINE

The kinetic energy from the wind is captured by the wind turbine and converted to mechanical power *Pm* [9], [23]. The wind power plant consists of a single DFIG-based wind tur- bine producing 500 kW with 400 Vac output voltage

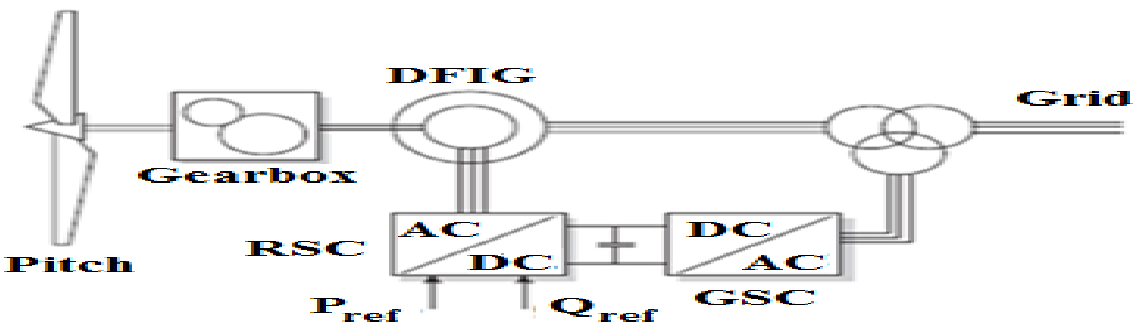

Fig. 2 wind generator

The power Pm captured by the turbine could be a operate of the blade radius, the pitch angle, and therefore the rotor speed.

DOUBLE FED INDUCTION GENERATOR (DFIG) MODELING

AC generators for renewable generation ar classified into mounted and variable speed applications.

Fixed-speed generators ar connected on to the grid like the synchronous generator (Permanent Magnet Synchronous Generator (PMSG)) and induction generator (Squirrel-cage Induction Generator). Variable-speed genera- tors embrace induction generator with variable rotor resistance (Wound Rotor Induction Generator), Doubly Fed Induction Generator (DFIG) and Generator with totally Rated device (FRC) [29].

One of the foremost disadvantages of mounted-speed generators besides their fixed speed vary is that the would like for power issue correction at the terminals of the induction generator.

DVR TOPOLOGY

Flexible AC transmission (FACTS) ar power electronics-based devices that have the power to regulate one or additional parameters to boost the capability and improve the soundness of the transmission. looking on the required compensation, FACTS devices is connected nonparallel, parallel, or a mixture of those configurations as shown in Fig. 17.

FACTS technologies supply new opportunities to regulate power flow and enhance the capability of existing, still as new and upgraded transmission lines [33]. These opportunities arise through the flexibleness of FACTS devices and their ability to produce quick management of the electrical parameters like voltage, current, point, and line impedances [33].

The first dynamic voltage renovator (DVR) was put in in South geographical region in August 1996 in twelve.47 kV substations and was rated at two MVA to safeguard a load of four MVA [34].

The DVR consists of a VSC and its change management, associate degree energy device and a coupling electrical device that during this case, is connected nonparallel with the AC system, as shown in Fig. 18. This controller is fitted to determination varied problems associated with power quality and responsibleness .

• Voltage disturbances like sags and swells

• Voltage unbalances

• Voltage harmonics

• Power issue correction

• Outages.

Basic types of FACTS controllers

The DVR injects a three-phase AC voltage in series and synchronized with the distribution feeder voltage of the AC system. The injected voltage amplitude and phase can be varied to control the bi-directional exchange of active and reactive power between the DVR and AC system

The main role of the DVR is to balance and regulate the voltages and prevent harmonics from the source voltage to reach the load [35].

The basic structure of the DVR consists of:

(1) Injection transformer

(2) Harmonic filter

(3) Energy storage device

(4) VSC

(5) DC charging circuit

(6) Control system.

B. LVRT CAPABILITY

Most interconnection standards lately need renewable energy farms to possess the facility to handle severe disturbances, ordinarily noted as fault ride through (FRT) capability or, in some cases, LVRT typically implies that a generator isn't allowed to disconnect within the case of a short-run voltage dip ensuing from a short-circuit within the grid [1], [14]. LVRT capability altogether probability represents the foremost necessary technical demand and thus the foremost important innovation for turbine generators and PV inverters with regard to system security [30], [44].

A comparative analysis of European Grid Codes and compliance standards for distributed power generation study is applied in [28].

So, the LVRT and HVRT capability are most important for fix operation of an impactfully system with shares of wind and PV generation. while not LVRT capability there would be a high risk that big amounts of wind and PV generation would disconnect if one fault on a significant line were to cause a voltage dip over an outsized space. The lost generation would need to be compelled to be protected by primary, secondary and tertiary management reserves and thus the associated prices would be large Therefore, it's typically accepted lately that LVRT (and HVRT) capability is vital thus on not endanger the protection of an influence system.

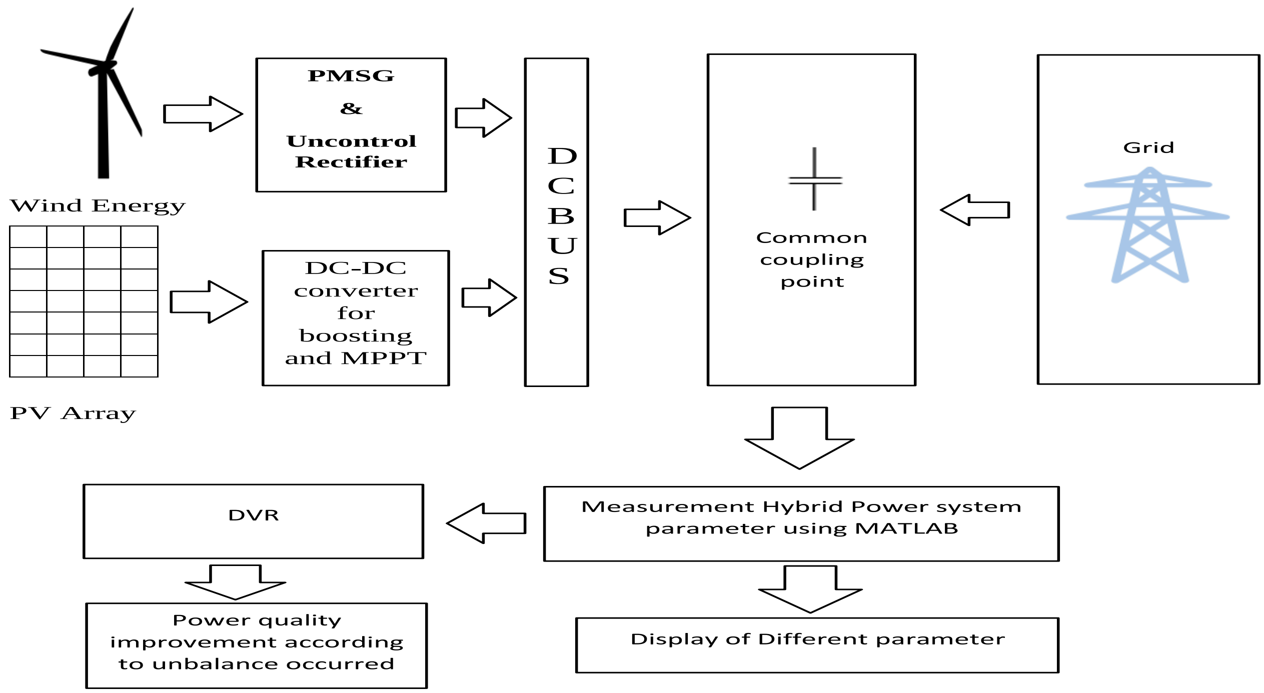

Fig.3 proposed method of project

Objective of proposed method

1. Demonstrate the effectiveness of the proposed DVR control system to improve the power quality and LVRT capability of the hybrid PV-WT power system.

2. Rapid recovery of voltage.

3. The power oscillations overshoot reduction.

4. control of rotor speed and preventing the system from having a DC link overvoltage and thus increasing the stability of the power system in accordance with LVRT requirements

CONCLUSIONS OF PREVIOUS PAPER, PROBABLE IMPLICATION AND FUTURE WORK

The simulation study was disbursed victimization MATLAB to demonstrate the effectiveness of the planned DVR system to boost the facility quality and LVRT capability of the hybrid PV-WT grid. The system has been tested below completely different fault condition situations. The results have shown that the DVR connected to the PV-Wind hybrid system at the medium voltage grid is extremely effective and is ready to mitigate voltage outages and contact failure with improved voltage regulation capabilities and adaptability within the correction of the facility issue.

The results of the simulation additionally prove that the system designed is secure since the specified voltage ranges area unit revered properly and therefore the metric weight unit generators operate dependably. The main advantage of the planned style is that the fast recovery of voltage; the facility oscillations overshoot reduction, management of rotor speed and preventing the system from having a DC link overvoltage and so increasing the steadiness of the facility system in accordance with LVRT needs.

The DVR adjusts the voltage at completely different buses by injecting AN applicable voltage. This voltage transfer is created by the discharge reactor of the coupling electrical device by generating a secondary voltage in section with the first voltage (gate side). throughout traditional operation, the DVR is in standby mode. once the fault happens, the negative feedback circuit detects the disturbance within the provide voltage and so the DVR injects the specified voltage. The contribution of the DVR in helpful the present at the conventional consumed price is reached speedily and swimmingly. The contribution of the DVR in maintaining the injected current at traditional values throughout faults is clearly incontestable.

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