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RESEARCH ARTICLE

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# IMPROVED FREQUENCY AND VOLTAGE REGULATION ON HYBRID WIND-DIESEL MICROGRID SYSTEM

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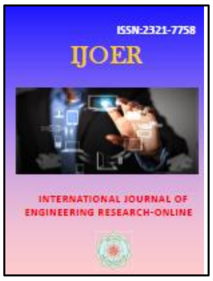


**ABSTRACT**
Frequency regulation is important to the made operation of remote wind–diesel electrical grids. Once the grid is in 'wind--diesel' mode, frequency regulation is (classically) the only duty of the diesel electrical generator (DEG).An alternate approach is planned whereby responsibility for frequency regulation is shared by the DEG and a network of autonomous distributed secondary load (DSLs) consisting of electrical thermal storage (ETS) devices, This permits surplus wind to be distributed to residential customers (as house heat) while not the necessity for a federal communication network. Numerical modeling of system dynamics with active DSLs is conducted employing a SIMULINK wind–diesel hybrid work model. The results of controller gain, put in capability, shift time and unit coordination temporal arrangement on frequency and voltage regulation is explored. It's shown that the DSLs will improve frequency regulation in wind–diesel mode whereas providing storable thermal energy to distributed customers.

Keyword—Diesel driven generators, frequency management, load management, power grid dynamic stability, wind energy



## I. INTRODUCTION

Generation allocation procedures adopted to control the small sources) or injecting power into the most MV grid (when the relation between the small sources put in capability and also the electrical hundreds The association of small generation to Low Voltage (LV) networks is getting down to merit considerable attention from specialists worldwide, encouraging investigations and pilot experiences. during this context, a small Grid (MG) idea has been developed beneath the framework of the small Grids EEC project. A MG will be outlined as a 55 distribution system to that little standard generation systems are connected. Generally, a MG corresponds to associate association of electrical hundreds and tiny generation systems through a 55 distribution network. this implies that hundreds and sources ar physically shut. Considering the presently offered technologies, small generation systems could embody many kinds of devices like fuel-cells, wind turbines or electrical phenomenon (PV) systems still as small turbines victimisation either gas or bio-fuels. Excluding a distribution network, small generators and electrical hundreds, a MG should conjointly embody some reasonably storage devices (such as batteries or flywheels) still as network management and management systems. The storage devices can play a vital role during this reasonably network, primarily in what issues quick load-following things. At this analysis standing, it's assumed that the MG will be operated in main situations:

I. Normal Interconnected Mode – the MG are going to be electrically connected to the most MV network either being equipped by this network (totally or partly, reckoning on the permits this sort of operation)

II.Emergency Mode – just in case there's a failure within the main MV network, the MG should have the power to control in associate isolated mode, that is, to control in associate autonomous means, kind of like the facility systems of physical islands. A simulation platform beneath the MatLab® Simulink® atmosphere was developed so as to gauge the dynamic behavior of many small sources operative along in an exceedingly 55 network beneath pre-specified conditions as well as interconnected and autonomous operation of the MG.

## II. RELATED WORK

Wind turbines are connected and start manufacturing power, current can flow into the grid from each the DEG and also the wind generator(s). The system is in wind-diesel mode. In an exceedingly classical system, the DEG regulates frequency and voltage, however its contribution is reduced. wind power could still increase to some extent at that the DEG becomes scarcely loaded, or perhaps back-driven. This example is to be avoided or the diesel will incur maintenance costs and/or reduced life. 2 choices exist to stop this. If alternative energy approaches current grid demand, either wind generation will be cut mistreatment pitch management, or the extra power will be directed to a secondary load. (It is economically favourable to use this excess energy.) This is often a special case of wind-diesel mode spoken as current of air penetration.

Instantaneous alternative energy exceeds grid demand, it's going to be potential to disconnect the DEG and provide the complete load with wind generation, as with success incontestable. Such a plant is alleged to be capable of wind solely mode, that remains the best level of technical quality among wind-diesel hybrid systems. Betting on this case, voltage management could also be either conducted by the DEG's Automatic transformer (AVR), a synchronous condenser, or some form of power convertor. What is more, frequency management will now not be performed by the DEG. Thus, a switched secondary load and/or energy storage system should be used as an influence sink. Advanced storage technologies, like flywheels and battery banks, need a DC bus and ar outside the scope of this study.

Electric thermal storage (ETS) devices ar another helpful application for excess wind energy. ETS devices use resistive heating parts to charge a ceramic core or hydronic storage mass for consequent regulator discharge. AN array of ETS units placed in households as distributed secondary masses (DSLs) might offer clean, affordable, domestic house heat or quandary whereas enjoying a section in frequency regulation. Such a network of DSLs would need some style of communication or different coordination technique. Units should apprehend once to activate or deactivate supported the requirements of the grid. Either a small grid central controller (MGCC), or a fervent distribution circuit centrally tied to the ability plant, would be required. For remote communities, either answer adds preventative value and/or gratuitous quality.

Intelligent masses are projected for frequency support on giant grids whereby the concept of two-way communication between the load and also the plant is abandoned. Masses instead react on to changes within the grid frequency error. The idea is extended to small grids, although voltage error is employed as AN indicator of load deficit. this work proposes a completely unique idea for coordination of distributed secondary masses in AN islanded weight unit while not the requirement for AN MGCC or dedicated distribution circuit through the employment of frequency-responding ETS devices.

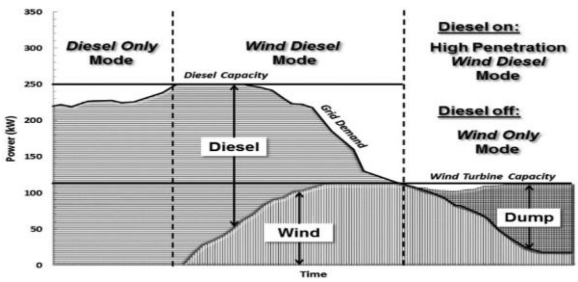


Fig. 1. Typical energy balance for a hybrid wind-diesel system [5].

## III. PROPOSED SYSTEM

At low wind speeds both the induction generator and the diesel-driven synchronous generator are required to feed the load. When the wind power exceeds the load demand, it is possible to shut down the diesel generator. In this all-wind mode, the synchronous machine is used as a synchronous condenser and its excitation system controls the grid voltage at its nominal value. A secondary load bank is used to regulate the system frequency by absorbing the wind power exceeding consumer demand. The Secondary Load block consists of eight sets of three-phase resistors connected in series with GTO thyristor switches. The nominal power of each set follows a binary progression so that the load can be varied from 0 to 446.25 kW by steps of 1.75kW. GTOs are simulated by ideal switches

The proposed system has reported several modes of operations similar to what is presented. Though the MG configuration has been verified with test results, the hybrid system is relatively small and the islanded mode of operation is not covered in the system. Based on the above, in this system relatively large MG, in few MW range, with Wind-Diesel hybrid system has been proposed.

The frequency is controlled by the Discrete Frequency Regulator block. This controller uses a standard three-phase Phase Locked Loop (PLL) system to measure the system frequency. The measured frequency is compared to the reference frequency (60 Hz) to obtain the frequency error. This error is integrated to obtain the phase error. The phase error is then used by a Proportional-Differential (PD) controller to produce an output signal representing the required secondary load power. This signal is converted to an 8-bit digital signal controlling switching of the eight three-phase secondary loads. In order to minimize voltage disturbances, switching is performed at zero crossing of voltage.

A complex structure must be developed in order to assure a robust MG operation. The Micro Grid Central Controller is in charge of such MG operation control. MG operation is based on a control scheme that exploits different inverter control modes.

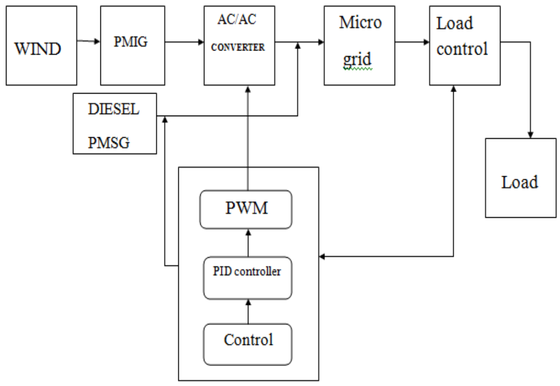


Fig.3.1 Block Diagram

## IV. CONTROL STRATEGIES

The main control strategy considered involves the passage to islanded operation mode of the MG in case of a fault in the MV network or in other exceptional cases. Contrary to the classic belief that islanded operation must be avoided at all costs, a new strategy is being developed that includes planned operation under these conditions. The islanding procedure is then controlled and made intentionally, corresponding to careful planning about operational conditions concerning not only load levels and levels of the distributed resources but also different types of defaults, etc. The control of the MG is a delicate issue. A complex structure must be developed in order to assure a robust MG operation. The Micro Grid Central Controller is in charge of such MG operation control. MG operation is based on a control scheme that exploits different inverter control modes. This scheme requires frequency and voltage references that can be provided by a small diesel engine or by a Voltage Source Inverter (VSI). In this case one VSI connected to a flywheel device is used and the other inverters present act likes current sources following the reference from the VSI or from the MV side, if available.MG Control and MGCC Structure -The MGCC includes a multiplicity of functionalities one of which is secondary load-frequency control. This functionality is similar to the one of a conventional Automatic Generation Control (AGC) system. The MGCC coordinates a hierarchical control scheme, where the control infrastructure.

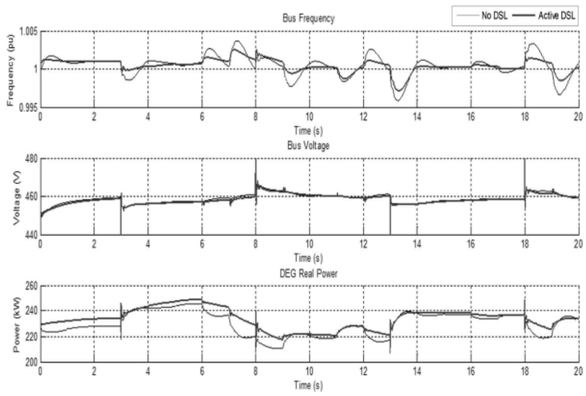


Fig. 4.1 Time series *f*, *V* , and *PDEG* without and with an active DSL. Perturbations include variable wind and a 20 kW load, switched every 5 sec.

**DIESEL GENERATOR SET**

The modelling of the diesel generator set is the first step of the micro grid modelling. The purpose of this section is to introduce the diesel generator set and describe the modelling of each of its components. The diesel generator set has to be controlled to maintain the frequency and voltage of the system while the micro grid is running in islanded mode. In this mode, it is also the only reactive power supplying component, as the wind turbine, modelled with a squirrel-cage induction generator, always consumes reactive power.

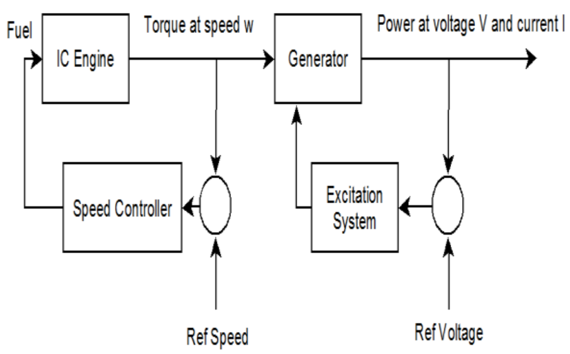


**Figure 4.2** Principal components and controls of a diesel generator set

**WIND TURBINE**

The electrical generator converts mechanical power into electrical power. Different kinds of generator may be used for wind turbines. Some small turbines use DC generators, but the most common types are synchronous and induction generators.

Induction generators have usually a simple construction, and relatively cheaper. They also simplify the connection and disconnection from the grid. Different types of induction generators are used, such as a cage rotor type, a wound rotor with variable rotor resistance type, or a doubly fed slip ring type. However, when induction generators are used in small or isolated electrical networks, special measures must be taken in order to supply reactive power or maintain the voltage stability.

**Operating scheme**

Wind turbines with induction generators may operate at a nearly constant rotor speed or at variable speed. In both cases, below rated wind speed, the goal is to maximize the energy production, while power has to be limited above rated speed. However, variable speed turbines require the use of power electronics, which increases the cost, and may introduce harmonics in the system.

**V. SIMULATION RESULTS**

The network with two generator technologies of Wind-Diesel is shown in Figure 1 was modelled in MATLAB/SIMULINK environment. The simulations are carried out to check the operation of the system with proposed controllers.

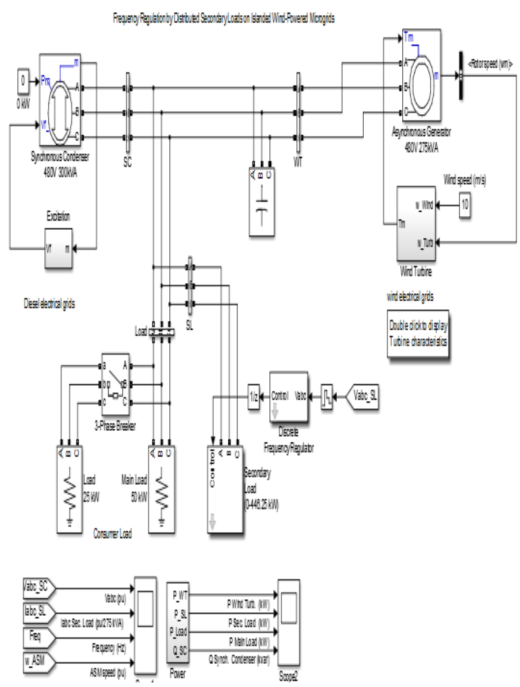

Figure 4.3 Simulation waveform for wind-diesel

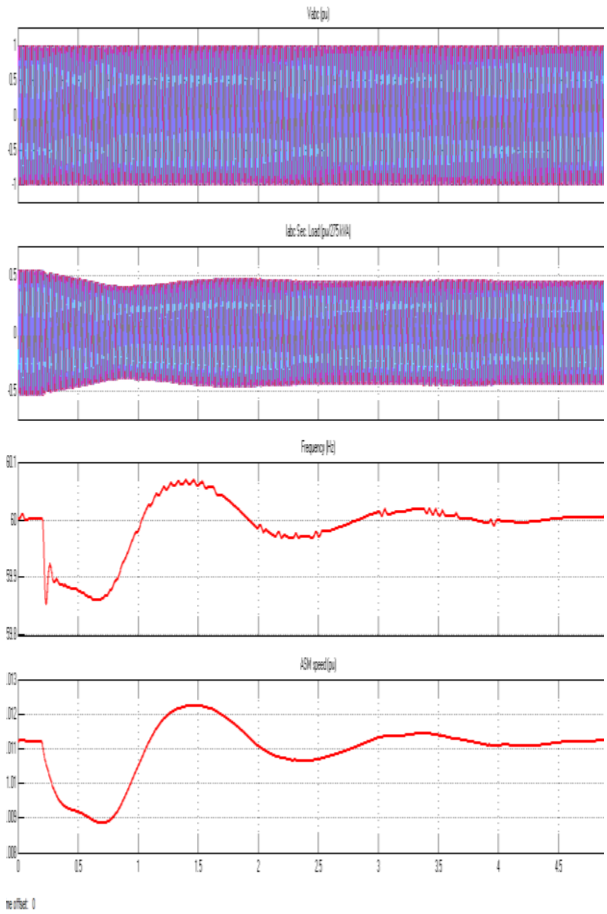

Fig.4.5 Simulation output waveform

## VI. CONCLUSION AND FUTURE WORK

As a goal of the present work is to increase the value of secondary loads on islanded wind-powered microgrids, future work must demonstrate the ability for a network of DSLs to function as a sole frequency regulator in high penetration *wind diesel* mode. Moreover, a smooth transfer of frequency control responsibility from the DEG to the DSLs must be confirmed. Thus, it may be necessary to improve the frequency sensing controller topology and load switching technology of the ETS units. Changes to the design, such as varying the impedance of the elements to a binary scheme would allow for more load resolution.

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