

# LOAD LEVELLING OF DIESEL GENERATOR SET USING BATTERY ENERGY STORAGE SYSTEM

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**Abstract** - The proposed system comprises a wound field synchronous generator driven by diesel engine run at a similar speed. A pulse width modulated voltage source converter is used to supply the reactive power request of the load. Direct current link of voltage source converter has a battery for doing the load leveling. The system is designed in such a manner that battery supplies the real power to the load during over load stages and stocks the energy during light loads so that current drawn from generator is always optimal from 80 % to 100% of its rated capacity of the generator. The load leveling contributions in minimization of fuel efficiency of diesel engine. In addition the use of pulse width modulation-voltage source converter helps in harmonics elimination and load balancing. A control algorithm based on composite state observer has been used in the proposed diesel generator set System to generate the gating pulses of pulse width modulation-voltage source converter.

**Key words:** Battery energy storage system, Diesel Generator set, Synchronous Generator, Unity power factor, etc.

## 1. INTRODUCTION

The wound field synchronous generator based diesel generator sets are important supply systems for spread and insulated generating systems. The operating principle of synchronous generator based diesel generator set is based on fixed speed operation for separate supply system. Excitation control of the generator regulates the system voltage. The frequency the system is controlled by variable the fuel injection of the diesel engine. The use of diesel generator set in concurrence with energy conversion systems based on wind energy to improve consistency of power supply of these systems have been proposed by many investigators. Most of research work on separately excited synchronous generator based diesel generator set focused on voltage and frequency control. Efforts on UPF operation and load leveling along with development other parameters of power quality of a individually excited synchronous generator based diesel generator sets.

In the proposed system the UPF operation and load leveling of the diesel generator are achieved with the help of a pulse width modulation-VSC having a battery on direct current link. The pulse width modulation-VSC is connected at a terminal called point of common coupling between generator and load. The PWM-VSC behaves as a static compensator. The static compensator supplies entire of reactive power of the load so that only real power demand is

drawn from the generator. Thus the generator operates at the unity power factor. The unity power factor operation of the generator helps in operation of full rated capacity of the generator and removes de-rating. The load leveling is attained by justifying the load fluctuation with the help of pulse width modulation-VSC by replacing the energy with battery energy storage system. The system is designed in such a manner that the generator supplies the current between 80% and 100% of its rated value irrespective of the actual load connected on the diesel generator set. When load current is less than 80% of rated current of the diesel generator set, the draws the surplus power and stores in battery on its direct current link in the form of energy. When connected load is more than generator rating the battery bank supplies the energy to meet additional load request. When load is from 80% to 100% of rated capacity of diesel generator set whole of the load current is supplied by generator. Thus, the battery bank supplies the real power to the load through over load periods and stores the energy during light loads. So, load on diesel generator set remainders between 80 % and 100% of rating of generator. This idea of load leveling also helps in minimization of fuel efficiency of the diesel engine. In addition, the use of pulse width modulation-VSC helps in harmonics removal and load balancing. A number of control algorithms have been reported in literature for generation of orientation source signals. A control algorithm based on a state spectator has been used in the proposed diesel generator system in instruction to generate the gating pulses of pulse width modulation-VSC. The observer based control procedure generates reference source current by removing important harmonic from load current.

## 2. Block Diagram

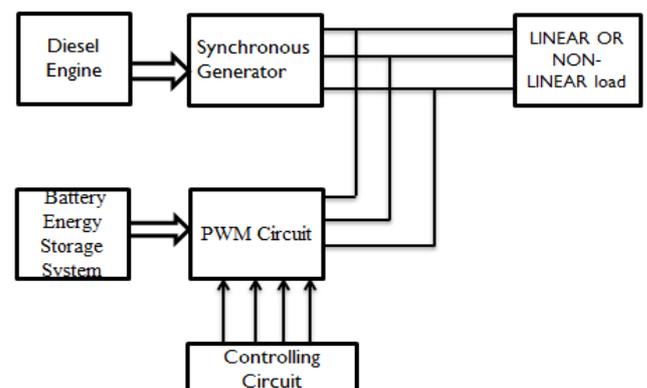


Fig.1. Block Diagram for Load Leveling Diesel Generator Set

In this paper system load leveling of the diesel generator are reached with the help of a pulse width modulation-VSC having a battery on direct current link. The pulse width modulation-VSC is connected at a terminal called point of common coupling between generator and load. The PWM-VSC behaves as a static compensator. The static compensator supplies complete of reactive power of the load so that only actual power request is drawn from the generator. Thus the generator operates at the unity power factor. The unity power factor operation of the generator helps in utilization of full rated capacity of the generator and removes de-rating. The load leveling is achieved by modifying the load fluctuation with the help of pulse width modulation-VSC by replacing the energy with battery energy storage system. The system is designed in such a method that the generator supplies the current between 80% and 100% of its rated value regardless of the actual load connected on the diesel generator set. When load current is less than 80% of rated current of the diesel generator set, the draws the extra power and stores in battery on its direct current link in the form of energy. When connected load is more than generator rating the battery bank supplies the energy to meet additional load demand. When load is from 80% to 100% of rated capacity of diesel generator set complete of the load current is supplied by generator. Thus, the battery bank supplies the real power to the load during over load periods and stores the energy during light loads. So, load on diesel generator set remains between 80 % and 100% of rating of generator. This concept of load leveling also reliefs in minimization of fuel efficiency of the diesel engine.

### 3. Concept of Block Diagram

#### 3.1 Synchronous Generators:

The major benefit of synchronous generator is that its reactive power characteristic can be controlled and therefore such machines can be used to supply reactive power to other items of power systems, which require the reactive power. It is normal for a stand-alone wind-diesel system to have a synchronous generator, usually connected to the diesel. Synchronous generators when fitted to a wind turbine must be controlled carefully to prevent the rotor speed accelerating through synchronous speed especially during turbulent winds. Moreover it requires flexible coupling in the drive train, or to mount the gearbox assembly on springs or dampers to absorb turbulence. Synchronous generators are more costly than induction generators, particularly in smaller size ranges. Synchronous generators are more prone to failures.

#### 3.2 Diesel Engine:

The proposed system comprises a wound field synchronous generator driven by diesel engine run at a constant speed. A diesel compression-ignition engine is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas.

#### 3.3 Load Leveling:

Load leveling is a load distribution method which lies between the two extremes of load balancing and load sharing. Instead of trying to get a strictly even distribution of load across all the nodes, or simply making use of the idle nodes, load leveling tries to avoid congestion on any one host. This term is most of the time used interchangeably with load balancing. In practical situation it is difficult to distinguish between load leveling and load balancing schemes.

#### 3.4 Lead-Acid Battery:

Lead acid batteries are slightly financial but they have substantial space and care necessities. They also have a shorter life, which decreases rapidly if battery is quit lower 30%. This results in the reduction of energy density amounting to increased capital costs. They are commonly installed in uninterruptible power supply systems as well as in renewable and distributed power systems. They have several key limits, they require relatively frequent maintenance to replace water lost in operation, they are relatively expensive compared to conventional options with limited reduction in cost expected, and because of their usage of lead, they are weighty, reducing their portability and increasing construction costs. The strengths of flooded lead-acid batteries center on their relatively long life span, durability, and the commercial availability of the technology.

### 3. CONCLUSION

This paper of the proposed diesel generator set is tested with non-linear and linear loads under various loading conditions. Here, it has been assumed during conversation that load is of pulsating nature and battery is originally charged to some optimal level. The diesel generator set is not put on overload continuously to escape deep discharge of batteries.

In this paper diesel generator set was intentional under various loading conditions and its presentation is observed to be suitable. The control process maintained generator optimally loaded from 80 % to 100% of rated capacity of the generator regardless of the load connected on the terminals of the generator. The source power factor remains unity under various loads. The battery energy storage system is effectively utilized by voltage source converter for load leveling of diesel generator set. Thus, unity power factor operation and load leveling of wound field synchronous generator are achieved successfully with the help of pulse width modulation-voltage source converter and a battery energy storage system.

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