

POWER QUALITY IMPROVEMENTS IN DIESEL GENERATOR SET BASED SUPPLY SYSTEMS

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**DEPARTMENT OF ELECTRICAL ENGINEERING
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**POWER QUALITY IMPROVEMENTS IN DIESEL
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By

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Electrical Engineering Department

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CERTIFICATE

It is certified that the thesis entitled “**Power Quality Improvements in Diesel Generator Set Based Supply Systems,**” being submitted by **Mr. Ram Niwas** for award of the degree of **Doctor of Philosophy** in the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of the students own work carried out by him under my supervision and guidance. The matter embodied in this thesis has not been submitted for award of any other degree or diploma.

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ABSTRACT

Diesel Generator (DG) set based standalone supply systems are source of electricity in many parts of world. DG sets are backbone of supply in trains, hospitals, institutes, telecommunication towers etc. Because of huge demand of electricity for air-conditioning, lighting, toiletries, pantry demands in trains, the railways has been one of the big consumer of DG set based supply systems. Moreover, nowadays many of such loads use power converters and some of them are single-phase loads. Such loads draw harmonics currents, negative and zero sequence currents and they result in the voltage distortion, increased losses, increased fuel consumption and derating of DG sets. Therefore, this work focuses on the power quality improvement of DG set based standalone supply systems.

The most commonly used machine in DG sets is wound rotor type conventional synchronous generator. This generator requires separate excitation system so the system requires reasonable maintenance. In addition, there are copper losses in their rotor so the efficiency is also low. Therefore, detailed investigations are made to improve the performance of these DG sets with different types of generators such as wound field synchronous generator (SG), self excited induction generator (SEIG), permanent magnet synchronous generator (PMSG) and synchronous reluctance generator (SyRG).

The performance of these generators is investigated for various configurations of loads such as single phase two wire (1P2W), three phase three wire (3P3W) and three phase four wire (3P4W). The frequency of the supply is controlled by the speed regulation of a diesel engine through governor mechanism and load leveling. However, the voltage is controlled using either AVR (Automatic Voltage Regulator) and/or a static compensator (STATCOM). The STATCOM has been used to control the terminal voltage, harmonics elimination, reactive

power compensation, power factor correction and load balancing. A battery energy storage system (BESS) is also used in 3P3W configuration to improve fuel efficiency of the diesel engine. The battery on DC link of VSC (Voltage Source Converter) of STATCOM is used to supply the active power to loads during heavy loads more than rating of the generator and it stores the energy during light load periods so that DG set is always loaded with an optimum load of 80% to 100% of the generator rating. An optimum loading of DG set helps in improving the fuel efficiency of the diesel engine. BESS also mitigates the fluctuations in real power demand of loads. The use of battery energy storage system helps in better voltage and frequency regulation of the system. The performance of the DG systems is tested under steady state and dynamic conditions for linear and nonlinear loads. The dynamic load is realized by online starting of a three phase induction motor.

The reference source currents are generated using different control algorithms to investigate the performance of DG set based on different generators. The performance of wound field synchronous generator based DG set is investigated using decoupled Adaline, FXLMS, composite observer and adaptive notch filter (ANF) based control algorithms. The performance of self excited induction generator based DG set is investigated using hyper-tangent function based LMS algorithm, improved linear sinusoid tracer (ILST), instantaneous synchronous component theory (ISCT) and decoupled Adaline based control algorithms. The performance of permanent magnet synchronous generator (PMSG) based DG set is investigated using improved linear sinusoid tracer (ILST), Adaline, hyper-tangent function based LMS algorithm and adaptive notch filter (ANF) based control algorithms. The performance of synchronous reluctance generator (SyRG) based DG set is investigated using synchronous reference frame (SRF) theory, power balance theory (PBT), instantaneous synchronous component theory (ISCT) and composite observer based control algorithms.

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