POWER QUALITY IMPROVEMENTS IN DIESEL GENERATOR SET BASED SUPPLY SYSTEMS

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INDIAN INSTITUTE OF TECHNOLOGY DELHI

MARCH 2015

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By

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Thesis Submitted
in fulfillment of the requirements of the degree of
DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

MARCH 2015

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.

Dated: 20.03.2015

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ACKNOWLEDGEMENTS

I express my deep gratitude and indebtedness to Prof. Bhim Singh for giving me an opportunity to carry out the Ph.D. work under his supervision. His keenness and vision have played a significant role in guiding me throughout this study. He has been actively involved in nurturing this work. Determination, dedication, innovativeness, resourcefulness and discipline of Prof. Bhim Singh were inspiration for me to complete this work. His consistent encouragement, continuous monitoring and commitments for excellence have always motivated me to improve my work and use best of my capabilities. It is a life time experience to work under the supervision of Prof. Bhim Singh, which I admire always.

I am thankful to Prof. T.S. Bhatti, Prof. G. Bhuvaneswari, and Dr. B. K. Panigrahi, all SRC members for their valuable guidance and consistent support during my research work. I wish to convey my sincere thanks to Prof. Bhim Singh, Prof. G. Bhuvaneswari, Prof. M. Veerachary and Prof. Sukumar Mishra for their valuable inputs during my course work which helped me to enrich my knowledge. I am grateful to IIT Delhi for providing me the research facilities. I would like to convey my sincere gratitude to Prof. K. R. Rajagopal, Prof. in-charge PG Machine Lab. for providing me immense facilities to carry out experimental work. Thanks are due to Sh. Srichand, Sh. Puran Singh, Sh. Jagbir Singh, Shri Gurcharan Singh, Sh. Tarachand of PG Machines Lab. , Power Electronics Lab and Power System Lab., IIT Delhi for providing me the facilities and assistance during this work. I am grateful to the staffs of PG section, Central library, Electrical Engineering Department, IIT Delhi for their valuable co-operation.

I must thank Shri V.K. Dutt, Ex. AML, Indian Railways for giving me opportunity to pursue my research at IIT, Delhi. I must be thankful to CEE/NR, Sh. Sunil Goyal, for appreciating

my research work. I am grateful to Sh. Ghanshyam Singh, CEE/Construction for his guidance and consistent support during my whole research work. I am thankful to Sh. A. K. Kapoor**,** CEE/WCR for his consistent motivation in completion of my study. I must be thankful to Sh. R.K. Atoliya, CEDE/NR, Sh. R.N. Rajput, CEGE /NR, Sh. Randhawa Suhag, CETE/NR, Sh. R.K. Saxena, CELE/NR for their unconditional support in completion of my research work. I cannot forget the support of my senior officers Sh. Mahendra Kumar, Sh. J.R. Meena, Sh. V.K. Singh, Sh. S.K. Dubey, Sh. Y.P. Malik, Sh. Ashish Srivastava, Sh. Aseem Kumar , Sh. Man Singh Meena and Sh. Deepak Grewal. I am grateful to my friends Neeraj Gupta, Vikas Tripathi, Omprakash, Prem Lochab, Rajendra Choudhary, Anurag Aggarwal and Vinod Choudhary for their moral support.

I would like to extend my sincere thanks to Dr. Sanjeev Singh, Dr. Sabhraj Arya, Dr. Ashish Srivastava, Dr. V. Rajagopal, Prof. D. K. Jain who have supported me during initial start-up of my research work. I also would like to thanks Mr. Vashist Bist, Mr. M. Rajesh, Mr. N.K.S. Naidu, Mr. M. Sandeep, Mr. Arun Verma, Mr. Chinmay Jain, Ms. Priya Nayar, Mr. Sunil Kumar Dube, Mr. Krishan Kant Bhalla, Mr. Sagar Goel, Mr. Ikhlaq Hussain, and Mr. Rajan Kumar for their valuable assistance and co-operation. A special thanks to Dr. Shailendra Sharma and family for their unconditional support and sound advices during my course work. I will remain unacknowledged if I don't mention Manoj Kumar Sinha and family for their support and motivations during my study. I am also grateful to those who have directly or indirectly helped me to complete my research work.

My deepest love and appreciation go to my wife Manju Rani and my daughters Lochan and Swasti for their sacrifices and wholehearted supports during this period. My indebtedness goes to my parents Sh. Lal Singh and Smt. Bhani Devi for their faith and belief in my

capabilities that always actuated me to achieve higher academic levels. My in-laws Mr. Balbir Singh and Mrs. Sushila Devi were always inspirational to me. All of my family members and relatives were helping and supportive during my research work.

At last, I am beholden to almighty for their blessings to help me to raise my academic level to this stage. I pray for their benediction in my future endeavors. May their blessings be showered on me for strength, wisdom and determination to achieve in future also.

Date : 20.03.2015 Ram Niwas

Place : New Delhi (2008EEZ8333)

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-tangenet 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-tangenet 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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