

CHAPTER- 9

HYDRO GENERATOR, CHARACTERISTICS AND PERFORMANCE

9.1 GENERAL

The electric generator converts the mechanical energy of the turbine into electrical energy. The two major components of the generator are the rotor and the stator. The rotor is the rotating assembly to which the mechanical torque of the turbine shaft is applied. By magnetizing or "exciting" the rotor, a voltage is induced in the stationary component, the stator. The principal control mechanism of the generator is the exciter-regulator which sets and stabilizes the output voltage. The speed of the generator is determined by the turbine selection, except when geared with a speed increaser. In general, for a fixed value of power, a decrease in speed will increase the physical size and cost of the generator.

The location and orientation of the generator is influenced by factors such as turbine type and turbine orientation. For example, the generator for a bulb type turbine is located within the bulb itself. A horizontal generator is usually required for small turbine e.g. tuba turbine and a vertical shaft generator with a thrust bearing is appropriate for vertical turbine installations.

Conventional cooling on a generator is accomplished by passing air through the stator and rotor coils. Fan blades on the rotating rotor assist in the air flow. For larger generator (above 5 MVA capacity) and depending on the temperature rise limitations of the winding insulation of the machine, the cooling is assisted by passing air through surface air coolers, which have circulated water as the cooling medium.

Large Generators interconnected with the grid should meet grid standards issued by Central Electricity Authority (CEA) (relevant extracts are enclosed as annexure-1).

9.2 Hydro Generators Early Design

9.2.1 Large Hydro

Large salient pole hydro generators specified for installation up to 1970 were constrained by following considerations.

Insulation Systems for Stator and Rotor was Class B insulation with organic binding material which permitted lower temperature rises.

Material for rotor rim punching etc. required limiting the diameter of the rotor so as to permit operation at runaway speed.

Bearing arrangements: Top thrust and guide bearing supported on heavy brackets, capable of supporting total generator weight was provided with a bottom guide bearing to all hydro generators including slow speed large generator which constitutes majority of large hydro generators. This resulted in high cost of machine and building.

Shaft mounted excitation systems were slow and unable to meet the requirements of quick response required from large generators feeding large modern grid systems.

Stability requirements for long distance transmission lines required to feed distant load centre/grids was achieved by manipulating reactances, excitation response ratio and Dywheel effect. This resulted in larger size of the machine.

Grids were small and there was no stringent requirement for voltage and frequency variation.

Typical section arrangement for Bhakra Left bank machines (100 MVA; 166.7 RPM) with top thrust and guide bearing and bottom guide bearing is shown in figure 9.1 and the capability curve is shown in figure 9.2.

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The Electric Generators Handbook - 2 Volume Set Ion Boldea,2005-11-16 The modern world hungers for electricity Traditionally this hunger was sated with predominantly constant speed regulated synchronous generators However new demands require the stable quick and efficient delivery and control offered by variable speed generators Surveying all of the technologies used to satisfy the world s demand for o Electric Generators Handbook - Two Volume Set Ion Boldea,2018-10-08 Electric Generators Handbook Second Edition Two Volume Set supplies state of the art tools necessary to design validate and deploy the right power generation technologies to fulfill tomorrow s complex energy needs The first volume Synchronous Generators explores large and medium power synchronous generator topologies steady state modeling transients control design and testing Numerous case studies worked out examples sample results and illustrations highlight the concepts Fully revised and updated to reflect the last decade s worth of progress in the field the Second Edition adds coverage of high power wind generators with fewer or no PMs PM assisted DC excited salient pole synchronous generators autonomous synchronous generators control line switching parameter identification for isolated grids synthetic back to back load testing with inverter supply and more The second volume Variable Speed Generators provides extensive coverage of variable speed generators in distributed generation and renewable energy applications around the world Numerous design and control examples illustrate the exposition Fully revised and updated to reflect the last decade s worth of progress in the field the Second Edition adds material on doubly fed induction generator control under unbalanced voltage sags and nonlinear loads interior permanent magnet claw pole alternator systems high power factor Vernier PM generators PM assisted reluctance synchronous motors generators for electric hybrid vehicles and more *Small Scale Power Generation Handbook* Umberto Desideri,Lorenzo Ferrari,2024-11-11 Provides an overview of various small scale sustainable energy technologies with examples and a clear focus on technological and research issues Beginning with an overview of the special characteristics challenges and opportunities of small scale power plants this book goes on to provide detailed assessments of a wide variety of renewable energy generation technologies Solar biomass hydroelectric and geothermal energy generation are all addressed with assessment of their performance availability reliability unique requirements for operation maintenance control and grid integration Combining technological advances with consideration of economic and application challenges the Small Scale Power Generation Handbook is an essential resource for graduate students academic researchers and industry professionals involved in the design and integration of small scale power generation for sustainable systems Examines a range of cutting edge renewable small scale generation systems from photovoltaic to hydropower and bioenergy Assesses the specific advantages and disadvantages of operation maintenance integration and control alongside conventional grid Applies technological insights to practical scenarios case studies and applications supporting real world improvements in sustainability and transition Variable Speed Generators Ion Boldea,2015-09-03 Variable Speed Generators the second

of two volumes in the Electric Generators Handbook provides extensive coverage of variable speed generators in distributed generation and renewable energy applications around the world. The book delves into the steady state transients control and design of claw pole rotor synchronous induction permanent magnet PM assisted synchronous and switched reluctance starter alternators for electric hybrid vehicles. It discusses PM synchronous transverse flux PM and flux reversal PM generators for low speed wind and hydro energy conversion. It also explores linear motion alternators for residential and spacecraft applications. Numerous design and control examples illustrate the exposition. Fully revised and updated to reflect the last decade's worth of progress in the field, this Second Edition adds new sections that address the ride through control of doubly fed induction generators under unbalanced voltage sags. Consider the control of stand alone doubly fed induction generators under unbalanced nonlinear loads. Detail a stand alone squirrel cage induction generator SCIG with AC output and a low rating pulse width modulated PWM converter. Present a twin stator winding SCIG with 50 percent rating inverter and diode rectifier and a dual stator winding induction generator with nested cage rotor. Examine interior permanent magnet claw pole alternator systems for more vehicle braking energy recuperation and high power factor Vernier PM generators. Depict a PM assisted reluctance synchronous motor generator for an electric hybrid vehicle and a double stator switched reluctance generator with segmented rotor. Describe the grid to stand alone transition motion sensorless dual inverter control of permanent magnet synchronous generators with asymmetrical grid voltage sags and harmonics filtering. The promise of renewable sustainable energy rests on our ability to design innovative power systems that are able to harness energy from a variety of sources. Variable Speed Generators Second Edition supplies state of the art tools necessary to design, validate and deploy the right power generation technologies to fulfill tomorrow's complex energy needs.

Synchronous Generators Ion Boldea, 2015-09-03. Synchronous Generators, the first of two volumes in the Electric Generators Handbook, offers a thorough introduction to electrical energy and electricity generation, including the basic principles of electric generators. The book devotes a chapter to the most representative prime mover models for transients used in active control of various generators. Then individual chapters explore large and medium power synchronous generator topologies, steady state modeling, transients control, design and testing. Numerous case studies, worked out examples, sample results and illustrations highlight the concepts. Fully revised and updated to reflect the last decade's worth of progress in the field, this Second Edition adds new sections that discuss high power wind generators with fewer or no permanent magnets (PMs). Cover PM assisted DC excited salient pole synchronous generators. Present multiphase synchronous machine inductances via the winding function method. Consider the control of autonomous synchronous generators. Examine additional optimization design issues. Illustrate the optimal design of a large wind generator by the Hooke Jeeves method. Detail the magnetic equivalent circuit population based optimal design of synchronous generators. Address online identification of synchronous generator parameters. Explain the small signal injection online technique. Explore line switching on or off parameter identification for isolated grids.

Describe synthetic back to back load testing with inverter supply The promise of renewable sustainable energy rests on our ability to design innovative power systems that are able to harness energy from a variety of sources Synchronous Generators Second Edition supplies state of the art tools necessary to design validate and deploy the right power generation technologies to fulfill tomorrow s complex energy needs *Design Optimization of Renewable Energy Systems Using Advanced Optimization Algorithms* Venkata Rao Ravipudi,Hameer Singh Keesari,2022-03-01 This book describes applications of Jaya and Rao algorithms on real case studies concerning different renewable energy sources In the last few decades researchers have focused on renewable energy resources like solar energy bio energy wave energy ocean thermal energy tidal energy geothermal energy and wind energy This has resulted in the development of new techniques and tools that could harvest energy from renewable energy sources Many researchers and scientists have focused on developing and optimizing the energy systems to extract and utilize renewable energy more efficiently In this book recently developed Jaya and Rao Rao 1 Rao 2 and Rao 3 algorithms are introduced for single and multi objective optimization of selected renewable energy systems The results of applications of the different versions of Jaya and Rao algorithms are compared with the other optimization techniques like GA NSGA II PSO MOPSO ABC etc and the performance of the Jaya and Rao algorithms is highlighted compared to other optimization algorithms in the case of renewable energy systems The book also includes the validation of different versions of the Jaya and Rao algorithms through the application to complex single and multi objective unconstrained benchmark functions The algorithms and computer codes of different version of Jaya and Rao algorithms are included in the book that will be very much useful to readers in industry and academic research **The Journal of Energy and Development** ,2004 **Sci-tech Book Profiles** ,1965 Includes title page table of contents list of contributors preface and all indexes of each book **Direct Energy Conversion** Stanley W. Angrist,1982 Modeling and Analysis of Reservoir System Operations Ralph Allen Wurbs,1996 Electrical Engineer's Reference Book Gordon Rees Jones,1993 The Electrical Engineer s Reference Book 15th edition long established as an ideal reference has been revised and includes complete rearrangement to take in chapters on new topics and regroup the subjects covered for easy access to information Government Reports Index ,1975 **Energy Research Abstracts** ,1983 Semiannual with semiannual and annual indexes References to all scientific and technical literature coming from DOE its laboratories energy centers and contractors Includes all works deriving from DOE other related government sponsored information and foreign nonnuclear information Arranged under 39 categories e g Biomedical sciences basic studies Biomedical sciences applied studies Health and safety and Fusion energy Entry gives bibliographical information and abstract Corporate author subject report number indexes *Energy Abstracts for Policy Analysis* ,1983 **Municipal Index** ,1918 *Hydro Power* Joachim Raabe,1985 Power ,1920 **An Introduction to the Study of Electrical Engineering** Henry Hutchison Norris,1908 **The Journal of the Engineering Institute of Canada** Engineering Institute of Canada,1919 Electrical Engineer of Australia & New

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