

## 48550 Electrical Energy Technology

### Chapter 6.

## Synchronous Machines

#### Topics to cover:

- 1) *Introduction*
- 2) *Synchronous machine structures*
- 3) *Rotating magnetic field*
- 4) *Equivalent circuit model*
- 5) *Performance as a generator*
- 6) *Performance as a motor*

#### Introduction

A synchronous machine is an ac rotating machine whose speed under steady state condition is proportional to the frequency of the current in its armature. The magnetic field created by the armature currents rotates at the same speed as that created by the field current on the rotor, which is rotating at the synchronous speed, and a steady torque results.

Synchronous machines are commonly used as generators especially for large power systems, such as turbine generators and hydroelectric generators in the grid power supply. Because the rotor speed is proportional to the frequency of excitation, synchronous motors can be used in situations where constant speed drive is required. Since the reactive power generated by a synchronous machine can be adjusted by controlling the magnitude of the rotor field current, unloaded synchronous machines are also often installed in power systems solely for power factor correction or for control of reactive kVA flow. Such machines, known as *synchronous condensers*, may be more economical in the large sizes than static capacitors.

With power electronic variable voltage variable frequency (VVVF) power supplies, synchronous motors, especially those with permanent magnet rotors, are widely used for variable speed drives. If the stator excitation of a permanent magnet motor is controlled by its rotor position such that the stator field is always  $90^\circ$  (electrical) ahead of the rotor, the motor performance can be very close to the conventional brushed dc motors, which is very much favored for variable speed drives. The rotor position can be either detected by using rotor position sensors or deduced from the induced *emf* in the stator windings. Since this type of motors do not need brushes, they are known as brushless dc motors.

# Chapter 6 Synchronous Machines Uts

**William Fred Schaller**



## Chapter 6 Synchronous Machines Uts:

**Southern Power and Industry**, 1951      *Synchronous Machines* Mulukutla S. Sarma, 1979      **Synchronous Machines** Charles Concordia, 1951      Elementary Theory of Synchronous Machines John Myron Bryant, Elmer Walter Johnson, 1934      **Analysis of Synchronous Machines** T. A. Lipo, 2008      **Analysis of Synchronous Machines, Second Edition** T.A. Lipo, 2012-06-25

Analysis of Synchronous Machines Second Edition is a thoroughly modern treatment of an old subject Courses generally teach about synchronous machines by introducing the steady state per phase equivalent circuit without a clear thorough presentation of the source of this circuit representation which is a crucial aspect Taking a different approach this book provides a deeper understanding of complex electromechanical drives Focusing on the terminal rather than on the internal characteristics of machines the book begins with the general concept of winding functions describing the placement of any practical winding in the slots of the machine This representation enables readers to clearly understand the calculation of all relevant self and mutual inductances of the machine It also helps them to more easily conceptualize the machine in a rotating system of coordinates at which point they can clearly understand the origin of this important representation of the machine Provides numerical examples Addresses Park s equations starting from winding functions Describes operation of a synchronous machine as an LCI motor drive Presents synchronous machine transient simulation as well as voltage regulation Applying his experience from more than 30 years of teaching the subject at the University of Wisconsin author T A Lipo presents the solution of the circuit both in classical form using phasor representation and also by introducing an approach that applies MathCAD which greatly simplifies and expands the average student s problem solving capability The remainder of the text describes how to deal with various types of transients such as constant speed transients as well as unbalanced operation and faults and small signal modeling for transient stability and dynamic stability Finally the author addresses large signal modeling using MATLAB Simulink for complete solution of the non linear equations of the salient pole synchronous machine A valuable tool for learning this updated edition offers thoroughly revised content adding new detail and better quality figures

Large Synchronous Machines Jack Holmes Walker, 1981      *Synchronous Machines* Charles Concordia, 1951      **Hunting of Synchronous Machines** William Fred Schaller, 2017-07-17

Excerpt from Hunting of Synchronous Machines Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Electrical Engineering in the Graduate School of the University of Illinois 1912 The phenomenon of hunting has been the chief source of trouble in the Operation of synchronous machines It was first shown by Dr John A Hopkins some twenty years ago that when a pair of generators paralleled electrically and running steadily with an equal division of load have their equilibrium of uniform motion disturbed by for instance retarding or Speeding up one or the other a balancing force will be set up with a tendency to restore the state of uniform rotation This force acts to accelerate the slow machine and retard the fast one thus tending to keep the system in synchronism This reference applies equally well to synchronous motors or to

synchronous condensers fed from alternating current supply mains there is a tendency to keep the whole system in step

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*Hybrid Excited Synchronous Machines* Yacine Amara, Hamid Ben Ahmed, Mohamed Gabsi, 2023-01-12 Our transition towards a cleaner and more sustainable future has seen an increase in the use of electrical energy in the functioning of our society This implies the need to develop tools and methods which allow us to study electromagnetic devices and ensure their functioning for as long as possible This requires us to use these tools to understand their behavior not just as one component but also in the entire systems in which they can be found throughout their life cycle This book provides electrical engineering students and researchers with the resources to analyze how synchronous machines behave over their entire field of operation particularly focusing on hybrid excited synchronous machines HESMs The field of HESMs although not a fundamental problem in the strict sense of the term provides answers to a range of fundamental problems the flux weakening of permanent magnet machines energy optimization and lastly the increasing costs of rare earths permanent magnets

*Analysis of Synchronous Machines Under Unbalanced Conditions* Donald C. Robinson, Syracuse University. Graduate School, 1933

**Starting Performance of Synchronous Machines** Harold Estus Keneipp, 1932

*Linear Synchronous Machines* Amal Souissi, Imen Abdennadher, Ahmed Masmoudi, 2018-11-17 This book introduces readers to two major sustainable applications of linear synchronous machines wave energy conversion and magnetic levitation train technology To do so it begins with a state of the art review of linear machines covering induction and synchronous topologies and their applications with a particular focus on sustainable applications This is followed by an analysis of the electromagnetic modeling of linear synchronous machines the goal being to investigate their main features especially their force production capabilities

*Synchronous Machines* Harold W. Bibber, 1936\*

*Hunting of Synchronous [sic.] Machines* John William Stokes, Roy L. Vaniman, 1912

*Hunting of Synchronous Machines* Owen Eugene Grigsby, George Edgar Ellison, 1911

**Two-axis Excitation Control of Synchronous Machines as Applied to Asynchronous Operation of a Synchronous Machine**, 1972

*Hunting of Synchronous Machines* William Fred Schaller, 1912

*The Starting Performances of Synchronous Machines* Alain Jean-Marie Bèle, 1959

*Optimal Control of Synchronous Machines* Claude Henri Sicard, 1971

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**Chapter 6 Synchronous Machines Uts Introduction**

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