SYNCHRONOUS MACHINES pdf

1: The basics of synchronous machines in power distribution networks | EEP

Type. Synchronous motors fall under the more general category of synchronous machines which also includes the synchronous www.enganchecubano.comtor action will be observed if the field poles are "driven ahead of the resultant air-gap flux by the forward motion of the prime mover".

Rotor of a large water pump. The slip rings can be seen below the rotor drum. Stator winding of a large water pump The principal components of a synchronous motor are the stator and the rotor. In some machines or when a large number of poles are needed, a salient pole rotor is used. The operation of a synchronous motor is due to the interaction of the magnetic fields of the stator and the rotor. Its stator winding, which consists of a 3 phase winding, is provided with a 3 phase supply, and the rotor is provided with a DC supply. The 3 phase stator winding carrying 3 phase currents produces 3 phase rotating magnetic flux and therefore a rotating magnetic field. The rotor locks in with the rotating magnetic field and rotates along with it. Once the rotor locks in with the rotating magnetic field, the motor is said to be in synchronization. A single-phase or two-phase derived from single phase stator winding is possible, but in this case the direction of rotation is not defined and the machine may start in either direction unless prevented from doing so by the starting arrangements. When the motor load is increased beyond the breakdown load, the motor falls out of synchronization and the field winding no longer follows the rotating magnetic field. Since the motor cannot produce synchronous torque if it falls out of synchronization, practical synchronous motors have a partial or complete squirrel-cage damper amortisseur winding to stabilize operation and facilitate starting. Because this winding is smaller than that of an equivalent induction motor and can overheat on long operation, and because large slip-frequency voltages are induced in the rotor excitation winding, synchronous motor protection devices sense this condition and interrupt the power supply out of step protection. This property is due to the inertia of the rotor; it cannot instantly follow the rotation of the magnetic field of the stator. Since a synchronous motor produces no inherent average torque at standstill, it cannot accelerate to synchronous speed without some supplemental mechanism. Very large motor systems may include a "pony" motor that accelerates the unloaded synchronous machine before load is applied. Such small synchronous motors are able to start without assistance if the moment of inertia of the rotor and its mechanical load is sufficiently small [because the motor] will be accelerated from slip speed up to synchronous speed during an accelerating half cycle of the reluctance torque. See Shaded-pole synchronous motor for how consistent starting direction is obtained. The operational economics is an important parameter to address different motor starting methods. Synchronous condenser V-curve of a synchronous machine By varying the excitation of a synchronous motor, it can be made to operate at lagging, leading and unity power factor. Excitation at which the power factor is unity is termed normal excitation voltage. This causes a demagnetizing effect due to armature reaction. With increasing field current armature current at first decreases, then reaches a minimum, then increases. The minimum point is also the point at which power factor is unity. Such power-factor correction is usually a side effect of motors already present in the system to provide mechanical work, although motors can be run without mechanical load simply to provide power-factor correction.

2: Synchronous Motor Working Principle

Construction of synchronous machines The rotor of a synchronous machine is a large electromagnet. The magnetic poles can be either salient (sticking out of rotor surface) or non-.

They are of 3-phase construction, even though some special exceptions can be found. A bulk of the applications are within power ranges roughly varying from a megawatt level to several tenths or even hundreds of megawatts with rated voltages from 3 kV to 15 kV. The basics of synchronous machines you MUST fully understand on photo: More complicated construction, control and protection demands of synchronous machines resulting higher unit costs limit the use of synchronous machines on lower output power levels. On the other hand, the excitation control features cater for more flexible means of operating the machine with the optimal reactive power flow according to the network conditions. The field winding is placed in the rotor whose design is quite different from the ones in asynchronous machines. Two different basic designs can be separated, namely round or cylindrical and salient pole. The round or cylindrical designs are used in machines operating on high speed, whereas the salient pole design is used in machines operating on slow or moderate speed. A typical example of slow-speed applications is a hydro power plant generator, whereas a steam turbine generator would represent an example of high-speed applications. In motor applications , the excited rotor rotates according to the speed of the three-phase AC-field in the stator. Under normal operation conditions, the rotating field in the stator and rotating rotor remain in synchronism. Unlike with asynchronous machines, the difference slip between rotor and rotating field speed in stator is an indication of abnormal operation situation and must be dealt with immediately. The synchronous speed ns [rpm] is given by equation 1 below: Where f is the network frequency [Hz] p is the number of poles in the machine Some synchronous machines rely on brushes for delivering the DC current to the rotor for excitation. A more modern solution is the so-called brushless design, where the needed power is transferred to the rotor by induction and the rectifying takes place in the rotor itself. For some applications, like for really low rotating speeds, the solution utilizing permanent magnets in the rotor is suitable. For generating the power for excitation purposes, PMGs are commonly used. Increased excitation current will result in a higher output voltage, and vice versa. The frequency control of the output voltage is carried out by controlling the running speed of the prime mover. When the generator is connected in parallel to a strong network, excitation control changes only the reactive power output of the generator. An increase of the excitation current makes the generator produce more inductive reactive power , thus compensating the inductive loads. A decrease in excitation ultimately leads to a situation where the generator starts to absorb inductive reactive power from the network. Instead, it increases the active power output of the generator. If the prime mover torque is decreased below the level of rotating losses of the generator, the generator starts to work as a motor trying to rotate the prime mover with the synchronous speed. This situation is referred to as reverse power operation. The reverse power operation is harmful to the generator and also to the prime mover, thus the situation has to be recognized by the protection relays. A normal operation is carried out overexcited, injecting reactive and active power to the network. When a synchronous generator is started, it is speeded up with the prime mover close to the network frequency and the excitation current is applied to reach the nominal terminal voltage. The synchronizer also checks the phasing and adjusts the prime mover speed to match the generator frequency with network frequency. This is to ensure that the generator starts producing active power right after network connection has taken place, otherwise the reverse power protection relays would disconnect the generator from the network. The construction of a synchronous generator and motor are basically identical, except regarding the external connections. The synchronous motor is not synchronized against the network in similar ways as with the synchronous generators. The simplest way to connect a synchronous motor to the network is the so-called Direct On-Line DOL starting , where the motor is started as an induction motor. The selection of the starting method depends on several criteria, like: By controlling the excitation of the synchronous motor, it is possible to compensate the variable reactive power needs in an industrial plant, thus minimizing the need of additional compensation devices. Special application of a synchronous motor is a setup where the motor does not supply any active power from its drive shaft, but it is used only to inject reactive power into the network. This kind of synchronous machine is called synchronous condenser. Today, the synchronous condensers are replaced with SVC devices:

3: Analysis of Synchronous Machines: T.A. Lipo: www.enganchecubano.com: Books

A synchronous generator is an electrical machine producing alternating emf (Elec- tromotive force or voltage) of constant frequency. In our country the standard commercial.

The stator is the stationary part of the machine. It carries the armature winding in which the voltage is generated. The output of the machine is taken from the stator. The rotor is the rotating part of the machine. The rotor produces the main field flux. The important parts of the Synchronous Machine are given below. It includes various parts like stator frame, stator core, stator windings and cooling arrangement. They are explained below in detail. Stator Frame It is the outer body of the machine made of cast iron, and it protects the inner parts of the machine. Stator Core The stator core is made of silicon steel material. It is made from a number of stamps which are insulated from each other. Its function is to provide an easy path for the magnetic lines of force and accommodate the stator winding. Stator Winding Slots are cut on the inner periphery of the stator core in which 3 phase or 1 phase winding is placed. Enameled copper is used as winding material. The winding is star connected. The winding of each phase is distributed over several slots. When the current flows in a distributed winding it produces an essentially sinusoidal space distribution of EMF. Rotor Construction The rotating part of the machine is called Rotor. There are two types of rotor construction, namely the salient pole type and the cylindrical rotor type. Salient Pole Rotor The term salient means projecting. Thus, a salient pole rotor consists of poles projecting out from the surface of the rotor core. The end view of a typical 6 pole salient pole rotor is shown below in the figure. Since the rotor is subjected to changing magnetic fields, it is made of steel laminations to reduce eddy current losses. Poles of identical dimensions are assembled by stacking laminations to the required length. A salient pole synchronous machine has a non uniform air gap. The air gap is minimized under the pole centers and it is maximum in between the poles. They are constructed for the medium and low speeds as they have a large number of poles. A salient pole generator has a large diameter. The salient pole rotor has the following important parts. Spider It is made of cast iron to provide an easy path for the magnetic flux. It is keyed to the shaft and at the outer surface, pole core and pole shoe are keyed to it. Pole Core and Pole Shoe It is made of laminated sheet steel material. Pole core provides least reluctance path for the magnetic field and pole shoe distributes the field over the whole periphery uniformly to produce a sinusoidal wave. Field Winding or Exciting Winding It is wound on the former and then placed around the pole core. DC supply is given to it through slip rings. When direct current flow through the field winding, it produces the required magnetic field. Damper Winding At the outermost periphery, holes are provided in which copper bars are inserted and short-circuited at both the sides by rings forming Damper winding. Non- Salient Pole Rotor or Cylindrical Rotor In this type of rotor, there are no projected poles, but the poles are formed by the current flowing through the rotor exciting winding. Cylindrical rotors are made from solid forgings of high-grade nickel chrome molybdenum steel. It has a comparatively small diameter and long axial length. They are useful in high-speed machines. The cylindrical rotor type alternator has two or four poles on the rotor. Such a construction provides a greater mechanical strength and permits more accurate dynamic balancing. The smooth rotor of the machine makes less windage losses and the operation is less noisy because of the uniform air gap. The figure below shows the end view of the 2 pole and 4 pole cylindrical rotors. They are driven by steam or gas turbines. Cylindrical synchronous rotor synchronous generators are called turbo alternators and turbo generators. The biggest size used in India has a rating of MVA installed in the super thermal power plant. Non salient pole type rotors have the following parts. They are as follows Rotor Core The rotor core is made of silicon steel stampings. It is placed on the shaft. At the outer periphery, slots are cut in which exciting coils are placed. Rotor Winding or Exciting Winding It is placed on the rotor slots, and current is passed through the winding in such a way that the poles are formed according to the requirement. Slip Rings Slip rings provide DC supply to the rotor windings. Miscellaneous Parts The miscellaneous parts are given below. Brushes Brushes are made of carbon, and they slip over the slip rings. A DC supply is given to the brushes. Current flows from the brushes to the slip rings and then to the exciting windings. Bearings Bearings are provided between the shaft and the outer stationary body to reduce the friction. They are made of high carbon steel. Shaft The shaft is made of mild steel. Mechanical power is taken or given to the machine through the shaft.

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4: Category:Synchronous machines - Wikimedia Commons

Synchronous machine definition is - a dynamoelectric machine (such as a generator or motor) that has a constant magnetic field and an armature which receives or delivers alternating current in synchronism with the motion of the machine and at a frequency equal to the product of the number of pairs of poles and the speed of the machine in.

Tweet AC motors can be divided into two main categories - i Synchronous motor and ii Asynchronous motor. An asynchronous motor is popularly called as Induction motor. Both the types are quite different from each other. Major differences between a synchronous motor and an induction motor are discussed below. Constructional difference Synchronous motor: Generally a salient pole rotor is used on which rotor winding is mounted. Rotor winding is fed with a DC supply with the help of slip rings. A rotor with permanent magnets can also be used. Synchronous motor Induction motor: Stator winding is similar to that of a synchronous motor. It is wound for a specific number of poles. A squirrel cage rotor or a wound rotor can be used. In squirrel cage rotor, the rotor bars are permanently short-circuited with end rings. In wound rotor, windings are also permanently short-circuited, hence no slip rings are required. Induction motor Difference in working Synchronous motor: Stator poles rotate at the synchronous speed Ns when fed with a three phase supply. The rotor is fed with a DC supply. The rotor needs to be rotated at a speed near to the synchronous speed during starting. Synchronous motor always runs at a speed equal to its synchronous speed. The rotor current gives rise to the rotor flux. Thus, the rotor will try to catch up with the RMF and reduce the relative speed. Induction motor always runs at a speed which is less than the synchronous speed. Other differences Synchronous motors require an additional DC power source for energizing rotor winding. Induction motors do not require any additional power source. Slip rings and brushes are required in synchronous motors, but not in Induction motors except wound type induction motor in which slip ring motors are used to add external resistance to the rotor winding. Synchronous motors require additional starting mechanism to initially rotate the rotor near to the synchronous speed. No starting mechanism is required in induction motors. The power factor of a synchronous motor can be adjusted to lagging, unity or leading by varying the excitation, whereas, an induction motor always runs at lagging power factor. Synchronous motors are generally more efficient than induction motors. Synchronous motors are costlier.

5: Synchronous Machine | Definition of Synchronous Machine by Merriam-Webster

B. Synchronous machine. The theory of the synchronous machine is well known, so only the basic model characteristics will be described here. A cross sectional view of a 3-phase, 2-pole, salient-pole synchronous machine is shown in Fig. SM

Based on the type of input we have classified it into single phase and 3 phase motors. Among 3 phase motors, we mostly sue induction motors and synchronous motors. When three-phase electric conductors are placed in certain geometrical positions In certain angle from one another , then an electrical field is generated. Now the rotating magnetic field rotates at a certain speed, that speed is called synchronous speed. Now if an electromagnet is present in this rotating magnetic field , the electromagnet is magnetically locked with this rotating magnetic field and rotates with the same speed of rotating field. Synchronous motors is called so because the speed of the rotor of this motor is the same as the rotating magnetic field. It is a fixed speed motor because it has only one speed, which is synchronous speed, or in other words, it is in synchronism with the supply frequency. Now, let us first go through the basic construction of this type of motor. From the above picture, it is clear that how do we design this type of machine. We apply three phase supply to the stator and DC supply to the rotor. Main Features of Synchronous Motors Synchronous motors are inherently not self starting. They require some external means to bring their speed close to synchronous speed to before they are synchronized. The speed of operation of is in synchronism with the supply frequency and hence for constant supply frequency they behave as constant speed motor irrespective of load condition This motor has the unique characteristics of operating under any electrical power factor. This makes it being used in electrical power factor improvement. Principle of Operation Synchronous Motor Synchronous motor is a doubly excited machine, i. Its stator winding which consists of a We provide three-phase supply to three-phase stator winding, and DC to the rotor winding. The 3 phase stator winding carrying 3 phase currents produces 3 phase rotating magnetic flux. The rotor carrying DC supply also produces a constant flux. Considering the 50 Hz power frequency, from the above relation we can see that the 3 phase rotating flux rotates about revolutions in 1 min or 50 revolutions in 1 sec. At a particular instant rotor and stator poles might be of the same polarity N-N or S-S causing a repulsive force on the rotor and the very next instant it will be N-S causing attractive force. But due to the inertia of the rotor, it is unable to rotate in any direction due to that attractive or repulsive forces, and the rotor remains in standstill condition. Hence a synchronous motor is not self-starting. Here we use some mechanical means which initially rotates the rotor in the same direction as the magnetic field to speed very close to synchronous speed. On achieving synchronous speed, magnetic locking occurs, and the synchronous motor continues to rotate even after removal of external mechanical means. Synchronous motors are mechanically coupled with another motor. It could be either 3 phase induction motor or DC shunt motor. Here, we do not apply DC excitation initially. It rotates at speed very close to its synchronous speed, and then we give the DC excitation. After some time when magnetic locking takes place supply to the external motor is cut off. Damper winding In this case, the synchronous motor is of salient pole type, additional winding is placed in rotor pole face. Initially, when the rotor is not rotating, the relative speed between damper winding and rotating air gap flux is large and an emf is induced in it which produces the required starting torque. As speed approaches synchronous speed, emf and torque are reduced and finally when magnetic locking takes place; torque also reduces to zero. Hence in this case synchronous motor first runs as three phase induction motor using additional winding and finally it is synchronized with the frequency. Application of Synchronous Motor Synchronous motor having no load connected to its shaft is used for power factor improvement. Owing to its characteristics to behave at any electrical power factor, it is used in power system in situations where static capacitors are expensive. Synchronous motor finds application where operating speed is less around rpm and high power is required. For power requirement from 35 kW to KW, the size, weight and cost of the corresponding three phase induction motor is very high. Hence these motors are preferably used. Ex- Reciprocating pump, compressor, rolling mills etc.

6: Construction of a Synchronous Machine - Circuit Globe

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.

Circuit Globe Synchronous Machines Synchronous Machine Synchronous Machine Synchronous Machine constitutes of both synchronous motors as well as synchronous generators. An AC system has some advantages over DC system. Therefore, the AC system is exclusively used for generation, transmission and distribution of electric power. The machine which converts mechanical power into AC electrical power is called as Synchronous Generator or Alternator. However, if the same machine can be operated as a motor is known as Synchronous Motor. A synchronous machine is an AC machine whose satisfactory operation depends upon the maintenance of the following relationship. Where, Ns is the synchronous speed in revolution per minute r. When connected to an electric power system, a synchronous machine always maintains the above relationship shown in the equation 1. If the synchronous machine working as a motor fails to maintain the average speed Ns the machine will not develop sufficient torque to maintain its rotation and will stop. Then the motor is said to be Pulled Out of Step. In case, when the synchronous machine is operating as a generator, it has to run at a fixed speed called Synchronous speed to generate the power at a particular frequency. As all the appliances or machines are designed to operate at this frequency. In some countries, the value of the frequency is 50 hertz. Basic Principles of Synchronous Machine A synchronous machine is just an electromechanical transducer which converts mechanical energy into electrical energy or vice versa. The fundamental phenomenon or law which makes these conversions possible are known as the Law of Electromagnetic Induction and Law of interaction. The detailed description is explained below. This law relates to the production of emf, i. Law of Interaction This law relates to the production of force or torque, i. The figure is shown below. Three Phase Synchronous Machine The machine which is used in the household appliance such as the small machine used in air coolers, refrigeration, fans, air conditioners, etc. However, large AC machines are three phase type synchronous machines because of the following reasons. For the same size of the frame, three phase machines have nearly 1. Three phase power is transmitted and distributed more economical than single phase power. Three phase motors are self-starting except synchronous motors. Three phase motors have an absolute uniform continuous torque, whereas, single phase motors have pulsating torque. In a small synchronous machine, the fielding winding is placed on the stator, and the armature winding is placed on the rotor whereas for the large synchronous machine the field winding is placed on the rotor, and the armature winding is placed on the stator.

7: What is a Synchronous Machine? - its Basic Principles - Circuit Globe

A synchronous machine is an AC machine whose satisfactory operation depends upon the maintenance of the following relationship. Where, N s is the synchronous speed in revolution per minute (r.p.m).

8: Synchronous motor - Wikipedia

Synchronous motor is a doubly excited machine, i.e., two electrical inputs are provided to it. Its stator winding which consists of a We provide three-phase supply to three-phase stator winding, and DC to the rotor winding.

9: Electrical Machines - Fundamentals

Synchronous Machine can be operated either Synchronous generator (Alternator) or Synchronous Motor. In Synchronous Generator, the rotor carries a field winding which is supplied with direct current through two slip rings by a separate d.c. source.

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