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INDUCTION VERSUS SYNCHRONOUS GENERATORS

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What is an Induction generator?

An inductive generator is electrically identical to an electric induction motor, where the utility creates a rotating electric field in the stator core, which has magnetic lines of force which cut the rotor core, thereby generating a torque in the rotor. This "cutting" action only takes place only if the rotor turns at a different speed to the rotating field (1800RPM in a 4 pole machine, 1200RPM in a 6 pole machine. The higher the difference in speed between the rotor and stator fields, the higher the torque generated in the rotor. Were the rotor and stator fields to run at the same speed, there would be no cutting action, and thus no torque being generated. In order to export power, the generator has to turn *faster* than the rotating field and at full load, the super-synchronous speed will have exactly the same slip frequency above synchronous, as a fully loaded electrical motor will have below synchronous.
By the same token, if instead of the motor being connected to a load which absorbed this torque, the rotor shaft was connected to an engine which tries to spin the rotor field faster than the stator field, a torque would also be generated which needs some place to go!! The only escape for this torque, is to try and force the current generating the magnetic field to increase in frequency beyond 60 HZ, but since this is practically impossible with the power network in the national grid being millions of times greater than the engine power turning the rotor, the only way equilibrium can be restored is if the rotor forces the stator current back into the network. (Current x Voltage = Power) A motor can thus become a generator if it is spun faster than its rated speed! The faster the rotor tries to turn, the more power is returned to the grid .
Induction generators are also called *asynchronous machines*, because the rotors and stators are not in electro-magnetically in synchronism!!

How does an induction generator differ from a synchronous generator?

In an ordinary synchronous generator as can be found in power stations and generator sets and pelton wheels, the rotor is what is called a *salient* pole in electrical engineer's jargon, which means that the frequency of the rotating field is determined by the *speed* at which the engine turns the rotor. In a synchronous machine it is the speed of the rotor which determines the speed of the rotating field in the stator. The frequency of the rotating field in the stator and rotor are in perfect synchronism, and must remain so in order to have the correct frequency feeding a connected load which is not connected to the grid. There is also "cutting of magnetic lines of force between rotor and stator, but the fundamental difference between synchronous and induction machines, is that the torque is determined by the *difference in angle of displacement between rotor and stator fields, not the difference in speed*!!! The greater the torque (power) being transmitted, the greater the *angle* between rotor and stator fields.

What are the advantages of induction generators?

- ***Reduced COST.*** The single greatest advantage of an asynchrounous system lies not in the reduced cost not only of the generator itself, but in the *avoided* costs. Synchronous machines being paralleled with the grid require very exacting control equipment which ensures that the machine is paralleled at exactly the right moment to prevent serious damage to the machine and to switchgear , power-lines, transformers and other consumers on the grid. Out-of-synch events are violent occurrences and broken crankshafts, generator pole-damage, massive voltage spikes and power surges are the order of the day . Modern electronics has made synchronization with the grid more reliable and cheaper but the fact remains that utilities need to take steps to protect their transformation, distribution and reticulation infrastructure, their employees and other customers and as a result have created very expensive protection schemes and elaborate procedures guidelines and policies. Compliance with these rules and regulations usually requires several layers of consulting engineers recommending protective designs, interconnection studies, potential fault levels, remote tripping etc and the list goes on and on! Small customer generators wanting grid synchronisation do not have the same potential or impact but the utilities impose the same set of rules and this is where contingent costs become out of proportion to the value of synchronization. Induction generators are "electrically friendly" and simply do not necessitate the same level of control and regulation. This is where the *avoided costs* become substantial.

- ***Reduced complexity***. Induction generators do not require synchronization, they can simply be closed onto the grid at virtually any time and speed. If closed on while the engine is stationary, it will simply run up to its slip-speed . In fact induction generators are used to crank and start the engine avoiding starter motors, batteries battery chargers etc.
- ***Simplicity.*** An induction generator needs no excitation winding, no salient pole windings and no automatic voltage regulators, just like a squirrel-cage electric motor. With larger generators (in excess of 1000kW) starting inrush in the starting phase can be reduced by having windings in the rotor like a slipring motor. The generator can be starting by providing a high resisitance across the sliprings which reduces the current inrush dramatically.
- ***Reduced operator skill levels.*** The simplicity of these generators requires a lower less expensive level of operator skill-sets.
- ***Lower ancillary costs.***The lower level of complexity and damage potential reduces liability and failure insurance costs.e
- ***Low potential for damage to utility infrastructure.*** From a utility's point of view an induction generator is simply an induction motor coupled to an engine and although it cannot generate out-of-synch faults ,

Disadvantages of Induction Generators

- ***Inability to produce power on their own.*** Without a utility to create the rotating field and provide a fixed-frequency "resistance", an induction generator cannot deliver any power is simply an engine driving an electric motor.***
- ***Inability to control power factor***. Synchronous generators running in synch with the utility can be used to improve a consumer's power factor by increasing or decreasing field excitation. This is only a desirable feature when the generator is being used to export and sell power to the utility.
- ***Absorbs VARS from the utility to produce power.*** An induction generator produces kilowatts, but it requires VARs in order to create the rotating field in the stator. This lowers the customer's load power factor which can be penalized by the utility if it drops below a preset level. These inductive VARs can be inexpensively countered by the use of a fixed capacitor to provide capacitive VARs. This method works effectively for export or peaking duty.
- ***Negative utility preceptions.*** Whether synchronous or asynchronous, some utilities, especially those with unsold capacity, view any customer generation negatively since it can threaten their revenue-stream if power is exported into the grid and it can also substantially reduce maximum demand revenue. The utilty could ask for current transformers and protection to prevent export of power into the grid, but the cost of this equipment is a fraction of the requirement for synchronous machines. They may also require a disconnect switch with visible contacts for nervous utility line workers.

FAQs

Can an induction generator be run in synch with another synchronous generator??

Yes, the synchronous generator will supply the VARs as well as a base frequency but balancing the output of the induction generator with load is a delicate balancing act and is not recommended

Where else are induction generators employed??

Virtually all wind-power generators are asynchronous because of their ability to pump power into the grid at varying input speeds determined by wind speed. This feature is made possible by virtue of modern power electronics which takes utility power and frequency and lowers the speed of the stator rotating field such that it is lower than the input rotor speed, enabling it to export power to the grid. This speed is fully variable with wind speed.

Are induction generators and electric motors the same thing??

Not entirely . The windings in purpose-built induction generators have a slightly different skew angle in the rotor laminations to improve on-line power factor. Also , purpose-built machines can be built as single-bearing machines to cut assembly costs. Apart from these two items, they are electrically and mechanically the same thing

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