Wound rotor induction generator pdf

Double-fed electric machines also slip-ring generators are electric motors or electric generators, where both field magnet windings and fixture windings are connected separately to equipment outside the machine. By feeding adjustable frequency AC power to field windings, the magnetic field can be made to run, allowing variation in engine or generator speed. This is useful, for example, for generators used in wind turbines. [1] DFIG-based wind turbines, due to their flexibility and ability to control active and reactive power, are almost the most interesting wind turbine technology. [2] [3] Introduction Double-fed generator for wind turbine. Dual-powered electric generators are similar to AC electric generators, but have additional features that allow them to run at speeds slightly above or below their natural synchronous speed. This is useful for large variable speed wind turbines, because the wind speed can change suddenly. When a gust of wind hits a wind turbine, the blades try to accelerate, but a synchronous generator is locked at the speed of the power grid and cannot accelerate. So great forces are developed in the power, gearbox and generator as the power grid pushes back. This causes wear and tear and damage to the mechanism. If the turbine can accelerate immediately when hit by a gust of wind, the voltages are lower with the force of the gust still converted into useful electricity. One approach to allowing wind turbine speed to vary is to accept what frequency the generator produces, convert it to DC, and then convert to AC at the desired output frequency using an inverter. This is common for small houses and farm wind turbines. But the inverters needed for megawatt-scale wind turbines are large and expensive. Double powered generators are another solution to this problem. Instead of the usual field winding fueled with D.C., and a fixture winding where the electricity generated comes from, there are two three-stage windings, one stationary and one rotating, both separately connected to equipment outside the generator. For example, the term double feeding is used for this type of machinery. One winding is directly connected to the output and produces 3-phase alternating current at the desired grid frequency. The other winding (traditionally called the field, but here both windings can be outputs) are connected to 3-phase WISSE current power at variable frequency. This input power is adjusted in frequency and phase to compensate for changes in turbine speed. [4] Adjusting the frequency and phase requires an AC to AC converter. This is usually made up of very large Semiconductors. The converter is two-way and can transmit current in both directions. Current can flow from both this winding and from the output winding. [5] History With its origins in wondrotor induction engines with multiphase winding sets on the rotor and stator, respectively, which was invented by Nikola Tesla in 1888,[6] the rotor-winding series of double-fed double-fed Machine is connected to a selection of resistors via multiphase slip rings before starting. However, the slip power was lost in the resistances. Thus means of increasing the efficiency in variable speed operation by retrieving the slip power were developed. In Krämer (or Kraemer) drive, the rotor was connected to an AC and DC machine set that fed a DC machine connected to the shaft of the slip ring machine. [7] Thus the slip power was returned as mechanical power and the drive could be controlled by the arousal currents of the machines DC. The disadvantage of the Krämer drive is that the machines have to be oversized in order to cope with the extra circulating power. This disadvantage was corrected in the Scherbius drive where the slip power is fed back to the AC-net by engine generator sets. [8] [9] Rotary machines used for the rotor supply were heavy and expensive. Improvement in this respect was the static Scherbius drive in which the rotor was connected to a rectifier inverter set built first by mercury arc-based devices and later with semiconductor diodes and thyristors. In the diagrams using a rectifier, the current was only possible from the rotor because of the uncontrolled rectifier. In addition, only subsynchronous operation as an engine was possible. Another concept using static frequency converter had a cyclo converter connected between the rotor and the AC net. The cyclo converter can power in both directions, so the machine can run both sub- and oversynchronous speeds. Large cycloconverter-controlled, double-powered machines have been used to run single phase generators that power 16 2.3 Hz rail network in Europe. [10] Cycloconverter powered machines can also operate the turbines in pumped storage plants. [11] Today the frequency changer used in applications up to few tens of megawatts consists of two back to back connected IGBT inverters. Several brushless concepts have also been developed to get rid of the slip rings that require maintenance. Double-fed induction generator Double-fed induction generator (DFIG), a principle widely used in wind turbines. It is based on an induction generator with a multi-stage wondrotor and a multiphase slipring mount with brushes for access to the rotor windings. It is possible to avoid the multiphase slip ring assembly, but there are problems with efficiency, cost and size. A better alternative is a brushless wondrotor that is double-powered with electric machines. [12] Principle of a double-powered induction generator connected to a wind turbine The principle of DFIG is that stator windings are connected to the grid and rotor winding is connected to the converter via slip rings and back-to-back voltage source which controls both the rotor and the grid currents. For example, the rotor frequency may differ freely from the grid frequency (50 or 60 Hz). By using the converter to control the rotor currents, it is possible to adjust the active and reactive current that is fed from the stator to the grid. the turning speed of the generator. The operating principle used is either the two-axis power vector control or direct torque control (DTC). [13] DTC has been found to have better stability than current vector control especially when high reactive currents are required from the generator. [14] Double-fed generator rotors are typically wound with 2 to 3 times the number of turns of the stator. This means that the rotor voltages will be higher and the currents will be lower respectively. Thus in the typical ±30% operational speed range around the synchronous speed, the estimated flow of the inverter is accordingly lower leading to a lower cost of the inverter. The disadvantage is that controlled operation outside the operational speed range is impossible due to the higher than nominal rotor voltage. Furthermore, the voltage disturbances resulting from the grid failures (especially three- and two-phase voltage dips) will also be increased. To prevent high rotor pressures (and high currents due to these stresses) from destroying the converter's isolated port bipolar transistors and diodes, a protective circuit (called crowbar) is used. [15] The crowbar will short-circuit the rotor windings by a small resistance when excessive currents or voltages are detected. In order to continue the operation as quickly as possible, an active crowbar should be used[16]. The active crowbar can remove the rotor briefly in a controlled manner, so the rotor side inverter can only be started after 20-60 ms from the start of the grid failure when the remaining voltage remains above 15% of the nominal voltage. Thus, it is possible to generate reactive current to the grid during the rest of the voltage dip and in this way help the grid recover from the fault. For zero voltage ride through, it is common to wait until the dip ends, otherwise it is not possible to know the stage angle where the reactive current should be injected. [17] As a summary, a double-fed induction machine is a wound-rotor double-powered electric machine and has several advantages over a conventional induction machine in wind energy applications. First, because the rotor circuit is controlled by a power electronics converter, the induction generator can both import and export reactive power. This has important implications for the stability of the electricity system and allows the machine to support the grid during severe voltage failures (low voltage drive-through; LVRT). [15] Secondly, the control of the rotor voltages and currents allows the induction machine to stay synchronized with the grid while the wind turbine speed varies. A variable-speed wind turbine makes more efficient use of the available wind source than a fixed-speed wind turbine, especially in light wind conditions. Thirdly, the cost of the compared to other variable speed solutions, because only a fraction of the mechanical power, usually 25-30%, is fed through the converter to the grid, be fed directly from the stator to the net. The efficiency of the DFIG is very good for the same reason. References ^ Generators for wind turbines Standard slip ring generator series for double fed concept of 1.5-3.5 MW (PDF). Abb. Picked up april 24, 2018. ^ M. J. Harandi, S. G. Liasi and M. T. 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