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Inverterless Grid Compatible Micro Turbine Generator

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Abstract : Micro-Turbine Generators (MTG) are small size power plants that consist of a high speed, gas turbine driving an electrical generator. MTGs may be fueled by either natural gas or kerosene and may also use sustainable and recycled green fuels such as biomass, landfill or digester gas. The typical ratings of MTGs start from 20 kW up to 200 kW. The primary use of MTGs is for backup for sensitive load sites such as hospitals, and they are also considered a feasible power source for Distributed Generation (DG) providing on-site generation in proximity to remote loads. The MTGs have the compressor, the turbine, and the electrical generator mounted on a single shaft. For this reason, the electrical energy is generated at high frequency and is incompatible with the power grid. Therefore, MTGs must contain, in addition, a power conditioning unit to generate an AC voltage at the grid frequency. Presently, this power conditioning unit consists of a rectifier followed by a DC/AC inverter, both rated at the full MTG's power. The losses of the power conditioning unit account to some 3-5%. Moreover, the full-power processing stage is a bulky and costly piece of equipment that also lowers the overall system reliability. In this study, we propose a new type of power conditioning stage in which only a small fraction of the power is processed. A low power converter is used only to program the rotor current (i.e. the excitation current which is substantially lower). Thus, the MTG's output voltage is shaped to the desired amplitude and frequency by proper programming of the excitation current. The control is realized by causing the rotor current to track the electrical frequency (which is related to the shaft frequency) with a difference that is exactly equal to the line frequency. Since the phasor of the rotation speed and the phasor of the rotor magnetic field are multiplied, the spectrum of the MTG generator voltage contains the sum and the difference components. The desired difference component is at the line frequency (50/60 Hz), whereas the unwanted sum component is at about twice the electrical frequency of the stator. The unwanted high frequency component can be filtered out by a low-pass filter leaving only the low-frequency output. This approach allows elimination of the large power conditioning unit incorporated in conventional MTGs. Instead, a much smaller and cheaper fractional power stage can be used. The proposed technology is also applicable to other high rotation generator sets such as aircraft power units.

Keywords : gas turbine, inverter, power multiplier, distributed generation
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