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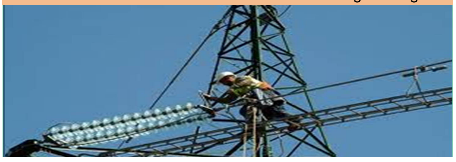

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Current developments for the controlling of grid-connected photovoltaic systems

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DESCRIPTION

Since the invention of electricity as an energy source in the late 19th century, this form of energy has been generated primarily from fossil fuels such as oil, gas and coal. However, this energy mix has been questioned in recent decades. The burning of hydrocarbons to generate electricity has been proven to be a major contributor to the release of greenhouse gases into the atmosphere, contributing to the looming problem of global warming.

Elimination of carbon emissions and reduction of fossil fuel reserves have gradually replaced traditional energy sources, paving the way for renewable energy technologies. European Union installed capacity by power generation technologies through projections to 2040 shows the evolution of the paradigm shift is clear that unconventional energy sources will dominate future energy systems. However, apart from the environmental benefits that renewable energy offers, managing this kind of energy is more complex than managing conventional energy sources. On the one hand, the discontinuous nature of renewable resources makes forecasts unstable and unpredictable to some extent. On the other hand, unlike traditional generators that are directly connected to the grid, renewable generators are disconnected from the grid using electronic converters to reduce the synchronous equivalent inertia of the system. The latter characteristic is essential for determining the behavior of the energy system in the event of faults caused by generator tripping on and off of large loads (Baumgarter et al 2001).

In AC networks, the speed of the synchronous generator in operation determines the frequency of the characteristic voltage curve (Anderson 1986). At rest, all synchronous generators in the system rotate with angular velocities that are multiplied by their respective pole pairs. They produce a single angular pulsation value. Therefore, from a frequency point of view, all generators rotate at a single speed operating synchronously (Dai et al 2001).

At the same time, the deviation of the frequency from the nominal value in the power system is closely related to the difference between the generated power and the power demand. This relationship can be seen very graphically if we consider a synchronous generator driven by a turbine feeding an independent electrical load. We assume that the steady-state mechanical and electrical losses are neglected. In this case, the mechanical power transferred from the turbine to the generator shaft equals the power required at the generator connection. If the value of the power consumed by the load suddenly increases and the value of the mechanical power exerted by the prime mover does not change, this increase in the requested power is taken over by the alternator using the kinetic energy stored in the rotor. This consumption of kinetic energy reduces the rotation speed of the machine and consequently the frequency (Kobayashi et al 2003).

The power generation capacity of a photovoltaic system is determined by the availability of renewable raw materials, which are influenced by atmospheric radiation and temperature conditions. To optimize renewable resources, DC-DC converters are usually equipped with maximum power point tracking algorithms that ensure that the system always produces the maximum available power. Let us now assume that the losses in the converter are negligible and that the power requested by the load matches the power delivered by the panel. When the load suddenly increases the power demand, the PV array cannot increase its power, the demand generation is unbalanced, and the frequency continuously drops. Alternatively, while the system is operating in steady state, a depletion of renewable resources can occur, for example due to passing clouds, affecting the generation demand balance.

CONCLUSION

The literature is replete with research papers on renewable energy system services, with solar and wind power being prominent.

Photovoltaic technology in particular has several characteristics that make it a prime choice for providing grid support services. Compared to other renewable generators, these features include reduced maintenance time, fully integrated power electronics for fast response, and no rotating mass to increase response time. In recent years, several contributions to photovoltaic systems have supported inertial response, and first-order frequency control has been proposed in the literature, an indication of the topic's current relevance. Two methodologies enable ancillary services to integrate solar energy.

Energy storage and operation of photovoltaic systems was below the maximum power point. Both approaches offer different alternatives that need to be evaluated for each facility, considering various aspects such as energy prices, additional equipment costs, capital costs, as well as financial rewards and obligations to provide ancillary services. Current limiting techniques are wasteful of energy, but require less initial investment and are another option given the uniqueness of each piece of equipment.

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