Flicker Emission Analysis of Photovoltaic Systems Connected to Distribution Networks Using DIgSILENT PowerFactory

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Abstract:
With the increased growth of photovoltaic (PV) systems in the LV distribution networks, voltage fluctuations leading to flicker is expected to become a main power quality concern to Distribution Network Service Providers (DNSPs). In the current research, the voltage fluctuations and flicker emission from PV systems due to passing clouds and temperature variations is investigated employing a simulation model of a network feeder with multiple PV systems. In addition, the effect of dynamic reactive power controllers, that may be integrated to PV systems in order to control the point of common coupling (PCC) voltage, on flicker levels in the distribution network is investigated. The paper reports although the passing clouds can lead to an increase in flicker emission from PV systems, the recorded flicker values are well below the stipulated emission limits and network compatibility levels.

SIMULATION MODEL OF A PV SYSTEM

A simulation model of a PV system consisting of 27, 185 W PV panels, connected to a 6 kW inverter was developed using DIgSILENT PowerFactory software.

FLICKER EMISSION FROM A SINGLE PV SYSTEM

5 kW PV system

AC voltage source

PCC

Fig. 1 Simulation model of the PV system

FLICKER EMISSION INVESTIGATION IN DISTRIBUTION NETWORKS

Ten 5 kW PV systems connected across a LV distribution network between Phase A and neutral of the distribution network were considered. Each PV system was subjected to the same irradiation and ambient temperature fluctuation corresponding to a heavy cloudy day as given by Fig. 3 and the voltage and short-term flicker severity index at each terminal of the distribution network were recorded for a period of four hours.

DYNAMIC VOLTAGE CONTROLLERS IN PV SYSTEMS

- Flicker emission from PV systems can be influenced by the varying irradiation, however, the recorded flicker levels are insignificant and well below the stipulated limits.
- When multiple PV systems are connected across a distribution feeder, flicker is extensively attenuated among different units.
- The net flicker levels observed at the end of the feeder is significantly less than the flicker compatibility levels of LV networks.
- Short-term flicker severity is observed to further reduce when the PV systems with dynamic reactive power control capability are connected to the distribution network.

CONCLUSIONS

- The active power output and flicker emission of a PV system consisting of a 3.6 kW commercial PV inverter, under fluctuating irradiance and temperature corresponding to the four-hour time window of heavy cloudy day has been obtained.
- A good correlation between the two system were observed in terms of the active power outputs.
- However, the flicker emission from the actual PV system is significantly different to the flicker values obtained using the simulation model.
- Other pertinent factors such as the employed maximum power point tracking algorithm can also have a significant influence the flicker emission from a PV system.

COMPARISON OF SIMULATION MODEL WITH AN ACTUAL PV SYSTEM

Fig. 2 Voltage fluctuations at 1, terminal of the distribution network before and after integrating dynamic reactive power control to PV systems

Fig. 3 Fluctuation of irradiation and ambient temperature corresponding to a heavy cloudy day.

Fig. 4 Voltage fluctuations and flicker emission at the PCC of the PV system, corresponding to a four hour time window of a heavy cloudy day.

Fig. 5 Test LV distribution network with multiple PV systems

Fig. 6 (a) Voltage fluctuations at different terminals of the network (b) Short-term flicker severity at different terminals of the distribution network.

Fig. 8 Comparison of active power output of an actual PV system and the simulation model

Fig. 9 Voltage fluctuations and flicker emission at the PCC of the PV system, corresponding to a four hour time window of a heavy cloudy day.