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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 kVA inverter was developed using DigSILENT PowerFactory software.

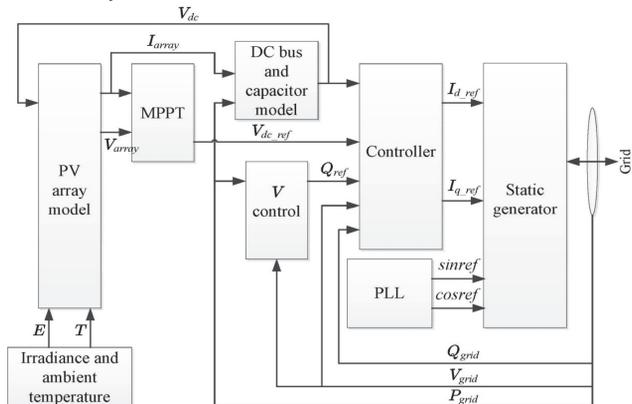


Fig. 1 Simulation model of the PV system

FLICKER EMISSION FROM A SINGLE PV SYSTEM

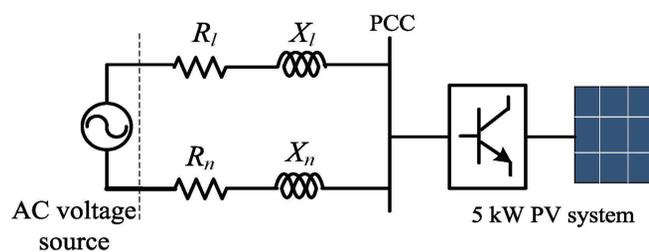


Fig. 2 PV system connected to a voltage source via the test impedance

A 5 kW PV system connected to a voltage source via a test impedance of as shown in Fig. 2 was considered. An irradiance and ambient temperature fluctuation corresponding to four hour time window of a heavy cloudy day as shown in Fig. 3 was used for simulation case studies. The flicker severity at the PCC of the PV system was measured in accordance with IEC 61000-4-15, using the in-built flickermeter of DigSILENT PowerFactory software.

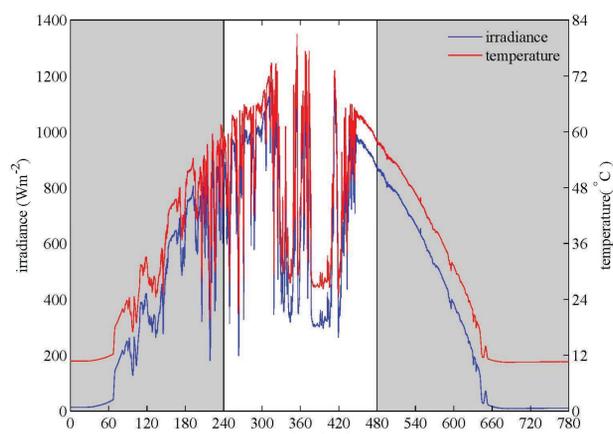


Fig. 3 Fluctuation of irradiance and ambient temperature corresponding to a heavy cloudy day.

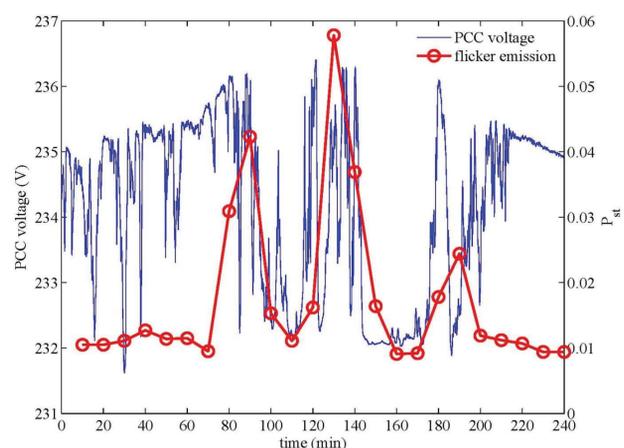


Fig. 4 Voltage fluctuations and flicker emission at the PCC of the PV system, corresponding to a four hour time window of a heavy cloudy day

FLICKER EMISSION INVESTIGATION IN DISTRIBUTION NETWORKS

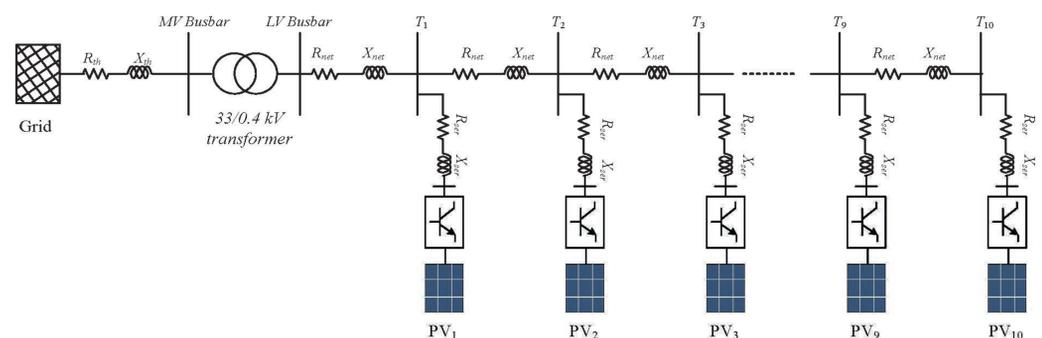


Fig. 5 Test LV distribution network with multiple PV systems

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 irradiance and ambient temperature fluctuation corresponding to the 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.

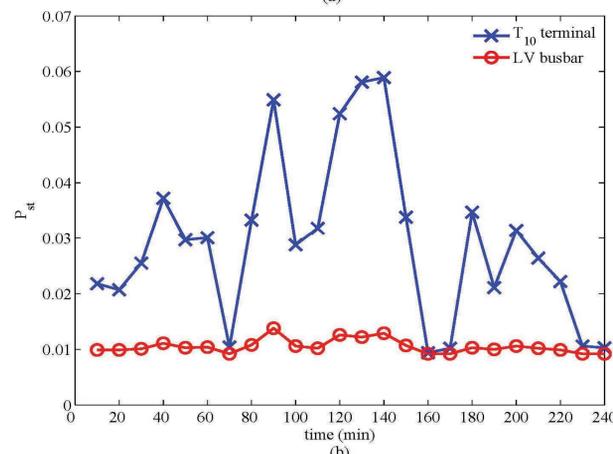
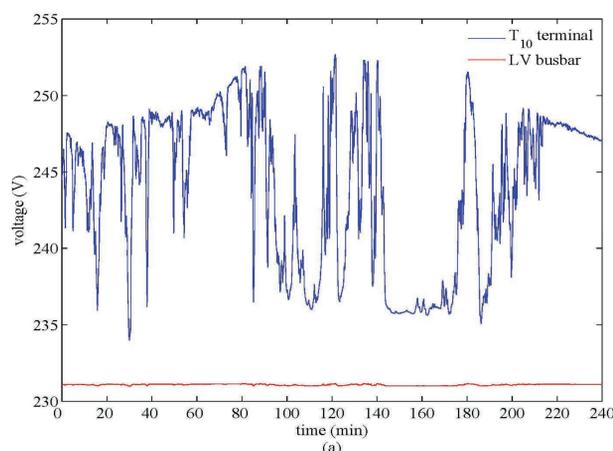


Fig. 6 (a) Voltage fluctuations at different terminals of the network (b) Short-term flicker severity at different terminals of the distribution network.

DYNAMIC VOLTAGE CONTROLLERS IN PV SYSTEMS

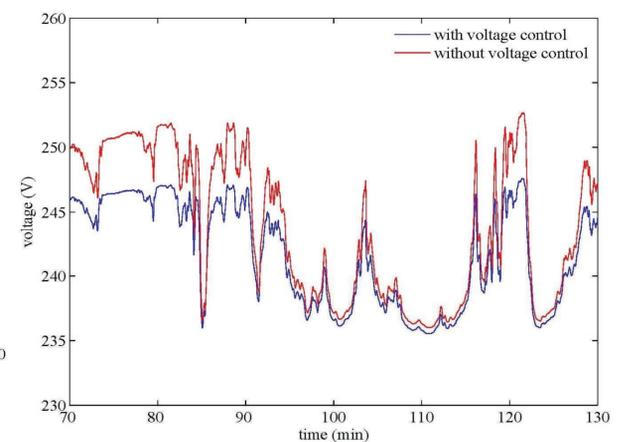


Fig. 7 Voltage fluctuations at T_{10} terminal of the distribution network before and after integrating dynamic reactive power control to PV systems

CONCLUSIONS

- Flicker emission from PV systems can be influenced by the varying irradiance, 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.

COMPARISON OF SIMULATION MODEL WITH AN ACTUAL PV SYSTEM

- 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.

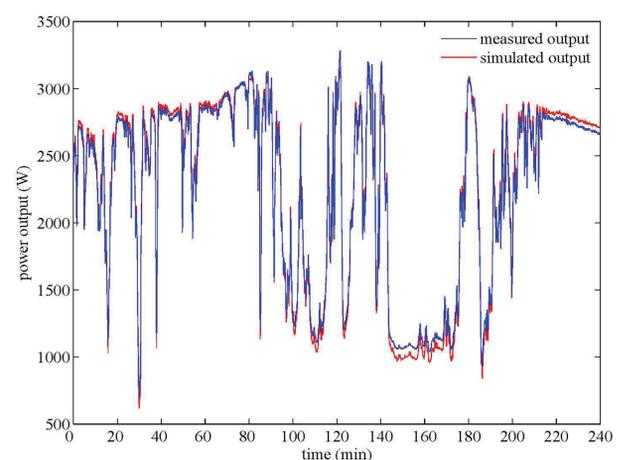


Fig. 8 Comparison of active power output of an actual PV system and the simulation model