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A Study of the Current Disturbance Caused by Wind Induced Vibrations of Photovoltaic Modules

Abstract

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Mechanical vibrations of a solar module mounting rack cause oscillations in the orientation of the module towards the sun. The resulting intensity oscillations of the incident light originate an a.c. current at the module's terminals. These current transients typically occur in the low to very low frequency regime. Hence they are extremely hard to remove in the circuitry by a low pass filter without the reduction of the useful d.c. output. Because of the need to optimise the exposure of solar modules to the incident sun light they are placed on mounting constructions which easily are stimulated to vibrate.
Purpose of the current work is (i) to investigate the response of photovoltaic devices to mechanical vibrations in the laboratory under well controlled conditions and (ii) to perform exemplary outdoor studies of the mechanical vibrations caused be wind forces in Vienna.

In the laboratory we examined the effect of changing light intensity distribution caused by the vibrations relative to the incident light beam over the area of the solar cells, with respect to different loads and circuit arrangements (i.e. parallel, serial and single). To supplement and confirm our results a simulation with the circuit simulation program Qucs was done.

The effects an mechanisms underlying our results, are yet to be fully understood. However we were able to derive some basic characteristics of the behaviour of ultra low frequency distortion in solar modules. As well in the laboratory experiments as in the simulation it became clear that the ratio of a.c. current to amplitude is significantly higher when the cells are connected in series than when they are connected parallely.

The simulation as well as the differentiated $I(V)_{DC}$ curve suggest that the maximum of the distortion signal lies below the maximum power point of the characteristic I(V) curve in relation to the voltage. This however could not yet be confirmed or falsified by the experimental measurements conducted.

Outdoor and laboratory experiments showed clearly that low incident angles of direct sun radiation can reduce the magnitude of the distortion. Therefore tracked concentrating systems potentially will experience less distortion than building integrated photovoltaic facades. Although in the first case the mounting system permits large displacements caused by external forces it is permanently facing the sun. Due to their large inclination angles facades are considerably misoriented towards the sun most of their operation time.

In the outdoor observations the magnitude of oscillations depend on the mounting construction and will increase with increasing wind forces. Due to thermal management of photovoltaic collectors construction design favours good ventilation conditions which in return eases wind attacks. Thus vibration induced distortion appears to be unavoidable

Although the collected results outdoor are specific and restricted to our experimental set up and environmental situation we deduce that vibration induced current transients and oscillations of a solar module's output most often will be the dominant origin of distortion in the low frequency regime.