Optimization of Electro-optic Systems for Self Cleaning Photovoltaic Panels and Concentrated Solar Reflectors

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***Abstract*— The current demand for energy usage in the world is increasing at a rapid pace, which is in turn causing for clean energy renewable sources to be relied upon for power production. Average terrestrial solar irradiance at AM1.5 under a clear sky is 1kW/m^2, therefore, multi-MW solar plants require installations in semi-arid or desert areas in mid-latitudes where direct normal irradiance is very high. High dust deposition rate in those locations cause large power losses due to the transmission and reflection losses. The loss of power output is compounded with a lack of natural water resources for conventional cleaning methods. To resolve this problem, a cost effective solution can be implemented by the application of electrodynamic screen (EDS), which consists of a set of parallel electrodes deposited on the sun facing surface of solar mirrors, concentrating lenses, or photovoltaic modules. The electrodes are embedded by a thin transparent dielectric film. Activating the electrodes with three-phase, low frequency, low current high voltage pulses, it is possible to remove the accumulated dust layer from the surface by electrostatic forces. This paper presents a discussion on the electro-optic optimization of the electrode grid geometry for (1) achieving high dust removal efficiency that require highly conductive electrodes closely spaced with each other with a specific electrode separation-to-width ratio computed by the application of electrostatic force model and (2) minimum light transmission (and hence reflection) losses by the EDS integration that require highly transparent electrodes with sub-micrometer thickness and large inter-electrode spacing as modeled by the FRED optical design tool. A compromise between the two opposing requirements is derived by Design of Experiments to reach an optimum parametric set of electrode configuration. This design is then implemented for experimental evaluation. The optical performance of the EDS electrode geometry is then compared with the dust deposition related transmission and reflection losses in photovoltaic modules and concentrating solar power applications respectably. To determine transmission (and reflection) losses Mie scattering theory was used. Both theoretical model predictions and data obtained from experimental verifications are presented. Laboratory evaluation of the EDS-integrated solar panels and solar mirrors are presented with dust samples obtained from different desert locations.**