Effect of Voltage Rise Time on the Efficiency of an Electrodynamic Dust Shield Device Using Trapezoidal Waveform

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***Abstract*—Electrodynamic dust shield (EDS) has been proposed as a potential anti-dust solution for solar PV power generation in the Earth atmosphere where airborne dust concentration is high. Various technical aspects of the EDS have investigated by other researchers from the U.S. and around the world. This study was motivated by a very practical technical aspect related to the high voltage sources needed to energize the EDS. That is, these high voltage sources can output a limited current while driving the capacitive load of an EDS device.**

EDS typically uses square wave alternating high voltage. Due to the finite current output from the high voltage source, the actual voltage waveform on the EDS is trapezoidal, with the ramping rate dependent on the high voltage source's current capacity. For real-world applications where the EDS devices' dimensions are large, the voltage source's current capacity can be a limiting factor for the shape of the trapezoid waveform and hence the EDS efficiency. It is therefore necessary to address the effect of voltage rise time, a characteristic of the shape of the trapezoid waveform, on EDS efficiency. In this study, we carried out laboratory experiments to measure the EDS efficiency at constant peak-to-peak voltage while varying the voltage rise time. The voltage amplitude was kept at 6 kVpp, but the current of the high voltage source was limited at 0.2 mA, 1 mA, 10 mA and 40 mA, corresponding to voltage rise time from about 100 ms to a fraction of a millisecond. The EDS was operated in both the single-operation mode and the cyclic-operation mode. The EDS efficiency was found to be essentially the same at current limits 1 mA or greater, or voltage rise time 16 ms or shorter. At current limit of 0.2 mA, or voltage rise time of 100 ms, the EDS efficiency was less than half that at the greater current limit or faster voltage rise time. In the case of cyclic operation, which is more relevant than single operation to real-world applications, the overall EDS dust removal efficiency with the faster voltage rise times was about 33%. The finding of this study shows that voltage sources for EDS applications in terrestrial solar PV power generation should be able to provide sufficiently fast voltage rise time. However, the underlying mechanism of the voltage size time effect on EDS efficiency should be further investigated in future research.