

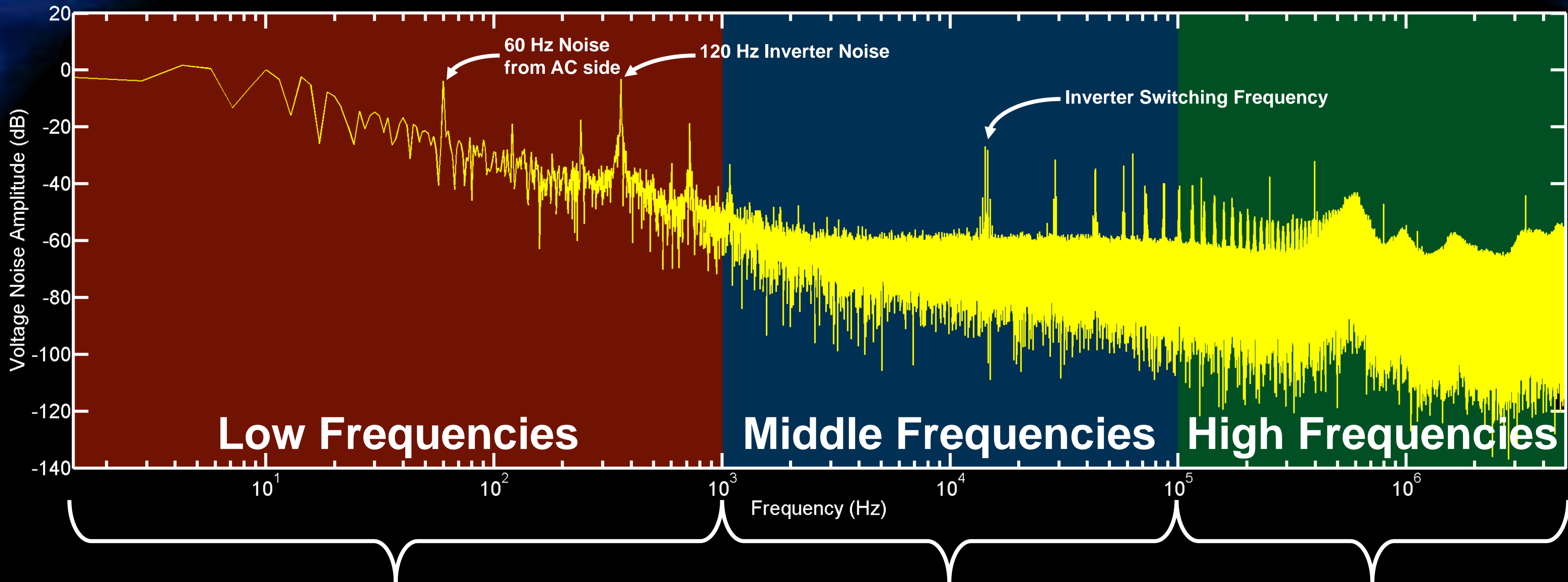
Using PV Module and Line Frequency Response Data to Create Robust Arc Fault Detectors

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Photovoltaic arc faults have caused residential and commercial building fires. Article 690.11 in the United States 2011 National Electrical Code requires new PV systems above 80 V on or penetrating a building to include a listed arc fault protection device to prevent fires.

Arc fault circuit interrupters (AFCIs) entering the market often use electrical frequencies for detection, but their operation is not fully characterized. Sandia National Labs is undergoing a major effort to identify detection difficulties to ensure AFCIs robustly detect arcing conditions while avoiding false trips from noise sources.

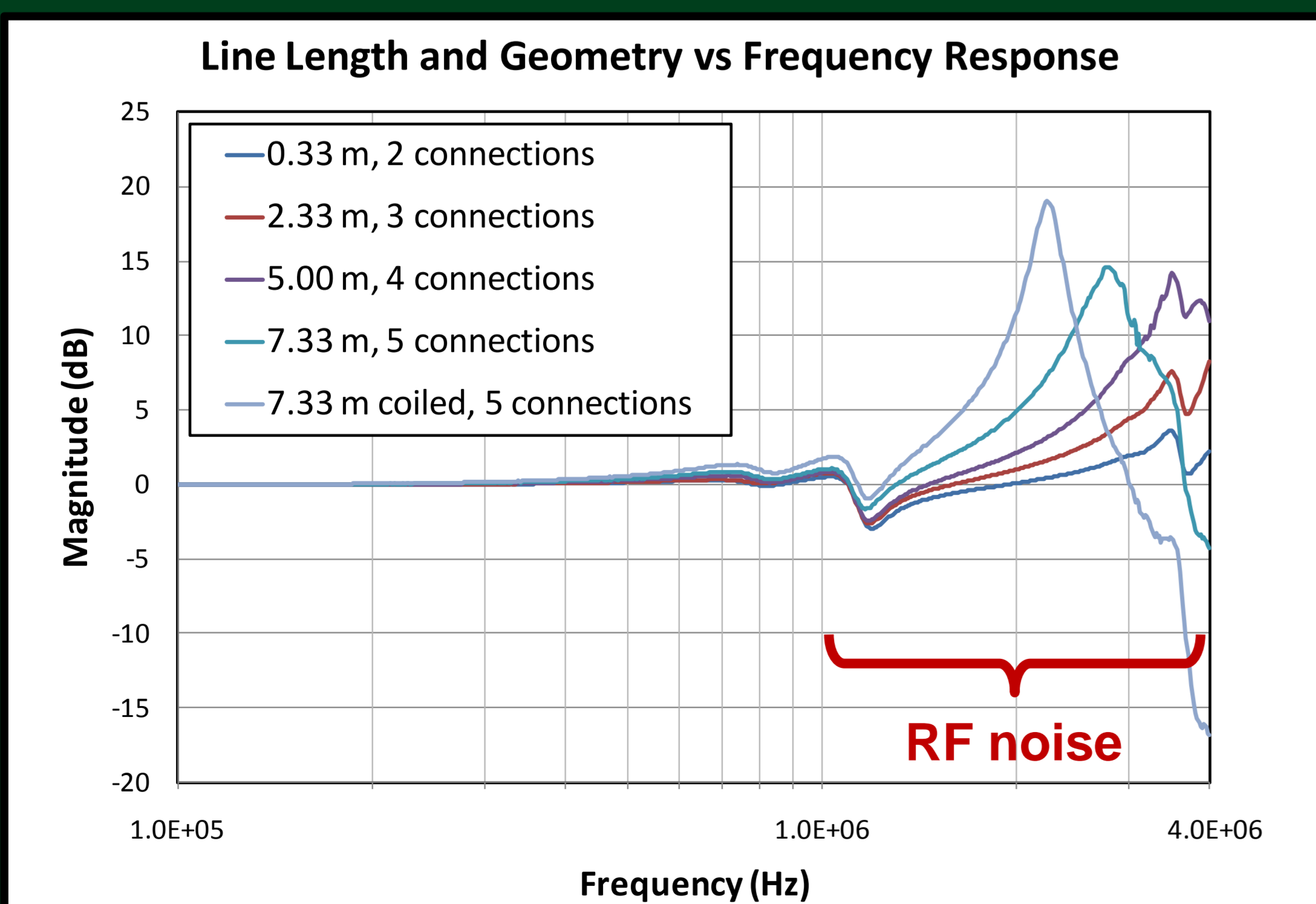
PV String Voltage Spectrum during a Series Arc Fault



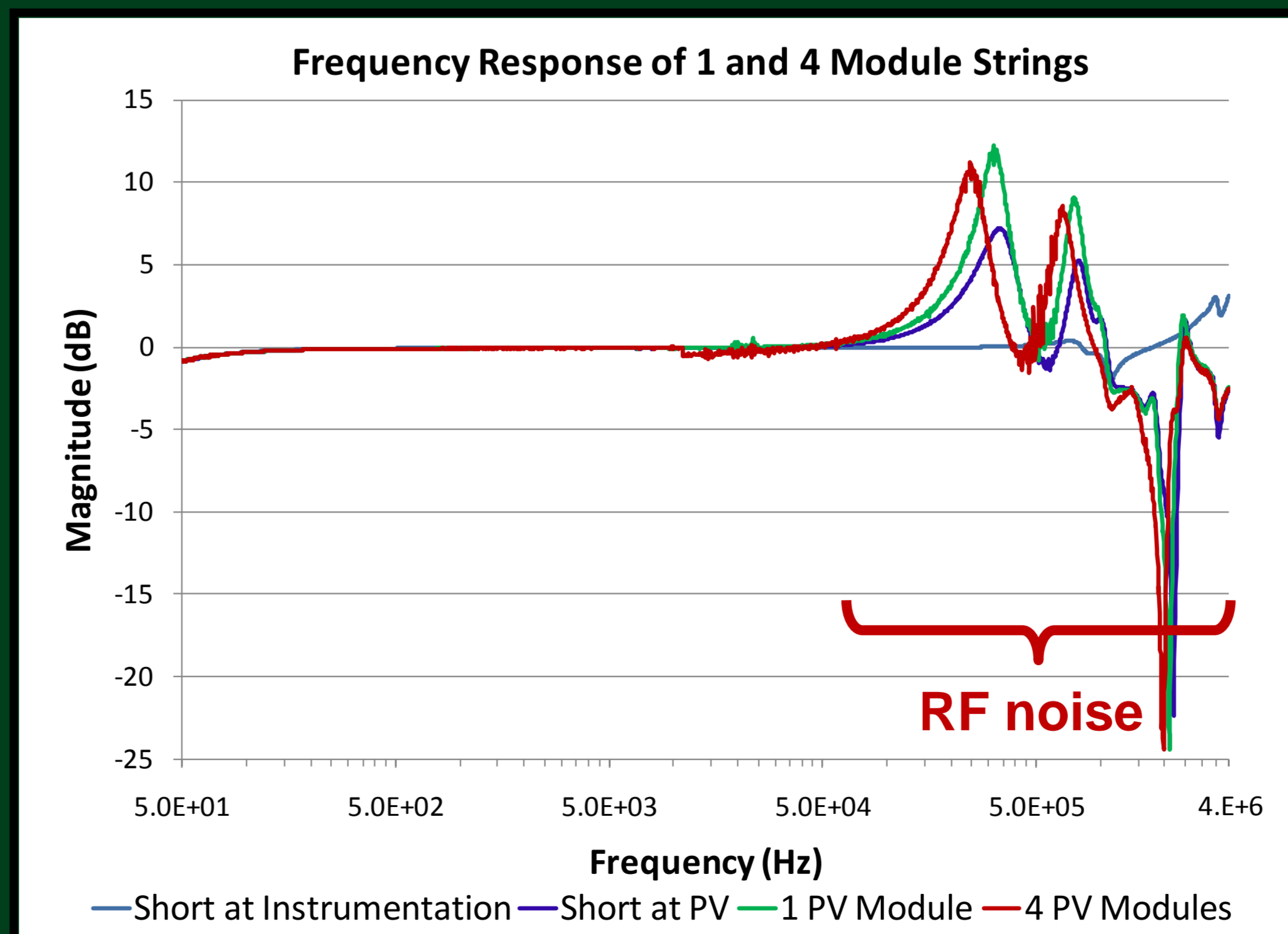
Arc detectors using low frequencies may have problems with nuisance tripping because frequencies below 1000 Hz are produced by solar variability from clouds and swaying foliage, 50/60 Hz noise from the AC side of the inverter, and 120 Hz noise from the power transistors switching in the inverter.

The middle frequencies are the "sweet spot" because PV arc fault signatures increase over baselines most significantly between 1-100 kHz and the only consistent noise source is from inverter switching.

The focus of this paper was to quantify the radio frequency (RF) and antenna effects in PV systems in order to determine the feasibility of high frequency arc fault detection. Irradiance did not affect module frequency response, but the length of unshielded wiring and module type changed the frequency response above 100 kHz. RF noise is caused by crosstalk, reflections at electrical connections, and antenna effects in DC cables and module traces. Since RF effects could cause false trips or mask the arc signature from the AFCI, it is recommended that arc fault circuit interrupters use detection frequencies below 100 kHz.



Frequency responses of different lengths of PV DC conductors. RF and antenna effects exist at frequencies above 1 MHz.



Frequency response of 1 module and a 4 module array with baselines of the instrumentation and instrumentation with 20 m of DC cabling.