INTRODUCTION

• Changes to the National Electrical Code® and emergence of UL 1699B require arc fault detectors in the DC systems of photovoltaic arrays
• Arc fault detectors have been required for years in AC systems and are well developed; DC versions are relatively new, less developed, and more expensive
• Existing arc detection methods include Fourier transform, frequency band analysis, time-domain amplitude monitoring, and analysis of electric field strength dynamics through electromagnetic sensors
• Low-cost, highly effective DC arc fault detectors must be developed to mitigate the hazards and enable the widespread adoption of photovoltaic systems

SIGNAL EXTENSION METHOD

• The complex frequency components of the Fourier half-spectrum of the inverter noise signature are used to reconstruct a time-domain signal:

\[ y[n] = \frac{N_{FFT}}{2} \sum_{m=0}^{N} X[m] \cos(2\pi m/n + \phi[m]) \]  

where \( X[m] \) and \( \phi[m] \) are the magnitude and phase of the FFT result at the \( m \)th frequency bin and \( y[n] \) is the output

SIGNAL EXTENSION CHALLENGES

• Radix-2 FFT requires integer powers of two signal lengths
• Zero-padding is used when the number of samples, \( N \), is less than the next largest power of two
• Signal expansion involves evaluating [1] for \( n > N \)
• After reconstruction, “gaps” appear in the time-domain waveform at multiples of the original signal duration (\( N/f_s \))
• The convergence requirement for the Fourier series is in general impossible to satisfy for all frequencies in a signal composed of an arbitrary number of non-harmonic frequencies

SIGNAL EXTENSION SOLUTION

• Constrain signal length to an integer power of 2

2^{16.68} points 1MHz Reconstructed Signal

FOURIER SPECTRA FROM INVERTER NOISE RECONSTRUCTION

WAVELET ANALYSIS OF 5MHz RECONSTRUCTED SIGNAL

PROBLEM STATEMENT

• Designing a detection evaluation experiment with scientifically repeatable results is difficult because of the lack of predictability and control over the arc characteristics
• The main source of background electrical noise in a PV system is the power electronics (inverter, etc.)
• Different inverters have different noise signatures
• Noise signatures can vary with the operating point
• Arc fault detectors must distinguish between inverter noise and the actual occurrence of an arc

ADD RESEARCH APPROACH

• A library of inverter noise and arc signatures was compiled from real-world measurements
• A technique to synthesize waveforms using these real-world signals was developed to enable systematic design and testing of arc fault detection methods
• A metric called the arc-signal to noise ratio was defined to quantify the ratio of arc to inverter signals

SUMMARY

• We used signal-extension, modification of sampling rates, and combination of arcing signal with background inverter noise to create test signals from real-world data
• These signals can be fed to digital algorithms providing computer simulation of results
• The test signals can also be recreated in hardware for more thorough testing of arc fault-detecting microcontroller prototypes

Damage resulting from an arc fault in the PV array. If left undetected, loss of life could result in addition to property damage. [source]

http://www.greentechmedia.com/articles/read/Putting-Out-The-Solar-Panel-Fire-Threat