

Grid Stability with Photovoltaic Inverters, Storage

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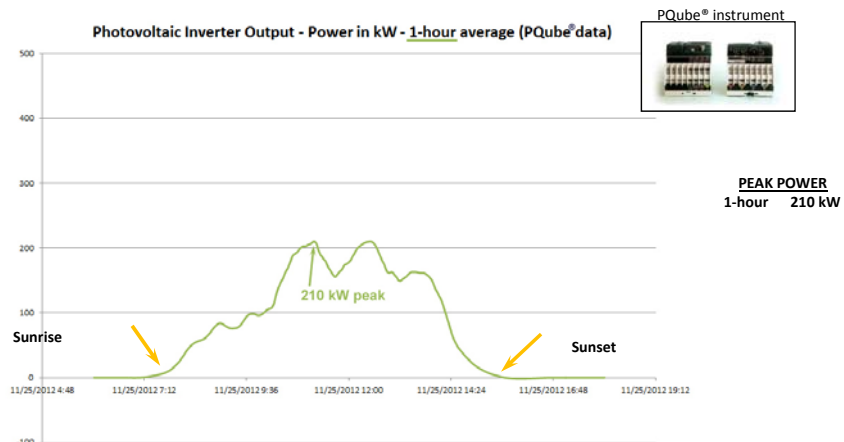
Some real-world data showing why high-resolution measurements are necessary when integrating Photovoltaic Arrays/Inverters into grids...



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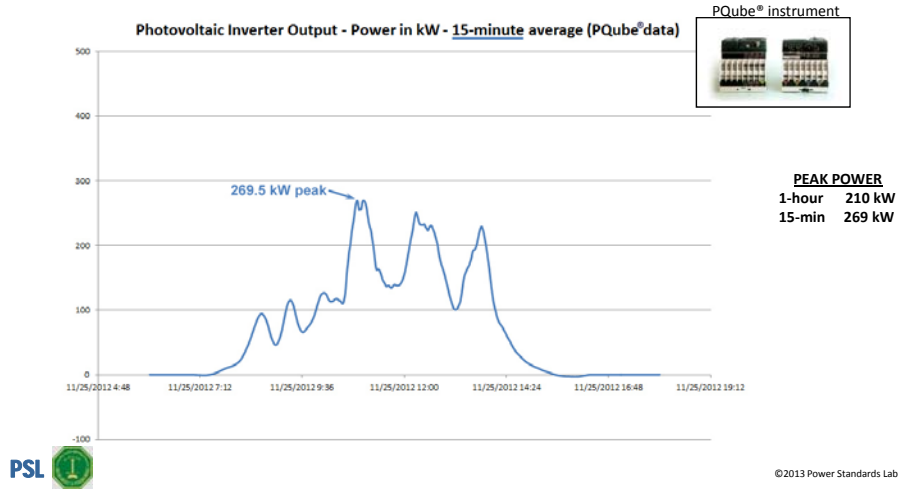
Time scales and grid stability

Photovoltaic integration into a microgrid



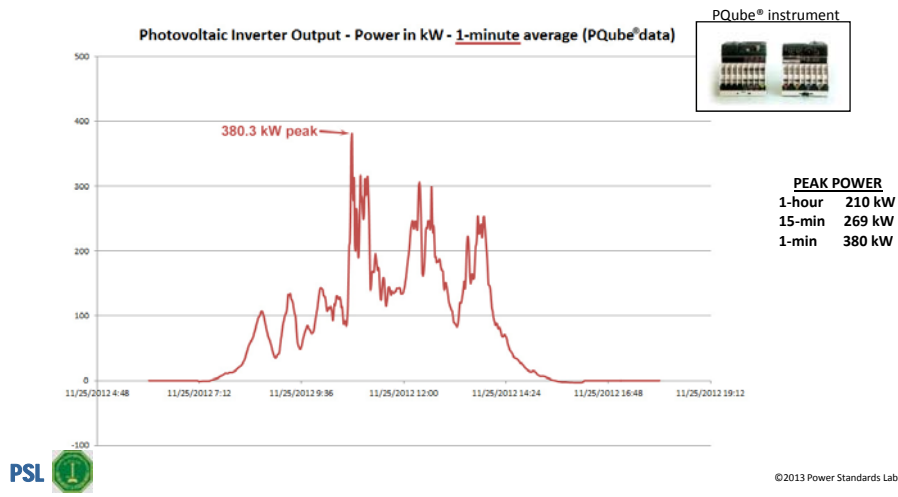
Time scales and grid stability

Photovoltaic integration into a microgrid – same day



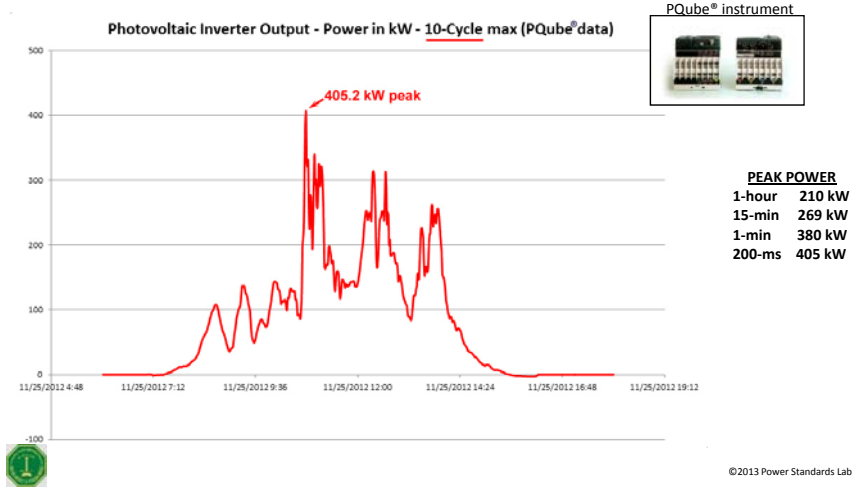
Time scales and grid stability

Photovoltaic integration into a microgrid – same day



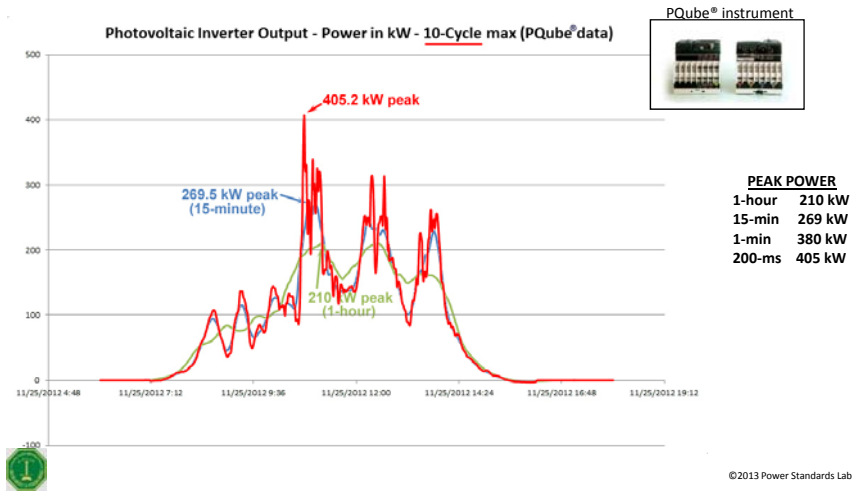
Time scales and grid stability

Photovoltaic integration into a microgrid – same day



Time scales and grid stability

Photovoltaic integration – **high resolution is required!**



Power flow direction

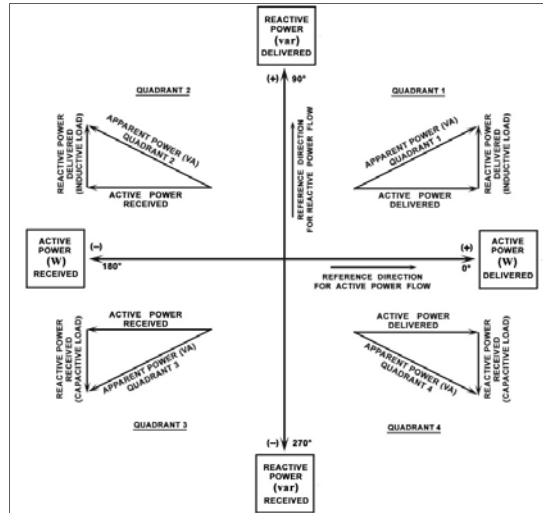


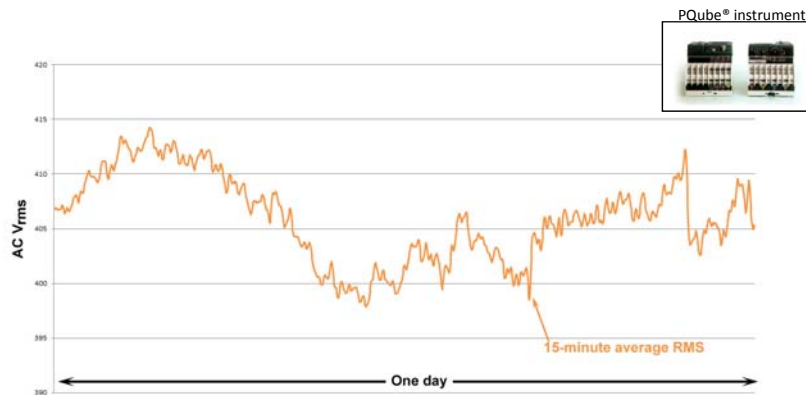
Figure 1 - Four-quadrant power flow directions
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(redrawn by McEachern for clarity, 2012)



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Time scales and grid stability

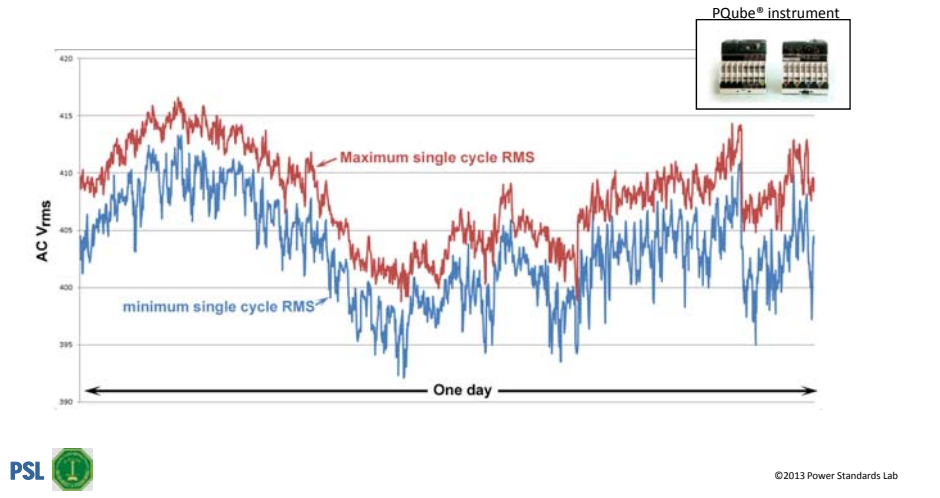
Photovoltaic integration – RMS voltage – 15-minute avg



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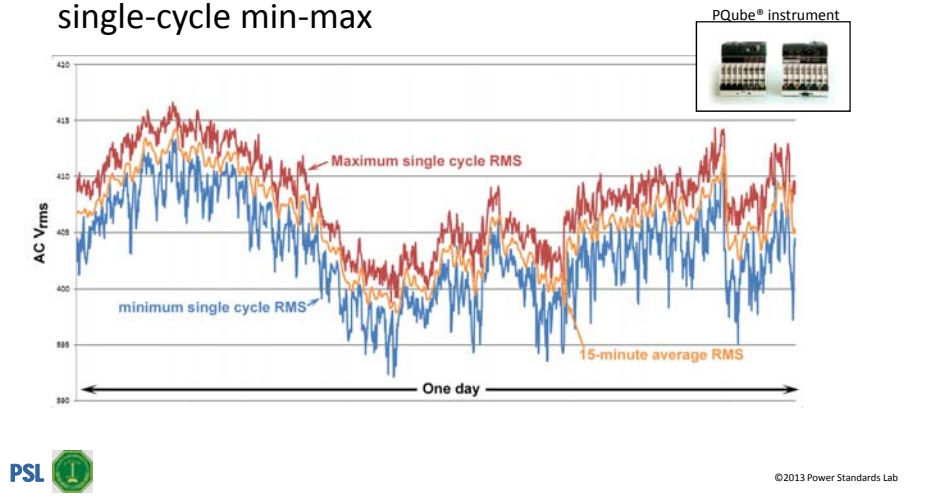
Time scales and grid stability

Photovoltaic integration – RMS voltage – single-cycle



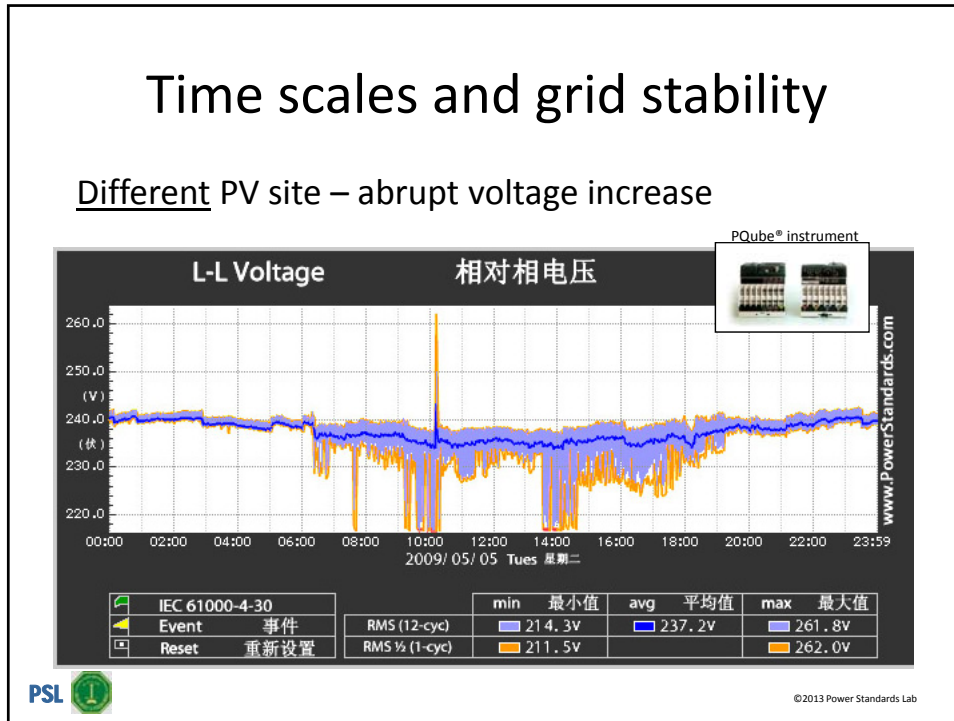
Time scales and grid stability

Photovoltaic integration – RMS voltage – 15-min avg,
single-cycle min-max



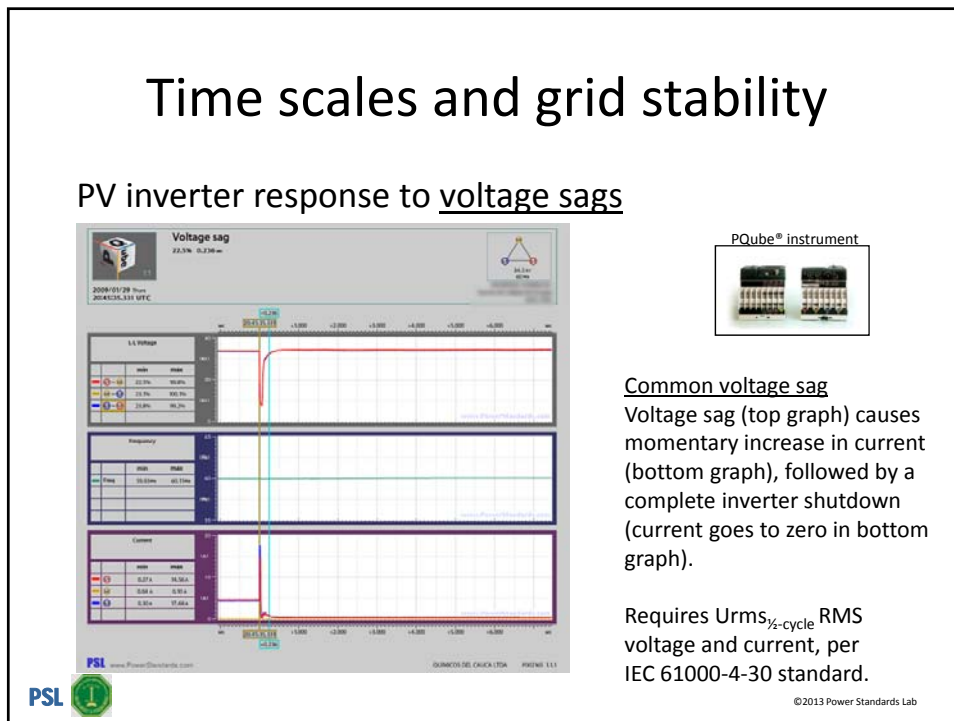
Time scales and grid stability

Different PV site – abrupt voltage increase



Time scales and grid stability

PV inverter response to voltage sags



PV inverters generate 2kHz-150kHz noise...



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Conclusions

Conclusions for PV inverter measurements:

1. Power (watt) measurements must be made at least 5 times per second to detect actual power peaks.
2. For moderately-sized grid-connected PV arrays, voltage measurements in the 1-minute range are sufficient, except:
 - a. Voltage sags can cause PV inverters to trip off-line, and must be meas
3. Require IEC 61000-4-30 Class A measurement standard.



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Time scales and grid stability

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Some sample data showing why high-resolution measurements are necessary when integrating Photovoltaic Arrays/Inverters into grids...



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