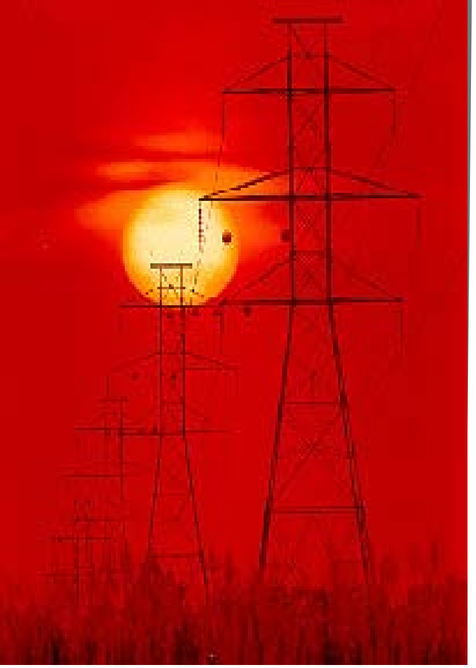

Inverter-based DER Generator and Storage Functions

Information Models using IEC 61850

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Topics

- Why Inverter Functions are Important for 12,000 MW of PV
- Key Inverter Functions and Concepts
- Possible IEEE 1547.8 Approach to Communications
- Possible Californian Approaches to Managing 12,000 MW of PV

Why are Inverters Important?

- ***Inverters, which convert DC to AC, are required for all PV systems***

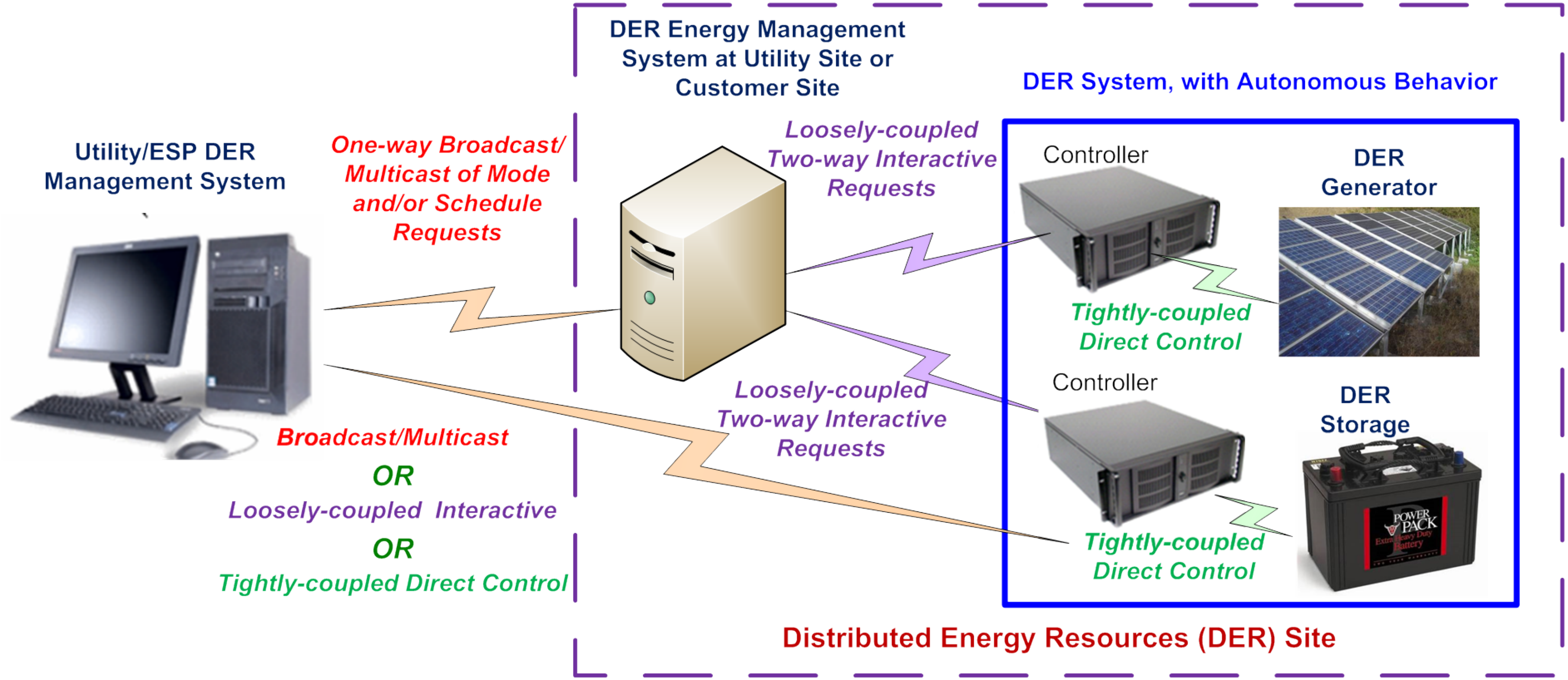
- Inverters are now "**software-driven**" and have some amazing capabilities to shift their output:
  - They can **manipulate Watts (energy) output** (as long as they remain within the capabilities of the PV system)
  - More importantly, they can **manipulate VArs**
  - Can provide capabilities like **volt-var control, frequency-watt control, and dynamic grid support** as part of low voltage ride-through
  - Inverters can **sense local conditions**, such as voltage and frequency, and **respond with autonomous actions**

Why are Inverter Functions Important to California’s 12,000 MW of PV

- Inverters are **smart**
  - Inverters can **autonomously** monitor local conditions and respond with **pre-set reactions**
  - These pre-set reactions will improve power system efficiency and **delay the need for distribution upgrades**
  - These pre-set reactions can help **avoid outages and system black-outs**
  - Inverter manufacturers are already adding these functions for the European market
- Expensive communications between utilities and these inverters are not immediately necessary
  - **Smaller inverters may never need communications**
  - **Medium** inverters may need to respond to **broadcast** commands
  - **Larger** inverters or those on more “sensitive” circuits may need **more interactive communications**

Different Configurations for Managing DER Generation and Storage Systems

Autonomous, Tightly-coupled, Loosely-coupled, and Broadcast/Multicast

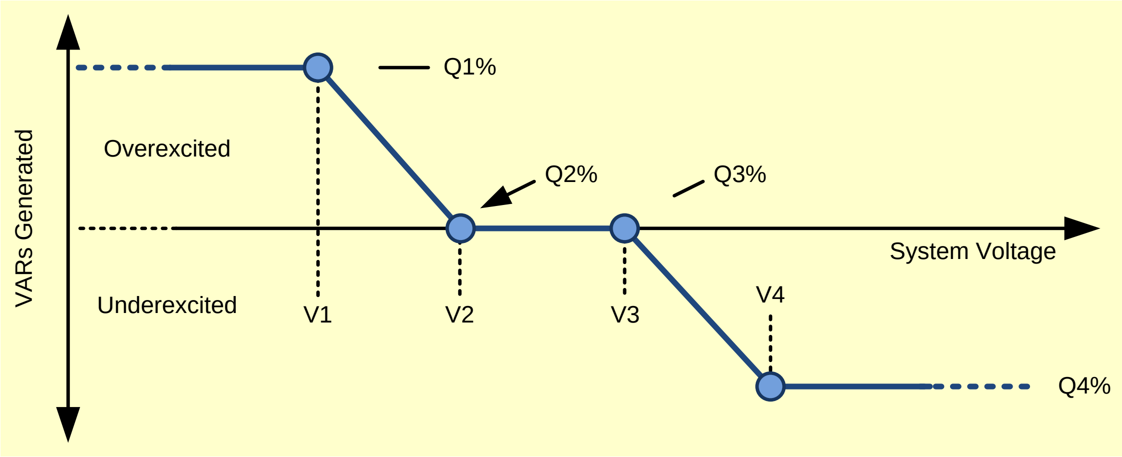


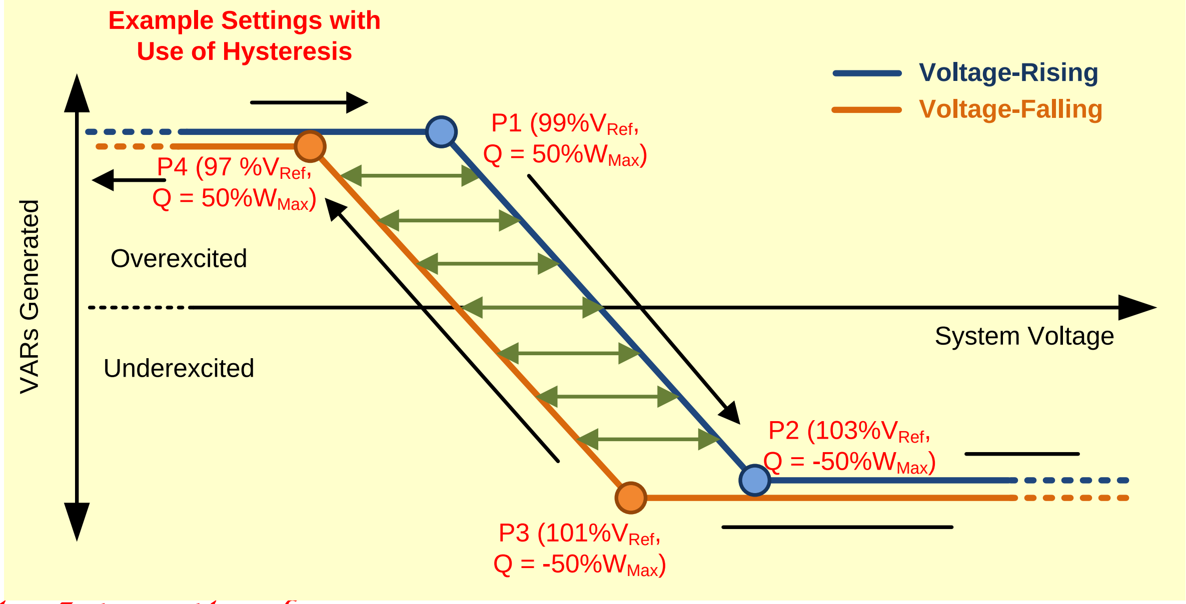
DER Management: Interactions between Components

Functions for Inverter-based DER Generation and Storage Systems

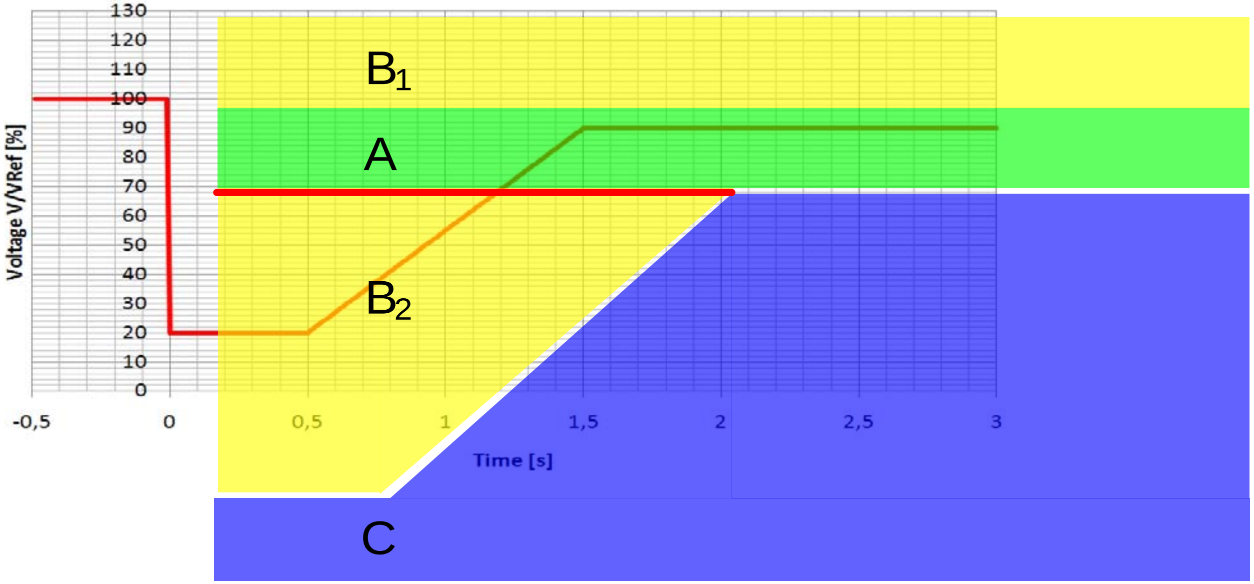
- **Immediate commands** for inverter-based DER functions:
  - Turn on/off
  - Limit maximum output
  - Status and event log information
- ”**Modes**” for pre-established autonomous behaviour:
  - Volt-Var control
  - Frequency-Watt control
  - Volt-Watt control
  - Dynamic grid support during low voltage ride-through
  - Temperature-var control
  - Pricing signal requests
- **Schedules** for hourly, daily, weekly, and/or seasonal actions:
  - Modes
  - Commands
- **IEC 61850-90-7 standard** (almost) exists for these functions
  - Is already being implemented in Europe
  - Already mapped to DNP3, web services, and (soon) Smart Energy Profile

Volt-VAr Modes: Basic and with Hysteresis



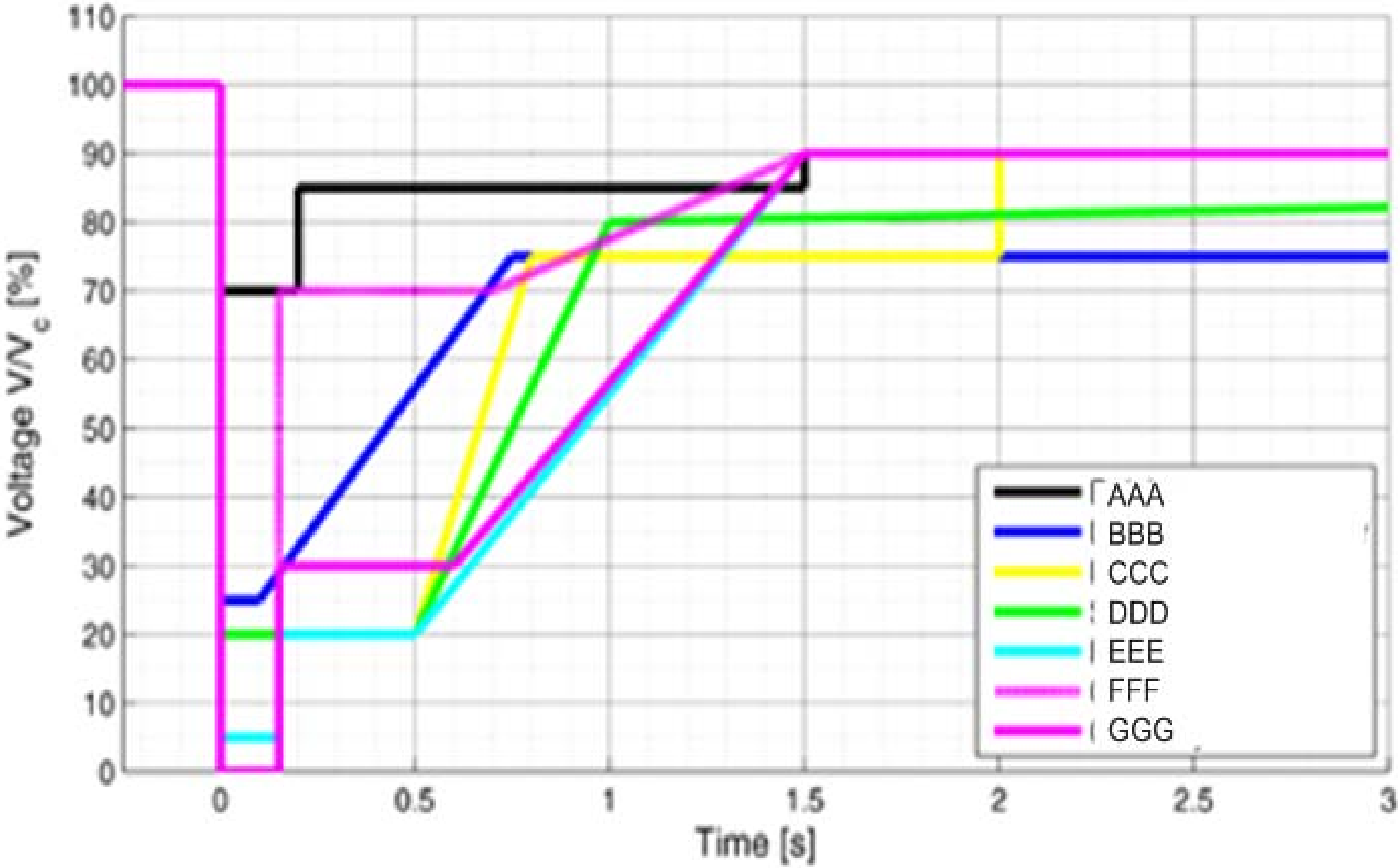


Dynamic Grid Support: Volt/Var Support in B_1 and B_2 Zones during High/Low Voltage Ride-Through



A	Generating unit shall stay connected Operation within this area must not cause instability or separation from the public distribution
B_1	Generating unit shall stay connected Injection of overexcited reactive current to support the grid, until the fault is disconnected
B_2	Generating unit shall stay connected Injection of underexcited reactive current to support the grid, until the fault is disconnected
C	No requirements; generating unit may disconnect or may stay connected

European "Must Stay Connected" Low Voltage Zones

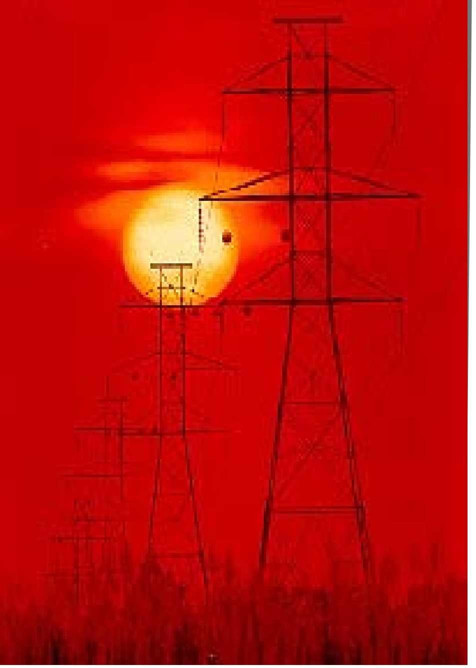


IEEE 1547.8: New Electrical Connectivity Standard for High Penetration of DER

- High penetration of DER will require some additional communications requirements
- Proposed idea is that these DER communications requirements be based on the “sensitivity” of its environment:
  - Size and capabilities of the DER system itself
  - Distribution system configuration and characteristics
  - Location of the DER PCC with respect to the circuit’s configuration
  - Sizes and capabilities of neighboring DER systems
  - Requirements of the transmission system for support from the distribution systems
  - The regulatory and financial environment of the utility, including utility economics, energy infrastructure, legacy systems, etc

Possible Californian Approaches to 12,000 MW of PV

- European approach:
  - Require all inverter-based PV to support **volt-var** and **frequency** management functions **autonomously** within a couple of years
- California could take the same approach in stages:
  - Initially require **autonomous** inverter functions to respond to local conditions via **pre-set** parameters specified by utilities
  - Require inverters to respond to **broadcast or multicast emergency** functions (turn off, limit generation output, increase storage output)
  - Start running **pilot tests and simulations** on autonomous pre-sets to **validate effectiveness** of improving efficiency and increasing reliability
  - Eventually require ability to **remotely upgrade** inverter parameters
  - Require more direct **monitoring and control** of PVs only in "**sensitive**" environments where high PV penetration or weak distribution circuits may impact reliability



Questions?