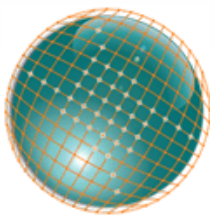
Smart Inverter Communication Workshop

Bob Schmitt

Design Support Manager, SMA America, LLC

Bob.Schmitt@SMA-america.com



4th International Conference on
Integration of Renewable and Distributed Energy Resources
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Albuquerque, NM, USA

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Content of Presentation

Grid Management Support:

- SMA Overview
- NA Projects
- European Initiatives
- PV Generation Characteristics
- Grid Support Functionality

SMA Solar Technology

- Founded in 1981
- Headquarters in Niestetal, Germany
- Publicly Traded on the Frankfurt Exchange
- Fourteen Subsidiaries on Four Continents
- More than 4,000 Employees
- Over 400 R&D Engineers
- Strong Balance Sheet
- Over 50% of Revenue Outside of Germany
- Ranked Best Inverter Company by Photon
- Ranked 2nd Best Solar Company in EU
- Top Awards in Product Innovations

2010 North American Utility Scale Projects

- Tilbury ON, Canada 5 MW 10 SMA 500 kVA
- Jacksonville, FL USA 10 MW 16 SMA 630 kVA
- Wyandot, OH USA 10 MW16 SMA 630 kVA
- San Antonio, TX USA 10 MW 16 SMA 630 kVA
- Alamosa, CO USA 19 MW 38 SMA 500 kVA
- Cimarron, NM USA 30 MW 48 SMA 630 kVA
- Sarnia, ON Canada 60 MW 120 SMA 500 kVA

Recent German energy Policy Announcements

In September 2010 the German Government announced a new aggressive energy policy with the following targets:[1]

- Reducing CO_2 emissions 40% below 1990 levels by 2020 and 80% below 1990 levels by 2050

- Increasing the relative share of renewable energy in gross energy consumption to 18% by 2020, 30% by 2030 and 60% by 2050

- Increasing the national energy efficiency by cutting electrical consumption 50% below 2008 levels by 2050

NA PV Generation Characteristics

• Inadequate Characteristics	• Required Characteristics
➢ Not Dispatched	➢ Ability to Dispatch
➢ Non-Voltage Regulating	➢ Voltage Control Mode
➢ Non-Frequency Responsive	➢ Frequency Response
➢ Unity Power Factor	➢ Power Factor Control
➢ Non-Controlled ramp-rate	➢ Ramp-Rate Control
➢ Trips-off during voltage fluctuations	➢ Ride-Through (LVRT)
➢ No Stability Models	➢ Stability Models

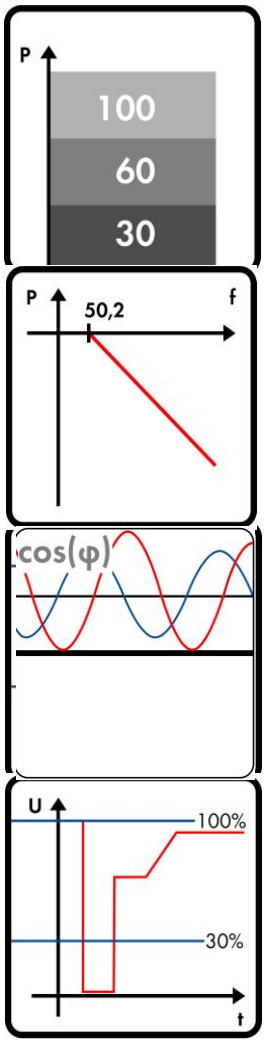
➢Currently PV Market "Regulated" by IEEE1547, UL1741

➢Automatic disconnection from the grid

➢NEC Code Limit of $600V_{DC}$

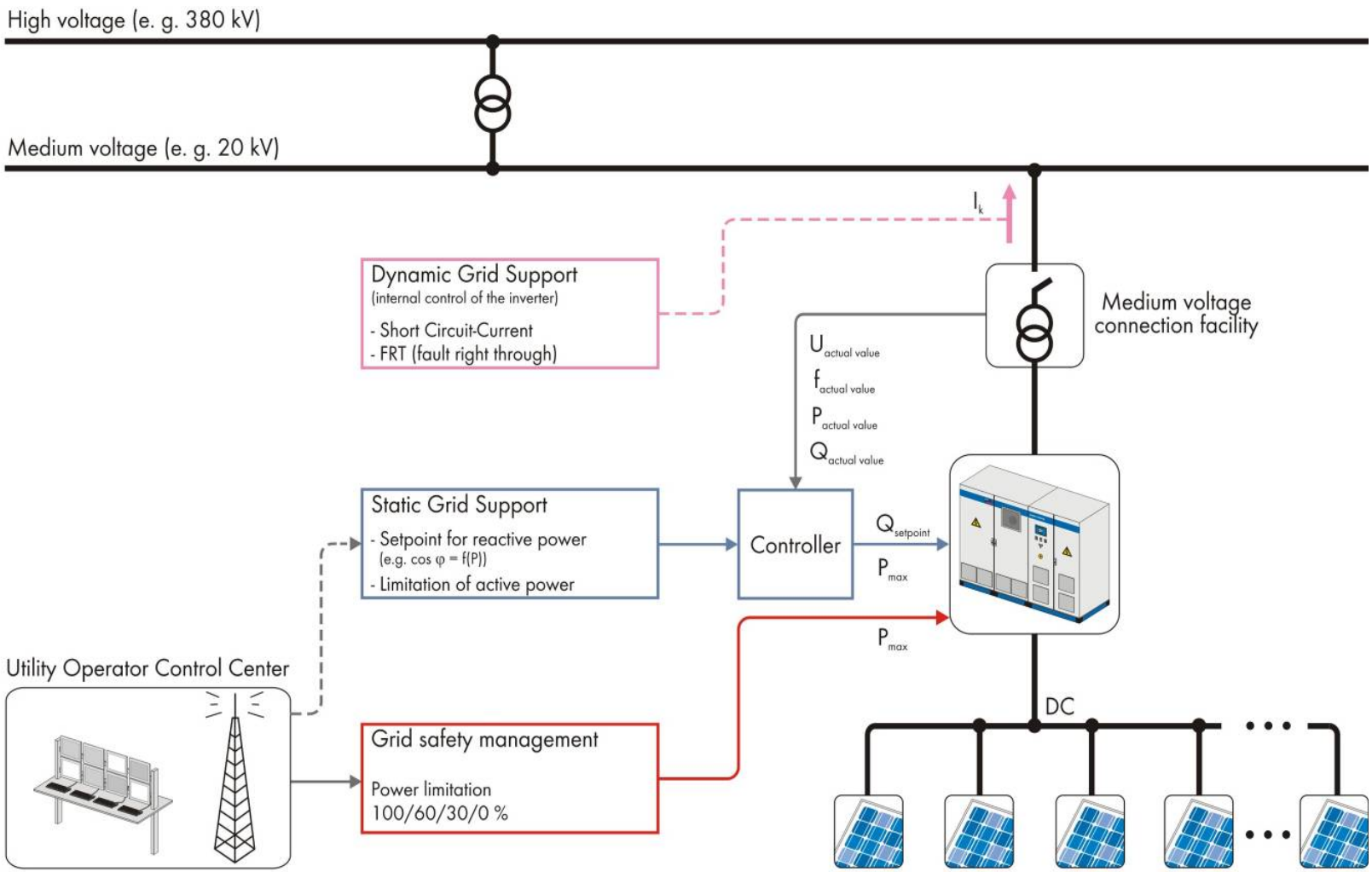
➢$1000V_{DC}$ of interest for large scale utility installations

Grid Support Functionality

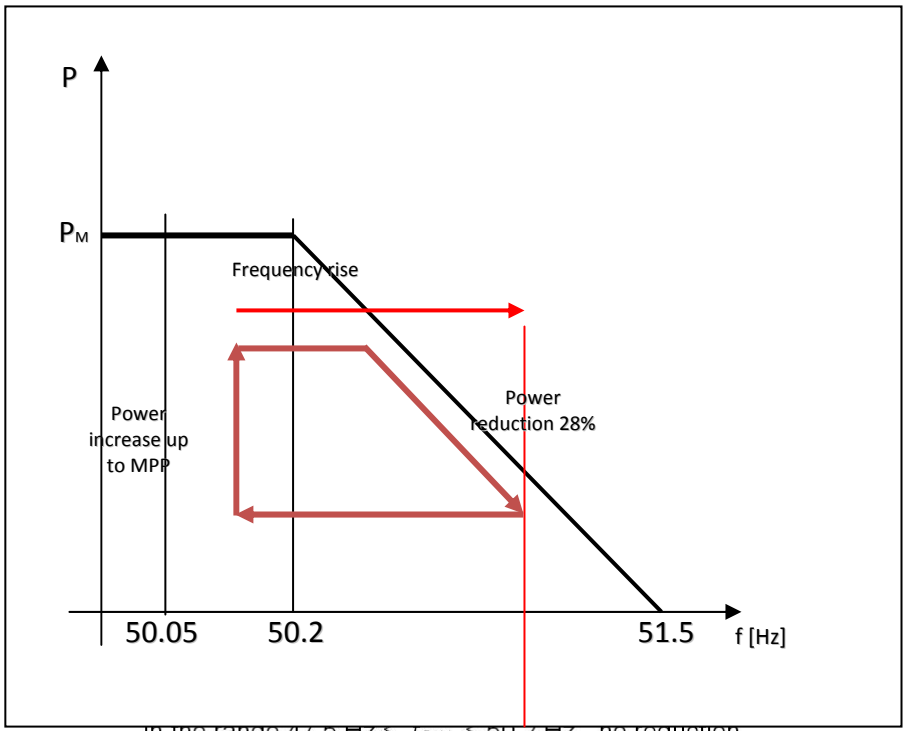


- Ability to control PV generation to a specified % of nominal power rating (Remote Dispatch)
- Ability to automatically reduce active power with frequency deviations (Over Frequency Response)
- Ability to supply/absorb reactive power during PV operation
- Ability to Control Power Factor (PF Control Mode)

Simplified Control Scheme



Grid Support: Over Frequency Response



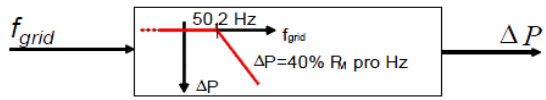
In the range 47,5 Hz ≤ f_{Grid} ≤ 51,2 Hz no reduction

At f_{Grid} ≤ 47,5 Hz and f_{Grid} ≥ 51,2 Hz disconnection from the grid

- Reduction of active power dependent on Grid Frequency.
  - in Case of Grid Failures
  - in Case of Power Surplus
  - to avoid Grid Instabilities

4% active power reduction / 0.1Hz

Configurable for 60Hz and various % slopes



$$\Delta P = 20\ P_M \frac{50{,}2\ Hz - f_{grid}}{50\ Hz} \quad \text{when } 50{,}2\ Hz \geq f_{grid} \leq 51{,}5\ Hz$$

P_M power currently available

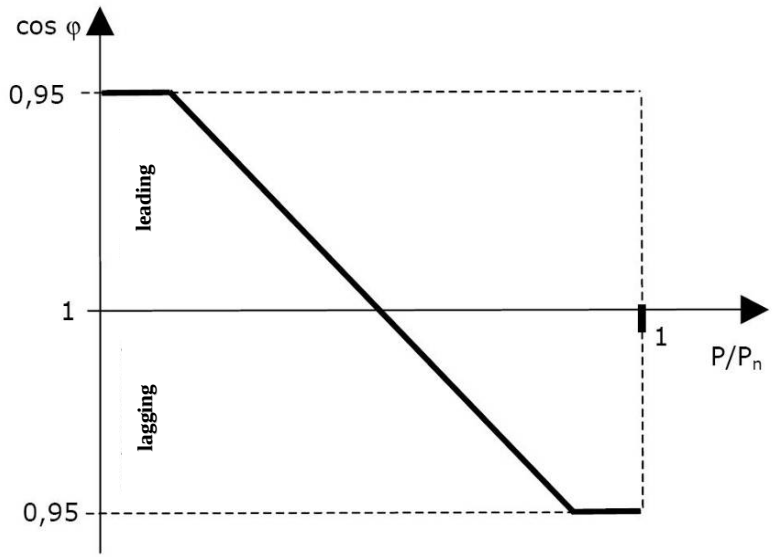
ΔP power reduction

f_{Netz} grid frequency

In the range 47,5 Hz ≤ f_{grid} ≤ 50,2 Hz no restriction

When f_{grid} ≤ 47,5 and f_{Netz} ≥ 51,5 Hz disconnection from grid

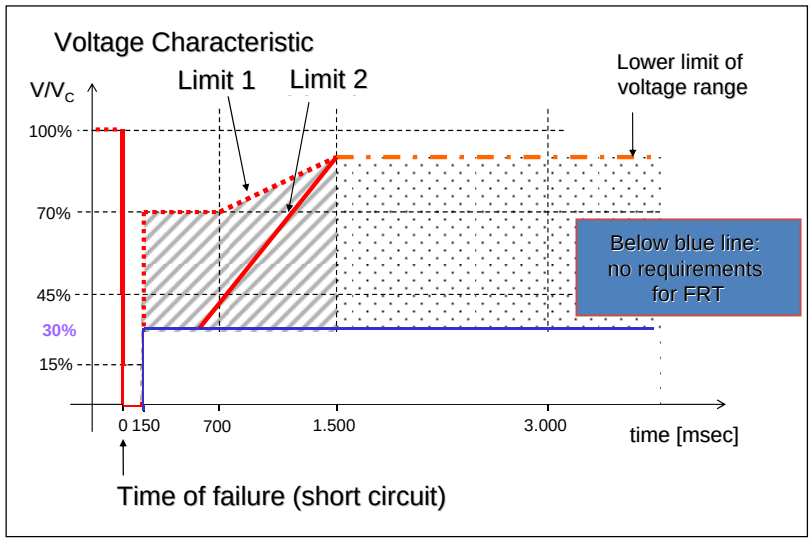
Reactive Power Requirements



- BDEW PF Requirement: 0.95 lagging to 0.95 leading at point of interconnection

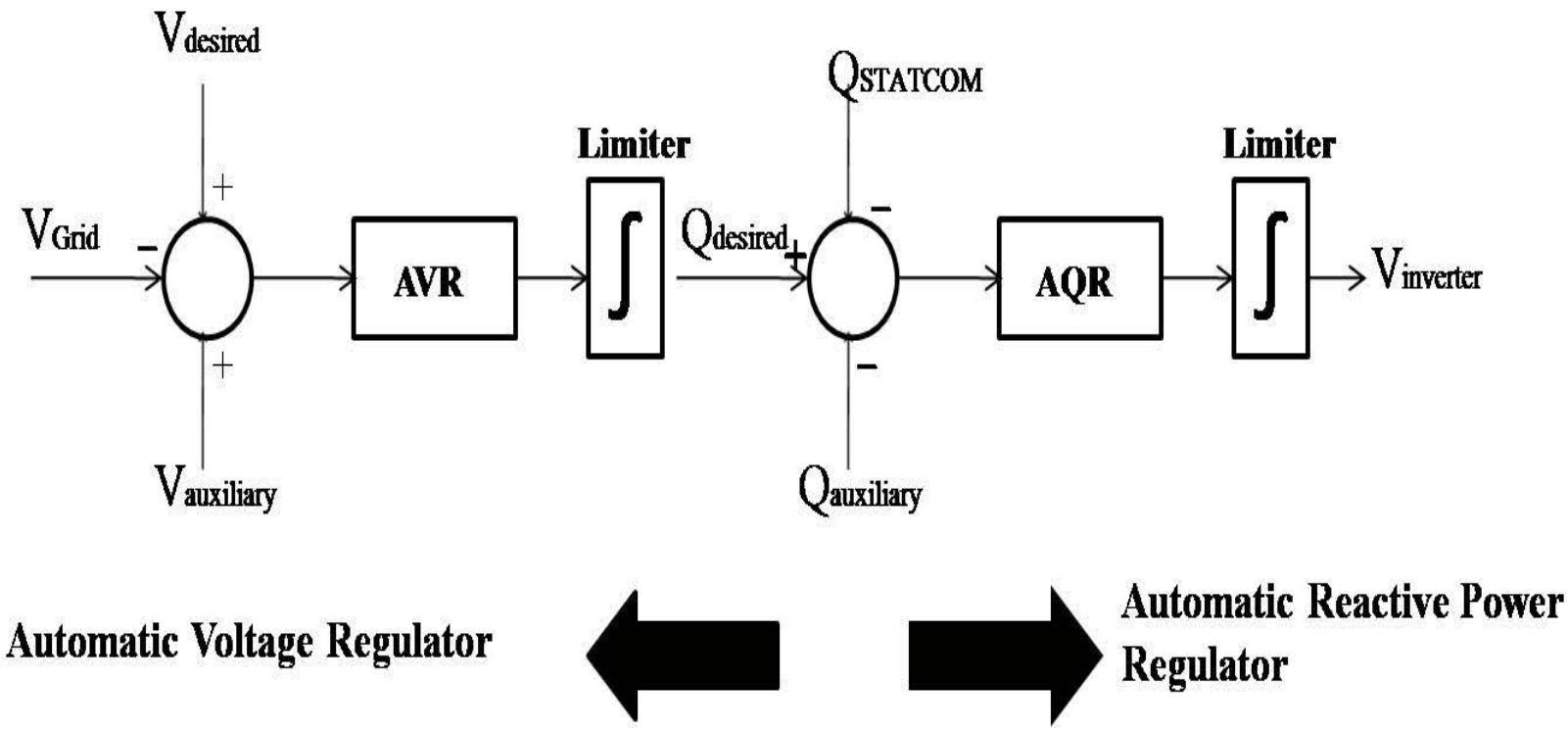
- Objective: Maintain stable grid voltage
  - Static (or fixed) power factor specified by utility
  - Dynamic reactive power on demand remotely controlled by utility
  - Dynamic reactive power depending on grid voltage
  - Dynamic power factor according to a pre-defined schedule
  - SMA Power Factor Range at Full Rated Power 0.9 Lag/Lead

Low Voltage Ride Through



- Objective: Stay connected during HV grid disturbances in a manner similar to FERC Order 661-A. Why? To avoid simultaneous shutdown of generation sources.
- Required performance:
- Voltage dips to "0" at utility interconnection point (HV side of the transformer)
- Inverter must stay connected during a grid failure for 150 ms (7.5 cycles for 50Hz systems)
- If within 150 ms voltage is back above Limit 1: *stable operation*
- If after 150 ms voltage stays below Limit 2 (30% of V_{nom}): *May disconnect from the grid*
- If voltage between Limit 1 and Limit 2, then recovery behaviour to be defined by utility interconnected to.

Automatic Voltage Control (AVR)



SOLAR TECHNOLOGY

Thank You

Bob Schmitt
Bob.Schmitt@SMA-America.com
(office) 916-635-0870