Adaptive Control Strategies and Communications for Utility Integration of Photovoltaic Solar Sites

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Rising Levels of DER

- Utility and commercial installations leading growth
- Contributors to growth
  - 30 states have renewable energy portfolio standards (RPSs)
  - Cost per watt for PV installations continues to drop
  - Net metering laws allow customers to offset energy consumption

Evaluating Current Interconnection Standard

- IEEE 1547: Standard for Interconnecting Distributed Resources With Electric Power Systems
- Key limitations
  - Prohibits voltage regulation
  - Prohibits frequency regulation
  - Ceases to energize EPS during faults

Progressing Toward New Paradigm

- Standards
  - IEEE 1547a amends IEEE 1547
  - CPUC Rule 21 is being updated
- Reasons for change
  - Significant penetration of DER expected in future
  - Advanced power electronics devices can contribute to EPS stability
  - Installation upgrades are costly

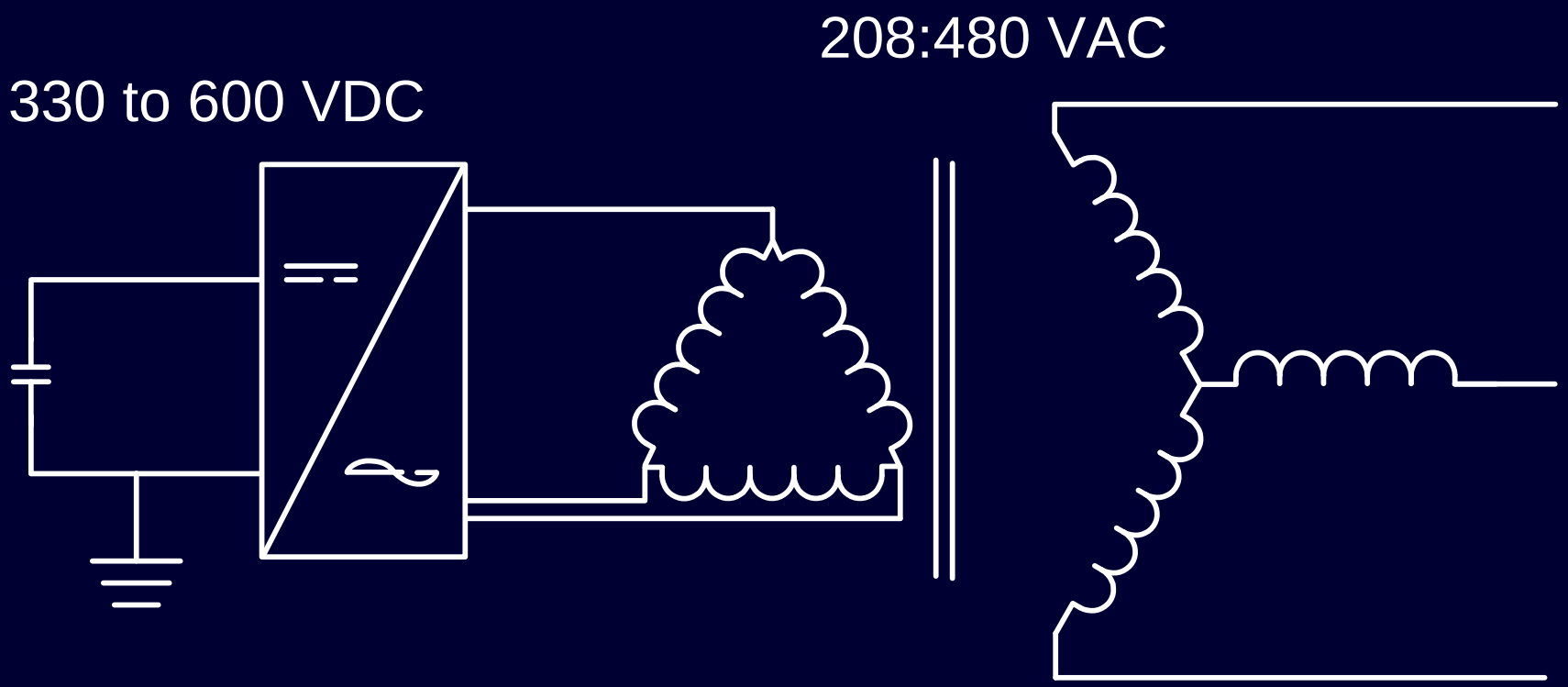
Building Infrastructure to Support DER Applications

Inverter Control Functions

Communications Networks

Infrastructure

Inverter Control Functions Review



Avoid Demand Charge With Fixed Power Factor and VAR Output

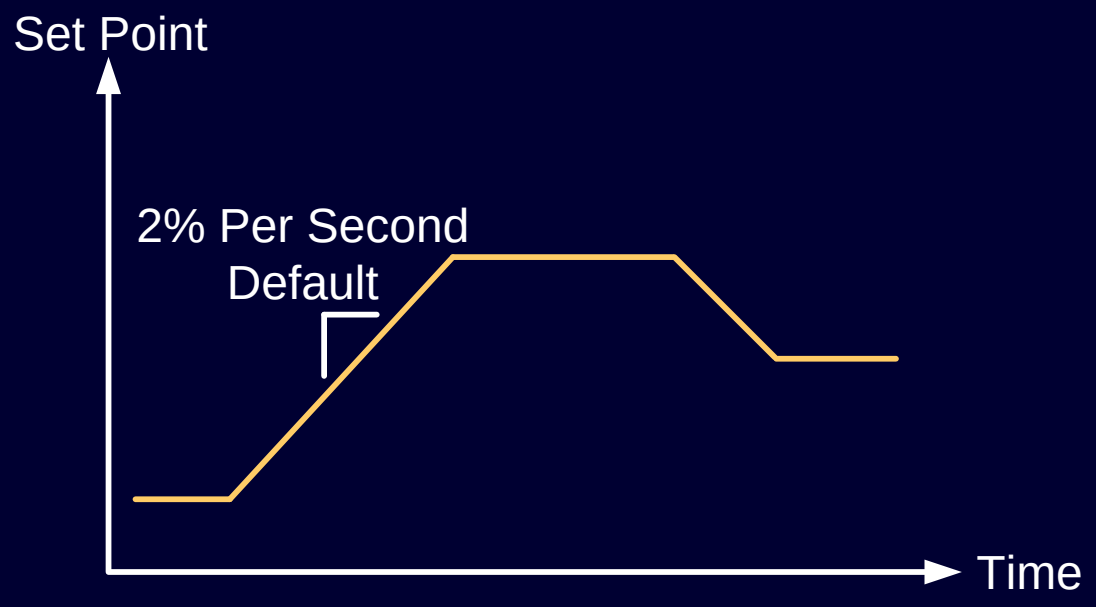
- Identify loads operating with poor PF
- Determine proper mode
- Offset with fixed VAR output or fixed PF
- Replace effect of capacitor bank with fixed VAR mode

Set Real Power in Curtailment Mode

- Inverters are controlled at fixed power output
- Output is set below nameplate capacity
- Breakers maintain connection on loss of load

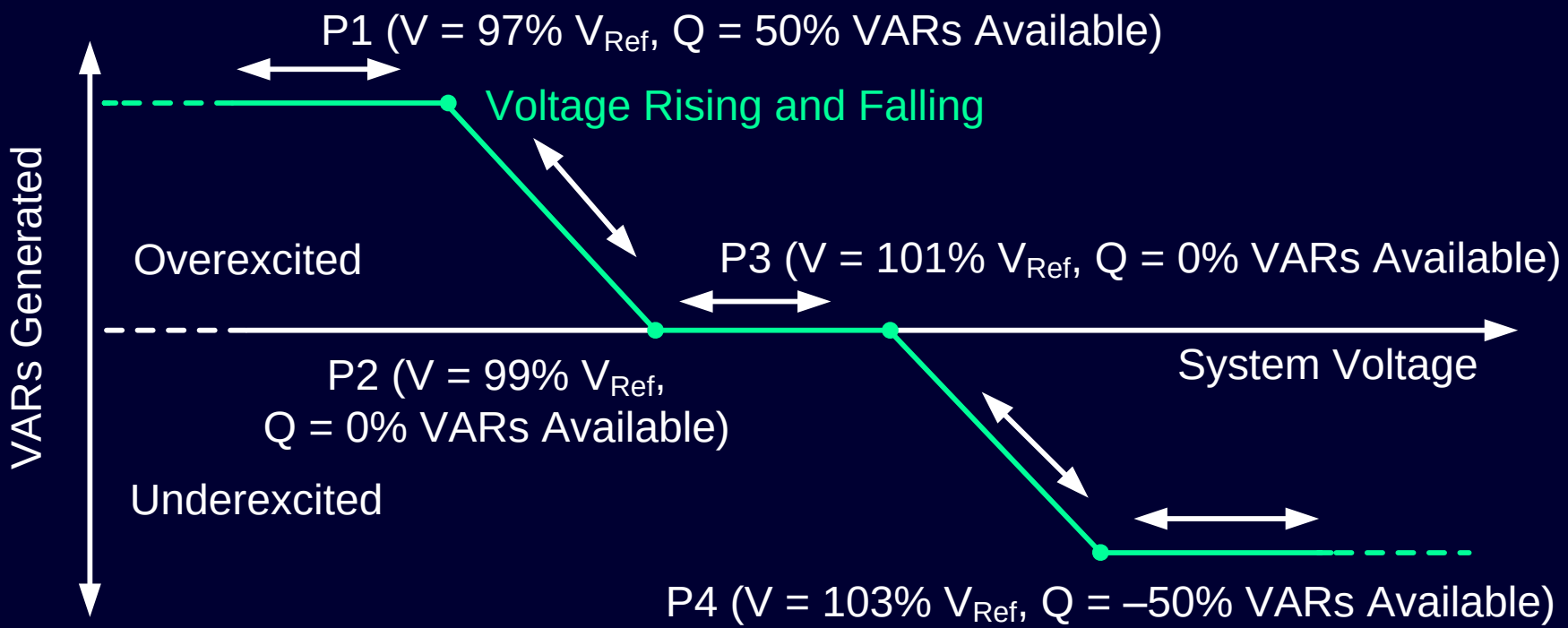
Minimize Disruptions With Ramped Output

- Multiple DER systems cause disturbances
- Ramp rates smooth transitions
- Ramped outputs used for normal transition and start / stop



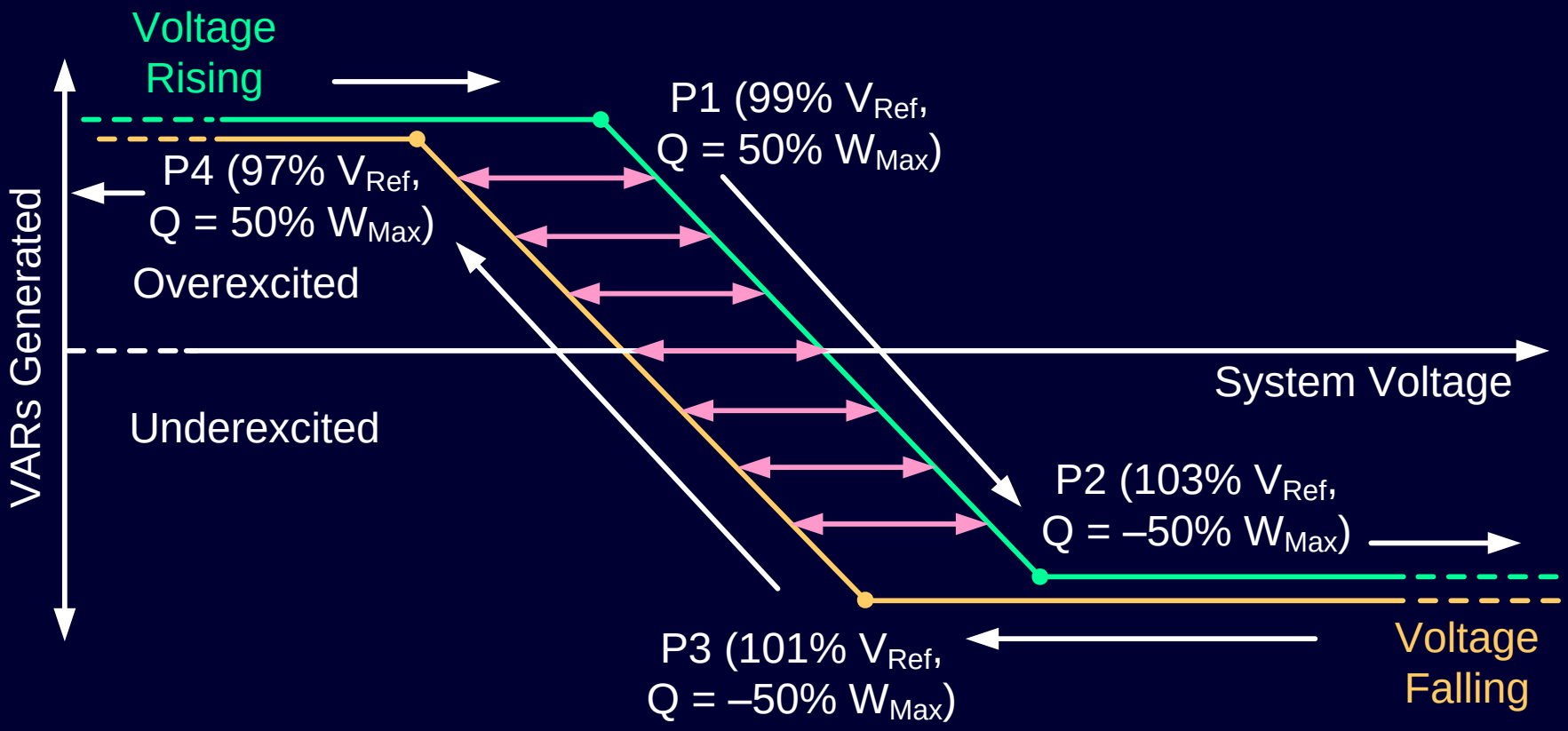
Voltage Control With Volt / VAR Mode

Example Settings for Providing Percent of Available VARs



Voltage Control With Volt / VAR Mode

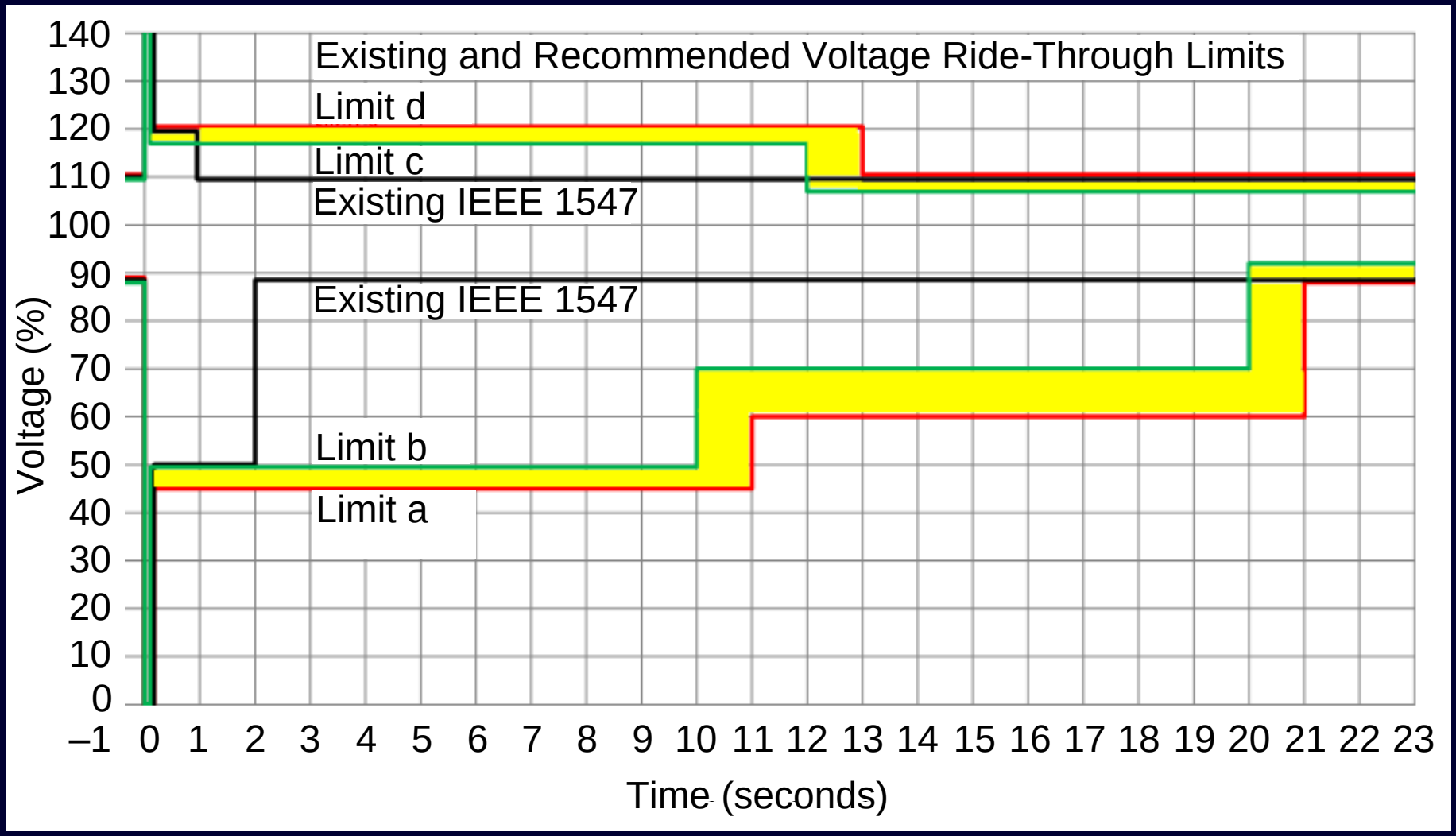
Example Settings With Use of Hysteresis



Respond to Frequency Events With Watt-Frequency Mode

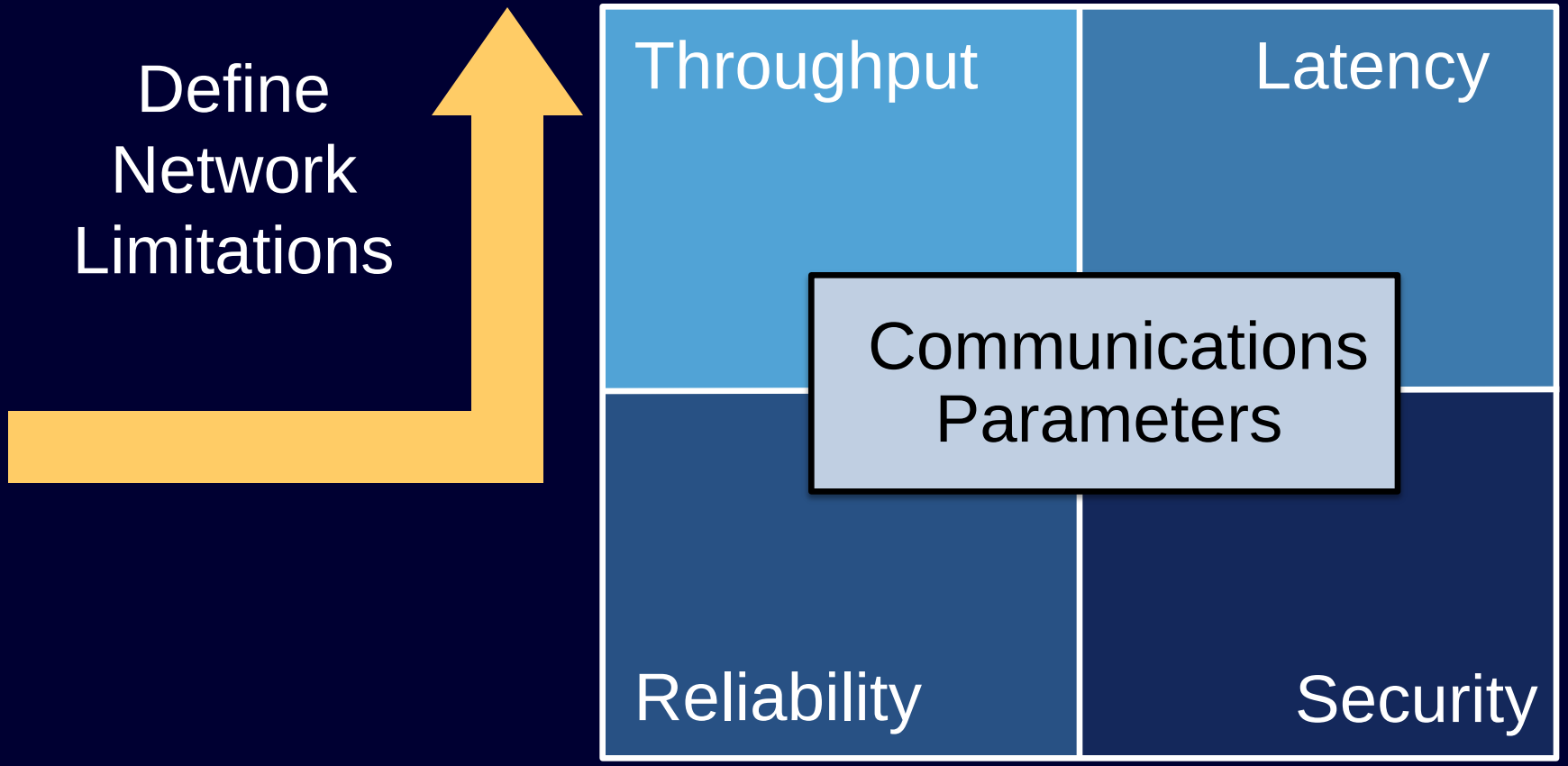
- Monitors for frequency variations
- Manages real power output upon event
- Functions similarly to volt / VAR mode

Voltage and Frequency Ride Through



Moving Data From Source to Destination Communications Networks

Design for Interoperability, Extensibility



Design for Interoperability

- Ability for one or more devices to exchange information without special effort
- Starts with common standards
  - Data objects
  - Protocols
  - Access methods

Design for Extensibility

- System must be able to accommodate future technological advancements
- DER installations expected to have more than 20-year life
- Future applications?

Defining Network Performance Throughput

- Throughput is amount of information transmitted through a network (bps)
- Goodput is amount of useful information that reaches destination application

Defining Network Performance Latency

- Accounts for time it takes to move packet from one point to another
- Determines which types of applications are recommended

Defining Network Performance Reliability

Every Dropped Packet Is a Near Miss

- Software malfunction
- Hardware malfunction
- Maintenance downtime
- Network reconfiguration

Defining Network Performance Security

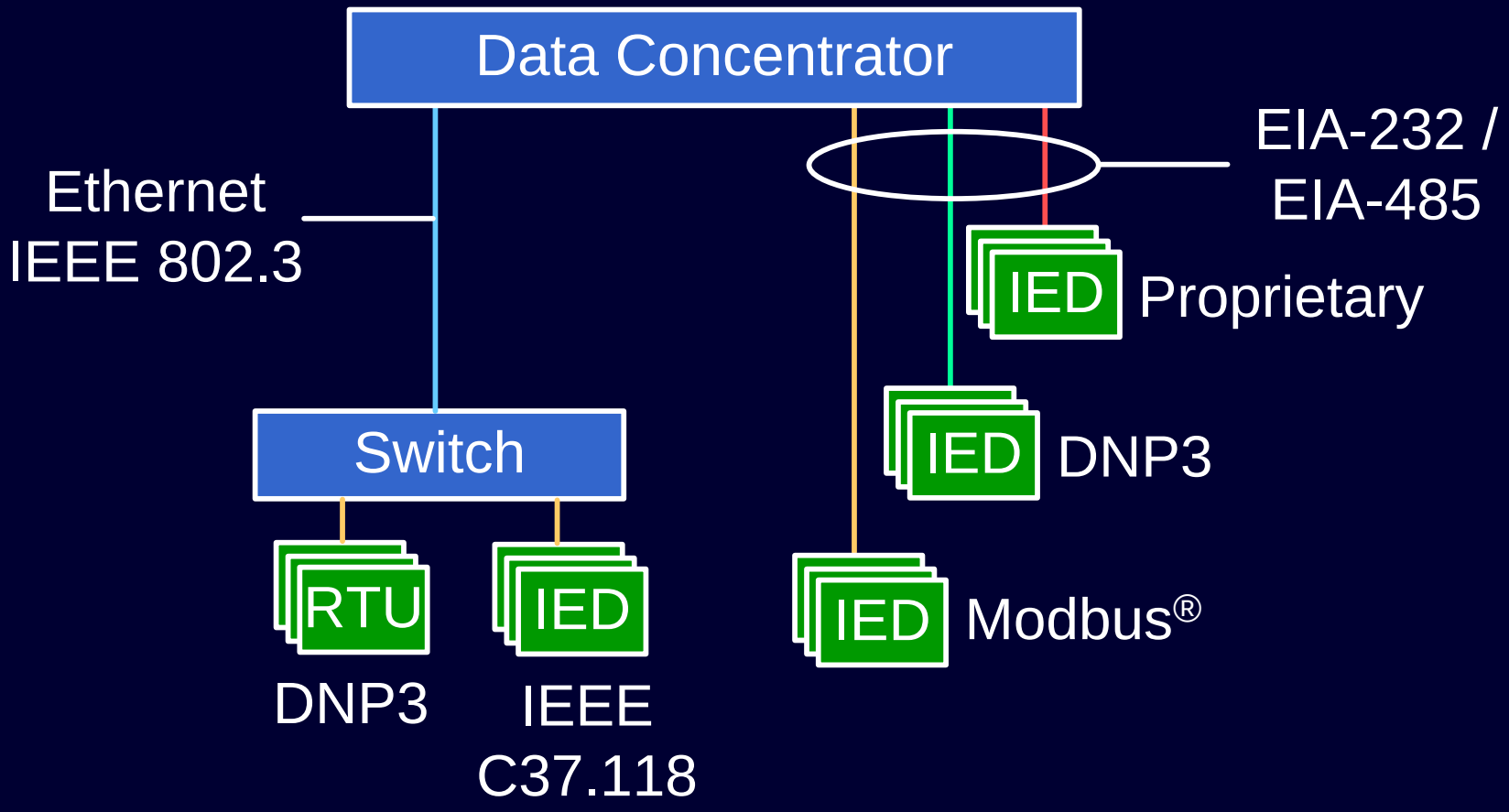
- Protect against unauthorized intrusions
- Block attempts to view and collect application data
- Prevent disruptions to normal communication



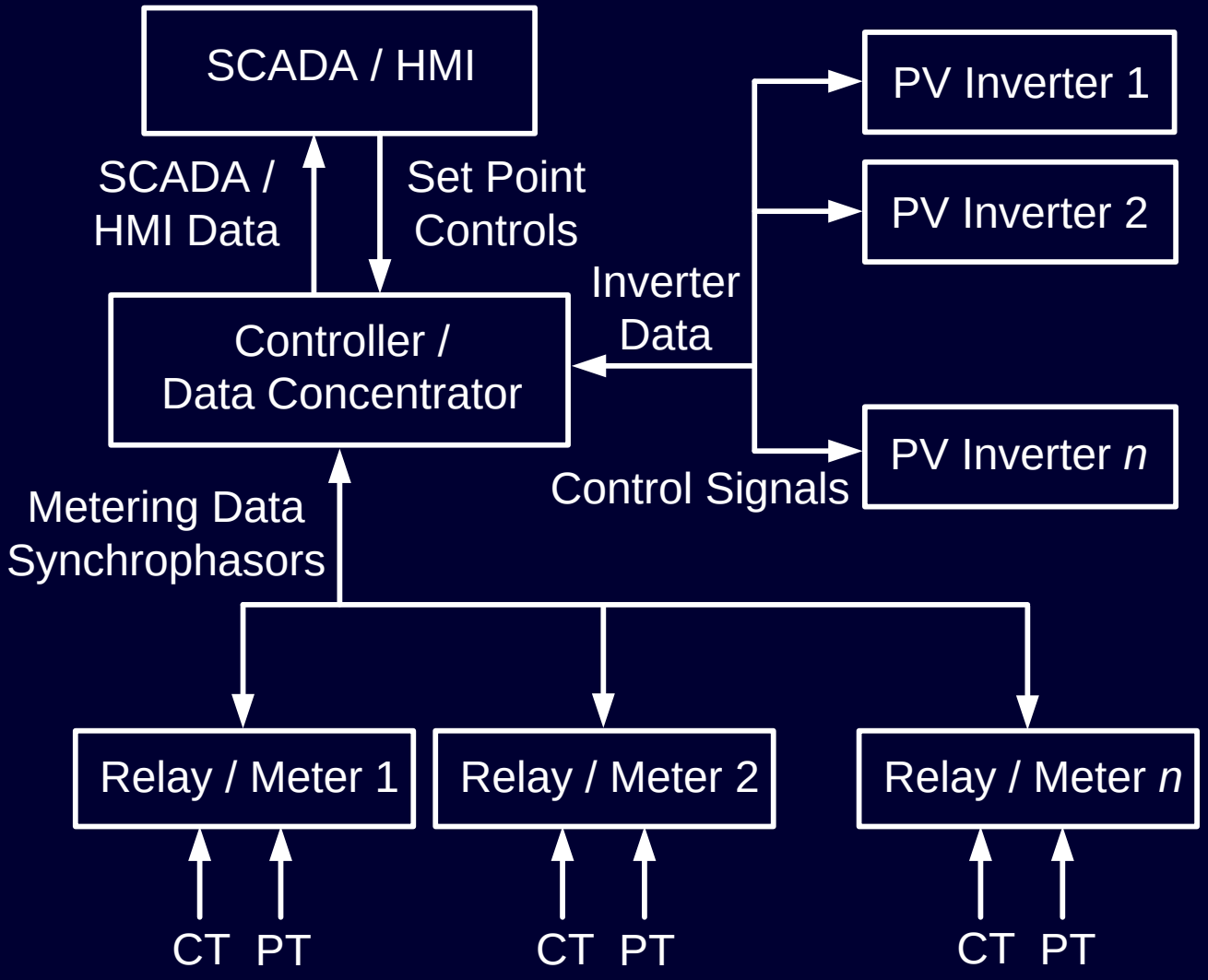
Understand Wide-Area Network Capabilities

Network Criteria	TDM (SONET / SDH)	Packet (Ethernet)
Latency	Low	High
Deterministic	Yes	No
Bandwidth	Dedicated	Shared

Integrating Technologies in a Local-Area Network



Data Concentrator Performs Data Aggregation

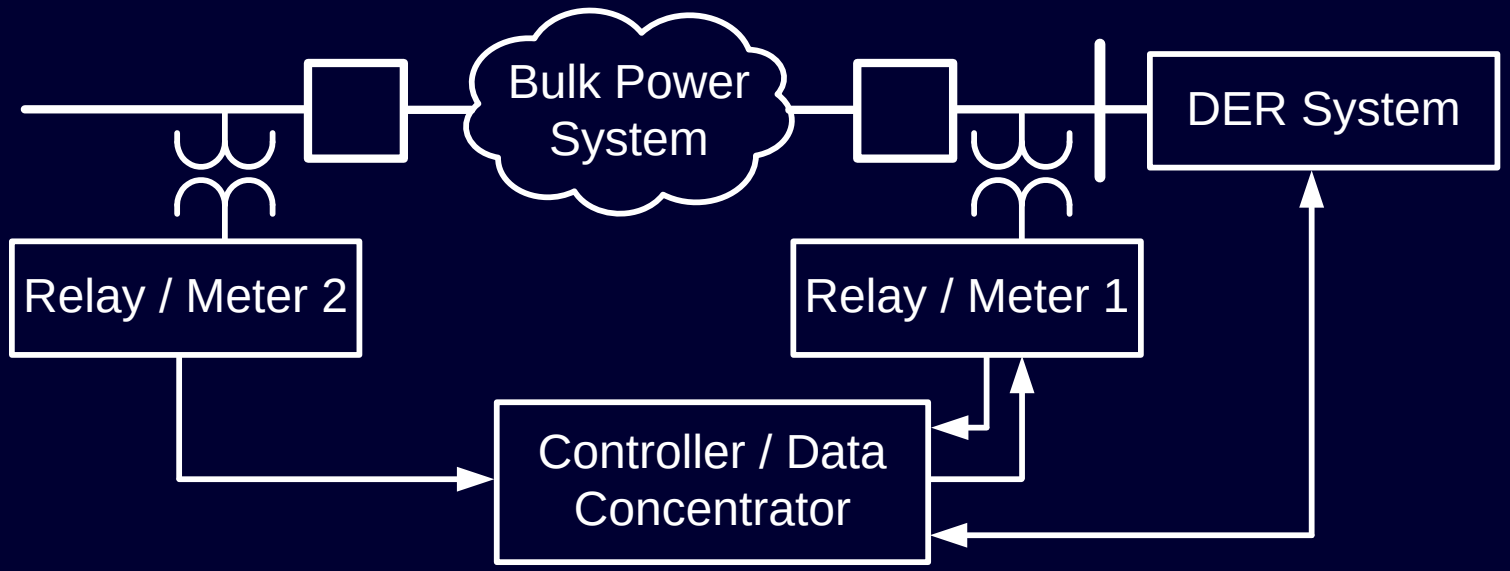


Enabling Control With Inverters

- Inverters provide reporting and control
- Modbus is commonly deployed
- Market is driving more integration
- IEC 61850 and DNP3 communities are engaged

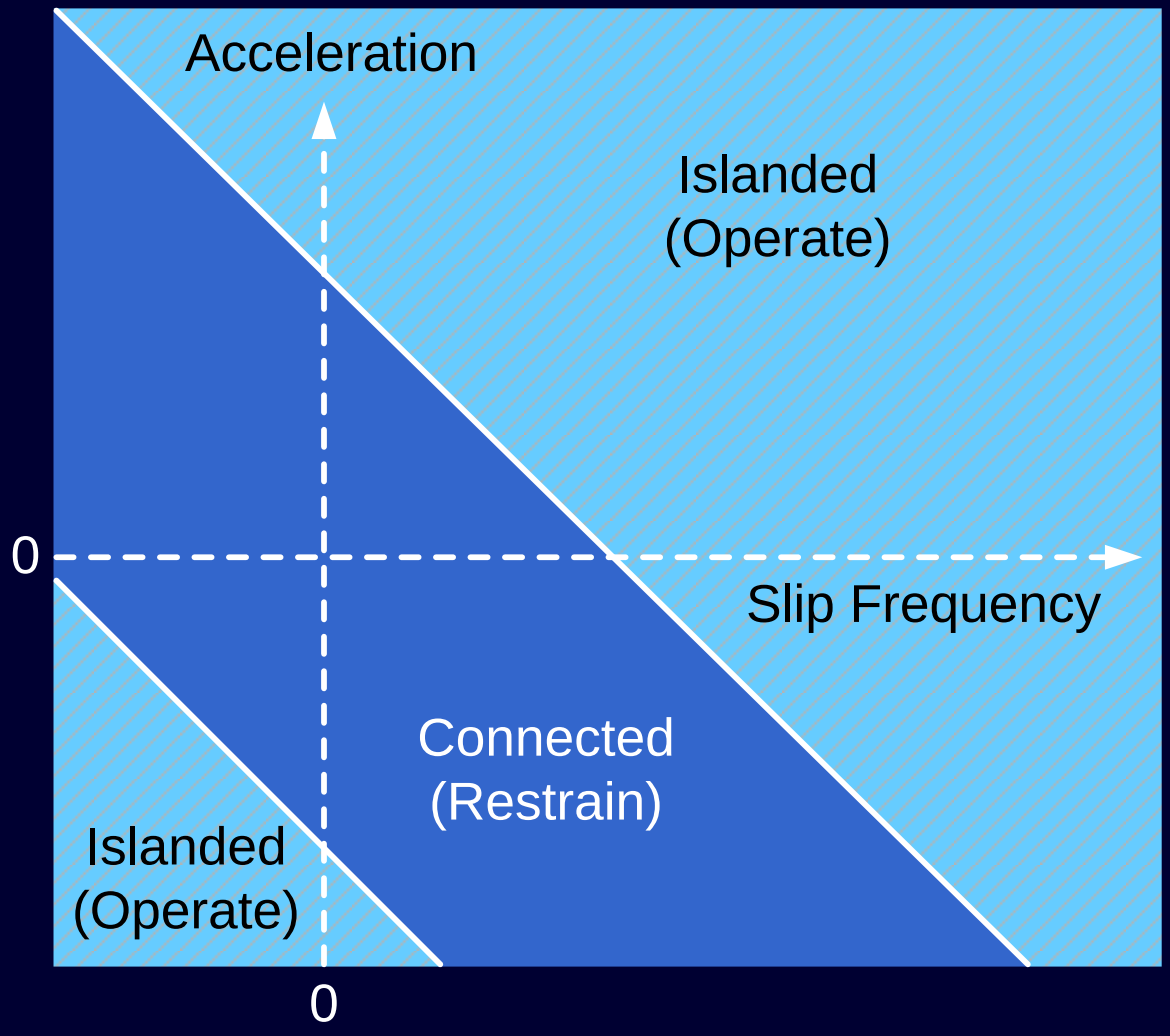
Use Existing IEDs

Controller Supervises Large Systems



- Manages priority control mode and set points
- Supervises and controls islanding
- Monitors and reports SCADA data
- Compensates for unbalanced conditions

Developing New Disconnect Algorithm



Conclusion

- There is increasing need for PV systems to function as active control element
- Installing inverter technology with advanced control capability will save resources in future
- Understanding communications architecture ensures applications function as expected
- Leverage existing infrastructure to enhance control capability

Questions?