

# Resilient and self-healing power distribution networks

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## Next generation power distribution networks



Ad hoc Micro-grids for emerging regions

Zero Energy Buildings: Singapore BCA

More electric aircrafts: US Air Force initiative

- Proliferation of **power electronics based energy processing**
- AC/DC **Hybrid networks** interfacing various voltage domains
- Local and distributed energy** generation and storage **systems**
- New types of load dynamics and **challenging mission** profiles
- Easily expandable and flexible network circuits
- Multi-tier controllability and re-configurability
- Multi-tier advanced diagnostics and prognostics

## Multi-tier advanced diagnostics and prognostics

Multi-tier advanced diagnostics and prognostics enable

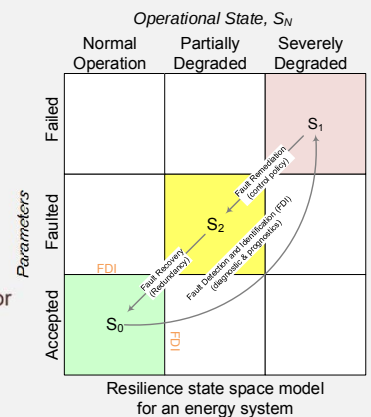
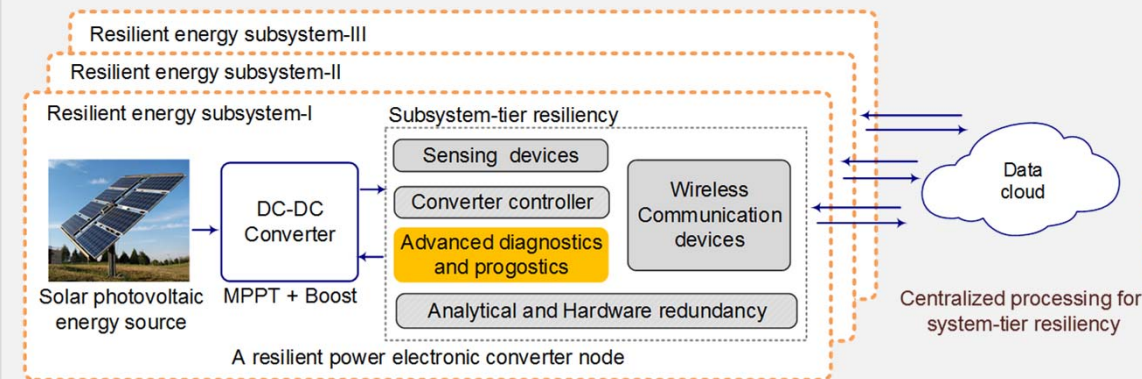
- Self-healing** and **fault tolerance** at each tier
- Easy and intelligent **maintenance**
- Increased power networks **availability** and **safety**
- In-depth **observability**
- Peace of mind

Approaches for fault diagnostics and prognostics range from **analytical models** to artificial intelligence and statistics.

**Tool box** for **quantitative model-based fault diagnosis** include:

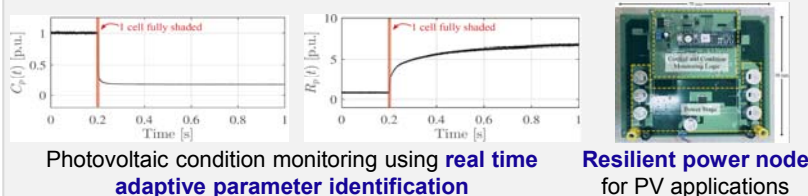
- State estimators: open-loop and closed loop
- Adaptive and diagnostic observers
- Parameter estimators

## Rendezvous of multi-tier diagnostics, prognostics and control system for Resiliency and Self-healing



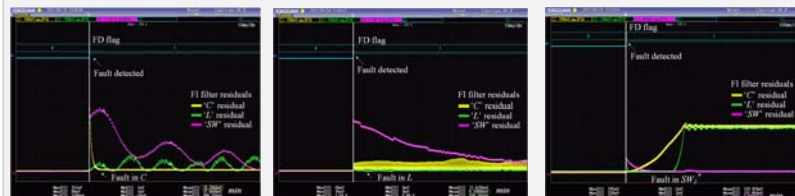
- Emerging power distribution networks consist of power electronics-enabled-**multiple energy subsystems**
- Fault diagnostics, prognostics and remediation at each energy subsystem tier through **local sensing**, **computing** and **actuation capabilities** of power electronics
- Locally processed data** collection **at central cloud** through communication capabilities of power electronics **for system-tier fault management**
- System-tier **reconfigurable control policy**, subsystem-tier **hardware and analytical redundancy** for resiliency and self-healing

## Experimental validations and Results



Photovoltaic condition monitoring using **real time adaptive parameter identification**

**Resilient power node** for PV applications



Fault detection and identification scheme for photovoltaic dc-dc converters using **real time Luenberger observers**

## Challenges and opportunities

Challenges

- Full **optimized digital implementation** of the model-based algorithms on fast digital platforms, such as, SoCs and FPGAs
- Performance-based analysis** of diagnostics and prognostics algorithms
- Fault remediation** through reconfigurable control policy
- Integration of **optimized hardware redundancy**
- Quantitative measure of system dependability** with and without model based multi-tier advanced diagnostics and prognostics

Opportunities

- Very **high level of dependability** in power distribution networks
- Active fault management** at multiple tier.
- Smart operation and maintenance**
- Fault-tolerant** design

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