Smart Distribution Systems Research at Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center

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http://www.freedm.ncsu.edu/

Freedm System Vision

Today

Centralized Generation

FREEDM System

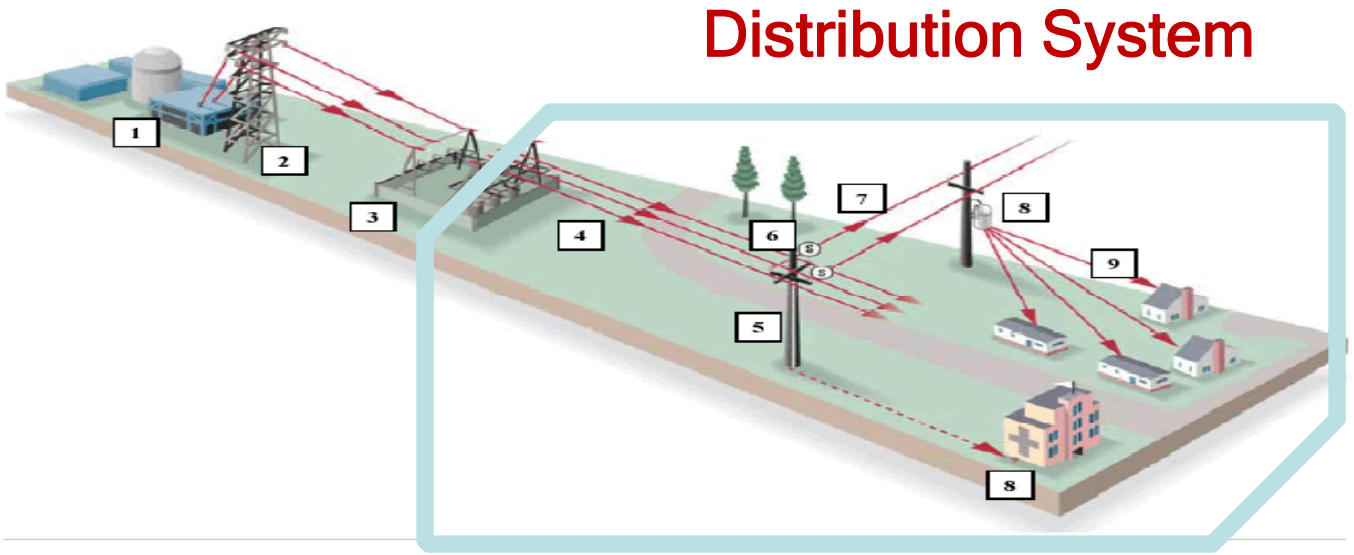
Distributed Renewable Energy Resources (DRER)

New technologies for distributed renewable energy

Innovation

DRER plug-play

Distribution Systems



Current System:

- Designed to supply loads
- Very limited monitoring and control

Problems:

- Large-scale integration of DRER
- Not user friendly
  - no plug-and-play interface

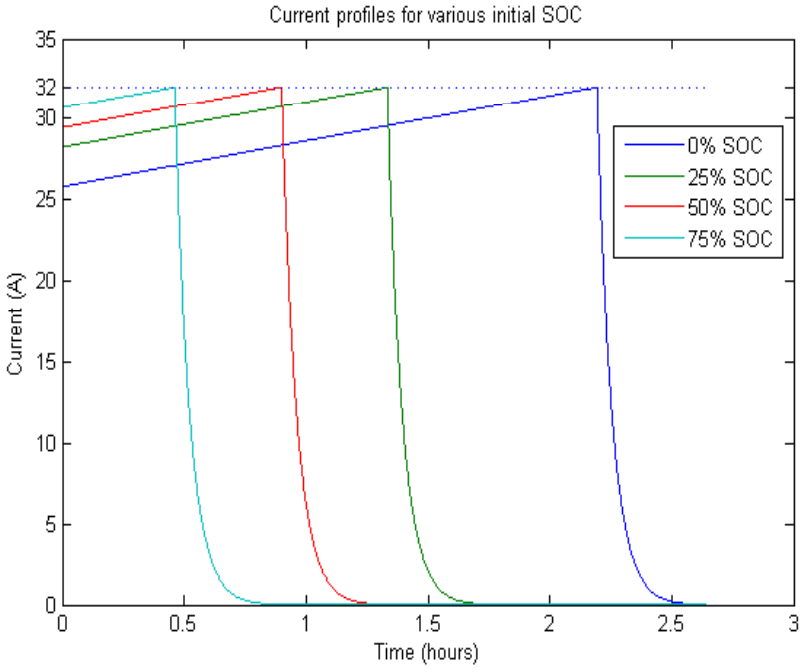
Future Load: Electric Vehicles

Charger Profile

Charger Plugs for PHEV (SAE J1772 specs)

Charger: Level 2 – 240 V, 32 A

Charger Current Profile



Typical Load ?

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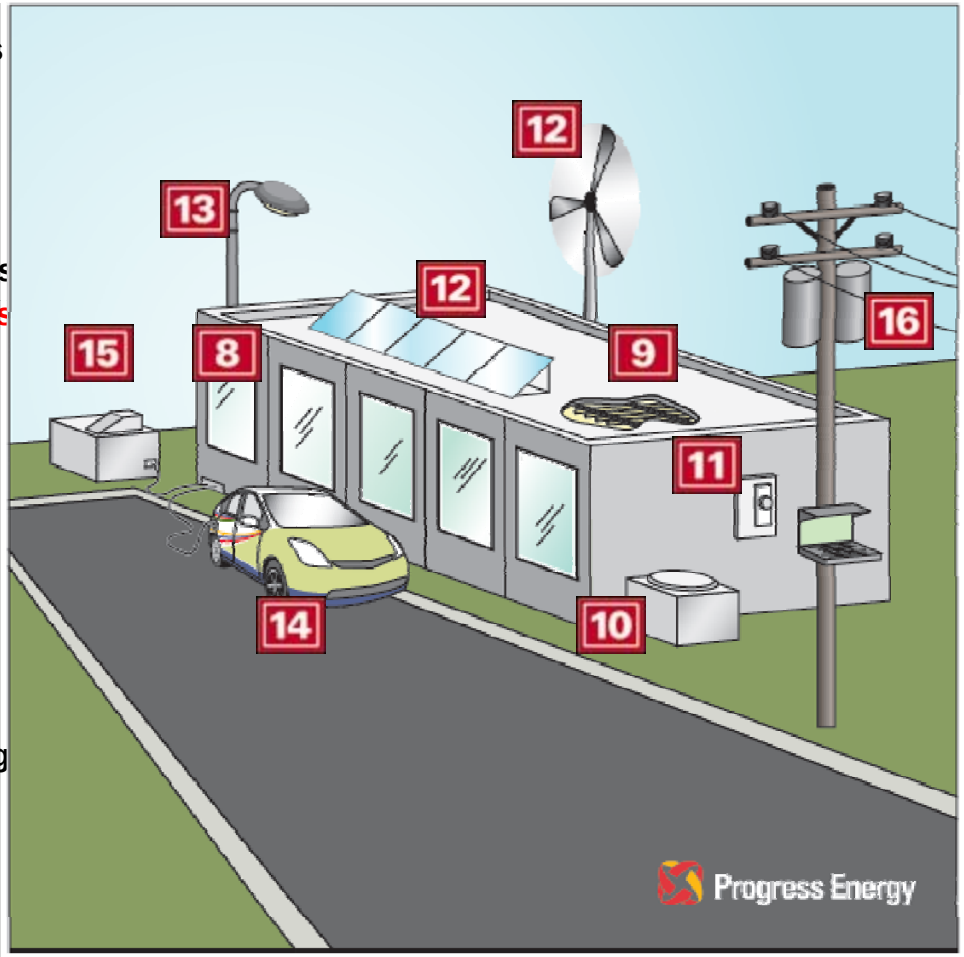
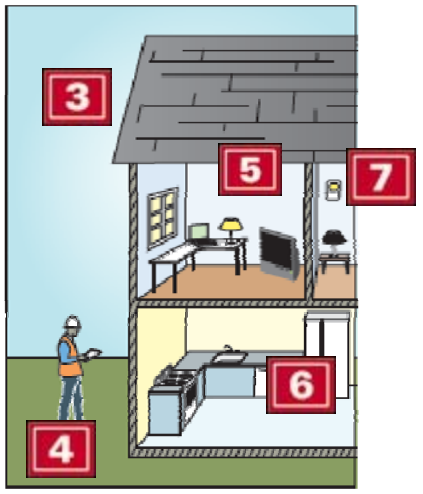
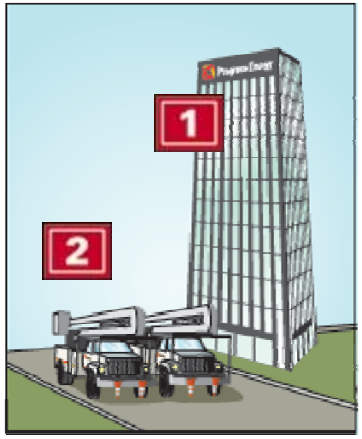
The Smart Distribution System

1) Progress Energy Facilities
2) Progress Energy Fleet
3) Residential Building Envelope
4) Home Energy Audits
5) Compact Fluorescent Bulbs
6) Energy Efficient Appliances
7) Smart Thermostats
* Smart Pricing
8) Commercial Building Envelope
9) Fluorescent Lighting
10) Heating & Cooling
11) Smart Metering
12) Distributed Renewable Energy
13) Efficient Outdoor Lighting
14) Plug-In Hybrids
15) Distributed Generation
16) Dist System Demand Response
* Emerging Technologies







Research for Smart Distribution

Goal: - Economic Power through a reliable and efficient system

Challenges: manage distributed and small scale
-Load: elastic wrt price
-PHEV: highly varying in time and place
-DER: highly intermittent

-> Distribution system needs the tool used for transmission grid
- Load Following & Management
- Resource Management
- Contingency Management

FREEDM Center Vision

- To develop an efficient and revolutionary distribution system
  - Utilize revolutionary **power electronics** technology and **information technology**
  - Integrate distributed and scalable alternative energy sources and storage with existing power systems
  - Automate the management of **load**, **generation** and **storage**

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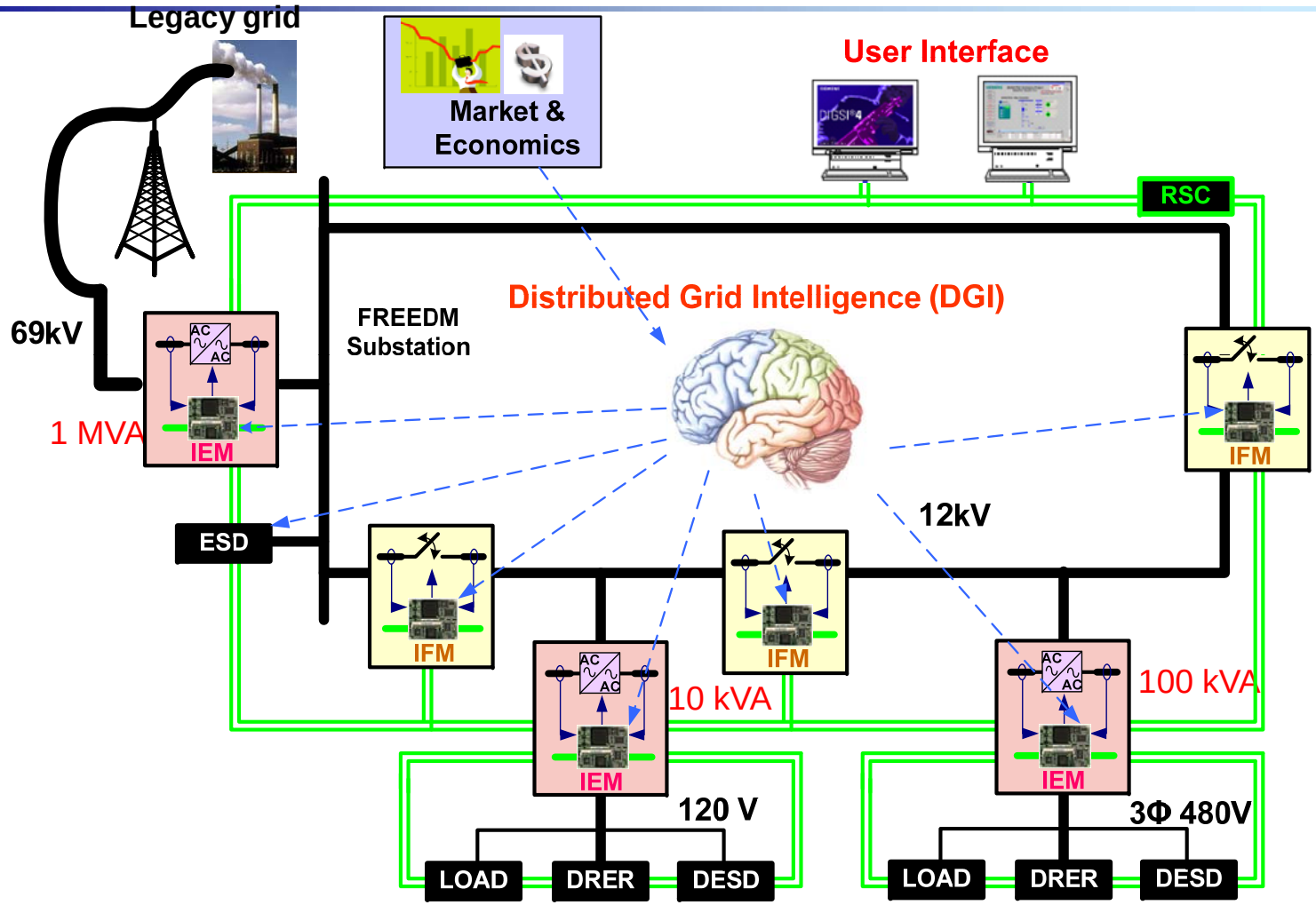
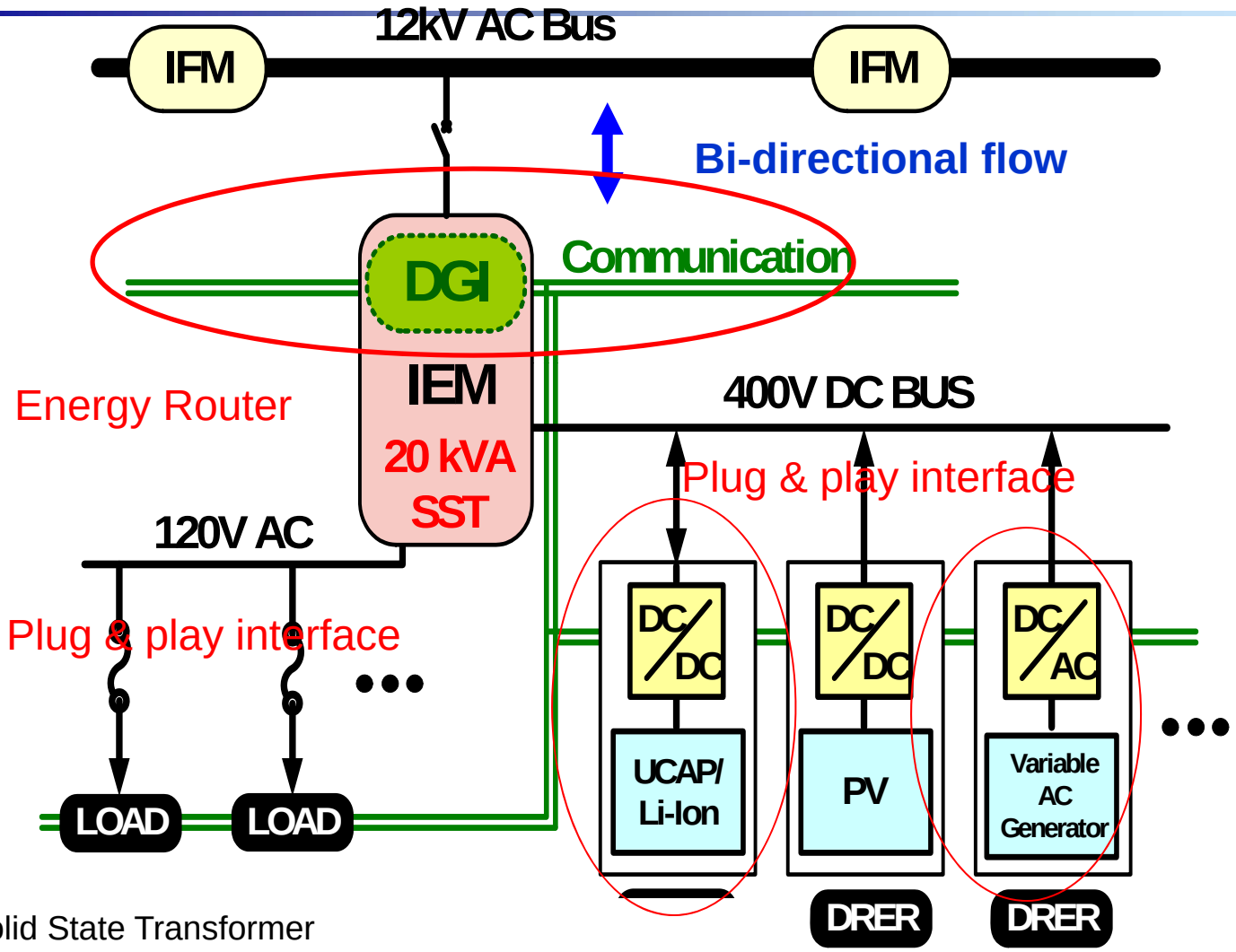
FREEDM System



IEM: Intelligent Energy Management **IFM**: Intelligent Fault Management

DRER: Distributed Renewable Energy Resource **DESD**: Distributed Energy Storage Device

Plug & Play Interface

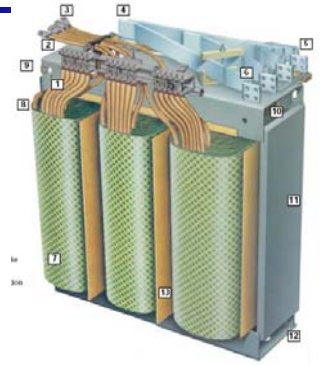


SST: Solid State Transformer

DGI: Distributed Grid Intelligence

IEM: Intelligent Energy Management Subsystem

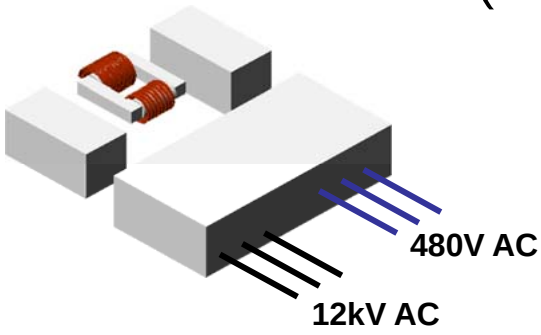
Enabling Technology



Conventional Transformer

5 X size reduction
10 X weight reduction

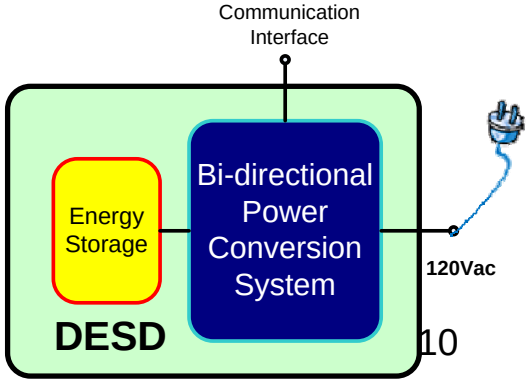
Solid State Transformer (SST)



Today's High Power Li-ion battery

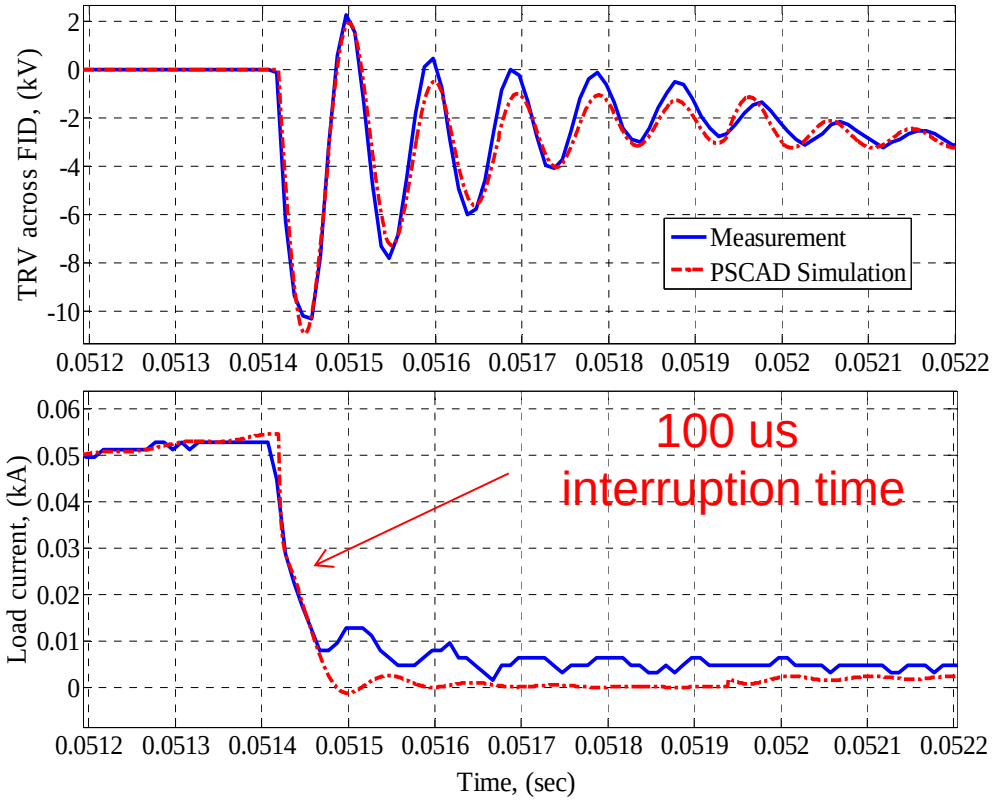
3 X reduction in size
cost reduction

5 kWH Distributed Energy Storage Device (DESD)

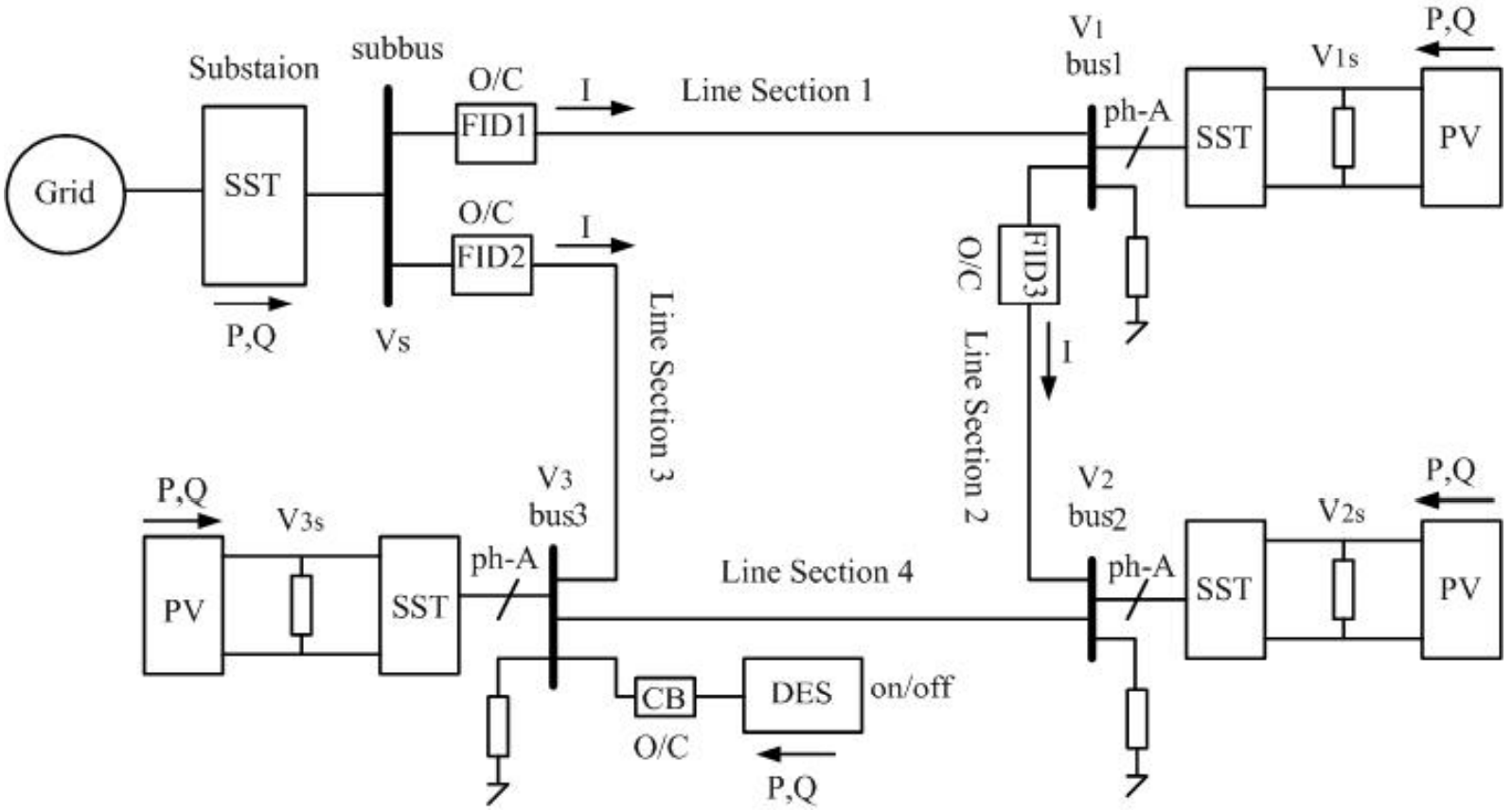


Solid State Fault Isolation Device

Successfully developed a 15 kV class FID based on silicon IGBT

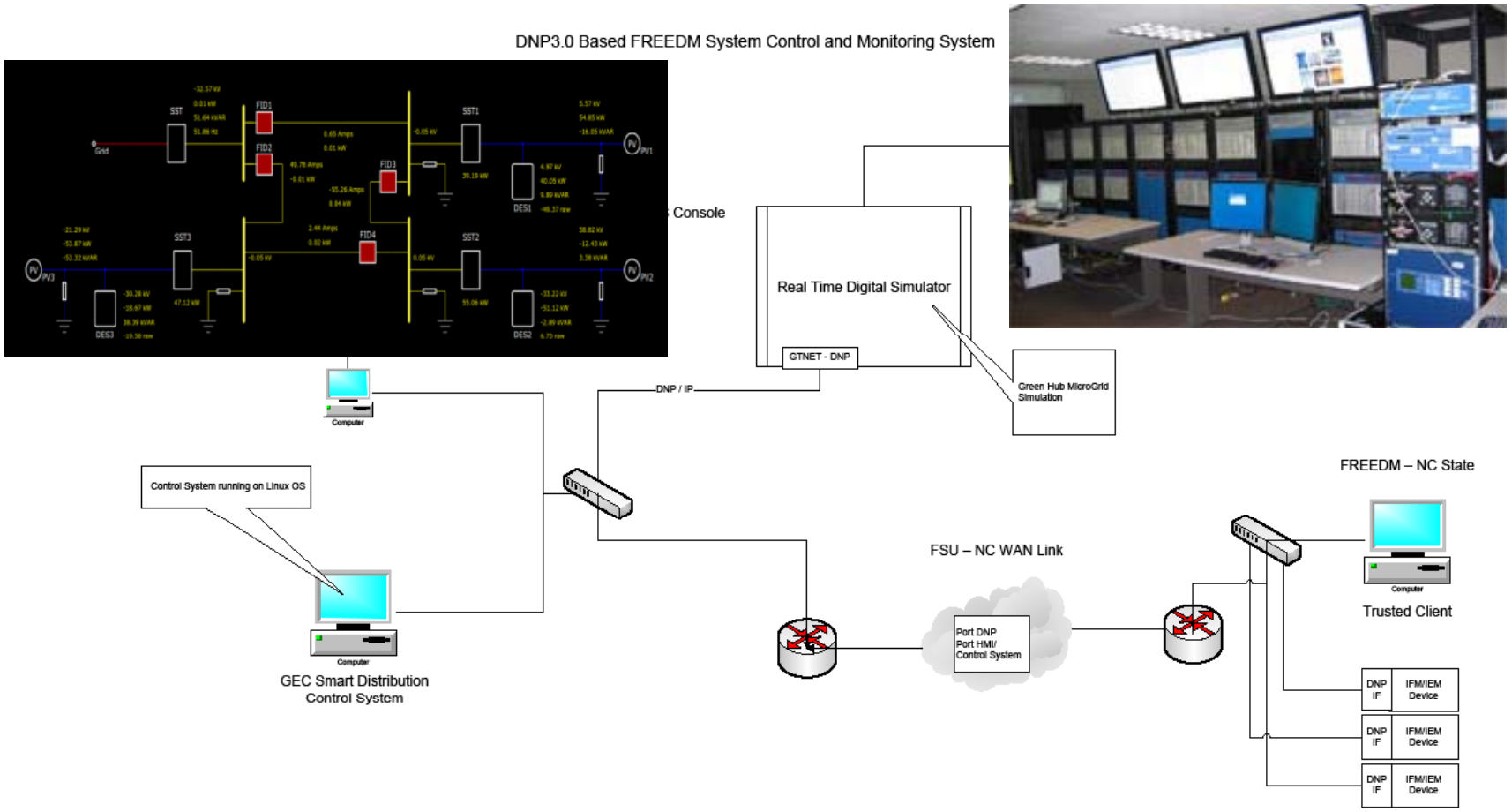


Digital Testbed – Green Hub



- New Devices SST, DER & DES, FID are rep by ave dynamic models
- Simulation Platform: Simulink & PSCAD

Real-Time Digital Testbed



Goals: - control and monitoring methods
- CIL testing

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Acknowledgement

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