OBG PRESENTS:

An Analytical Engine for DER Interconnection Studies

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Distribution System Analysis

DISTRIBUTION SYSTEM ANALYSIS

- Power Flow Analysis
- Power Quality Analysis
- Fault Analysis
- Dynamic Analysis

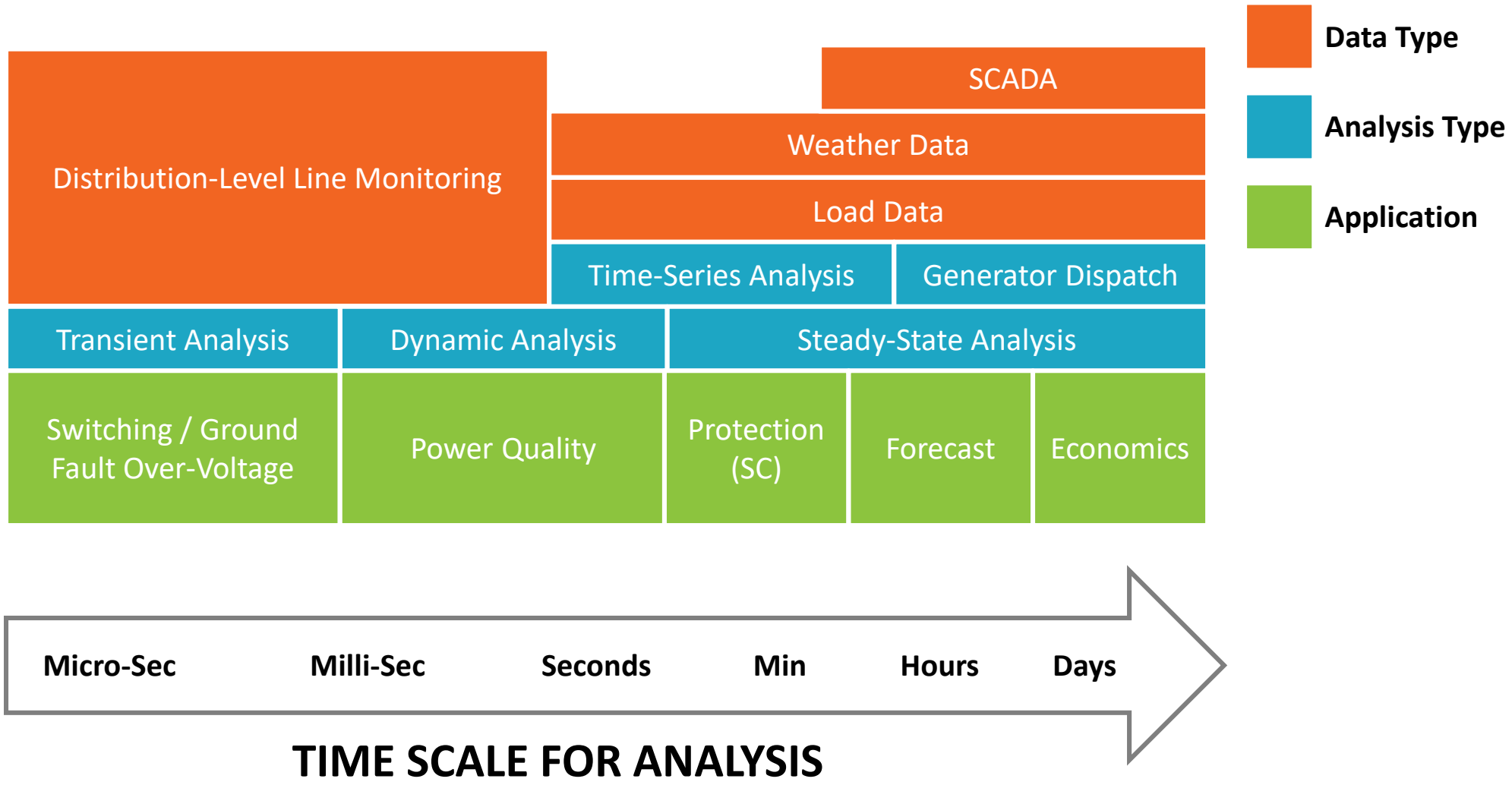
DISTRIBUTION SYSTEM STUDIES WITH DERS

- DERs and Net Load Projection
- Distribution Engineering
- Time-Series Power Flow Analysis
- Advanced Optimization
- Hosting Capacity
- Interconnection
- Dynamic Studies
- Co-Simulation with Transmission Systems

MARKET ANALYSIS

- Utility Revenue
- Costumer Billing
- Time-of-Use Pricing
- Demand Response Revenue
- Transactive Energy Analysis

Time Scale Analysis for Utilities



Source: Ernest Orlando Lawrence Berkeley National Lab

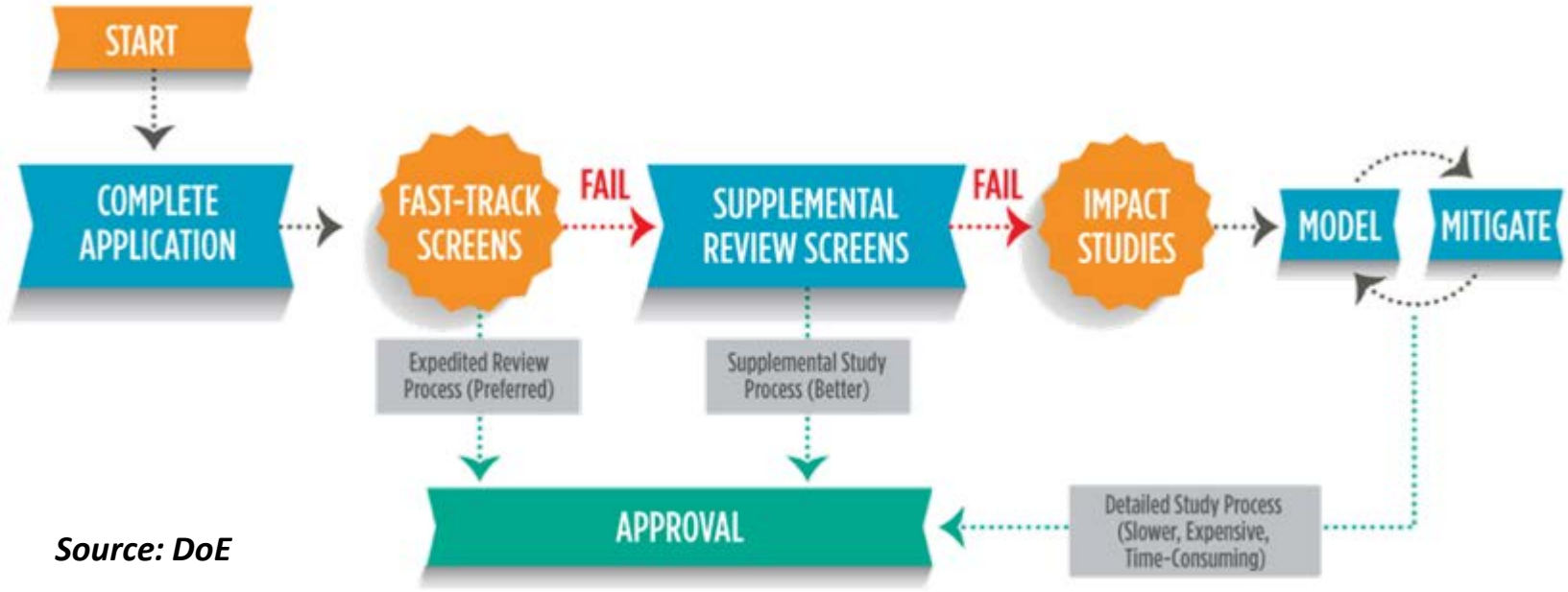
DER Interconnection

Major Utility Concern Related to DER	
Concern	**Number of Utilities (Out of 21)**
Voltage regulation	16
Reverse power flow	11
Protection coordination	10
Increased duty on line regulators	8
Unintentional islanding	8
Secondary networks	6
Variability due to clouds	5
Capacitor switching	4

Source: Coddington and Smith 2014

Transient	▪ Transient voltage impacts ▪ Islanding ▪ Microrgird
Dynamic	▪ Protection ▪ Power Quality
Quasi-Static	▪ Variability Impact ▪ OLTC Cycling

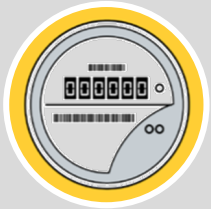
Interconnection Process



Source: DoE

Electric Utility Systems

- National Electric Safety Code
- Utility Regulations
- ANSI C84.1



Point of Common Coupling (PCC)

- IEEE 1547.x
- IEEE 1453

Load

- National Electric Code
- UL 1741

Interconnection Process Challenges

Streamlining the Review and Interconnection Process

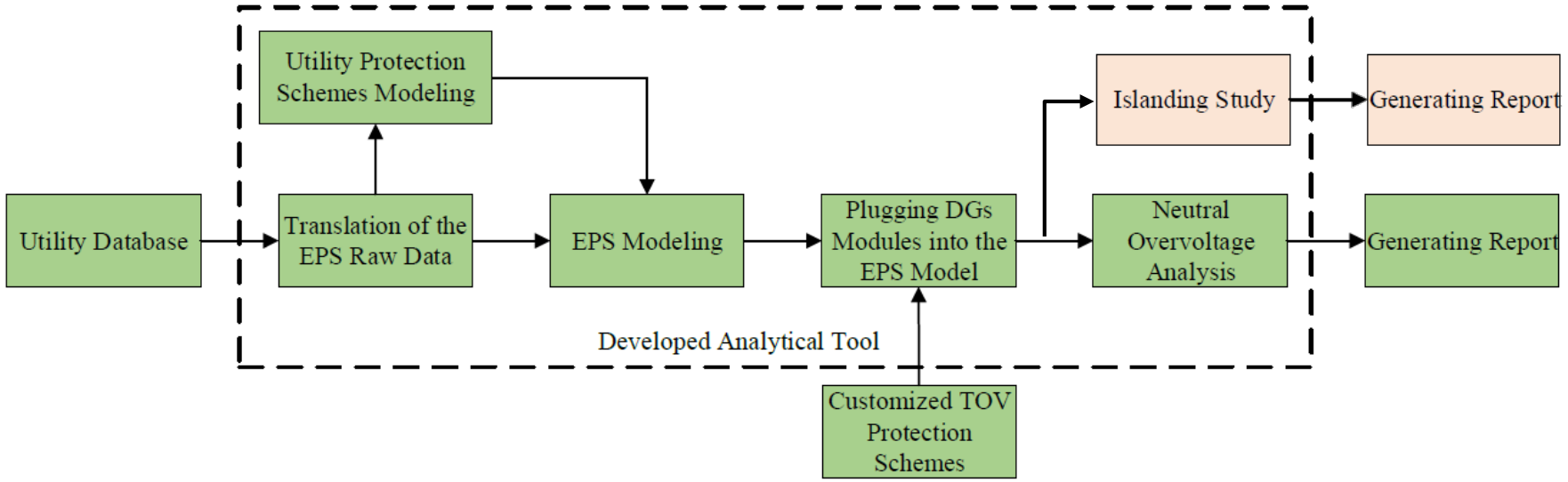
DER Dynamic Model

Enhancing Methods for Impact Analysis

Integrating Transmission, Distribution, Market, and Loads

An Advanced Distribution System Analytical Tool

Distribution System Analytical Tool (DSAT)



EDS Component Modeling	DER	Protection Systems
• Load • Overhead Line • Underground Cable • Transformer • Load • Voltage Regulator • Cap Bank	• Rotating Generators • PV • Energy Storage • Inverter • Active and Reactive Power Control • Active Anti-Islanding Module (SFS and SMFS) • Passive Anti-Islanding Module	• Breaker • Switch • Fuse • Digital Measurement Unit • IEDs

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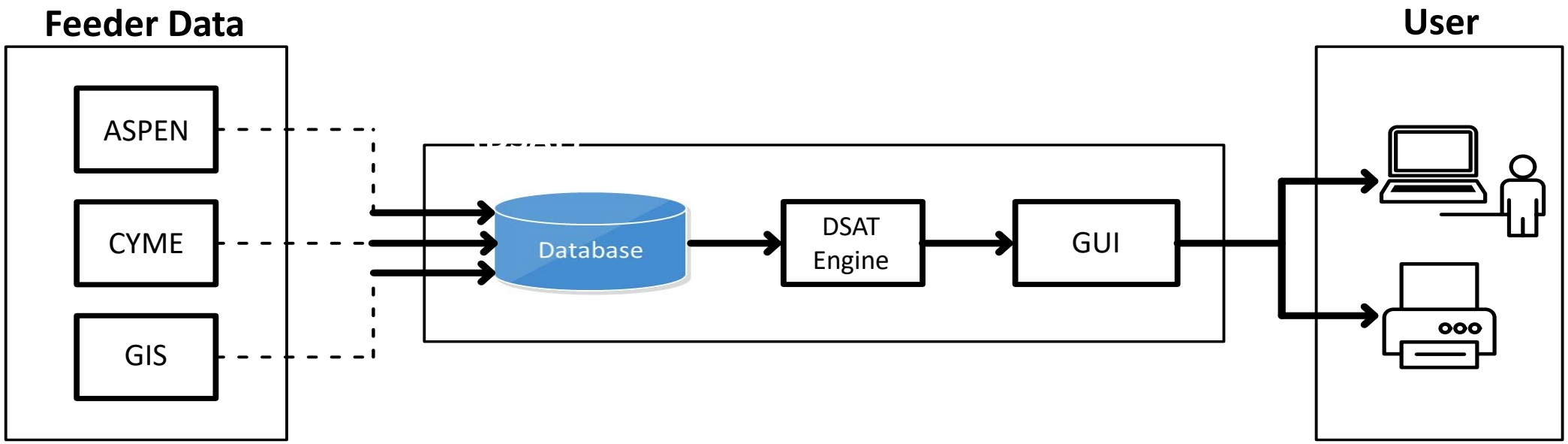
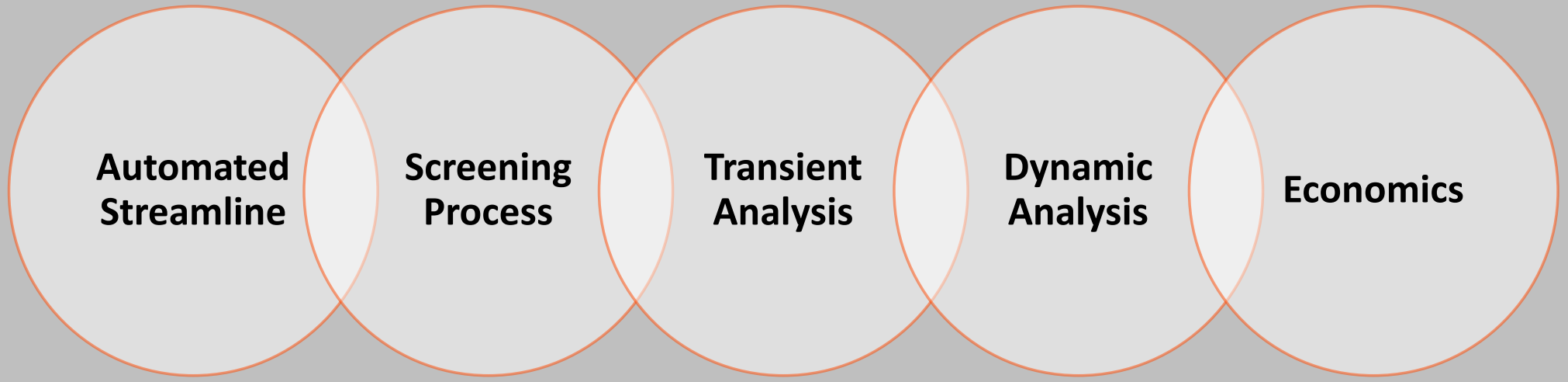
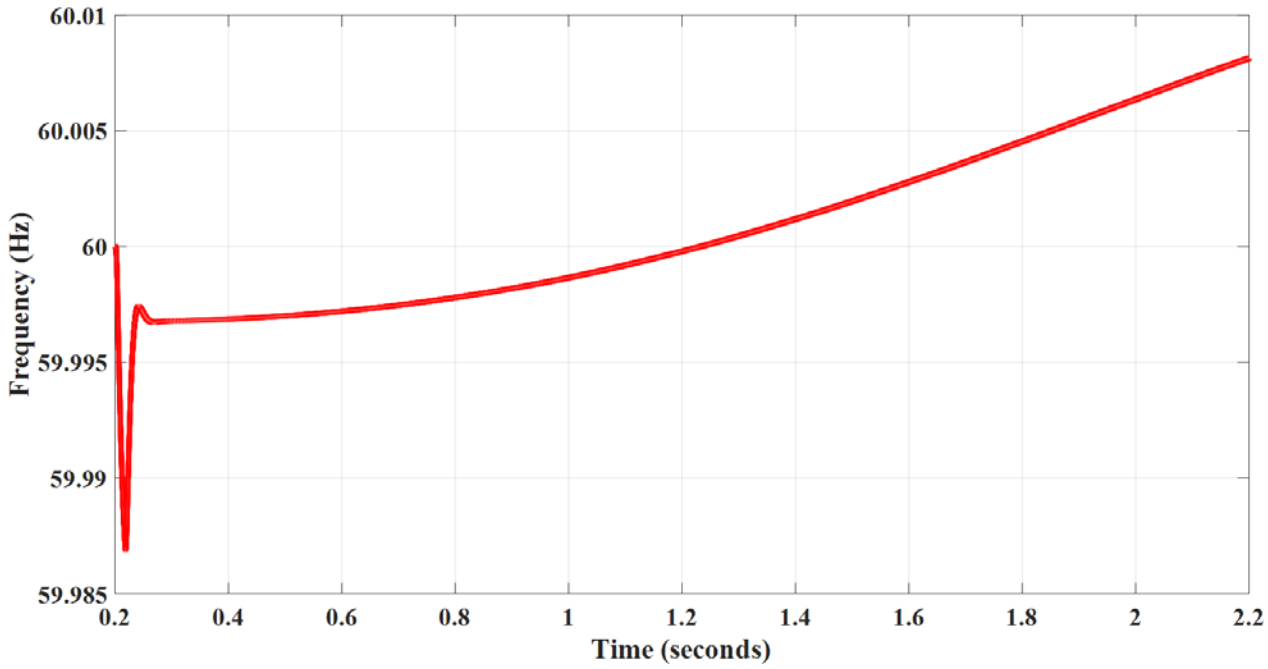
DSAT Characteristics

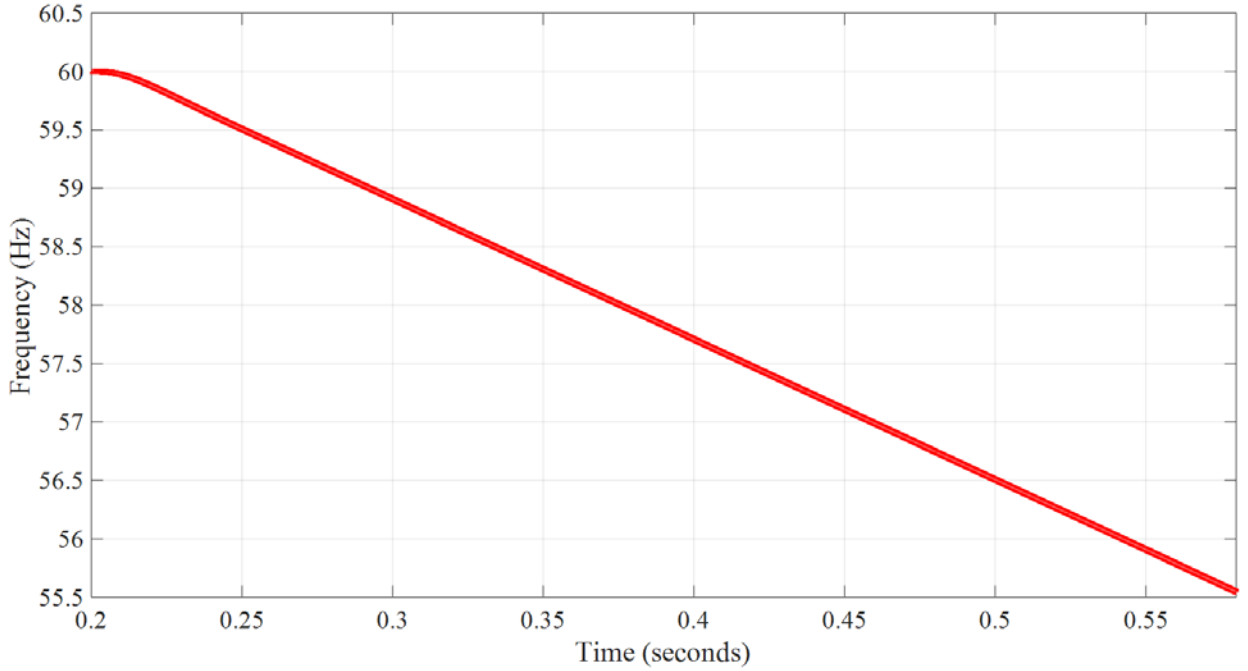




Transient Response of PV Systems

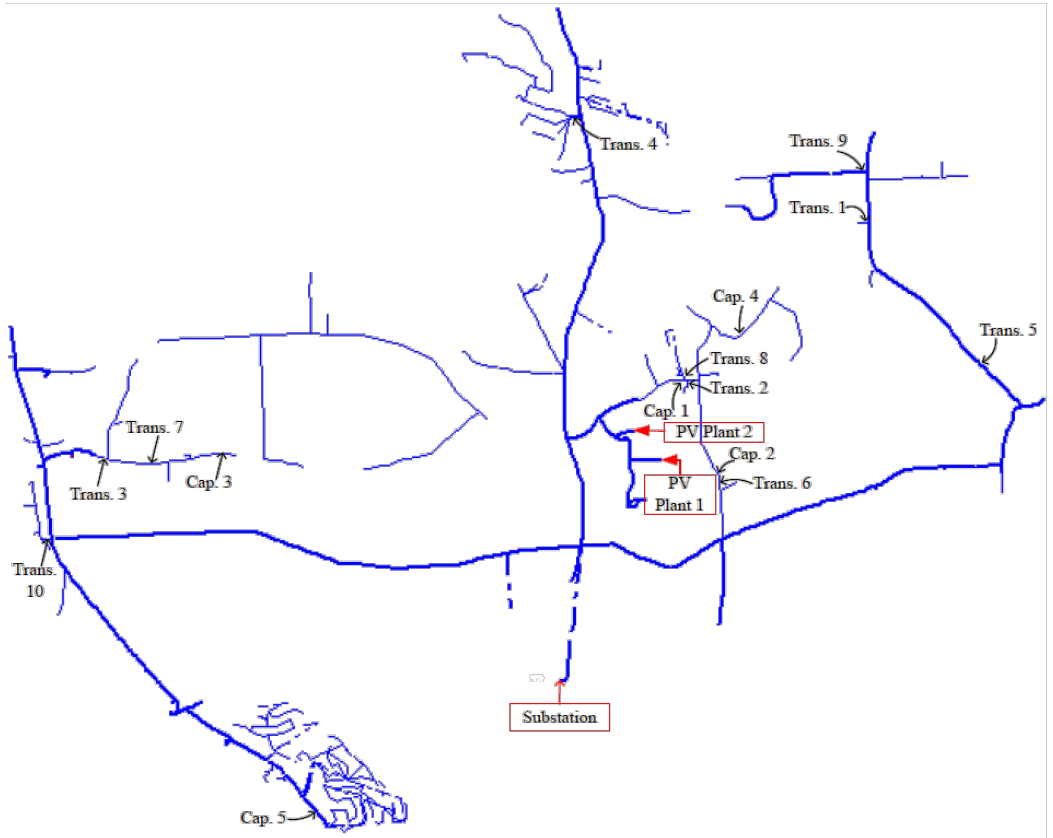


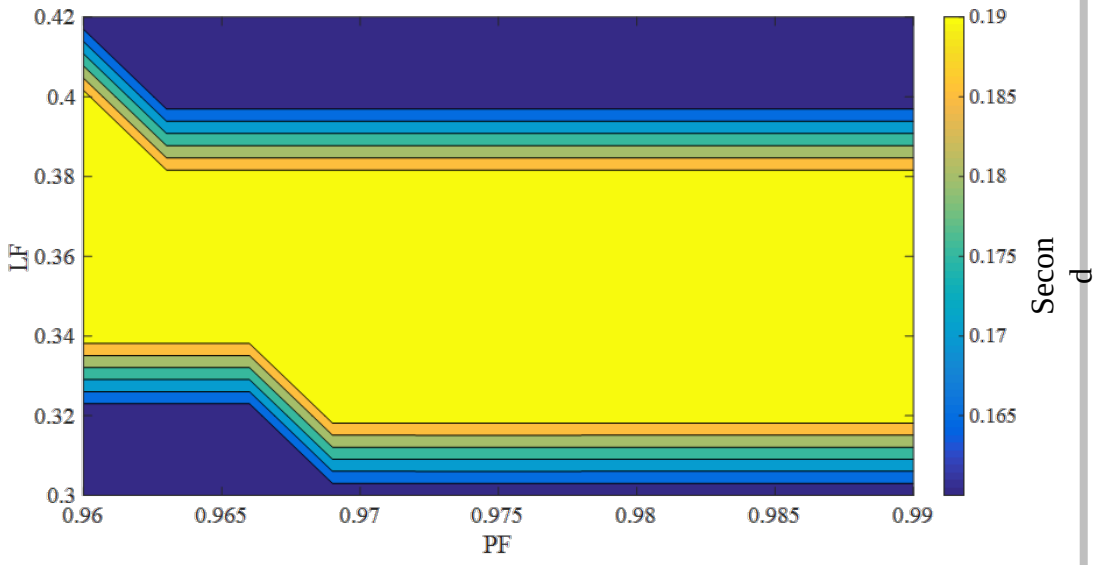
Passive Anti-Islanding



Active Anti-Islanding
(Sandia Frequency Shift)

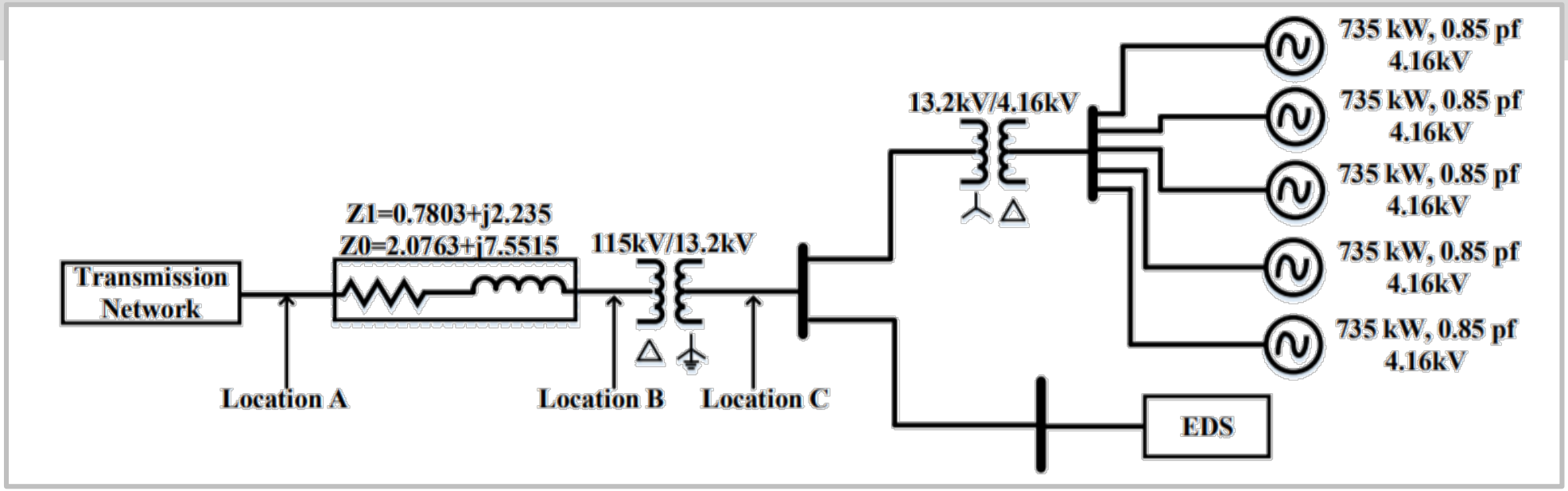
Islanding Analysis





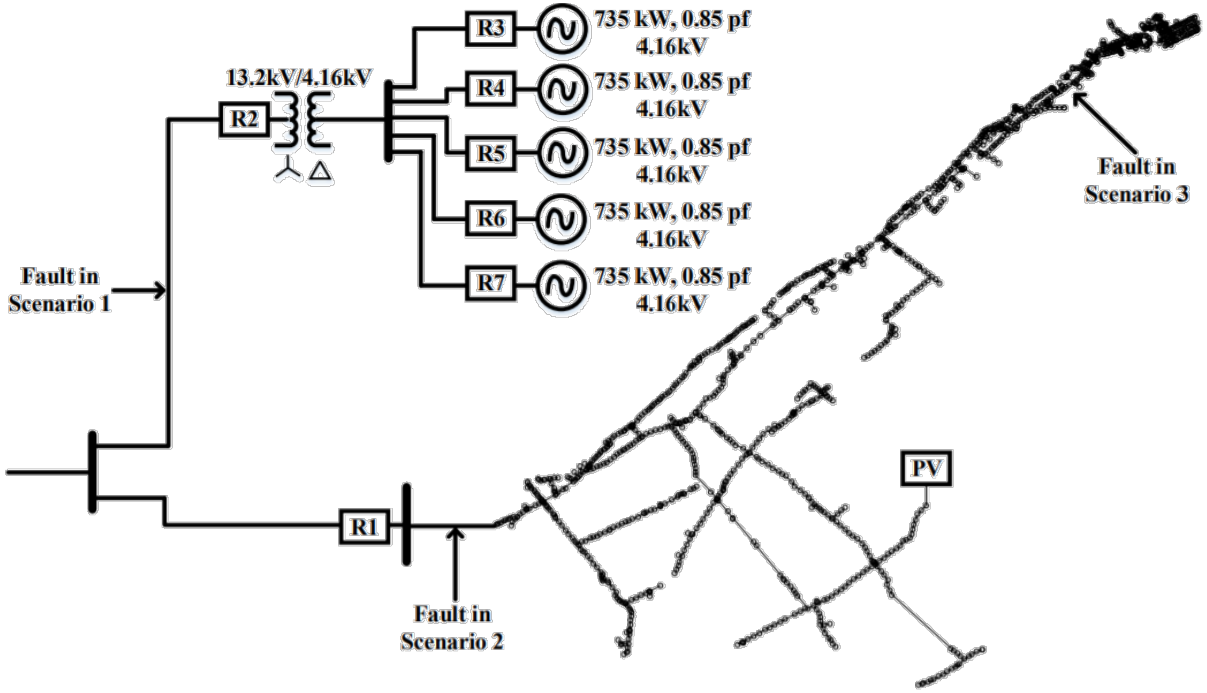
Run-On Time of PVs after Loss of the Grid

PROTECTION ANALYSIS

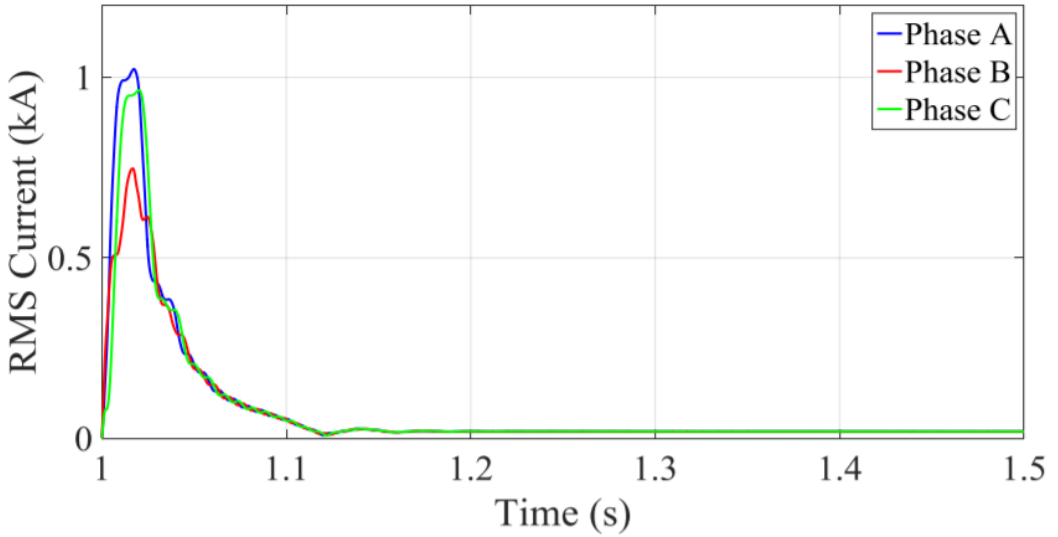


Fault Location	Fault Type	ASPEN Result	DSAT Result	Error (%)
A	L-L-L	4,070.90 A	4,074.70 A	0.0933
	L-L	3,524.50 A	3,540.15 A	0.444
	L-G	3,727.60 A	3,767.10 A	1.055
B	L-L-L	3,555.70 A	3,554.90 A	-0.022
	L-L	3,078.50 A	3,090.43 A	0.387
	L-G	3,017.80 A	3,043.70 A	0.857
C	L-L-L	6,063.40 A	5,996.18 A	-1.109
	L-L	5,250.80 A	5,220.80 A	-0.571
	L-G	7,096.20 A	7,151.80 A	0.784

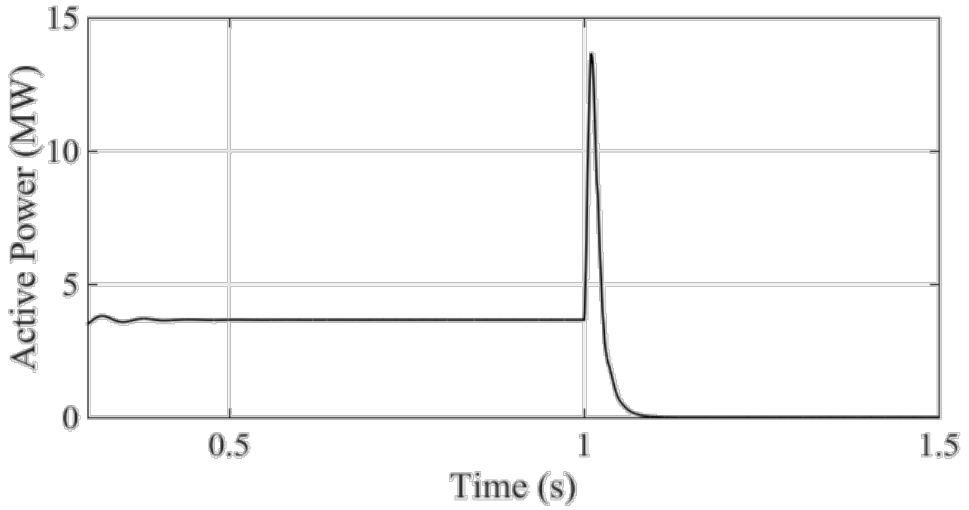
MICROGRID



Relay	CT Ratio	Pick-up Value	Time Dependancy	Time Parameter	Sampling Frequency
R1	1/120	6	Extra Inverse	12.5 ms	2400 Hz
R2	1/80	4	Very Inverse	74.1 ms	2400 Hz
R3-R7	1/30	0.75	Standard Inverse	7.14 s	2400 Hz

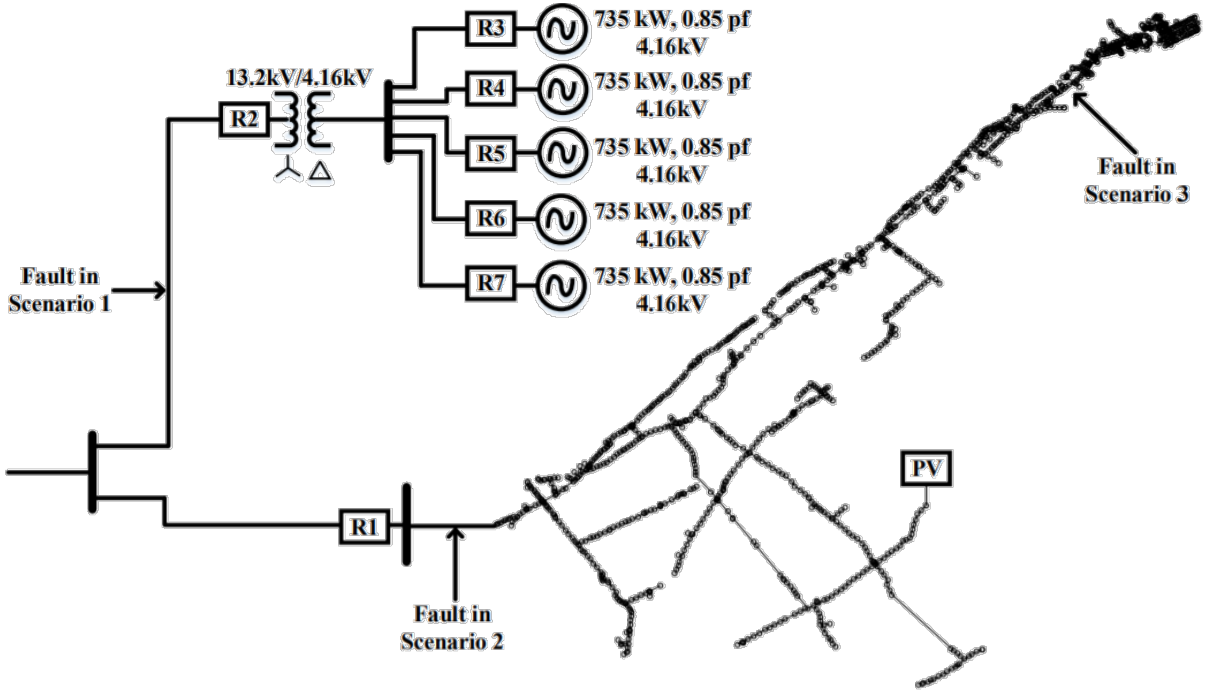


Fault current for L-L-L fault under Scenario 3.



Generated active power by the induction generators during a L-L-L fault under Scenario 3.

MICROGRID



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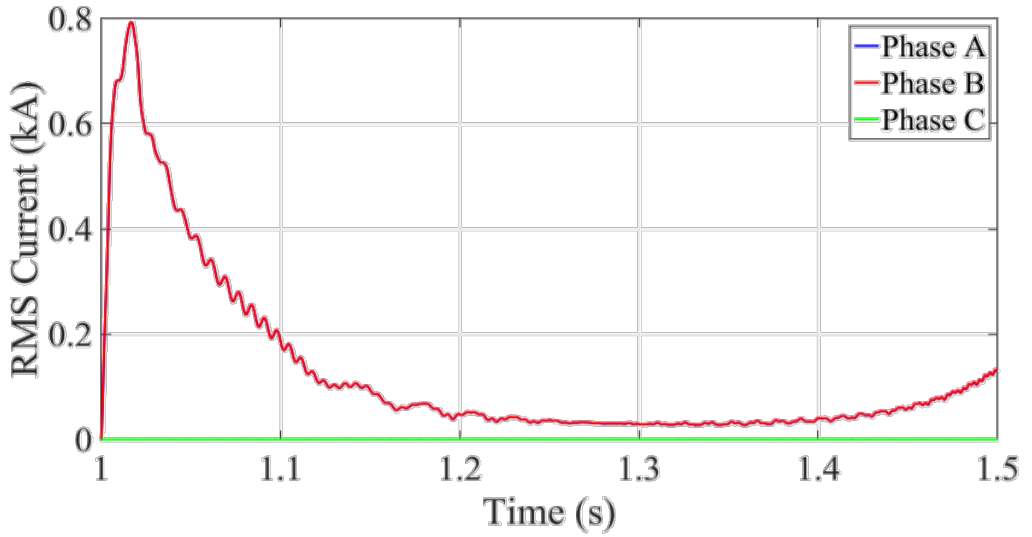
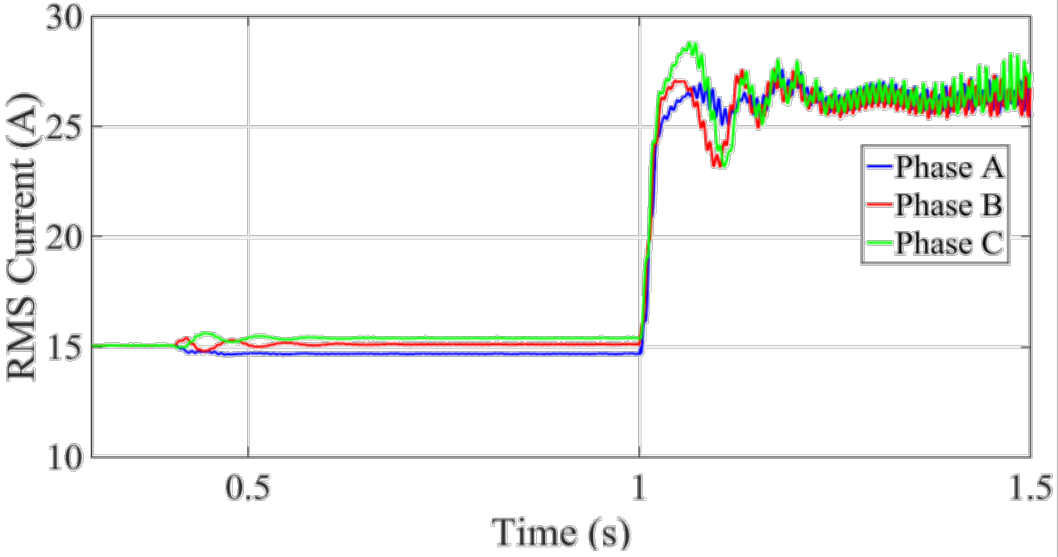


Fault current for L-L fault under Scenario 3.



PV current during a L-L fault under Scenario 3.

Accomplished

- Streamlining Interconnection Process
- Automating Interconnection Studies
- Transient and Dynamic Analysis

In Progress

- Improving the Speed of Analysis
- Flicker Analysis
- Customized Solutions

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Thank you!