INTERNATIONAL DISTRICT ENERGY ASSOCIATION

ISLAND LIFE – OPERATING YOUR MICROGRID IN ISLAND MODE

Michael Dempsey

February 21, 2017

Agenda

- System Configuration – Utility and Campus
- Grounding Considerations
- Protection Issues
- Case Studies

Microgrid Definition

A microgrid is

"a group of interconnected loads

and distributed energy resources

within clearly defined electrical boundaries

that acts as a single controllable entity with respect to the grid

[and can] connect and disconnect from the grid

to enable it to operate in both grid-connected or island-mode."

*- the **U.S. Department of Energy***

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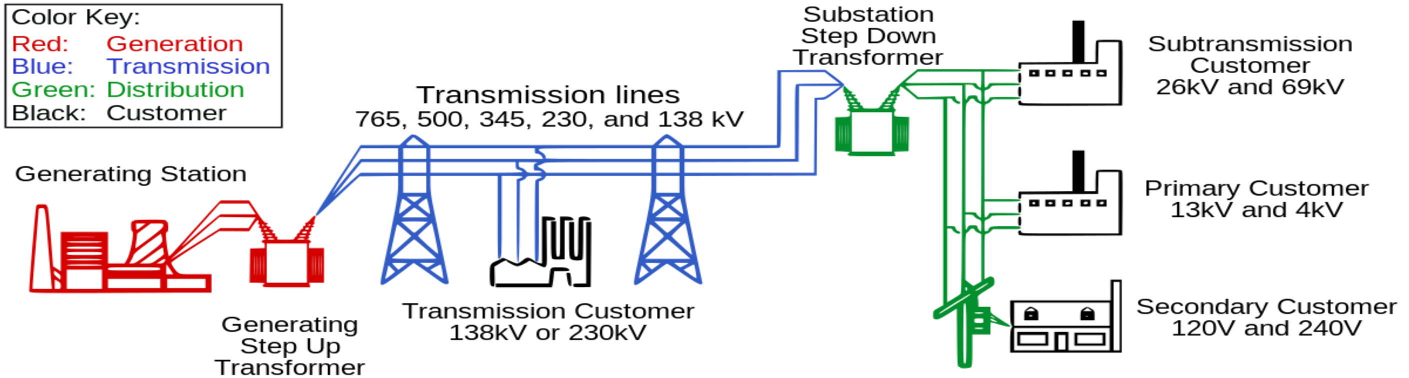
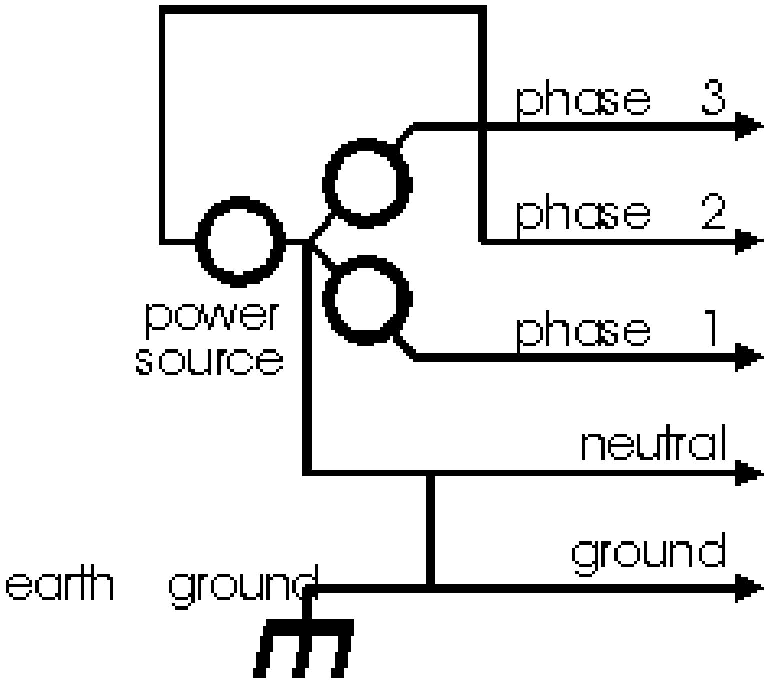
System Configuration

- Utility System
  - Typically 3-Phase 4-Wire Multipoint Grounded Wye
- Campus Distribution System
  - 3-Phase 3-Wire Solidly Grounded Wye
  - 3-Phase 4-Wire Solidly Grounded Wye
  - 3-Phase 3-Wire Low Impedance Grounded Wye
  - 3-Phase 3-Wire Ungrounded



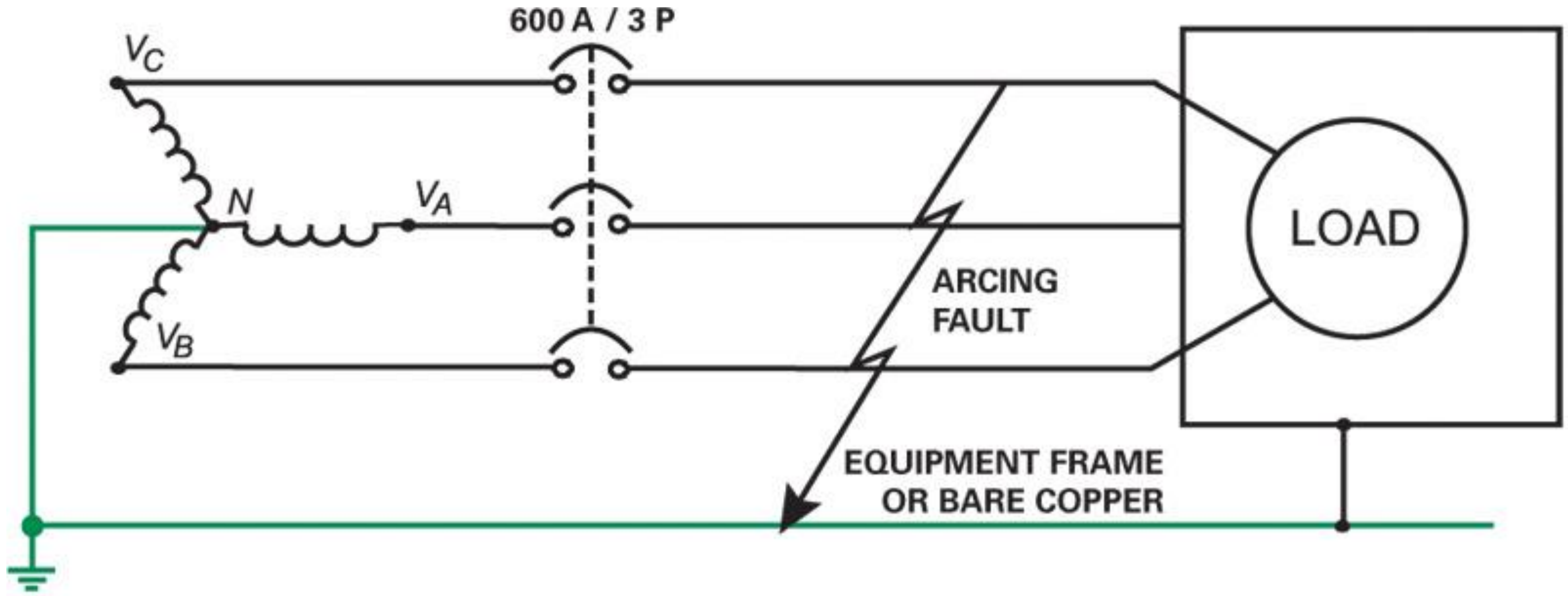
System Configuration

- Utility System
  - Typically 3-Phase 4-Wire Multipoint Grounded Wye
- Serves Both 3-Phase and 1-Phase Load
  - Load Current Normally Flows on Neutral Conductor



System Configuration

- Campus System
  - 3-Phase 3-Wire Solidly Grounded Wye
- Serves Only 3-Phase Load
  - No Load Current Normally Flows on Neutral/Ground Conductor



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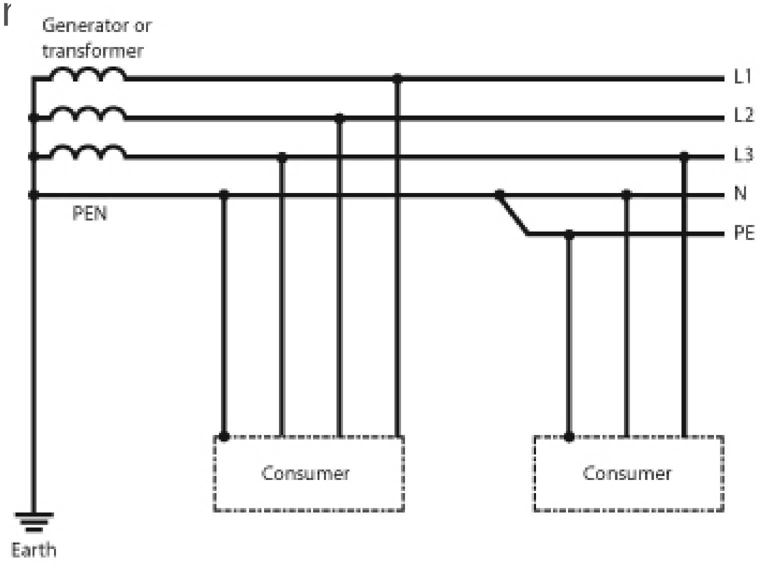
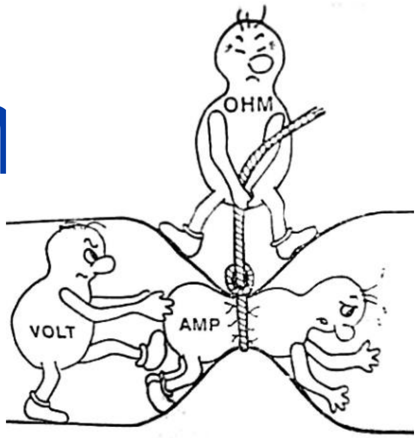
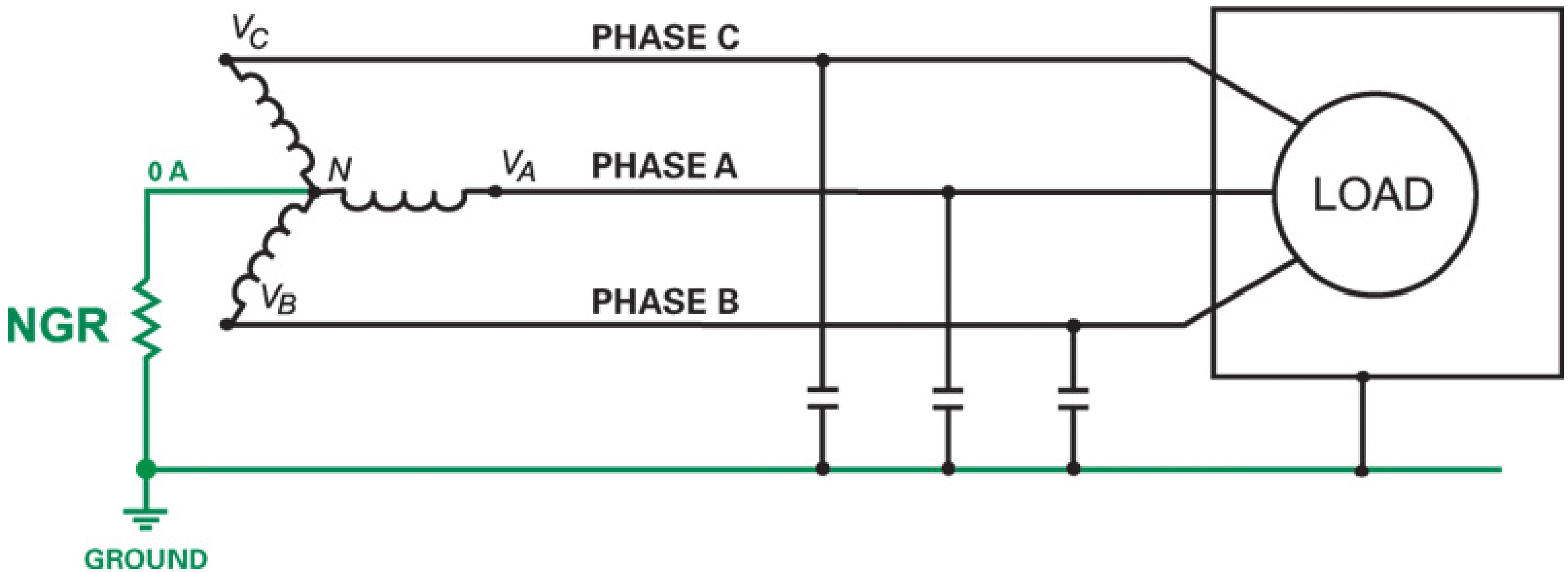


System Configuration

- Campus System
  - 3-Phase 3-Wire Low Impedance Grounded Wye
- Serves Only 3-Phase Load
  - Ground Current Limited By NGR





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  - 3-Phase 3-Wire Ungrounded
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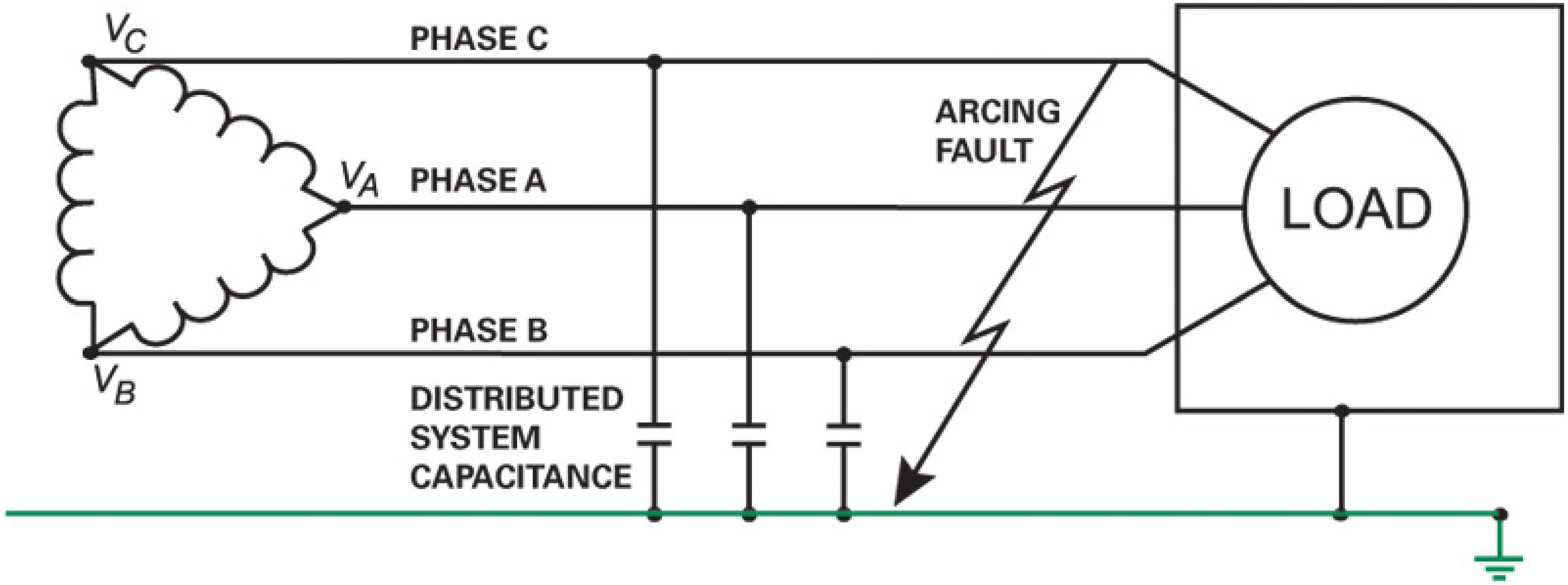
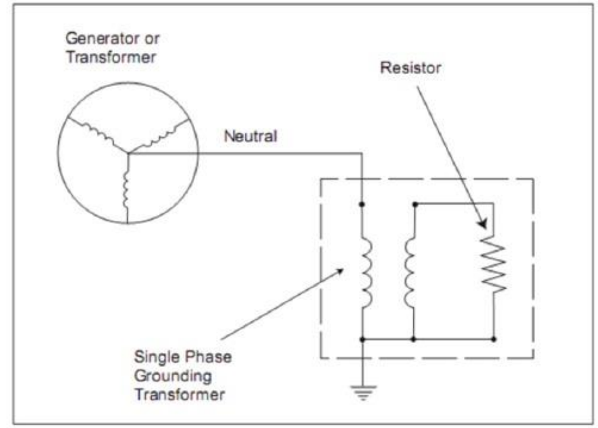
  - No Ground Current Flows Ground Conductor

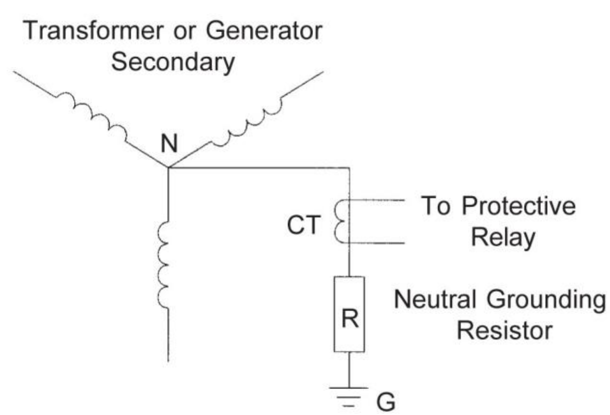


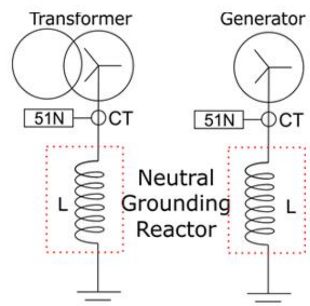
Grounding Conside



- Synchronous Generators
  - Zero Sequence Impedance Much Less Than Positive Sequence
  - Some Neutral Impedance Typically Needed
  - Method Depends on Load Served
    - Single Phase
    - Three Phase

Neutral Grounding Resistor Schematic





CODE	4P73-5500	DATE	20-Jan-17
FRAME NO.	73	NAME	Ben Johnson
INQUIRY NO.	DC17-10205	E-CARD	E234*R4001
ENCLOSURE	ODP		

GENERATOR RATING

KW	KVA	VOLTAGE	AMPS	PHASE	HERTZ	POLES
16000	18823.5	12470	872	3	60	4
				RATED TEMP. RISE IN °C		
RPM	CONNECTION	PITCH	INSULATION CLASS	STATOR (RTD)	FIELD (BY RES.)	AMB. °C
1800	WYE	0.7619	H	80	80	40

GENERATOR OPERATING CHARACTERISTICS

EFFICIENCY (%)			HEAT REJ.
% LOAD	@ 0.9 PF	@ 1.0 PF	BTU/HR
100%	97.5	97.9	1623690
75%	97.2	97.6	1376635
50%	96.3	96.9	1182841
25%	93.5	94.4	1042249
LOSSES (KW)		LOAD (0.9 PF)	NO LOAD
CORE		90.3	90.3
F&W		175.0	175.0
STRAY LOAD		66.9	0.0
I^2R STATOR		41.3	0.0
I^2R ROTOR		25.8	3.7
EXCITER		3.9	0.5
TOTAL		**403.1**	**269.5**

REACTANCES (VALUES ARE % AT KVA RATING)		SAT.	UNSAT.	
DIRECT AXIS SYNCHRONOUS	Xd	190.6	206.7	NOTE: DIVIDE BY 100 FOR P.U. VALUES
DIRECT AXIS TRANSIENT	X'd	22.6	25.7	
DIRECT AXIS SUBTRANSIENT	X"d	16.6	19.6	
QUADRATURE AXIS SYNCHRONOUS	Xq	85	82.2	
QUADRATURE AXIS TRANSIENT	X'q	85	82.2	
QUADRATURE AXIS SUBTRANSIENT	X"q	7.9	9.3	
NEGATIVE SEQUENCE	X2	12.3	14.4	
ZERO SEQUENCE	X0	4.3	5	
LEAKAGE REACTANCE	XL	11.1	12.7	

X/R RATIO	77	BIL (volts)	45857	3-PH CAP-GND	0.323	micro-farads

Grounding Considerations

- IEEE 1547
  - Section 4.1.2 Integration with Area EPS Grounding
    - Not cause overvoltages exceeding rating of equipment connected to EPS
    - Not disrupt coordination of ground fault protection on area EPS
- Unit Connected
- Isolation Transformer
  - Delta-Wye
  - Wye – Wye
  - Delta-Delta
- Can Affect Islanded Operation

Grounding Conside

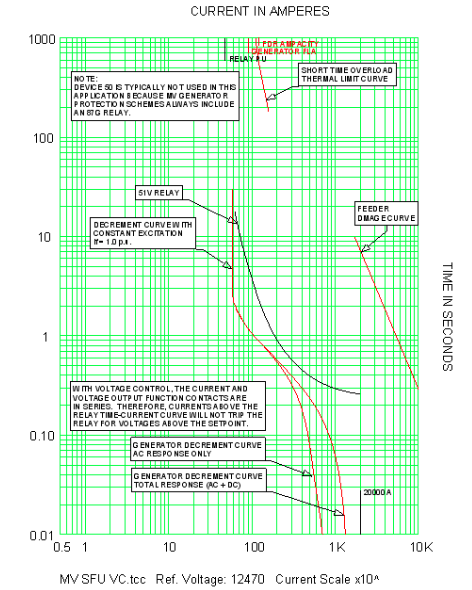
- Unit Connected
  - Connect Generation at Distribution Voltage
  - Typical for Medium-Voltage Installations
  - Low Impedance Grounding
  - Hybrid High Resistance Grounding
- Generation Subject to Utility Short Circuit Current
- Islanding Simplified

Grounding Considerations

- Isolation Transformer
  - Delta-Wye
    - Eliminates Ground Current Contribution to Utility
  - Wye – Wye
    - Eliminates Overvoltage Potential
  - Delta-Delta
    - Eliminates Ground Contribution to Utility
    - Generator High Impedance Ground
- Islanding Must Account for Isolation Transformer Impact
  - Potential for Ungrounded Island

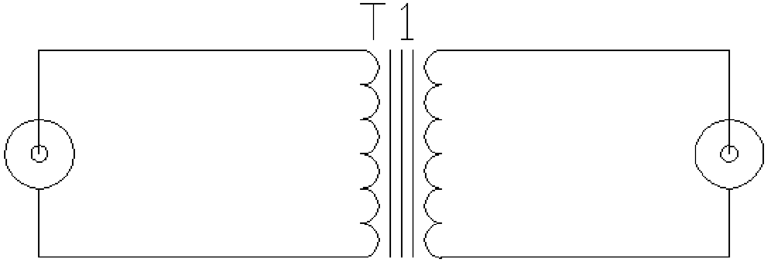
Generator Protection Issues

- Unit Connected
  - High Short Circuit Available to Generator Regardless of Grounding Method When Utility Connected
  - Coordination When Islanded – Generation Only Source of



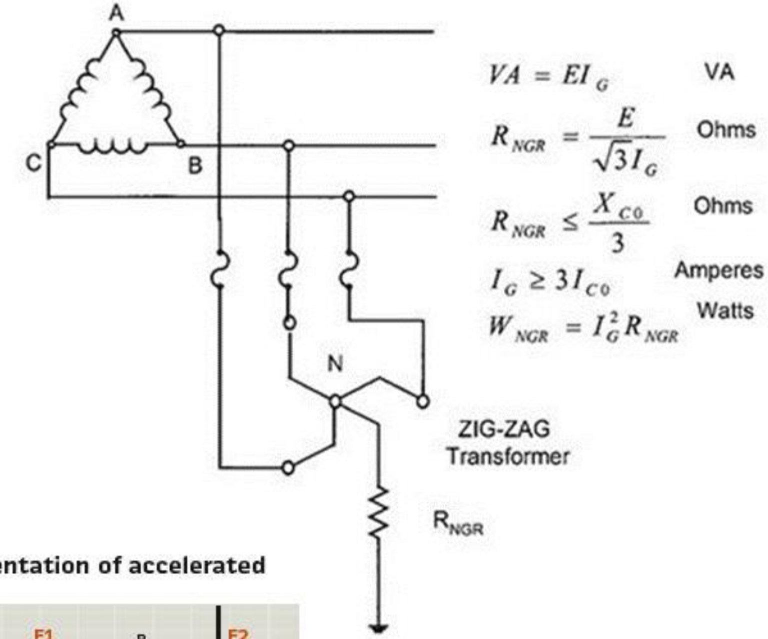
Generator Protection

- Isolation Transformer
  - Delta-Wye
    - High Short Circuit Available to Generator Regardless of Grounding Method When Utility Connected
    - Can Result in Ungrounded Island
  - Wye – Wye
    - Eliminates Overvoltage Potential
    - High Short Circuit Available to Generator Regardless of Grounding Method When Utility Connected
  - Delta-Delta
    - Eliminates Utility Ground Fault Contribution
    - Can Result in Ungrounded Island

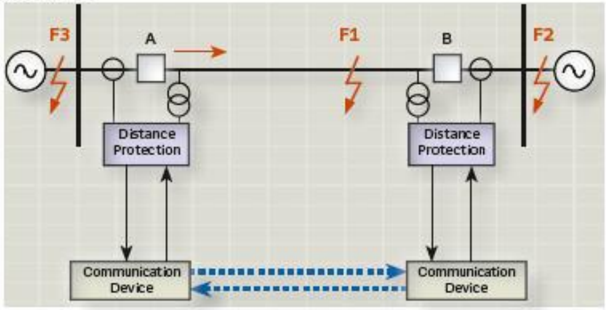


Generator Protection Issues

- Ungrounded Island
  - Connect Zig-Zag Grounding Transformer to Island
- Inverter Based Generation
  - Very Low Short Circuit Current Available When Islanded
  - Incorporate Communication-Assisted Tripping
    - Zone Interlocking



7 Conventional implementation of accelerated scheme



Case Study

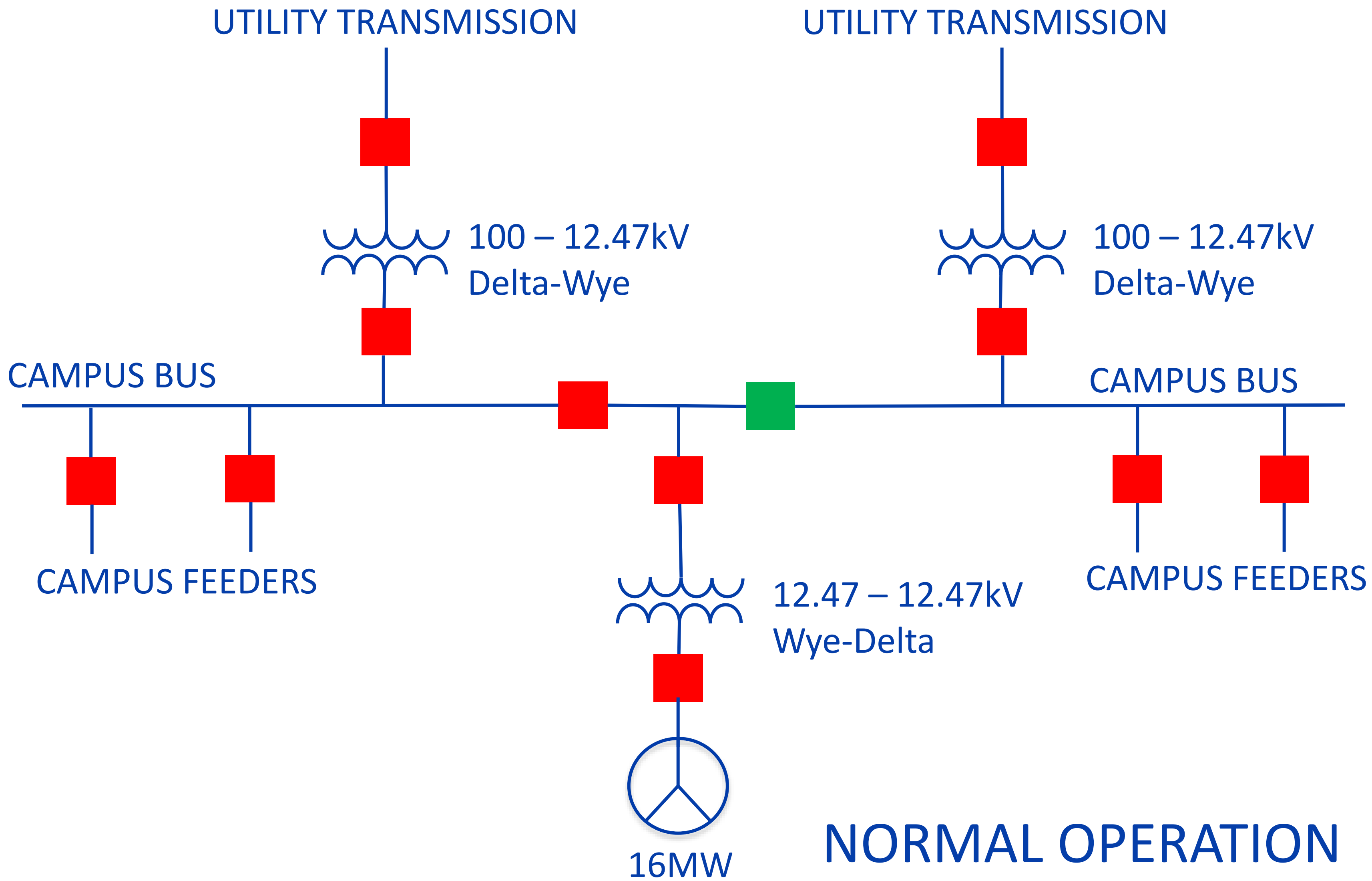
Clemson University/Duke Energy CHP

Project Background

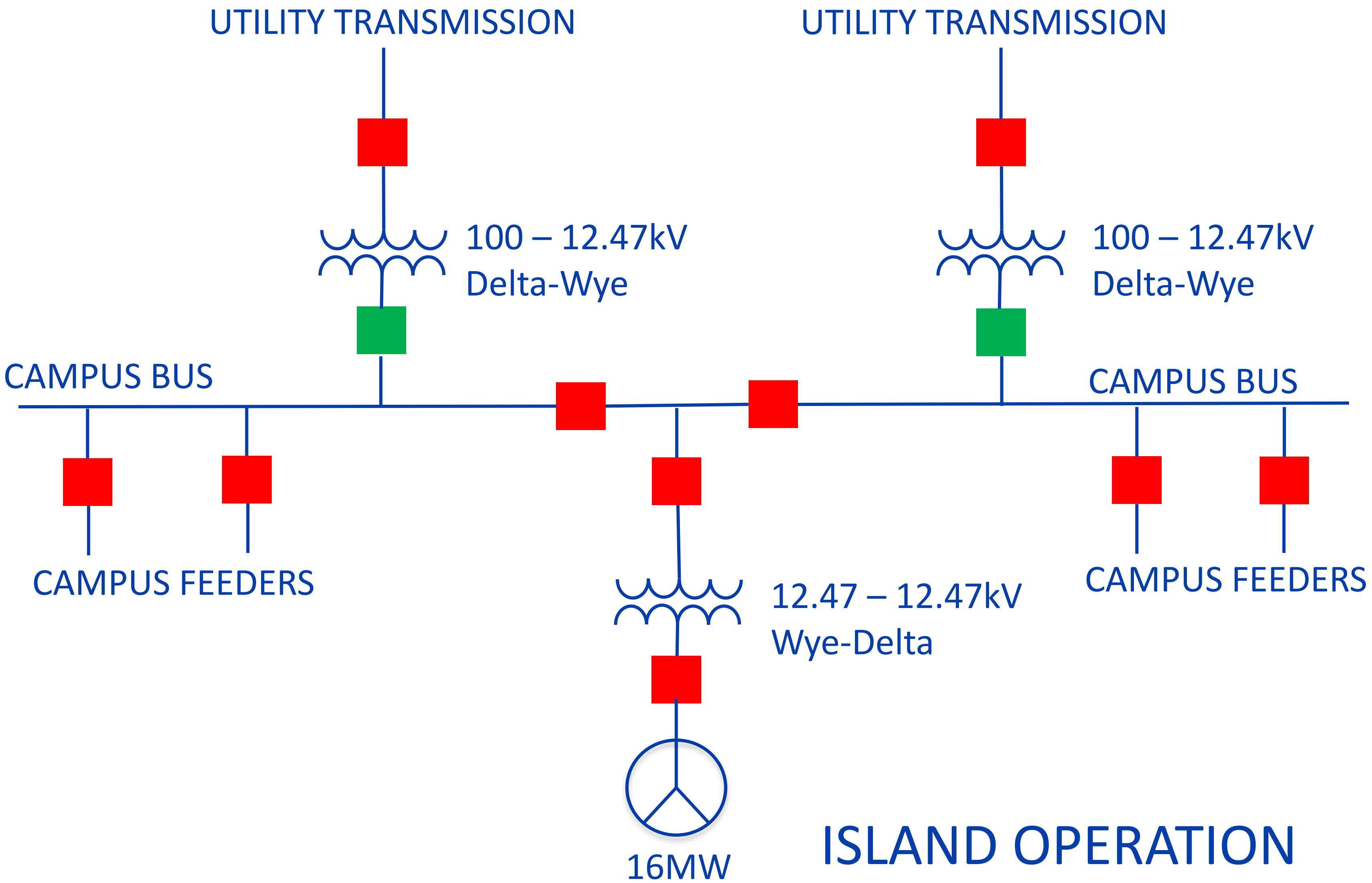
- Primary Distribution Interconnect
- Utility owned substation
- 16MW Synchronous Generation – Utility Owned
  - Normally designed to operate grid connected
  - Capable of Islanded Operation and Blackstart
- Clemson Distribution System
  - 3PH 4W Solidly Grounded Wye
  - Serves Both 3-Phase and 1-Phase Load
- Duke Distribution System
  - 3PH 4W Solidly Grounded Wye

Design Consideration

- Island Operation Required
- Generator Protection Critical – Operational Continuity
- Ground Fault Coordination
  - Ground Current Contribution from Generation Acceptable



NORMAL OPERATION



ISLAND OPERATION

Case Study

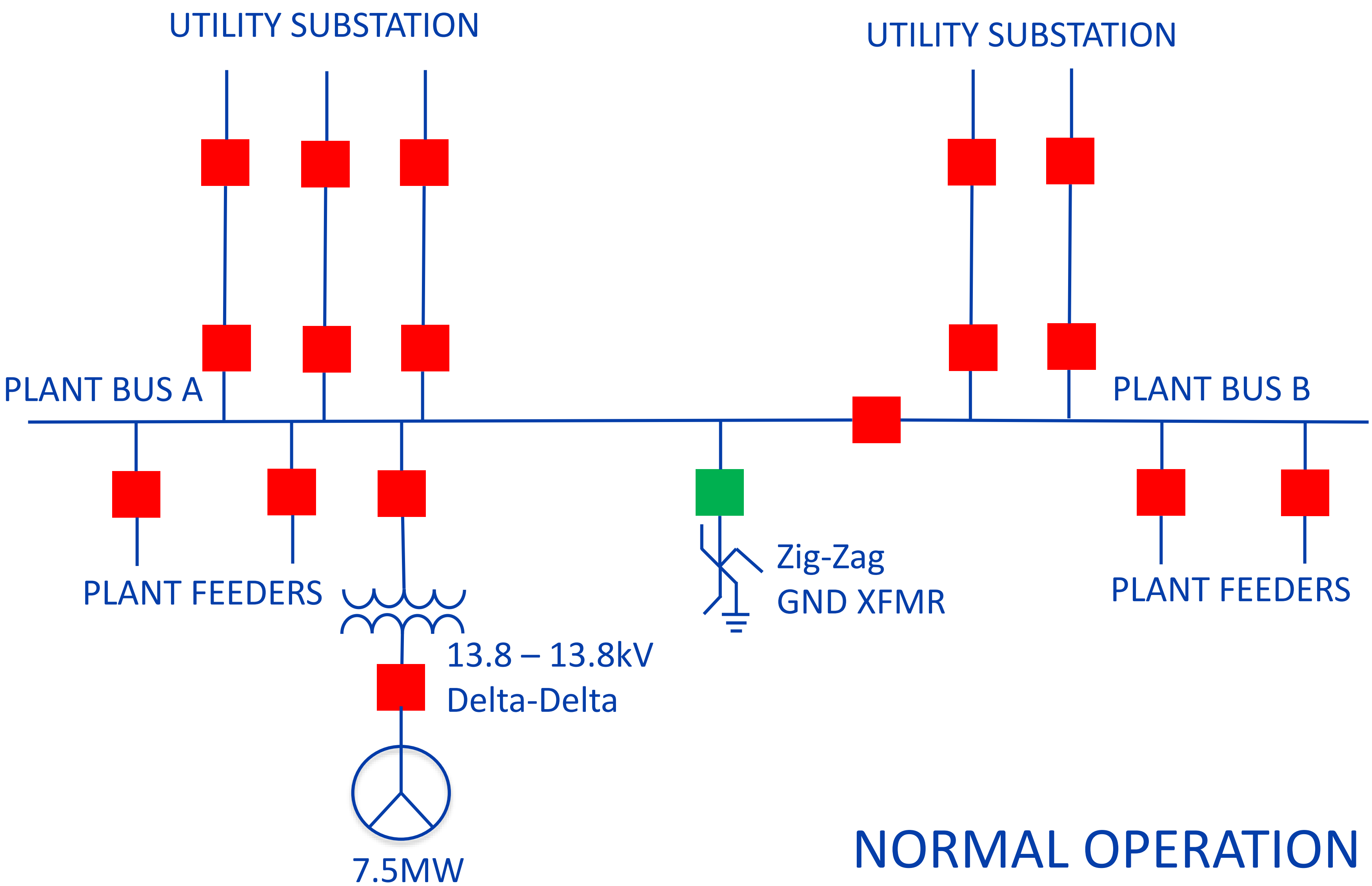
Architect of the Capitol CHP

Project Background

- Primary Distribution Interconnect
- Utility owned substation
- 7.5MW Synchronous Generation
  - Normally designed to operate grid connected
  - Capable of Islanded Operation and Blackstart
- AOC Distribution System
  - 3PH 3W Solidly Grounded Wye
  - Serves 3-Phase Load Only
- PEPCO Distribution System
  - 3PH 4W Solidly Grounded Wye

Design Considerations

- Island Operation Required
- Generator Protection Critical – Operational Continuity
- Isolation Transformer Mandated by PEPCO
  - Delta Connection to Utility
  - Eliminate Ground Current Contribution from Generation



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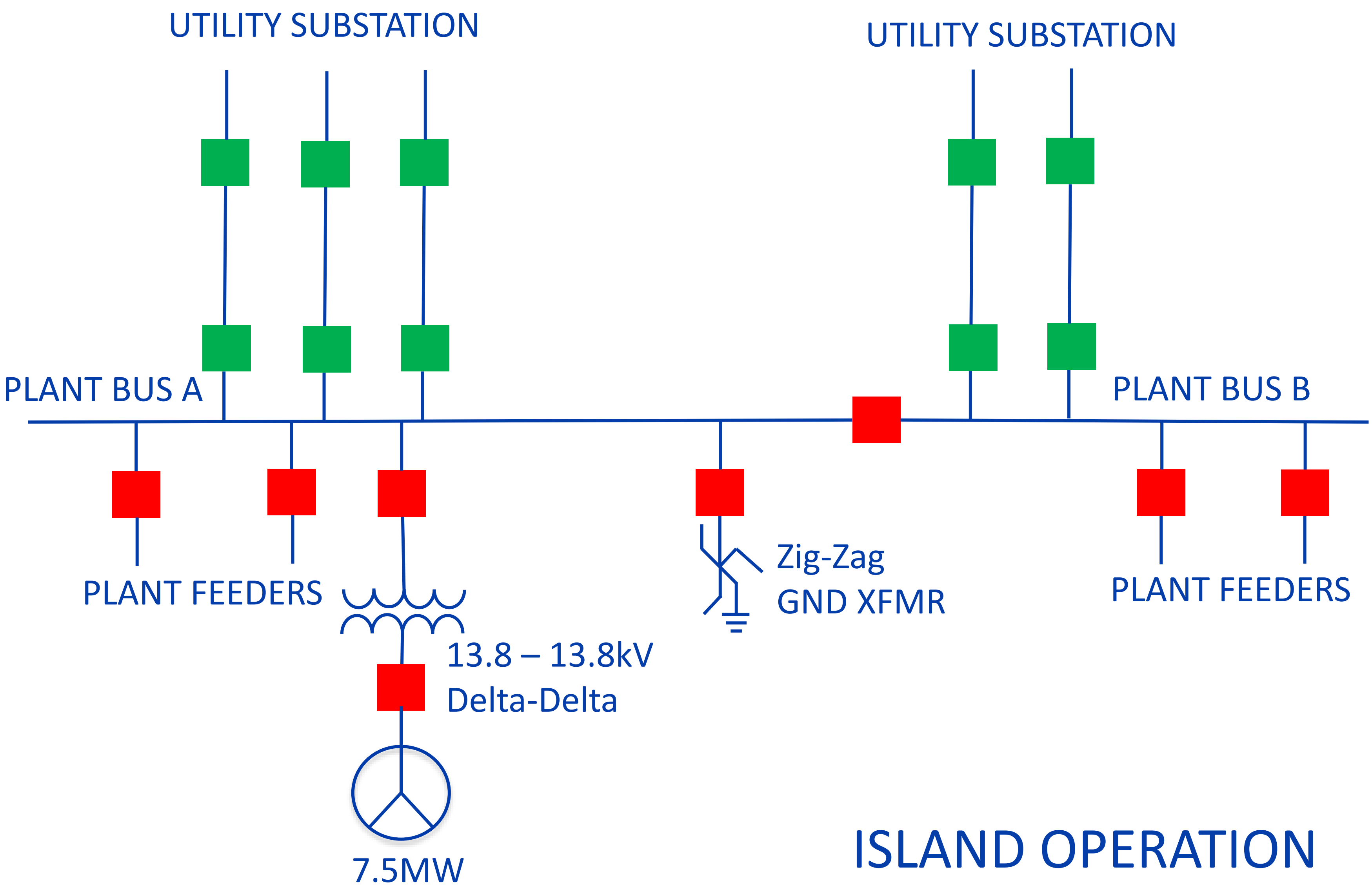

ISLAND OPERATION

Summary

- Island Operation Requires Careful Planning and Design
- Driven by Connected System Configuration
- Proper Design of System Grounding
- Careful Consideration of Generator Protection Requirements
- Understanding Coordination Limitations

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CONTACT

Michael Dempsey, P.E.
Electrical Department Manager
P 817-733-8186
E mdempsey@burnsmcd.com