# Utility Interconnection and System Protection

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# Utility paralleling vs. isolated operation.

- Isochronous kW load sharing
- Reactive power (VAR) sharing
  - Voltage droop
  - Cross current compensation
- Active synchronizing
  - fast and slow synchronizing
- Voltage matching

# Utility paralleling - modes of operation

- Base Load mode of operation
- Import/Export mode of operation
- Soft loading operation
  - dual dynamic loading control
- Bumpless load transfer operation
- Automatic stand-by with closed transition return operation
- 100 mS closed transition transfer

### Interconnection protection

- Loss of utility before connection
  - utility undervoltage (3 phase, device 27 and 47)
  - start inhibit
  - synch inhibit
  - circuit breaker closing inhibit
  - utility disconnect device operation is required before putting generator on-line

## Interconnection protection

- Loss of utility while interconnected
  - utility reclosing
  - 200 mS requirement
  - hot bus reclosing inhibit
  - high speed frequency protection (device 810/U)
  - utility disconnect device operation human error

## More terminology

- Circuit Breakers vs. Switches
- Interrupting Rating
- Available Fault Current
- Wye vs. Delta Systems
- Transformer Inrush and Reactance
- Voltage Class 5kV, 15kV, and Higher
- Grounding

#### Circuit Breakers vs. Switches

- Disconnect switches are devices capable of connecting or disconnecting a no load circuit.
- Load break switches are devices capable of interrupting load current.
- Circuit breakers are devices capable of interrupting fault currents.

#### Available Fault Current

• Available fault current is the maximum amount of fault current the system (utility and generators) is capable of producing.

## Interrupting Rating

- The amount of fault current the circuit breaker is capable of interrupting at defined voltage.
- Calculated available fault current should be less than the interrupting rating of the circuit breaker.
- System X/R ratio should be considered.

### Wye vs. Delta Systems

- Two most common connections schemes for 3 phase transformers and generators.
- Wye connected system allows for neutral to be grounded, generating ground fault upon connection of line to ground. Most flexible.
- Delta connection has no neutral, can be useful from harmonics control standpoint, requires different ground fault detection method.

## Transformer Inrush and Reactance

• Upon initial energization, transformer can require up to 12 times of it's rated current for the initial 0.1 sec.

• Transformer reactance is the parameter used by the power systems engineers to calculate the available fault current.

# Voltage Classes 5kV, 15kV, and Higher

- Medium voltage classes:
  - 5 kV any voltage between 600 V and 4.76 kV
  - 15 kV any voltage between 4.76 kV and 15 kV
  - 27 kV any voltage between 15 kV and 27 kV

High voltage class: any voltage above 27 kV

## Grounding

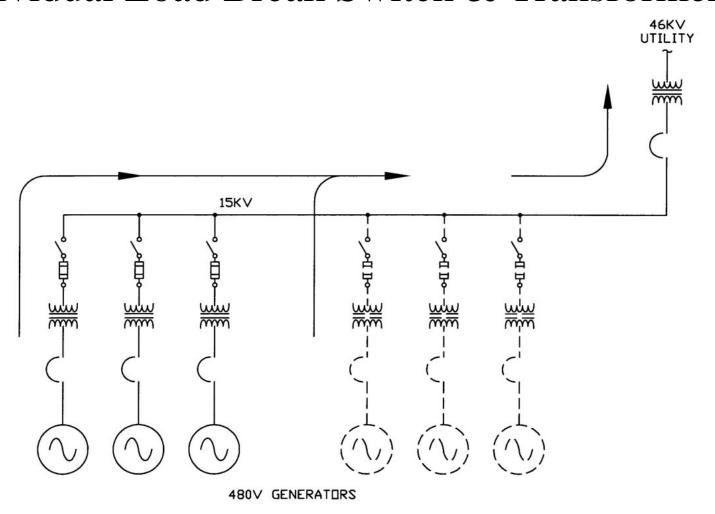
- Equipment grounding
  - safety considerations
  - neutral conductor ampacity should be 15% of the phase conductors ampacity
- Neutral grounding
  - system considerations
  - safety considerations

## Utility Interconnect Systems

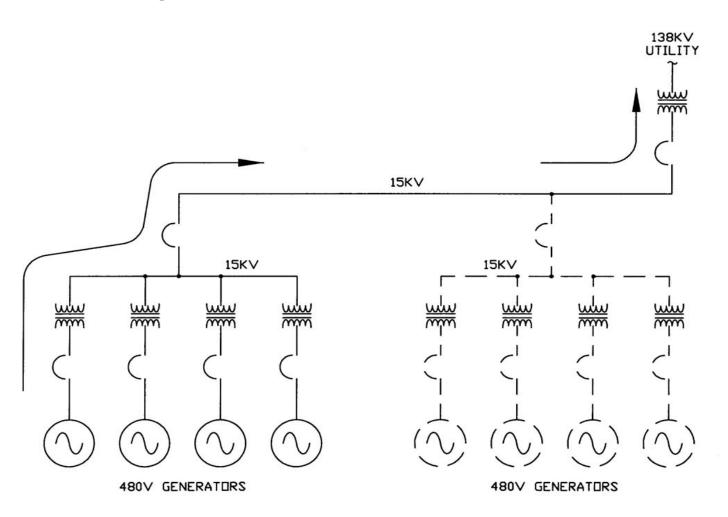
- Common Substation Tie–In Methods
  - Individual Load Break Switch & Transformers
  - Large Substation Tie-In, >15 KV
  - Feeder Circuit Tie-In, 15 KV
- Typical Industrial User Utility Tie-In

## Utility Interconnect Systems

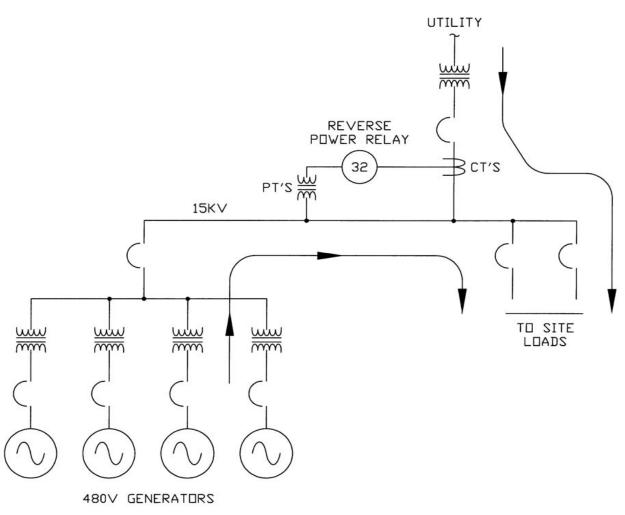
#### Individual Load Break Switch & Transformer



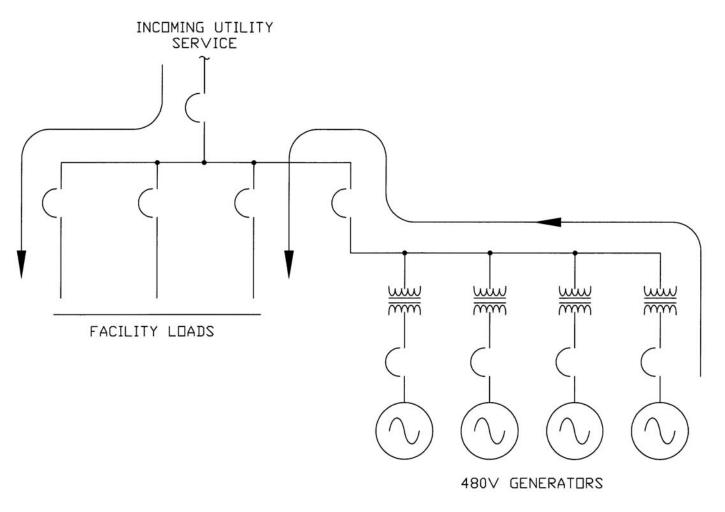
## Utility Interconnect Systems Large Substation Tie-In, >15 KV



## Utility Interconnect Systems Feeder Circuit Tie-In, 15 KV



## Utility Interconnect Systems Typical Industrial User Utility Tie-In



### System Protection

- Generator Protection
  - Time Over Current / Instantaneous (50/51)
  - Reverse Power Protection (32)
  - Over / Under Voltage (59/27)
  - Reverse VARs (40)
  - Current Balance (40)
  - Over / Under Frequency Protection (81)
  - Generator Differential Protection (87)
  - Ground Fault Protection (50/51G)

## System Protection

Equipment and personnel protection

Grounding Grid

### System Protection

• Typical Utility Protective Requirements

# Caterpillar utility grade and utility convertible switchgear

#### Utility grade switchgear

- Draw-out main circuit breaker
- Distribution transformer, 480/240-120V
- Dedicated metering
- Reverse VARs, undervoltage and ground fault protection

# Caterpillar utility grade and utility convertible switchgear

#### Utility convertible switchgear

- Fixed main circuit breaker
- Shore power plugs
- Integrated metering
- Overvoltage and reverse power protection only
- Standby/Peak Shave selector switch

## Scope of Responsibilities

- Power System Supplier
- Utility Company
- Consultant
- Contractor
- Commissioning Agent
- System Integrator

## Site Electrical Commissioning

- Cable and Transformer Insulation
- Genset Start
- Switchgear and Generator Functionality
- Phase Rotation
- Synchronizing
- Impact of added generation on utility voltage level.
- Transfer Tripping
- Trouble Shooting
- Relay Settings Adjustment