

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 81O/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

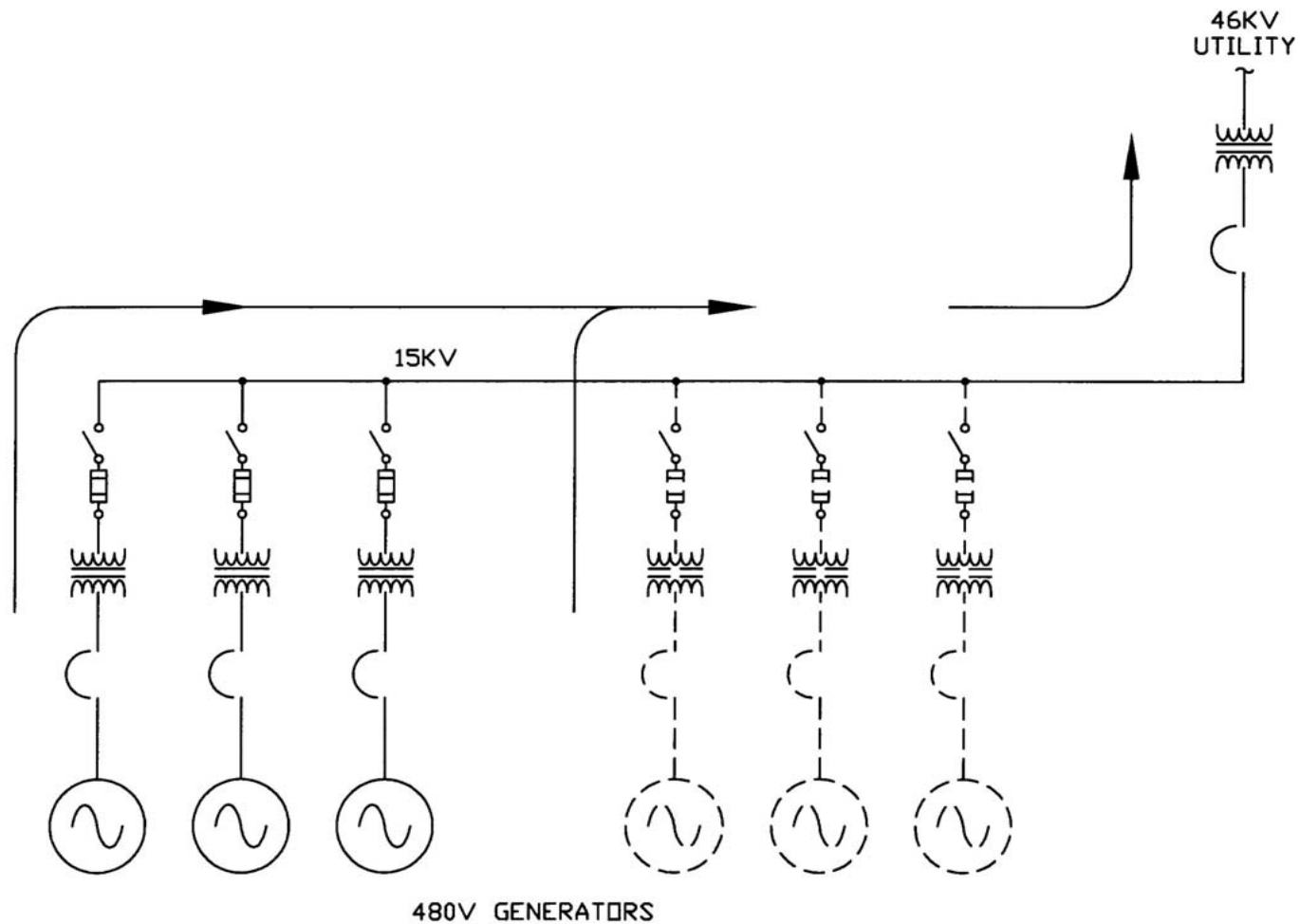
- Equipment grounding
 - safety considerations
 - neutral conductor ampacity should be 15% of the phase conductors ampacity
- Neutral grounding
 - system considerations
 - safety considerations

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

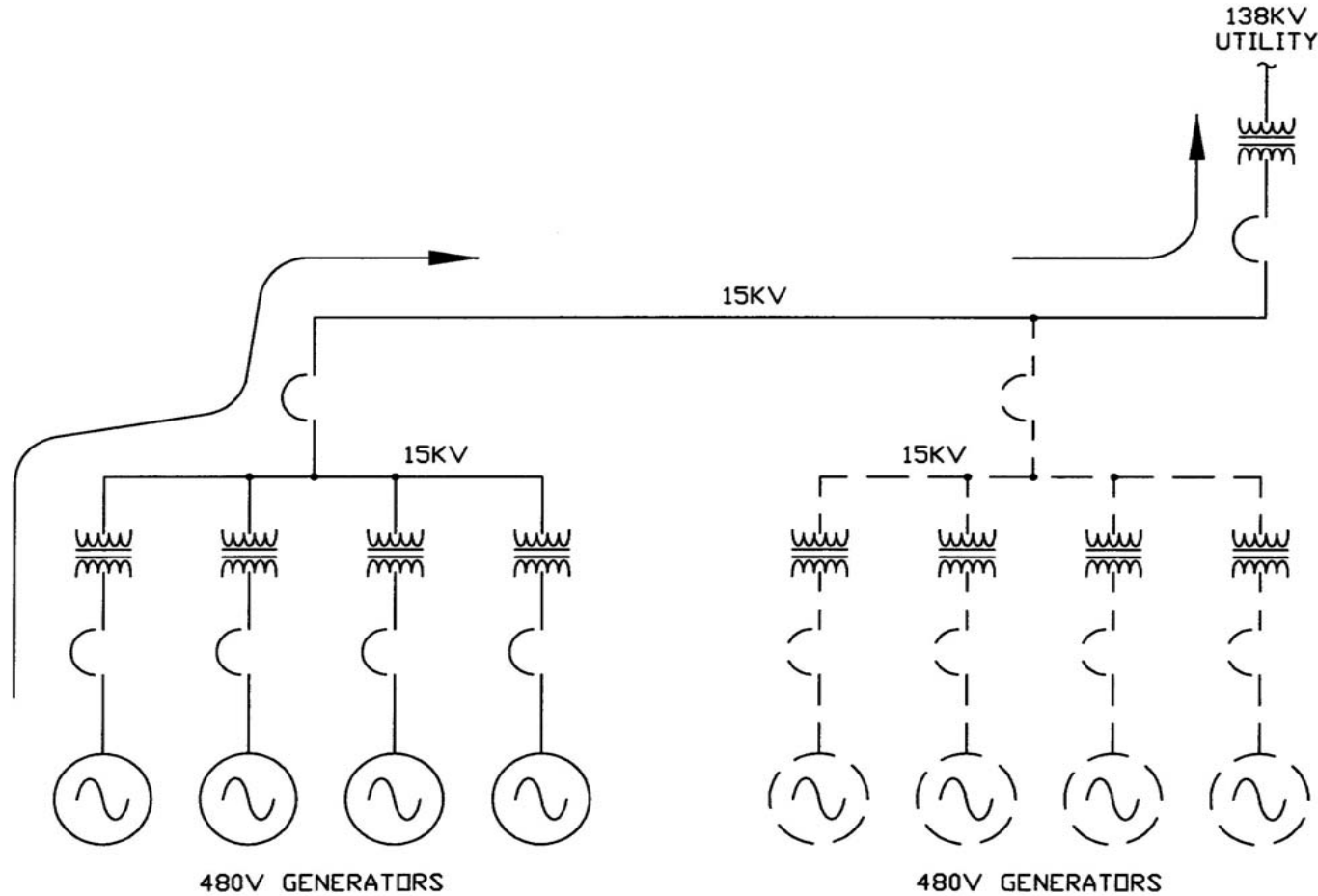
Utility Interconnect Systems

Individual Load Break Switch & Transformer



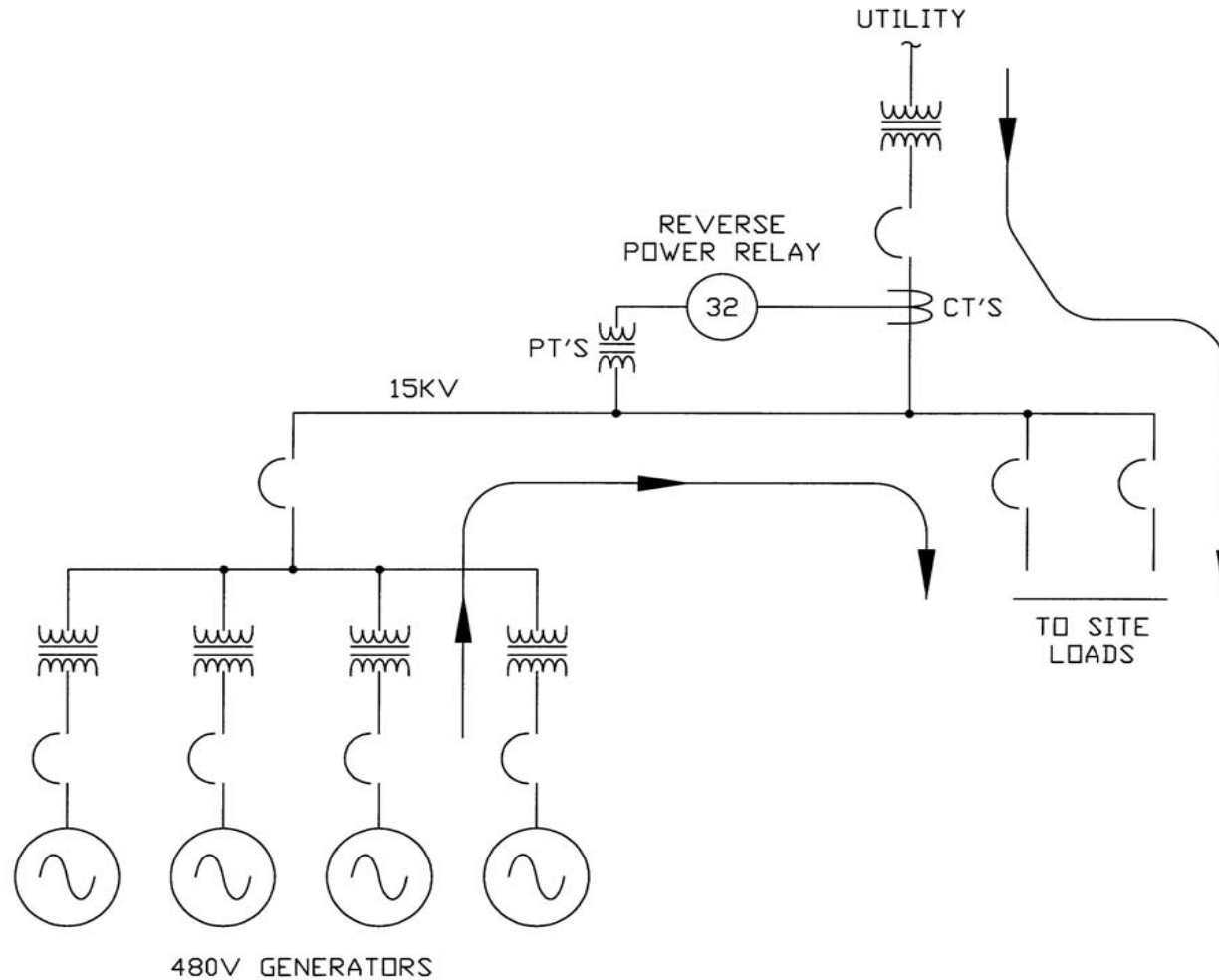
Utility Interconnect Systems

Large Substation Tie-In, >15 KV



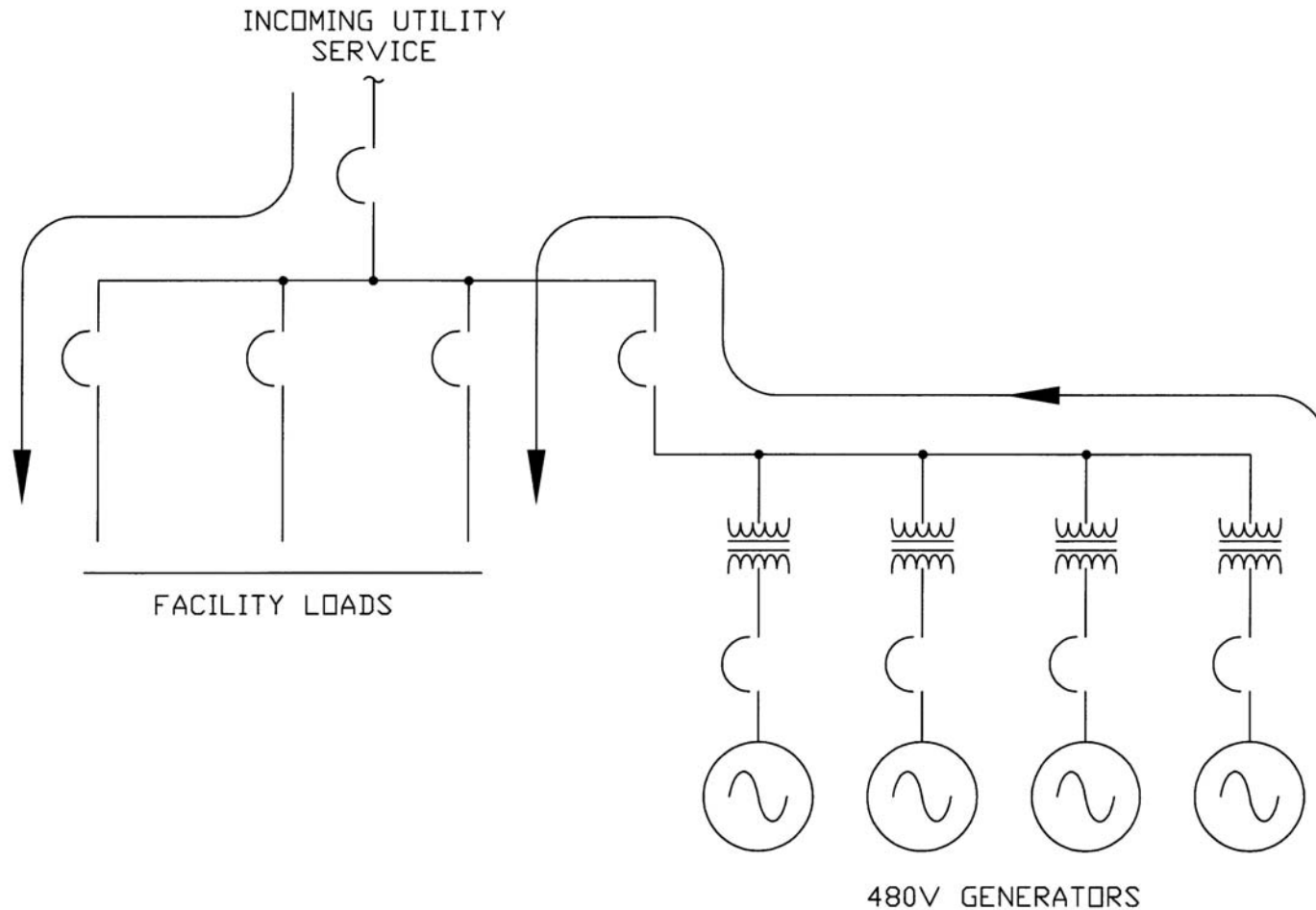
Utility Interconnect Systems

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