

ECE 528 – Understanding Power Quality

<http://www.ece.uidaho.edu/ee/power/ECE528/>

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Today...

- More on Distributed Resources
 - Power Quality and Reliability Issues
 - Operating conflicts
- Some more terms (from IEEE-1547)
 - Area EPS : Area Electric Power System
 - Typically a distribution system feeder
 - Local EPS – the system downstream of one point of common coupling
 - May have DR, load, or both

PQ issues with DG/DR

- Sustained interruptions
 - How DR may help
 - Individual customers can run on DR during the interruption
 - Portable DR can be used for critical loads during planned outages
 - How DR may hurt
 - If the utility relies on DG for base capacity and the DG becomes unavailable, load shedding may be required

PQ issues with DG/DR

- Voltage Regulation
 - Per IEEE-1547 - Active voltage regulation not permitted. DR may not cause voltage at other local EPSs to go outside ANSI C84.1 range A.
 - How DR may help
 - If the DR reduces load fluctuations on a feeder by responding to a large variable load, it will also reduce voltage fluctuations
 - How DR may hurt
 - Following a fault, DR may not reconnect for up to 5 minutes, or until system voltage is in ANSI C84.1 range B. (IEEE-1547) Load may connect before DR.

PQ issues with DG/DR

- Harmonics
 - Harmonic current injection is limited by IEEE 519 and 1547
 - How DR may help
 - To the extent that DR increases system capacity at a location, the voltage distortion due to distorted load current there will be lower
 - How DR may hurt
 - DG connected through an inverter may inject some harmonic current
 - Switching frequencies may correspond to system resonances
 - Capacitors may cause resonances

PQ issues with DG/DR

- Voltage Sags
 - How DG may help
 - Rotating machines, including DG, can help support system voltage during a voltage sag
 - How DG may hurt
 - DG is required by IEEE-1547 to trip during certain voltage sags. Loss of generation may result in a more severe sag or an interruption.

Operating conflicts

- Distribution systems are normally designed for radial, single-source operation
- DG may change the direction of power flow, and impact the response of the distribution system to faults
- Reverse power flow may impact the operation of voltage regulators

Operating conflicts

- Reclosing
 - Issues:
 - Reclosing on rotating generators can damage them
 - DG can feed a fault and prevent it from clearing
 - Solution (Rules):
 - DG is required (IEEE-1547) to disconnect from the "Area EPS" during faults on the Area EPS and prior to reclose by the Area EPS

Operating conflicts - Voltage

DG interruption requirements per IEEE-1547 (voltage at the PCC):

- $V < 50\%$: 0.16 seconds
- $50\% \leq V < 88\%$: 2.00 seconds
- $110\% < V < 120\%$: 1.00 second
- $120\% \leq V$: 0.16 seconds

Operating conflicts - Frequency

DG interruption requirements per IEEE-1547

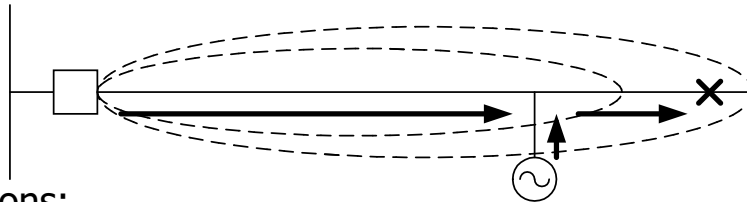
DR Size	Frequency range (Hz)	Clearing time(s)*
$\leq 30\text{kW}$	>60.5	0.16
	<59.3	0.16
$>30\text{kW}$	>60.5	0.16
	$\{59.8-57\}$ (adjustable)	Adjustable 0.16 to 300
	<57.0	0.16

*maximum for DR up to 30kW, default for $>30\text{kW}$

Operating conflicts

- Interference with relaying

- Reduction of "reach"



- Solutions:

- Adjust relay to increase reach
 - Add recloser to add another protection zone
 - Minimize DG contribution to ground faults

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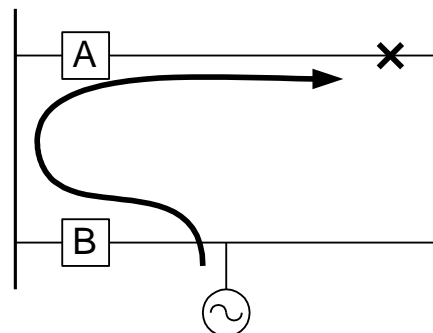
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Operating conflicts

- Interfering with relaying

- sympathetic tripping

- Issues
 - May make finding faults difficult
 - Increases area affected by fault
 - Solutions
 - Directional relays
 - Changes to circuit breaker settings

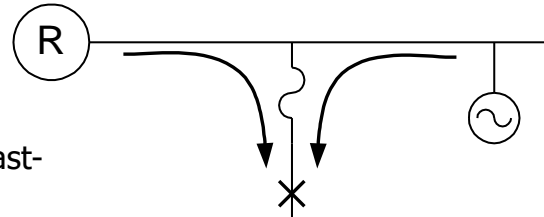


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Operating conflicts

- Interference with relaying
 - Defeat of fuse saving
 - Issue:
 - Fuse coordinate with recloser fast-trip varies with DG operation
 - Solutions
 - Larger fuses
 - Do without fuse saving
 - Minimize DG contribution to ground faults



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Operating conflicts

- Voltage regulation
 - IEEE-1547 limits individual DG to 5% or less voltage fluctuation at the PCC when paralleling
 - IEEE-1547 requires DG to disconnect during relaying, but impact on distribution system is not addressed in the standard
 - LTC (load tap changing) transformers and regulators adjusted for the load with the DG may be set too low without the DG

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Operating conflicts

- Voltage regulation - solutions
 - Limit the DG on a feeder
 - Increase regulator step speed
 - Disconnect load when DG disconnects
 - Allow DG to reconnect more quickly

Operating conflicts

- Harmonics
 - Issues
 - Line-commutated, thyristor-based inverters generate significant harmonics
 - Some synchronous generators can generate large zero-sequence currents
 - Solutions
 - Newer PWM inverters have lower current distortion
 - Use non-resonant switching frequencies
 - Use reactors in the neutral, or generators with a 2/3 coil winding pitch

Operating conflicts

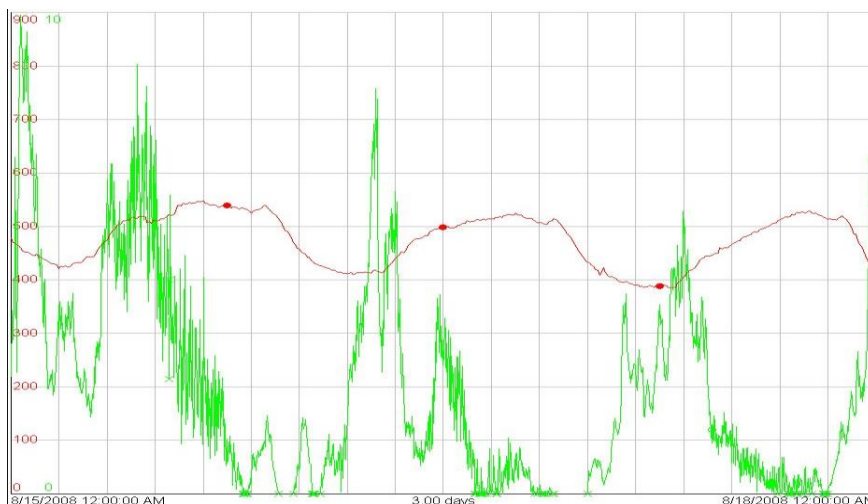
- Distribution system engineering challenges:
 - DR will likely require changes to the distribution system protection and voltage regulation scheme
 - Changes made to accommodate DR must still provide acceptable system protection and voltage regulation when DR is not online
 - Complex modeling and analysis may be required to identify and resolve potential operating conflicts

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Wind generation versus load

(Note: vertical scales are not the same)



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Next time...

- More DG/DR issues
 - Islanding
 - Location issues