On-Site Power Systems

Developing the single line
Writing the sequence of operation

Presented by:

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Kohler Power System
About Me

• Mike Pincus, PE
  – Manager – Systems, Kohler Power Systems
    • 20 years of experience in on site power systems
      – Manager - Switchgear Engineering, Kohler (13 Years)
      – Project Engineer - Switchgear Engineering, Kohler (2 Years)
      – Field Test Engineer - On Site Power Systems (3 Years)
      – Consulting Engineer - Power Systems (2 Years)

• BSEE – UW Madison
• MBA – UW Milwaukee
About Kohler Power Systems

- **Generator sets from 4 to 3250kW**
  - Most genset accessories:
    - Enclosures, Tanks, Genset Controllers, etc.
- **Transfer Switches from 30 to 4000 Amps**
  - Standard (open) Transition, Closed (100ms) or Programmed Transition
  - Available in Bypass Isolation and Service Entrance Configurations
- **Low and Medium Voltage Paralleling Switchgear**
The most common on-site power system
What are the components of an ATS

Contactor

Controller
Selecting the correct ATS

- Frame size
- Transfer Type
- Withstand rating
- Frame Type
- Neutral Switching
Frame Size
Transfer Type

Open
Break before make

Closed
Make before break
(under 100mS)

Programmed Transition
Break – OFF - Make

[Diagrams showing load connections for each transfer type]
Withstand Rating

- Series, 3, 30, or?

Swbd/CB
UL 891/489 or UL 1558/1066

Swgr/CB

Diagram showing electrical connections and components such as G1, G2, F1, F2, F3, Load, and MA.
Frame Type

- Bypass / Isolation
  - Two TS mechanisms in parallel
    - Automatic
      - Drawout
    - Manual
      - Fixed
Neutral Switching

3-Pole
Generator is NOT separately derived source – NO GF on Gen

4-Pole
Generator IS separately derived source – GF on Gen OK
1 Gen + 2 (or more) ATS
2 (or more) Gen + 2 (or more) ATS
What if One Gen Cannot Support P1?

[Diagram showing a power system with generators G1 and G2, transformers T1, F1, and F2, and loads connected.]
The Nine (9) Common Configurations
One Gen and One Utility

- Types of transfers
  - Open
  - Closed
    - Fast
    - Soft
- Maintain Parallel
  - Peak Shave
  - Utility as load bank
    - Base load
    - Import mode
Two or More Gen and One Utility
Two or More Gen and One Utility with Gen Main

[Diagram of power system with labeled components: UA, FX, GM, G1, G2, Load]
Two or More Gen and Two Utility
Two or More Gen and Two Utility with Tie
Two or More Gen and Two Utility With Ties
It is OK to Mix and Match
The secret

- Turning words into action
  - Tell you how it will work…..It will work like we tell you

Section 2  Modes of Operation

2.1 Emergency Mode
2.1.1 Response to Loss of Utility

The loss of utility causes the Engine Start Delay timer in the PLC to start. If this timer expires, then the following sequence will occur:

1. The Utility Breaker (52U) opens.
2. The priority 2 and 3 feeder breakers open.
3. The generators start.
4. The first generator that has stable voltage and frequency closes its breaker.
5. The Breaker (52T) closes.
6. The other generator synchronizes to the bus. When synchronized, its circuit breaker closes.
7. The priority 2 and 3 feeder breakers close.

2.1.2 Response when Utility Returns

When the utility returns, the Utility Stable timer in the PLC starts. When this timer expires, the following sequence occurs:

3. The generators ramp up load.
4. When the generators reach their unloaded setpoint, 52T and the generator breakers open.
5. The generators shut down after completing a cool down cycle.

2.2 Isolate Mode

Isolate mode is used to manually initiate a transfer to generator power. This can be used to test the system or in anticipation of a potential power failure.

2.2.1 Start—Transfer to Generator

Momentarily touching the isolate mode start push-button on the touch-screen starts the following sequence:

If open transfer mode is selected:

1. The generators start.
2. The first generator that has stable voltage and frequency closes its breaker.
3. The other generator synchronizes to the bus. When synchronized, its circuit breaker closes.

NOTE: If the second generator fails to start or go on-line, the operator can depress the isolate GCL Bypass push-button and the circuit breaker for the second generator.
There had to be a better way
Sequence of Operation

- How every on-site power system works (AKA Operate)
  - Automatic Operation
  - Manual Operation (Operated initiated operation)
Sequence of Operation – Normal Operation

1.1.1 Overview
When utility A voltage or frequency falls out of tolerance, the Utility A Failure timer in the PLC starts. When utility B voltage or frequency falls out of tolerance, the Utility B Failure timer in the PLC starts. When both timers expire, or when one of the timers expires while the other is timing, the bus A and B loads transfer to generator power.

1.1.2 Sequence

<table>
<thead>
<tr>
<th>Step</th>
<th>Event</th>
<th>Response</th>
<th>If Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Utility A and utility B out of tolerance.</td>
<td>Utility A Failure timer starts.</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Utility B Failure timer starts.</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>Both utility failure timers expire or one</td>
<td>All generators start.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>timer expired while the other is still</td>
<td>Utility breaker UA opens.</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>timing.</td>
<td>Utility breaker UB opens.</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required GOL Bypass timer starts.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Utility breaker UA is open.</td>
<td>Bus A Dead/Live Open Transfer timer starts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Startup Shed Option:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Selected loads on bus B are lost.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Generator Stabilization timer expires and</td>
<td>Generator main breaker GMB closes.</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Bus B Dead/Live Open Transfer timer expired.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Generator main breaker GMB is closed.</td>
<td>Bus B is on generator power.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Bus A and B on generator power.</td>
<td>Startup Shed Option:</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shed loads add back on bus A and B according</td>
<td></td>
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<td></td>
<td></td>
<td>to the Load Management settings.</td>
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<tr>
<td></td>
<td></td>
<td>Generator Management Option:</td>
<td></td>
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<td></td>
<td></td>
<td>Becomes active if in Auto and all loads</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>added.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial State</th>
<th>UA</th>
<th>Bus A</th>
<th>GMA</th>
<th>Gen Bus</th>
<th>GMB</th>
<th>Bus B</th>
<th>UB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>E</td>
<td>O</td>
<td>D</td>
<td>O</td>
<td>E</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final State</th>
<th>UA</th>
<th>Bus A</th>
<th>GMA</th>
<th>Gen Bus</th>
<th>GMB</th>
<th>Bus B</th>
<th>UB</th>
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<tr>
<td></td>
<td>O</td>
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<td>X</td>
<td>E</td>
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<td>E</td>
<td>O</td>
</tr>
</tbody>
</table>
## Sequence of Operation – Response to Failures

<table>
<thead>
<tr>
<th>Step Fail</th>
<th>Event</th>
<th>System Response</th>
<th>Operator Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Utility A power returns before Utility A Failure and Utility B Failure timers expire.</td>
<td>Bus A remains on utility A. Utility B Failure Timer Expires; Bus A loads transfer to generator power (Seq. 605) or utility A power (Seq. 606).</td>
<td>No operator action required.</td>
</tr>
<tr>
<td>B</td>
<td>Utility B power returns before Utility A Failure and Utility B Failure timers expire.</td>
<td>Bus B remains on utility B. Utility A Failure Timer Expires; Bus B loads transfer to generator power (Seq. 601) or utility B power (Seq. 602).</td>
<td>No operator action required.</td>
</tr>
<tr>
<td>C</td>
<td>Utility breaker UA fails to open.</td>
<td>Utility A Remains Failed; Utility B Remains Failed; Bus A is without power. Generator main breaker GMA does not close. After the required generators are online, generator main breaker GMA closes.</td>
<td>Option #1. Reset the Fail To Open alarm. System retries to open utility breaker UA. When breaker opens, transfer automatically continues.</td>
</tr>
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<td></td>
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<td></td>
<td>Option #2. Manually open utility breaker UA. Transfer automatically continues if system is in Auto.</td>
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<td></td>
<td>Option #3. 1. Place system in Manual. 2. Manually open utility breaker UA. 3. If required, shed load. 4. Manually close generator main breaker GMA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Utility A Remains Failed. Utility B Returns; Bus A is without power. The system transfers bus B from generator power to utility B power following the expiration of the Utility B Stable timer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Utility A Returns. Utility B Remains Failed; Bus A remains on utility A. Bus B remains on generator power.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Utility A and Utility B Return;</td>
</tr>
</tbody>
</table>
One Document does it All

- One document used for many purposes
  - Submittal approval (Draft O&M)
  - PLC Programming instructions
  - FAT (factory acceptance test) document
  - SAT (site acceptance test)
  - Final O&M manual
How we Program the PLC
Weymouth Water Treatment Plant
Paralleling Switchgear Projects

• Prime Power
  – 3 Gens
Paralleling Switchgear Projects

- Medical Center
  - 3 Utilities
  - 5 Gens
Thank you and Questions?

• Thank you
• Questions?