WECC CMPLDW Phase 2 Study update

LMTF
April 18th, 2017
Atlanta, GA
CMPLDW load model phase 1 has been in approved WECC cases since 2013, it’s the best available model to capture system oscillations, FIDVR, and other phenomena.

Phase 1 has single phase air conditioner stalling disabled. Phase 2 will enable stalling.

Phase 1 has single phase air conditioner stalling disabled because:
- System impact studies done in 2011-2013 showed that with stalling enabled simulations were more pessimistic than actual events.
- System impact studies with stalling enabled did not meet old WECC performance criteria; compliance problem.

The old phase 2 parameters used $V_{\text{stall}} = 0.55$ to 0.60:
- Parameters were based on lab tests that applied instantaneous voltage dip, no ramp.
- Also, voltage dip was applied at zero crossing of the wave form, giving more severe results.
New Phase 2 parameters

- In August 2016, WECC LMTF proposed a new set of CMPLDW phase 2 parameters because
  - New lab tests show stall threshold depends on many factors (ramp duration, sag duration, sag magnitude, POW, recovery voltage, temperature)
  - The voltage “ramp” effect decreases Vstall significantly
  - New proposal is Vstall= 0.45 to account for this effect
  - Simulations are now more in line with historical events
  - WECC has approved new dip criteria to accommodate FIDVR
  - Proposal also includes updated protection parameters for all motor types to match NERC default data set
Proposed new parameters

Table I: proposed parameter ranges for Phase II composite load model (highlighted values indicate large change)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Phase II – Proposed</th>
<th>Phase I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor D, AC stall voltage, Vstall</td>
<td>0.4 to 0.45</td>
<td>0.55 to 0.6</td>
</tr>
<tr>
<td>Motor D, AC stall time, Tstall</td>
<td>0.032 sec</td>
<td>99999 sec</td>
</tr>
<tr>
<td>Motor A fraction 1 trip, Ftr1a</td>
<td>0.2 to 0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Motor A, voltage 1 trip, Vtr1a</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Motor A, time 1 trip, Ttr1a</td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Motor A voltage 1 reclose, Vrc1a</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Motor A time 1 reclose, Trc1a</td>
<td>99999</td>
<td>99999</td>
</tr>
<tr>
<td>Motor A fraction 2 trip, Ftr2a</td>
<td>= 0.95 – Ftr1a</td>
<td>0.7</td>
</tr>
<tr>
<td>Motor A, voltage 2 trip, Vtr2a</td>
<td>0.5 to 0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>Motor A, time 2 trip, Ttr2a</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Motor A voltage 2 reclose, Vrc2a</td>
<td>=Vtr2a + 0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Motor A time 2 reclose, Trc2a</td>
<td>0.05</td>
<td>0.1</td>
</tr>
</tbody>
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<tr>
<th>Parameter</th>
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<th>Phase I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor B fraction 1 trip, Ftr1b</td>
<td>0.2 to 0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Motor B, voltage 1 trip, Vtr1b</td>
<td>0.55 to 0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Motor B, time 1 trip, Ttr1b</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Motor B voltage 1 reclose, Vrc1b</td>
<td>=Vtr1b + 0.1</td>
<td>0.75</td>
</tr>
<tr>
<td>Motor B time 1 reclose, Trc1b</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Motor B fraction 2 trip, Ftr2b</td>
<td>= 0.8 – Ftr1b</td>
<td>0.3</td>
</tr>
<tr>
<td>Motor B, voltage 2 trip, Vtr2b</td>
<td>0.45 to 0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Motor B, time 2 trip, Ttr2b</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Motor B voltage 2 reclose, Vrc2b</td>
<td>=Vtr2b + 0.1</td>
<td>0.65</td>
</tr>
<tr>
<td>Motor B time 2 reclose, Trc2b</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*Motor C settings are same as Motor B settings*
AC Stall, Instantaneous Voltage Dip

Previous assumption

Zero Crossing

Peak

45°

Fault Voltage

Fault Duration (cycles)

Source: Bernie Lesieutre, University of Wisconsin
AC Stall: 1 Cycle Voltage Ramp Down

Previous assumption

New assumption

Peak

45°

Zero Crossing

Source: Bernie Lesieutre, University of Wisconsin
Phase 2 timeline

- WECC LMTF presented results of new phase 2 studies at the November 2016 MVWG meeting
- March MVWG approval
- May TSS approval
- Seek approval of phase 2 parameters in time for 2018 study program
Participants in phase 2 study

• We originally reached out
  – BPA
  – SRP
  – PG&E
  – APS
  – SDG&E
  – SCE
  – SCL
  – LADWP
  – PGE
  – PSE
  – PAC

• We now have results from
  – BPA
  – SRP
  – SDG&E
  – SCE
  – PSE
  – PAC
  – APS supports results from the above in lieu of direct participation
Analysis for phase 2 study

- Had each participant choose most severe base cases and contingencies for their area
- Varied Vstall from 0.4 to 0.6
- Compared simulations in principle with historic events
- Compared events to new WECC performance criteria
- Analyzed voltage and frequency at critical buses
- Went through large number of results Nov. 2016 MVWG meeting
- The results were well received by MVWG. Approval is expected in March 2017
SRP Study Details

- Studied 2018 summer case on PSLF version 19.0_02
- Outages:
  - Jojoba – Kyrene 500kV Line Outage
  - Palo Verde Outage: 2 Units Trip
- Vstall Parameters
  - Studied Vstall at 0.4, 0.45, 0.5, 0.525, 0.55, 0.575, & 0.6
  - Noticed big jump from 0.5 to 0.6, so additional Vstall parameters were investigated
  - Set Tstall to 0.032 for all load models
  - Had issues with “0.45 Trip”; PSLF would crash
- Monitored Jojoba, Kyrene, & Palo Verde bus voltages and frequencies for 30 seconds
Kyrene 500kV Bus Voltage for Jojoba - Kyrene 500kV Line Outage

Vstall = 0.4
Vstall = 0.45
Vstall = 0.5
Vstall = 0.525
Vstall = 0.55
Vstall = 0.575
Vstall = 0.6
SCE Setup and Assumptions

• Tstall enabled at 0.032 seconds
• Vstall varied as follows: 0.40, 0.45, 0.50, 0.55 and 0.60
• Contingencies placed at 500kV 3ph, Normal Clearing.
• 4 contingencies:
  – Devers – Valley
  – Valley – Devers
  – Lugo – Miraloma
  – Serrano – Valley
• Voltage and Active Power for selected locations monitored
SCE Summary of Results

• Phase-2 Vstall (0.40, 0.45) contrast significantly with Phase-1 (0.55-0.6).
• Adopting Phase 2 will effectively eliminate stalling in some buses that are not necessarily electrically close to faults.
• FIDVR is still observed for certain conditions especially close-in faults.
• From a high-level perspective, implementation of Phase 2 parameters seem adequate as it eliminates excessive FIDVR and Tripping while capture FIDVR in other locations.
• Additional tests may need to be carried out to cover other conditions not evaluated with this assessment.
PSE Results

• Ran normal and delayed clearing faults on a 2018 Heavy Summer Case
• Used Power World Simulator
• Vstall varied as follows: 0.40, 0.45, 0.50, 0.55 and 0.60
• Performance is significantly better for Vstall 0.45 compared to Vstall 0.60
PSE- Lakeside 115 kV BSBF
PAC Results

- Used PSSE
- Song Wang ran studies
Closing Remarks

- There is no one “correct” set of parameters; lab tests show that a range of values are reasonable.
- The latest lab tests from Nov. 2016 support $V_{\text{stall}}=0.45$ and $T_{\text{stall}}=0.032$ s as reasonable, conservative default values.
  - A more optimistic sensitivity study can use $V_{\text{stall}}=0.40$, $T_{\text{stall}}=3$ cycles or $V_{\text{stall}}=0.45$ and $T_{\text{stall}}=5$ cycles.
- Simulation results from 6 major utilities across WECC show satisfactory performance with these default values.
- We would like to get these new default values approved for the 2018 study program.
- Scripts are available to insert the new parameters. We encourage anyone interested to reach out to WECC LMTF to do additional testing now.
Questions?
Extra Results slides

- These slides were presented at the Nov. 2016 MVWG meeting
  - SRP
  - PAC
  - SCE
  - PSE
CMPLDW Phase 2 Test Bench Results

WECC MVWG
Load Modeling Task Force

Zak Baumann, Senior Engineer
Salt River Project
Transmission Compliance & Modeling
October 2016
Study Details

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Kyrene 500kV Bus Voltage for Jojoba - Kyrene 500kV Line Outage

Voltage (pu)

Time (s)

Vstall = 0.4
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Jojoba 500kV Bus Frequency for Jojoba - Kyrene 500kV Line Outage

Frequency (Hz)

Time (s)

Vstall = 0.4
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Vstall = 0.55
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Vstall = 0.6
Kyrene 500kV Bus Frequency for Jojoba - Kyrene 500kV Line Outage

Frequency (Hz) vs Time (s)

- Vstall = 0.4
- Vstall = 0.45
- Vstall = 0.5
- Vstall = 0.525
- Vstall = 0.55
- Vstall = 0.575
- Vstall = 0.6
Palo Verde 500kV Bus Voltage for 2 Palo Verde Unit Outage

Voltage (pu) vs. Time (s) for different Stall voltages:
- Vstall = 0.4
- Vstall = 0.45
- Vstall = 0.5
- Vstall = 0.55
- Vstall = 0.6
Palo Verde 500kV Bus Frequency for 2 Palo Verde Unit Outage

Vstall = 0.4
Vstall = 0.45
Vstall = 0.5
Vstall = 0.55
Vstall = 0.6
Conclusions

• Very little difference when varying Vstall from 0.4 to 0.5.
• More delayed voltage recovery when Vstall is 0.55 or higher.
CMPLDW Phase 2 Validation

Raul E. Perez-Guerrero
Advanced Technology
Southern California Edison
Setup and Assumptions

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Serrano-Valley Outage

- 3ph Fault at Serrano – Valley 500 kV line near Serrano
- Fault cleared in normal clearing time
Serrano-Valley Outage (Bus Voltages)
Serrano-Valley Outage (Bus Voltages)
Serrano-Valley Outage (Bus Voltages)

Faulted Bus
Serrano-Valley Outage (Active Power - Load)
Serrano-Valley Outage (Active Power - Load)
Serrano-Valley Outage (Active Power - Load)
Valley-Devers Outage

- 3ph Fault at Valley – Devers 500 kV line near Valley
- Fault cleared in normal clearing time
Valley-Devers Outage (Bus Voltages)
Valley-Devers Outage (Bus Voltages)
Valley-Devers Outage (Bus Voltages)
Valley-Devers Outage (Active Power - Load)

Faulted Bus
Valley-Devers Outage (Active Power - Load)
Valley-Devers Outage (Active Power - Load)
Devers – Valley Outage

- 3ph Fault at Devers – Valley 500 kV line near Devers
- Fault cleared in normal clearing time
Devers – Valley Outage (Bus Voltages)
Devers – Valley Outage (Bus Voltages)

Faulted Bus

Devers 500kV

Miraloma 500kV
Devers – Valley Outage (Bus Voltages)

Serrano 500kV

Vincent 500kV
Devers – Valley Outage (Active Power - Load)
Devers – Valley Outage (Active Power - Load)
Devers – Valley Outage (Active Power - Load)
Lugo-Miraloma Outage

• 3ph Fault at Lugo – Miraloma 500 kV line near Lugo
• Fault cleared in normal clearing time
Lugo-Miraloma Outage (Bus Voltages)

Faulted Bus

- Lugo 500kV
- Valley 500kV
Lugo-Miraloma Outage (Bus Voltages)

Devers 500kV

Miraloma 500kV
Lugo-Miraloma Outage (Bus Voltages)
Lugo-Miraloma Outage (Active Power - Load)
Lugo-Miraloma Outage (Active Power - Load)

Miraloma 66kV

Villa Park 66kV
Lugo-Miraloma Outage (Active Power - Load)

**Vista 66kV**

**Chino 66kV**