Fault Induced Delayed Voltage Recovery (FIDVR) Advisory

NERC Synchronized Measurement Subcommittee (SMS)
NASPI Engineering Analysis Task Team (EATT)
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The goal of this advisory is to:

1. Provide information related to the characteristics of FIDVR, and the impact it can have on transmission and distribution systems
2. Provide high-level background information on the current findings of FIDVR events, studies, and testing (see appendix)
3. Provide information related to capturing FIDVR events on the transmission and distribution systems
4. Provide a point of contact in the event a FIDVR event is found such that detailed analysis can be explored collaboratively
• FIDVR is characterized by depressed system voltage voltages for a prolonged period of time following a system fault
  ▪ Transmission, sub-transmission, or distribution system fault causes depression in system voltage
  ▪ After fault has been cleared (whether normal or delayed clearing), voltage remains at significantly reduced levels for several seconds
  ▪ Voltages slowly return to acceptable levels after many seconds
  ▪ Voltage overshoot may occur due to capacitor switching and load tripping

• FIDVR events are known to cause large amounts of bulk power system load to trip on undervoltage
  ▪ Potential for insufficient reactive resources, large load loss, and potentially cascading events
What Happens During a FI DVR Event?

Richard Bravo, SCE, presentation at 2014 IEEE PES T&D Meeting
• FIDVR can be captured on the transmission and distribution level
• Recent findings show that FIDVR much more prevalent on distribution system than previously expected
  ▪ Does not always propagate up to transmission level
  ▪ Can be captured at Transmission-Distribution substations (head of feeder)
• Can utilize all high resolution monitoring equipment available:
  ▪ Phasor measurement units (PMUs)
  ▪ Digital fault recorders
  ▪ Relay point on wave recordings
  ▪ Power quality meters
  ▪ PQube® meters
• Looking for (synchronized) measurements of voltages, currents, real and reactive power, and frequency
• Archive data from:
  ▪ Phasor measurement units (PMUs)
  ▪ Digital fault recorders
  ▪ Relay point on wave recordings
  ▪ Power quality meters
  ▪ PQube® meters

• State estimator snapshot case (and dynamics models)

• Fault event sequence of events

• Contact Ryan Quint (ryan.quint@nerc.net) with questions or to discuss next steps for modeling and validation
Appendix:

Supplemental Information on FI DVR
• FIDVR is caused by stalling of single phase motors, primarily residential air-conditioners (particularly high-efficiency ACs) during transmission level faults
• Single phase AC motors can stall for normally cleared 3-phase faults
• Strong sensitivity to:
  - Fault point-on-wave
  - Voltage degradation rate of change
  - Voltage magnitude
  - Duration of voltage dip
  - Ambient temperature
Event Synopsis:

- Shield wires of two 500kV lines in SCE system contacted due to small plane
- One line reclosed into three-phase fault, with two cycle clearing
- Distribution voltages dipped to 0.6 pu
- Fifty nine (59) distribution circuits tripped, approximately 3500 MW of load lost in Southern California Edison area
- System voltages recovered to 0.95 pu within 20-25 seconds.
SCADA vs. PMUs During FI DVR Events

- Known information
  - Fault on system
  - CB’s opened normally

- SCADA resolution not sufficient for FIDVR events assessment
  - SCADA shows the high voltage point (~1.09 p.u.)

Tony Johnson, SCE, presentation at NERC OC meeting December 7, 2010
Another Example of SCADA vs. PMUs
• Compressor loading and stall voltage depend on ambient temperature.

• Point on wave in which fault is instantiated affects the stall voltage of the motor.
• Point on wave sensitivity affected significantly by rate of change of voltage decline
• May explain why FIDVR not always prominent
NERC will be holding a FIDVR Workshop, tentatively scheduled for September 30-October 1, 2015 in Washington DC area. Industry announcement to come shortly.

For more information about Fault Induced Delayed Voltage Recovery (FIDVR):

- [https://fidvr.lbl.gov/](https://fidvr.lbl.gov/)
- [http://www.nerc.com/docs/pc/tis/FIDVR_Tech_Ref%20V1-2_PC_Approved.pdf](http://www.nerc.com/docs/pc/tis/FIDVR_Tech_Ref%20V1-2_PC_Approved.pdf)
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