SUPPLEMENTAL DYNAMIC VOLTAGE/VAR RESPONSE TESTING PROCEDURE GUIDELINES

The following guidelines were developed to aid the Interconnection Customer/Developer aid in producing a valid test procedure for a Class IV Generating Facility with an aggregate generator nominal nameplate rating of 10 MW or greater. Each site should, at a minimum, incorporate the following guidelines into the site specific test procedure. At APS option and mutually agreed to with the Customer, APS can witness the test procedure. All testing is subject to electrical system and environmental conditions. Customer shall provide APS with a certified test report demonstrating conformance to the guidelines noted below in addition to the APS Interconnection Requirements.

Power Quality:

1. Power quality testing is undertaken at the option of APS to verify compliance with section 8.4 of the APS Interconnection Requirements for Distributed Generation ("Interconnection Requirements").
2. Power quality is measured at the point of interconnection with a suitable power quality instrument (ie BMI 3030a or modern equivalent.)
3. For each measurement, record:
    a. Individual voltage harmonics for each phase
    b. Individual current harmonics for each phase
    c. Voltage and current total harmonic distortion for each phase
    d. Voltage, current, current imbalance, and real and reactive power output corresponding to the measurement
4. At minimum, measurements should be made at three separate plant operating points at unity power factor, typically:
    a. Low power (5%-20% of plant nameplate capacity)
    b. Medium power (40-60% of plant nameplate capacity)
    c. Full power (80%-100% plant nameplate capacity)
5. For solar sites: if advanced grid interaction features are enabled at the plant and are expected to contribute additional harmonic distortion, additional measurements may be taken while operating in these modes, at the discretion of APS.

Dynamic Performance of Digital Regulator(s) Operating modes:

1. All testing is subject to system conditions; for example system voltage may limit reactive power production or absorption.
2. Measurement and verification will be performed with the relevant instrumentation at the testing engineer's discretion, typically a BMI 3030a and Dataq DI-730.
3. The performance of the modes specified in section 8.9 of the Interconnection Requirements will be verified as follows:

    a. Power Factor Control Mode (PF control mode)
        i. The customer will demonstrate the successful operation of the PF control mode at unity power factor (i.e. by adjusting

the X/R ratio until the power factor is 1.0). Check at least 2 separate plant operating points, typically:

1. Medium power (40-60% of plant nameplate capacity)
2. Full power (80%-100% plant nameplate capacity)

ii. The customer will demonstrate the ability to change the setpoint of the GF within the .95 lagging to .95 leading range in accordance with 8.9(a) of the Interconnection Requirements (i.e. by adjusting the X/R ratio until the power factor is +/- 0.95). Check at least 2 points for both leading and lagging power factor, typically:

1. Medium power (40-60% of plant nameplate capacity)
2. Full power (80%-100% plant nameplate capacity)

b. Reactive Power Control Mode (VAR Control Mode)

i. The customer will demonstrate the successful operation of VAR control mode by varying plant VAR output within the range specified in 8.9(b) of the Interconnection Requirements.

1. At full plant output, increase reactive output until the plant reaches maximum boosting VARs, 1.05 pu voltage is reached, or power factor of 0.95 lagging is reached.

2. At full plant output, decrease reactive power output until the plant reaches the VAR buck limit, 0.95 pu voltage or until power factor of 0.95 leading is reached.

c. Automatic Voltage Regulator Mode (AVR Mode)

i. The customer will demonstrate the successful operation of the AVR at typical system voltage.

ii. The AVR will be subject to setpoint step testing to determine its dynamic voltage response speed.

iii. Readings may be taken at either the Point of Interconnection or the low side of the step up transformer, at the discretion of the testing engineer.

iv. The following is an example of a typical test sequence:

1. Record baseline system voltage.

2. Bring the GF online at unity power factor and full output.

3. Verify APS test equipment is connected at the appropriate metering point.

4. The APS test coordinator will inform ECC that step testing is imminent and to expect variation in plant voltage and reactive power output.

5. Record initial voltage setpoint, bus voltage, real and reactive power output. Start continuous recording.

6. Step the voltage setpoint up or down 1%, depending on system conditions. Verify magnitude and speed of voltage step change. Log time of step, allow voltage and reactive power to settle and log bus voltage, real and reactive power output.
7. Step back to the initial voltage setpoint. Verify magnitude and speed of voltage step change. Log time of step, allow voltage and reactive power to settle and log bus voltage, real and reactive power output.
8. Repeat steps 6 and 7 with a 2% step. If a suitable response is not achieved, continue to increment the step size. Stop testing when a response suitable for analysis is obtained. Do not exceed the voltage rating of the equipment or execute a step larger than 5%. If voltage or reactive power alarms come in, log the alarms and do not execute steps larger than what caused the alarms; the test range is subject to equipment or system voltage and reactive power limits.
9. Return the AVR to the as-found voltage setpoint. Log voltage setpoint, bus voltage, real and reactive power output.
10. The APS test coordinator will inform ECC testing is complete.
11. Stop the Dataq and BMI test recorders. Make backup test data copies and carefully disconnect equipment.