Subject: EPCL program cc.p - generating unit data tests - cross-compound generating units

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Date: 26 November, 2011

1 General

cc.p is an EPCL program for checking the dynamic modeling of turbine-generators in PSLF. It runs a set of dyanmic response tests on a single turbine-generator unit as follows:

1 Current interruption test; open main circuit breaker while generator is delivering (0-j0.2)per unit MVA at rated voltage.

2 Voltage regulator reference step with generator connected to a nearby infinite bus and loaded at (0.3+j0) per unit MVA through outgoing impedance of 0.3 per init on generator MVA base

3 Voltage regulator reference step with generator connected to a remote infinite bus and loaded at user-specified per unit MW through outgoing impedance of 0.5 per init on generator MVA base - PSS out of service

4 Voltage regulator reference step with generator connected to a remote infinite bus and loaded at user-specified) per unit MW through outgoing impedance of 0.5 per init on generator MVA base - PSS in service if present

5 Transmission fault - 3 cycle 3 phase fault at generator terminals - outgoing impedance is 0.4 per unit on generator MVA base

6 Governor reference step with generator connected to remote infinite bus through 0.4 per unit impedance and loaded to user-specified per unit of generator MVA base.

7 Sudden load increase while operating isolated from grid and loaded initially at user-specified per unit of generator MVA base

The parameters of the events simulated by these tests are listed in table 1. The ** entries in table 1 indicated that generator reactive power output is as necessary to maintain scheduled bus voltage.

Table 1: Test Descriptions

Test	Pgen	Qgen	$Z - outgoing$	Event	$\Delta Vref$	$\Delta Pref$
1	0.00	-0.2	n/a	Open 52G	0	0
2	0.50	*	0.3	AVR Ref step	0.03	0
3	**	*	0.5	AVR Ref step, no PSS	0.03	0
4	**	*	0.5	AVR Ref step with PSS	0.03	0
5	**	*	0.4	3ph 3cy fault	0	0
6	**	*	0.4	Gov Ref Step	0	0.005
7	**	*	n/a	Step load increase	0	0

The value ** is entered by the user in response to a prompt from the epcl program.

2 Test System Configuration

Test simulations are made simultaneously on two alternative representations of the generators connected at a single bus. These generators might be the HP and LP rotors of a cross-compound unit or a pair of hydro generators that share a common step-up transformer, for example. One complete representation (generator, exciter, turbine, etc) is built up at bus 1; the second alternative representation is built up at bus 2. The required load flow base case is cc.sav.

This test system configuration is coordinated with the *4ia* program which extracts dyd records for a single generating unit from a WECC dyd file and exchanges the models used to represent the machine. The dyd files produced by *4ia* normally place an unmodified generating unit model set at bus 1 and a modified model set at bus 2.

The dynamics data file (.dyd file) for cc.p must have the generator records, particularly *gencc* records, for each representation alternative appearing consecutively. Depending on the sequencing of generator records in the original dyd file that provided input to 4ia, it may be necessary to use a text editor to reorder generator records in the dyd file to be used with cc.p.

The buses at whith the two generating unit representations are made up are connected to an infinite source at bus 100 as shown in figure 1. Note that there will be multiple generator rotors connected at each of buses 1 and 2. The source implemented by a *gthev* model so that its voltage and frequency can be programmed by use of the *plnow* command.

The base voltage of all buses in this test system is 13.8kV. When extracting generator data records from existing dyd files the *4ia* program changes the base voltage field of the bus identifier to 13.8. Note that changing the base voltage of the bus to which a generator is connected *does not* affect the validity of the generator data since all generator data is stated in per unit terms and is insensitive to the base voltage of the bus.

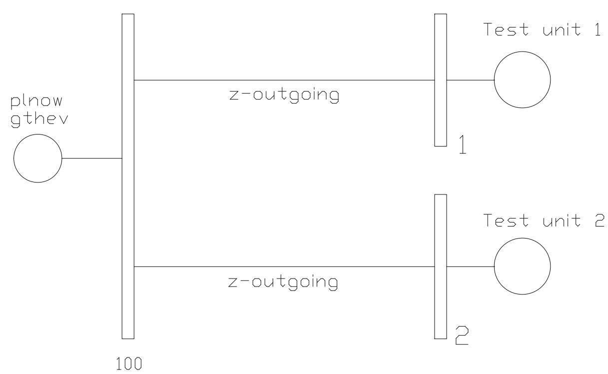

Figure 1: System configuration - identical tests made on two generators

3 Test Descriptions and Expected Form of Results

3.1 Test 1 - Current Interruption Test

Test 1 is the interruption of zero power factor current in the stator of the generator. It reveals the dynamic characteristic of the excitation system when the generator is isolated. Because the current that is interrupted is leading, or magnetizing, current the interruption causes generator terminal voltage to dip instantaneously. The voltage regulator must sense this dip and respond promptly and stably to restore voltage to its initial value.

3.2 Test 2 - Voltage Reference Step - Strong Connection

Test 2 simulates the response to a step change of voltage regulator reference when the generator is a a moderate real power output and is strongly connected to a large external system. In this test the change of voltage regulator reference will cause the generator to change its reactive power output. The change in terminal voltage will be equal to the step change only if the voltage regulator has in integral element. The response of the system in this test is expeceted to be stable. The sudden change in excitation will produce a small change in real power and a small transient variation of speed and rotor angle. The response should be stable and rotor angle motion should be well damped.

3.3 Test 3 - Voltage Reference Step - Weak Connection - PSS Off

Test 3 simulates a voltage reference step but differs from test 3 in that the generator output is specified by the user and the connection to the external large grid has a high impedance in relation to the rating of the generator. It is recommended that the power setting for this test, and subsequent tests, should be between 0.7 and 0.85 per unit.

The power system stabilizer is turned off in this test (if it is present). This high impedance configuration provides the possibility that a voltage regulator with a high transient gain will reduce the damping of rotor angle motion and it is to be expected that the damping seen in this test will be less than seen in test 2. Units whose voltage regulators have a high transient gain may show a growing oscillation in this test.

3.4 Test 4 - Voltage Reference Step - Weak Connection - PSS On if present

Test 4 is identical to test 3 except that power system stabilizer, if present, is turned on. If the power system stabilizer is effective the damping of rotor angle motion should be much better in this test than in test 3.

3.5 Test 5 - Transmission fault

In test 5 a 3 cycle transmission fault is applied at the terminals of the generator. Removal of the fault does not change the outgoing connection impedance. The generator should remain in synchronism with the external system and rotor angle oscillations should be well damped.

3.6 Test 6 - Governor Reference Step - Weak Connection

This test shows the response of the governor to a load-change command of the type that a plant operator would issue when he needs to increase output. Of equal importance this test also shows the effect of the governor on low frequency oscillations of rotor angle of the type associated with inter-area power flows. The turbine power and generator real power should increase reasonably promptly and should be stable. Oscillations of real power and turbine power will be apparent if the governor is poorly adjusted with regard to low frequency power flow oscillations.

3.7 Test 7 - Step Increase in Load with in Isolated Operation

The unit is placed in isolated operation supplying a load the user-specified load. This load is increased suddenly. The load increases causes a dip in turbine speed and a corresponding response from the governor to increase turbine power. This response should be stable.

4 Dialog Responses

`Enter dyd file name (do not append .dyd):`

Enter the name of the dyd file from which records are to be extracted

`Enter MW Load in per unit of turbine MVA base :`

Enter the machine output for tests 3-7 in per unit with respect to the MW capability of the turbine. A value between 0.7 and 0.9 is suggested.

`Enter higher outgoing impedance in pu of PLANT MVA base :`

Enter the outgoing transmission impedance to be used in tests 3 and 4 in per unit relative to the generator MVA. A value between 0.5 and 0.7 per unit is suggested.

`Enter speed/load reference step PU :`

Enter the per unit step to be applied to the governor speed-load reference in test 6. This value should be approximately 0.005 for machines whose reference is in terms of speed and approximately .05 for machines whose reference is in terms of power.

5 Required Files

Ths EPCL program requires that the load flow history file *cc.sav* is present in the working directory. This file provides the skeleton for the simulation and is modified by the EPCL program. The savf command should NOT be used after the EPCL program has been used.