Transformer Energization Using the Multiple Run Component

Written for PSCAD v4.5 and v4.6.

1. General Description of the Example

This example illustrates the point-on-wave study for transformer energization.

To accomplish this, the multiple-run component is used to control the closing time (BRK1) of the breaker from one run to another. Therefore the multiple-run component can change the energization time (EngTime) of the transformer as shown in Figure 1.

Also In this way, it can be discovered on which point-on-wave (when breaker closes) the maximum inrush current occurs.

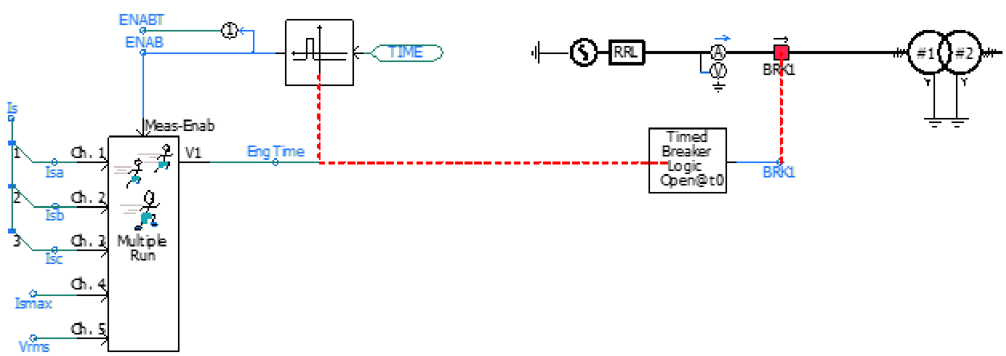

Figure 1: The multiple-run component is used to change the closing time of the breaker to study the energization of the transformer

2. Multiple-run Component Settings

To obtain a point-on-wave study for transformer energization, the closing time of the breaker (BRK1) closes as a variable in the multiple component. Figure 2 shows the settings for the multiple-run component.

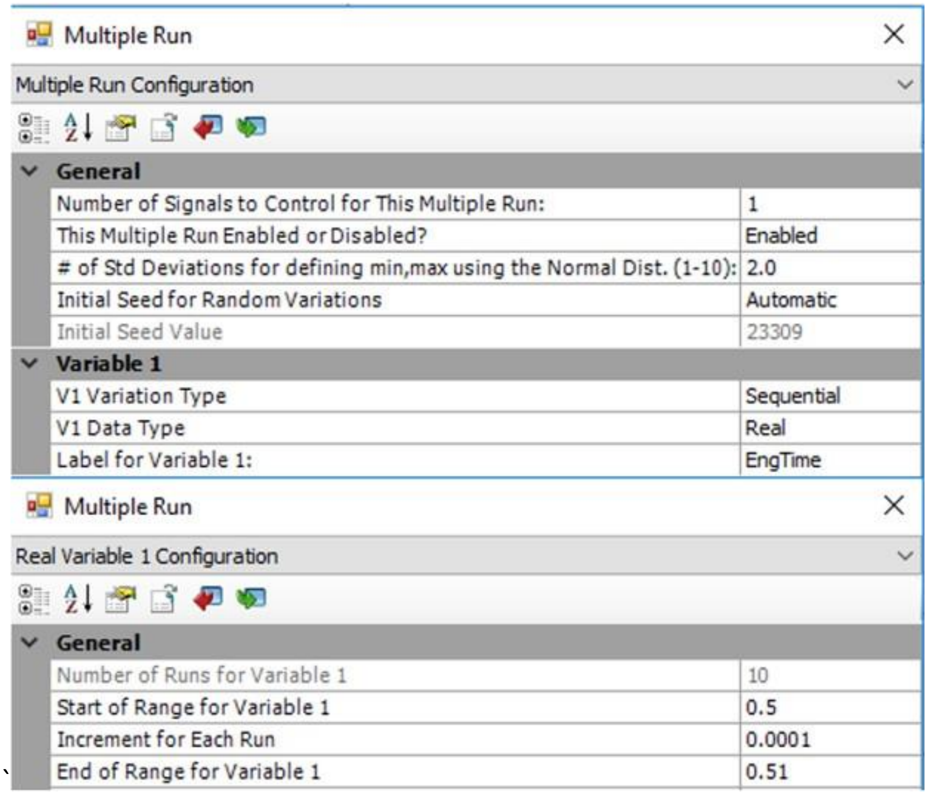

Figure 2: Settings for the multiple-run component to change the closing time of the breaker between 0.5 and 0.51 sec (more than half cycle) with increment steps of 0.001 sec

As shown in Figure 3, the control signal "Meas-Enab" can be set to 0 to reset the automatic processing functions of multiple run, and set to 1 to enable them. This is useful to avoid the recording of transients during start-up or initialization.

As shown in Figure 3, when the simulation time exceeds the energization time (EngTime), the ENAB signal turns to 1. This is the time at which the input channels of the multiple-run component are saved to a file (out1.out).

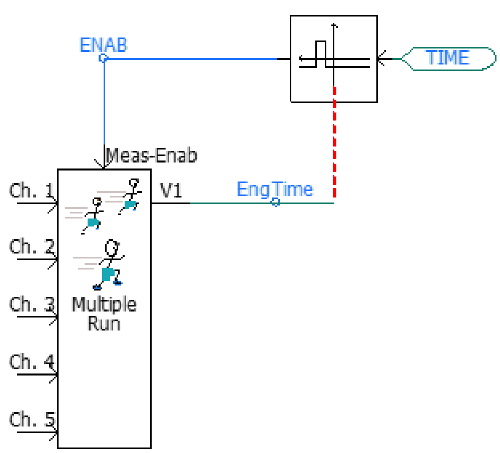

Figure 3: Meas-Enab signal is controlled externally to make sure the channels are saved to the file immediately after transformer energization

Figure 4 shows the signals connected to the channels of the multiple-run component to be saved to the output file (out1.out).

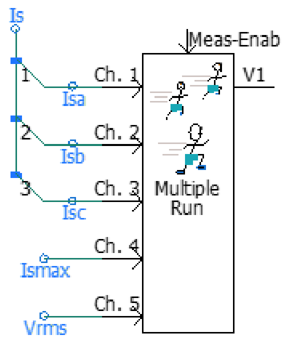

Figure 4: The multiple-run component used to save the channels to the output file "Out1.out"

Figure 5 shows the settings for the multiple-run component to record the channels. These channels connect to external signals such as:

- Maximum of absolute value of transformer currents Is_phaseA, Is_phaseB and Is_phaseC.
- Maximum inrush current (I_Max).
- rms voltage (V_rms) at the terminal of transformer.

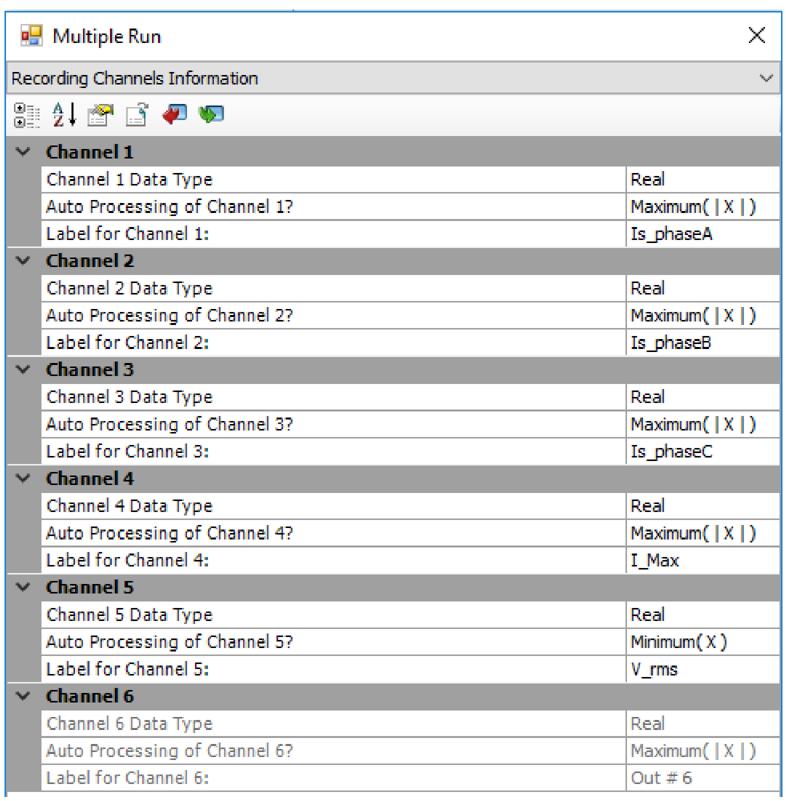

Figure 5: Recording channels in the multiple-run component

In addition, criteria defining an optimum run can be set as shown in Figure 6. In this example, the maximum inrush current of the transformer (worst case scenario) which is connected to channel # 4 is considered as the criteria for optimum run. When the multiple-run component runs all the simulations, the option run based on channel #4 is deteremined, and the simulation is run again for that optimum run.

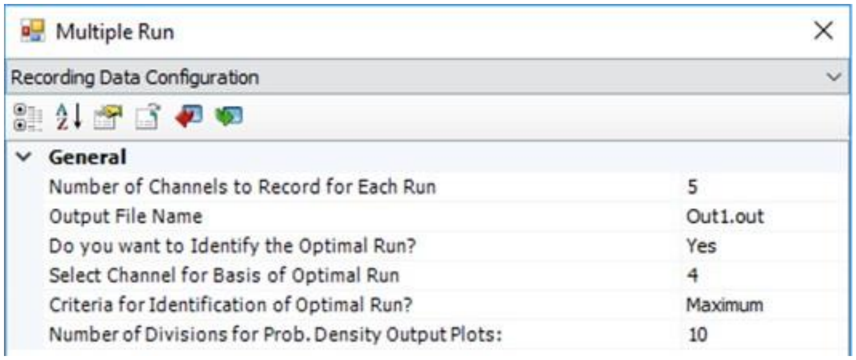

Figure 6: Recording data in the multiple-run component; the channel 4 which is the maximum inrush current is selected as the criteria for the optimum run

3. Project Settings for the Snapshot to Reduce Simulation Time

A snapshot of the simulation may be used to reduce simulation time. A snapshot is taken from the simulation when a steady-state is reached. The multiple simulations can be run from the snapshot.

Figure 7 shows the steps to set up a snapshot:

- Disable the multiple-run component.
- Set a snapshot at 0.49 sec (in the Project Settings of the case).
- Run the case to create the snapshot.
- Enable the multiple-run component.
- Wet start-up of the case from snapshot, and change the simulation time to 0.1sec (in the Project Settings of the case).
- Run the case.

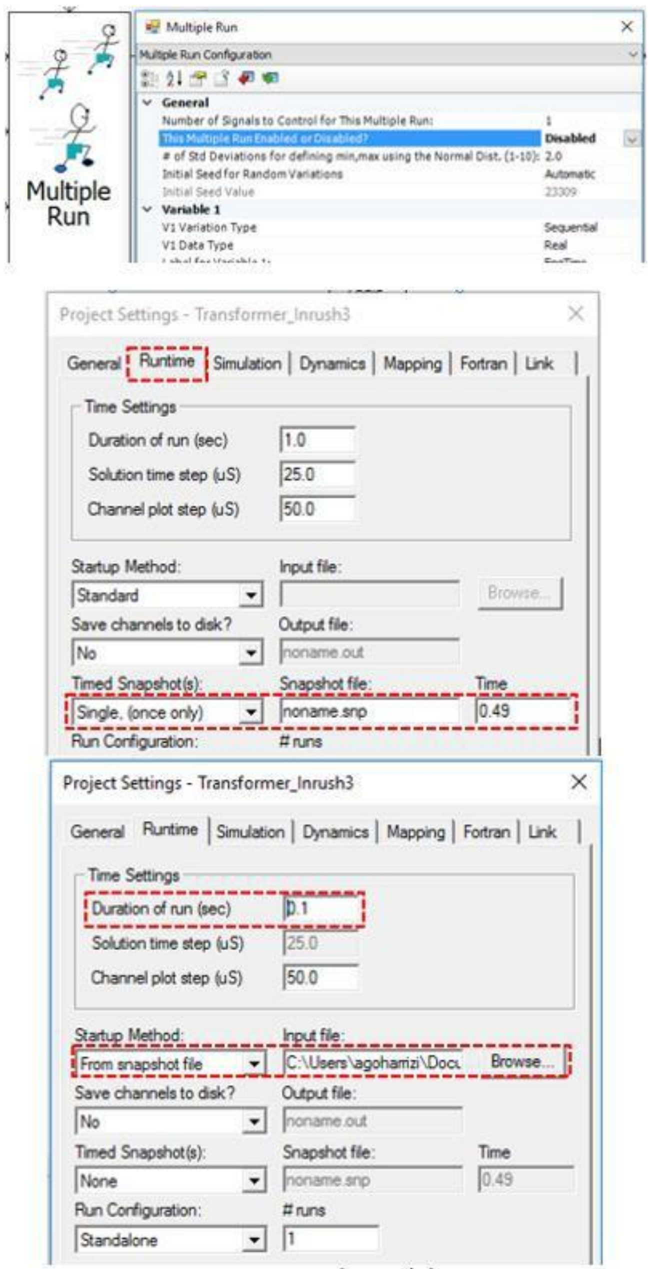

Figure 7: Steps to create a snapshot and the project settings

4. Simulation results

When the simulation runs are completed, the output file (out1.out) is available in the folder created by PSCAD.

Figure 8 shows the simulation results for the first 25 runs. It can be seen that the at run # 24 maximum inrush current occurs.

Multiple Run Output File

Run #	EngTime	Is_phaseA	Is_phaseB	Is_phaseC	I_Max	V_rms
1	0.5000000000	2.501254580	0.7309737172	2.094063607	2.501254580	0.8309579586
2	0.5001000000	2.488827077	0.7609050330	2.137587468	2.488827077	0.8286863913
3	0.5002000000	2.473930676	0.7951347103	2.179786970	2.473930676	0.8263920024
4	0.5003000000	2.456582105	0.8327813568	2.220582043	2.456582105	0.8241088089
5	0.5004000000	2.436800090	0.8732212480	2.259894601	2.436800090	0.8218891974
6	0.5005000000	2.414605922	0.9159924694	2.297649601	2.414605922	0.8196919257
7	0.5006000000	2.390023762	0.9607334958	2.333776636	2.390023762	0.8176129254
8	0.5007000000	2.363080802	1.007148916	2.368212459	2.368212459	0.8155658113
9	0.5008000000	2.333807349	1.054988556	2.400898551	2.400898551	0.8136721402
10	0.5009000000	2.302236866	1.104034207	2.431770298	2.431770298	0.8118243477
11	0.5010000000	2.268405980	1.154090938	2.460758218	2.460758218	0.8101544281
12	0.5011000000	2.232354469	1.204981232	2.487796450	2.487796450	0.8085434110
13	0.5012000000	2.194125237	1.256540954	2.512825340	2.512825340	0.8071314444
14	0.5013000000	2.153764137	1.308635625	2.535790822	2.535790822	0.8057876179
15	0.5014000000	2.111324304	1.361081505	2.556643300	2.556643300	0.8046615916
16	0.5015000000	2.066854030	1.413760146	2.575337342	2.575337342	0.8036238892
17	0.5016000000	2.020408213	1.466539318	2.591831053	2.591831053	0.8027962110
18	0.5017000000	1.972044661	1.519291975	2.606086114	2.606086114	0.8020964172
19	0.5018000000	1.921823975	1.571895568	2.618067711	2.618067711	0.8015785897
20	0.5019000000	1.869809477	1.624231592	2.627744545	2.627744545	0.8012335446
21	0.5020000000	1.816067127	1.676185242	2.635088847	2.635088847	0.8010385059
22	0.5021000000	1.760665444	1.727645144	2.640076397	2.640076397	0.8010585846
23	0.5022000000	1.703675425	1.778503167	2.642686539	2.642686539	0.8011956197
24	0.5023000000	1.645170453	1.828654278	2.642902197	2.642902197	0.8015874894
25	0.5024000000	1.585226214	1.877996449	2.640709879	2.640709879	0.8020580788

Figure 8: Inrush current magnitude and terminal voltage for the first 25 points on the voltage waveform

Figure 9 shows the simulation results for the optimum run # 24, which resimulated at the last run (run # 102).The maximum inrsh current reaches to 2.6429kA.

The optimum occurred for run # 24 and has been repeated for the last run below:

Run #	EngTime	Is_phaseA	Is_phaseB	Is_phaseC	I_Max	V_rms
102	0.5023000000	1.645170453	1.828654278	2.642902197	2.642902197	0.8015874894

Figure 9: The multiple-run component discovers Run#24 is the optimum run