

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.

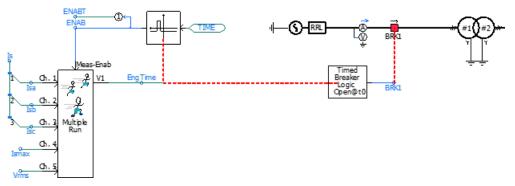


Figure 1: The multiple-run component is used to change the closing time of the breaker to study the energization of the transformer

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.



0	Multiple Run	×					
Mu	Itiple Run Configuration	~					
•	21 🔐 🗊 🐙 🥨						
~	General						
	Number of Signals to Control for This Multiple Run:	1					
	This Multiple Run Enabled or Disabled?	Enabled					
	# of Std Deviations for defining min,max using the Normal Dist. (1-10):	2.0					
	Initial Seed for Random Variations	Automatic					
	Initial Seed Value	23309					
~	Variable 1						
	V1 Variation Type	Sequential					
	V1 Data Type	Real					
	Label for Variable 1:	EngTime					
	Multiple Run	×					
Rei	al Variable 1 Configuration	~					
•	21 🗃 🗊 🛷 🦻						
~	General						
	Number of Runs for Variable 1	10					
	Start of Range for Variable 1	0.5					
	Increment for Each Run	0.0001					
	End of Range for Variable 1	0.51					

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).

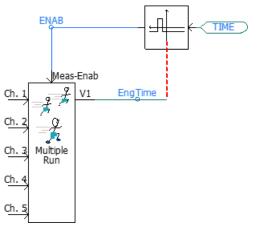


Figure 3: Meas-Enab signal is controlled externally to make sure the channels are saved to the file immediately after transformer energization



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

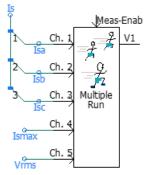


Figure 4: The multiple-run component used to save the channels to the output file "Out1.out"

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.

🖳 Multiple Run	×					
Recording Channels Information						
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Channel 1						
Channel 1 Data Type	Real					
Auto Processing of Channel 1?	Maximum(X)					
Label for Channel 1:	Is_phaseA					
V Channel 2	Channel 2					
Channel 2 Data Type	Real					
Auto Processing of Channel 2?	Maximum(X)					
Label for Channel 2:	Is_phaseB					
Channel 3						
Channel 3 Data Type	Real					
Auto Processing of Channel 3?	Maximum(X)					
Label for Channel 3:	Is_phaseC					
✓ Channel 4	Channel 4					
Channel 4 Data Type	Real					
Auto Processing of Channel 4?	Maximum(X)					
Label for Channel 4:	I_Max					
Channel 5						
Channel 5 Data Type	Real					
Auto Processing of Channel 5?	Minimum(X)					
Label for Channel 5:	V_rms					
Channel 6						
Channel 6 Data Type	Real					
Auto Processing of Channel 6?	Maximum(X)					
Label for Channel 6:	Out # 6					

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 determined, and the simulation is run again for that optimum run.

Recording Data Configuration	×
∄ 2↓ 🕾 📑 🛷 🐲	
✓ General	
Number of Channels to Record for Each Run	5
Output File Name	Out1.out
Do you want to Identify the Optimal Run?	Yes
Select Channel for Basis of Optimal Run	4
Criteria for Identification of Optimal Run?	Maximum
Number of Divisions for Prob. Density Output Plots:	10

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.



Q			
- Ar la	Multiple Run		
	Multiple Run Configu		
	能 21 🗗 🗳 4	40	
0	✓ General		
4	Number of Sign	nais to Control for This Multiple F	tun: 1 Disable
Z	# of Std Deviat	tions for defining min, max using	
	Initial Seed for	Random Variations	Automat
iple	Initial Seed Val	lue	23309
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	V1 Data Type	i ye	Real
	t shal fee tracs	lata +.	EnsTime
roject Set	tings - Transf	ormer_Inrush3	×
General	Runtime Simi	ulation Dynamics Map	oing Eatran Link
L		addorf cyridinica map	ping roman bink
Time Set	ttings		
Dente	n of run (sec)	1.0	
Duration	t of run (sec)	11.0	
Solution	time step (uS)	25.0	
Channel	l plot step (uS)	50.0	
Channe	piot step (u.s)	150.0	
Startup Me	athod:	Input file:	
Standard		•	Browse
	and the state?	·	
-	mels to disk?	Output file:	
No		▼ noname.out	
Contraction of the	spshot(s):	Snapshot file:	Time
Timed Sna			0.49
		 Inoname.snp 	
Single, (or	nce only)	Inoname.snp	
Single, (or	nce only)	▼ Inoname.snp # runs	
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Single, (or Run Config roject Set	nce only) guration: ttings - Transf	# runs	×
Run Config roject Set General	nce only) guration: ttings - Transf Runtime Sim	# runs former_Inrush3	×
Single, (or Run Config roject Set	nce only) guration: ttings - Transf Runtime Sim	# runs former_Inrush3	×
Single, (or Run Config roject Set General Time Se	nce only) guration: ttings - Transf Runtime Simi ttings	# runs former_Inrush3 ulation Dynamics Map	×
Single, (or Run Config Iroject Set General Time Se Duration	nce only) guration: ttings - Transf Runtime Sim ttings n of run (sec)	# runs former_Inrush3 ulation Dynamics Map D.1	×
Single, (or Run Config roject Set General Time Se Duration	nce only) guration: ttings - Transf Runtime Simi ttings	# runs former_Inrush3 ulation Dynamics Map D.1	×
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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 R	un Output File					
Run #	EngTime	Is_phaseA	Is_phaseB	Is_phaseC	I_Max	V_rms
1	0.500000000	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 bel	OW:	
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

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