Benchmark Systems
Modeling Description

Abstract: This document describes the modeling of the Benchmark Examples using the OpenDSS Library from the Typhoon HIL toolchain. The main goal of these systems is to support a starting point for the usage of the library applying its key features. The library modeling technique/features are applied according to the electrical system characteristics in the study.

CONTENTS

CIGRE SYSTEMS

CIGRE EUROPEAN MEDIUM VOLTAGE (DISTRIBUTION SYSTEMS)

The CIGRE Medium Voltage distribution network is derived from a physical network in southern Germany [1], which supplies a small town and the surrounding rural area. In the European version, the modeling does not include unbalances on lines and loads.

Figure 1 shows the modeling of the feeder in the Typhoon Schematic Editor tool. The system operates at 20 kV 50 Hz via separate transformers (T1 and T2) from the 110 kV transmission network. The topology can be modified between radial/radial/meshed configurations through S1, S2, and S3 switches.

The data modeling is presented in the following subsections. All lines are symmetrical, and the loads are represented as constant impedance. A fixed tap at the transformers T1 and T2 is set manually on the transformer parameterization (without voltage regulator).

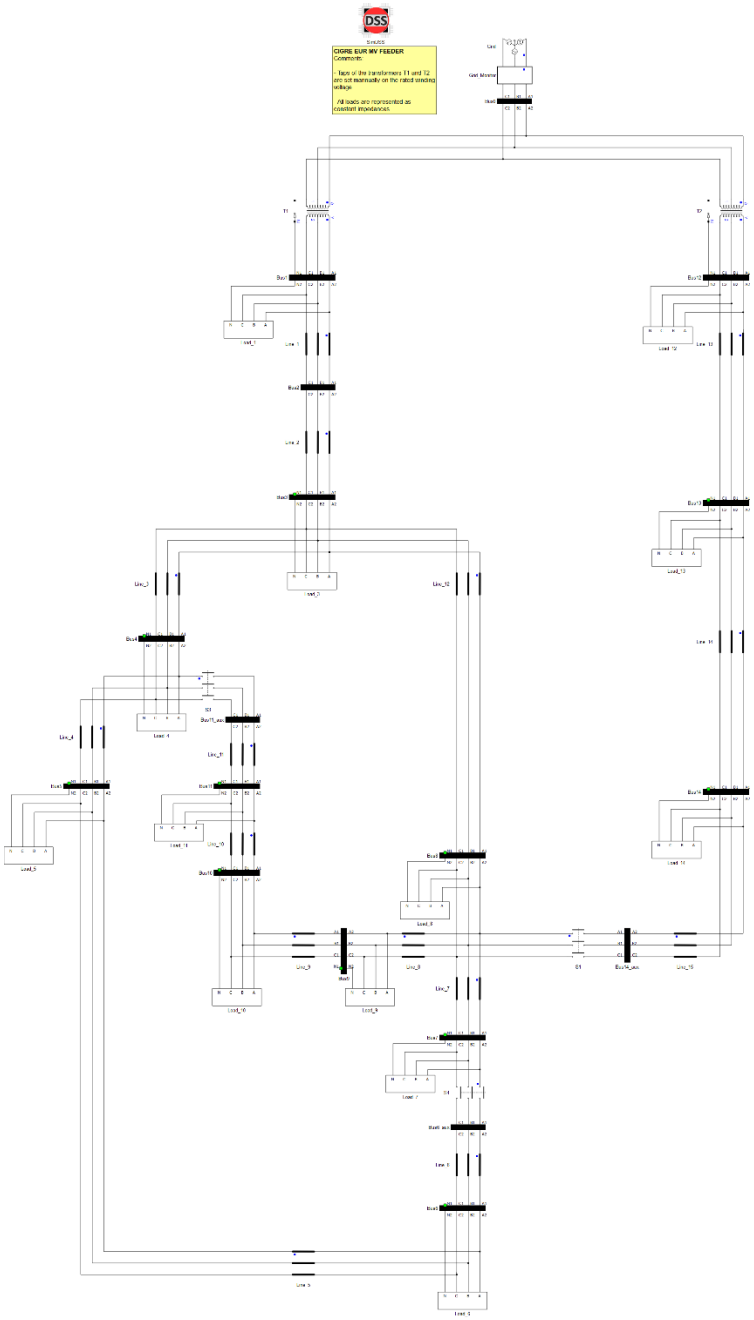

Figure 1 – Implementation of the CIGRE European MV Feeder in the Schematic Editor.

Figure 2 shows how to execute a snapshot simulation from the OpenDSS engine by clicking the “Run” button on the “Simulation” tab of the SimDSS component. The power flow results are accessed by the “Show” properties tab (Figure 2.b). After compiling and loading the model into the HIL, the user can observe a similar operational point as shown in Table 1 to Table 3 (Results section). The results show the CIGRE reference against the OpenDSS and the HIL SCADA (runtime) implementations. Figure 3 shows the SCADA Panel running the CIGRE system simulation.

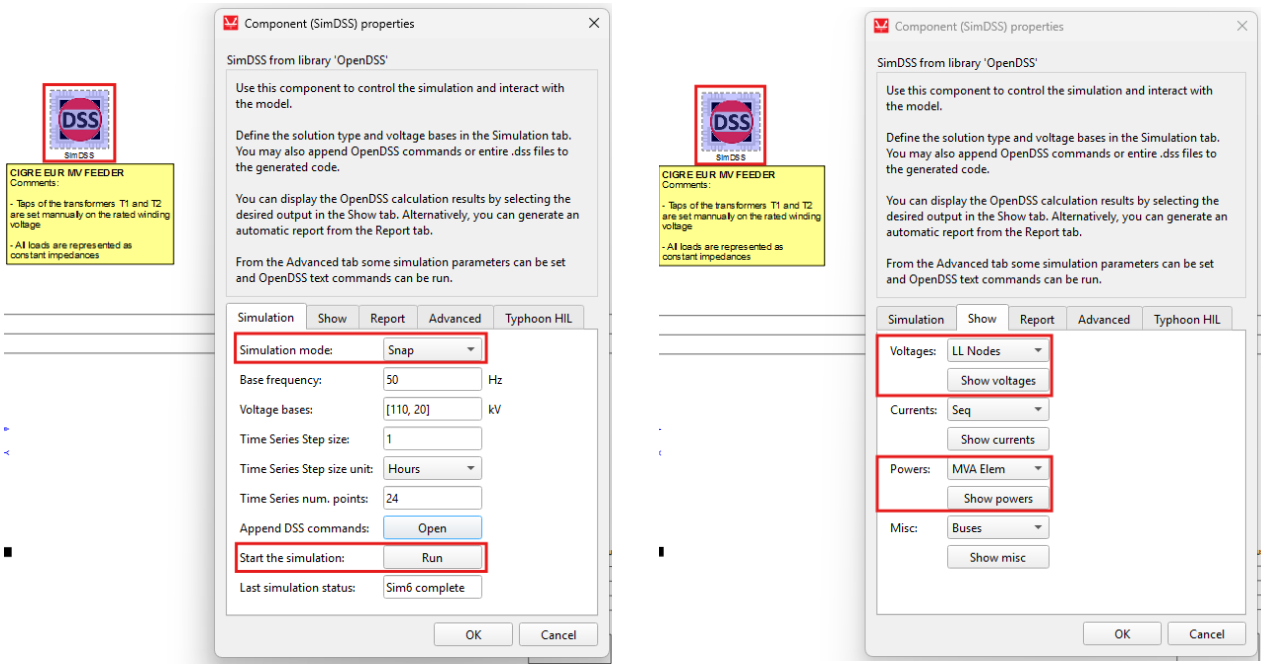

Figure 2 – Implementation of the CIGRE European MV Feeder in the Schematic Editor.

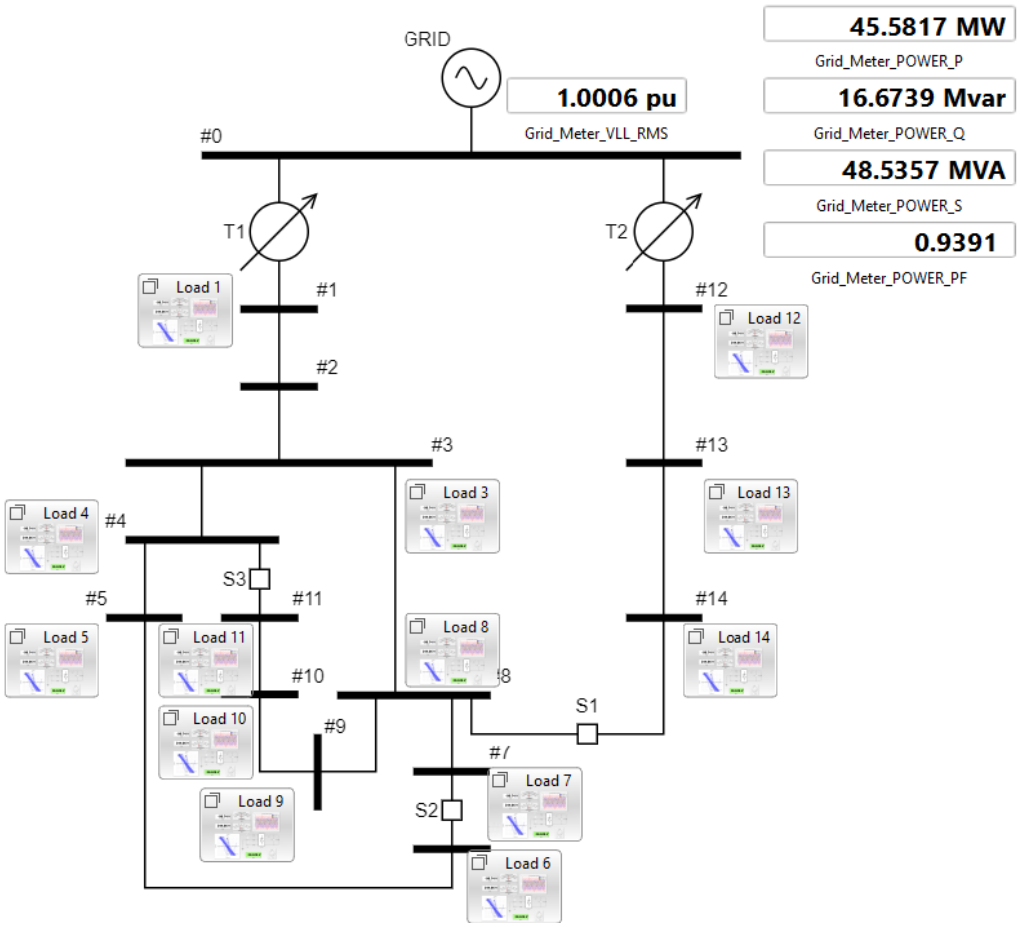

Figure 3 – Implementation of the CIGRE European MV Feeder in the Schematic Editor.

Results

Table 1. Power Flow – Load Voltages Magnitudes.

Bus	CIGRE	DSS	SCADA	Bus	CIGRE	DSS	SCADA
#0	1.0000	1.0005	1.0005	**#8**	0.9665	0.9696	0.9692
#1	1.0260	1.0288	1.0287	**#9**	0.9655	0.9687	0.9683
#2	1.0045	1.0077	--	**#10**	0.9645	0.9676	0.9672
#3	0.9715	0.9745	0.9741	**#11**	0.9645	0.9674	0.9670
#4	0.9700	0.9728	0.9725	**#12**	1.0020	1.0060	1.0059
#5	0.9690	0.9717	0.9713	**#13**	0.9970	1.0012	1.0011
#6	0.9675	0.9704	0.9700	**#14**	0.9940	0.9984	0.9983
#7	0.9665	0.9693	0.9689				

Table 2. Power Flow – Load Voltages Errors.

Bus	DSS	SCADA	Bus	DSS	SCADA
#0	-0.05%	-0.05%	**#8**	-0.32%	-0.28%
#1	-0.27%	-0.26%	**#9**	-0.33%	-0.29%
#2	-0.32%	--	**#10**	-0.32%	-0.28%
#3	-0.31%	-0.27%	**#11**	-0.30%	-0.26%
#4	-0.29%	-0.26%	**#12**	-0.40%	-0.39%
#5	-0.28%	-0.24%	**#13**	-0.42%	-0.41%
#6	-0.29%	-0.26%	**#14**	-0.45%	-0.43%
#7	-0.29%	-0.25%			

Table 3. Power Flow – System Input.

Meas.	CIGRE	DSS		SCADA	
		Value	Error	Value	Error
P (MW)	45.9076	46.1480	-0.52%	46.2200	-0.68%
Q (Mvar)	16.5096	16.0790	2.61%	15.9428	3.43%
S (MVA)	48.7860	48.8690	-0.17%	48.8923	-0.22%
PF	0.9410	0.9443	-0.35%	0.9453	-0.46%

Modeling Data

Table 4. Line Segment Data.

Line	From (#Bus)	To (#Bus)	R1 (Ω/km)	X1 (Ω/km)	C1 (nF/km)	R0 (Ω/km)	x0 (Ω/km)	C0 (nF/km)	km
Line_1	#1	#2	0.501	0.716	151.175	0.817	1.598	151.175	2.82
Line_2	#2	#3	0.501	0.716	151.175	0.817	1.598	151.175	4.42
Line_3	#3	#4	0.501	0.716	151.175	0.817	1.598	151.175	0.61
Line_4	#4	#5	0.501	0.716	151.175	0.817	1.598	151.175	0.56
Line_5	#5	#6	0.501	0.716	151.175	0.817	1.598	151.175	1.54

Line	From (#Bus)	To (#Bus)	R1 (Ω/km)	X1 (Ω/km)	C1 (nF/km)	R0 (Ω/km)	x0 (Ω/km)	C0 (nF/km)	km
Line_6	#6	#7	0.501	0.716	151.175	0.817	1.598	151.175	0.24
Line_7	#7	#8	0.501	0.716	151.175	0.817	1.598	151.175	1.67
Line_8	#8	#9	0.501	0.716	151.175	0.817	1.598	151.175	0.32
Line_9	#9	#10	0.501	0.716	151.175	0.817	1.598	151.175	0.77
Line_10	#10	#11	0.501	0.716	151.175	0.817	1.598	151.175	0.33
Line_11	#11	#4	0.501	0.716	151.175	0.817	1.598	151.175	0.49
Line_12	#3	#8	0.501	0.716	151.175	0.817	1.598	151.175	1.30
Line_13	#12	#13	0.510	0.366	10.097	0.658	1.611	4.0743	4.89
Line_14	#13	#14	0.510	0.366	10.097	0.658	1.611	4.0743	2.99
Line_15	#14	#8	0.510	0.366	10.097	0.658	1.611	4.0743	2.00

Table 5. Transformers T1 and T2 data.

Rated Primary Voltage:	110 kV
Rated Secondary Voltage:	20 kV
Connection:	Dyn
Rated Power:	25 MVA
R:	1 %
X:	12 %

Table 6. Load Data.

Bus	Residential		Industrial	
	S [kVA]	PF	S [kVA]	PF
#1	15300	0.98	5100	0.95
#2	---	---	---	---
#3	285	0.97	265	0.85
#4	445	0.97	---	---
#5	750	0.97	---	---
#6	565	0.97	---	---
#7	---	---	90	0.85
#8	605	0.97	---	---
#9	---	---	675	0.85
#10	490	0.97	80	0.85
#11	340	0.97	---	---
#12	15300	0.98	5280	0.95
#13	---	---	40	0.85
#14	215	0.97	390	0.85

References

[1] - TF C6.04.02 : TB 575 -- Benchmark Systems for Network Integration of Renewable and Distributed Energy Resources.