MITSUBISHI ELECTRIC
Changes for the Better

EMTP-RV 2015 UGM

Performing Large-Scale System Studies with the Assistance of Scripting in EMTP-RV

Date:

July 11th 2015

Presented By:

Mitsubishi Electric Power Products, Inc. (MEPPI)
Power System Engineering Services Department
Warrendale, Pennsylvania

Presentation Outline

- Introduction and Objective
- Overview of JavaScript Scripting in EMTP-RV
  – References and Examples
  – Application Case 1
  – Application Case 2
- Conversion of Short-Circuit and Load Flow Databases into EMTP-RV Models
  – Model Building Approach for a Typical Switching Study
  – Data Importation, Screening, and Correction
  – Automated Model Building and Validation
  – Application Case 3

Introduction

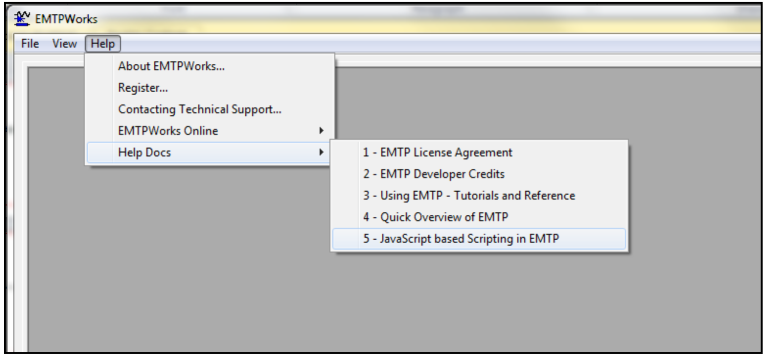
Introduction and Objective

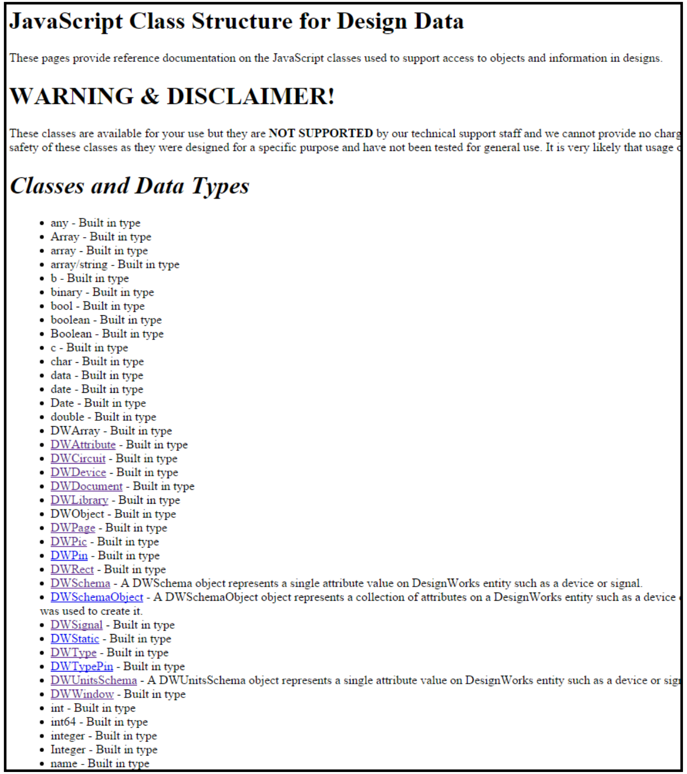
- The scripting capabilities internal to EMTP-RV are a very powerful tool that can greatly simplify and expedite large scale electromagnetic transient analyses.
- The objective of the presentation is to provide a brief introduction to the program's scripting capabilities. A few small case examples will be provided to demonstrate the levels to which the program can be interfaced with via scripting.
- The presentation will conclude with a demonstration of a scripting tool written by MEPPI which enables the rapid conversion of short-circuit and load flow databases into EMTP-RV models.

Overview of JavaScript Scripting in EMTP-RV

References: JavaScript Class Structure

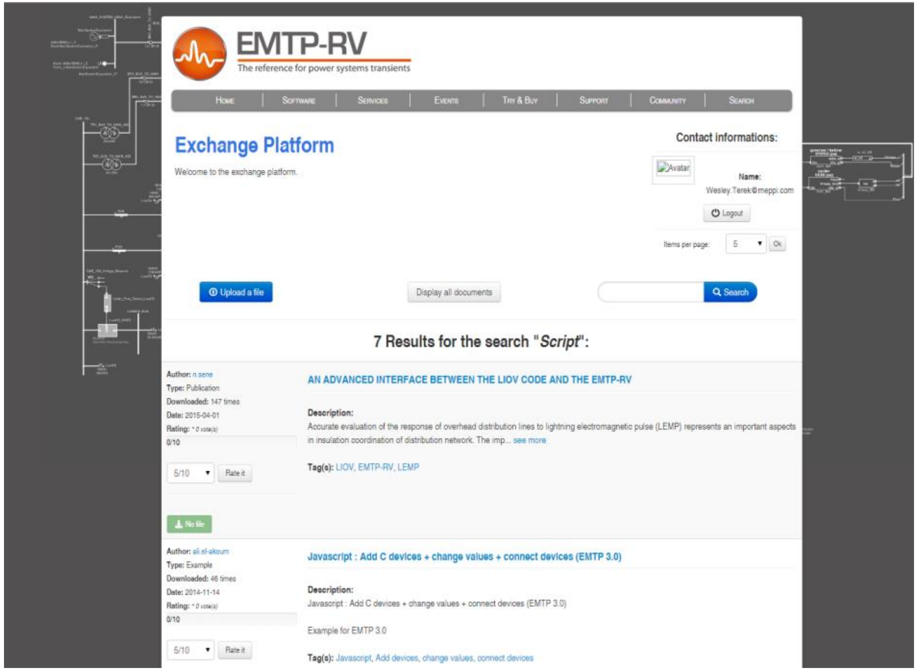
- High level overview of inherent JavaScript tools available in EMTP-RV is available in the programs help menu.
- Comprehensive listing of the built classes/functions along the available objects, properties, and methods for each.
- Allows for control of EMTP-RV at the GUI, circuit, and sub-circuit/device level.





References: Available JavaScript Examples

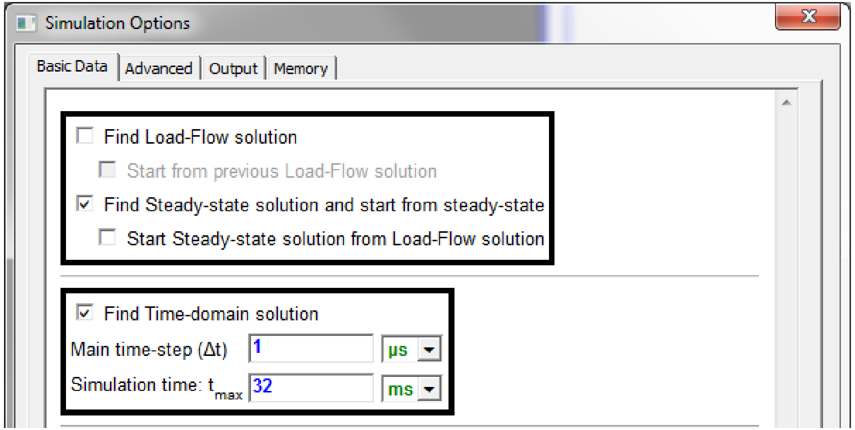
- EMTP-RV Online Exchange Platform
  - http://emtp.com/site/
- Installed Example Application Cases
  - C:\Program Files (x86)\EMTPWorks X.X\Examples\

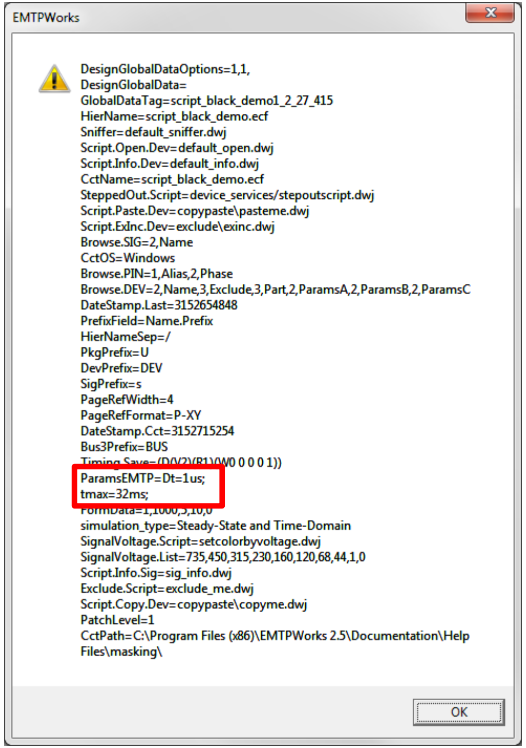


Application Case 1: Identify and Change Simulation Run-Time

Step 1: Identify the properties of the open circuit.

```
cct = currentCircuit();
alert(cct.attributeList());
```



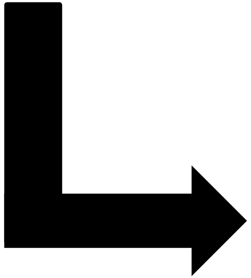


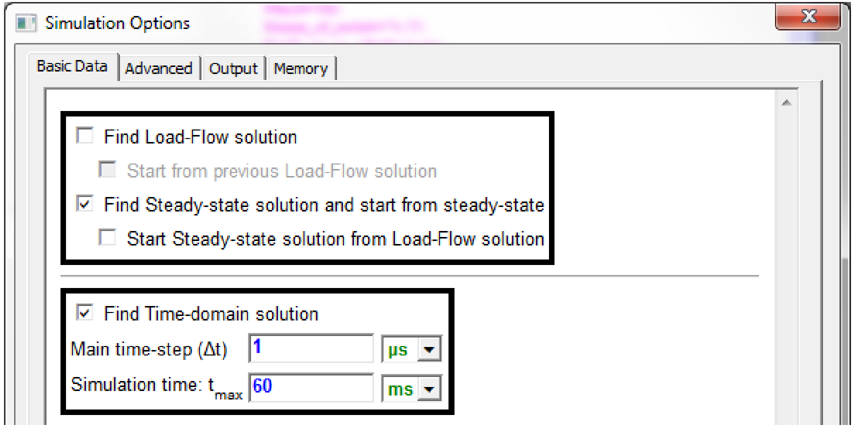
MITSUBISHI ELECTRIC
Changes for the Better

Application Case 1: Identify and Change Simulation Run-Time

Step 2: Replace the identified property's string with a the desired simulation time

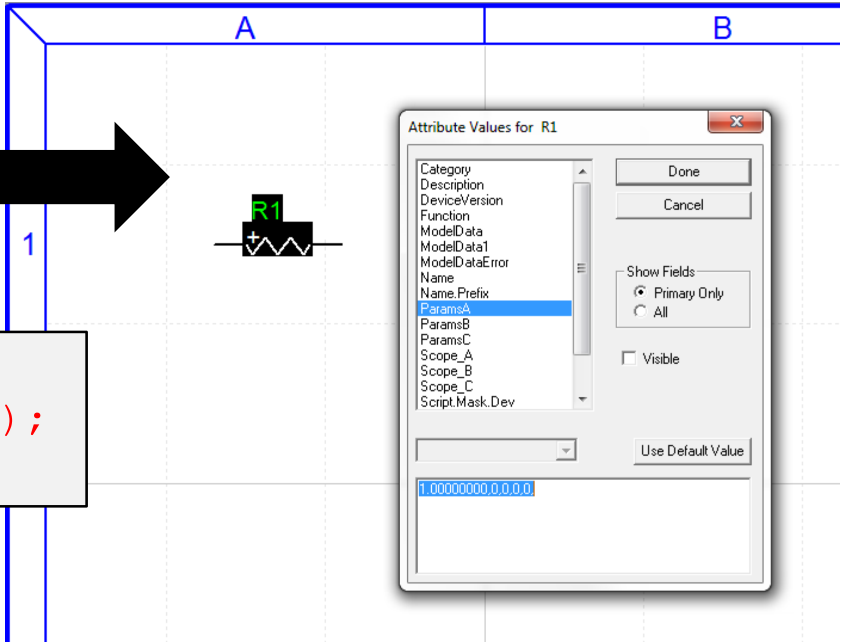
```
SimTime='Dt=1us;\ntmax=60ms;';
cct.setAttribute("ParamsEMTP",SimTime)
```





Application Case 2: Identify and Change a Device Parameter

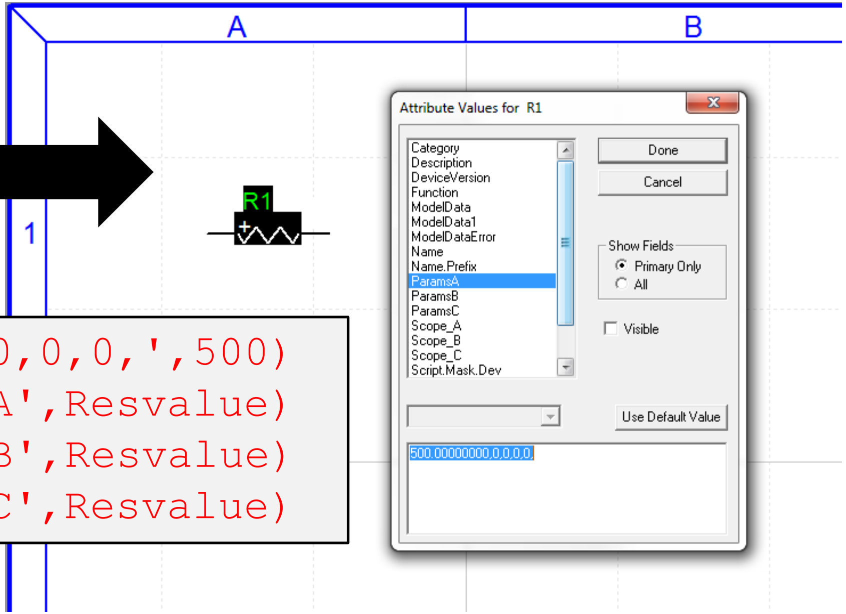
Step 1: Locate the device in the open circuit.




```
cct = currentCircuit();
Ress=cct.devices('Name', 'R1');
devRes=Ress[0];
```

Application Case 2: Identify and Change a Device Parameter

Step 2: Replace the identified property’s string with a the desired value




```
Resvalue = sprintf('%.8f,0,0,0,0,',500)
devRes.setAttribute('ParamsA',Resvalue)
devRes.setAttribute('ParamsB',Resvalue)
devRes.setAttribute('ParamsC',Resvalue)
```

Conversion of Short-Circuit and Load Flow Databases into EMTP-RV Models

Model Building Approach for a Typical Switching Study

1. **Identify key substations (buses) of interest and develop one-line diagram with cut-point equivalent locations.**
   - Generally 2-3 buses away from primary study area is sufficient for a switching surge analysis.
   - Cut-point equivalents "tuned" to represent appropriate short-circuit strength (three-phase and single-phase fault current contributions) from areas of the system not modeled.

2. **Input system impedances for lines, transformers, cut-point equivalents, and series/shunt compensation devices.**
   - Models for equipment in the primary study area "beefed up" for the phenomena of interest for the switching analysis.

3. **Model is verified against the short-circuit database.**
   - Voltage profile verified to be near 1.0 p.u.
   - Power flow verified to be minimal (no-load case simulated to represent limiting case for transients analysis in terms of system damping).
   - Three-phase and single-phase fault currents verified to be within 10% of the short-circuit database.

Data Importation, Screening, and Correction

Short-Circuit and Load Flow Databases are a common data sources for EMT models, however, they are often not directly translatable and/or missing critical data for EMT studies and must be used with caution.

<u>Short Circuit Databases</u>

- Advantages
  - Positive and Zero Sequence Resistances and Inductances normally available
- Disadvantages
  - Usually do not contain Charging Data
  - Often include breaker arrangements which introduce unnecessary nodes and switches

<u>Power Flow Databases</u>

- Advantages
  - Positive Sequence Resistances, Inductances, and Charging normally available
- Disadvantages
  - Usually do not contain Zero Sequence Data
  - Often include tap points which introduce unnecessary nodes and erroneous branches

Automated Model Building and Validation

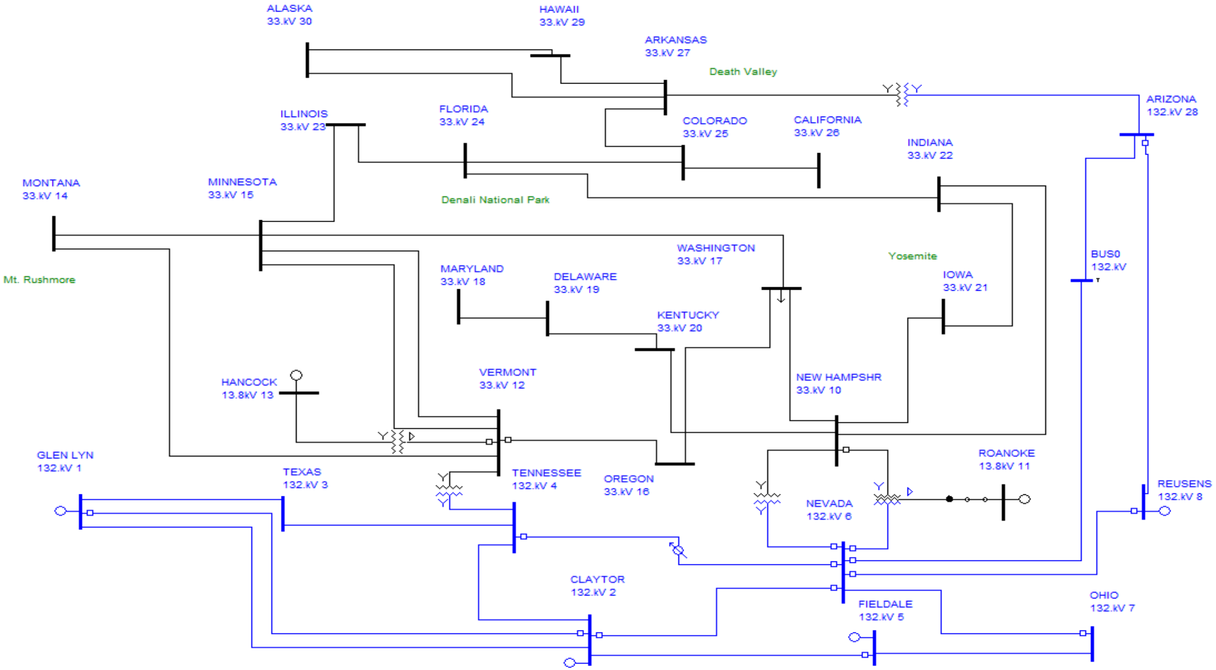
Existing Features

- Importation from MS Excel Spreadsheets
- Grid Placement Method
- Utilization of Signal Names for Model Linking
- Automated Short-Circuit Validation Tool

Potential Future Goals

- Intelligent Grid Placement and Automated Signal Drawing Algorithm
- Direct Importation, Screening, and Model Reduction Capabilities

Application Case 3: IEEE 30 Bus Model



MITSUBISHI ELECTRIC

Changes for the Better

Application Case 3: IEEE 30 Bus Model – Data Screening

Ref No.	From Bus Number	From Bus	To Bus Number	To Bus	Voltage (kV)	MVA Base	R1 (p.u.)	X1 (p.u.)	B1 (p.u.)	R0 (p.u.)	X0 (p.u.)	B0 (p.u.)	R1 (ohms)	X1 (ohms)	C1 (uS)	R0 (ohms)	X0 (ohms)	C0 (uS)	Z (ohms)	Travel Time (us)
1	0	BUS0	28	ARIZONA	132	100	0.00017	0.00060	0.00013	0.00051	0.00180	?	0.0294	0.1044	0.7576	0.0883	0.3131	?	371.2	0.7
2	1	GLEN LYN	2	CLAYTOR	132	100	0.0192	0.0575	0.0528	0.0384	0.1150	?	3.3454	10.0188	303.0303	6.6908	20.0376	?	181.8	146.2
3	1	GLEN LYN	3	TEXAS	132	100	0.0452	0.1852	0.0408	0.0452	0.1852	?	7.8756	32.2692	234.1598	7.8756	32.2692	?	371.2	230.6
4	2	CLAYTOR	4	TENNESSEE	132	100	0.0570	0.1737	0.0368	0.0000	0.3500	?	9.9317	30.2655	211.2029	0.0000	60.9840	?	378.6	212.1
5	2	CLAYTOR	6	NEVADA	132	100	0.0581	0.1763	0.0372	0.0581	0.1763	?	10.1233	30.7185	213.4986	10.1233	30.7185	?	379.3	214.8
6	2	CLAYTOR	5	FIELDALE	132	100	0.0472	0.1983	0.0416	0.0472	0.1983	?	8.2241	34.5518	238.7511	8.2241	34.5518	?	380.4	240.9
7	3	TEXAS	4	TENNESSEE	132	100	0.0132	0.0379	0.0084	0.0132	0.0379	?	2.3000	6.6037	48.2094	2.3000	6.6037	?	370.1	47.3
8	5	FIELDALE	7	OHIO	132	100	0.0460	0.1160	0.0204	0.0460	0.1160	?	8.0150	20.2118	117.0799	8.0150	20.2118	?	415.5	129.0
9	6	NEVADA	8	REUSENS	132	100	0.0120	0.0420	0.0088	0.0120	0.0420	?	2.0909	7.3181	50.5051	2.0909	7.3181	?	380.7	51.0
10	6	NEVADA	0	BUS0	132	100	0.0167	0.0593	0.0131	0.0502	0.1779	?	2.9152	10.3326	75.0000	8.7456	30.9978	?	371.2	73.8
11	6	NEVADA	7	OHIO	132	100	0.0267	0.0820	0.0172	0.0267	0.0820	?	4.6522	14.2877	98.7144	4.6522	14.2877	?	380.4	99.6
12	8	REUSENS	28	ARIZONA	132	100	0.0636	0.2000	0.0428	0.1908	0.6000	?	11.0817	34.8480	245.6382	33.2450	104.5440	?	376.7	245.4
13	1	GLEN LYN	2	CLAYTOR	132	100	0.0192	0.0575	0.0000	0.0384	0.1150	?	3.3454	10.0188	0.0000	6.6908	20.0376	?	Inf	0.0
14	10	NEW HAMPSHR	17	WASHINGTON	33	100	0.0324	0.0845	0.0000	0.0972	0.2535	?	0.3528	0.9202	0.0000	1.0585	2.7606	?	Inf	0.0
15	10	NEW HAMPSHR	21	IOWA	33	100	0.0348	0.0749	0.0000	0.1044	0.2247	?	0.3790	0.8157	0.0000	1.1369	2.4470	?	Inf	[illegible]
16	10	NEW HAMPSHR	22	INDIANA	33	100	0.0727	0.1499	0.0000	0.0727	0.1499	?	0.7917	1.6324	0.0000	0.7917	1.6324	?	Inf	[illegible]
17	10	NEW HAMPSHR	20	KENTUCKY	33	100	0.0936	0.2090	0.0000	0.2808	0.6270	?	1.0193	2.2760	0.0000	3.0579	6.8280	?	Inf	[illegible]
18	12	VERMONT	14	MONTANA	[illegible]	[illegible]	[illegible]	.2559	0.0000	0.1231	0.2559	?	1.3406	2.7868	0.0000	1.3406	2.7868	?	Inf	[illegible]
19	12	VERMONT	15	MINNESOTA	[illegible]	[illegible]	[illegible]	.1304	0.0000	0.0662	0.1304	?	0.7209	1.4201	0.0000	0.7209	1.4201	?	Inf	[illegible]
20	12	VERMONT	16	OREGON	[illegible]	[illegible]	[illegible]	[illegible]	0.0000	0.2862	0.5961	?	1.0389	2.1638	0.0000	3.1167	6.4915	?	Inf	[illegible]
21	14	MONTANA	15	MINNESOTA	[illegible]	[illegible]	[illegible]	.1997	0.0000	0.6630	0.5991	?	2.4067	2.1747	0.0000	7.2201	6.5242	?	Inf	0.0
22	15	MINNESOTA	17	WASHINGTON	[illegible]	[illegible]	[illegible]	.2185	0.0000	[illegible]	[illegible]	?	1.1652	2.3795	0.0000	3.4957	7.1384	?	Inf	0.0
23	15	MINNESOTA	23	ILLINOIS	[illegible]	[illegible]	[illegible]	.2020	0.0000	0.1000	0.2020	?	1.0890	2.1998	0.0000	1.0890	2.1998	?	Inf	0.0
24	16	OREGON	17	WASHINGTON	33	100	0.0824	0.1932	0.0000	0.2472	0.5796	?	0.8973	2.1039	0.0000	2.6920	6.3118	?	Inf	0.0
25	18	MARYLAND	19	DELAWARE	33	100	0.0639	0.1292	0.0000	0.1917	0.3876	?	0.6959	1.4070	0.0000	2.0876	4.2210	?	Inf	0.0
26	19	DELAWARE	20	KENTUCKY	33	100	0.0340	0.0680	0.0000	0.1020	0.2040	?	0.3703	0.7405	0.0000	1.1108	2.2216	?	Inf	0.0
27	21	IOWA	22	INDIANA	33	100	0.0116	0.0236	0.0000	0.0116	0.0236	?	0.1263	0.2570	0.0000	0.1263	0.2570	?	Inf	0.0
28	22	INDIANA	24	FLORIDA	33	100	0.1150	0.1790	0.0000	0.1150	0.1790	?	1.2524	1.9493	0.0000	1.2524	1.9493	?	Inf	0.0
29	23	ILLINOIS	24	FLORIDA	33	100	0.1320	0.2700	0.0000	0.1320	0.2700	?	1.4375	2.9403	0.0000	1.4375	2.9403	?	Inf	0.0
30	24	FLORIDA	25	COLORADO	33	100	0.1855	0.3292	0.0000	0.1855	0.3292	?	2.0201	3.5850	0.0000	2.0201	3.5850	?	Inf	0.0
31	25	COLORADO	27	ARKANSAS	33	100	0.1093	0.2087	0.0000	0.1093	0.2087	?	1.1903	2.2727	0.0000	1.1903	2.2727	?	Inf	0.0
32	25	COLORADO	26	CALIFORNIA	33	100	0.2544	0.3800	0.0000	0.2544	0.3800	?	2.7704	4.1382	0.0000	2.7704	4.1382	?	Inf	0.0
33	27	ARKANSAS	29	HAWAII	33	100	0.2198	0.4153	0.0000	0.6594	1.2459	?	2.3936	4.5226	0.0000	7.1809	13.5679	?	Inf	0.0
34	27	ARKANSAS	30	ALASKA	33	100	0.3202	0.6027	0.0000	0.9606	1.8081	?	3.4870	6.5634	0.0000	10.4609	19.6902	?	Inf	0.0
35	29	HAWAII	30	ALASKA	33	100	0.2399	0.4533	0.0000	0.7197	1.3599	?	2.6125	4.9364	0.0000	7.8375	14.8093	?	Inf	0.0
36	12	VERMONT	15	MINNESOTA	33	100	0.0662	0.1304	0.0000	0.1986	0.3912	?	0.7209	1.4201	0.0000	2.1628	4.2602	?	Inf	0.0

Tap Bus

Short Line

Missing Charging Data

Suspicious Surge Impedance

MITSUBISHI ELECTRIC
Changes for the Better

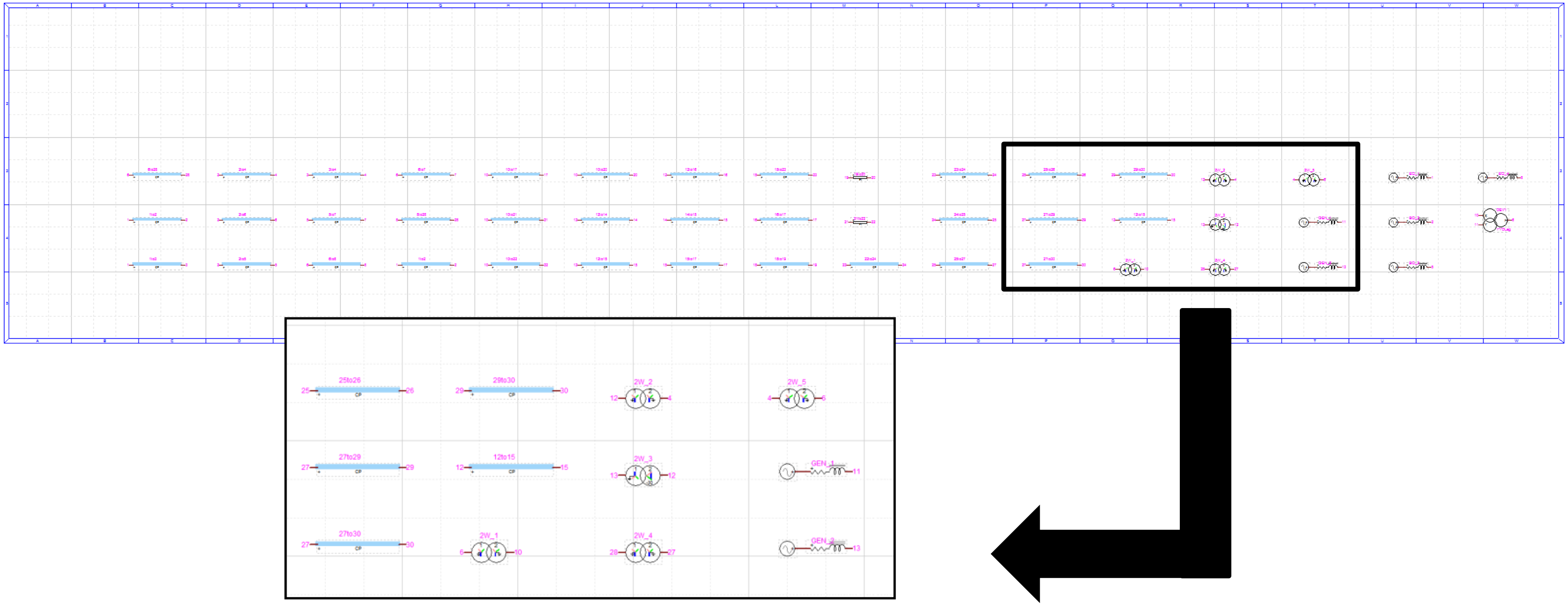
Application Case 3: IEEE 30 Bus Model – Data Correction

Merge Short Line to Remove Tap Bus

Estimate Charging Data

Ref No.	From Bus Number	From Bus	To Bus Number	To Bus	Voltage (kV)	MVA Base	R1 (p.u.)	X1 (p.u.)	B1 (p.u.)	R0 (p.u.)	X0 (p.u.)	B0 (p.u.)	R1 (ohms)	X1 (ohms)	C1 (uS)	R0 (ohms)	X0 (ohms)	C0 (uS)	Z (ohms)	Travel Time (us)
1	6	NEVADA	28	ARIZONA	132	100	0.0169	0.0599	0.0132	0.0507	0.1797	0.00833	2.9447	10.4370	75.7576	8.8340	31.3109	47.7869	371.2	74.6
2	1	GLEN LYN	2	CLAYTOR	132	100	0.0192	0.0575	0.0528	0.0384	0.1150	0.03298	3.3454	10.0188	303.0303	6.6908	20.0376	189.2552	181.8	146.2
3	1	GLEN LYN	3	TEXAS	132	100	0.0452	0.1852	0.0408	0.0452	0.1852	0.02548	7.8756	32.2692	234.1598	7.8756	32.2692	146.2426	371.2	230.6
4	2	CLAYTOR	4	TENNESSEE	132	100	0.0570	0.1737	0.0368	0.0000	0.3500	0.02298	9.9317	30.2655	211.2029	0.0000	60.9840	131.9051	378.6	212.1
5	2	CLAYTOR	6	NEVADA	132	100	0.0581	0.1763	0.0372	0.0581	0.1763	0.02323	10.1233	30.7185	213.4986	10.1233	30.7185	133.3389	379.3	214.8
6	2	CLAYTOR	5	FIELDALE	132	100	0.0472	0.1983	0.0416	0.0472	0.1983	0.02598	8.2241	34.5518	238.7511	8.2241	34.5518	149.1101	380.4	240.9
7	3	TEXAS	4	TENNESSEE	132	100	0.0132	0.0379	0.0084	0.0132	0.0379	0.00525	2.3000	6.6037	48.2094	2.3000	6.6037	30.1088	370.1	47.3
8	5	FIELDALE	7	OHIO	132	100	0.0460	0.1160	0.0204	0.0460	0.1160	0.01274	8.0150	20.2118	117.0799	8.0150	20.2118	73.1213	415.5	129.0
9	6	NEVADA	8	REUSENS	132	100	0.0120	0.0420	0.0088	0.0120	0.0420	0.00550	2.0909	7.3181	50.5051	2.0909	7.3181	31.5425	380.7	51.0
10	6	NEVADA	7	OHIO	132	100	0.0267	0.0820	0.0172	0.0267	0.0820	0.01074	4.6522	14.2877	98.7144	4.6522	14.2877	61.6513	380.4	99.6
11	8	REUSENS	28	ARIZONA	132	100	0.0636	0.2000	0.0428	0.1908	0.6000	0.02673	11.0817	34.8480	245.6382	33.2450	104.5440	153.4114	376.7	245.4
12	1	GLEN LYN	2	CLAYTOR	132	100	0.0192	0.0575	0.0124	0.0384	0.1150	0.00772	3.3454	10.0188	70.9510	6.6908	20.0376	44.3119	375.8	70.7
13	10	NEW HAMPSHR	17	WASHINGTON	33	100	0.0324	0.0845	0.0001	0.0972	0.2535	0.00004	0.3528	0.9202	5.8196	1.0585	2.7606	3.6225	397.6	6.1
14	10	NEW HAMPSHR	21	IOWA	33	100	0.0348	0.0749	0.0001	0.1044	0.2247	0.00003	0.3790	0.8157	5.1584	1.1369	2.4470	3.2109	397.6	5.4
15	10	NEW HAMPSHR	22	INDIANA	33	100	0.0727	0.1499	0.0001	0.0727	0.1499	0.00007	0.7917	1.6324	10.3237	0.7917	1.6324	6.4262	397.6	10.9
16	10	NEW HAMPSHR	20	KENTUCKY	33	100	0.0936	0.2090	0.0002	0.2808	0.6270	0.00010	1.0193	2.2760	14.3939	3.0579	6.8280	8.9598	397.6	15.2
17	12	VERMONT	14	MONTANA	[illegible]	[illegible]	[illegible]	.2559	0.0002	0.1231	0.2559	0.00012	1.3406	2.7868	17.6240	1.3406	2.7868	10.9704	397.6	18.6
18	12	VERMONT	15	MINNESOTA	[illegible]	[illegible]	[illegible]	.1304	0.0001	0.0662	0.1304	0.00006	0.7209	1.4201	8.9807	0.7209	1.4201	5.5902	397.6	9.5
19	12	VERMONT	16	OREGON	[illegible]	[illegible]	[illegible]	[illegible]	0.0001	0.2862	0.5961	0.00009	1.0389	2.1638	13.6846	3.1167	6.4915	8.5182	397.6	14.4
20	14	MONTANA	15	MINNESOTA	[illegible]	[illegible]	[illegible]	.1997	0.0001	0.6630	0.5991	0.00009	2.4067	2.1747	13.7534	7.2201	6.5242	8.5611	397.6	14.5
21	15	MINNESOTA	17	WASHINGTON	[illegible]	[illegible]	[illegible]	.2185	0.0002	0.3210	0.6555	0.00010	1.1652	2.3795	15.0482	3.4957	7.1384	9.3670	397.6	15.9
22	15	MINNESOTA	23	ILLINOIS	[illegible]	[illegible]	[illegible]	.2020	0.0002	0.1000	0.2020	0.00009	1.0890	2.1998	13.9118	1.0890	2.1998	8.6597	397.6	14.7
23	16	OREGON	17	WASHINGTON	33	100	0.0824	0.1932	0.0001	0.2472	0.5796	0.00009	0.8973	2.1039	13.3058	2.6920	6.3118	8.2824	397.6	14.0
24	18	MARYLAND	19	DELAWARE	33	100	0.0639	0.1292	0.0001	0.1917	0.3876	0.00006	0.6959	1.4070	8.8981	2.0876	4.2210	5.5388	397.6	9.4
25	19	DELAWARE	20	KENTUCKY	33	100	0.0340	0.0680	0.0001	0.1020	0.2040	0.00003	0.3703	0.7405	4.6832	1.1108	2.2216	2.9151	397.6	4.9
26	21	IOWA	22	INDIANA	33	100	0.0116	0.0236	0.0000	0.0116	0.0236	0.00001	0.1263	0.2570	1.6253	0.1263	0.2570	1.0117	397.6	1.7
27	22	INDIANA	24	FLORIDA	33	100	0.1150	0.1790	0.0001	0.1150	0.1790	0.00008	1.2524	1.9493	12.3278	1.2524	1.9493	7.6737	397.6	13.0
28	23	ILLINOIS	24	FLORIDA	33	100	0.1320	0.2700	0.0002	0.1320	0.2700	0.00013	1.4375	2.9403	18.5950	1.4375	2.9403	11.5748	397.6	19.6
29	24	FLORIDA	25	COLORADO	33	100	0.1855	0.3292	0.0002	0.1855	0.3292	0.00015	2.0201	3.5850	22.6722	2.0201	3.5850	14.1127	397.6	23.9
30	25	COLORADO	27	ARKANSAS	33	100	0.1093	0.2087	0.0002	0.1093	0.2087	0.00010	1.1903	2.2727	14.3733	1.1903	2.2727	8.9469	397.6	15.2
31	25	COLORADO	26	CALIFORNIA	33	100	0.2544	0.3800	0.0003	0.2544	0.3800	0.00018	2.7704	4.1382	26.1708	2.7704	4.1382	16.2905	397.6	27.6
32	27	ARKANSAS	29	HAWAII	33	100	0.2198	0.4153	0.0003	0.6594	1.2459	0.00019	2.3936	4.5226	28.6019	7.1809	13.5679	17.8038	397.6	30.2
33	27	ARKANSAS	30	ALASKA	33	100	0.3202	0.6027	0.0005	0.9606	1.8081	0.00028	3.4870	6.5634	41.5083	10.4609	19.6902	25.8376	397.6	43.8
34	29	HAWAII	30	ALASKA	33	100	0.2399	0.4533	0.0003	0.7197	1.3599	0.00021	2.6125	4.9364	31.2190	7.8375	14.8093	19.4328	397.6	32.9
35	12	VERMONT	15	MINNESOTA	33	100	0.0662	0.1304	0.0001	0.1986	0.3912	0.00006	0.7209	1.4201	8.9807	2.1628	4.2602	5.5902	397.6	9.5

Application Case 3: IEEE 30 Bus Model – Automated Model Building



Application Case 3: IEEE 30 Bus Model - Validation

Model Validation Steps

1. Minimal Power flow

- Max = 0.265 MW

2. Voltage profile verified to be near 1.0 p.u.

- Max = 1.01 p.u.
- Min = 1.00 p.u.

3. Three-phase and single-phase fault currents verified to be within 10% of the short-circuit database.

- 3PG Max = 1.05%
- 1PG Max = 0.69%

Ref. No.	Bus Number	Bus Name	Bus Voltages		
			$kV_{peak, L-G}$	$kV_{RMS, L-L}$	p.u.
1	1	GLEN LYN	108.99	133	1.01
2	2	CLAYTOR	109.09	134	1.01
3	3	TEXAS	109.50	134	1.02
4	4	TENNESSEE	109.50	134	1.02
5	5	FIELDALE	108.64	133	1.01
6	6	NEVADA	109.10	134	1.01
7	7	OHIO	109.01	134	1.01
8	8	REUSENS	109.00	134	1.01
9	10	NEW HAMPSHR	27.16	33	1.01
10	11	ROANOKE	11.30	14	1.00
11	12	VERMONT	27.17	33	1.01
12	13	HANCOCK	11.27	14	1.00
13	14	MONTANA	27.17	33	1.01
14	15	MINNESOTA	27.17	33	1.01
15	16	OREGON	27.17	33	1.01
16	17	WASHINGTON	27.17	33	1.01
17	18	MARYLAND	27.16	33	1.01
18	19	DELAWARE	27.16	33	1.01
19	20	KENTUCKY	27.16	33	1.01
20	21	IOWA	27.16	33	1.01
21	22	INDIANA	27.17	33	1.01
22	23	ILLINOIS	27.17	33	1.01
23	24	FLORIDA	27.17	33	1.01
24	25	COLORADO	27.19	33	1.01
25	26	CALIFORNIA	27.19	33	1.01
26	27	ARKANSAS	27.20	33	1.01
27	28	ARIZONA	109.22	134	1.01
28	29	HAWAII	27.20	33	1.01
29	30	ALASKA	27.20	33	1.01

Ref. No.	Fault Location			3 Phase Fault Current (A_{RMS})			1 Phase Fault Current (A_{RMS})		
	Bus Number	Bus Name	Bus kV	Aspen / S-C	EMTP-RV	% Diff.	Aspen / S-C	EMTP-RV	% Diff.
1	1	GLEN LYN	132	9019	9045	0.29%	8686	8721	0.41%
2	2	CLAYTOR	132	9213	9235	0.24%	8801	8834	0.38%
3	3	TEXAS	132	5070	5100	0.59%	4904	4938	0.69%
4	4	TENNESSEE	132	6698	6726	0.42%	6307	6341	0.55%
5	5	FIELDALE	132	7251	7280	0.39%	7212	7244	0.44%
6	6	NEVADA	132	7853	7876	0.30%	7607	7640	0.44%
7	7	OHIO	132	4907	4936	0.60%	4855	4887	0.67%
8	8	REUSENS	132	6151	6179	0.46%	6004	6037	0.55%
9	10	NEW HAMPSHR	33	13635	13724	0.66%	12893	12979	0.67%
10	11	ROANOKE	13.8	52921	53065	0.27%	48627	48754	0.26%
11	12	VERMONT	33	16168	16251	0.52%	11733	11796	0.53%
12	13	HANCOCK	13.8	54277	54409	0.24%	59067	59218	0.25%
13	14	MONTANA	33	7030	7074	0.63%	5646.3	5682	0.62%
14	15	MINNESOTA	33	12667	12740	0.57%	9804.3	9862	0.58%
15	16	OREGON	33	8507	8561	0.63%	5677.8	5715	0.65%
16	17	WASHINGTON	33	11551	11624	0.64%	8745.8	8804	0.67%
17	18	MARYLAND	33	3058	3081	0.77%	1993.7	2009	0.78%
18	19	DELAWARE	33	4080	4111	0.76%	2741.7	2763	0.78%
19	20	KENTUCKY	33	4949	4986	0.75%	3415.6	3442	0.77%
20	21	IOWA	33	10342	10414	0.69%	9350.8	9417	0.71%
21	22	INDIANA	33	10243	10314	0.70%	9451.3	9518	0.71%
22	23	ILLINOIS	33	6881	6929	0.69%	6284.8	6328	0.69%
23	24	FLORIDA	33	7502	7558	0.74%	7101.7	7155	0.75%
24	25	COLORADO	33	4846	4889	0.90%	4669.4	4712	0.91%
25	26	CALIFORNIA	33	2159	2180	0.98%	2123.7	2144	0.98%
26	27	ARKANSAS	33	5151	5201	0.96%	4908.7	4956	0.97%
27	28	ARIZONA	132	4482	4509	0.62%	3462.8	3489	0.74%
28	29	HAWAII	33	2616	2643	1.04%	1924.9	1945	1.06%
29	30	ALASKA	33	2385	2410	1.05%	1719.8	1738	1.07%
					Maximum % Diff. >>	1.05%		Maximum % Diff. >>	0.69%
					Average % Diff. >>	0.62%		Average % Diff. >>	0.48%

THANK YOU!

Wesley Terek
System Studies Engineer
Power Systems Engineering Services Dept.
MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
530 Keystone Drive, Warrendale, PA 15086
ph:(724)-779-1615; fax:(724)-778-5146;
Email: Wesley.Terek@MEPPI.com