

Play-in time series measurement data with **PlayInGen** model for Power Plant Model Validation (**PPMV**)



NASPI & NERC SMS MODEL VERIFICATION TOOLS TECHNICAL WORKSHOP

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Overview of Tool

Transient Stability in Simulator



Case: GEN_GAS_2-Bus_Event-02-2016.pwb Status: Initialized | Simulator 19

File Case Information Draw Onelines Tools Options Add Ons Window

Edit Mode Abort Primal LP Log SCOPF... OFF Case Info OFF Options and Results... PV... QV... Refine Model ATC... Transient Stability... Stability Case Info - Transient Stability (TS) GIC... Scheduled Actions... Topology Processing...

Run Mode Log Optimal Power Flow (OPF) PV and QV Curves (PVQV) ATC GIC Schedule Topology Processing (ITP)

Mode Log Optimal Power Flow (OPF) PV and QV Curves (PVQV) ATC GIC Schedule Topology Processing (ITP)

Model Explorer: Buses

Explore Fields

Recent Network

- Branches by Type
- Branches Input (1)
- Branches State (1)
- Buses (2)
- DC Transmission Lines
- Generators (2)
- Impedance Correction Tables
- Line D-FACTS Devices
- Line Shunts
- Loads
- Mismatches (2)
- Multi-Terminal DC
- Switched Shunts
- Three-Winding Transformers
- Transformer Controls (1)
- Voltage Control Groups
- VSC DC Transmission Lines

Aggregations

- Areas (1)
- Balancing Authorities (1)
- Data Maintainers
- Injection Groups
- Interfaces
- Islands (1)
- Multi-Section Lines
- MW Transactions
- Nomograms
- Owners (3)
- Substations
- Super Areas
- TieLines between Areas
- TieLines between Balancing Auth
- TieLines between Zones
- Transfer Directions
- Zones (1)

Solution Details

- Case Information and Auxiliary
- Contingency Analysis
- Optimal Power Flow
- Transient Stability
- User-Defined

Open New Explorer

Search

Number	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar
1	101_HS_GAS	NW	500.00	1.09462	542.310	69.21		
2	102_LS_GAS	NW	16.80	1.08352	17.878	71.40		

Transient Stability Analysis

Simulation Status: Not Initialized

Run Transient Stability

For Contingency: Find My Transient Contingency

Select Step

- Simulation
- Control
- Definitions
- Violations
- Options
- Result Storage
- Plots
- Results from RAM
- Transient Limit Monitors
- States/Manual Control
- Validation
- SMB Eigenvalues
- Modal Analysis
- Dynamic Simulator Options

Simulation Time Values

Start Time (seconds): 0.000

End Time (seconds): 40.000

Time Step (cycles): 0.500

Specify Time Step in: Seconds Cycles

Categories: Change...

Summary Results

Generation	Load
Tripped	
Islanded	

Transient Contingency Elements

Insert Clear All Insert Apply/Clear/Open Time Shift (seconds)

Records Set

Object Pretty	Time (Cycles)
None	1
None	Defined

Transient Contingency Monitor Violations

Limit Monitor Name	Contingency Name
None	Defined

Process Contingencies

- One Contingency at a time
- Multiple Contingencies

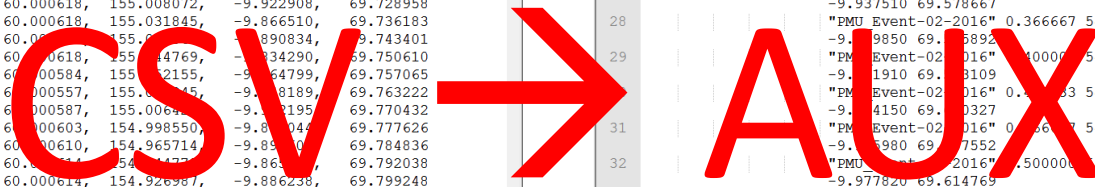
Save All Settings To Load All Settings From Show Transient Contour Toolbar Auto Insert... Help Close

Input PMU Data Play-In Signals in Auxiliary File Format



```
G:\saurav\NASPI PPMV Workshop - Playback Datasets\Unit 1-GAS\Event-02-2016.csv - Notepad++
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

Event-02-2016.csv [3] PMUMeasurements_Event-02-2016.aux [2]
1 5
2 Time Vact Fact Pact Qact Angl // Head
3 1 500 60 1 1 1 // Scale
4 0 0 0 0 0 0 // Offset
5 0 0 0 0 0 0 // Tf
6 0 0.8 0.99 0 -200 -180 // min
7 0 1.2 0.99 1000 200 180 // max
8 75 1 1 1 1 // Plot
9 0.0000000, 542.296265, 60.000015, 154.990845, -9.933385, 69.542328
10 0.0333333, 542.298096, 60.000053, 154.991501, -9.931389, 69.543076
11 0.0666667, 542.300171, 60.000092, 154.972137, -9.920259, 69.544426
12 0.1000000, 542.302734, 60.000156, 154.927948, -9.942898, 69.546822
13 0.1333334, 542.305786, 60.000195, 154.919159, -9.932243, 69.549393
14 0.1666667, 542.308838, 60.000256, 154.885406, -9.955445, 69.552979
15 0.2000000, 542.311768, 60.000294, 154.876816, -9.941589, 69.556740
16 0.2333333, 542.314880, 60.000355, 154.863480, -9.969045, 69.561539
17 0.2666666, 542.311401, 60.000397, 154.873459, -9.959331, 69.566505
18 0.2999999, 542.305908, 60.000458, 154.893097, -9.950490, 69.572517
19 0.3333332, 542.300354, 60.000496, 154.902679, -9.937510, 69.578674
20 0.3666665, 542.310242, 60.000557, 154.922028, -9.969851, 69.585892
21 0.3999998, 542.326904, 60.000587, 154.958344, -9.961906, 69.591309
22 0.4333331, 542.332703, 60.000603, 154.976517, -9.994149, 69.600327
23 0.4666664, 542.338501, 60.000610, 155.009735, -9.985982, 69.607552
24 0.4999997, 542.344421, 60.000614, 155.042999, -9.977822, 69.614769
25 0.5333330, 542.350342, 60.000618, 155.066147, -9.965909, 69.621986
26 0.5666663, 542.361450, 60.000618, 155.065659, -9.990742, 69.629196
27 0.5999996, 542.381165, 60.000618, 155.082657, -9.975339, 69.636414
28 0.6333329, 542.389282, 60.000618, 155.061142, -9.992643, 69.643616
29 0.6666662, 542.394409, 60.000610, 155.053726, -9.969913, 69.650665
30 0.6999995, 542.402466, 60.000572, 155.052216, -9.997538, 69.656637
31 0.7333328, 542.419678, 60.000595, 155.013107, -10.007557, 69.664032
32 0.7666661, 542.431152, 60.000607, 154.972351, -10.017484, 69.671234
33 0.7999994, 542.424500, 60.000610, 154.946625, -10.034550, 69.678444
34 0.8333327, 542.439575, 60.000614, 154.927109, -10.052022, 69.685654
35 0.8666660, 542.432617, 60.000614, 154.926376, -10.032403, 69.692856
36 0.8999993, 542.424255, 60.000618, 154.925262, -10.012730, 69.700073
37 0.9333326, 542.417664, 60.000618, 154.944855, -10.000566, 69.707298
38 0.9666659, 542.399658, 60.000618, 154.961197, -9.988181, 69.714516
39 0.9999992, 542.377686, 60.000618, 154.991333, -9.935273, 69.721733
40 1.0333329, 542.361206, 60.000618, 155.008072, -9.922908, 69.728958
41 1.0666667, 542.352356, 60.000618, 155.031845, -9.866510, 69.736183
42 1.1000005, 542.335144, 60.000618, 155.047699, -9.890834, 69.743401
43 1.1333343, 542.318176, 60.000618, 155.044769, -9.934290, 69.750610
44 1.1666681, 542.321594, 60.000584, 155.02155, -9.964799, 69.757065
45 1.2000018, 542.325134, 60.000557, 155.0145, -9.978189, 69.763222
46 1.2333356, 542.328613, 60.000587, 155.0069, -9.970195, 69.770432
47 1.2666694, 542.332031, 60.000603, 154.998550, -9.87044, 69.777626
48 1.3000032, 542.335693, 60.000610, 154.965714, -9.8903, 69.784836
49 1.3333369, 542.328918, 60.000614, 154.947, -9.866, 69.792038
50 1.3666707, 542.314331, 60.000614, 154.926987, -9.886238, 69.799248
51 1.4000045, 542.314270, 60.000618, 154.938324, -9.870455, 69.806465
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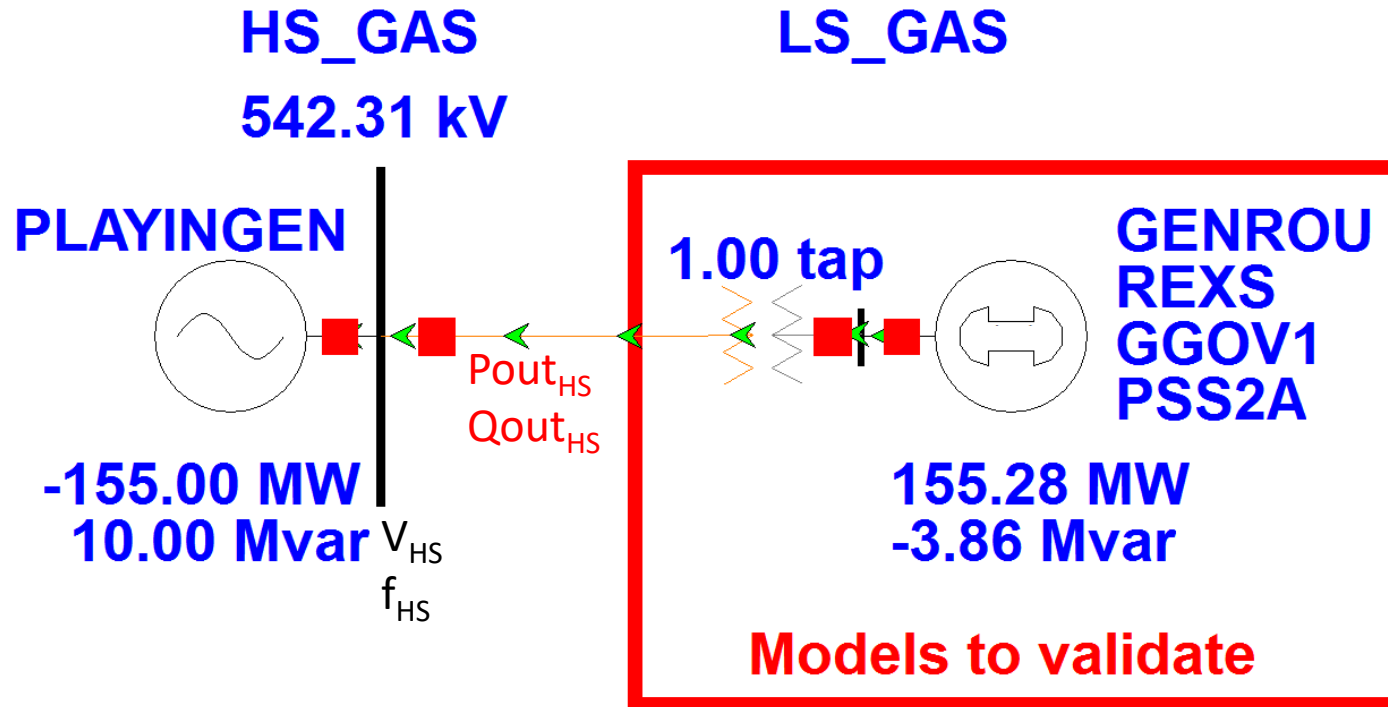


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G:\saurav\NASPI PPMV Workshop - Playback Datasets\Unit 1-GAS\PPMV PowerWorld Files\Event-02-2016\PMUMeasurements_Event-02-2016.aux - Notepad++
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?

Event-02-2016.csv [3] PMUMeasurements_Event-02-2016.aux [2]
1 DATA (PlayIn, [TSName, TSTimeOffset], AUXDEF, YES)
2 {
3     "PMU_Event-02-2016" -10.0
4 }
5
6 DATA (PlayInInfo, [TSName, TSSignalIndex, TSInfoName, TSScale],
7     AUXDEF, YES)
8 {
9     "PMU_Event-02-2016" 0 "V pu" 0.002
10    "PMU_Event-02-2016" 1 "Frequency pu" 0.016667
11    "PMU_Event-02-2016" 2 "Output MW" 1.0
12    "PMU_Event-02-2016" 3 "Output Mvar" 1.0
13    "PMU_Event-02-2016" 4 "V Angle Degrees" 1.0
14 }
15 DATA (PlayInSignal, [TSName, TSTime, TSSignal, TSSignal:1,
16     TSSignal:2, TSSignal:3, TSSignal:4], AUXDEF, YES)
17 {
18     "PMU_Event-02-2016" 0.000000 542.296265 60.000019 154.990845
19     -9.933380 69.542328
20     "PMU_Event-02-2016" 0.033333 542.298096 60.000050 154.991501
21     -9.931390 69.543083
22     "PMU_Event-02-2016" 0.066667 542.300171 60.000092 154.972137
23     -9.920260 69.544434
24     "PMU_Event-02-2016" 0.100000 542.302734 60.000160 154.927948
25     -9.942900 69.546822
26     "PMU_Event-02-2016" 0.133333 542.305786 60.000191 154.919159
27     -9.932240 69.549393
28     "PMU_Event-02-2016" 0.166667 542.308838 60.000259 154.885406
29     -9.955450 69.552979
30     "PMU_Event-02-2016" 0.200000 542.311768 60.000290 154.876816
31     -9.941590 69.556740
32     "PMU_Event-02-2016" 0.233333 542.314880 60.000351 154.863480
33     -9.969040 69.561539
34     "PMU_Event-02-2016" 0.266667 542.311401 60.000401 154.873459
35     -9.959330 69.566513
36     "PMU_Event-02-2016" 0.300000 542.305908 60.000462 154.893097
37     -9.950490 69.572517
38     "PMU_Event-02-2016" 0.333333 542.300354 60.000500 154.902679
39     -9.937510 69.578667
40     "PMU_Event-02-2016" 0.366667 542.310242 60.000561 154.922028
41     -9.969850 69.585892
42     "PMU_Event-02-2016" 0.400000 542.326904 60.000591 154.958344
43     -9.961910 69.591309
44     "PMU_Event-02-2016" 0.433333 542.332703 60.000599 154.976517
45     -9.970190 69.600327
46     "PMU_Event-02-2016" 0.466667 542.338501 60.000610 155.009735
47     -9.955980 69.607552
48     "PMU_Event-02-2016" 0.500000 542.344421 60.000610 155.042999
49     -9.977820 69.614769
50     "PMU_Event-02-2016" 0.533333 542.350342 60.000622 155.066147
```

Case Setup

2-Bus Reduced System



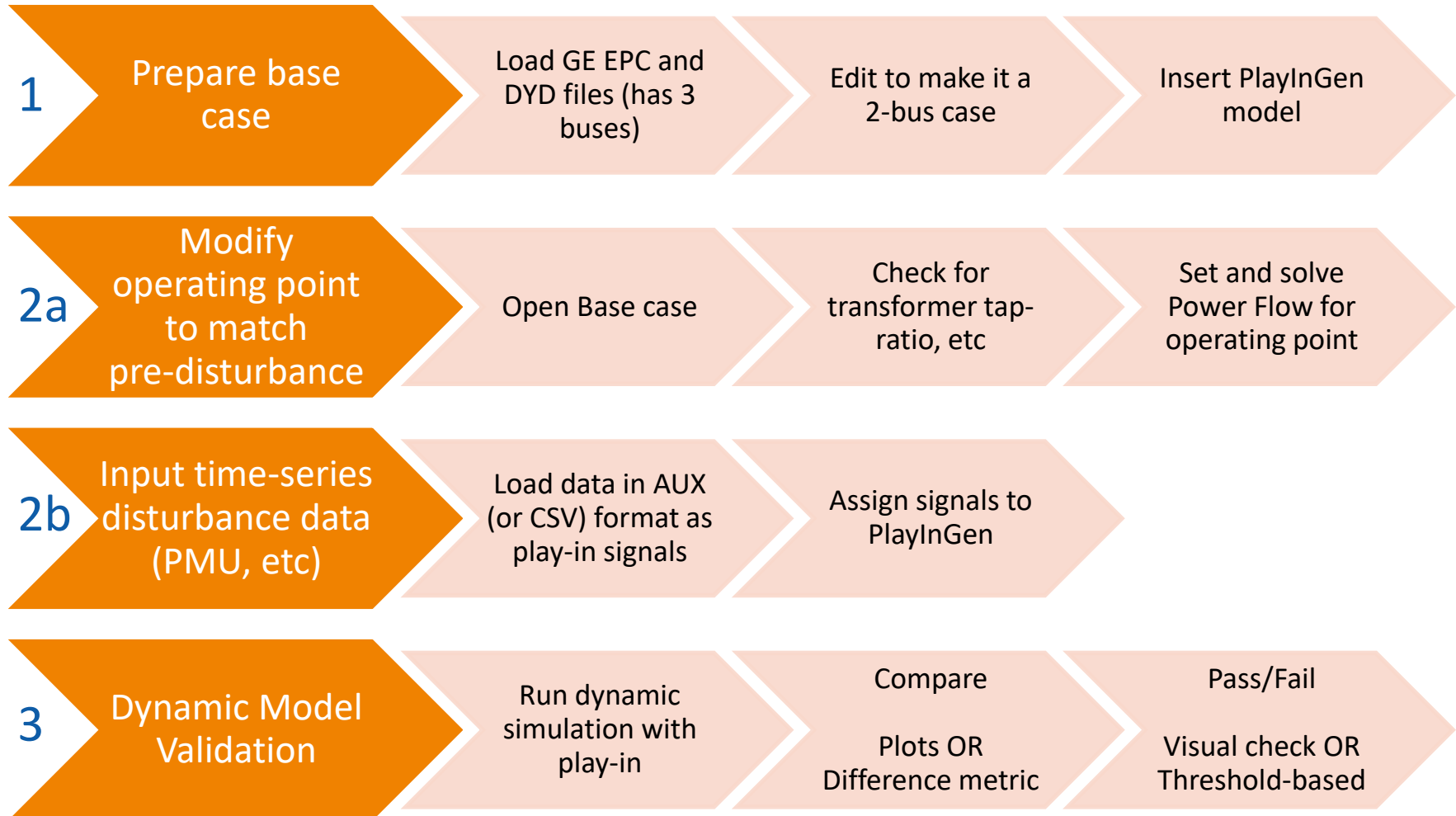
Play-In Signals	Signals Compared
Voltage (V_{HS})	Real Power Output ($P_{out_{HS}}$)
Frequency (f_{HS})	Reactive Power Output ($Q_{out_{HS}}$)

Events used for validation



	Event-02-2016	Event-04-2016
Duration	30 seconds	180 seconds
Initial Conditions at High Side		
V [kV]	542.31	535.26
Pout [MW]	155	153
Qout [Mvar]	-10	0

Steps



Prepare Base Case



- Load GE EPC and DYD files
- Convert to a 2-bus case

Power Flow Model

- Bus HS_GAS
 - AGC OFF, AVR OFF
- Bus LS_GAS
 - AGC ON, AVR ON, Slack

Dynamics Data

- GENROU, REXS, GGOV1, PSS2A models automatically loaded from EPC file
- Add PlayInGen to Bus HS_GAS
 - $R_{th} = 0$ and $X_{th} = 1E-6$

- Solve Power Flow

Pre-Disturbance Operating Point



- Generator at HS_GAS
 - Set Gen MW and GenMvar
- Generator at LS_GAS
 - Tweak Set Volt until voltage at HS_GAS matched operating point
(This step might be automated in the future)
- Solve Power Flow

Load Time-Series Disturbance Data



- Load Auxilliary Files
 - Disturbance data in PlayInSignals format
- Assign Vindex and Findex variables of the PlayInGen model
 - Match TSSignal index in Auxilliary files (zero-based)

Performing PPMV Playback Dynamic Simulation



- Set time-step of simulation (typically 0.5 cycle)
- Transient case validation in Simulator
 - Relax heuristic to accommodate small time-constants (only okay for small cases like this)
- Results Storage
 - Define plots
 - Specify sampling rate to save
- Run Transient Stability

Results from RAM



Transient Stability Analysis - Case: GEN_GAS_2-Bus_Event-02-2016_WithPlots.pwb Status: Running (PF) | Simulator 19 GSO

File Case Information Draw Onlines Tools Options Add Ons Window

Edit Mode Abort Primal LP SCOPF... OFF Case Info... OFF Options and Results... PV... QV... Refine Model ATC... Transient Stability... Stability Case Info... GIC... Scheduled Actions... Schedule

Run Mode Log Script - SCOPF... OFF Case Info... OFF Options and Results... PV... QV... Refine Model ATC... Transient Stability... Stability Case Info... GIC... Scheduled Actions... Schedule

Mode Log Optimal Power Flow (OPF) PV and QV Curves (PVCV) ATC Transient Stability (TS) GIC Schedule

Simulation Status Finished at 40.000000

Run Transient Stability Pause Abort Restore Reference For Contingency: Find My Transient Contingency

Select Step

- Simulation
- Options
- Result Storage
 - Store to RAM Options
 - Save to Hard Drive Options
- Plots
 - Plot Designer
 - Plot Definition Guide
- Results from RAM
 - Time Values
 - Generator
 - Bus
 - Load
 - Switched Shunt
 - Branch
 - Transformer
 - DC Transmission Line
 - VSC DC Line
 - Multi-Terminal DC Recd
 - Multi-Terminal DC Con.
 - Area
 - Zone
 - Interface
 - Injection Group
 - Substation
 - Line Shunt
 - Case Information
 - Measurement Model
- Summary
- Events
- Solution Details
 - Transient Limit Monitors
 - States/Manual Control
 - Validation
 - SMB Eigenvalues
 - Modal Analysis
 - Dynamic Simulator Options

Results from RAM

Time Values Minimum/Maximum Values Summary Events Solution Details

Generator Bus Load Switched Shunt Branch Transformer DC Transmission Line VSC DC Line Multi-Terminal DC Record Multi-Terminal DC Converter Area Zone Interface Injection Group

Column Order Object then Field Column Filtering Filter Modify... Columns: Set Columns: f(x) Options

Time	Bus HS_GAS V pu	Bus HS_GAS V angle	Bus HS_GAS Frequency	Bus LS_GAS V pu	Bus LS_GAS V angle	Bus LS_GAS Frequency
1	0	1.0846	69.2077	60	1.0835	71.3971
2	0.033333	1.0846	69.2147	60.0006	1.0835	71.4013
3	0.066667	1.0846	69.22	60.0009	1.0835	71.4053
4	0.1	1.0846	69.2228	60.0011	1.0835	71.4077
5	0.133333	1.0846	69.2229	60.0012	1.0835	71.4086
6	0.166667	1.0846	69.2207	60.0012	1.0835	71.4079
7	0.2	1.0846	69.2171	60.0012	1.0835	71.4061
8	0.233333	1.0846	69.2132	60.0012	1.0835	71.4041
9	0.266667	1.0846	69.2103	60.0012	1.0836	71.4025
10	0.3	1.0846	69.209	60.0012	1.0836	71.4018
11	0.333333	1.0846	69.2099	60.0012	1.0836	71.4024
12	0.366667	1.0846	69.2128	60.0012	1.0836	71.4043
13	0.4	1.0846	69.217	60.0012	1.0836	71.4071
14	0.433333	1.0846	69.2218	60.0012	1.0836	71.4103
15	0.466667	1.0846	69.2263	60.0012	1.0836	71.4135
16	0.5	1.0846	69.2295	60.0012	1.0835	71.4159
17	0.533333	1.0846	69.2311	60.0012	1.0835	71.4174
18	0.566667	1.0846	69.231	60.0012	1.0835	71.4178
19	0.6	1.0846	69.2294	60.0012	1.0835	71.4171
20	0.633333	1.0846	69.2269	60.0012	1.0836	71.4158
21	0.666667	1.0846	69.2242	60.0012	1.0836	71.4142
22	0.7	1.0846	69.222	60.0012	1.0836	71.4128
23	0.733333	1.0846	69.2208	60.0012	1.0836	71.4119
24	0.766667	1.0846	69.2207	60.0012	1.0836	71.4117
25	0.8	1.0846	69.2218	60.0012	1.0836	71.4122
26	0.833333	1.0846	69.2237	60.0012	1.0836	71.4133
27	0.866667	1.0846	69.2259	60.0012	1.0836	71.4146
28	0.9	1.0846	69.2279	60.0012	1.0836	71.4159
29	0.933333	1.0846	69.2292	60.0012	1.0835	71.4168
30	0.966667	1.0846	69.2296	60.0012	1.0835	71.4172
31	1	1.0846	69.229	60.0012	1.0835	71.4169
32	1.033333	1.0846	69.2278	60.0012	1.0835	71.4162
33	1.066667	1.0846	69.2261	60.0012	1.0836	71.4152
34	1.1	1.0846	69.2244	60.0012	1.0836	71.4141
35	1.133333	1.0846	69.223	60.0012	1.0836	71.4131
36	1.166667	1.0846	69.2222	60.0012	1.0836	71.4125
37	1.2	1.0846	69.2221	60.0012	1.0836	71.4122
38	1.233333	1.0846	69.2226	60.0012	1.0836	71.4124
39	1.266667	1.0846	69.2236	60.0012	1.0836	71.4128
40	1.3	1.0846	69.2246	60.0012	1.0835	71.4134
41	1.333333	1.0846	69.2255	60.0012	1.0835	71.4139

Choose Fields to Display

- Frequency
- Gen Mvar
- Load MW
- Status
- V angle
- V angle No shift
- V pu

Process Contingencies

- One Contingency at a time
- Multiple Contingencies

Load from Hard Drive File into RAM results specified by Store to RAM Options Clear Time Values from RAM Clear Min/Max Values, Summary, Events, and/or Solution Details from RAM

Save All Settings To Load All Settings From Show Transient Contour Toolbar Auto Insert... Help Close

Run Mode Solution Animation Stopped AC Viewing Current Case

Comparing Model vs. Measurements

Define Plots





Thank you for watching!

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