# Impact Study for Generation Interconnection Request GEN-2003-020

# Restudy

*SPP Tariff Studies*

*(#GEN-2003-020)*

**January 2009**

## Summary

ABB Inc. Electric Systems consulting (ABB) performed the attached Study at the request of the Southwest Power Pool (SPP) for Generation Interconnection request GEN-2003-020. The request for interconnection was placed with SPP in accordance with SPP's Open Access Transmission Tariff which covers new generation interconnections on SPP's transmission system.

GEN-2003-020 is a 160 MW wind farm that is proposed to be interconnected to a new 115kV ring bus substation to be built near the existing Carson County substation. Originally this request consisted of using GE 1.5 MW turbines, and an impact study has been completed using GE 1.5 turbines. Phase I of the GEN-2003-020 wind farm is currently under construction using GE turbines. However, the Customer has requested that Phase II consist of wind turbines other than GE. This request, and the subject of this report, is the system impact study in which Mitsubishi 2.4 MW turbines are used to generate 80MW of the 160 MW requested in GEN-2003-020.

The results of the stability analysis indicated that interconnecting the proposed wind farm, GEN-2003-020, utilizing 80 MW generated by Mitsubishi 2.4 MW turbines and 80 MW generated by GE 1.5 MW turbines will not adversely affect the stability of the system.

If the Customer wishes to construct Phase II of the wind farm with Mitsubishi WTG, a revised IA will need to be executed. The revised IA will include changes identified in this Study:

- Use Mitsubishi WTG MHI95 (2.4 MW) to produce 80 MW out of the 160 MW total (the other 80 MW to be produced by GE 1.5 MW WTG).
- Due to the reactive capabilities of the Mitsubishi WTG, no additional reactive power support is required at the windfarm.

Using Mitsubishi MHI95 2.4 MW turbines the Customer wind farm will comply with FERC Order #661A, Low Voltage Ride Through (LVRT) Requirements.

Frequency Trip Settings – The documentation submitted by the Customer indicated that the Mitsubishi wind turbines will trip at 59 Hz. This trip setting will not meet SPP underfreqency load shed plan requirements. SPP requires that all generators on the transmission system be able to withstand frequency excursions down to 58.5 Hz. Discussions with the Customer, who contacted Mitsubishi, indicated that the Mitsubishi wind turbines frequency trip settings can be modified to meet SPP underfrequency load shed plan requirements. This requirement will be denoted in the modified LGIA.

# POWER SYSTEMS DIVISION
# GRID SYSTEMS - CONSULTING

**Southwest Power Pool**
**System Impact Study of GEN-2003-020 Generation Interconnection (Mitsubishi WTG MHI95)**

# FINAL REPORT

**REPORT NO.:** 2008-E750-0050-1-R0
**Issued On:** November 4, 2008
**Revised on:** November 7, 2008
**Revised On:** November 24, 2008

**ABB Inc.**
**Power Systems Division**
**Grid Systems - Consulting**
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**Raleigh, NC 27606**

# Legal Notice

# ABB Inc – Grid Systems - Consulting

**Technical Report**

| **Southwest Power Pool** | **No.** 2008-E750-0050-1-R0 | |
|---|---|---|
| **System Impact Study of GEN-2003-020 Generation Interconnection (Mitsubishi WTG MHI95)** | Date : November 4, 2008 | # Pages 22 |


| **Author(s):** | **Reviewed by:** | **Approved by:** |
|---|---|---|
| **Chong Han** | **Amit Kekare** | **Willie Wong** |


## Executive Summary


The main objective of this study is to assess the impact on local stability of interconnecting the proposed GEN-2003-020 wind farm located in Carson County, Texas. This proposed wind farm (GEN-2003-020) would be interconnected to the existing Carson county substation (Xcel Energy). System impact study for this wind farm was previously performed by ABB by using GE 1.5 MW and Mitsubishi 1.0MW wind turbines (Report: '2004-10963-R1', '2006-11209-2R1.0', and '2006-11266-R1'). While the phase-I of this wind farm (80 MW) has been installed with GE 1.5 MW wind turbines, the developer requested Phase-II (80 MW) in the wind farm to be studied with the Mitsubishi 2.4 MW wind turbines. Hence, the system impact study of 80 MW of GEN-2003-020 (Phase-II) wind farm with Mitsubishi 2.4 MW wind turbine is the subject of this report.

A comprehensive range of faults defined by SPP has been run in the study. Overall, the post-fault recoveries show stable system performance for GEN-2003-020 with Mitsubishi 2.4 MW wind turbine generators in 80 MW size. The voltage and power factor at the POI were acceptable in both pre-contingency and post-fault transient period. Hence, there was no need of additional reactive power support for the proposed windfarm.

The results of stability analysis indicated that interconnecting the proposed wind farm, GEN-2003-020, at a level of additional 80 MW with Mitsubishi 2.4 MW WTGs will not adversely affect the stability of the system.

FERC Order 661A Compliance – The Low Voltage Ride through (LVRT) capability was verified for compliance with Federal Energy Regulatory Commission's (FERC) standard for Interconnection of Wind generating plants: 'Low Voltage Ride-Through (LVRT) requirement. The proposed project (GEN-2003-020, 80 MW with Mitsubishi 2.4 MW WTGs) complies with the latest FERC order on low voltage ride through for wind farms. With this arrangement, the proposed wind farm would not trip off line by voltage relay actuation for local faults near the POI.

A full description of the study, and results, are given in this report.


***The results of this study are based on available data and assumptions made at the time this study was conducted. The results included in this report may not apply if any of the data and/or assumptions made in developing the study models change.***

| Rev No. | Revision Description | Date | Authored by | Reviewed by | Approved by |
|---|---|---|---|---|---|
| 0 | Draft Report | 11/4/08 | Chong Han | A. Kekare | W. Wong |
| 1 | Updated per SPP's comments | 11/7/2008 | Chong Han | A. Kekare | W. Wong |
| 2 | Final Report | 11/24/08 | Chong Han | A. Kekare | W. Wong |

**DISTRIBUTION:**

Charles Hendrix, Southwest Power Pool (SPP)

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# Table of Contents

# 1 Introduction

Southwest Power Pool (SPP) commissioned ABB Inc., to perform the Impact Study for a Generation Interconnection request – wind farm GEN-2003-020 (80MW) besides the original 80 MW (Phase-I) with GE 1.5 MW wind turbines The main objective of this study was to assess the impact of interconnecting the proposed 80 MW Phase-II of GEN-2003-020 with Mitsubishi 2.4 MW wind turbines on the stability of the system. The proposed wind farm would be interconnected at the Carson county substation (SPS d/b/a/ Xcel Energy). The System Impact Study for this wind farm was previously performed by ABB by using 1.5 MW GE-DFIG and 1.0 MW Mitsubishi wind turbine generators (See Report: ‘2004-10963-R1’, ‘2006-11209-2R1.0’, and ‘2006-11266-R1’). While the phase-I of this wind farm (80 MW) has been installed with GE 1.5 MW wind turbines, the developer requested Phase-II (80 MW) in the wind farm to be studied with the Mitsubishi 2.4 MW wind turbines. Hence, the system impact study of 80 MW of GEN-2003-020 (Phase-II) wind farm with Mitsubishi 2.4 MW wind turbine is the subject of this report.

The faults simulated for the stability analysis were those defined in the SPP document "*Scope of Interconnection Impact Study for GEN-2003-020*".

Section 2 describes the efforts of base case development.

Section 3 describes the faults simulated.

Section 4 describes the simulation of all fault cases.

Section 5 describes the conclusions of the study.

# 2 Base Case Development

SPP provided two (Summer Peak 2008 and Winter Peak 2008) load flow cases (file names: 'gen-2003-020_sp.sav' and 'gen-2003-020_wp.sav'). The proposed wind farm (GEN-2003-020) was added to the base cases. The plant was re-dispatched against the generation as per the information provided by SPP. Figure 2-2 to Figure 2-5 show one line diagram for the local area with and without proposed GEN-2003-020 project.

**<u>GEN-2003-020 Windfarm modeling</u>**

The proposed 80 MW windfarm was modeled as a single equivalent generator representing thirty-three (33) wind turbine generators. The single equivalent wind turbine generator was connected to the 34.5 kV collector bus via a 0.69/34.5 kV equivalent generator step-up transformer (GSU). The collector bus system was modeled representing equivalent collector bus system impedance. The 34.5 kV collector bus was connected to the 115 kV Point of Interconnection (POI) through a 34.5/115 kV step-up transformer. Figure 2-1 shows the one-line diagram for the GEN-2003-020 windfarm. As per the modeling guidelines for Mitsubishi 2.4 MW[1] the reactive power capacity of the wind turbine generator was set to -0.90/+0.95 p.f. Also, a permanently connected shunt capacitor of 3.63 Mvar (=0.11 Mvar for each WTG X 33 WTGs) was modeled. The voltage and power factor at the POI were acceptable and there was no need for additional reactive power compensation. The power flow model representation is included in Appendix A.

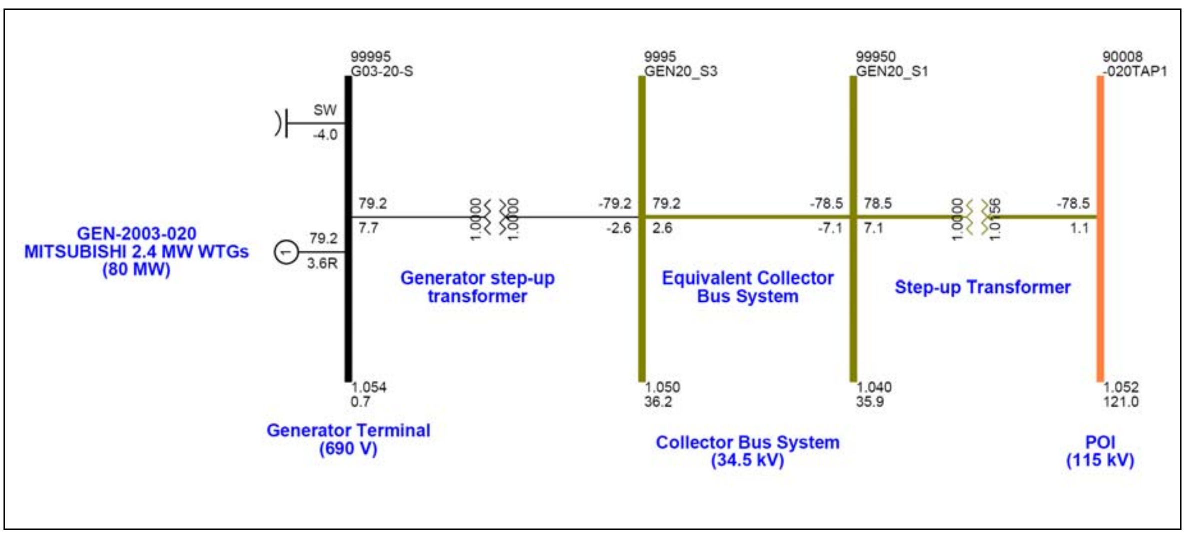


Figure 2-1: One-line diagram for GEN-2003-020 windfarm (Mitsubishi 2.4 MW WTGs)

[1] 'Rpt102-07_MWT9295_PSSEmodelUpgrade_rev3', October 15, 2007

Dynamic Data

Snapshot files corresponding to the Summer Peak 2008 and Winter Peak 2009 load flow cases were provided by SPP for the study.

The Mitsubishi dynamic data for the proposed GEN-2003-020 plant is added to create the snapshot for GEN-2003-020 case. The stability model parameters were based on default data provided with the Mitsubishi Wind model. The wind model included several sub-models representing doubly-fed induction generator, electrical control, turbine control, aerodynamic conversion, pitch control, wind disturbance etc. The under/over voltage and frequency protection was modeled per the manufacturer's default settings. The stability model representation is included in Appendix B.

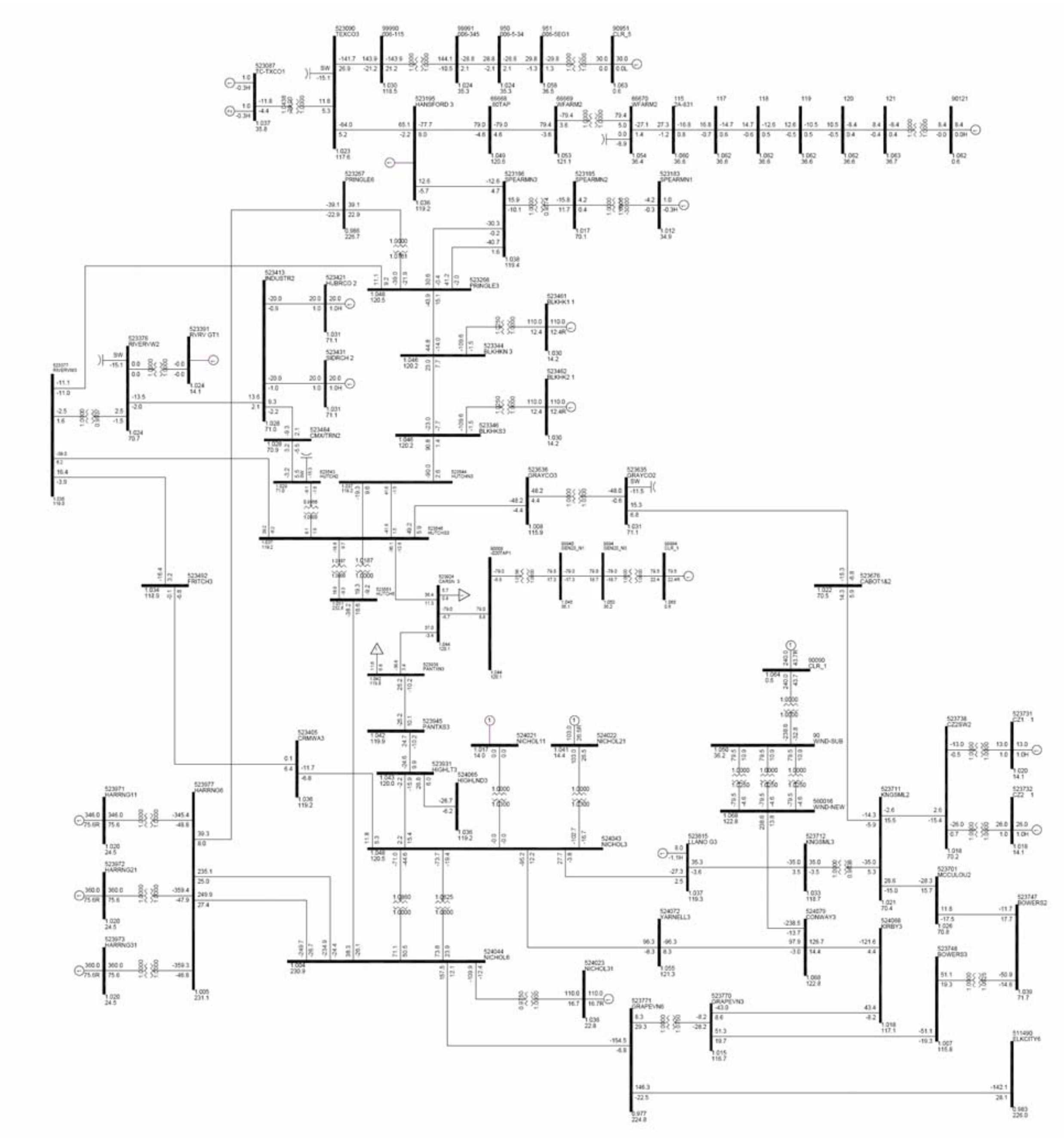

Figure 2-2: One-line diagram <u>without</u> Mitsubishi 2.4 MW WTGs (80 MW) - 2008 Summer Peak

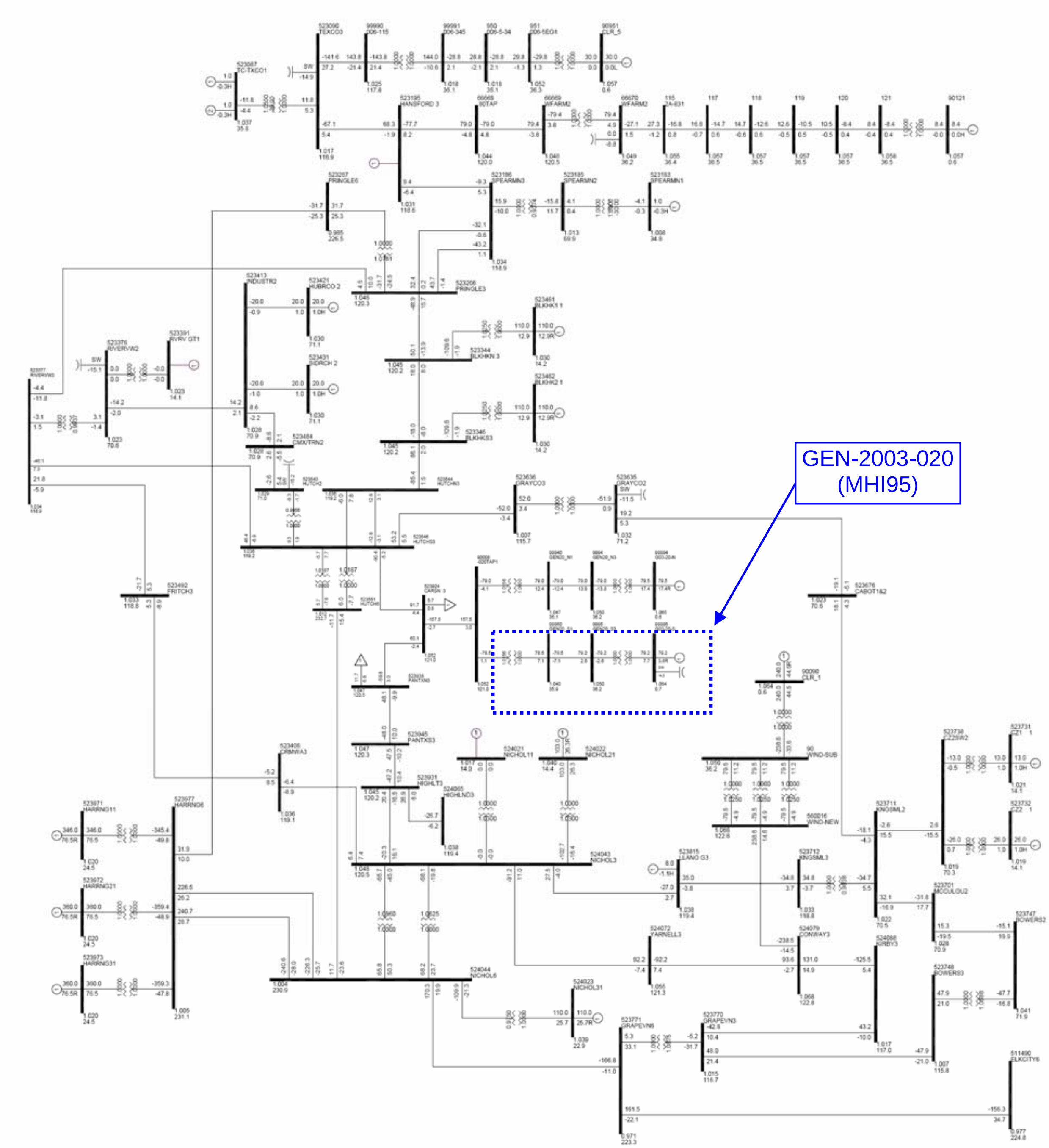


Figure 2-3: One-line diagram with Mitsubishi 2.4 MW WTGs (80 MW) - 2008 Summer Peak

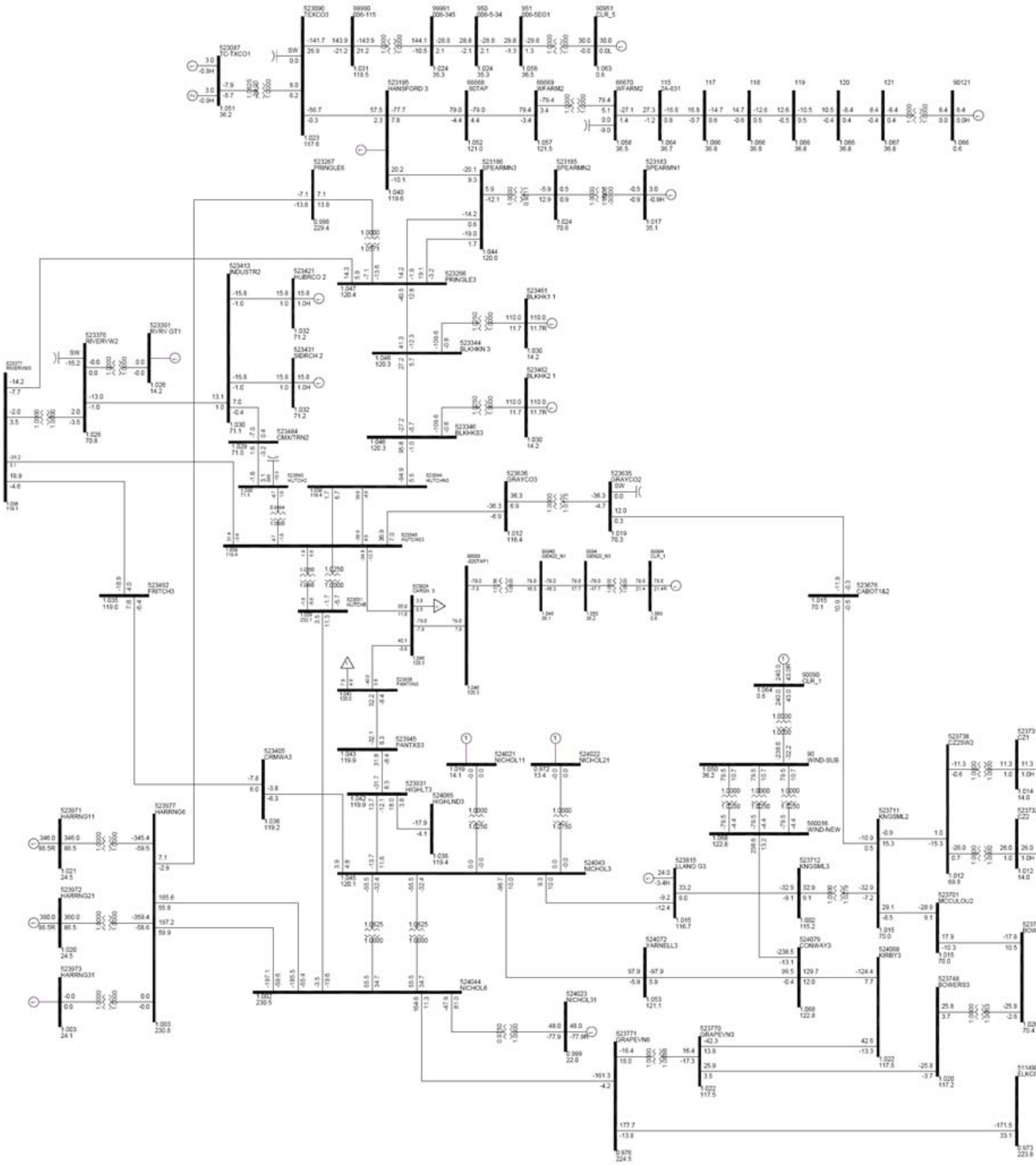

Figure 2-4: One-line diagram <u>without</u> Mitsubishi 2.4 MW WTGs (80 MW) - 2008 Winter Peak

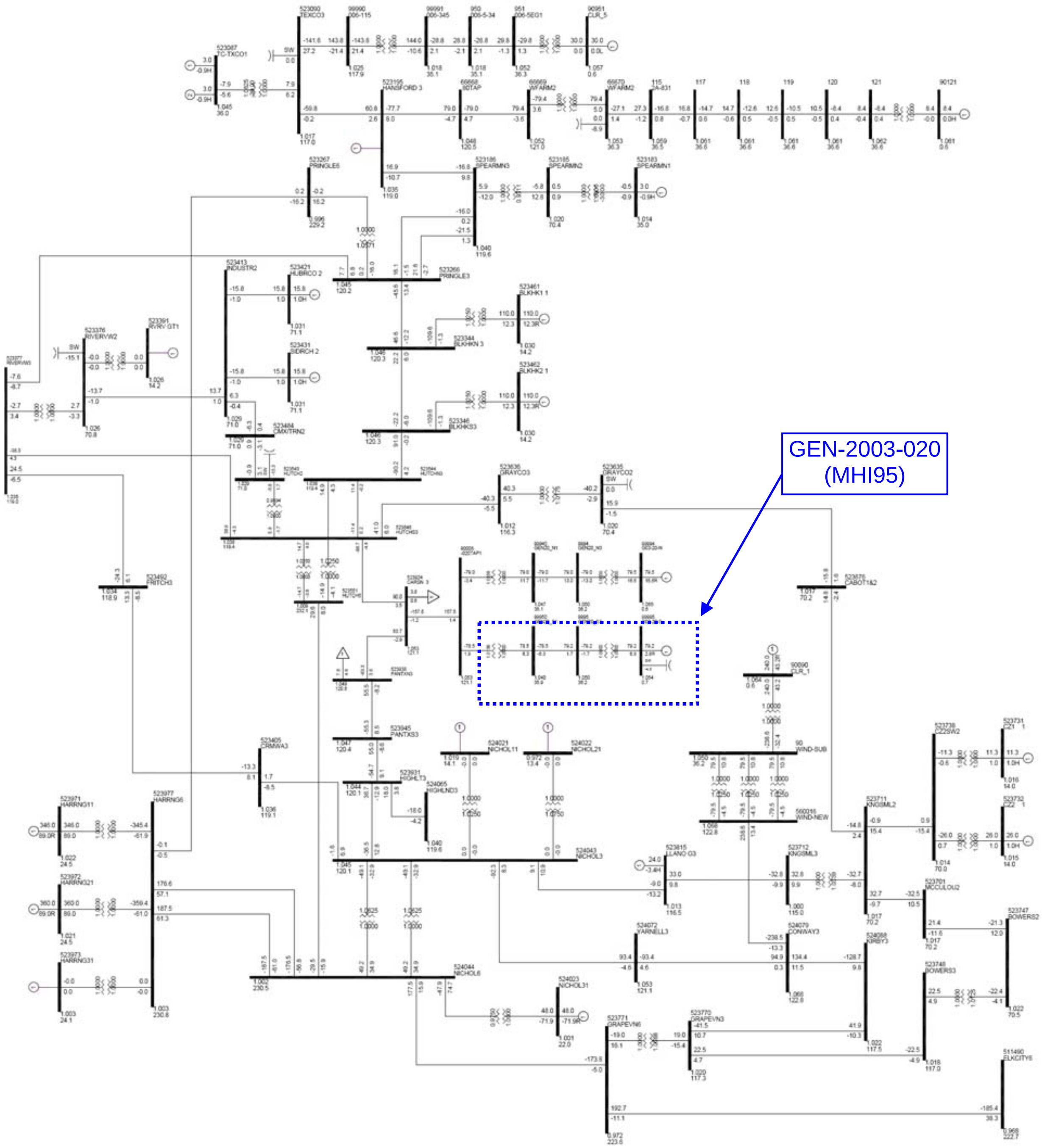


Figure 2-5: One-line diagram with Mitsubishi 2.4 MW WTGs (80 MW) - 2008 Winter Peak

# 3 Fault Cases

The fault scenarios considered for the local stability assessment are listed in Table 3-1. The sequence impedance used to model the SLG faults were estimated by ABB.

Table 3-1: List of Disturbances simulated for Local Stability Analysis

| FAULT | FAULT DESCRIPTION |
|---|---|
| FLT_1_3PH | 3 Phase Fault on the Nichols (524044) to Grapevine (523771), 230kV line near Grapevine<br>After 5cy, Trip the Nichols (52404)-Grapevine (523771) 230kV line<br>After 20cy, and then re-close the Nichols-Grapevine 230kV line into the fault<br>After 5cy, trip the Nichols-Grapevine 230kV line and remove fault |
| FLT_2_1PH | SLG fault same as FLT_1_3PH |
| FLT_3_3PH | 3 Phase Fault at Elk City 230kV bus (511490)<br>After 5cy, trip Grapevine (523771) -Elk City (511490) 230kV line<br>After 20cy, and then re-close the Elk City-Grapevine 230kV line into the fault<br>After 5cy, trip the Elk City-Grapevine 230kV line and remove fault |
| FLT_4_1PH | SLG fault same as FLT_3_3PH |
| FLT_5_3PH | 3 Phase Fault at Kirby bus 115kV (524088)<br>After 5cy, trip the following lines<br>Kirby (524088)-Conway (524079)<br>Conway (524079)-Yarnell (524072)<br>Yarnell (524072)-Nichols (524043)<br>After 20cy, reclose the Kirby-Conway-Yarnell-Nichols lines into the fault<br>After 5cy, trip Kirby-Conway-Yarnell-Nichols lines and clear the fault |
| FLT_6_1PH | SLG fault same as FLT_5_3PH |
| FLT_7_3PH | 3Phase Fault at Hutchinson Co. Interchange (523546)<br>After 5cy, trip Hutchinson Co. Interchange (523546)-Riverview Interchange (523377) 115kV<br>After 20cy, reclose Hutchinson Co. Interchange-Riverview Interchange 115kV into the fault<br>After 5cy, trip Hutchinson Co. Interchange-Riverview Interchange 115kV and clear the fault |
| FLT_8_1PH | SLG fault same as FLT_7_3PH |
| FLT_9_3PH | 3 Phase fault at Carson Bus (523924)<br>After 5cy, trip Hutchinson Co. Interchange (523546)-Carson (523924) 115kV line<br>After 20cy, reclose the Hutchinson Co. Interchange-Carson 115kV line<br>After 5cy, trip the Hutchinson Co. Interchange-Carson 115kV line and clear the fault |
| FLT_10_1PH | SLG fault same as FLT_9_3PH |
| FLT_11_3PH | 3 Phase fault at Carson Bus (523924)<br>After 5cy, trip Carson (523924)- Pantex N (523938) 115kV line<br>After 20cy, reclose the Carson-Pantex N 115kV line into the fault<br>After 5cy, trip the Carson-Pantex N 115kV line and clear the fault |
| FLT_12_1PH | SLG fault same as FLT_11_3PH |
| FLT_13_3PH | 3 Phase fault at HighLt3 (523931)<br>After 5cy, Trip HighLt3 (523931)-Pantex S (523945) 115kV line<br>After 20cy, reclose the HighLt3-Pantex S 115kV line into the fault<br>After 5cy, trip the HighLt3-Pantex S 115kV line and clear the fault |
| FLT_14_1PH | SLG fault same as FLT_13_3PH |
| FLT_15_3PH | 3 Phase fault at Nichols (524044)<br>After 5 cy, trip Nichols (524044)-Harrington (523977) 230kV line<br>After 20cy, reclose the Nichols-Harrington 230kV line into the fault<br>After 5cy, trip the Nichols-Harrington 230kV line and clear the fault |
| FLT_16_1PH | SLG fault same as FLT_15_3PH |

# 4 Study Results

The results for local stability simulations for Summer Peak 2008 and Winter Peak 2008 are summarized in Table 4-1 and Table 4-2.

All faults were run for 10 seconds.

The detailed simulation plots for all the faults are included in Appendix C.

No stability criteria violations were observed following all the simulated faults. The proposed wind farm remains on-line for all the simulated faults.

A local area wind farm (240 MW) connected to Conway 115 kV bus was tripped following two faults (FLT_5_3PH, and FLT_6_3PH). These two faults involve loss of Kirby – Conway – Yarnell – Nichols 115 kV line, islanding the windfarm. As the windafarm is an induction generator, it can not operate in the island mode. The prior-queued windfarm connected to Conway 115 kV was tripped following the two faults in both cases, with and without proposed wind farm.

Table 4-1: Results for Stability Analysis GEN-2003-020 (Summer Peak 2008)

| FAULT | WITHOUT GEN-2003-020 | WITH GEN-2003-020 |
|---|---|---|
| FLT_1_3PH | Not Tested | Stable |
| FLT_2_1PH | Not Tested | Stable |
| FLT_3_3PH | Not Tested | Stable |
| FLT_4_1PH | Not Tested | Stable |
| FLT_5_3PH | Stable ** | Stable ** |
| FLT_6_1PH | Stable ** | Stable ** |
| FLT_7_3PH | Not Tested | Stable |
| FLT_8_1PH | Not Tested | Stable |
| FLT_9_3PH | Not Tested | Stable |
| FLT_10_1PH | Not Tested | Stable |
| FLT_11_3PH | Not Tested | Stable |
| FLT_12_1PH | Not Tested | Stable |
| FLT_13_3PH | Not Tested | Stable |
| FLT_14_1PH | Not Tested | Stable |
| FLT_15_3PH | Not Tested | Stable |
| FLT_16_1PH | Not Tested | Stable |

**Note**: - **The 240 MW windfarm (#90090) connected to Conway 115 kV (524079) tripped. The fault involves loss of Kirby-Conway-Yarnell-Nichols 115 kV islanding the windfarm.

Table 4-2: Results for Stability Analysis GEN-2003-020 (Winter Peak 2008)

| FAULT | WITHOUT GEN-2003-020 | WITH GEN-2003-020 |
|---|---|---|
| FLT_1_3PH | Not Tested | Stable |
| FLT_2_1PH | Not Tested | Stable |
| FLT_3_3PH | Not Tested | Stable |
| FLT_4_1PH | Not Tested | Stable |
| FLT_5_3PH | Not Tested | Stable ** |
| FLT_6_1PH | Not Tested | Stable ** |
| FLT_7_3PH | Not Tested | Stable |
| FLT_8_1PH | Not Tested | Stable |
| FLT_9_3PH | Not Tested | Stable |
| FLT_10_1PH | Not Tested | Stable |
| FLT_11_3PH | Not Tested | Stable |
| FLT_12_1PH | Not Tested | Stable |
| FLT_13_3PH | Not Tested | Stable |
| FLT_14_1PH | Not Tested | Stable |
| FLT_15_3PH | Not Tested | Stable |
| FLT_16_1PH | Not Tested | Stable |

**Note**: - **The 250 MW windfarm (#90090) connected to Conway 115 kV (524079) tripped. The fault involves loss of Kirby-Conway-Yarnell-Nichols 115 kV islanding the windfarm.

# 5 Conclusions

A comprehensive range of fault cases has been simulated for stability analysis. Overall, the post-fault recoveries show stable system performance for GEN-2003-020 with Mitsubishi 2.4 MW wind turbine generators in 80 MW size. The voltage and power factor at the POI were acceptable in both pre-contingency and post-fault transient period. Hence, there was no need of additional reactive power support for the proposed windfarm.

The results of stability analysis indicated that interconnecting the proposed wind farm, GEN-2003-020, at a level of additional 80 MW with Mitsubishi 2.4 MW WTGs will not adversely affect the stability of the system.

FERC Order 661A Compliance – The Low Voltage Ride through (LVRT) capability was verified for compliance with Federal Energy Regulatory Commission's (FERC) standard for Interconnection of Wind generating plants: 'Low Voltage Ride-Through (LVRT) requirement. The proposed project (GEN-2003-020, 80 MW with Mitsubishi 2.4 MW WTGs) complies with the latest FERC order on low voltage ride through for wind farms. With this arrangement, the proposed wind farm would not trip off line by voltage relay actuation for local faults near the POI.

***The results of this study are based on available data and assumptions made at the time this study was conducted. The results included in this report may not apply if any of the data and/or assumptions made in developing the study models change.***

# APPENDIX A – Load Flow Data for GEN-2003-020

```
0,   100.00          / PSS/E-30.2    FRI, OCT 31 2008  14:40
SPP MDWG 2007 STABILITY BASE CASE: STAB2-08W-30-RED 4-12-07
2008 SUMMER PEAK: GEN-2003-020 INTERCONNECTION STUDY
  9995,'GEN20_S3    ',  34.5000,1,     0.000,     0.000, 526,1403,1.05000,  15.4666,   1
 99950,'GEN20_S1    ',  34.5000,1,     0.000,     0.000, 526,1403,1.03993,  14.9233,   1
 99995,'G03-20-S    ',   0.6900,2,     0.000,     0.000, 526,1403,1.05436,  19.1494,   1
0 / END OF BUS DATA, BEGIN LOAD DATA
0 / END OF LOAD DATA, BEGIN GENERATOR DATA
 99995,'1 ',    79.200,     3.633,    26.070,   -38.280,1.05000,  9995,    83.160,
0.00000,9999.00000,   0.00000,   0.00000,1.00000,1,  100.0,    79.200,     0.000,   1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
  9995,  99950,'1 ',   0.01250,   0.01390,   0.04860,    0.00,    0.00,    0.00,  0.00000,
0.00000,  0.00000,  0.00000,1,   0.00,   1,1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
  9995, 99995,     0,'1 ',1,2,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.00000,   0.08000,    89.10
1.00000,   0.000,   0.000,    89.10,    89.10,    89.10, 0,      0, 1.05000, 0.95000, 1.05000,
0.95000,   5, 0, 0.00000, 0.00000
1.00000,   0.000
 90008, 99950,     0,'1 ',1,2,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.00000,   0.10000,    70.00
1.01560,   0.000,   0.000,    90.00,    90.00,    90.00, 0,      0, 1.05000, 0.95000, 1.05000,
0.95000,   5, 0, 0.00000, 0.00000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
 526,525561,   -66.000,     1.000,'SPS        '
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN SWITCHED SHUNT DATA
 99995,0,1.00000,1.00000,     0,  100.0,'            ',    3.63, 1,   3.63
0 / END OF SWITCHED SHUNT DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
1403,'SPS-AMA     '
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
   1,'CENT HUD    '
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA
```

# APPENDIX B – Stability Data for GEN-2003-020

```
     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS/E      FRI, OCT 31 2008  14:47
SPP MDWG 2007 STABILITY BASE CASE: STAB2-08W-30-RED 4-12-07
2008 SUMMER PEAK: GEN-2003-020 INTERCONNECTION STUDY

PLANT MODELS

REPORT FOR ALL MODELS                    BUS 99995 [G03-20-S    0.6900] MODELS


** M9295G **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S       VAR        ICON
            99995 G03-20-S     0.6900 1  111171-111174  41918-41921   12052-12055    8289-8291

    Kpll      Kipll     PLLMX     Tconv

 30.0000    0.0000    0.1000    0.0750


    Type of the wind turbine: MWT   95
    number of lumped original machines:    42


** M9295E **  BUS X-- NAME --X BASEKV MC       C O N S     S T A T E S     VAR        ICON
             99995 G03-20-S     0.6900 1  111175-111192  41922-41923   12056-12059    8292-8293

    Wmin      Wmax      Kopt     PRTLIM     KPP        KIP
 -0.3210    0.1333    0.3006    1.0416    5.8830    1.2265

      PFDEM     LIM_I      PitchMin     V_UP      V_LOW
     0.0000    1.0000    21.0000     1.1000     0.9000

      V_CROW     T_VT         K_Q      SN      TNDH_OFF
     0.1000    0.0050     2.0000     0.1300     3.0000

      TNDH_CROW     TCROW_OFF
     0.2000     0.2000


     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS/E      FRI, OCT 31 2008  14:47
SPP MDWG 2007 STABILITY BASE CASE: STAB2-08W-30-RED 4-12-07
2008 SUMMER PEAK: GEN-2003-020 INTERCONNECTION STUDY

CONEC MODELS

REPORT FOR ALL MODELS                    BUS 99995 [G03-20-S    0.6900] MODELS


 ** M9295W ** BUS X-- NAME --X BASEKV MC    C O N S       V A R S       ICONS
            99995 G03-20-S     0.6900 1  111193-111199  12060-12063    8294-8295

    VWMAX     T1G       TG       MAXG     T1R       T2R       MAXR
  25.000 9999.000    3.000    3.000 9999.000    3.000    3.000

              Wind generator Bus #  99995

              Wind Generator ID       1



** M9295T  **  BUS X-- NAME --X     BASEKV MC       C O N S         STATE          VAR
ICON
               99995    G03-20-S     0.6900 1  111200-111204   41924-41927   12064-12067
8296-8298

     H           DAMP          Htfrac        Freq1        DSHAFT
   7.7260       0.0000        0.8562       2.3000       3.0000
```

```
              Wind Generator Bus #  99995
              Wind Generator ID        1


** M9295A ** BUS X-- NAME --X BASEKV MC      C O N S       STATE         VAR           ICON
            99995 G03-20-S     0.6900 1  111205-111213  41928-41928   12068-12071   8299-8301

    Lambda_Max   Lambda_Min   PITCH_MAX    PITCH_MIN      Ta
     19.5000       0.0000     109.0000      21.0000      0.0000

      RHO       Radius           GB_RATIO     SYNCHR
      1.2250      47.5000       90.5880        1200.00


              Wind Generator Bus #  99995
              Wind Generator ID        1


** M9295P **    BUS X-- NAME --X BASEKV MC     C O N S        STATE          VAR           ICON
             99995 G03-20-S     0.6900 1  111214-111228   41929-41931       0-0         8302-8304

       Tp             Kp1         Ki1            Kp2           Ki2
      0.1000      152.6400      62.2070        0.1750        0.0594

           TetaMax       TetaMin         RTetaMax     RTetaMin    GSPit1
           109.0000       21.0000        7.5000       -6.0000     20.0000

        GSPit2         GSDiv1       GSDiv2         Wmin         Wmax
        50.0000        1.0000       4.0000       -0.3210        0.1333


              Wind Generator Bus #  99995
              Wind Generator ID        1


 ** M925PT ** BUS X-- NAME --X     BASEKV MC       V A R S       ICONS
            99995    G03-20-S      0.69001       12072-12080    8305-8306


              Wind generator Bus #  99995
              Wind Generator ID        1

     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS/E      FRI, OCT 31 2008  14:47
SPP MDWG 2007 STABILITY BASE CASE: STAB2-08W-30-RED 4-12-07
2008 SUMMER PEAK: GEN-2003-020 INTERCONNECTION STUDY

CONET MODELS

REPORT FOR ALL MODELS                     BUS 99995 [G03-20-S    0.6900] MODELS


              *** CALL VTGDCA(  8307,111229,     0, 12081) ***

               BUS    NAME  BSKV        GENR BUS    NAME  BSKV    ID
             99995 G03-20-S.690            99995 G03-20-S.690    1

                  I C O N S      C O N S       V A R
                  8307-8312   111229-111232   12081

                    VLO       VUP       PICKUP     TB
                    0.025     5.000     0.150     0.080


              *** CALL VTGDCA(  8313,111233,     0, 12082) ***

               BUS    NAME  BSKV        GENR BUS    NAME  BSKV    ID
             99995 G03-20-S.690            99995 G03-20-S.690    1

                  I C O N S      C O N S       V A R
                  8313-8318   111233-111236   12082
```

```
     VLO       VUP      PICKUP     TB
     0.200     5.000     0.783     0.080


*** CALL VTGDCA(  8319,111237,     0, 12083) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8319-8324   111237-111240   12083

     VLO       VUP      PICKUP     TB
     0.250     5.000     0.942     0.080


*** CALL VTGDCA(  8325,111241,     0, 12084) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8325-8330   111241-111244   12084

     VLO       VUP      PICKUP     TB
     0.350     5.000     1.258     0.080


*** CALL VTGDCA(  8331,111245,     0, 12085) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8331-8336   111245-111248   12085

     VLO       VUP      PICKUP     TB
     0.450     5.000     1.575     0.080


*** CALL VTGDCA(  8337,111249,     0, 12086) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8337-8342   111249-111252   12086

     VLO       VUP      PICKUP     TB
     0.550     5.000     1.892     0.080


*** CALL VTGDCA(  8343,111253,     0, 12087) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8343-8348   111253-111256   12087

     VLO       VUP      PICKUP     TB
     0.650     5.000     2.208     0.080


*** CALL VTGDCA(  8349,111257,     0, 12088) ***

 BUS   NAME  BSKV        GENR BUS   NAME  BSKV   ID
99995 G03-20-S.690          99995 G03-20-S.690    1

    I C O N S      C O N S       V A R
    8349-8354   111257-111260   12088
```

```
       VLO        VUP       PICKUP      TB
       0.750      5.000      2.525      0.080


 *** CALL VTGDCA(  8355,111261,     0, 12089) ***

  BUS    NAME  BSKV        GENR BUS    NAME  BSKV   ID
99995 G03-20-S.690            99995 G03-20-S.690    1

     I C O N S      C O N S       V A R
     8355-8360   111261-111264   12089

       VLO        VUP       PICKUP      TB
       0.850      5.000      2.842      0.080


 *** CALL VTGDCA(  8361,111265,     0, 12090) ***

  BUS    NAME  BSKV        GENR BUS    NAME  BSKV   ID
99995 G03-20-S.690            99995 G03-20-S.690    1

     I C O N S      C O N S       V A R
     8361-8366   111265-111268   12090

       VLO        VUP       PICKUP      TB
       0.900      5.000      3.000      0.080


 *** CALL VTGDCA(  8367,111269,     0, 12091) ***

  BUS    NAME  BSKV        GENR BUS    NAME  BSKV   ID
99995 G03-20-S.690            99995 G03-20-S.690    1

     I C O N S      C O N S       V A R
     8367-8372   111269-111272   12091

       VLO        VUP       PICKUP      TB
       0.000      1.100      0.020      0.080


 *** CALL FRQDCA(  8373,111273,     0, 12092) ***

  BUS     NAME    BSKV      GEN BUS    NAME    BSKV   ID
99995  G03-20-S  .690       99995  G03-20-S  .690     1

     I C O N S      C O N S       V A R
     8373-8378   111273-111276   12092

       FLO        FUP       PICKUP      TB
      59.000     70.000      0.300      0.080


 *** CALL FRQDCA(  8379,111277,     0, 12093) ***

  BUS     NAME    BSKV      GEN BUS    NAME    BSKV   ID
99995  G03-20-S  .690       99995  G03-20-S  .690     1

     I C O N S      C O N S       V A R
     8379-8384   111277-111280   12093

       FLO        FUP       PICKUP      TB
      50.000     61.000      0.300      0.080
```

# APPENDIX C – Plots for Stability Simulations with Gen-2003-20