PSSE Year 0 Topology 0 Analysis

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Chapter 1

Introduction

1.1 Study Description

The Year 0 Topology 0 contingency analysis of the hypothetical SAVNW system is carried out to report the branches reporting loading greater than 100% and buses reporting upper and lower voltage limit violations.

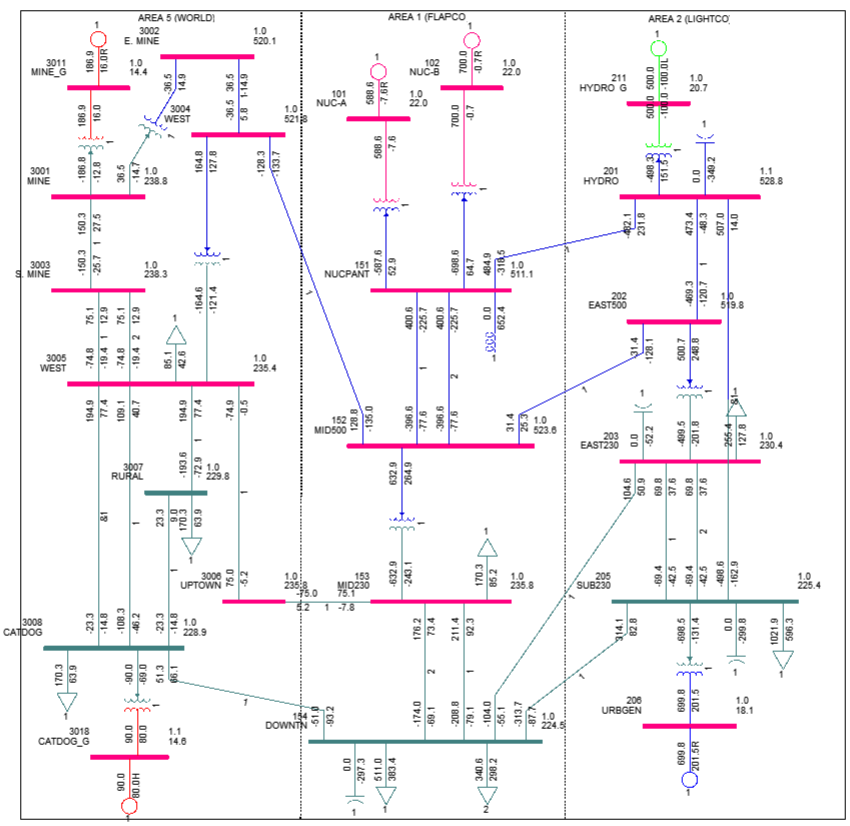

Figure 1.1: Single Line Diagram Year 0, Topology 0

For the hypothetical SAVNW system, the Year 0 Topology 0 of the system represents the present year system as shown in Figure 1.1. There are 6 generators in 3 areas. Total installed capacity of the system is the sum of firm capacity provided by 6 generating units and equals 4153.25 MW.

Detailed analysis of Year 0 Topology 0 Base Case was carried out and can be found here. The combined total generation in all areas of 2765 MW is serving a total load of 2723 MW with the generators 102 NUC-B, 211-HYDRO_G, 3018-CATDOG_G operating at their nominal power output of 700 MW, 500 MW and 90 MW respectively. The swing generator in each area operates to meet the load, loss and interchange criteria. The desired interchange for all the scenarios studied is highlighted in Figure 1.2. For all the scenarios studied the desired interchange from FLAPCO to LIGHTCO is 100 MW, and from FLAPCO to WORLD is 150 MW.

X-- AREA --X	FROM GENE- RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	TO XFRMR MAGNE- TIZING	FROM CHARGING	TO LOSSES	NET INTERCHANGE TO TIE LINES	NET INTERCHANGE TO TIES + LOADS	DESIRED NET INT
1	1288.6	0.0	0.0	1021.9	0.0	0.0	0.0	0.0	0.0	15.3	251.5	1103.0	250.0
FLAPCO	-8.2	0.0	0.0	766.7	355.0	0.0	-0.0	-0.0	878.1	317.3	-569.2	112.3	
2	1199.8	0.0	0.0	1277.3	0.0	0.0	0.0	0.0	0.0	21.1	-98.6	-950.2	-100.0
LIGHTCO	101.5	0.0	0.0	724.1	-701.1	0.0	-0.0	-0.0	651.0	396.2	333.3	-348.2	
5	276.9	0.0	0.0	425.7	0.0	0.0	0.0	0.0	0.0	4.1	-152.9	-152.9	-150.0
WORLD	96.0	0.0	0.0	170.4	-0.0	0.0	-0.0	-0.0	366.0	55.8	235.9	235.9	
COLUMN	2765.3	0.0	0.0	2724.8	0.0	0.0	0.0	0.0	0.0	40.5	0.0	0.0	0.0
TOTALS	189.3	0.0	0.0	1661.2	-346.1	0.0	0.0	0.0	1895.2	769.3	0.0	0.0	

Figure 1.2: System Totals for Year - 0, Topology - 0

1.2 Contingency Analysis

AC contingency calculation was conducted on the hypothetical SAVNW system for Year 0 Topology 0. The configuration files used are:

- Subsystem file savnw.sub - Studied subsystems of the studied case defined via the Subsystem Definition data file (Figure 1.3)
- Monitor file savnw.mon - Monitored Element Data File identifies the branches that are to be monitored for flow violations and the buses that are to be monitored for voltage violations (Figure 1.4)
- Contingency file savnw.con - Contingency cases that are to be tested are defined in the Contingency Definition data file (Figure 1.5)

```
SUBSYSTEM CON
 AREA 1
 AREA 2
 AREA 5
END

SUBSYSTEM MON
 AREA 1
 AREA 2
 AREA 5
END

END
```

Figure 1.3: The subsystem file corresponding to Year 1 Topology 1

```
MONITOR VOLTAGE RANGE ALL BUSES 0.9 1.1
MONITOR ALL BRANCHES
MONITOR TIES FROM AREA 1 TO AREAS 2 5
MONITOR TIES FROM AREA 2 TO AREA 5
END
END
```

Figure 1.4: The monitored file corresponding to Year 1 Topology 1

```
SINGLE BRANCH IN AREA 1
SINGLE BRANCH IN AREA 2
SINGLE BRANCH IN AREA 5
SINGLE BUS IN AREA 1
SINGLE BUS IN AREA 2
SINGLE BUS IN AREA 5
SINGLE MACHINE IN AREA 1
SINGLE MACHINE IN AREA 2
SINGLE MACHINE IN AREA 5
END
```

Figure 1.5: The contingency file corresponding to Year 1 Topology 1

The API DFAX_2 is used to construct distribution factor data files corresponding to the case .sav file, and the defined .sub, .mon, .con configuration files. By running the AC contingency calculation function ACCC_WITH_DSP_3, the contingency solution output .acc files is obtained.

Python code to conduct AC contingency calculation is:

```
import psspy
psspy.case(r"""savnw.sav""")
psspy.fdns([0,1,0,0,0,0,99,0])
psspy.dfax_2([1,1,0],r"""savnw.sub""",r"""savnw.mon""",r"""savnw.con""",r"""savnw.dfx""")
psspy.accc_with_dsp_3(0.1,[0,0,0,0,1,2,0,0,0,2,0],r"""CON""",r"""savnw.dfx""",r"""savnw.acc""","",
                                                    "","")
```

Using the contingency solution output file savnw.acc, the results is exported as an excel file for further analysis. The results exported are ACCC Analysis Summary, Monitored Branch Flow (MVA), Monitored Bus Voltage. ¡br¿

Python code to export AC contingency solution output file as excel is:

```
import psspy
import pssexcel
pssexcel.accc('savnw.acc', ['s','b'], colabel='',stype='contingency', busmsm=0.5, sysmsm=5.0,
                rating='a', namesplit=False,xlsfile='out.xlsx', sheet='', overwritesheet=True,
                                                            show=False, ratecon='b',
                baseflowvio=False,basevoltvio=False, flowlimit=100.0, flowchange=0.0, voltchange=0
                                                            .0,swdrating='a',
                swdratecon='b',baseswdflowvio=False,basenodevoltvio=False,overloadreport=False)
```

Contingency analysis was carried out in PSSE for the studied case for Year 0 Topology 0. It was seen that the power flow solution did not converge for some of the tested contingencies. For the studied case, 42 contingencies were converged out of the 47 contingencies tested, the contingencies not converged are UNIT 206(1), SING OPN LIN 14 205-206(1), BUS 152, BUS 154, BUS 201.

For the converged contingencies for the studied case, the result of the contingency analysis is analysed to check for branch overload ($> 100\%$) and out of range bus voltage violations (lower emergency limit $< 0.9PU$ and upper emergency limit $> 1.1PU$). It was seen that for some of the contingencies there were no branch overload or bus voltage violations reported. Rest of the contingencies violating branch overload and bus voltage emergency range violation are reported. Chapter 2 gives the observed branch flow violations, upper and lower emergency voltage violations for the studied case. As load flow analysis checks the power balance of the network at the instant the fault occurred on the system, it will not give the information regarding the dynamic behaviour of the system. Chapter 3 gives the result of the dynamic stability analysis carried out to see if the system is stable after the occurrence of the fault. To conclude, Chapter 4 summarises the results of all the analysis carried out on Year 0, Topology 0 of the hypothetical SAVNW system.

Chapter 2

Contingency Limit Violations

2.1 Introduction

In this chapter, for Year 0, Topology 0, the branches that are loaded more than 100% of their rating, and buses violating the upper and lower emergency ratings are reported.

2.2 Branch Overload Violation

For Year 0, Topology 0, loading violations were reported for 3 branches 153-154(1), 3001-3003(1), and 154-203(1). For the branch 153-154(1), loading of 102.62% was reported for the contingency SING OPN LIN 11 202-203(1). The branch 3001-3003(1), reporting a loading of 199.87% for the contingency BUS 151 is considered as severe/ critical loading. For the branch 154-203(1), loading of 117.68 was reported for the contingency BUS 205. The Table gives the loading violations in tabular form.

BRANCH	CONTINGENCY	MVAFLOW	AMPFLOW	RATE RATE1/RATE2	Loading
153-154(1)	SING OPN LIN 11 202-203(1)	-349.97	359.16	350.00	102.62
3001-3003(1)	BUS 151	616.28	599.62	300.00	199.87
154-203(1)	BUS 205	266.19	294.19	250.00	117.68

Table 2.1: Branch Loaded greater than 100% for Topology 0

2.3 Upper Emergency Bus Voltage Violation

The only upper voltage violation was reported by the bus 201 for the bus fault at bus 151 labelled BUS 151. The reported violation is tabulated in Table 2.2.

BUS	CONTINGENCY	BASE VOLTS	CONT VOLTS	RANGE VIO
201	BUS 151	1.058	1.101	0.001

Table 2.2: Upper emergency range violation for Topology 0

2.4 Lower Emergency Bus Voltage Violation

There was no lower emergency voltage limit violation reported for the studied case for the Year 0 Topology 0.

Chapter 3

Dynamic Stability Analysis

3.1 Introduction

As load flow analysis checks the power balance of the network at the instant the fault occurred on the system, it will not give the information regarding the dynamic behaviour of the system. Dynamic stability analysis is carried out to see if the system is stable after the occurrence of the fault. From chapter 2, the faults causing overloading and/ or voltage limit violations are 'BUS 205 ,'SING OPN LIN 11 202-203(1)', 'BUS 151'. Dynamic simulation is carried out on the studied case by applying each individual fault at TIME = 2 Seconds to check the dynamic stability of the faulted system. The python script used to carry out this simulation is given in the Appendix 4 of the document.

3.2 BUS 151

Dynamic simulation was conducted on the system for a bus fault at bus 151. When the bus fault at bus 151 was applied on the system at 2.0 seconds, Network not converged was first reported at TIME = 2.1167 seconds (Figure 3.1). At TIME = 3.175 seconds, 3 bus(es) in island(s) were reported (Figure 3.2). At TIME = 4.9667 seconds, 19 bus(es) in island(s) with no in-service machines was reported(Figure 3.3). Hence, the system is not dynamically stable for a bus fault at BUS 151.

```
Network not converged at TIME = 2.1167

Network not converged at TIME = 2.125
```

Figure 3.1: Progress bar output for Bus fault at BUS 151

```
AT TIME =  3.175 VOLTAGES OUTSIDE OF BAND 0.50000 TO 1.50000:

X--------- B U S ---------X VOLTAGE      X--------- B U S ---------X VOLTAGE
   101     [NUC-A       21.600] 0.20868LO       102     [NUC-B       21.600] 0.00000LO
   151     [NUCPANT     500.00] 0.00000LO

 3.1750   0.0000       0.0000       0.0000       0.0000       237.21       617.52
    7     552.14       0.0000       226.79       0.0000       887.23       887.30
   13     1.3039      0.88552       1.2939       1.3291      0.83704       1.2811
   19     1.2812      6.43503E-02   0.0000       9.1740       5.3491       13.489
   25     0.0000       3.0499       0.0000       3.6616       1.7310      0.89153
   31     0.0000      0.20829       0.0000      0.95247       1.3220       1.2858
   37     0.0000      0.20868      7.67088E-07  0.95247       1.3220       1.2858
   43     0.0000

3 bus(es) in island(s) with no in-service machines
The following buses are disconnected:
  BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV
   101     NUC-A       21.600     102     NUC-B       21.600     151     NUCPANT     500.00
```

Figure 3.2: Progress bar output for Bus fault at BUS 151 - continued

```
Power unbalance=**********; Threshold=   1.10000
MACHINE 1  AT BUS   3011 [MINE_G      13.800] TRIPPED AT TIME = 4.9667


Network not converged at TIME = 4.9667


AT TIME =  4.967 VOLTAGES OUTSIDE OF BAND 0.50000 TO 1.50000:

X--------- B U S ---------X VOLTAGE      X--------- B U S ---------X VOLTAGE
   152     [MID500      500.00]********HI     153     [MID230      230.00]********HI
   154     [DOWNTN      230.00]********HI     201     [HYDRO       500.00]********HI
   202     [EAST500     500.00]********HI     203     [EAST230     230.00]********HI
   204     [SUB500      500.00]********HI     205     [SUB230      230.00]********HI
   206     [URBGEN      18.000]********HI     211     [HYDRO_G     20.000]********HI
  3001     [MINE        230.00]********HI    3002     [E. MINE     500.00]********HI
  3003     [S. MINE     230.00]********HI    3004     [WEST        500.00]********HI
  3005     [WEST        230.00]********HI    3006     [UPTOWN      230.00]********HI
  3007     [RURAL       230.00]********HI    3008     [CATDOG      230.00]********HI
  3011     [MINE_G      13.800]********HI

 4.9667   0.0000       0.0000       0.0000       0.0000       1.09211E+19  1.30051E+20
    7   1.26405E+20   0.0000      1.03619E+19   0.0000       5.03233E+19  5.59668E+19
   13   2.94688E+08  4.35145E+08  3.94863E+08  3.33065E+08  4.37460E+08  1.60471E+08
   19   1.78467E+08   0.0000       0.0000       0.0000       0.0000      -2.16108E+11
   25    0.0000       0.0000       0.0000       0.0000       0.0000      -5.13488E+12
   31    0.0000       0.0000       0.0000       0.0000       0.0000       3.49605E+05
   37    0.0000       0.0000       0.0000      4.34224E+08  3.94863E+08  1.24794E+08
   43    0.0000

19 bus(es) in island(s) with no in-service machines
The following buses are disconnected:
  BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV
    152     MID500      500.00     153     MID230      230.00     154     DOWNTN      230.00
    201     HYDRO       500.00     202     EAST500     500.00     203     EAST230     230.00
    204     SUB500      500.00     205     SUB230      230.00     206     URBGEN      18.000
    211     HYDRO_G     20.000    3001     MINE        230.00    3002     E. MINE     500.00
   3003     S. MINE     230.00    3004     WEST        500.00    3005     WEST        230.00
   3006     UPTOWN      230.00    3007     RURAL       230.00    3008     CATDOG      230.00
   3011     MINE_G      13.800
```

Figure 3.3: Progress bar output for Bus fault at BUS 151 - continued

3.3 BUS 205

Dynamic simulation conducted on the system with fault applied at Bus 205 at TIME = 2.0 seconds. At TIME = 6.558 seconds, 21 bus(es) in island(s) with no in-service machines was reported and the bus disconnected from the system were reported. Hence, the system is not dynamically stable for a bus fault at BUS 205.

```
AT TIME =  6.558 VOLTAGES OUTSIDE OF BAND 0.50000 TO 1.50000:

X--------- B U S ---------X VOLTAGE      X--------- B U S ---------X VOLTAGE
   102     [NUC-B       21.600] 0.44607LO     151     [NUCPANT     500.00] 0.44607LO
   152     [MID500      500.00] 0.21566LO     153     [MID230      230.00] 0.17566LO
   154     [DOWNTN      230.00] 0.02762LO     201     [HYDRO       500.00] 0.30992LO
   202     [EAST500     500.00] 0.19825LO     203     [EAST230     230.00] 0.09376LO
   204     [SUB500      500.00] 0.10468LO     205     [SUB230      230.00] 0.00000LO
   211     [HYDRO_G     20.000] 0.30992LO    3001     [MINE        230.00] 0.14231LO
  3002     [E. MINE     500.00] 0.14619LO    3003     [S. MINE     230.00] 0.14027LO
  3004     [WEST        500.00] 0.16050LO    3005     [WEST        230.00] 0.13265LO
  3006     [UPTOWN      230.00] 0.16338LO    3007     [RURAL       230.00] 0.09603LO
  3008     [CATDOG      230.00] 0.07039LO    3011     [MINE_G      13.800] 0.14231LO

 6.5583    52.316       43.485       8.2551       6.8819       4.1568       116.51
    7      85.348       117.77       14.051       55.697       3.7696       3.7157
   13     0.17566     2.76161E-02  0.30992      0.19825     9.37593E-02  0.14231
   19     0.14027      1.1741       0.0000       0.0000       0.0000       0.0000
   25      0.0000      13.216       0.0000       0.0000       0.0000       0.0000
   31      0.0000     0.72615       0.0000       0.0000       0.0000       0.0000
   37      0.0000     0.71372      0.44607       0.0000      0.30992      0.14231
   43      0.0000

21 bus(es) in island(s) with no in-service machines
The following buses are disconnected:
  BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV    BUS#-SCT X-- NAME --X BASKV
    101     NUC-A       21.600     102     NUC-B       21.600     151     NUCPANT     500.00
    152     MID500      500.00     153     MID230      230.00     154     DOWNTN      230.00
    201     HYDRO       500.00     202     EAST500     500.00     203     EAST230     230.00
    204     SUB500      500.00     205     SUB230      230.00     211     HYDRO_G     20.000
   3001     MINE        230.00    3002     E. MINE     500.00    3003     S. MINE     230.00
   3004     WEST        500.00    3005     WEST        230.00    3006     UPTOWN      230.00
   3007     RURAL       230.00    3008     CATDOG      230.00    3011     MINE_G      13.800
```

Figure 3.4: Progress bar output for Bus fault at BUS 205 - continued

3.4 SING OPN LIN 11 202-203(1)

Dynamic simulation was conducted with bus fault applied at 2.0 seconds. It was seen that the system was dynamically stable. Slight overloading was reported (Figure 3.5) for the branch 153-154(1) similar to the overload reported in Table 2.1 from the contingency analysis.

```
SUBSYSTEM LOADING CHECK (INCLUDED: LINES; BREAKERS AND SWITCHES; TRANSFORMERS) (EXCLUDED: NONE)
LOADINGS ABOVE 100.0 % OF RATING SET 2 (MVA FOR TRANSFORMERS, CURRENT FOR NON-TRANSFORMER BRANCHES):

X----------- FROM BUS ------------X X------------ TO BUS -------------X
  BUS#-SCT X-- NAME --X BASKV  AREA   BUS#-SCT X-- NAME --X BASKV  AREA CKT LOADING   RATE2 PERCENT
   153     MID230      230.00     1    154     DOWNTN      230.00*    1  1    360.9   350.0   103.1
```

Figure 3.5: System Totals for Year - 0, Topology - 0

Chapter 4

Conculsion

The contingency analysis was carried out on the hypothetical SAVNW study system for the Year 0, Topology 0 to study the (N-1) bus, single line open, unit contingencies. Out of all the studied (N-1) contingencies, the contingencies for which the system did not converge are the contingencies UNIT 206(1), SING OPN LIN 14 205-206(1), BUS 152, BUS 154, BUS 201.

For the converged contingency scenarios, Chapter 2 reported the branch overload, upper and lower limit voltage violations. From the branch overload table, Table 2.1 branches reporting loading greater than 130% was the branch 3001-3003(1), for a bus fault BUS 151. There was a slight violation from upper emergency voltage value for Bus 201 and no lower limit voltage violations were reported for any of the studied Buses.

In the Chapter 3 for the faults reporting the violations, dynamic simulations were carried out to determine the dynamic stability of the system. For the bus fault at buses 151 and 205, the system was not dynamically stable. For the single line open 202-203(1), the system was dynamically stable with the branch 153-154(1) still reporting overload violations.

Hence it can be concluded that in addition to the contingencies not converging reported by contingency analysis, the contingencies corresponding to the bus faults BUS 151 and BUS 205 also causes system to be unstable.

Appendix

4.1 Python program to check dynamic stability of the system for contingencies reporting violations

```
import psspy
psspy.case(r"""savnw.sav""")
psspy.fdns([0,1,0,0,0,1,99,0])
psspy.cong(0)
psspy.conl(0,1,1,[0,0],[40.0,30.0,40.0,30.0])
psspy.conl(0,1,2,[0,0],[40.0,30.0,40.0,30.0])
psspy.conl(0,1,3,[0,0],[40.0,30.0,40.0,30.0])
psspy.ordr(1)
psspy.fact()
psspy.tysl(1)
psspy.dyre_new([1,1,1,1],r"""savnw.dyr""","","","")
psspy.set_osscan_2(1,1,0)
psspy.set_relscn(1)
psspy.set_vltscn(1,1.5,0.5)
psspy.set_genpwr(1,1.1)
psspy.set_genang_3(1,180.0,0.0,1)
psspy.set_genspdev(1,10.0,1)
psspy.set_volt_viol_subsys_flag(0)
psspy.set_voltage_dip_check(1,0.8,0.2)
psspy.set_voltage_rec_check(1,1,0.8,0.4,0.9,1.0)
psspy.set_netfrq(1)
psspy.set_relang(1,0,"")
psspy.bsys(1,0,[0.0,0.0],0,[],8,[153,154,202,203,3001,3003,203,201],0,[],0,[])
psspy.chsb(1,0,[1,9,1,1,17,0])
psspy.bsys(1,0,[0.0,0.0],0,[],7,[153,154,202,203,3001,3003,201],0,[],0,[])
psspy.chsb(1,0,[13,21,37,1,13,0])
psspy.strt_2([0,0],r"""slg_202_203.out""")
# For Bus fault at 205
psspy.run(0,2.0,2,2,0)
psspy.dist_3phase_bus_fault(205,0,1,0.0,[0.0,-0.2E+10])
psspy.run(0,10.0,2,2,0)
# For Bus fault at 151
psspy.run(0,2.0,2,2,0)
psspy.dist_3phase_bus_fault(151,0,1,0.0,[0.0,-0.2E+10])
psspy.run(0,10.0,2,2,0)
# for Single Line Open from 202 to 203
psspy.dist_branch_fault(202,203,r"""1""",1,500.0,[0.0,-0.2E+10])
psspy.run(0,10.0,2,2,0)
# Power flow after dynamic simulation
psspy.ordr(1)
psspy.fact()
psspy.tysl(1)
# Overload check > 100%
psspy.rate_2(0,1,1,1,1,2,100.0)
# range violation check V < 0.9 PU, V > 1.1 PU
psspy.vchk(0,1,0.9,1.1)
```