A New Adaptive Technique in Development of IT Based Island Scheme For The Power System Utility Needs.

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Abstract:

This paper provides a new strategy in design and development of simple power system controlled separation scheme, aimed at maintaining of supply to certain important sector of loads and making fast restoration of the grid in the events of cascade outages leading to blackouts. This is found to be the need of an hour, particularly with respect to the emerging structural changes in power system and in the operation paradigms of utility grid. Special emphasis is given for modeling of the state grid with the base case, from which the reduced system is derived by making unique approach of load groping based on island participation index, for making the island scheme to extend supply to metros, in case of severe disturbances leading to blackout. The motivation behind is, that the recent blackout of new grid, occurred on 30th & 31st July 2012, in India, wherein the complete nations capital activity got paralyzed.

Keywords : Islanding, Island participation index, blackout, metros, slow cohesive – generators, SCADA.

INTRODUCTION:

The power system network in this new scenario of deregulation and restructuring, is experiencing higher degree of stress, whatever so be the reasons like rapid load growth, penetration of large generators, without associated transmission system in place, maximum utilization of transmission system oscillating around maximum permissible limits etc. The ability of power system to be stable depends on the operation states. The various probable states that may occur during any disturbance are normal, alert, emergency, extreme emergency and restorative. In the extreme emergency the effective control strategy is to resort for control system islanding. The blackouts and disturbances which were experienced in US and Italy in 2003 and in central Europe in 2006 have demonstrated the vulnerability of new grids. In this trade the ultimate challenge for the system operators and transmission system planners is to ensure the system reliability and security by aiming to prevent the total system blackout by implementing proper control action to limit the extent of disturbance. The bases of formation of island is to reduce in to a small grid, making load-generation balance, thereby facilitating the easy restoration process in making final integration of the whole system

In this article the various aspects are described under different sections. In section II, the research aspects in island formation discussed. In section III, the analytical basis to form island by making use of new proposed approach in modeling of the system is presented. In section IV, the study results along with the simulation results are provided. section V, presents the conclusion and Section VI, includes References.

SECTION II - Research Aspects in Vogue

2.1: Preamble

In the power system major blackouts were initiated by local disturbances that cascaded across the transmission network. Based on various studies and inferences, it is to understand that the power system contingencies comprises three stages, depending on the duration of fault persistence. Initial stage wherein the temporary system fault occur and cleared rapidly in mille seconds. Intermediate stage, where in the system separates in seconds and final stage where the load and generation imbalance in minutes causes a blackout. In power systems which are now operated critically resulting in growing risk for a local failure, to cascade into catastrophic blackout. At this inception of disturbance, relays located on faulty transmission lines, operate to clear the fault. Because of these outages, depending on the severity, it induces variations in electrical power outputs, with the generator mechanical inputs remaining almost constant. The resultant effect of this power imbalance is formation of groups of coherent generators operating at different speeds swinging one against the other, which leads to the loss of synchronism and the splitting of the network.

2.2 Various adopted Methodologies

However the islands so formed unintentional, may not have a balance of generation and load, which makes the failure to propagate further until a complete collapse of the system occurs. In order to prevent this, intentional controlled island schemes came in to the existence, based on many research contributions. The studies depicts that in the intentional islands, the power system is designed to deal with the situation and can survive, as this scenario has been planned. In unintentional island mode, there was no design and islanding occurs in unplanned fashion and hence the survival is doubtful. Controlled islands would occur, when the whole power system is divided into several islands, wherein the load generation should be in balance. The problem and the aim of research in this field is, where to form? When to form ? and how to form? The various approaches for island formations are

1. Controlled islanding approach based on the graph spectral method [1]
2. Slow coherency grouping of generators and determination of minimal cut sets [2], [3] by using DYNRED (Dynamic Reduction Program Software)
3. Graph theoretical approach called OBDD i.e., ordinary binary decision diagram [4], [5]

SECTION-III proposed new approach and modeling

3.1 Why is it needed?

With the increased size of the grid, the various approaches earlier presented based on main principle of grouping of various generators on slow coherency and determining the minimal cut sets taking into account the least generation load imbalance, doesn't ensure the choice of specific essential loads grouping. This is required to be addressed on top priority for ensuring supply atleast to metro's in the event of black out. Earlier the power plant capacities were of lower capacity and are distributed apart. Now with the increased available size of the unit, to the extent of around 800MW per each unit, the power plant capacity is increased. A light is thrown on the search of new methodology, were in the large power plant as source, the major computational burden involving grouping of generators with slow coherency could be avoided. In this paper, the issue is addressed in new dimension by grouping all the required essential loads like metro's, maintaining the generation load balance.

3.2 Modeling

AP power system is modeled with the 89 generators and 575 load buses. The transmission system is also modeled consisting of 400kv, 220kv and 130kv EHT lines making 1215 branches in the study. The basic power flow study is conducted for the maximum demand condition of 11946 MW. CYME international software is used for carrying over the power flow studies. The next steps involves the identification of specified loads and designing of the island with single large power plant. Here RTPS (Ramagundam thermal power station) is considered as the large single source with installed capacity of 2600MW. The power flows are obtained for all the loads grouped based on the I_{px}, which determines the inclusion of the loads in the proposed island schemes. The cut sets obtained for fixing the island boundaries are made use in bifurcation of the whole system. The resulting island consists of RTPS, metro's and other essential loads observing the generation load balance. The methodology adopted for island detection is, by providing of under frequency relays [6] on the determined cut set edges.

SECTION-IV Simulation Results

4.1 Scenario (1)

The table (1) and the power flow diagram(1) shows power flows of whole system intact. The total generation found required is 11946MW for meeting the demand of 11527MW. In this the RTPS was injecting 2074MW.With the automatic islanding initiation by the under frequency relays, the predetermined inter connecting lines are disconnected in facilitating for the formation of the required islanding.

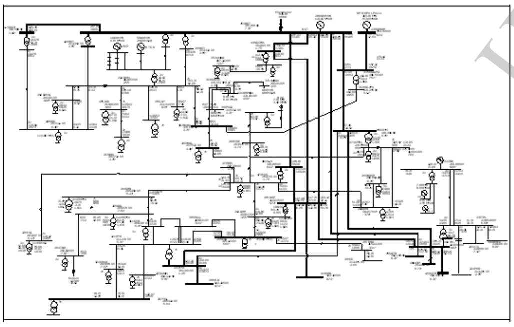

Figure 1. Power Flow Diagram of an Integrated System

Table 1. Modeled Integrated System Power Flow Results.

		---VOLTAGE---		----LOAD-	
NAME	ZN	KVOLT	DEGREE	MW	MVAR
403RST	21	404.012	1.2	0.00	0.00
-> 225RST	21	1M FX		205.12	-7.79
-> 225RST	21	2M FX		205.12	-7.79
-> 299RST	21	1M FX		198.37	105.25
-> 402GHP	15	3M		274.79	-42.86
-> 402GHP	15	4M		274.79	-42.86
-> 404TPL	23	1		209.18	-86.88
-> 404TPL	23	2		209.18	-86.88
-> 413DICH	18	1		255.92	-17.88
-> 420GAJWL	17	1		367.26	3.08
-> 435OGLAPU	20	1		158.99	-54.21
-> 491MLK	15	1		286.39	-33.13
->1131RST	21	1M FX		174.95	49.98
->1131RST	21	2M FX		174.95	49.98
->7001RST-G	70	1		0.00	0.00
->7002RST-CH	70	1		-921.00	-448.41
224RDM	21	216.451	-3.5	0.00	0.00
-> 225RST	21	1		-205.03	24.57
-> 225RST	21	2		-205.03	24.57
-> 265DRS	21	1		109.46	23.96
-> 265DRS	21	2		109.46	23.96
-> 280NML	19	1		156.03	12.79
-> 302RSTD	21	1		-116.62	-79.90
-> 308JGT	21	1		101.04	27.77
-> 312NAGA	20	1		-30.90	-42.31
-> 312NAGA	20	2		-30.90	-42.31
-> 356BLPL	19	1		44.15	-26.70
->1127RDM	21	1M FX		34.17	26.80
->1127RDM	21	2M FX		34.17	26.80
402GHP	15	400.427	-5.0	0.00	0.00
-> 210GHP	15	1M FX		183.78	21.95
-> 210GHP	15	2M FX		183.78	21.95
-> 210GHP	15	3M FX		183.78	21.95
-> 403RST	21	3		-272.03	-35.87
-> 403RST	21	4		-272.03	-35.87
-> 404TPL	23	1		-52.22	-58.64
-> 410KNL	13	1		72.23	-100.83
-> 411HYD	15	1		-107.32	-24.95
-> 420GAJWL	17	1M		-39.44	29.28
-> 491MLK	15	1M		119.47	60.82
205CHG	15	214.957	-10.7	0.00	0.00
-> 210GHP	15	1		-94.28	1.67
-> 210GHP	15	2		-94.28	1.67
-> 295DND	16	1		-41.12	0.49
-> 295DND	16	2		-41.12	0.49
- > 245GBL	15	1		123.27	10.75
-> 309HIAL	15	1		-10.70	-33.01
->1027CHG	15	1M FX		53.56	5.46
->1027CHG	15	2M FX		53.56	5.46
->1027CHG	15	3M FX		87.19	8.88
->1027CHG	15	4M FX		87.19	8.88
210GHP	15	215.923	-9.2	0.00	0.00
-> 205CHG	15	1M		94.78	-3.80
-> 205CHG	15	2M		94.78	-3.80
-> 272MLK	15	1		88.90	7.59
-> 272MLK	15	2		88.90	7.59
-> 402GHP	15	1 FX		-183.78	-8.38
-> 402GHP	15	2 FX		-183.78	-8.38
-> 402GHP	15	3 FX		-183.78	-8.38
->1042GHP	15	1M FX		50.71	4.84
->1042GHP	15	2M FX		50.71	4.84
->1042GHP	15	3M FX		82.55	7.87
226SHN	15	213.083	-11.7	0.00	0.00
-> 217KTS	22	1M		-118.17	-8.55
-> 245GBL	15	2		0.00	0.00
-> 245GBL	15	3		84.26	7.08
-> 245GBL	15	4		0.00	0.00
-> 272MLK	15	1		-168.57	-15.33
-> 272MLK	15	2		-168.57	-15.33
->1138SHN	15	1M FX		93.62	8.07
->1138SHN	15	2M FX		93.62	8.07
->1138SHN	15	3M FX		60.54	5.22

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259MLI    15 214.671 -10.5    0.00    0.00
   -> 272MLK   15 1       -110.62   1.45
   -> 272MLK   15 2       -110.62   1.45
   ->1089MLI   15 1M FX     51.98  -0.68
   ->1089MLI   15 2M FX     84.62  -1.11
   ->1089MLI   15 3M FX     84.62  -1.11
245GBL    15 212.095 -12.7    0.00    0.00
   -> 226SHN   15 1M      -122.87 -10.77
   -> 226SHN   15 2M         0.00   0.00
   -> 226SHN   15 3M       -83.99  -8.54
   -> 226SHN   15 4M         0.00   0.00
   -> 237YML   17 1M        69.74  19.68
   -> 294TND   15 1        125.74  43.02
   -> 311SVR   15 1        -78.37 -25.81
   -> 311SVR   15 2       -125.87 -37.07
   ->1189GBL   15 1M FX     46.59   4.21
   ->1189GBL   15 2M FX     46.59   4.21
   ->1189GBL   15 3M FX     46.59   4.21
   ->1189GBL   15 4M FX     75.85   6.86
272MLK    15 215.035 -10.0    0.00    0.00
   -> 210GHP   15 1M       -88.65  -8.80
   -> 210GHP   15 2M       -88.65  -8.80
   -> 226SHN   15 1M       169.60  17.90
   -> 226SHN   15 2M       169.60  17.90
   -> 259MLI   15 1M       110.82  -1.70
   -> 259MLI   15 2M       110.82  -1.70
   -> 283NRK   23 1        -85.49 -25.15
   -> 283NRK   23 2        -85.49 -25.15
   -> 284BHN   23 1        -56.65  -7.22
   -> 284BHN   23 2        -56.65  -7.22
   -> 288MDC   15 1        121.37  50.53
   -> 288MDC   15 2        121.37  50.53
   -> 491MLK   15 1   FX  -201.38 -40.45
   -> 491MLK   15 2   FX  -201.38 -40.45
   ->1474MLK   15 1M FX     60.77  29.79
291HYD    15 216.451 -10.5    0.00    0.00
   -> 205CHG   15 1M         0.00   0.00
   -> 309HIAL  15 1M       124.77  49.75
   -> 309HIAL  15 2M       109.89  44.04
   -> 311SVR   15 1        185.33  59.07
   -> 363SHAM  14 1        189.12  57.27
   -> 364SHAD  16 1        168.56  47.87
   -> 411HYD   15 1   FX  -259.22 -86.00
   -> 411HYD   15 2   FX  -259.22 -86.00
   -> 411HYD   15 3   FX  -259.22 -86.00
311SVR    15 214.183 -11.6    0.00    0.00
   -> 245GBL   15 1M        78.69  23.83
   -> 245GBL   15 2M       126.45  35.11
   -> 291HYD   15 1M      -184.52 -56.57
   -> 309HIAL  15 1       -214.62 -57.42
   ->1147SVRP  15 1M FX     64.67  18.35
   ->1147SVRP  15 2M FX     64.67  18.35
   ->1147SVRP  15 3M FX     64.67  18.35
241DIC1   18 212.019  -5.8    0.00    0.00
   -> 240DIC   18 1M       127.10  23.99
   -> 240DIC   18 2M       127.10  23.99
   -> 413DICH  18 1   FX  -127.10 -23.99
   -> 413DICH  18 2   FX  -127.10 -23.99
225RST    21 216.486  -3.4    0.00    0.00
   -> 224RDM   21 1M       205.12 -24.31
   -> 224RDM   21 2M       205.12 -24.31
   -> 403RST   21 1  FX  -205.12  24.31
   -> 403RST   21 2  FX  -205.12  24.31
309HIAL   15 216.098 -10.6    8.24    4.00
   -> 205CHG   15 1M        10.74  30.80
   -> 291HYD   15 1       -124.69 -49.70
   -> 291HYD   15 2       -109.82 -44.08
   -> 311SVR   15 1M       215.54  58.98
316GJWL   17 212.434  -8.4    0.00    0.00
   -> 288MDC   15 1M         0.00   0.00
   -> 289MIN   17 1        105.75  45.23
   -> 353KMRD  18 1M        82.45   2.26
   -> 420GAJWL 17 1  FX  -162.14 -43.20
   -> 420GAJWL 17 2  FX  -162.14 -43.20
   ->1243GAJWLN17 1M FX     68.04  19.46
   ->1243GAJWLN17 2M FX     68.04  19.46
224RDM    21 216.451  -3.5    0.00    0.00
   -> 225RST   21 1       -205.03  24.57
   -> 225RST   21 2       -205.03  24.57
   -> 265DRS   21 1        109.46  23.96
   -> 265DRS   21 2        109.46  23.96
   -> 280NML   19 1        156.03  12.79
   -> 302RSTD  21 1       -116.62 -79.90
   -> 308JGT   21 1        101.04  27.77
   -> 312NAGA  20 1        -30.90 -42.31
   -> 312NAGA  20 2        -30.90 -42.31
   -> 356BLPL  19 1         44.15 -26.70
   ->1127RDM   21 1M FX     34.17  26.80
   ->1127RDM   21 2M FX     34.17  26.80
265DRS    21 212.139  -6.2    0.00    0.00
   -> 224RDM   21 1M      -108.41 -25.17
   -> 224RDM   21 2M      -108.41 -25.17
   -> 268SDP   17 1         46.43 -16.51
   -> 268SDP   17 2         46.43 -16.51
   ->1078DRS   21 1M FX     41.32  27.79
   ->1078DRS   21 2M FX     41.32  27.79
   ->1078DRS   21 3M FX     41.32  27.79
268SDP    17 212.649  -7.8    0.00

   -> 265DRS   21 1M       -46.18   9.42
   -> 265DRS   21 2M       -46.18   9.42
   ->1136SDP   17 1M FX     46.18  -9.42
   ->1136SDP   17 2M FX     46.18  -9.42
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From the study, the elements of cut sets, which determines the formation of the proposed island are shown in the table no (2)

Table 2. Elements of Cut set

Sl. No	Form bus	To bus
1	403	435
2	403	404
3	408	411
4	409	411
5	291	368
6	291	363
7	245	237
8	245	294
9	226	217
10	272	284
11	272	283

4.2 Scenario (2)

The table (3) and the power flow diagram(2) shows power flows of the proposed new island. The total generation found required is 1976MW form RTPS power plant alone to meet the demand of 1934MW including 38 number of buses and 91 number of branches feeding the essential loads of metro's.

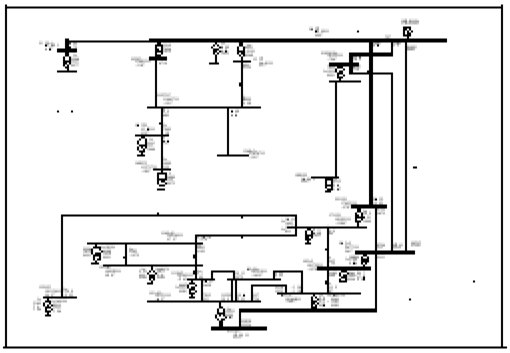

Figure 2. Power Flow Diagram of Designed Island to Feed Metros

Table 3. Modeled Island System Power Flow Results

NAME	ZN	---VOLTAGE--- KVOLT	DEGREE	-------LOAD---- MW	MVAR
Generation/Demand					1976.82
					1934.
402GHP	15	376.773	-9.6	0.00	0.00
-> 210GHP	15	1M	FX	198.90	27.08
-> 210GHP	15	2M	FX	198.90	27.08
-> 210GHP	15	3M	FX	198.90	27.08
-> 403RST	21	3		-407.37	-114.01
-> 403RST	21	4		-407.37	-114.01
-> 411HYD	15	1		450.89	152.23
-> 420GAJWL	17	1M		-280.12	-99.29
-> 491MLK	15	1M		47.26	5.11
403RST	21	400.000	0.0	0.00	
		1976.82	376.34	(SW.)	
-> 225RST	21	1M	FX	60.91	-41.42
-> 225RST	21	2M	FX	60.91	-41.42
-> 299RST	21	1M	FX	59.20	70.46
-> 402GHP	15	3M		414.53	88.84
-> 402GHP	15	4M		414.53	88.84
-> 413DICH	18	1		50.08	-69.78
-> 420GAJWL	17	1		439.84	92.47
-> 491MLK	15	1		416.81	90.04
->1131RST	21	1M	FX	30.00	-0.84
->1131RST	21	2M	FX	30.00	-0.84
420GAJWL	17	383.995	-7.1	0.00	0.00
-> 316GJWL	17	1M	FX	76.44	14.52
-> 316GJWL	17	2M	FX	76.44	14.52
-> 402GHP	15	1		281.47	77.10
-> 403RST	21	1M		-434.36	-106.15
491MLK	15	376.453	-9.8	0.00	0.00
-> 272MLK	15	1M	FX	228.39	65.41
-> 272MLK	15	2M	FX	228.39	65.41
-> 402GHP	15	1		-47.25	-16.74
-> 403RST	21	1M		-409.54	-114.09
316GJWL	17	208.083	-9.0	0.00	0.00
-> 288MDC	15	1M		152.88	23.83
-> 420GAJWL	17	1	FX	-76.44	-11.91
-> 420GAJWL	17	2	FX	-76.44	-11.91
288MDC	15	201.542	-14.5	0.00	0.00
-> 272MLK	15	1M		0.00	0.00
-> 272MLK	15	2M		0.00	0.00
-> 316GJWL	17	1		-150.00	-16.72
->1370MDC-1	15	1M	FX	41.35	4.61
->1370MDC-1	15	2M	FX	41.35	4.61
->1370MDC-1	15	3M	FX	67.31	7.50
265DRS	21	215.822	-3.2	0.00	0.00
-> 224RDM	21	1M		-70.04	2.18
-> 224RDM	21	2M		-70.04	2.18
-> 268SDP	17	1		20.04	-7.17
-> 268SDP	17	2		20.04	-7.17
->1078DRS	21	1M	FX	33.33	3.33
->1078DRS	21	2M	FX	33.33	3.33
->1078DRS	21	3M	FX	33.33	3.33
268SDP	17	215.717	-3.8	0.00	0.00
-> 265DRS	21	1M		-20.00	-1.29
-> 265DRS	21	2M		-20.00	-1.29
->1136SDP	17	1M	FX	20.00	1.29
->1136SDP	17	2M	FX	20.00	1.29
272MLK	15	202.093	-15.8	0.00	0.00
-> 210GHP	15	1M		-94.95	0.60
-> 210GHP	15	2M		-94.95	0.60
-> 226SHN	15	1M		182.72	8.22
-> 226SHN	15	2M		182.72	8.22
-> 259MLI	15	1M		110.23	16.05
-> 259MLI	15	2M		110.23	16.05
-> 288MDC	15	1		0.00	0.00
-> 288MDC	15	2		0.00	0.00
-> 491MLK	15	1	FX	-228.39	-40.11
-> 491MLK	15	2	FX	-228.39	-40.11
->1474MLK	15	1M	FX	60.77	30.48
288MDC	15	201.542	-14.5	0.00	0.00
-> 272MLK	15	1M		0.00	0.00
-> 272MLK	15	2M		0.00	0.00
-> 316GJWL	17	1		-150.00	-16.72
->1370MDC-1	15	1M	FX	41.35	4.61
->1370MDC-1	15	2M	FX	41.35	4.61
->1370MDC-1	15	3M	FX	67.31	7.50
299RST	21	216.825	-1.4	0.00	0.00
-> 302RSTD	21	1		59.19	67.10
-> 403RST	21	1	FX	-59.20	-67.10

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  309HIAL   15 202.930 -16.6     8.24     4.00

    -> 205CHG    15 1M        33.33    29.44
    -> 291HYD    15 1       -125.41   -30.81
    -> 291HYD    15 2       -110.49   -27.42
    -> 311SVR    15 1        194.33    24.79

  311SVR    15 201.642 -17.6     0.00     0.00

    -> 245GBL    15 1M        62.77     6.00
    -> 245GBL    15 2M       100.30     7.34
    -> 291HYD    15 1M      -169.53   -26.98
    -> 309HIAL   15 1M      -193.53   -23.47
    ->1147SVRP   15 1M FX     66.67    12.37
    ->1147SVRP   15 2M FX     66.67    12.37
    ->1147SVRP   15 3M FX     66.67    12.37
  241DIC1   18 214.884  -1.4     0.00     0.00
    -> 413DICH   18 1  FX    -25.00   -13.06
    -> 413DICH   18 2  FX    -25.00   -13.06
    ->1168DICH   21 1M FX     16.67     8.70
    ->1168DICH   21 2M FX     16.67     8.70
    ->1168DICH   21 3M FX     16.67     8.70
  259MLI    15 201.356 -16.4     0.00     0.00
    -> 272MLK    15 1       -110.00   -15.99
    -> 272MLK    15 2       -110.00   -15.99
    ->1089MLI    15 1M FX     51.69     7.51
    ->1089MLI    15 2M FX     84.15    12.23
    ->1089MLI    15 3M FX     84.15    12.23
1089MLI    15 120.643 -20.0   220.00   110.00
    -> 259MLI    15 1  FX    -51.69    -4.26
    -> 259MLI    15 2  FX    -84.15    -6.93
    -> 259MLI    15 3  FX    -84.15    -6.93
 1189GBL    15 119.746 -22.7   275.00   130.00
    -> 245GBL    15 1  FX    -59.42     7.47
    -> 245GBL    15 2  FX    -59.42     7.47
    -> 245GBL    15 3  FX    -59.42     7.47
    -> 245GBL    15 4  FX    -96.73    12.17
  226SHN    15 200.364 -18.0     0.00     0.00
    -> 245GBL    15 1         66.93   -21.05
    -> 245GBL    15 2          0.00     0.00
    -> 245GBL    15 3         45.84   -14.79
    -> 245GBL    15 4          0.00     0.00
    -> 272MLK    15 1       -181.38    -3.70
    -> 272MLK    15 2       -181.38    -3.70
    ->1138SHN    15 1M FX     94.46    16.34
    ->1138SHN    15 2M FX     94.46    16.34
    ->1138SHN    15 3M FX     61.08    10.56
291HYD    15 203.211 -16.4    0.00    0.00
    -> 205CHG    15 1M        42.27    27.56
    -> 309HIAL   15 1M       125.49    30.92
    -> 309HIAL   15 2M       110.56    27.45
    -> 311SVR    15 1        170.25    29.23
    -> 411HYD    15 1  FX   -149.53   -38.39
    -> 411HYD    15 2  FX   -149.53   -38.39
    -> 411HYD    15 3  FX   -149.53   -38.39
  316GJWL   17 208.083  -9.0     0.00     0.00
    -> 288MDC    15 1M       152.88    23.83
    -> 420GAJWL  17 1  FX    -76.44   -11.91
    -> 420GAJWL  17 2  FX    -76.44   -11.91
```


The validity of the adopted process in formation of island is compared with the real time SCADA data by modeling the same. The figure (3) shows the real time simulation snapshot of the proposed, utility modeled and implemented island scheme.

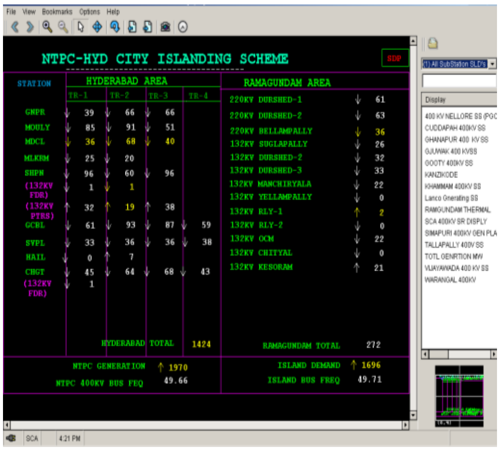

Figure 3. Simulated Islanding Scheme

SECTION-V

Conclusion:

The methodology proposed for providing an island of the required capacity to feed the metro's and other essential loads, which is the concern of the state grid is addressed by suitably modeling. The survival of this island, will help in extending the restorative support in integration of the whole state power system during the black out, as the extension of the startup power for generating plants during the restoration is a very critical and time consuming. This is the first largest island modeled and implemented in the entire southern region of the country. The simulation results demonstrates the validation of the model by comparing with the real time SCADA model for its performance operation.

SECTION-VI

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