Contemporary Engineering Sciences, Vol. 5, 2012, no. 9, 427 - 436

Industrial Experience on IT Based Modeling and Implementation of SPS in Andhra Pradesh State Utility

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Abstract

Power system protection brings schemes, desired to isolate faults in transmission network components. The size and complexity of power system grid makes electrical system vulnerable to wide spread cascade failures, leading to collapse under critical situations of multiple outages.

To detect and take preventive action for these conditions, a class of protective scheme known as SPS/remedial action schemes (RAS) are developed. This paper discusses the simulation challenges involved and solution implemented which is unique in real time large power network of AP System. The AP power system is modeled and new SPS is designed which is successfully implemented in reality.

Keywords: Special protection schemes, disturbance, outages, blackout, generation rejection scheme, contingency, remedial action plan

Introduction

Blackout prevention /mitigation and power system security, are the order of the day. Outages, congestion, generation-load balancing, monitoring of over loads and maintaining of grid parameters in safe limits are some of the key elements of successful power system operation.

Recent, wide-area electrical disturbances, have raised many questions, about the causes and cures for such occurrences and demonstrates the vulnerability of interconnected power system, When operated outside its intended permissible limits. The transmission sector mission especially is to develop technologies and policy option, that will contribute to, maintaining and enhancing the reliability, of state and central electrical power system network, in this new era of open access.

It is a fact that, the issues faced in many cases could not easily overcome. The Transmission owners are facing challenges, when new generators are added to the system, without transmission system strengthening. Deregulation, high cost building of new transmission infrastructure and time constraints, have placed the transmission owner under tremendous pressure, to maximize the existing assets utilization. The real time monitoring system parameters and availability of secured high speed telecommunication network provides, an opportunity for implementation of the automatic control scheme known as SPS/RAS designed, to detect the abnormal system conditions and take corrective action to maintain the system reliability.

Food for thought

1. Grid tripping occurred on 16-4-2009 at 220 kV chinakampally substation by blasting of CT in B Phase of LV ICT of 315mva, 400/220 kV, created Bus fault, resulting into tripping of all the generator units at RTPP (Rayalaseema Thermal Power Plant of 1050MW capacity) and other associated transmission lines.

2. Grid tripping occurred on 12-7-2008 on operation of the bus bar protection on both the buses of 220kV chinakampally substation, the simultaneously tripping of 220kV RTPP-chinakampally feeders 1 and 2 caused the outage of all the generators at RTPP with the loss of generation of the total RTPP power plant and other associated transmission lines.

The wide spread cascade failures, when the systems are highly loaded, due to the critical line outages, emphasized the need for analytically tractable models to understand and quantify the risks of failure, so that the network system can be designed and operated in safe mode during the contingencies, without propagation of failure into the large portion of the network.

Preamble

Determining the safe limits and designing of SPS for controlling of power system operation in protective fashion are challenging. According to Ander son (1996) SPS is defined as the protection scheme that is designed to detect a particular system condition that is known to cause, unusual stresses to power system and to take systematic and predetermined actions to counter act the abnormal condition that is known to cause instability by overloadings or voltage collapse. The action program may require, opening of one or more lines, tripping of generators, ramping of HVDC power transfer and instantaneous shedding of loads, which will alleviate the problem of concern.

In 1992 CIGRE and IEEE preformed a survey, about the installation of SPS among utilities. The interesting observations extracted are 1) the degree of complexity is rapidly increasing and solutions are more and more sophisticated in SPS implementation 2) all SPS installed are dedicated solutions for particular power systems. There are no schemes that could be applied to another power systems with minimal modifications. 3) all the installed SPS are either fully and major part designed and installed by the utilities. There is no company that would offer SPS to the utilities as complete solution ranging from data acquisition to the execution of control action.

What is New

First time in AP power sector, the generation rejection scheme (GRS) is modeled and implemented considering total AP power system consisting of 672 buses and 1228 lines, for RTPP power plant of 1050MW installed capacity. A method of strategic evaluation of limits of SPS i.e. when to arm the GRS is analyzed and first time documented such procedure. Here the system study is carried out on the total AP system network including of all the loads, generators and transmission lines, and contingency analyses carried out by making use of “CYME” international software and the limits, so derived are utilized for trigging of the GRS.

Formulation of SPS

The system studies are carried out including all the generating units at RTPP (Rayalaseema Thermal Power Plant) along with the associated transmission lines. The power flow results so obtained are tabulated in table-1

Table – 1

```
Global Summary Report
-----------------------------
      GENERATION/LOAD
        MW    MVAR
-----------------------------
 TOTAL   11354.24  -123.18
      10934.00  4842.00
CYMFLOW

 Bus Report
--------------------------------------------
        ---VOLTAGE---  -------LOAD----
#  NAME  ZN  KVOLT  DEGREE  MW    MVAR
--------------------------------------------

 256MDN   11 220.415 -12.2    0.00    0.00

   -> 206CNP   11 1M      248.27    9.42
   -> 206CNP   11 2M      248.27    9.42
   -> 257YGT   11 1       90.62  -13.90
   -> 257YGT   11 2       90.62  -13.90
   -> 258ATP   12 1       88.96  -15.26
   -> 258ATP   12 2       88.96  -15.26
   -> 384PULIVE11 1       47.16   -9.46
   -> 384PULIVE11 2       47.16   -9.46
   ->9030MDN   11 1  FX  -190.00   11.68
   ->9031MDN   11 1  FX  -190.00   11.68
   ->9032MDN   11 1  FX  -190.00   11.68
   ->9033MDN   11 1  FX  -190.00   11.68
   ->9034MDN   11 1  FX  -190.00   11.68

 384PULIVE11 220.174 -12.9             0.00        0.00

   -> 256MDN   11 1M      -47.04    1.91
   -> 256MDN   11 2M      -47.04    1.91
   ->1504PULIV111 1M FX    47.04   -1.91
   ->1504PULIV111 2M FX    47.04   -1.91

 244HDP   12 212.958 -21.6             0.00        0.00

   -> 238GTN   12 1M      -82.21  -28.64
   -> 263RMG   12 1       -89.11  -20.96
   ->1051HDP   12 1M FX    57.11   16.53
   ->1051HDP   12 2M FX    57.11   16.53
   ->1051HDP   12 3M FX    57.11   16.53
```

Table - 2

```
Global Summary Report
 -------------------------------------
           GENERATION/LOAD
             MW     MVAR       MW
 -------------------------------------
  TOTAL   11411.93   317.59     0.00
          10934.00  4842.00
 Bus Report
 -------------------------------------
              ---VOLTAGE---   ----LOAD----
 #   NAME  ZN  KVOLT  DEGREE   MW     MVAR
 ------------------------------------------

  256MDN   11 220.275  15.5    0.00    0.00

     -> 206CNP   11 1M        0.00    0.00
     -> 206CNP   11 2M        0.00    0.00
     -> 257YGT   11 1        90.62  -14.68
     -> 257YGT   11 2        90.62  -14.68
     -> 258ATP   12 1       337.22    0.53
     -> 258ATP   12 2       337.22    0.53
     -> 384PULIVE11 1        47.16   -9.96
     -> 384PULIVE11 2        47.16   -9.96
     ->9030MDN   11 1  FX  -190.00    9.65
     ->9031MDN   11 1  FX  -190.00    9.65
     ->9032MDN   11 1  FX  -190.00    9.65
     ->9033MDN   11 1  FX  -190.00    9.65
     ->9034MDN   11 1  FX  -190.00    9.65

  384PULIVE11 220.061  14.8   0.00    0.00

     -> 256MDN   11 1M      -47.04    2.42
     -> 256MDN   11 2M      -47.04    2.42
     ->1504PULIV111 1M FX    47.04   -2.42
     ->1504PULIV111 2M FX    47.04   -2.42

  244HDP   12 211.774  -9.8   0.00    0.00

     -> 238GTN   12 1M      -21.70  -43.63
     -> 263RMG   12 1      -149.62    9.80
     ->1051HDP   12 1M FX    57.11   11.28
     ->1051HDP   12 2M FX    57.11   11.28
  ->1051HDP  12 3M FX  57.11  11.28
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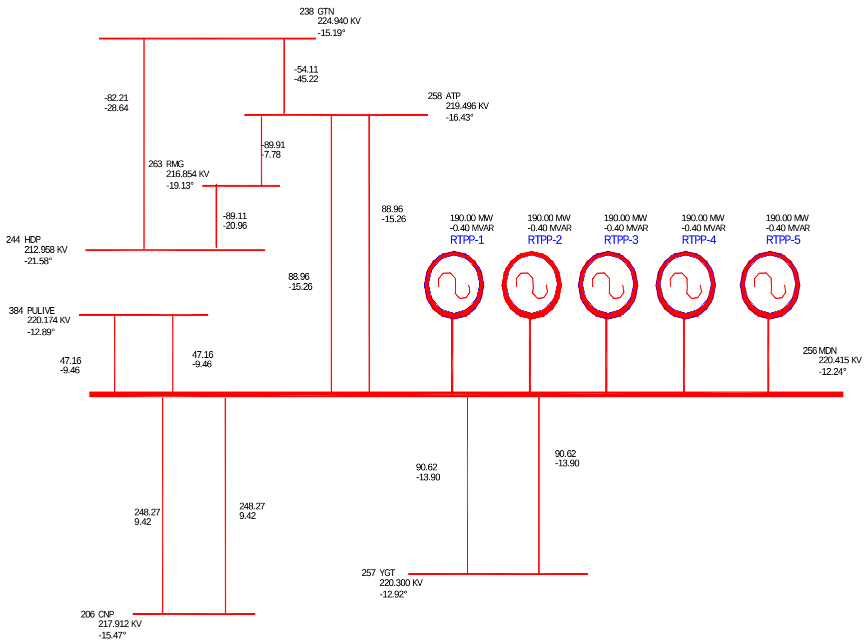


Figure 1: Load flow diagram for RTPP evacuation

With the simultaneous outage of two lines from the RTPP to chinakampally the power flows are computed for assessing the criticality and identifying the critical lines. The study results are tabulated Table-2.

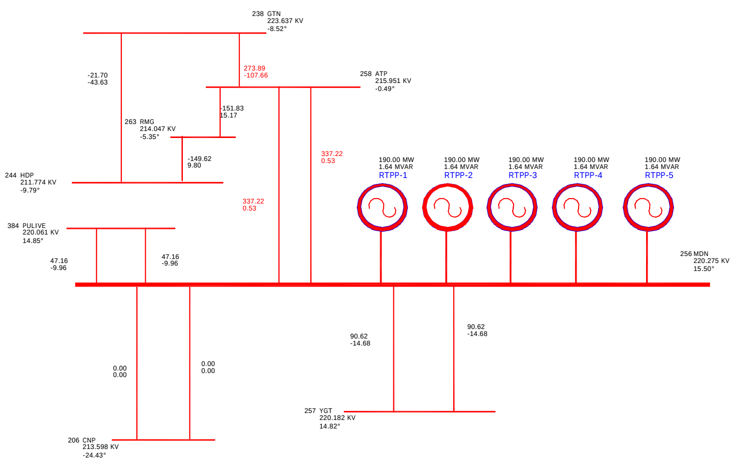


Figure 2: Load flow diagram for RTPP evacuation with the outage of 220kV DC Line-220kV RTPP-Chinakampally

With the simultaneous outage of two lines from the RTPP to chinakampally and with one unit generation rejection the power flows are computed for assessing the criticality and identifying the critical lines.The study results are tabulated Table -3.

Table-3

CYMFLOW

Global Summary Report

	GENERATION/LOAD MW	MVAR
TOTAL	11393.93	236.48
	10934.00	4842.00

Bus Report

# NAME	ZN	KVOLT	DEGREE	MW	MVAR
		---VOLTAGE---		----LOAD----	
256MDN	11	220.755	4.0	0.00	0.00
-> 206CNP	11	1M		0.00	0.00
-> 206CNP	11	2M		0.00	0.00
-> 257YGT	11	1		90.62	-11.98
-> 257YGT	11	2		90.62	-11.98
-> 258ATP	12	1		242.23	-13.06
-> 258ATP	12	2		242.23	-13.06
-> 384PULIVE	11	1		47.16	-8.24
-> 384PULIVE	11	2		47.16	-8.24
->9030MDN	**11**	**1**	**FX**	**-190.00**	**16.64**
->9031MDN	**11**	**1**	**FX**	**-190.00**	**16.64**
->9032MDN	**11**	**1**	**FX**	**-190.00**	**16.64**
->9033MDN	**11**	**1**	**FX**	**-190.00**	**16.64**
->9034MDN	**11**	**1**	**FX**	**0.00**	**0.00**
244HDP	12	212.495	-15.0	0.00	0.00
-> 238GTN	12	1M		-44.05	-39.15
-> 263RMG	12	1		-127.27	-4.27
->1051HDP	12	1M	FX	57.11	14.47
->1051HDP	12	2M	FX	57.11	14.47
->1051HDP	12	3M	FX	57.11	14.47
384PULIVE	11	220.450	3.4	0.00	0.00
-> 256MDN	11	1M		-47.04	0.66
-> 256MDN	11	2M		-47.04	0.66
->1504PULIV1	11	1M	FX	47.04	-0.66
->1504PULIV1	11	2M	FX	47.04	-0.66

Table - 4

CYMFLOW

Global Summary Report

	GENERATION/LOAD MW	MVAR
TOTAL	11388.90	236.42
	10934.00	4842.00

Bus Report

# NAME	ZN	KVOLT	DEGREE	MW	MVAR
		---VOLTAGE---		----LOAD----	
256MDN	11	221.100	-7.6	0.00	0.00
-> 206CNP	11	1M		0.00	0.00
-> 206CNP	11	2M0.00			0.00
-> 257YGT	11	1		90.61	-10.03
-> 257YGT	11	2		90.61	-10.03
-> 258ATP	12	1		147.23	-15.53
-> 258ATP	12	2		147.23	-15.53
-> 384PULIVE	11	1		47.16	-6.99
-> 384PULIVE	11	2		47.16	-6.99
->9030MDN	**11**	**1**	**FX**	**-190.00**	**21.70**
->9031MDN	**11**	**1**	**FX**	**-190.00**	**21.70**
->9032MDN	**11**	**1**	**FX**	**-190.00**	**21.70**
384PULIVE	11	220.730	-8.3	0.00	0.00
-> 256MDN	11	1M		-47.04	-0.62
-> 256MDN	11	2M		-47.04	-0.62
->1504PULIV1	11	1M	FX	47.04	0.62
->1504PULIV1	11	2M	FX	47.04	0.62
244HDP	12	212.889	-20.6	0.00	0.00
-> 238GTN	12	1M		-67.36	-32.85
-> 263RMG	12	1		-103.97	-15.82
->1051HDP	12	1M	FX	57.11	16.22
->1051HDP	12	2M	FX	57.11	16.22
-> 1051HDP	12	3M	FX	57.11	16.22

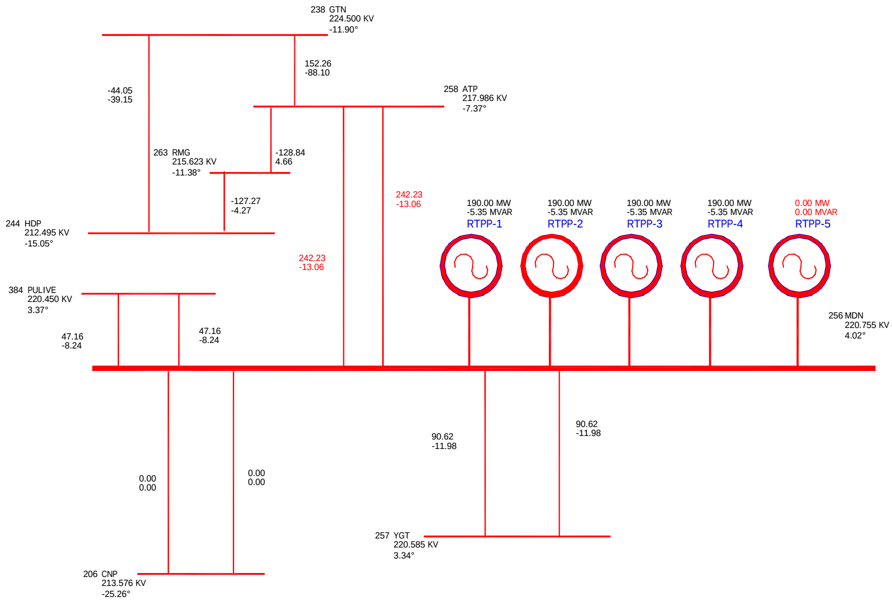


Figure 3: Load flow diagram for RTPP evacuation with the outage of 220kV DC Line-220kV RTPP-Chinakampally and with one generator unit outage.

With the simultaneous outage of two lines from the RTPP to chinakampally and with two units generation rejection, the power flows are computed for assessing the criticality and identifying the critical lines. The study results are tabulated Table-4.

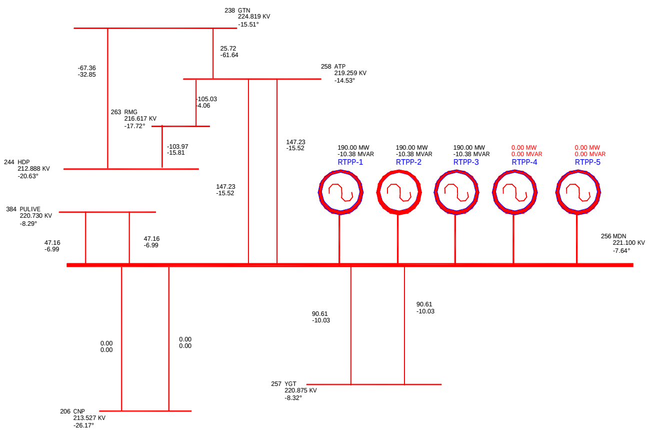


Figure 4: Load flow diagram for RTPP evacuation, with the outage of 220kV DC Line-220 kv RTPP-Chinakampally and with two generator units outage.

Based on the above study results the arming limits of GRS are determined.

Solution planning and development

From the system study and contingency analysis it can be inferred that,

1. The critical line loadings are observed on 220kV RTPP-ananthapur DC-line during the outage of 220kV RTPP chinakampally DC line which is found to be the root cause for the creation of disturbance.
2. Scheme arming should be on contingency condition.

Scenario 1

Remedial action plan is designed in such a way that whenever the power flow on 220 kV RTPP Ananthapur lines excides 275MW, with the precondition of outage of, 220kV DC lines of RTPP chinakampally, the GRS should trigger to trip two units simultaneously. With this, based on the study result it is observed that the power flow was around 150MW on each of the line bringing the system to secure state from the emergency state.

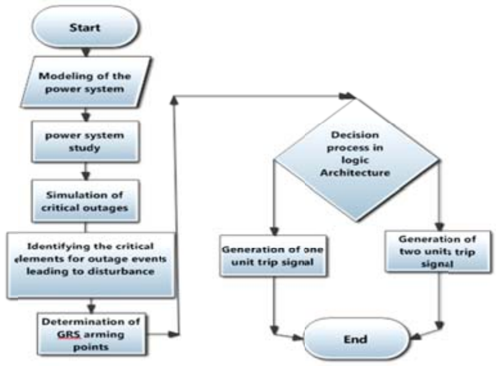
Scenario 2

Whenever the generation at RTPP was not to its full capacity, the simultaneous triggering of the two units is not required as it leads to further loss of generation. Hence the GRS should be armed, such that it will trigger only one unit, whenever the power flow on the 220kV RTPP Ananthapur is greater than 225MW.

Thus with this determined arming limits of GRS, the system operation can be carried out in real time system even during the contingencies without initiation of disturbance so that the system will be in secured state.

Implementation solution

Once the application planning aspects of SPS have been defined, next comes the design of logic development and implementation

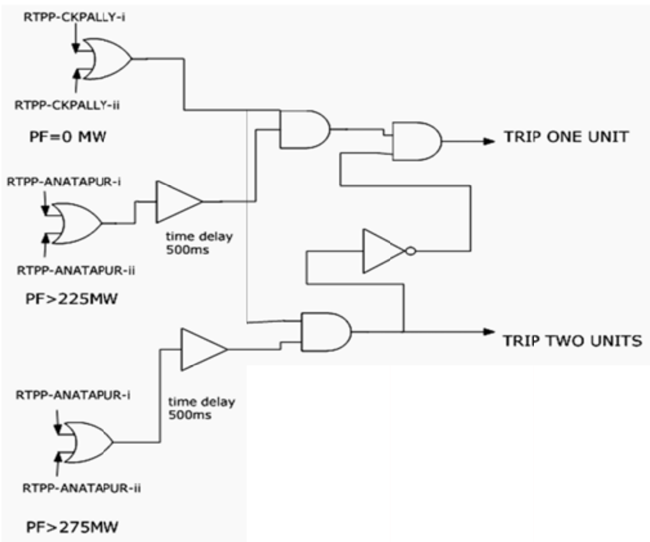


Action flow chart

GRS is designed to trip the preselected generating unit, at power plant, in order to prevent the blackout of entire power plant

Logic development

The signal from the breaker contacts status, power flow on 220kV RTPP to chinakampally DC line and 220kV RTTP to Ananthapur DC line are feed as input to the logic circuit device. Based on the line outage detection and generation rejection arming limits the appropriate signals will be generated and sent as output signal to take appropriate action of triggering either one or two units, in real time system operation, avoiding the blackout of the total power plant by simultaneous tripping all the units.



Logic architecture-special protection scheme of GRS

Conclusion

This paper has presented, the generic procedure developed, modeled and implemented for the first time of its kind in state utility. SPS known as remedial action scheme is a major technological advancement that aids the grid security, by preventing the major blackouts of total power plants, in the event of critical line outages, by arming GRS, based on preset SPS arming points, evaluated in contingencies of two different scenario's. This sort of protection schemes are now a day's playing vital role and found very essential especially when generation expansions are coming up at faster rate than the associated transmission system, to maximize the utilization of the available and existing network in safe and secured manner.

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Received: August, 2012