SPS Protection in Large Thermal Power Station

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Abstract— System Protection Schemes (SPS) are widely accepted as an effective tool for increasing the utilization of power networks by enhancing the resilience of the power system towards rare contingencies. These schemes are considered as 2nd generation protection philosophy after the unit protection philosophy. In the last few years several SPS have been designs and implemented successfully in the Indian Power System. These paper discuss the need for SPS in TATA Mundra Power Plant outgoing line which further connected to western grid. In this paper details analysis of different SPS schemes on different condition and Fast load cut off analysis in Thermal Power Plant. Outage of such higher capacity elements is not totally avoidable and endangers the normal operation of the power system and may lead to a blackout if automatic fast suitable corrective action is not taken with the increased complexity of the power system and reduced margin, Special Protection Schemes(SPS) are to be designs and implemented to combat such eventuality.

Key words: System Schemes, Safety net, Fast Load Cut Off

I. INTRODUCTION

Mitigation and power system security are the order of the day. Managing congestion, balancing load and on line generation , maintaining spinning reserve capacity margins and managing reactive power support through reliable real-time data are some of the key elements of successful power system operation.

Recent newsworthy wide-area electrical disturbances have raised many questions about the causes and cures for such occurrences and have demonstrated the vulnerability of the interconnected power system when operated outside its intended design limits. The exposure of the power system to wide area collapse has increased in recent year as the system has been pushed to its operating limits-often resulting in violation of operating policies and planning standards.

Electric reliability and efficiency are affected by four segments of the electricity valve chain; generation, transmission, distribution and end use. Satisfactory system performance requires investments in all these segments of the system. Increasing supply without improving transmission and distribution infrastructure for example may actually lead to more serious reliabilities.

The Transmission Reliability Program is developing advanced technologies, including information technologies, software programs and reliability/analysis tools, to support grid reliability and efficient markets during this critical transition.

There are often many issues to address reliable system operation; however the primary issue is typically the heavily power losses. This overloading is often at the root of system instability problems. The understanding of this issue is not lost on legislators and regulatory bodies who have expressed their concerns about potential blackout scenarios. Reactive power flow analysis, including mitigation of voltage instability should become an integral part of planning and operation studies.

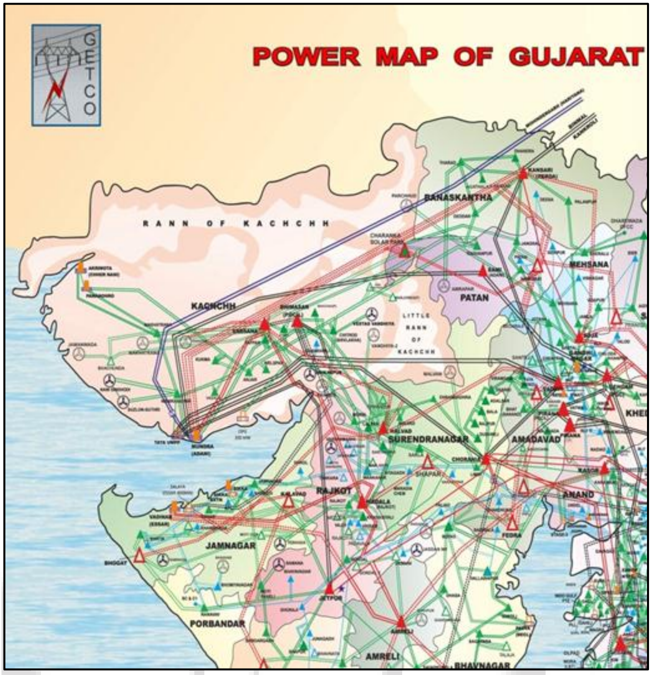

Fig. 1: Power Map

II. NEED FOR SYSTEM PROTECTION SCHEME IN LARGE THERMAL POWER PLANT

Mundra Power Plant have six transmission line that are connected to western grid .Each line have their rated power transmission capacity in terms of loading.

This large thermal power plant has five generators that connected with 400KV switchyard with setup transformer (26KV/400KV) that further connected with 400KV transmission line.

Total power flow on transmission line has been 3800MW when all unit in service. TATA Mundra power plant have six transmission line with different load capacity so that each line has constraint to limit their maximum power transfer and also substation equipment’s have their maximum operating limit.

Following are some of the reasons why a special scheme is required in power system:

1) The standard protection schemes available are rightly designed to protect men and the individual elements from damage. Sometimes such operations may results in widespread disturbance. To reduce the impact of power failure and ensure early restoration, protection schemes are required to sense the danger in the system and take corrective action.
2) The cyclic nature of generation and loads causes overloading to be seasonal and transmission lines get over loaded during some seasons. This may not justify putting new lines.

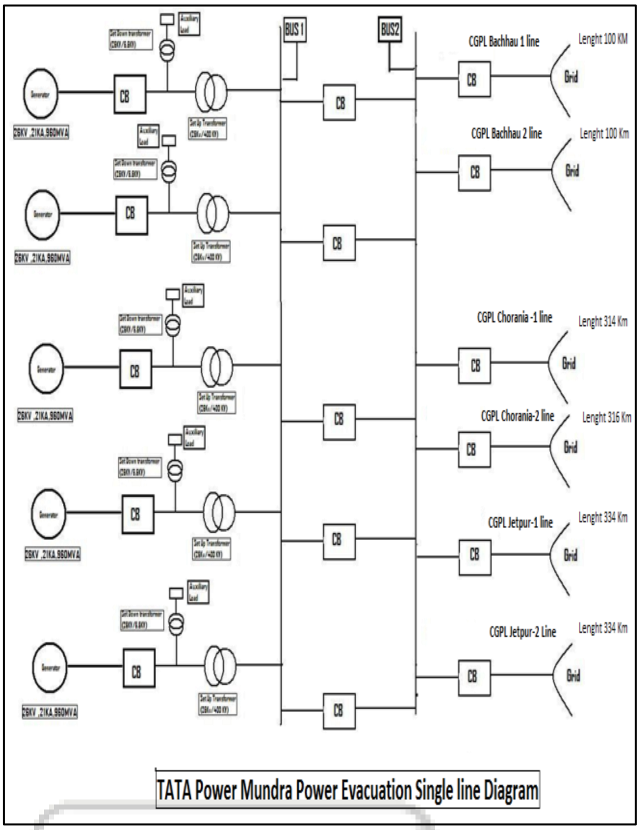

Fig. 2: Total power flow on transmission

III. EFFECT OF LINE CONGESTION

Congestion, as used in deregulation parlance, generally refers to a transmission line hitting its limit. The ability of interconnected transmission networks to reliably transfer electric power may be limited by the physical and electrical characteristics of the systems including any or more of the following:

A. Thermal Limits:

Thermal limits establish the maximum amount of electrical current that a transmission line or electrical facility can conduct over a specified time period before it sustains permanent damage by overheating.

B. Voltage Limits:

System voltages and changes in voltages must be maintained within the range of acceptable minimum and maximum limits. The lower voltage limits determine the maximum amount of electric power that can be transferred.

C. Stability Limits:

The transmission network must be capable of surviving disturbances through the transient and dynamic time periods (from milliseconds to several minutes, respectively). Immediately following a system disturbance, generators begin to oscillate relative to each other, causing fluctuations in system frequency, line loadings, and system voltages. For the system to be stable, the oscillations must diminish as the electric system attains a new stable operating point. The line loadings prior to the disturbance should be at such a level that its tripping does not cause system-wide dynamic instability.

The limiting condition on some portions of the transmission network can shift among thermal, voltage, and stability limits as the network operating conditions change over time. For example, for a short line, the line loading limit is dominated by its thermal limit. On the other hand, for a long line, stability limit is the main concern. Such differing criteria further lead to complexities while determining transfer capability limits.

D. Transmission line Transient Overvoltage:

The establishment of potential difference between the conductors of an overhead transmission line is accompanied by the production of an electrostatic flux, whilst the flow of current along the conductor results in the creation of a magnetic field. The electrostatic filed are due, in effect, to series of shut capacitors whilst the inductances are in series with the line.

The gradual establishment of the line voltage can be regarded as due to a voltage wave travelling from the generator toward the far end and the progressing charging of the line capacitance will account for the associated current wave.

Eventually the field gradient reaches an intensity sufficient to initiate a leader stroke or dart, which starts toward ground. The progress of this dart is not continues, but by jerks, each jerk depending upon the supply of additional charge to the head of the dart .As the dart approaches earth, the field gradient at the transmission line increases and this causes a migration of charge up through the towers onto the ground wire, and from the remote parts on the line conductors toward the region of filed concentration. The dart finally makes contact say with the ground wire at the tower inducing waves on the line conductors. But when these waves reach the next tower, reflection occur and very soon all the neighboring spans are filled by numerous wave reflecting back and forth, and perhaps flashovers have taken place to the line conductors .These wave are rushing with the speed of light toward the power station, where they may enter the windings of transformers and generators, causing and oscillations which may develop destructive voltages on the major insulation to ground.

IV. SPS PROTECTION SCHEME

Maximum export from TATA Mundra Plant with all five units at full load is 3800.This load is exported procurers via 6 numbers of PGCIL lines;

- 400kV CGPL-Bachhau 1 ---100km
- 400kV CGPL-Bachhau 2---100km
- 400kV CGPL-Chorania-1--314km
- 400kV CGPL-Chorania-2--316km
- 400kV CGPL-Jetpur 1--- 334km
- 400kV CGPL-Jetpur 2--- 334km

Due to any line tripping, the generated load gets distributed through balance 5 transmission lines. If more than 1 line trips, then there is instability in network, as balance lines are not capable to carry full export.

A. SPS Protection:

Protections scheme are devised to counter such situations when total export exceed 3300MW. The scheme implemented is as follows;

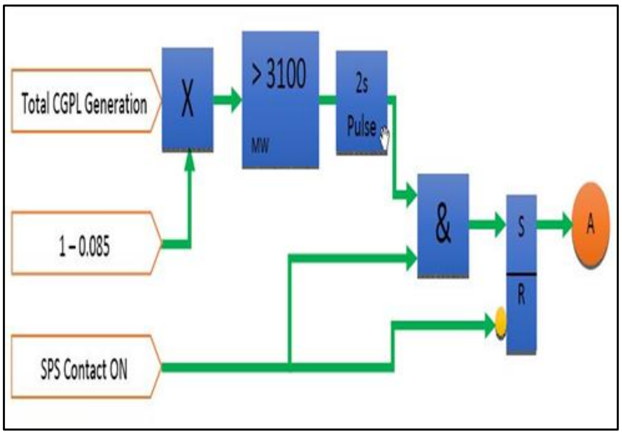

Fig. 3: SPS

1) SPS-1: If export is more than 3300MW and one circuit of CGPL-Bachhau trip then runback activated in two selected unit and load bring down to 800MW(400 MW each).
2) SPS-2: Is export is more than 3300MW and if CGPL chorania 1 or CGPL chorania 2 or CGPL jetpur 1 or CGPL jetpur 2 trip then runback activate in two selected unit and load bring down to 500MW (250MW each)
3) If any two line trip out of six then trip one selected unit immediately.
4) SPS-3: If Bina-Gawalior line trip then 180MW Run down of Total station load (all five running unit reduced 36 MW each).

If Grid frequency is greater then 51.5Hz for more than 30sec then unit 40 trip immediately (800MW back down).

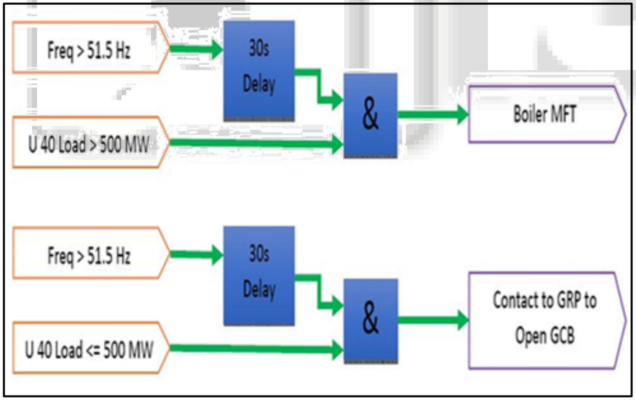

Fig. 4: Grid frequency

V. SPS PROTECTION CASE STUDY FOR TATA POWER MUNDRA

In case study of SPS schemes, an incident data are used for analysis the protection system. In Tata Power Mundra for generating the mechanical input are taken as steam so that in the case of grid disturbance mechanical input change accordingly to maintain the system stable.

For case study SPS-2 protection are taken in which if one line trip out of six then two selected unit ramp down 800MW(400 MW each). For analysis the mechanical system response for SPS, logics are implemented in the system. Logics are as follow:

1) In Coal firing system total number of mills is six in which five mills in service with high GCV coal. At the time of SPS act two upper mill and one lower mill trip directly (If five mill in operation then one upper mill and one lower mill trip directly).
2) Boiler master ramp down from full load condition (85%) to 38% to maintain the load 400MW. Air flow and feed water flow adjust accordingly with coal flow rate.

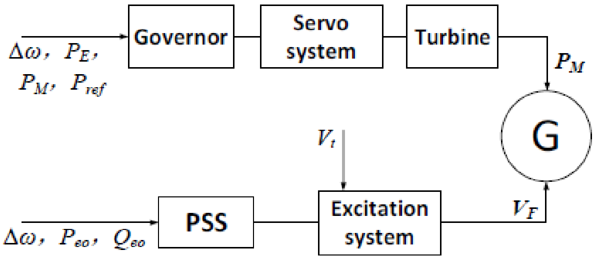

Fig. 5: SPS schemes

A. *Generator MW Ramp Down:*

At TATA power Mundra all unit are running at full load 835MW at time of SPS act when one line trip out of six then two selected unit ramp down from full load to 400MW as shown Graph. Other running units are maintaining their full load without any disturbance.

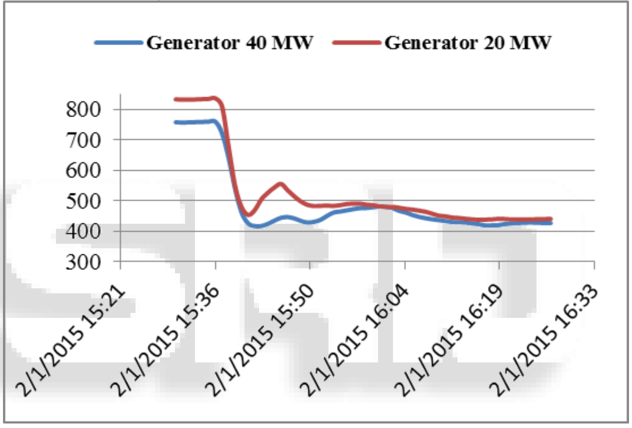

Fig. 6: MW Ramp down with time.

B. *Boiler Master Ramp down:*

At time of SPS act steam input reduced by reducing the coal firing so that boiler master ramp down from full load condition to 38% to maintain the 400MW of selected unit .

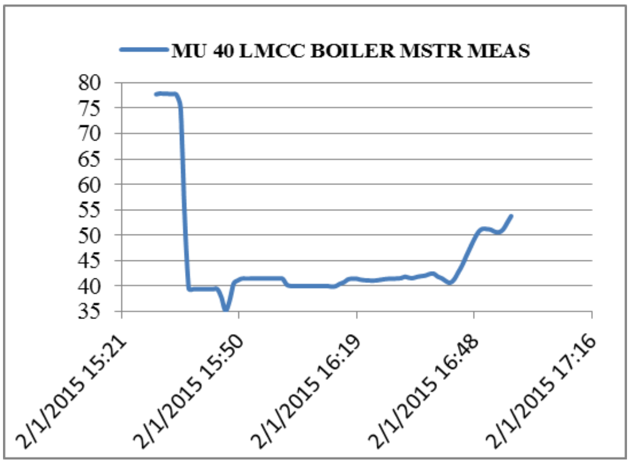

Fig. 7: Boiler master ramp down with time.

C. *Total Export Power:*

At TATA Power Mundra total export power is 3800MW when all unit running at full load .SPS act when load greater than 3100 MW and any one line trip out of six.

Selected unit ramp down 800MW (400 MW each unit) and total export power should reduce below 3100 MW to prevent the line congestion.

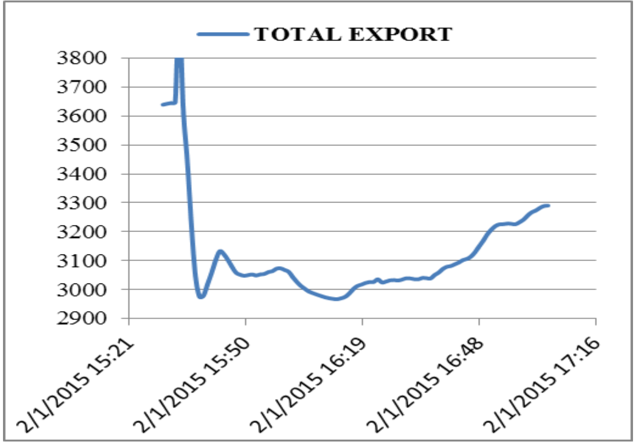

Fig: 8: Total Export power with time.

D. Export of Trip line MW Deviation:

In TATA mundra case study, Limdi-1 line trip of phase to phase short protection and circuit breaker at both end open.MW flow from this line reduced to zero due to this other parallel line are overloaded and for prevention this line congestion SPS act and reduced the total export power to desirable limit below 3100MW .As per graph that taken data from line loading shown that line loading reduced from 600 MW to zero within short duration. After detected the fault corrective action taken and line charge again.

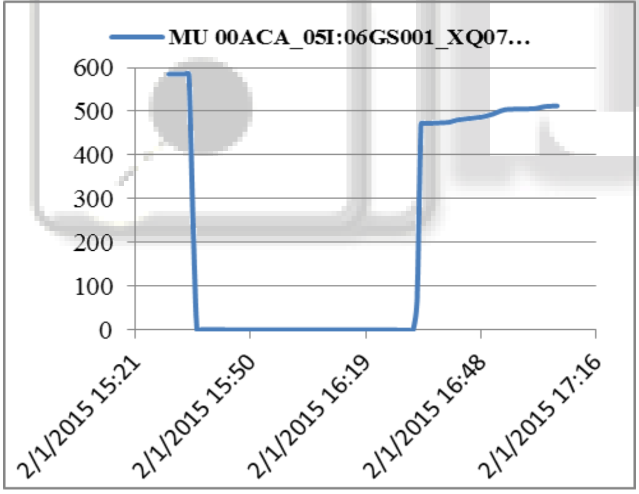

Fig. 9: Export MW Deviation with time.

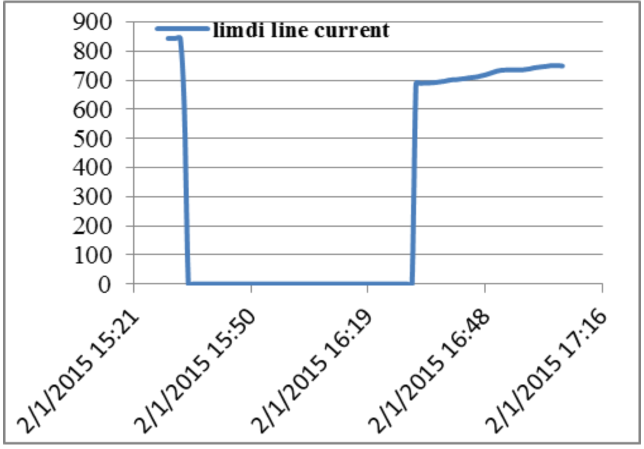

Fig. 10: Export current Deviation with time

E. Frequency Flucation.:

Generator having the rated capacity of 26KV termianl voltage and 21KA generator current.At the time of SPS act sudden load through off due to this generators begin to oscillate relative to each other,causing fluctuations in system frequency .For the system toe be stable, the oscillations must diminish as the electric system attains a new stable operating condition.

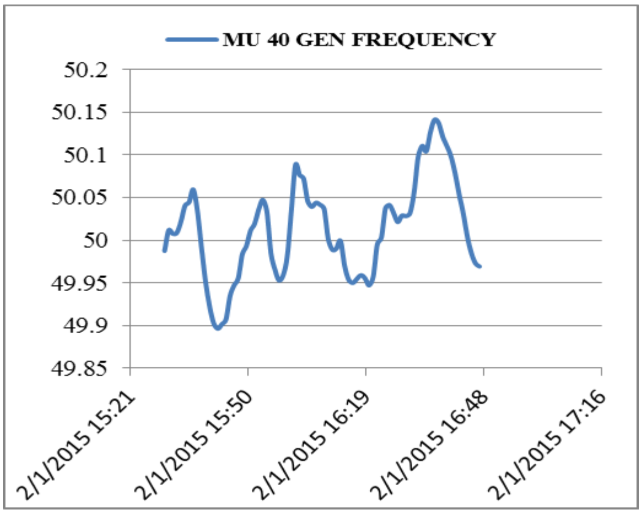

Fig. 11: Generator Frequency Deviation with time.

VI. CONCLUSIONS

In a large interconnected system the risks and stakes are very high. It is difficult to plan and secure the system for all contingencies that are experienced in real time. The operational experience with the System Protection Schemes has been encouraging as they have been found to be effective in mitigating the security threats to a large extent. However SPS should not be conceived as a substitute for adequacy in transmission

Unit protection system is generally considered as first generation protection philosophy and the SPS are 2nd generation protection system. The SPS try to automate what otherwise would have been implemented through a series of manual operator actions. It assists in maintaining system stability by cutting down on the time taken between a contingency and corrective actions. Thus the total operating time of the SPS is of vital importance. Suitable care must therefore be taken to avoid undesirable delays in SPS operation. The reduction in SPS operation time would enhance the stability of the system and facilitate larger power transfer.

The miss operations in SPS need to be minimized to sustain the stakeholders' faith and confidence on the SPS. The inadequacy of high speed dedicated communication network is emerging to the biggest infrastructural bottleneck during execution of the SPS. Attention is also required for creating in capacity building for simulation of SPS logic and its impact on the system.

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