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A Near Miss: 200911281326

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Abstract

On 28th November, 2009, at 13:26 Hrs 400 kV Bina-Gwalior S/C carrying around 1000 MW tripped on R-phase fault. This led to subsequent cascade tripping of other parallel lines in the corridor causing a step jump in the quantum of power being wheeled from WR to NR through ER. Such step jump resulted in heavy line loadings and a sharp dip in system voltages. The system could however survive on account of well meshed transmission network, support from generators and quick operator action.

Keywords: Contingency, Transfer Capability, Reliability

1. Backdrop

Maintaining reliability and integrity of the system is of prime importance to any power system engineer. The system parameters like voltage and power-flow should be within their specified limits under all the conditions. Transfer capability between two areas indicates the maximum power-flow that can take place between the two areas without violation of any system parameter even after a credible (n-1) contingency.

In India the transfer capability is declared by each Regional Load Despatch Centre (RLDC) three months in advance, so that the anticipated margin left in transmission corridors after long term and medium term allocation can be commercially utilized for other power transactions. The value of transfer capability declared is arrived at by considering the credible contingency in the anticipated scenario. Operating the system at a level beyond the transfer capability limit might be similar to compromising on the security and reliability of the system which has also been corroborated by the operational experience.

2. Antecedent Conditions

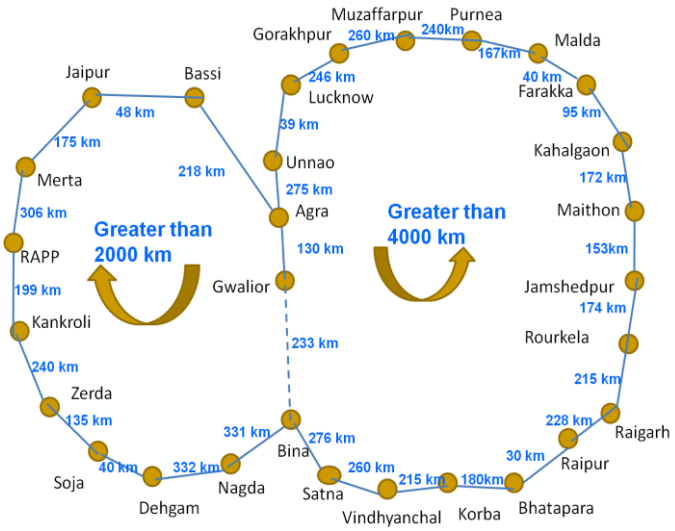
System frequency of NEW grid was 50.16 Hz and all the system parameters were within their limit. Northern Region was drawing 4200 MW against a transfer capability of 4250 MW. However the power-flow on WR-NR corridor was 2045 MW against a transfer capability of 1500 MW. The load generation balance in the country was as follows:

Region	Demand Met (MW)	Generation (MW)
NR	22518	19518
WR	24424	26033
ER	8139	9794
NER	841	666
SR	23036	23018

3. The Event

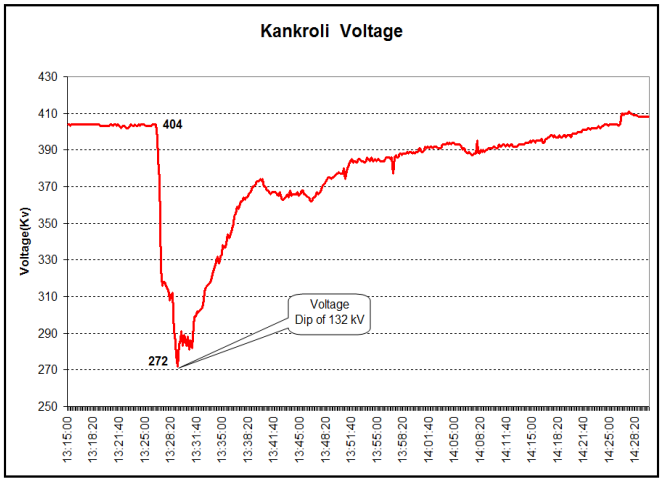
At 13:26 hrs on 28/11/09, 400 kV Bina-Gwalior-S/C tripped on R-phase to earth fault, 2 km from Bina. As a result, cascade tripping of other 220 kV parallel lines emanating from Badod and Gwalior took place.

Consequently power-flow in the grid took place via a much longer route, which is evident from the following figure:



In ER 400 kV Kahalgaon-Patna-I tripped on sensing 3-Phase fault in Zone-II at Kahalgaon. However, no carrier inter-trip was received at Patna end and the line remained closed at Patna end. 400 kV Kahalgaon-Biharshariff-II tripped on overload as reported by Kahalgaon. No carrier inter-trip was received at Biharshariff end and the line breaker remained closed at Biharshariff end. Both the above events further worsened the scenario.

The severity of the situation is epitomized by voltage at Kankroli substation falling from 404 kV to 272 kV i.e a dip of 132 kV.



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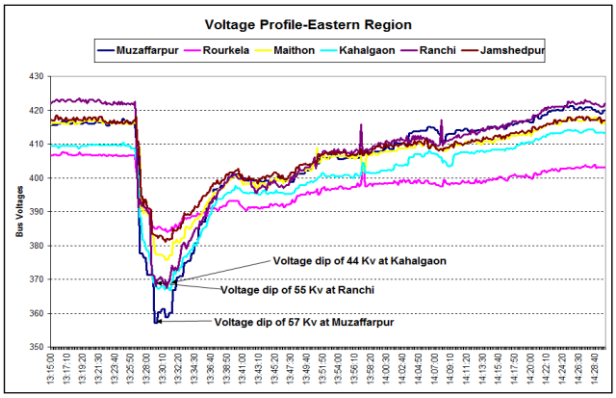
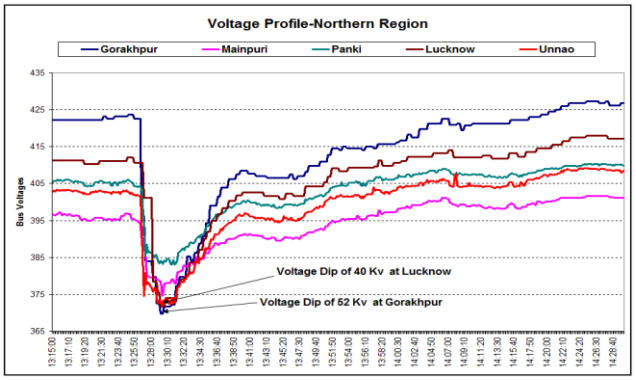
4. Voltage Variation

A steep and severe dip in system voltages was observed at different nodes throughout the country, after the contingency.

In ER fall in voltage took place at Kahalgaon, Patna, Biharshariff, Maithon, Muzzaffarpur and Ranchi. Voltages at Biharshariff and Muzzaffarpur touched 350 kV and 357 kV respectively.

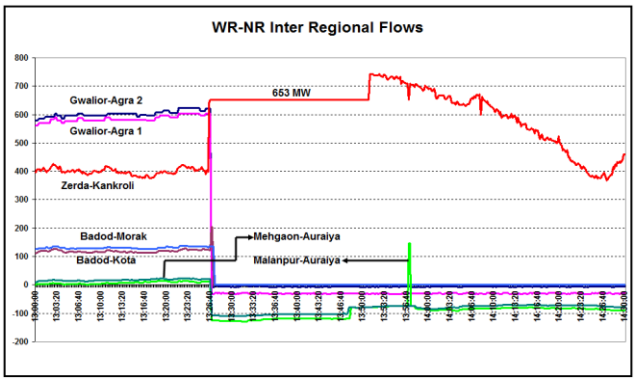


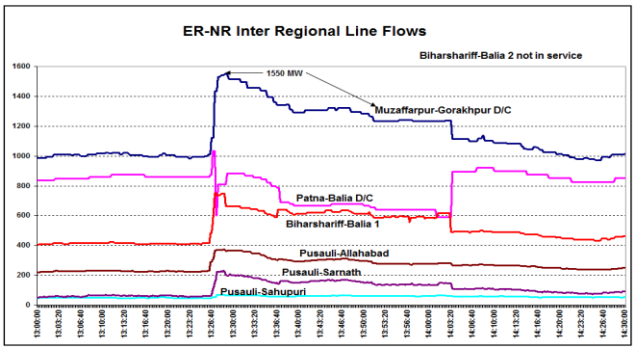
In NR a dip of 40 kV and 52 kV was observed at Lucknow and Gorakhpur respectively, whereas in WR Kansari voltage dropped from 385 kV to 294 kV.

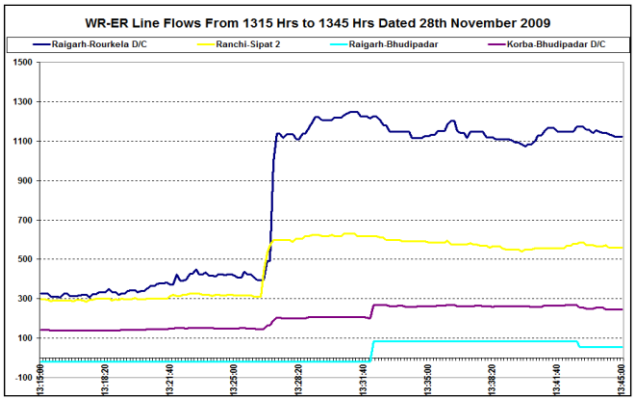


5. Power-flow Variations

After the incident a large quantum of power was wheeled to NR via ER. Import of ER from WR increased from 883 MW to 2245 MW (increase by 1362 MW). Flow on NR-ER corridor also increased from 2627 MW to 3770 MW (increase by 1143MW). Such step jump in power being wheeled from WR to NR through ER resulted in heavy line loadings and steep dip in ER system voltages.







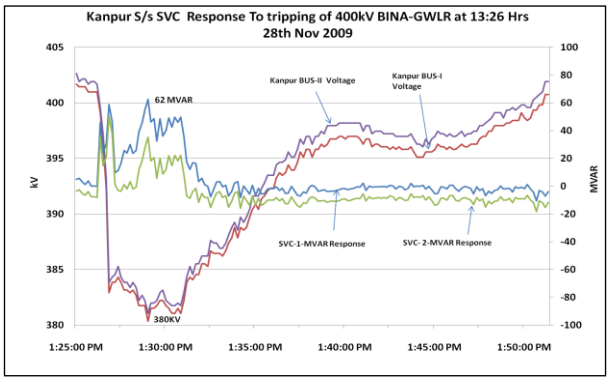
In WR, line loading of 400 kV Soja-Kansari-S/C reached up to 960 MW. In ER, flow on 400 kV Farakka-Malda D/C, Malda-Purnea and Rourkela-Jamshedpur shot up. However their values got frozen at 663 MW at NLDC/RLDC due to saturation of 1000/1 CTs in these lines. Visualization to the grid operator got hampered in this case due to the CT limitations. As per offline simulation of the event, power-flow in Malda-Purnea might have reached upto 820 MW from 552 MW.

6. Response/Actions

6.1. Automatic Response

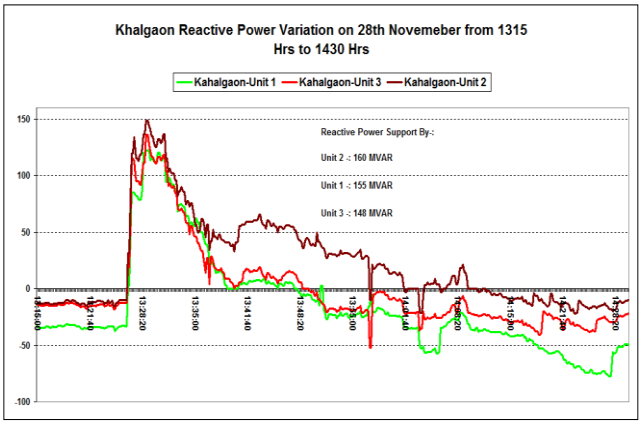
6.1.1. Kanpur SVC

The SVC at Kanpur was being operated in susceptance mode with a dead band of -3% to +2%. MVAr support was received from it when the voltage at Kanpur fell below 388 kV, which is also evident from the graph below.



6.1.2. *Dynamic VAR Generation*

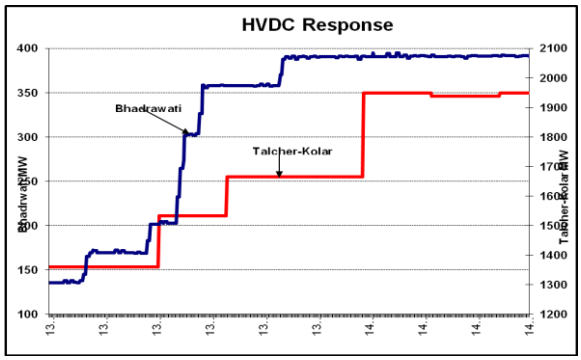
After the contingency almost all the generators in the affected area rapidly picked up their MVAr generation to support the voltages at their respective buses.



Some units of Kahalgaon, Farakka even provided support of 100 MVAr. This support was crucial in terms of system security during the contingency.

6.2. *Operator Action*

After the event, surplus in ER and WR was reduced especially in Gujarat (500MW), M.P (200) and West Bengal (100 MW). Power was transferred from NEW grid to SR by changing the settings of HVDC links. Talcher-Kolar flow was ramped up from 1406 MW to 2065 MW and Bhadrawati flow was ramped up from 150 MW to 350 MW.



Load shedding was also done in NR to control the loading of lines. 400 kV Kahalgaon-Biharshariff-IV and 400 kV Kahalgaon-Patna-I were taken into service at 14:02 Hrs and 14:00 Hrs respectively. Both 50 MVAr Bus reactors were taken out to improve voltages at Kahalgaon.

7. *Offline Simulation Observations*

Some more value addition to the observations was done by simulating the contingency case in offline study (PSS/E):

- Maximum Angular separation in the NEW grid between Birsinghpur (WR) and Amritsar (NR) changed from 93^{O} to 148^{O}
- Angular difference between Vindhyachal west and north bus swung from 37^{O} to 83^{O}
- MW Losses in the NEW grid changed from 3034 MW to 3578 MW – increase of 544 MW
- MVAr losses in the NEW grid changed from 31235 MVAr to 35603 MVAr –increase of 4368 MVAr.
- The impact of contingency is similar to switching on of 100 reactors of 50 MVAr.
- Malda-Purnea flow reached 820 MW from 552 MW and Soja-Zerda flow touched 831 MW from a per-contingency value of 506 MW.

The increase in quantum of MW and MVAR losses can be attributed to the fact that post contingency; the power has to take a path which is many times in length than the pre-contingency power flow path through Bina- Gwalior.

8. Points to Ponder

The contingency case was certainly a near miss from a partial system collapse which is apparent from the trends of voltages and power-flows. Outage of only one element in the system might have lead to a collapse thus we need to revisit n-1 contingency plan for better security in future.
Telemetry and reproduction of the system parameters to the control room operator is critical especially during such contingencies. Limitations like 1000/1 CT ratio and angle transducer limit (-60 to +60) at Vindhyachal can be addressed for better understanding of critical situations at control centers.
Transfer capability assessment and ensuring that the same is not breached during real time operation also plays a vital role in order to ensure that the system remains secure under credible contingencies.

Acknowledgement

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