by . P. K. Agarwal, DGM, NRLDC/Powergrid, India

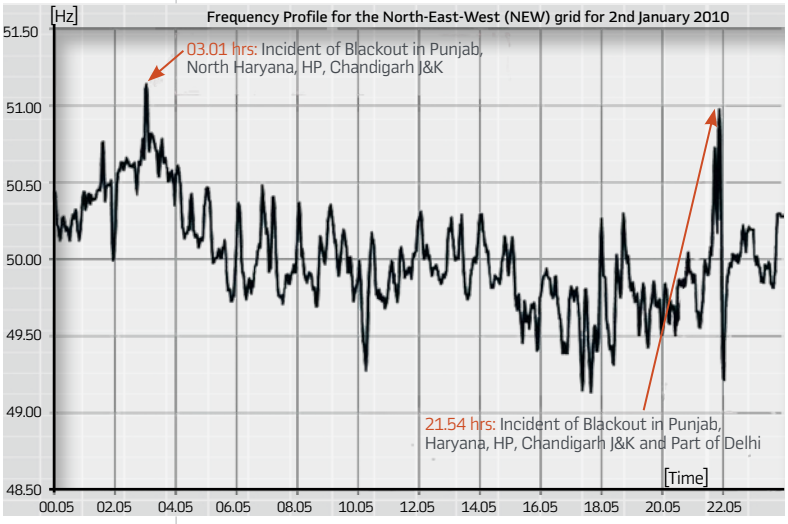
Indian Blackout 2010

Blackout Watch

Grid disturbances in Northern Part of India on 2nd January, 2010.

On 2nd January 2010, Northern part of the Indian Power system network was operating with depleted network caused by tripping of multiple transmission lines due to dense fog in most of the areas. Dense fog mixed with pollution reduces the breakdown strength of insulators and increases the conductivity along the surface of insulators causing the flash over across insulators and tripping of lines on earth fault. It has been observed that whenever temperature is low i.e. below 9 degree and humidity is high, more than 90 degree, formation of sufficient smog takes place causing flash over across insulators strings. Evening peak hours of 1st Jan 2010 were normal, however low ambient temperature (below 100 C) and high relative humidity (above 90 %) were observed in the region. Such atmospheric condition was witnessed for the first time during this winter season. Situation was under alert condition as it has been experienced in the past that such atmospheric conditions are favorable for fog / smog formation and tripping of transmission lines may occur.

1 Event frequency profile



Power grid of India has five regional grids namely Northern Region, Western Region, Eastern Region, Southern Region and North Eastern Region. All regional grids are synchronized with each other except Southern Region. The larger grid is known as NEW (North-East-west) Grid. Each region manages a group of state grids from a Regional Load Despatch Center. Northern Regional Load Despatch Center monitors and coordinates the state grids of Punjab, Haryana, Himachal, J&K, Rajasthan, Delhi, UT Chandigarh, Uttar Pradesh and Uttarakhand.

Northern Region experienced a partial grid disturbance on the night of 2nd January, 2010 at 03:01 hrs. in which power supply in Punjab, North Haryana, Himachal Pradesh, Jammu & Kashmir and UT Chandigarh sub-system were affected. This was followed by another partial disturbance almost on the same pattern, during the late evening hours on the same day i.e. 2nd January, 2010 at 21:54 hrs.

Brief details of the disturbance: Grid was running with depleted network and the situation worsened by 02:55 hours of 2nd January 2010 with 14 x 400 kV lines and 79 x 220 kV lines out. Following the multiple tripping of lines in the early morning of 2nd January 2010, the affected area remained connected with very few critically loaded tie-lines with main grid importing about 1800 MW to 2500 MW. At 03:01 hrs tripping of one of these critically loaded tie-lines resulted into cascade tripping of remaining tie-lines and complete blackout in the north-west area of northern regional grid (Punjab, North Haryana, HP, J & K and UT Chandigarh). Load affected in this area was about 7,500 MW and there was about 4,000 MW loss of generation.

Incidence of multiple tripping again occurred at 21:54 hrs of 2nd January 2010 as some of the transmission lines tripped during the morning incidence were still out and tripping of some additional major inter-linking 400 KV tie lines resulted into blackout in Punjab, Haryana, HP, J & K, UT Chandigarh and North/West Delhi areas affecting around 9,000 MW load and 5,000 MW generation. Some of the tie-line tripping during the above incidence was due to the mal-operation of the protection system with incorrect protection settings due to leaving default values intact in numerical relays for distance protection during initial commissioning activity.

Main causes of the disturbance: It has been observed that the disturbances were initiated due to the foggy weather conditions when a number of transmission elements in the Northern Regional grid, more particularly in the North West

part of the region had gone under outage resulting into poor connectivity of the affected area with the rest of the main grid. Prima facie, the main attributor for the disturbances can be identified as:

- Depletion of transmission network due to heavy fog / smog conditions
- Unintended and unexpected operation of protective system/switchgear of some of the critical transmission elements in already depleted network
- Operator's inability to adequately comprehend the situation in certain cases as a result of which the system conditions were aggravated
- Inadequate safety net in the form of automatic load shedding through under frequency relays, df/dt relays and under voltage relays

It has been seen that grid frequency remained above 50.5 Hz between 02:00-03:00 hours. This was primarily on account of the disruption in load fed from several 220 kV substations on account of tripping of 220 kV lines. Even then the generating stations in the entire grid could have back down generation in a pro-active manner (barring the generators in the North West part) as per the frequency linked dispatch guidelines and ensure that the frequency does not go much beyond 50 Hz. This action was obviously inadequate. The frequency profile for the NEW grid for 2nd Jan 2010 as given in the figure 1 depicts the above observation.

Consequences of the Grid Disturbance: On account of disturbance in the grid the estimated quantum of energy not served from 1st to 3rd Jan 2010 is as summarized below.

Sl. #	Date	Estimated quantum of energy not served (MWh)
1	1st January 2010	3,600
2	2nd January 2010	112,000
3	2rd January 2010	43,000

Efforts to ensure reliability of the transmission system: As mentioned earlier, line tripping during dense winter fog conditions was hitherto a common feature in Northern region. The winter of 2002-03, 2005-06, 2006-07, 2007-08 had witnessed several tripping on the EHV transmission system in Northern Region. Historically, this tripping occurred mainly between mid-December to mid-February every year. However, during the winter of 2007-08, the Northern Region witnessed tripping on the EHV transmission system on three consecutive days viz. 7th, 8th and 9th March 2008 which led to a large section of consumers getting affected.

A Crisis Management Group (CMG) was constituted at the level of Member (Grid Operation and Distribution), CEA to monitor the long-term measures required to minimize such large scale tripping of the EHV transmission system. Certain measures were decided. The following actions were taken:

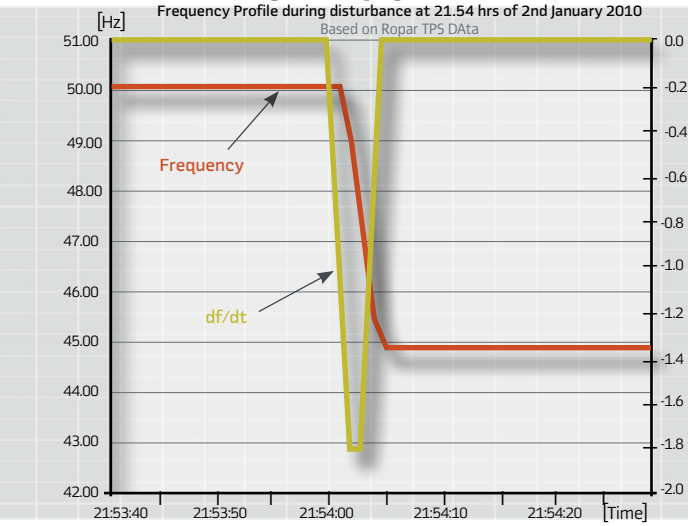
- Replacing the porcelain insulators in heavily polluted or vulnerable areas with polymer insulators
- Hotline washing of insulators either through helicopters or otherwise
- Intensive manual cleaning of insulators prior to the onset of winter
- Mock Black Start Trial exercise
- Real time monitoring of humidity and temperature and weather forecast from different agencies

After these incidences, in order to enhance the reliability of the grid the following measures are also being taken up now:

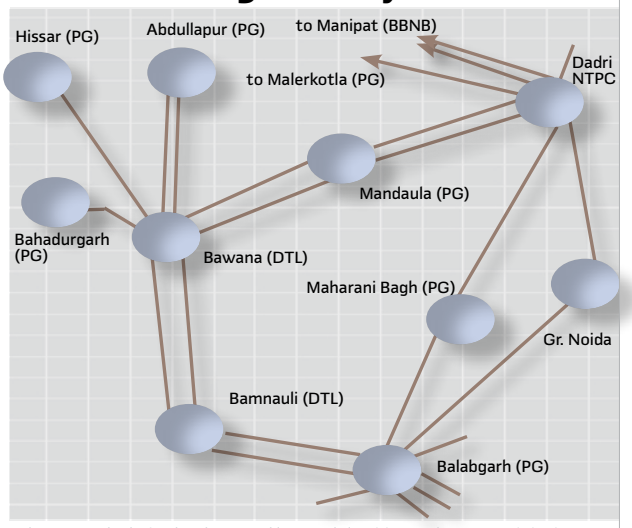
- Monitoring of Under Frequency Relay Load Shedding (UFRLS) and Under Voltage Load Shedding (UVLS)
- Protection audit for up-gradation of protection system in Northern Grid
- Availability of real time data from different generating stations and sub stations ■

P. K. Agarwal is an electrical engineer. He worked in the area of construction of EHV transmission lines and substations up to 1989, and in HVDC system in the area of control systems and modification and testing of control software of ABB. In the year 1993, he Shifted to Powergrid on transfer of HVDC assets to Powergrid Corporation of India Ltd. He Implemented SCADA/EMS system of Northern Region, the complete system of daily data processing for energy booking, etc, on UNIX server, the computer system infrastructure presently operational at NRLDC, etc. Agarwal is actively involved in finalizing procedures and software requirements for REC mechanism in India, and is a member of IEEE, USA, Institution of Engineers and All India Management Association, India. He participated in many seminars, and published papers on SCADA system and commercial mechanism.

2 **Frequency profile at 21.54**



3 **Delhi ring main system** - 400 kv



The text of the article is based on report on Grid Disturbance prepared by Northern Regional Dispatch Center and Submitted to the Honorable Central Electricity Regulatory Commission in compliance to the CERC's order dated 14th January 2010 in Petition number 2/2010 in the matter of grid disturbances in the Northern Region on 02nd January 2010.