



Black Start Mock Drill from Pench Hydro Power Station in Madhya Pradesh for Khaparkheda Thermal Power Station in Maharashtra, India

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Abstract

The periodic testing and validation of grid recovery procedures are mandated by The Indian Electricity Grid Code (IEGC) 2010⁵, which includes Black start procedure for total/partial blackouts and re-synchronization of Island and this procedure needs to be practiced at least twice a year. Black Start mock drills are carried out to learn the behavior of the system while recovering from total/partial blackouts and from such mock drills the engineers will be able to figure out the challenges and responses of the equipment's at different stages of the procedure. Pench Hydro Power Station is the only Hydro Power Station available nearby and there is no gas generation available in the vicinity of Nagpur district of Maharashtra, India. And Thermal generation available around area is 10000 MW. This paper is the experience about carrying out black start mock drill for 220 kV Khaparkheda Thermal power station from Pench Hydro Power Station and synchronizing of Small Island with national grid created during the mock drill.

Keywords: Black Start Mock Drill, Grid Recovery Procedure, Khaparkheda Thermal Power Station, Pench Hydro Power Station

1. Introduction

Indian power system is one of the largest synchronized electrical grid in the world with installed generation capacity of more than 374 GW⁴ with maximum demand of 200 GW⁴. Indian power system is demarcated in five different regions such as Eastern, Western, Northern, Southern and North Eastern. In current scenario all the regions are connected to one national grid via different tie lines. Western region is a part of Indian power system with installed capacity of 123 GW⁴ and includes Maharashtra, Gujarat, Goa, Madhya Pradesh, Chhattisgarh, Daman and Diu and Dadra and Nagar Haveli. Installed capacity of Maharashtra state is 43745 MW⁴ with maximum demand recorded was 26222 MW⁷, out of the above installed capacity, the generation

around Nagpur district is about 10000 MW⁸ thermal generation. The large size of the grid has strengthened the grid in term of reliability and economy on one hand; at the same time it also poses new operation challenges wherein a disturbance in one small part can adversely impact the reliability of rest of the grid. The Indian grid disturbance of July 2012 has shown the impact of such an occurrence and its fast spreading effect on the rest of the grid. In view of such emergencies, preparedness for grid restoration with the black start capable generator has to be ensured at any point of time. This will help in faster restoration of the system and reduce economic and other losses during such emergencies. Black start is the activity where restoration of grid is done with the help of self-starting generators, which are generally hydro or gas-based station with local

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standalone supply source such as diesel generator sets for feeding station auxiliaries and restoring the grid by extending power supply to thermal generating units. So, it becomes essential to have black start capable generating stations to be equipped and ready all the time, therefore black start mock drills are being carried out. Considering the huge generation available around Nagpur district (Maharashtra) carrying out black start mock drill in the region will make power system operator ready for any crisis situation in case of total/partial blackouts. Pench Hydro power generation is the only hydro source available nearby and there is no gas generation available in vicinity.

2. Geographical Locations and Facilities

2.1 Pench and Khaparkheda

Pench Hydel project is joint venture of Maharashtra and Madhya Pradesh and built on Totaladoh dam in Madhya Pradesh with the capacity of 2*80 (160) MW. The share of Maharashtra in Pench Hydel project is 1/3rd (53 MW) and share of Madhya Pradesh is 2/3rd (107 MW). Pench Hydro power station is connected to Maharashtra via 132 kV Pench – kanhan ckt and 132 kV Pench – Mansar ckt with line length of 60 km. 220 kV Khaparkheda is having thermal generation with installed capacity of 840 MW (4 set each of 210 MW). 220 Kv Khaparkheda is connected to 220/132 kV Kanhan s/s via 220kV transmission lines. Extending auxiliary supply to thermal generating units of Khaparkheda from pench HPS would help in speedy recoveries in case of total/partial blackouts.

2.2 Technical Details

Table 1. Parameters used and other details of pench HPS

AC Generator	KW: 80000, 88.88 MVA, 11kV,0.90 PF(lag),50 Hz,231 RPM, Excitation V: 166 A: 1260,Connection type:Y, Specification - IS 4722-1968, Rotor weight including runner : 220 ton
Governor AC generator	KVA – 1, Volts – 120 , Amp – 4.8,231 RPM, 50 Hz, 26 poles, 3 P.H , 0.25 PF, Specification– IS4722-1968,Magnetization 72 V 618 A ,Connection type-Y

D.C Exciter	KW– 300, Volts – 207 , Amp –1450,231 RPM, Specification – IS 4722-1968
Settings/Mode/Type/capacity	Droop setting :4% (3% to 6%) Governing Mode: FGMO Turbine Type: - Francis Diesel Generator capacity: 250 KVA

3. Successful Black Start Mock Drill at Pench Hydro Power Plant on dt. 19/01/2022

On date 19/01/2022 the small Island was created from Pench HPS to 220 Kv Khaparkheda for black start mock drill and separated from the national grid. After discharging all the elements in island, the Pench HPS Generator unit – 2 is started using auxiliary supply from diesel generator at Pench.

After extension of unit -2 supply to Kanhan s/s, 132/33 kV transformer charged and 33 kV feeders were

Table 2. Line details

Sr.No	Elements	Conductor type, length	Details: PU/ km/100 MW
	132kV Kanhan- Pench Ckt	0.2 ACSR Panther 52 km	Positive sequence: R – 9.310E-41, X-2.216E-3 B- 5.10E-4 , Zero sequence: R0-2.328E-3 X0-9.310E-3
2	220kV Kanhan- Khaparkheda (new)	0.4 ACSR Zebra 60 km	Positive sequence: R – 1.440E-4 X-8.220E-4 B - 1.41E-3, Zero sequence: R0-4.231E-4 X0-2.757E-3 B0-8.843E-4

3	220 kV Khaparkheda (new) – Khaparkheda old ckt	0.4 ACSR Zebra 1 km	Positive sequence: R – 1.440E-4 X-8.220E-4 B - 1.41E-3, Zero sequence: R0-4.231E-4 X0-2.757E-3 B0-8.843E-4
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taken in service with approx load of 14 MW and supply is extended further to 220 kV Khaparkheda s/s via 400 kV Khaparkheda. At 220 kV khaparkheda, station transformer is taken in service alongwith auxiliary load of approx 3 MW of 210 MW GT-II. Total 17 MW load were taken in service on Pench hydro generator unit – 2 and small island is synchronized with national grid by closing 132 kV bus coupler at 132 kV Pench HPS substation.

Following steps are followed after discharging of created Island portion.

- At 11:10 hrs, 80 MW GT – II synchronized on Bus-I at 132 kV Pench.
- At 11:16 hrs, 132 kV Kanhan – Pench ckt charged and phasing out carried at Kanhan substation to verify the phase sequence.

- At 11:28 hrs, 132/33 kV 25 MVA Tf – I and Tf – II charged at 220/132 kV Kanhan substation.
- At Kanhan substation following DISCOM loads are taken in service-
 - At 11:30 hrs, 33 kV Water works ckt charged.
 - At 11:33 hrs, 33 kV Gondegaon ckt charged.
 - At 11:35 hrs, 33 kV Mansar ckt charged.
 - At 11:40 hrs, 33 kV NMC ckt charged.
 - At 11:40 hrs, 33 kV Dragon Palace ckt charged.
 - At 11:41 hrs, 33 kV Borda ckt charged.
- At 11:46 hrs, in 220 kV Kanhan 220/132 kV 200 MVA ICT – II charged .
- At 11:59 hrs, 220 kV Kanhan- Khaparkheda (new) ckt charged.
- At 12:02 hrs, 220 kV Khaparkheda(new) – Khaparkheda(old) ckt – I charged.
- At 12:43 hrs, 220 kV Khaparkheda (old) – Khaparkheda (new) ckt charged.
- At 12:48 hrs, 220/6.6 kV 40 MVA station Tf – II charged at 220 kV Khaparkheda(old) substation.
- At 13:12 hrs, Load taken by Thermal power station of CT fan (8x110 kW) and BFP -3.5 MW at 220 kV Khaparkheda.
- At 13:22 hrs 132 kV Pench 132 kV Bus coupler charged at 132 kV Pench HPS and synchronized with national grid.

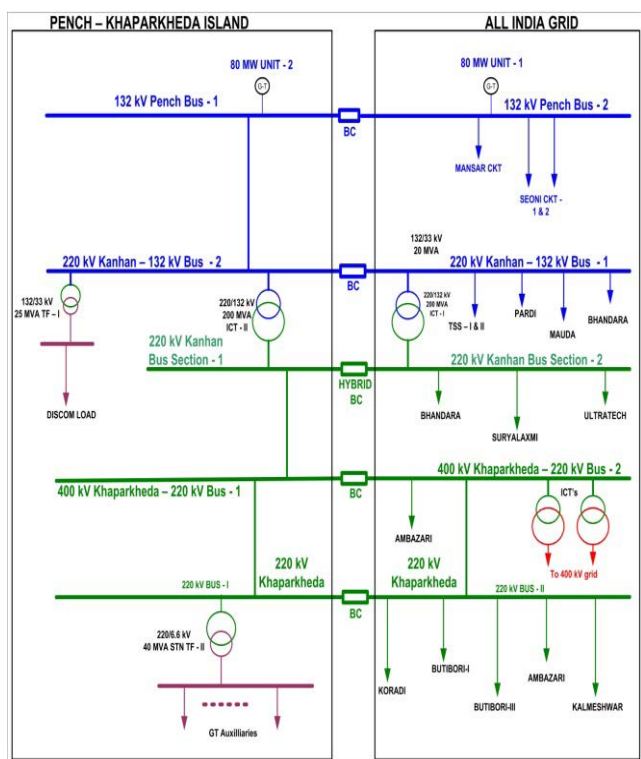


Figure 1. Single line diagram.

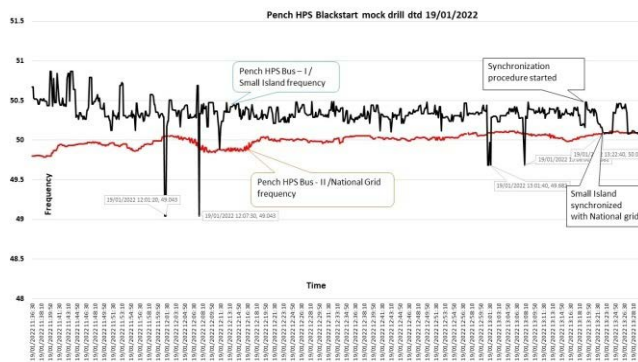


Figure 2. Frequency response of island - national grid and synchronization.

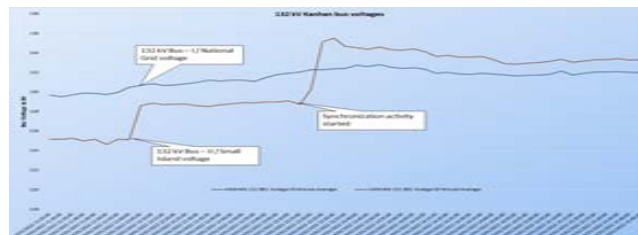


Figure 3. Voltage profile of 132 KV bus at 220 KV kanhan substation during black start mock drill.

To synchronize the island with the national grid the frequency of the island was regulated by adjusting generator output. Bus voltage of 132 kV Pench bus- I was a part of island was at 127.77 kV while the voltage of the bus which was connected to grid was 132.04 kV so the generator excitation was controlled to bring the voltage of island bus near to 132 kV. The voltage magnitude and frequency were closely monitored and it was checked synchronized at 13:22 hrs. Figure 2 shows the national and island frequency during the black start mock drill.

Figure 3 shows the voltage profile at 220/132 kV Kanhan s/s.

4. Conclusion

The black start mock drill was carried out successfully on dt.19/01/2022, during trial the

- Variation in frequency is from 49.043 Hz to 50.869 Hz, variation in frequency of national grid from 49.784 Hz to 50.113 Hz.
- Voltage variation is from 124.65 kV to 130.26 kV.
- Before synchronization bus voltage of islanded portion at 132 kV Kanhan bus was 128.77 kV. And bus voltage at the national grid was 132.04 kV at 132 kV Kanhan.
- Before synchronization bus voltage of islanded portion at 400 kV Khaparkheda s/s 220 kV bus was 219.43 kV. And 220 kV bus voltages at the national grid was 226.56 kV at 400 kV Khaparkheda.
- Voltage difference between 132 kV Bus and 132 kV Pench bus was nearly 1 kV of Island.

During this black start mock drill the auxiliary load such as Boiler Feed Pump and Cooling Tower fan of Khaparkheda thermal power station were taken in service.

5. Acknowledgement

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