Case Study of Power System Faults and its Detection using PMU

Roushan
Deptt. of EEE
R.V.S.C.E.T,
Jamshedpur-831012,
INDIA.

Aman Kumar
Deptt. of EEE
R.V.S.C.E.T,
Jamshedpur-831012,
India

Dipti Yugal
Deptt. of EEE
R.V.S.C.E.T,
Jamshedpur-831012,
India

Puja Tudu
Deptt. of EEE
R.V.S.C.E.T,
Jamshedpur-831012,
India

Amit Kumar
Deptt. of EEE
R.V.S.C.E.T,
Jamshedpur-831012,
India

***Abstract*— In this paper, we discuss some special cases of power system faults and their detection in India. The Phasor Measurement Unit has tremendous applications in detection of power system faults and in taking the necessary corrective measures before the failure of the power system. In this paper, we discuss some case studies in which the Phasor Measurement Unit was effective in the detection of faults. We discuss three of such case studies, namely Tripping of Omkareshwar HPS, disturbance in Karnataka system due to the resistive nature of the fault and detection of fault cleared by back up protections in Biharsharif.**

Keywords—Phasor Measurement Unit; Fault Detection.

I. INTRODUCTION

The power grid of India is one of the largest grid of the world with the capacity of 229GW as on October 2013. The Indian power grid is divided into five regions viz Nothern grid, Eastern grid, North-Eastern grid, Western grid and Southern grid. By the year 2014, the first four of these were synchronized and measures are being taken to synchronize the southern grid also.

PMU [1] was developed to obtain information about the power grid in a dynamic manner. With the development of PMU we are able to monitor voltage, currents, reactive power, active power, frequency, rate of change of frequency etc. within a separation of every few millisecond. These parameters are an indication of the health of the power grid. By having this information we can have a dynamic map of the power grid. In this paper, we are going to discuss some of the case studies in which the power system faults were detected successfully using the PMU.

The organization of the paper is as follows: the first section is the introduction. In the second section we are going to deal with Tripping Omkareshwar HPS. In the third section we are going to deal with Disturbance in Karnataka system due to the resistive nature of the fault. In the fourth section we are going to deal with Detection of fault cleared by back up protections [2]. Finally, we will present the conclusion in the last section.

II. TRIPPING OMKARESHWAR HPS

This case of tripping Omkareshwar HPS, involves the high impedance arcing type fault, delayed fault clearance, oscillation in the grid and tripping of a working generating plant. It occurred on 02-09-2013 at 13:47 and 14:06 Hrs. Data which have been used for event analysis are :

Itarsi, Satana, Dehgam, Raipur, Bhadrawati, Sugen PMU DR/EL/SOE.

A.) Event Descripition:

Before the failure, all the units of Omkareshwar HPS were running properly. At 13:47 Hrs. R phase fault appeared in the 220 KV Itarsi-Barwaha circuit. As the fault was of resistive nature, so it wouldn't trip immediately. It tripped when the Y phase was also affected after 1 second from Barwha and Itarsi end. During this fault 220 KV Omkareshwar-Barwha was sensed and the line got tripped in earth fault protection from OSP end. The Fig. 1. shows the affected area by this fault.

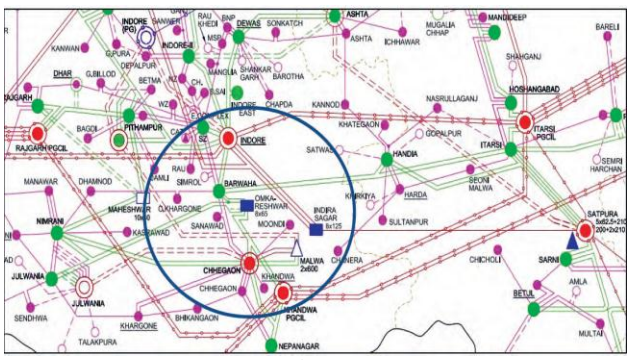

Fig. 1. Schematic Diagram of Omkareshwar and Near By area

After this first trial charging attempt of 220 KV Itarsi-Barwaha line from Barwaha end at 14:06 Hrs was taken and similar fault was observed again.

The 220 KV Omkareshwar-Nimrani line which was tripped from Omkareshwar on the earth fault trip as observed by the Omkareshwar end relay. After the trip whole 390 MW power was passing the 220 KV Omkareshwar-Chhegaon line. At 14:07 Hrs 220 KV Omkareshwar-Chhegaon line was tripped from Chhegaon and because of this all outgoing feeder from Omkareshwar caused the tripping of all eight units on over frequency.

B.) Analysis

In the Fig. (2) we can observe that the R phase of Itarsi PMU decreased initially by 4 KV. But, after 1 second it decreased by 4 KV along with 6 KV in Y phase.

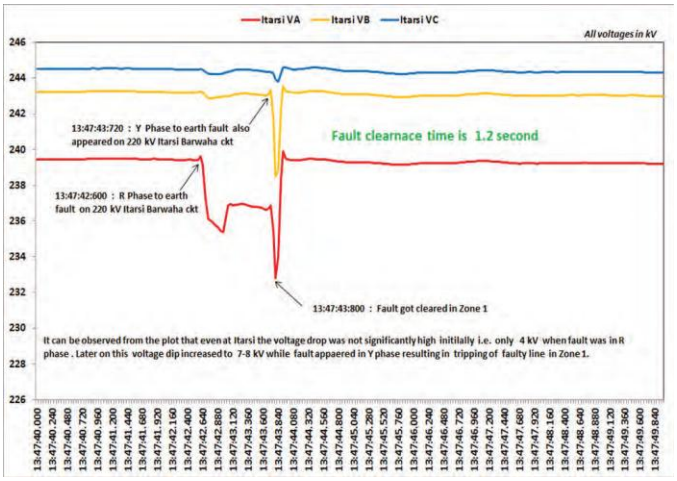

Fig. (2): Phase Voltages from Itarsi PMU during the fault at 13:47 Hrs

Similar characteristics were observed in DR of 220 KV Barwaha-Itarsi as observed in PMU voltage displaced as shown in fig.(3)

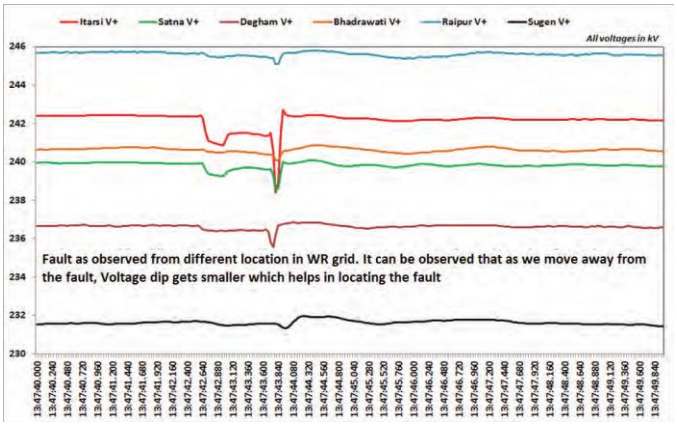

Fig.(3): Phase Voltages from Itarsi PMU during the fault at 13:47 Hrs

As the current observed by the DR was high, but due to the slight voltage decrease, it created an illusion that all is well, as the fault impedance didn't change in the relay of zone 1. Later, as the fault appeared in the Y phase it tripped the line phase to phase indication in the zone 1and the same is shown in Fig.(4). At the location where fault occurred the voltage drop is higher at the nearest locating area and it decreases as we start getting further away from the faulty region.

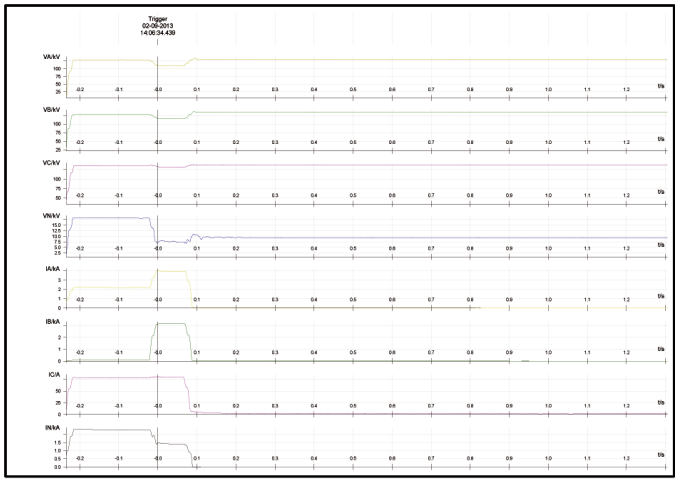

Fig.4(a): Continuation of Figure 5-70 DR indicating the phase to phase fault appeared after 1 sec. resulting in tripping of line in zone 1.

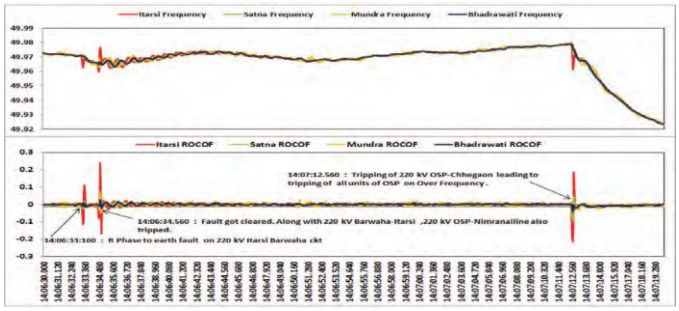

Fig.4(b): Frequency observed by various PMUs during the fault on 220 kV Itarsi Barwaha at 14:06 Hrs.

III. DISTURBANCE IN KARNATAKA SYSTEM DUE TO RESISTIVE NATURE OF FAULT.

A. Overview:

Disturbance in Karnataka system due to the resistive nature of the fault which sustained for 5 second before it got cleared. It occurred on 18-09-2013 at 15:59 Hrs. Data which have been used for the event analysis are: Nawandra PMU, KPTCL report.

B. Event description:

At Karnataka's 220 KV system, the tripping of transmission line and generation loss occurred. There was a fault in 220 KV Kemar-Varahi line-3. The stations tripped during the incident were 220 KV Kemar-Varahi line-3, 220 KV UPCL-Kemar line 1&2, 400 KV Hassan-UPCL line 1&2, running unit-2 at Udipi power station.

There was a generation loss of 350 MW at Udupi power station. The network connectivity of affected portion is shown in Fig. (5).

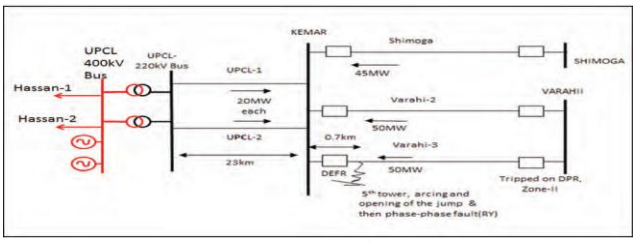

Fig.(5): Connectivity Diagram of Udipi Power Station

C. *Analysis:*

It can be observed from the PMU voltage plot in Fig. (6) that a high resistance fault had started at15:59:50.400 Hrs. Just after 5 sec i.e at 15:59:55.800 Hrs a dip in voltages of all the phases was observed. Snapping of Y phase jumper of 220 KV Kemar-Varahi line-3 occurred. There was a tripping in 220KV Kemar-Varahi line-3 at Varahi end on operation of distance protection, zone2, as there was no provision of carrier aided protection.

The line also tripped at Kemar end during the operation of the directional earth fault relay. The same incident occurred at UPCL 220 KV UPCL Kemar line-2.

There was a tripping at unit 2 of Udupi power station due to the operation of back up earth fault protection. The 400KV Hassan-UPCL line-2 also reclosing from Hassan end after sensing the fault in zone-1,due to this line tripped 400ms after auto reclosing due to the operation of zone-2.

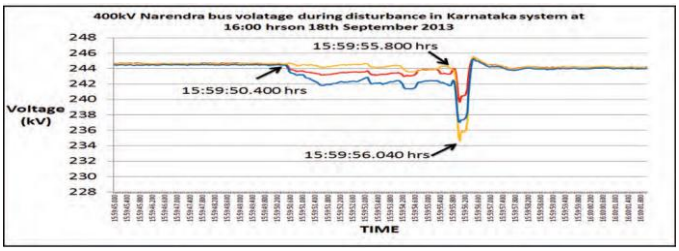

Fig.(6): 400 kV Narendra bus voltage

IV. DETECTION OF FAULT WHICH WERE CLEARED BY BACKUP PROTECTION AT BIHARSHARIF

A. *Overview:*

The tripping analysis of all three 315MVA ICT$_s$ at Biharsharif substation is being dealt in this case study. It occurred on 25-06-2013 at 12:13 Hrs. Data which have been used for the event analysis is Farakka PMU.

B. *Event description:*

A tripping at 220 KV Fatuah-Patna(PG) circuit occurred at 12:13 Hrs on Y-phase to ground fault at a distance of 9.6 km from Patna (PG) end. Due to the operation of back up HV-side overcurrent protection, tripping occurred at all the three 315MVA,400/200 KV ICT$_s$ at Biharsharif (PG). Due to outage of all 220 KV & 132 KV lines from Biharsharif substation, a load loss of about 240 MV occurred in area adjoining Biharsharif.

C. *Analysis:*

All the above sequence of events was initiated due to Y-phase to ground fault in 229 KV Patna-Fatuha s/c (zone-2 from Fathua;9.6 km from Patna). However, the single phase to ground fault can be corroborated only from sequence plots. The observation from the PMU plot of 3-phase Farakka voltage Fig (7) was that the highest initial voltage dip was observed in y-phase indicating the presence of y-phase fault.

Fig.(7): 400 kV Farakka Bus voltage

Although the fault was isolated properly at Patna(PG) end, but there was a delayed clearance/non-clearance at Fatuah end. The fault was also not cleared from Biharsharif(BSEB) end. The fault was isolated due to the triggering of HV side overcurrent protection for all the three 400/220 KV ICT$_s$ at Biharsharif(PG) end.

V. CONCLUSIONS

We have discussed three case studies, where the faults in the power system were detected using the PMU. Three cases, namely: Tripping of Omkareshwar HPS, disturbance in Karnataka system due to the resistive nature of the fault and detection of fault cleared by back up protections in Biharsharif were discussed. PMU plays an important role in the detection of faults and in future we may be able to predict the occurrence of fault and avoid it even before it actually happens.

REFERENCES

[1] Phadke.A.G., Thorp. J. S. , “Synchronized Phasor Measurement and Their Application,” Springer.

[2] “Synchrophasors initiative in India,” Power System Operation Corporation Limited, December-013