Anta Gas Power Station
Electrical Maintenance Section

Case Study
on
GT#2, Unit tripping on REF Protection
By

Ravindra Sharma
AGM(EM)
NTPC-Anta

S.SBhadoriya
DGM(EM)
NTPC-Anta

Abstract:

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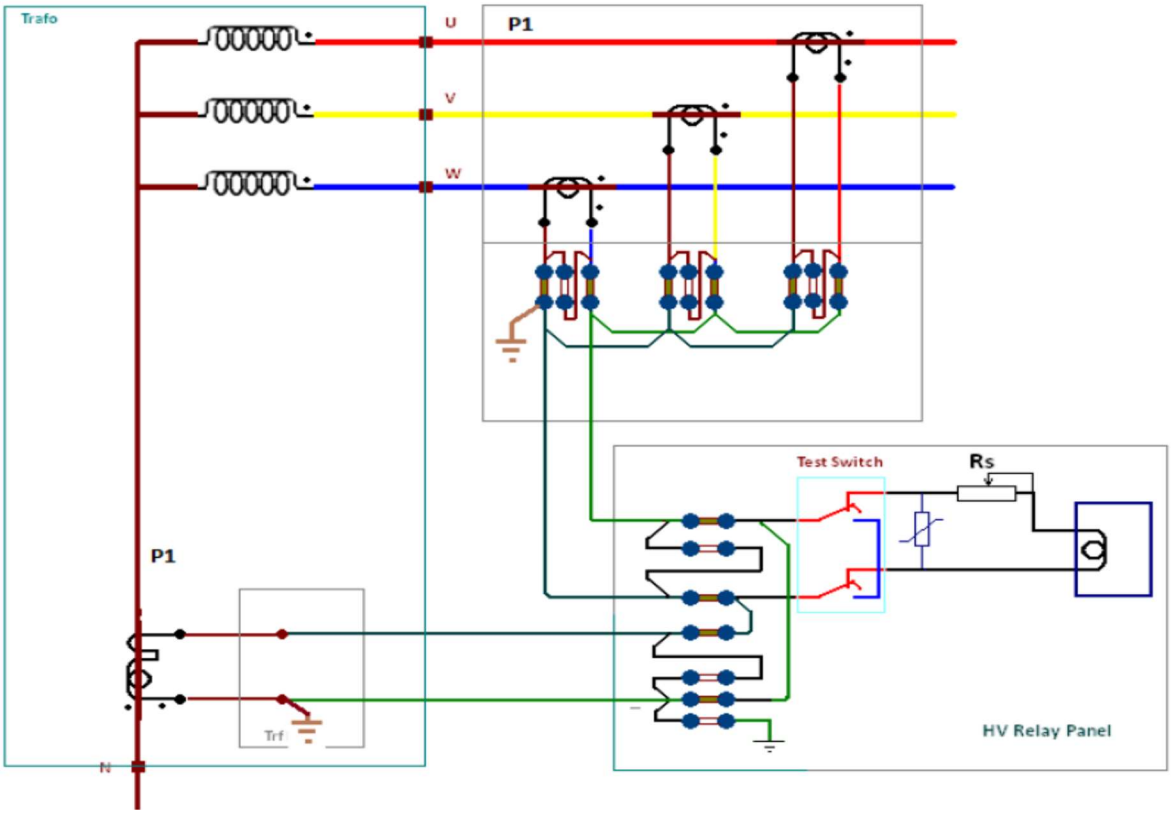
This document outlines Current transformer secondary circuit earthing importance for Restricted Earth fault relay stability. The case study is about GT#2 tripping on REF protection in through fault condition at Anta 220kV Switchyard.

Introduction:

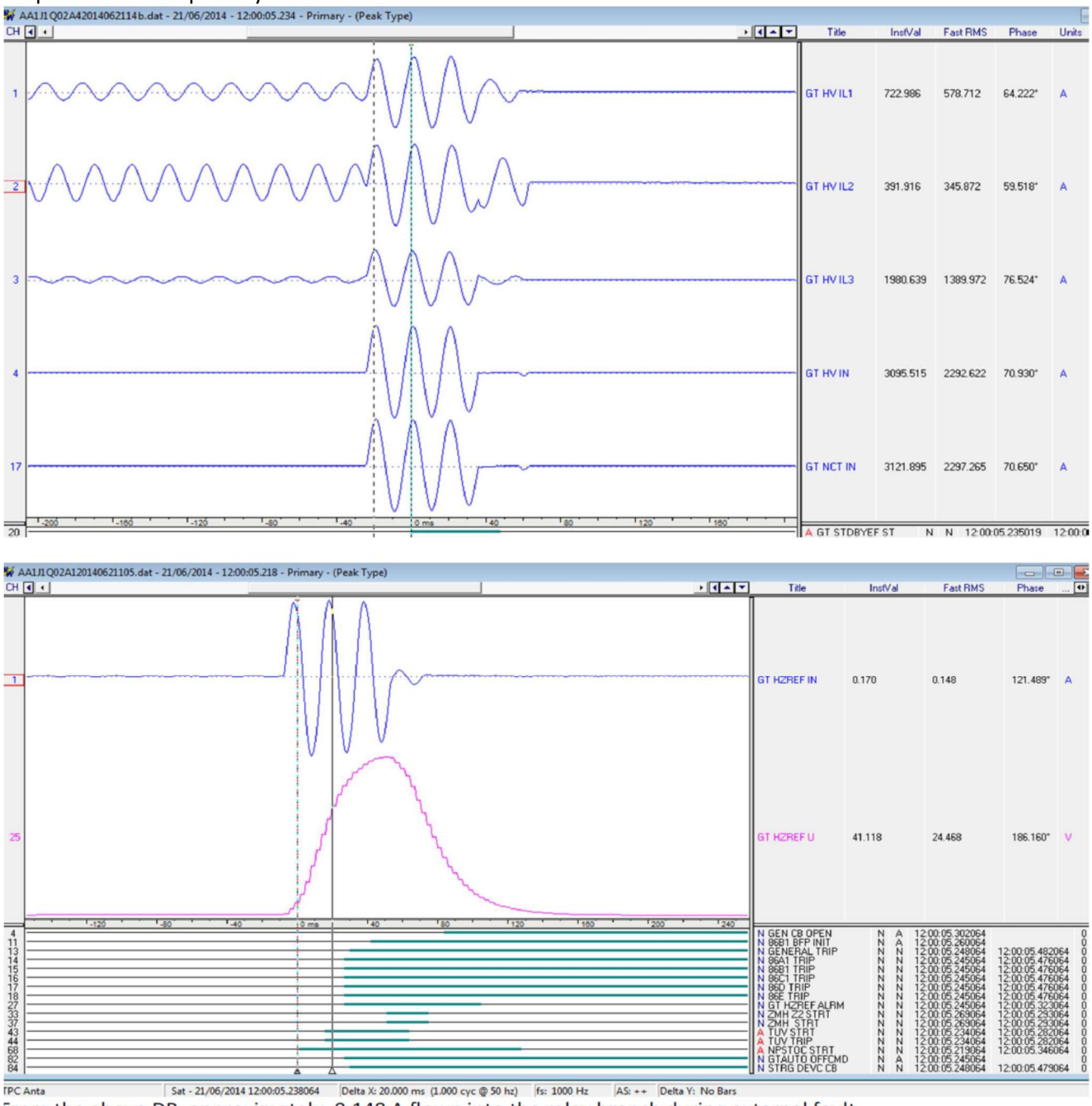
Transformers are one of vital and expensive components of transmission and distribution networks. In protection scheme of Transformer, Restricted Earth fault Protection (REF) (Fig1) is used to detect any earth fault in system. In this protection, the residual current of three line current transformers is balanced against the output of a current transformer in the neutral conductor.



REF Circuit Scheme Fig1.

Case Study: **Analysis on 64R-GT mal-operation in unit-2 GRP.**

GT high impedance restricted earth fault (64R-GT) tripped unit-2 for a fault in unit-1 GT-HV side. As per trip record (fig2) it was observed that NCT current channel used for stand by earth fault 64N, and derived residual current from GT-HV phase CT's are identical. This indicates, this fault is external to Unit-2. The shape of the REF channel current is looks like undistorted sinusoidal wave, for 3 cycles. From this we can say there was no transient CT saturation. Therefore, if current flows more than expected leakage, we suspected for NCT polarity or summation mistake.



From the above DR, approximately, 0.148 A flown into the relay branch during external fault.

Fig.2

To Ascertain the above probable reasons Protection Circuit stability checking by primary circuit injection conducted using the different circuit conditions checked. here are the results:

A- REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of CT (Normal)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S1 earth (single earth) 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)	3.65/3.65 /3.76 A	3.85 A	3.75 A	3.75 A
Tr. LV (Current)	79.2 A	47 A	47 A	47.4 A
GRP TB-1 (Current) HV Summation CT(S1)	0.018 mA	6.15 mA	6.15 mA	6.17 mA
GRP TB-2(Current) HV Summation CT(S2)	0.018 mA	6.17 mA	6.18 mA	6.18 mA
GRP TB-3 (Current) NCT (S1)	0.015 mA	6.16 mA	6.16 mA	6.13 mA
GRP TB-4 (Current) NCT (S2)	0.014 mA	6.18 mA	6.20 mA	6.20 mA
REF Relay(Current)	0.002 mA	0.038 mA	0.029 mA	0.038 mA
Stab Resistor (Current)	0.002 mA	0.034 mA	0.026 mA	0.035 mA
Metrosil (Current)	0.002 mA	0.003 mA	0.001 mA	0.001 mA
Voltage across Summation CT secondary at Switchyard MK				
Voltage across REF Relay (GRP)				

B-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of NCT (Reversed at GRP)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S1 earth (single earth) 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT :S1 earth (single earth) 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)		3.75 A	3.76 A	3.76 A
Tr. LV (Current)		47.1 A	47 A	47.2 A
GRP TB-1 (Current) HV Summation CT(S1)		4.84 mA	4.87 mA	4.86 mA
GRP TB-2(Current) HV Summation CT(S2)		4.84 mA	4.87 mA	4.86 mA
GRP TB-3 (Current) NCT (S1)		5.92 mA	5.94 mA	5.95 mA
GRP TB-4 (Current) NCT (S2)		5.92 mA	5.94 mA	5.94 mA
REF Relay(Current)		10.60 mA	10.60 mA	10.61 mA
Stab Resistor (Current)		10.40 mA	10.42 mA	10.41 mA
Metrosil (Current)		0.01 mA	0.01 mA	0.01 mA
Voltage across Summation CT secondary at Switchyard MK		3.8 V		
Voltage across REF Relay (GRP)		3.99 V		

C-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of NCT (Reversed at GRP)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S1 earth and Transformer NCT :S1 earth 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth

		1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)		3.75 A	3.76 A	3.76 A
Tr. LV (Current)		47.3 A	47.1 A	47.4 A
GRP TB-1 (Current) HV Summation CT(S1)		6.35 mA	6.50 mA	5.84 mA
GRP TB-2(Current) HV Summation CT(S2)		6.35 mA	6.95 mA	6.06 mA
GRP TB-3 (Current) NCT (S1)		6.12 mA	7.10 mA	5.70 mA
GRP TB-4 (Current) NCT (S2)		6.11 mA	6.30 mA	6.20 mA
REF Relay(Current)		0.368 mA	0.467 mA	0.369 mA
Stab Resistor (Current)		0.319 mA	0.406 mA	0.319 mA
Metrosil (Current)		0.001 mA	0.001 mA	0.001 mA
Voltage across Summation CT secondary at Switchyard MK		0.14 V	0.183 v	0.146 V
Voltage across REF Relay (GRP)		0.08 V	0.08 V	0.08 V

D-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of CT (Normal)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S1 earth and Transformer NCT :S1 earth 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT : CT :S1 earth and Transformer NCT :S1 earth 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)	3.65/3.7/ 3.61 A	3.75 A	3.76 A	3.76 A
Tr. LV (Current)	79.4 A	47.2 A	47.3 A	47.1 A
GRP TB-1 (Current) HV Summation CT(S1)	0.15 A	0.15 A	0.17 A	0.12 A
GRP TB-2(Current) HV Summation CT(S2)	0.230 mA	6.15 mA	6.41 mA	5.98 mA
GRP TB-3 (Current) NCT (S1)	0.15 A	0.14 A	0.17 A	0.12 A
GRP TB-4 (Current) NCT (S2)	0.09 mA	6.06 mA	6.25 mA	6.18 mA
REF Relay(Current)	0.212 mA	0.178 mA	0.250 mA	0.218 mA
Stab Resistor (Current)	0.188 mA	0.158 mA	0.220 mA	0.192 mA
Metrosil (Current)	0.001 mA	0.001 mA	0.001 mA	0.001 mA
Voltage across Summation CT secondary at Switchyard MK	0.045 V	0.045 V	0.045 V	0.045 V
Voltage across REF Relay (GRP)	0	0.08 V	0.008 V	0.08 V

E-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of CT (Normal)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S2 earth and Transformer NCT :S1 earth 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)	3.63/3.64 /3.65 A	3.75 A	3.76 A	3.76 A
Tr. LV (Current)	79.4 A	47 A	47.1 A	47.2 A
GRP TB-1 (Current) HV Summation CT(S1)	0.635 mA	6.44 mA	5.45 mA	6.28 mA
GRP TB-2(Current) HV Summation CT(S2)	0.408 mA	6.37 mA	6.48 mA	5.80 mA

GRP TB-3 (Current) NCT (S1)	0.824 mA	6.20 mA	5.26 mA	6.60 mA
GRP TB-4 (Current) NCT (S2)	0.104 mA	6.08 mA	6.28 mA	6.15 mA
REF Relay(Current)	0.409 mA	0.379 mA	0.471 mA	0.345 mA
Stab Resistor (Current)	0.355 mA	0.329 mA	0.408 mA	0.299 mA
Metrosil (Current)	0.001 mA	0.001 mA	0.001 mA	0.001 mA
Voltage across Summation CT secondary at Switchyard MK	0.159 V	0.159 V	0.189 V	0.132 V
Voltage across REF Relay (GRP)	0.151 V	0.140 V	0.128 V	0.128 V

F-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of NCT (reversed at GRP)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S2 earth and Transformer NCT :S1 earth 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT : CT :S2 earth and Transformer NCT :S1 earth 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)	3.66/3.65 /3.64 A	3.76 A	3.76 A	3.76 A
Tr. LV (Current)	79.1 A	47.1 A	47 A	47 A
GRP TB-1 (Current) HV Summation CT(S1)	0.206 mA	4.87 mA	4.81 mA	4.85 mA
GRP TB-2(Current) HV Summation CT(S2)	0.14 A	0.12 A	0.15 A	0.12 A
GRP TB-3 (Current) NCT (S1)	0.14 A	0.12 A	0.15 A	0.12 A
GRP TB-4 (Current) NCT (S2)	0.084 mA	5.83 mA	5.90 mA	5.86mA
REF Relay(Current)	0.189 mA	10.58 mA	10.56 mA	10.61 mA

Stab Resistor (Current)	0.166 mA	10.36 mA	10.35 mA	10.36 mA
Metrosil (Current)	0.001 mA	0.01 mA	0.01 mA	0.01 mA
Voltage across Summation CT secondary at Switchyard MK	0.038 V	4.02 V	4.06 V	3.913 V
Voltage across REF Relay (GRP)	0.07 V	3.94 V	3.94 V	3.95 V

G- REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of CT (Normal)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S2 earth (single earth) 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)		3.73 A		
Tr. LV (Current)		47.1 A		
GRP TB-1 (Current) HV Summation CT(S1)		6.06 mA		
GRP TB-2(Current) HV Summation CT(S2)		6.09 mA		
GRP TB-3 (Current) NCT (S1)		6.11 mA		
GRP TB-4 (Current) NCT (S2)		6.13 mA		
REF Relay(Current)		0.040 mA		
Stab Resistor (Current)		0.035 mA		
Metrosil (Current)		0.001 mA		
Voltage across Summation CT secondary at Switchyard MK		0.0		
Voltage across REF Relay (GRP)		0.014 V		

H-REF Stability Test: GT#2 transformer LV Winding Three phase shorted, Polarity of NCT (Reversed at GRP)

Sr. No.	Condition	Test Condition Description
1-	Case-I	Switch yard Summation CT :S2 earth (single earth) 415 V balance 3 phase supply applied At switch yard
2-	Case-II	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (R-phase) applied At switch yard
3-	Case-III	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (Y-phase) applied At switch yard
4-	Case-IV	Switch yard Summation CT :S2 earth (single earth) 1 phase supply (B-phase) applied At switch yard

Measurement	Case-I	Case-II	Case-III	Case-IV
Tr. HV (Current)		3.76 A		
Tr. LV (Current)		47.1 A		
GRP TB-1 (Current) HV Summation CT(S1)		4.84 mA		
GRP TB-2(Current) HV Summation CT(S2)		4.86 mA		
GRP TB-3 (Current) NCT (S1)		5.88 mA		
GRP TB-4 (Current) NCT (S2)		5.87 mA		
REF Relay(Current)		10.58 mA		
Stab Resistor (Current)		10.34 mA		
Metrosil (Current)		0.01 mA		
Voltage across Summation CT secondary at Switchyard MK		3.96 V		
Voltage across REF Relay (GRP)		3.94 V		

Finding and corrective action:

Even when polarities of connected REF CTs are proper, it has been observed from REF stability test results that current distribution to relay is not proper which is attributed to CT secondary earthing at two ends. When the Test conducted with single secondary earthing at switchyard summation CT, the relay current

and secondary current with normal and reverse polarity found ok. Therefore, CT secondary S-1 is earthed at one end only.

About Author:

Mr. Ravindra Sharma : He is B. Tech (Electrical)- MNIT Jaipur, M. Tech (Power Generation Technology)- IIT Delhi. He is having more than 25 Years experience in Gas & Coal Power Stations in areas of Erection, Commissioning and Maintenance of Electrical system.

Mr. S.S.Bhadoriya : He is B. Tech (Electrical)- GBPUA&T Pantnagar, M. Tech (Power Generation Technology)- IIT Delhi. He is having more than 15 Years experience in Gas & Coal Power Stations in areas of Erection, Commissioning and Maintenance of Electrical system