ELECTRICAL SYSTEM DESIGN OF POWER PLANT

Project report submitted

In partial fulfillment of the requirement for the degree of

Master of Technology

In

ELECTRICAL ENGINEERING SPECIALIZATION IN POWER AND ENERGY SYSTEM

By

SOURABH TIWARI (2001700003)

Under the guidance of

DR. BHAVESH VYAS

(ASSISTANT PROFESSOR)

Department of Electrical Engineering

School of Engineering & Technology

K. R. Mangalam University, Gurugram - 122003

July-2023

DECLARATION

We declare that this written submission represents our ideas in our own words and where other's ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and canal so evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed. We further declare that if any violation of the intellectual property right or copyright, my supervisor and university should not be held responsible for the same.

Sourabh Tiwari (Roll No. 2001700003) (Signature)

Place: K.R. Mangalam University

Date: 03rd July 2023

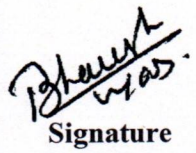
Registrar
K.R. Mangalam University
Sohna Road, Gurugram, (Haryana)

CERTIFICATE

It is certified that the work contained in the project report titled "Electrical System Design of Power Plant" by the following student:

Name of the Student: Sourabh Tiwari **Roll Number: 2001700003**

has been carried out under our/my supervision and this work has not been submitted elsewhere for a degree.



Signature

Dr. Bhavesh Vyas

Assistant Professor

Dean (SOET)

Date: - 03rd July 2023

Place: - K.R. Mangalam University

ACKNOWLEDGEMENT

"Enthusiasm is the feet of all progress, with it there is accomplishment and Without it there are only slits alibis."

Acknowledgment is not a ritual but is certainly an important thing for the successful completion of the project. At the time when we were made to know about the project, it was really tough to proceed further as we were to develop the same on a platform, which was new to us. More so, the coding part seemed tricky that it seemed to be impossible for us to complete the work within the given duration.

We really feel indebted in acknowledging the organizational support and encouragement received from the university.

The task of developing this system would not have been possible without the constant help of our faculty members and friends. We take this opportunity to express our profound sense of gratitude and respect to those who helped us throughout the duration of this project.

We express our gratitude to our supervisors Dr. Bhavesh Vyas for giving their valuable time and guidance to us.

Place: - K.R. Mangalam University

Date: -03rd July 2023

Sourabh Tiwari

ABSTRACT

The Design of Electrical System of a Power Plant includes sizing calculation of various Electrical Equipments, fault calculation and various Power System studies. This project covers the following:

a) Sizing calculations for Generator Transformers (GTs), Unit Transformers (UTs), Unit Auxiliary Transformers (UATs) and Station Transformer (ST).

b) Neutral grounding resistor for 11KV & 6.6 KV system.

c) Normal current ratings of generator busducts & GCB.

d) Normal current ratings of 11kV busducts, 6.6kV busducts, 11kV switchgear and 6.6kV switchgear.

e) Fault calculations for 11kV & 6.6kV systems, generator busduct connections and GCB.

f) Voltage regulation calculations for 11 KV & 6.6kV system.

***Key Words*: Fault Calculations, Load Flow Study, Voltage Regulations, Short Circuit Study, Neutral Grounding.**

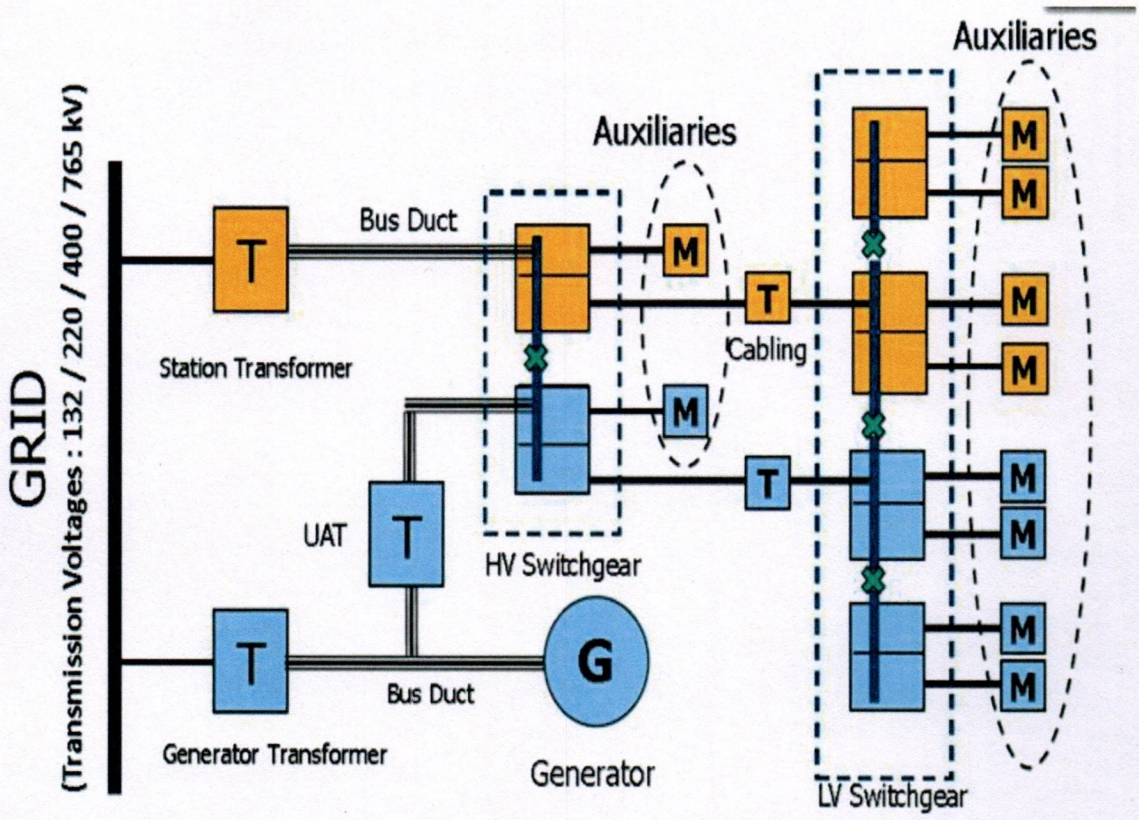
TABLE OF CONTENTS

Chapter 1: INTRODUCTION

The project involves the electrical system design of Auxiliary Power Distribution of Thermal Power Plant having two (2) units of 800MW generators. The design involves the sizing calculation of electrical equipment viz. Transformers, 11kV/ 6.6kV Switchgears, Bus-ducts, Neutral Grounding Resistor.

The project also includes the load flow studies, short circuit studies and motor starting studies on ETAP platform. The results of these studies are the basis of selection of ratings of above mentioned electrical equipments.

Typical single line diagram of a power plant is as below:



Chapter 2: PROBLEM FORMULATION AND OBJECTIVES

The objective of the project is to define the rating of various electrical equipment listed below in power plant for auxiliary power distribution. Rating includes the continuous current rating as well as short circuit rating.

a) Generator Transformers (GTs),

b) Unit Transformers (UTs),

c) Unit Auxiliary Transformers (UATs)

d) Station Transformer (ST)

e) MV Switchgear

f) Bus-ducts

g) Neutral Grounding Resistor for MV System

h) Generator Circuit Breaker

Chapter 3: METHODOLOGY OF THE PROJECT

To find out the ratings of various electrical equipment, design calculation has been performed through ETAP studies for the transformer sizing, short circuit calculations, motor starting studies, load flow studies. Switchgear & Bus-duct ratings have been derived from the selected transformer rating through manual calculations. Further, Neutral Grounding Resistor have been selected through manual calculations. All the design calculations & studies are shown in Chapter 4.

Equipment Parameter	**Methodology**
Transformer MVA Rating	Load Flow Studies through ETAP
Transformer Impedance	Short Circuit Studies & Motor Starting Studies
Transformer Tap Range Selection	Motor Starting Studies
GCB, Switchgear & Bus-duct Continuous Rating	Manual Calculations from the selected transformer rating
Switchgear & Bus-duct Continuous Rating Short Circuit Rating	Short Circuit Studies through ETAP
Neutral Grounding Resistor	Manual Calculations

Chapter 4: IMPLEMENTATION

1.0 SYSTEM FAULT LEVELS & MAIN EQUIPMENT RATINGS

SYSTEM FAULT LEVELS

765kV System	50 kA
230 kV System	40 kA

GENERATOR

Rating (MW)	800
Voltage (kV)	27
Power Factor	0.85
Xd" sat. (%)	15
Permissible voltage variation	+5% to -5%

GENERATOR TRANSFORMER

3 nos. single phase banks of rating (MVA)	330
Voltage HV side (kV)	765/SQRT(3)
Voltage LV side (kV)	27
Off circuit taps	+5% to -5%
Tapping steps (%)	2.5%
Z at principal tap (%)	20
Tolerance on Z at principal tap	+7.5% to -7.5%
Vector group	YNd11

UNIT TRANSFORMER

Rating HV (MVA)	90/72
Rating LV1(MVA)	45/36
Rating LV2 (MVA)	45/36
Voltage HV side (kV)	27
Voltage LV1 side(KV)	11.5
Voltage LV2 side (KV)	11.5
On load taps(+/-)%	10%
Tapping steps ,%	1.25%
Z at 80 MVA base(principal tap)	
ZHV-LV1	16.0%
ZHV-LV2	16.0%
ZLV1-LV2	32.0%
Tolerance on Z at principal tap	+7.5% to -7.5%
Vector group	Dyn1yn1

STATION TRANSFORMER

Rating HV (MVA)	125/ 100/ 75
Rating LV1(MVA)	62.5/ 50/ 37.5
Rating LV2 (MVA)	62.5/ 50/ 37.5
Voltage HV side (kV)	230
Voltage LV1 side (KV)	11.5
Voltage LV2 side (KV)	11.5
On load taps (+/-) %	10%
Tapping steps, %	1.25%
Z at 125 MVA base (principal tap)	
ZHV-LV1	24.0%
ZHV-LV2	24.0%
ZLV1-LV2	48.0%
Tolerance on Z at principal tap	+7.5% to -7.5%
Vector group	YNyn0yn0

UNIT AUXILIARY TRANSFORMER

Rating (MVA)	16 MVA (ONAN)
Voltage HV side(kV)	11
Voltage LV side(kV)	6.9
off circuit taps	+5% to -5%
Tapping steps (%)	2.5
Z at principal tap	11%
Tolerance on Z at principal tap	+7.5% to -7.5%
Vector group	Dyn11

2.0 SIZING CALCULATIONS

GENERATOR TRANSFORMER

The Generator Transformer is sized so that it is possible to export the generator output under
VWO conditions to grid.

Generator output under VWO conditions (MW)	=	840	=(800 X 1.05)
Power factor	=	0.85	
Corresponding MVA	=	988.2	
MVA rating of single phase GT selected	=	988.2/3	
	=	330	

SIZING OF UNIT TRANSFORMER

REFERENCE	Connected load on UT-1A/ UT-2A, LV WDG-1 (Unit Bus-1BA/ 2BA) (MVA)	Connected load on UT- 1A/ UT-2A, LV WDG-2 (Unit Bus-1BB/ 2BB) (MVA)	Connected load (Total) - LV1 + LV2 (MVA)
Annexure-I	30.00	34.70	64.70
4% No load correction factor	31.20	36.09	67.29
Rating with 10% margin	34.32	39.70	74.02
RATINGS SELECTED (MVA)	**45**	**45**	**90**

SIZING OF UNIT AUX. TRANSFORMER

Total load connected on both sections of 1CA (MVA) - (Refer Annexure - III)	12.90
4% No load correction factor	13.42
Rating with 10% margin	14.76
RATING SELECTED (MVA)	**16**

SIZING OF STATION TRANSFORMER

REFERENCE	Connected load on ST, LV WDG-1 (Station Bus-0BA) (MVA)	Connected load on ST, LV WDG-2 (Station Bus-0BB) (MVA)	Connected load (Total) - LV1 + LV2 (MVA)
Annexure-IV	44.30	38.60	82.90
4% No load correction factor	46.07	40.14	86.22
Rating with 10% margin	50.68	44.16	94.84
RATINGS SELECTED (MVA)	**62.5**	**62.5**	**125**

SIZING OF GENERATOR BUS-DUCT MAIN RUN & GCB

The continuous current rating of generator busduct & GCB is selected so as to permit continuous operation of the generator to be exported to the grid at min, generator terminal voltage under VWO condition.

Maximum continuous generator output current at minimum generator voltage

$$= \frac{800 \times 1.05 \times 1000}{\sqrt{3} \times 27 \times 0.95 \times 0.85}$$

$$= 22244 \text{ A}$$

Selected Rating = 25000 A

SIZING OF UNIT SWITCHGEAR

UT Rating = 90/45/45MVA, 27/11.5/11.5kV

Rated LV current with 10% margin = 1.1 X 45 X 1000/ (1.732 X 11.5)
= 2485.19A

Selected Rating = 2750 A

SIZING OF STATION SWITCHGEAR

ST Rating = 125/62.5/62.5MVA, 230/11.5/11.5kV

Rated LV current with 10% margin = 1.1 X 62.5 X 1000/ (1.732 X 11.5)
= 3451.65A

Selected Rating = 4000 A

SIZING OF UNIT AUX. SWITCHGEAR

UAT Rating = 16MVA, 11/6.9kV

Rated LV current with 10% margin = 1.1 X 16 X 1000/ (1.732 X 6.9)
= 1472.7A

Selected Rating = 1600 A

SIZING OF NEUTRAL GROUNDING RESISTOR

11 kV NGR FOR UNIT TRANSFORMER & STATION TRANSFORMER

11kV system is earthed by means of medium resistance connected to UT & ST LV neutral. NGR is to be chosen to ensure an earth fault current of the order of 300A in case of terminal earth fault

Voltage behind E/F current = 11.5/√3 kV

Fault current = 300A

R = (11.5 * 1000/√3)/300

= 22.13 ohm

Since adequate earth fault protection is provided on various incomers & outgoing feeders, a time rating of 10 seconds for NGR is adequate

Rating of NGR selected is 11.5kV, 22.13 ohm, 300A for 10 sec.

6.6 kV NGR FOR UNIT AUX. TRANSFORMER

6.6kV system is earthed by means of medium resistance connected to UAT LV neutral. NGR is to be chosen to ensure an earth fault current of the order of 300A in case of terminal earth fault.

Voltage behind E/F current= 6.9/√3 kV

Fault current = 300A

R = (6.9*1000/√3)/300

= 13.28 ohm

Since adequate earth fault protection is provided on various incomers & outgoing feeders, a time rating of 10 seconds for NGR is adequate

Rating of NGR selected is 6.9kV, 13.28 ohm, 300A for 10 sec.

2.0 FAULT CALCULATIONS AS PER ENCLOSED SHORT CKT STUDIES

DESIGN VALUES SELECTED FOR 11 UNIT & STATION SWITCHGEAR 50 KA(RMS) FOR 3 SECOND AND 125KA (PEAK)

DESIGN VALUES SELECTED FOR 6.6 UNIT AUX SWITCHGEAR 40 KA(RMS) FOR 1 SECOND AND 100KA (PEAK)

Chapter 5: RESULT/ PROPOSAL

Result of various system studies are enclosed as Annexure-I to Annexure-XV

Chapter 6: Conclusion

Sizing calculations, Load Flow Studies, Short Circuit Calculations & Motor starting study for selection electrical equipment viz. Transformers, Switchgears, Bus-ducts, Neutral Grounding Resistor have been completed and their parameters are detailed out in the report.