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An Overview of Classes & Grouping in Generator Protection at V. I. P. L. (Nagpur)

Prof. V. R. Doifode [1], Manali V.Aranke[2], Suyash M.Choudhary[2],Vividha V.Dhengre[2], Anmol M.Thawkar[2]

[1] Departement of Electrical Engineering Yeshwantrao Chavan College of Engineering, Wanadongri, NAGPUR.
[2] Departement of Electrical Engineering Yeshwantrao Chavan College of Engineering, Wanadongri, NAGPUR.

Abstract— *This paper accustom a case study on classes of protection of Generator and the Generator Relay installed at Butibori, V.I.P.L that recognizes the faults in 300MW Generator quickly and prevent them from unnecessary tripping or disconnections. This paper contains the information about all the different types of Generator protections along with tripping. The paper depict various protections working under the respective protection classes set at VIPL. Negative phase sequence protection, Generator Rotor earth fault protection, 95% & 100% stator earth fault protection, Low forward power protection, Differential protection and dead machine protection have been explained in details. In addition, the paper discusses the role of Numerical Relay for the generator protection.*

Keywords—Classes of protection, Differential protection and dead machine protection, Generator protection, Faults, Negative phase sequence protection, Generator Rotor earth fault protection, 95% & 100% stator earth fault protection, Low forward power protection, Generator numerical relay.

I. INTRODUCTION

Vidarbha Industries Power Limited (VIPL) is a 600 MW coal based Thermal Power Plant with 2 units of 300 MW. Following are the ratings of generator installed at VIPL:

Rated Capacity	353 MVA
Rated Power Factor	0.85
Rated Stator voltage	20kV
Rated stator current	10189 A
Rated speed	3000 rpm
Rated Frequency	50 Hz

Generator protection is an important part in any thermal power plant. The two major losses; Losses due to current and Losses due to voltage are most responsible for any Generator that needs protection. Losses due to current can be prevented by injecting active power by the means of increasing the stator's speed whereas losses due to voltages may be reduced by addition of capacitors (compensation) or, in short by providing exciter. Another major factor is the continuously varying frequency which may cause various losses inside the generator. So, to prevent all these losses, various Generator schemes are installed inside the plant.

Generator Protection Schemes are particular groupings of various protections of generator.

These classes are actually based on three factors:

1. Change in load current
2. Stator temperature and resistance
3. Rotor speed

After taking all these three factors into consideration, the Generator protection is classified into Class AI, Class AII and Class B.

1.1 CAUSES OF FAILURE IN GENERATOR

Generator is an electrical device which is used to convert mechanical energy into electrical energy by using external field. So like other electrical devices, occurrence of faults in Generator is frequent. This causes failure in Generators. Following are the causes of failure:

- Bad environmental conditions and irregular maintenance.
- Field and turbine failure

II. PROTECTION OF GENERATOR

The Generator Protection at V.I.P.L.mainly includes following Protections:

1) Voltage Controlled Over Current Protection (51V)
2) Dead Machine Protection (50/27)
3) Generator Circuit Breaker Failure (50BF)
4) Over Excitation Protection (24G)
5) Over Voltage Protection (59)
6) Reverse Power Protection (32R)
7) Low Forward Power Protection (32F)
8) Differential Protection (87G)
9) Under Frequency Protection (81G)
10) Over Frequency Protection (81G)

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11) Loss of Excitation (40G)
12) 95 % Stator Earth Fault (64G1)
13) 100 % Stator Earth Fault (64G2)
14) Generator Rotor Earth Fault (64F)
15) Exciter Rotor Earth Fault
16) I&C Trip from ETS.
17) Excitation System Fault
18) Generator Pole Slipping (78)
19) Negative Phase Sequence Protection (46)
20) Backup Impedance Protection (21)
21) Generator Cooling Water Loss
22) Conductivity High Loss

III. TYPES OF PROTECTION CLASSES:

1) **CLASS A-I**
2) **CLASS A-II**
3) **CLASS B**

3.1 OBJECTIVE OF CLASSIFICATION OF PROTECTION TRIPPING:

- Damage is minimum.
- Auxiliaries if possible are kept energized and time to restart the unit is minimum.
- Over speeding of TG due to sudden load throw off is avoided.

3.2 CLASSIFICATION DEPENDS UPON FOLLOWING:

1. Plant layout
2. Means how generator is connected to high voltage transmission line.
3. There are two different ways:
   A) Without GCB scheme
   B) With GCB scheme

A) **WITHOUT GCB SCHEME:**

- Generator synchronizing done at switchyard.
- Generator, GT& UAT are directly connected to switchyard.
- If any faults in generator then we have to open switchyard breaker..

3.3 Classification of generator protection tripping in this scheme is

1. Class A
2. Class B
3. Class C

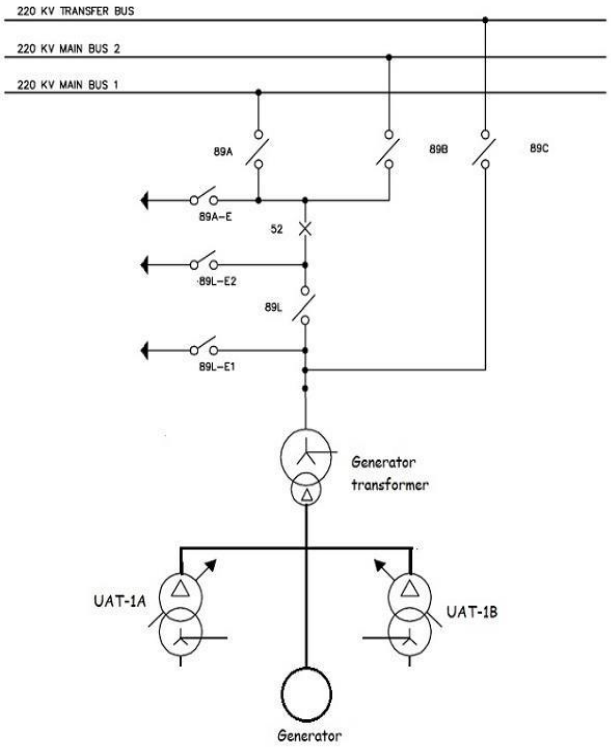

Figure:1 Without GCB scheme

- **Class A**

Class A trip involves a serious electrical fault like differential, stator earth fault etc. and is considered to be the most dangerous in terms of the shock on the unit.

Since it involves serious electrical faults, connections from both generator and the EHV bus is immediately switched off to limit the damage at the fault point and also to isolate the healthy system. Hence the unit (turbine, generator and boiler) has to be tripped.

- **Class B**

Class B primarily relates to mechanical problems. This results in tripping of turbine followed by generator.

- **Class C**

Class C involves basically external system related problems like frequency, overvoltage etc. This does not involve instant tripping of the unit. CPP unit operates on house load.

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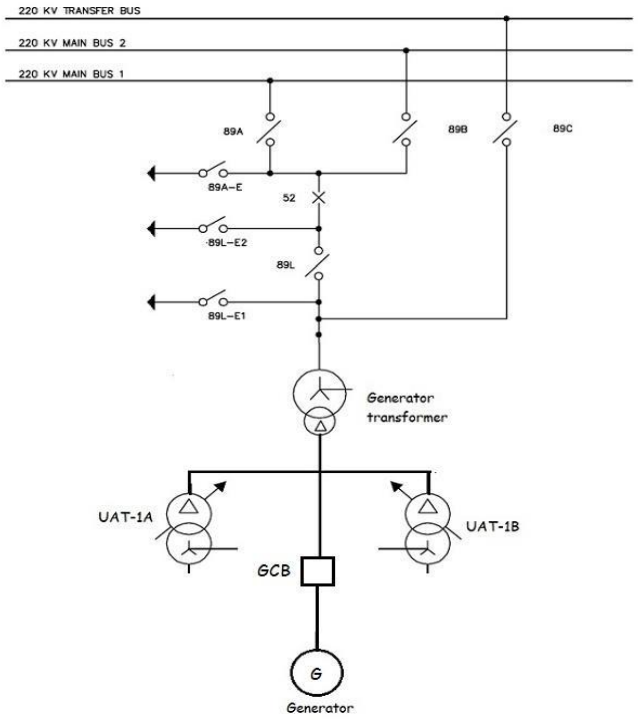

Figure: With GCB scheme

3.4 WITH GCB SCHEME

- Generator synchronizing done at TG building.
- Generator is not directly connected to GT,UAT & switchyard
- If any faults in generator then we have to open GCB.
- Classification of generator protection tripping in this scheme are
  1. Class AI
  2. Class AII
  3. Class B

- **Class AI**

Class A-I trip is mainly for faults in generator transformer and unit transformer.

In this class, trip goes to following equipments without time delay.

- Turbine.
- Generator Breaker (GCB).
- EHV Breaker.
- UAT LV breaker and Field Breaker.

- **Three generator protections come into Class-AI.**
  1. Voltage Controlled Over Current Protection (51V).
  2. Dead Machine Protection (50/27).
  3. Generator Circuit Breaker Failure (50BF).

- **Class AII**

Class AII trip is for faults in generator.

In this class, trip goes to following equipments without time delay.

- Turbine,
- Generator breaker (GCB),
- Field breaker.

- **Advantage of GCB scheme:**

The auxiliaries are fed through unit transformer by back charging of GT. Thus in Class A2 trip we are able to maintain uninterrupted power to the Unit bus and auxiliaries which was not possible in the scheme without GCB.

- **There are 13 generator protections into Class AII:**
  1. Over Excitation Protection (24G)
  2. Over Voltage Protection (59)
  3. Reverse Power Protection (32R)
  4. Under Frequency stage – 2 (81)
  5. Low Forward Power Protection (32F)
  6. Differential Protection (87G)
  7. Loss of Excitation (40G)
  8. 95 % Stator Earth Fault (64G1)
  9. 100 % Stator Earth Fault (64G2)
  10. Generator Rotor Earth Fault (64F)
  11. Exciter Rotor Earth Fault
  12. I&C Trip from ETS
  13. Excitation System Fault

- **Class B**

Class B trip also leads to generator breaker (GCB) tripping.

In this class, trip goes to only turbine.

There are 7 generator protections come into Class B

1. Under frequency stage-1 (81)
2. Over Frequency Stage-2 (81)
3. Generator Pole Slipping (78)
4. Negative Phase Sequence Protection (46)
5. Backup Impedance Protection (21)
6. Generator Cooling Water Loss
7. Conductivity High loss.

- **Generator Protection Relay:**.
  1. 7UM6225 Main Protection relay
  2. 7UM6115 Backup Protection relay
  3. 7XT33X & 7XT34X for 100% SEF

All the numerical relays used here are of Siemens make.

7UM6225 is used for primary protection. It is the main protection relay. There are total 25 primary functions inside this relay.

7UM6115 is used for secondary protection i.e. back up protection.

Both the relays are connected in a parallel interface.

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IV. RELAY SETTINGS FOR PROTECTION

➢ CLASS A-I

Protection Type		Pickup current	Time delay	Voltage pickup	V/F pick up
Voltage controlled over current protection		14400 A	0.30 Sec	Less than 13.64 kV	–
Dead machine protection		19200 A	0.30 Sec	Less than 14 kV	–
Over Excitation Protection	**S-1**	–	10 sec	–	1.15
	S-2	–	2 sec	–	1.25
Generator circuit breaker failure		1200 A	0.20 Sec	–	–

➢ CLASS A-II

Protection Type		Pickup current	Time delay	Voltage pickup	V/F pickup
Over voltage protection	**S-1**	-	3 Sec	24 kV	-
	S-2	-	0.5 Sec	26 kV	-
Under frequency protection	**S-1**	-	20 Sec	-	47.50 Hz
	S-2	-	4 Sec	-	47 Hz
Over frequency protection	**S-1**	-	5.0 Sec	-	51.50 Hz
	S-2	-	10 Sec	-	52.50 Hz
95% stator earth fault		-	0.5 Sec	5 V	-

➢ CLASS –B

Protection	Details
100% stator earth fault	R< SEF Alarm = 128 ohm R<< SEF Trip = 26 ohm T SEF Alarm = 10 sec T SEF Trip = 2 sec
Low forward power protection	Low forward pickup < 0.5% i.e. 1.5 MW Time delay < 3 Sec. Low forward Supervision pickup > 17% i.e. 51MW Time delay = ∞
Reverse power protection	Reverse power pickup < -0.5% i.e. -1.5 MW Time delay without stoppage = 15 Sec. Time delay with stoppage = 2 Sec.
I&C trip	No setting required.
Excitation system fault	No setting required.

NUMERICAL RELAY: -

The main relay for protection is Numerical relay.
7UM6225 Main Protection relay
7UM6115 Backup Protection relay
7XT33X & 7XT34X for 100% Stator Earth Fault

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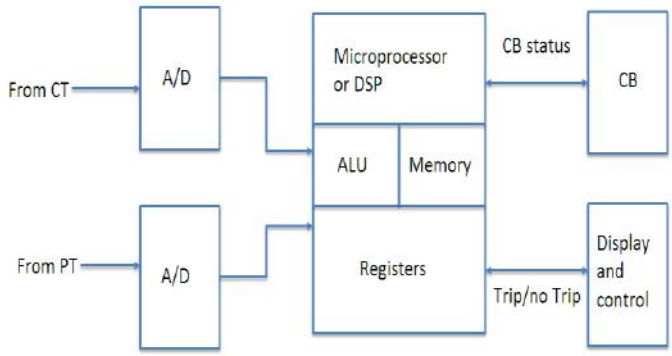

TYPICAL GROUPING OF RELAYS:-

GROUP-I -

- Generator Differential Relay
- Generator Transformer Differential Relay
- Generator Stator Earth Fault Relay for protection of 100% stator winding
- Generator Over-voltage Relay
- Generator Under-frequency Relay
- Generator Rotor Earth Fault Relay
- Generator Field Failure Relay
- Generator Low Forward Power Relay
- Generator Reverse Power Relay
- Generator voltage restrained O/C Relay

- Generator Transformer HV side O/C Relay (for backup protection)
- Unit Auxiliary Transformer(s) Differential Relay(s)
- Generator Negative Phase Sequence Current Relay

GROUP-II -

- Unit overall Differential Relay
- Generator Stator Earth Fault Relay for protection of 95% stator winding.
- Generator Transformer Overfluxing Relay
- Generator Overvoltage Relay.
- Generator Rotor Earth Fault Relay.
- Generator Field Failure Relay.
- Generator Pole Slipping Relay.
- Generator Low Forward Power Relay.
- Generator Reverse Power Relay.
- Generator Distance Backup Relay.
- Generator HV standby Earth Fault Relay.
- Unit Aux Transformers H.V. side overcurrent Relay (for back up protection)
- Generator Negative Phase Sequence Current Relay.
- Generator definite time over-current Relay.

V. CONCLUSION

This paper displays information about Generator installed at V.I.P.L. with its ratings. The faults occurring with respect to generator are studied and reasons are thus mentioned. To recover the Generator from these kinds of faults, the Generator Protection scheme of the plant is designed in such a way that groupings of generator protection are made respect to the plant's need and by considering convenience of operation of every protection with ease by all the employees and Engineers at V.I.P.L. Also, the paper describes about the Generator Circuit breaker scheme and its need. This Paper also give basic key points about the various Generator protections. For e.g. Dead machine protection, over excitation protection etc. Moreover information about the main relay used for Generator protection i.e. 7UM6225 and the backup relay 7UM6115 is also cited in this paper. The paper has discussed in short all considerations regarding Generator protection for the generator installed at Vidarbha Industries Power Limited.

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