Case Study on Generator Protection in N.T.P.S. (Eklahare)

[1]Diksha Amrutkar, [2]Rajashree Chavan, [3]Sushama Avhad
[1]Student, [2]Student, [3]Student
[1]Vishal khanderao vaidya,
[1]PRESS Sir Visvesvaraya Institute of technology, Nashik, India

Abstract : This Paper accommodate a case study on Protection of generator and Generator relay installed at Eklahare, NTPS that recognizes faults in 210MW unit and prevent them from unnecessary tripping. an electrical protection system design is most important to ensure reliable and efficient operation in thermal power plant. The paper describes various generator protections working under respective protections classes set at NTPS on the basis of tripping. Differential protection of generator, stator inter turn protection, stator earth fault protection, loss of excitation, generator under and over frequency protection have been explained in details.

***Index Terms* - Generator, Classes of Protection, Differential Protection, Loss of Excitation, Reverse Power Protection, over voltage protection.**

I. INTRODUCTION

Nashik Thermal Power Station (NTPS) is 630MW coal based thermal power plant with 3 units of 210 MW. Generator is costly equipment and one of the major links in a power system. The basic function of protection applied to generators is to reduce the outage period to a minimum by rapid discriminative clearance of faults. Unlike other apparatus, opening a breaker to isolate the faulty generator is not sufficient to prevent further damage, since the generator will continue to supply power to a stator winding fault until its field excitation is suppressed. It is therefore necessary that the field is opened, fuel supply to prime mover is stopped and sometimes braking application becomes imperative. While selecting the scheme generator protection, the protection of complete unit and stability of system due to disturbance in the generator should be considered in addition to the protection of generator itself. Following are ratings of generator installed at NTPS**:**

Make	BHEL
KVA Rating	247,000 KVA
KW Rating	210,000 KW
Rated Terminal Voltage	15750 V
Stator Current	9050 A
Power Factor	0.85 lag
Rated Frequency	50 Hz
Rated Speed	3000 RPM

1.1 Causes of Failure in Generator

A generator is a device that converts one form of energy into another especially motive power from turbine to electrical power for use in an external circuit. The source of mechanical energy include hand crank to an internal combustion engine and turbine used in power plants .Following are causes of failure in generator:
1. Faults in protective system
2. Failure of relay contact leading to improper circuit breaker closure
3. Failure in steam turbine blade

II. PROTECTION OF GENERATOR

The Generator Protection at (NTPS) mainly include following protections:
1. Differential protection (87G)
2. Stator Earth fault protection(64G)
3. Stator inter turn protection (95)
4. Loss of excitation (40G)
5. Under & over Frequency protection (81G)

6. Reverse Power Relay (32R)
7. Under & over voltage (59G)

III. TRIPPING CLASSIFICATION OF GENERATOR

The tripping classification of generator is based on the need of isolation of generator on the basis of type of fault. Trips are mainly classified as Class A, Class U, Class B, Class C, Class D (also Class E- electrical system not included) etc.

3.1 Class A trip (Simultaneous tripping)

Provides the fastest means of isolating the generator. This tripping mode is used for all internal generator faults and severe abnormalities in the generator protection zone. Isolation is accomplished by simultaneously tripping the generator breakers and field breaker, shutting down the prime mover by closing the turbine valves and transferring unit auxiliary loads to standby power.

3.1.1 Class-A1 trip

The protections for the faults in the generator which need immediate isolation are grouped under this class-A1. There is list of faults which are kept under this class. They are as follows:

1. Generator differential protection
2. Stator earth fault protection
3. Generator over voltage protection
4. Starting over current protection
5. Generator inter-turn protection
6. Generator negative phase sequence

3.1.2 Class-A2 trip

The protections for the faults in generator transformer, isolated phase bus duct, and unit transformer which need immediate isolation are grouped under this class-A2. Normally following protections are kept under this class:

1. Back up impedance protection of generator
2. Differential protection of GT
3. Buchholz relay of GT
4. Over fluxing protection of generator
5. Trip of GT
6. Fire protection of GT
7. Differential protection of UT
8. Restricted earth fault

3.2 Class-B Trip

The purpose of sequentially tripping a turbine generator is to minimize the possibility of damaging the unit as the result of an over speed condition following the opening of the main generator breaker. The protections for the faults in the generator which do not need immediate isolation are grouped under this class-B. This results in tripping of turbine first. Let us suppose that there is some fault in the process side i.e. in steam cycle, under that condition also turbine will be tripped first while generator will continue to run utilizing trapped steam till reverse power relay operates. Generator circuit breaker is tripped on initiation of reverse power. Normally,

1. Stator water flow very low
2. Hp heater level very high
3. Turbine hand trip
4. Loss of excitation
5. Generator reverse power

3.3 Class-C Trip

The protections for the faults / abnormal condition in the grid which call for disconnection of the generator from the grid are grouped under this class-C. In this case, generator is isolated from the grid by opening the suitable breaker i.e. generator transformer HV side breaker. Mind that in this case only generator is isolated from the grid. Thus generator continues to feed station loads (also known as house load). Such scheme where generator is operated on house load at reduced power is known as generator islanding. Normally following protections of generator are kept under this class:

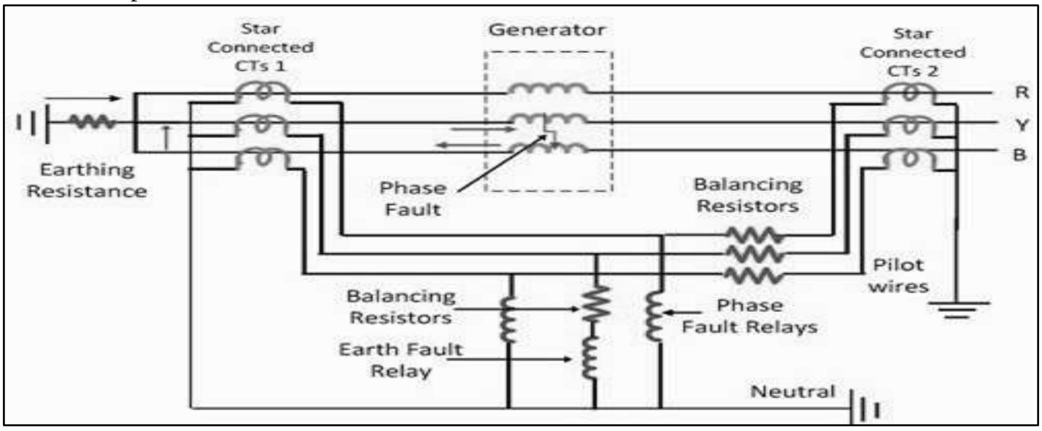
1. Unbalance or negative sequence protection
2. Back up impedance protection
3. Under frequency
4. Over frequency

IV. TYPES OF GENERATOR PROTECTION

4.1 Class A Trip

4.1.1. Generator Differential protection

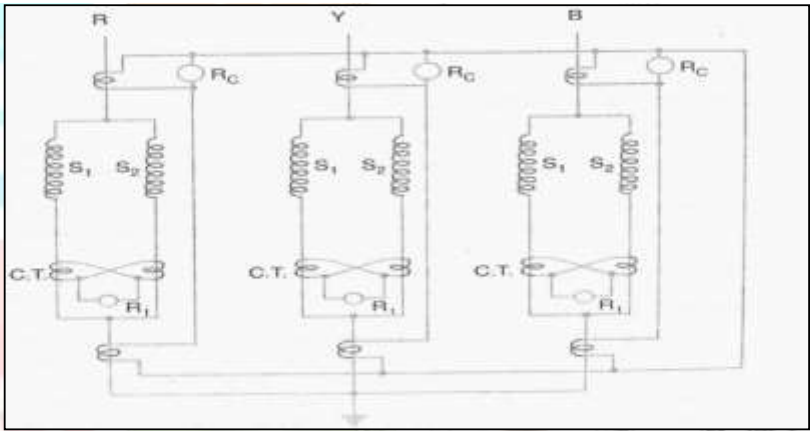
A Differential protection is effective method of providing protection to electrical equipment against internal fault. For differential protection one group of CT are located at neutral side and another group of CT located at generator phase side. It consist of restraining coil connected with the help of pilot wires and current in both CT's flow through it. The operating coil placed between midpoint of restraining coil. Under normal operating condition torque produced by restraining coil is greater than operating coil torque so relay remains inoperative. When internal fault occur operating torque exceeds restraining torque causes tip circuit contacts close to open circuit breaker.



"Fig.4.1 Merz-price differential protection"

4.1.2. Stator Inter turn Protection

The primaries of CT's are inserted in this parallel path and the secondary's are cross connected as shown in fig when there is not fault currents flowing through the two parallel paths of stator winding will be equal and therefore no current will flow through relay operating coil but during inter turn fault in the phase winding the currents flowing through the two parallel paths will be different and current proportional to the different up to current will flow through the relay operating coil which will close the trip circuit and isolate the machine from the power system such protection can be externally sensitive.



"Fig. 4.2 Inter turn protection of stator winding"

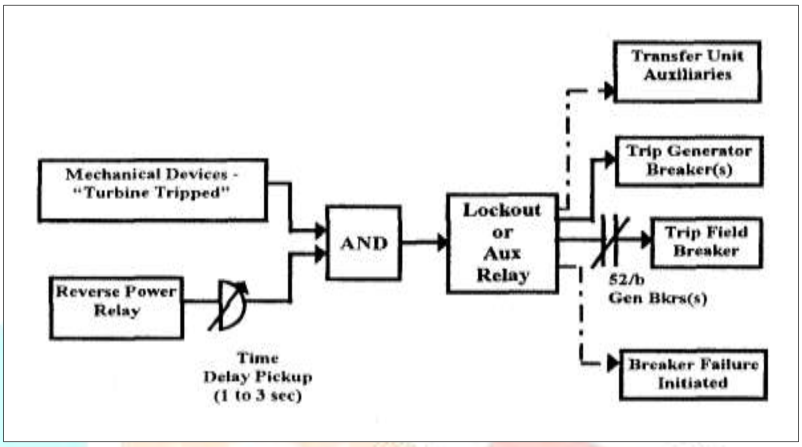
4.2 Class B Protection

4.2.1 Loss of Excitation

When excitation is lost on a synchronous generating unit, it continues to supply real power to the system as an induction generator Its speed increases above rated as it obtains its excitation from the system. The unit becomes a large reactive drain on the system. This large reactive drain causes problems in the machine, adjacent machines and the power system. Operation as an induction generator causes induced currents to flow in the field winding and the rotor body (rotor teeth, wedges, retaining rings, etc) The high reactive component of the armature current can also overload the stator winding. The permissible time before damage can occur depends on the type of machine, type of excitation loss, turbine governor characteristics and system conditions. This time can be as short as seconds Of course, should the loss of field condition be caused by a short-circuit in the excitation systems, tripping should occur as soon as possible to minimize damage at the point of the fault. Additionally, a large reactive drain on the system can cause low system voltages which, if excessive or prolonged, can cause system instability or problems of reactive supply on other portions of the system Due to the immediacy of the effects of the abnormality on the generator, the unit should be tripped from the power system by means of a simultaneous trip or a generator trip. Especially important is that all excitation power be removed, since it is possible that the exciter power is feeding an internal fault.

4.2.2 Reverse power protection

By definition, a generating unit is motoring when rei31 power flows into the generator from the power system. The generator performs as a motor, driving the turbine. Power required to motor depends upon the friction and windage losses of the steam turbine generator, typically in the range of 0.5 to 3% of rated generator power output. A sensitive electrical relay which can detect reverse power flow into the unit is the best means of detecting a motoring condition. All manufacturers surveyed recommend that an electrical reverse power relay supervise the mechanical device(s), see Figure since it may not be possible to set the mechanical devices to accurately measure the point where reverse power flows into the machine. The reverse power relay must exhibit the necessary sensitivity to detect a reverse power condition and incorporate sufficient time delay to avoid nuisance tripping. It is typically set to pickup below machine rated motoring power, by a margin, to insure that there is not sufficient steam flow into the turbine to cause an over speed when the generator breakers are opened. Some older steam turbine generators are not equipped with stop valve limit switches. For those units, a reverse power relay should be used at a minimum as the method of detecting a motoring condition. A time delay is also used in the logic circuit to provide maximum security against a possible over speed condition Since permissible monitoring times for most units arc on the order of minutes, the additional time delay (typically one to three seconds is recommended) will not increase the likelihood of equipment damage. Should a main generator breaker fail to open in the sequential trip shutdown process, the generator will operate as an induction motor after the field breaker trips. Thus type of operation can result in a severe local system voltage depression, and damaging currents can be induced in the generator rotor winding and body. To protect against this possibility, one can supervise the field breaker trip by using auxiliary “b” contacts from the generator breaker. Delayed tripping of the field breaker will not result in any additional damage to the unit Breaker failure should be initiated by the sequential tripping scheme lockout as shown in Figure



“Fig.4.3 Sequential Tripping Logics”

4.3 Class C Protection

4.3.1 Under & Over frequency Protection (81G)

Generally, Generator can be operated continuously at rated output with a frequency variation of ± 5% over the rated value. However, the performance of the generator with frequency variation is limited by the turbine capability. In case of under frequency, two tripping’s are provided. One with a time delay and another instantaneous at lower frequency than the time delay trip frequency level. In case of over frequency, only one tripping with a time delay is provided. If there are No. of sets at a station, the tripping of individual sets on over frequency protection is segregated, so as to avoid simultaneous tripping of all the sets on over frequency protection. Single tripping of one / two sets may bring down the frequency. The speed of a turbo-generator set rises when the steam input is in excess of that required for the load. The Speed Governor can normally control the speed, and in any case, a set running in parallel with others in an interconnected system cannot accelerate much independently even if synchronism is lost. However, if load is suddenly lost when Main Circuit Breaker is tripped, the set will begin to accelerate. The Speed Governor is designed to prevent a dangerous speed rise even with a 100% load throw off, but nevertheless an additional centrifugal over speed trip device is provided to trip the emergency steam valves, if the over speed exceeds 10% and 11%. Despite these safety measures, a risk still remains, if the steam valves fail to close completely, even a very narrow residual opening can pass enough steam to cause an over-speed with no load on the generator. Protections associated with severe electrical faults is arranged to trip the main circuit breaker, field breaker and turbine steam valves simultaneously. This action is necessary to minimise consequential damage and has been assessed as presenting the least overall risk. For less urgent protective trips i.e. turbine tripping, the risk of over-speeding is avoided by delaying the opening of main circuit breaker until the output of generator is reduced to about 1% of rated value. This is done through the low forward power relay. Even if steam input is not reduced any further, tripping of main circuit breaker at such a small load will not cause a dangerous speed rise.

4.3.2 Generator over Voltage Protection (59)

Depending on the type of insulation and insulation level used for stator winding, the manufacturer specifies the operational limits of the generator **voltage.** For 200 / 210 MW BHEL Sets, these are as Rated Voltage 15-75 ± 5% for continuous full load operation. The Machine can be operated continuously up-to 110% over voltage at reduced loads, but operation above 110% over voltage is not allowed. Hence, to detect the over voltages and trip the machine quickly, this protection is provided. Two types of over voltages can occur:

4.3.2.1 Transient over Voltage-

These are originated largely in the transmission system because of witching and atmospheric disturbances. According to the degree of risk, such surges are dealt with by coordinating gaps shunting the EHV terminals to earth, or surge diverters connected to incoming lines or station bus bars. Surge diverters are also connected to the generator terminals.

4.3.2.2 Power Frequency over-voltage

Generally over voltages should not occur on a machine fitted with AVR. But some times over voltages may occur due to various reasons such as Response time of AVR and Excitation system, when there is a sudden loss of load due to line tripping etc. Defective operation of AVR, When AVR is on manual control, a sudden variation of load in particular the MVAR component.

V. CONCLUSION

This paper displays information about generator installed at NTPS with its ratings. The fault occurring with respect to generator is studied and reasons are thus mentioned. To recover generator from this kind of faults generator protections schemes of plant is designed in such a way that grouping of generator protection are made respect to plants need and by considering convenience of operation of every protection with ease by all employees and engineers at NTPS.

VI. REFRENCES

[1] A book on “Switchgear Protection and Power System” by Sunil S. Rao.
[2] McGrath, R.V., Izquierdo, N.A. and Wirth, G.J. “Reverse-power Relay Response Under High-VARUnit Conditions.” Proceedings of the American Power Conference, April 199 1.
[3] Steam Station Protection Working Group “Minimum Recommended Protection, Interlocking and Control for Fossil-Fuel Unit-Connected Steam Station, Part I: Overall Protection”. IEEE Transactions on Power Aptmatus and Systems. Vol. 92, No. 1. Jan/Feb. 1973. Pages 374-380.
[4] IEEE Standard C37.102, IEEE Guide for AC Generator Protection.
[5] https://en.wikipedia.org/wiki/Nashik_Thermal_Power_Station
[6] IEEE/PSRC Working Group Report, “Sequential Tripping of Steam Turbine Generators,” IEEE Transactions on Power Delivery, Vol. 14, No. 1, January 1999, pp. 132–141.