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The Optimum Tests For High Voltage SF6 Circuit Breaker In The New Substation Before Energizewith The National Grid

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ABSTRACT: Its high coast to design and manufacture high voltage substation that may be fail service at any small fault or problem in the equipment, the protective equipment will operate to restrict danger to human life and high voltage equipment. High-voltage circuit breakers are mechanical switching devices which connect and break current circuits (operating currents and fault currents) and carry the nominal current in closed position, in this paper will show and discuss the circuit breaker, SF6 circuit breaker type and the optimal tests for the high voltage circuit breaker (timing test, contact resistance test, gas sf6 analyzer test, gas leakage test and high voltage test).

Keywords: High voltage, Test circuit Breaker, Timing test, Contact Resistance Test, gas sf6 analyzer test, gas leakage test and high voltage test

1. Introduction

Circuit breaker is mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions. Also capable of making and carrying for a specified time and breaking currents under specified abnormal circuit conditions, such as those of a short circuit see figure (1) Where fuses are unsuitable or inadequate, protective relays and circuit breakers are used in combination to detect and isolate faults. Circuit breakers are the main making and breaking devices in an electrical circuit to allow or disallow flow of power from source to the load. These carry the load currents continuously and are expected to be switched ON with loads (making capacity). These should also be capable of breaking a live circuit under normal switching OFF conditions as well as under fault conditions carrying the expected fault current until completely isolating the fault side (rupturing/breaking capacity). Under fault conditions, the breakers should be able to open by instructions from monitoring devices like relays. The relay contacts are used in the making and breaking control circuits of a circuit breaker, to prevent breakers getting closed or to trip breaker under fault conditions as well as for some other interlocks.

2. Operation of Circuit Breaker

A medium voltage breaker performs the following functions:
- Allows buses and components to be energized and de-energized as needed during normal switching operation.
- When a system component develops a short circuit or other problem activating a protective relay; it must interrupt current and voltage to associated loads and from power sources to protect the system.

Circuit breakers are classed or referred to by their voltage size and arc extinguishing method.

2.1 Operating voltage

Circuit breakers are grouped by voltage classes that are normally defined as low, medium, and high. We will find some texts refer to only two classes, Low Voltage and High Voltage, but the breaker industry generally use three voltage size groupings. Low Voltage (0-600V): Generally includes Molded Case breakers, and the new design large molded frame power breakers b- Medium Voltage (600V through 15KV): this includes 4160V, 6.9KV and 13.8KV. Sometimes 34KV breakers are included. c- High Voltage (Above 15KV): These are usually breakers associated with transmission and first line step down coming off transmission. Also anything above 34KV is generally outdoor gear.

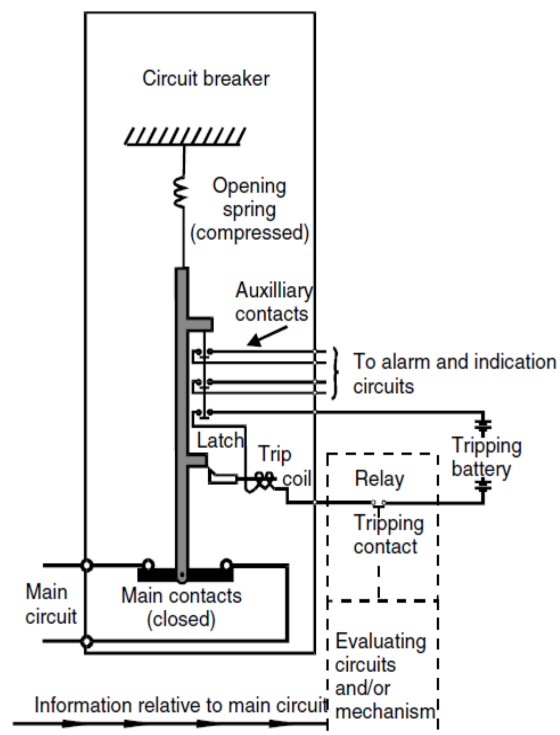

***Fig. 1** Design for the high voltage circuit breaker*

2.2 Circuit Breaker Ratings

Common current ratings for medium voltage breakers are 1200 Amp, 2000 Amp and some applications also have a

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3000 Amp rating. As the current rating is increased the breaker will require: larger copper bus and additional contacts to carry the increased load (amps), stronger operating springs are required to provide additional acceleration for the contacts closing and opening, and larger arc chutes to dissipate the additional fault currents. The circuit breaker types (Air-Break Circuit Breakers,Oil Circuit Breaker, Vacuum and SF6 isolation type where the circuit breaker vacuum and sf6 have larger interrupters.

2. SF6-Gas Circuit Breakers

SF6 gas and its characteristics were discovered in 1920s but the development of SF6 gas as an interrupting medium applied for circuit-breakers began in 1940s. However, the SF6 circuit breakers first came to the market in 1960s. The properties of SF6 gas are superior to other interrupting mediums as follows:

a. High dielectric withstand characteristic. For example, SF6 gas at absolute pressure has twice the dielectric strength of air and at 3 bar it is comparable to oil.
b. High thermal conductivity and short thermal time constant (1000 times shorter than air) result in better arc quenching.
c. Arc voltage characteristic is low thus resulting in reduced arc-removal energy.
d. At normal conditions, SF6 is inert, non-flammable, non-corrosive, odorless and nontoxic. However, at the temperature over 1000°C, SF6 decomposes to gases including S2F10 which is highly toxic. Fortunately, the decomposition products recombine abruptly after arc extinction (when the temperature goes down).

The problem of moisture from the decomposition products must be considered. The moisture can be absorbed by a mixture of soda lime (NaOH + CaO), activated alumina (dried Al2O3) or molecular sieves. The other problem is the condensation of SF6 at high pressures and low temperatures. For example, at a pressure of 14 bars, SF6 liquefies at 0°C. In the areas with low ambient temperature such as Canada, Scandinavian countries and Russia, gas heaters must be utilized. The other solution is the introduction of gas mixtures such as nitrogen (N2). Although the gas mixture of SF6/N2 can be used in the low ambient temperature, the dielectric withstands capability and arc interruption performances are reduced. For example, the short-circuit capacity rating of 50kA is reduced to 40kA. The development and types of SF6 circuit breakers can be represented as follows

3.1 Double-pressure SF6 circuit-breakers

This type is developed by using principles similar to air-blast circuit-breakers. The contacts are located inside the compartment filled with SF6 gas. During the arc interruption, the arc is cooled down by compressed SF6 from a separate reservoir. After the interruption, SF6 gas is pumped back into the reservoir. This reservoir must be equipped with heating equipment to ensure that the SF6 will not liquefy. However, failures of heating equipment can result in this type being unable to operate as circuit-breakers. This type of SF6 circuit-breaker is rarely used in the market nowadays because of its high failure probability.

3.2 Self-blast SF6 circuit-breakers

The interrupting chamber of this type of circuit-breaker is divided into two main compartments with the same pressure (around 5 atm). During the arc interruption, the gas pressure in the arcing zone is heated resulting in high pressure. This high pressure gas fromthe other compartment then blasts into the arcing zone and in the meantime cools the arc column. Finally, the arc is extinguished. This type of circuit-breaker is normally used in highvoltage levels up to 123 kV.

4. Puffer-type SF6 circuit-breakers

The principle of this type is to generate compressed gas during the opening process. The moving contacts move the piston and thus compressing the gas in the chamber. As a result, the compressed gas flows along the arc channel and thereby extinguishing the arc. The development of puffer-type SF6 circuit-breakers can be divided into two generations: first and second generations. The principle of arc interruption of both generations is similar but the improvements of the second generation concentrate on the better design, improvement of short-circuit rating, arcing contact lifetime and the material of the nozzle Since the gas has to be compressed, the puffer-type SF6 circuit-breaker must have a strong operating mechanism. For example, when large current such as three-phase fault is interrupted, the opening speed of circuit-breakers is slowed down because of thermal pressure. The operating mechanism should have adequate energy to move the contacts apart. Consequently, the reliable operating mechanisms dominate the costs of circuit-breakers. At present, SF6 circuit-breakers are predominant in high voltage levels with the high short circuit capability up to 63 kA. They can be used as dead tank circuit-breakers, live tank circuit-breakers and in gas insulated substation (GIS).

5. Tests for the circuit breaker

Circuit breaker before operation or after maintenance should be operating the timing test and the contact resistance test and gas Sf6 test

5.1Timing tests for the circuit breaker

Timing test the breaker should be ability to cut off the power circuit at the trip order , also ability to close the power circuit at close order without pole discrepancy, noted that if the close at the fault the breaker will be trip so the breaker should ability to close-trip order, also if the fault operate the breaker should be trip , we should to test the circuit breaker for the trip at 56% from the normal operation voltage, close at 72% from the normal operation voltage and close and trip at 110% from the normal operation voltage.Experiment for the timing test on the circuit breaker 110kv. Using tester (meager timing) instrument which showing in the figure (2) and the connection shown in the figure (3). Note that the result writing in the table printed with the figure an example the test for (close) completely result printed sheet shown in figure (4).

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Fig.2 *tester (meager timing) instrument.*

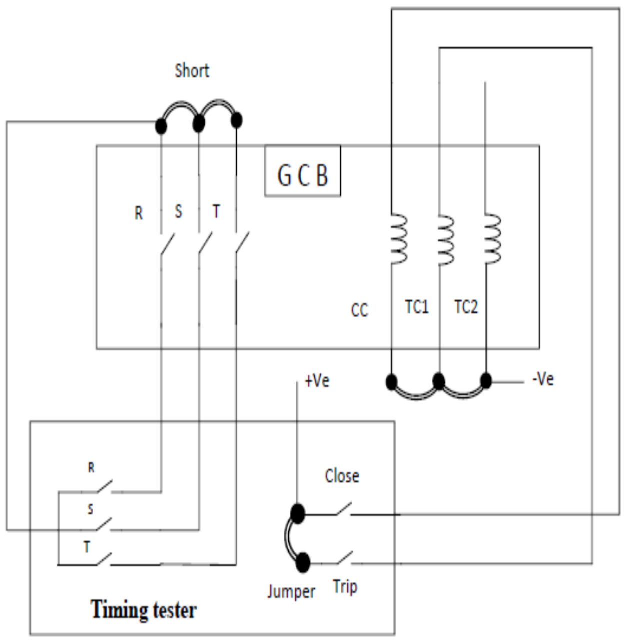

Fig3. *Connection test timing with the circuit breaker*

Test for the circuit breaker by expectation all operation which can to operation for the circuit breaker high voltage can this action operate so this needed to test, Table 1. Shows all test result from all test printed sheet.

a. (Close)test (the result sheet shown in the figure (4)
b. Open order for trip coil 1 (the result test sheet shown in the figure (5)
c. Open order for trip coil 2 (the result test sheet shown in the figure (6)
d. (Close-open) test, by assume that the circuit connected at the fault so the protection will send order to trip coil1 , trip coil 2 for the circuit breaker so we test (close-open 1) and (close-open 2) the
e. (open-close-open) test, for over-head transmission line the protection operate an auto reclose to the circuit breaker after the trip order where if the fault not accrued, the protection relay will send trip order so the circuit breaker will operate an (open – close – open) this test is shown in the figure (7).

Note: the experiment for test at normal voltage 125 v dc, and the test for132 KV circuit breaker.

TABLE 1
All result from all test printed sheet

Control Voltage	Operation	Main Contact			Coil cur.(A)
		Phase-R(ms)	Phase-Y (ms)	Phase-B (ms)	
125 V DC	C	84.8	85.4	84.7	6.76
	O-1	23.8	23.6	23.6	7.758
	O-2	23.7	23.5	23.5	7.936
	C-O-1	121.6	121.3	121.6	
	C-O-2	121.8	121.4	121.9	
	O-C-O (1)	320.8	320.3	320.7	

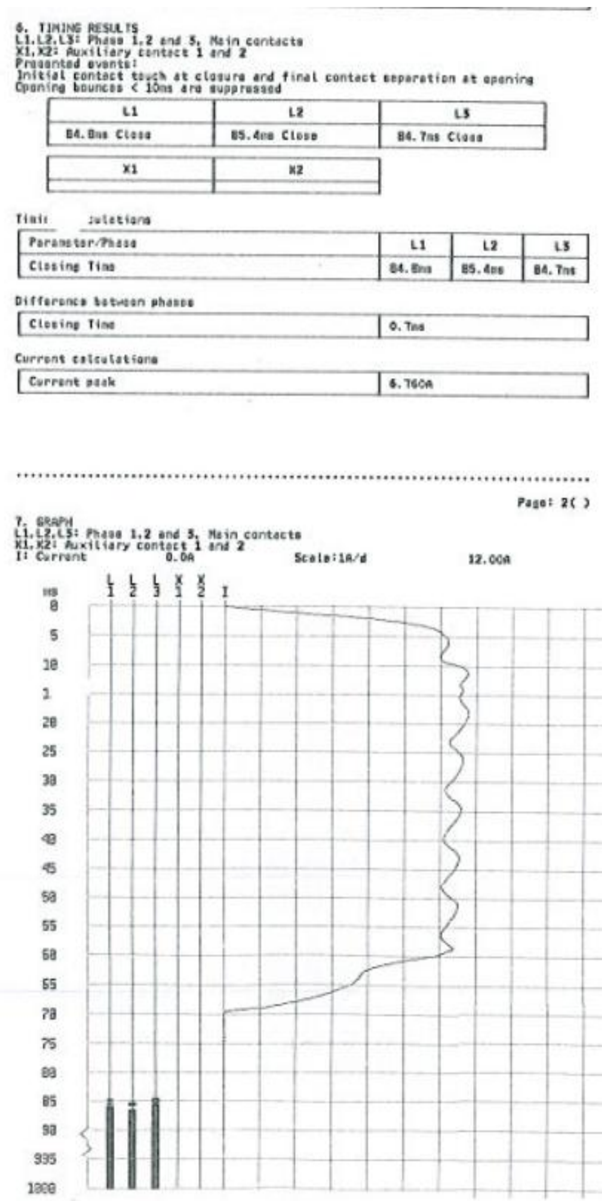

Fig.4 *completely closing result sheet*

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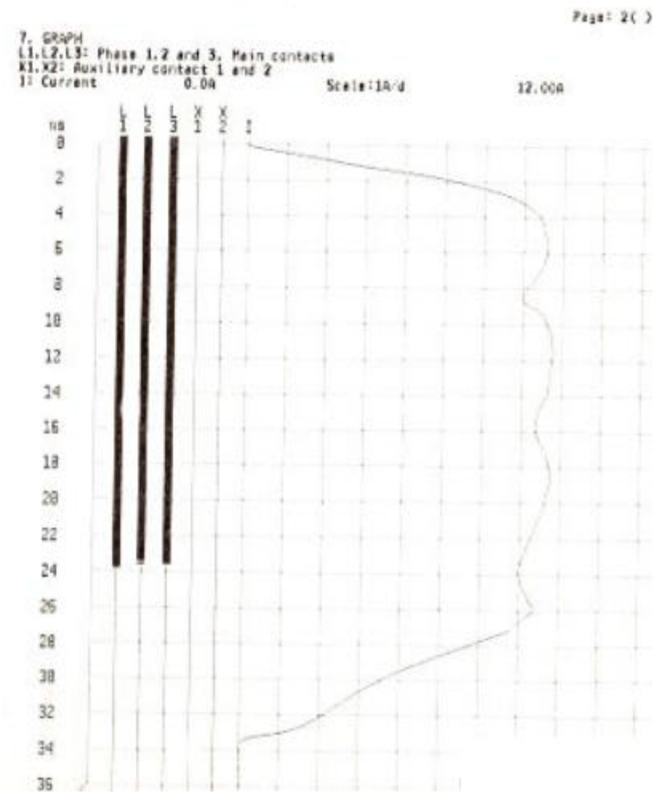

Fig.5 *open circuit breaker test (by trip coil 1)*

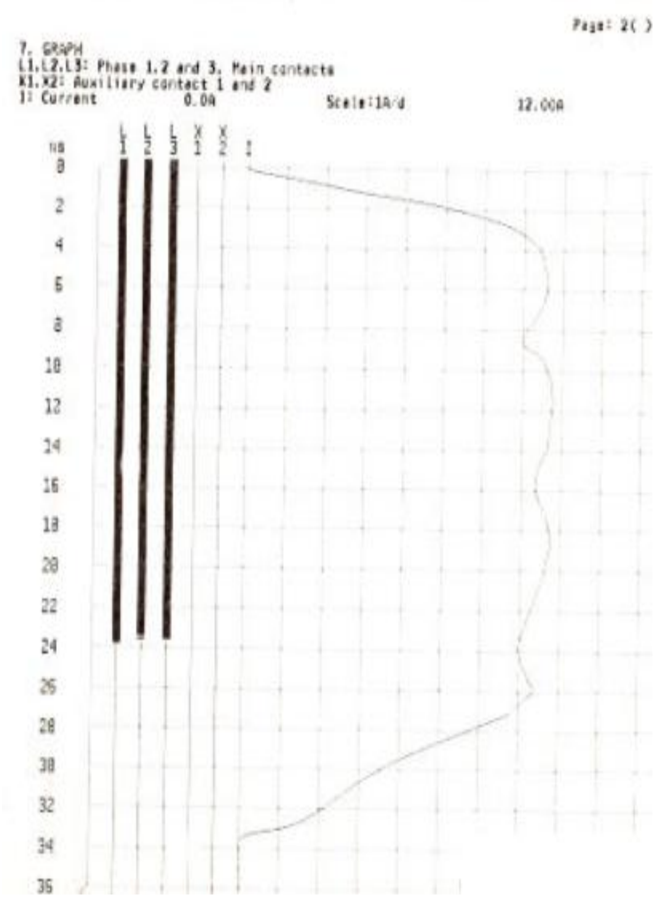

Fig.6 *open circuit breaker test (by trip coil 2)*

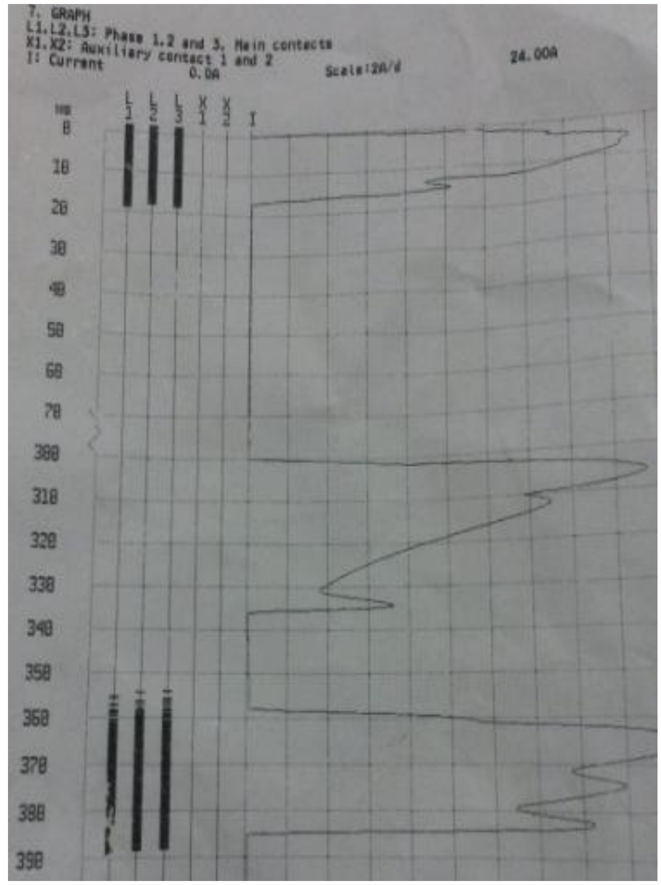

Fig.7 *open close open printed test sheet*

5.2 Contact resistance Test

This test to know the contact resistance at close circuit breaker that should be very small and at test its used the instrument inject current= 100 A and measure the voltage at tow pole then calculate the resistance. The connection in the figure (8)

In Table (2) shown Test result for the value from the instrument.

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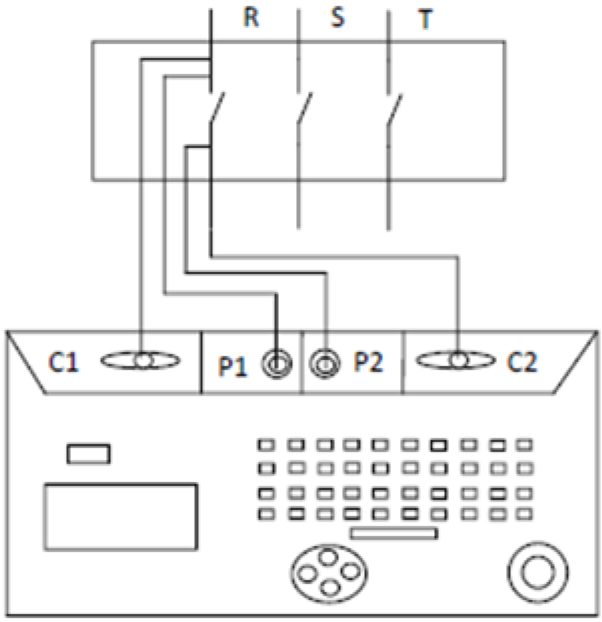

Fig.8 *the connection for the contact resistance test*

Table.2
Test result for the value from the instrument.

Connection Point between	Phase	Measured Resistance micro Ohm At 100A DC	FACTORY TEST
Circuit breaker -Q0-	R	250	247
	Y	243	236
	B	253	249

5.3 Gas SF6 test for the circuit breaker
Gas analyzer tester is shown in the figure (9), which connected with the valve from the circuit breaker. The result for test the pressure for the gas in the circuit breaker, the percentage of the SF6 gas inside the circuit breaker and the temperature for the gas converted to liquid. The experiment test the 380 kv (GIS) circuit breaker and the result from SF6 gas tester are shown in the table (3)

Fig. 9 *SF6 Gas analyzer tester (SF6 MULTI-Analyzer)*

Table.3
Test result for the value from the SF6 gas analyzer

Test type	Result	Remark
Gas pressure	-55 C degree	ok
Temperature the gas convert to liquid	5.7 bar	ok
Percentage of the gas in the breaker	99.99 %	ok

5.4leakage test for Gas SF6
The connection parts in circuit breaker should be no any leakage gas from the circuit breaker this test by using the gas leakage tester where the test by moving the sensor from the tester beside the circuit breaker connection chamber where at at any gas leakage the tester will be sound , the tester shown in figure (10)

Fig.10 *Gas leakage tester instrument*

5.4High voltage test.
The design for the circuit breaker should be not fail at any over voltage so the design should be tested under (normal voltage * sqr(3)) , and to sure that the isolation between three phase designed to operate at normal voltage and not fail at over voltage in the grid, where the test applied for one phase by one , another two phase connected with ground, the tester will measure losses current in the phase under test (this value by small 10 to 20 mA), and it any flash over the tester will be stop and give alarm for the flash over this means the phase under test not accuracy for isolation from the ground or with another phase.High voltage tester is shown infigure (11).

Fig. 11 *High voltage tester*

CONCLUSIONS
Testing of high-voltage circuit breakers in the high-power substation and the related measurements and measuring equipment are the main important test for the circuit breaker before energize the substation with the national grid.

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So after this discussion for the test high voltage circuit breaker should be test

1. The timing at any expected condition for the operation.
2. Contact resistance test to show the connection between the two part from circuit breaker
3. SF6 gas analyzer test, to test the presure for the gas in the circuit breaker, the percentage of the SF6 gas inside the circuit breaker and the temperature for the gas converted to liquid.
4. Leakage test for Gas SF6
5. High voltage test

REFERENCES

[1] Mazenabdelsalam, Hussein Anis, Ahdab EL-morshedy, Roshdyradwan, “High voltage engineering theory and practice” second edition.

[2] “Protection Relay Theory” – Walter A. Elmore - second edition

[3] Applications of High Voltage Circuit-Breakersand Development of Aging Models, VomFachbereich 18– Elektrotechnik und Informationstechnik –der TechnischenUniversität DarmstadtzurErlangung der Würdeeines, Doktor-Ingenieurs, Darmstadt 2007

[4] J. Lewis Blackburn and Thomas J. Domin “Protective Relaying “Principles and Applications “Third Edition (2006) , ISBN10: 1-57444-716-5

[5] ABB - Protection Application Handbook, BA THS/BU Transmission Systems and Substations ABB Transmission and Distribution Management Ltd book no (6), BA THS / BU Transmission Systems and Substations, P. O. Box 8131, CH - 8050 Zürich Switzerland

[6] “ Various Types of Circuit Breakers used inPower System for Smooth Working of theTransmission Line “MIT International Journal of Electrical and Instrumentation Engineering, ISSN 2230-7656, Aug. 2012.