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High Power Laboratory

To meet the growing needs of short circuit testing of switchgear and power transformers, the high power laboratory was established in CPRI, Bangalore, in 1991. The laboratory was planned with total installed capacity of 7500 MVA, which is to be achieved in three stages. In the first stage, 2500 MVA direct test facility with parallel current injection synthetic test circuit was installed. The technical consultancy for the laboratory was provided by EDF High Power Laboratory, Les Renardiers, France. The vital equipments of the laboratory, viz, short circuit generator, short circuit testing transformers and the master circuit breakers and make switches, are specially designed with essential technical characteristics required for short circuit testing of switchgear, power transformer and other electrical power equipments. The laboratory is having the most modern measuring, control and protection equipment. The short circuit and switching tests conducted in the laboratory are strictly in accordance with IS, IEC, ANSI standards. The short circuit generator has been converted into motorless system with state-of-art technology electronic controllers, which ensure trouble-free testing service to customers from our country and abroad. The two decades of service rendered by CPRI High Power Laboratory has resulted in quality-rich, reliable switchgear and power equipment for the utilities and end users. The laboratory is providing continual service to nation building activities in the field of power sector.

When a new power equipment is manufactured, it needs to be tested for proving its design and performance characteristics. The most important and the crucial type test for the electrical equipment is the short circuit test. There are two distinct methods to carryout short circuit test, viz; (a) using the grid power directly from the line and (b) using specially designed short circuit generator.

To carry out short circuit tests, using electrical network as source is has certain limitations: (a) availability of the enormous amount of grid power; (b) the time at which the short circuit loading can be done; (c) Grid stability problems; (d) Reduced flexibility to meet the various ranges of test equipment rated at different voltage and current levels. Whereas, the short circuit generator-based testing laboratory is largely beneficial, that is there will be no disturbances to the electrical network. It has got an excellent flexibility to meet all the test requirements of various switchgears, transformers and other power equipments of different voltage and current ratings. The critical aspect of generator-based high power laboratory is that there are only few manufacturers around the world who can supply the short circuit generator.

Not only the short circuit generator, the associated equipments like short circuit testing transformers, back up master circuit breakers, high precision making switches, high current reactors and other vital equipments needed for the high power laboratory can be supplied by only few manufacturers all around the world. This makes establishment of the Short Circuit High Power Test Laboratory capital-intensive and time-consuming. The time taken to establish the High Power Lab is also more due to the complication of non-conventional and special design, requirement of special jigs and fixtures during manufacturing process, transportation of heavy equipment over long distances and also the constraint of the limited suppliers of the raw materials like the forge for the rotor of the

generator and other equipments needed for the laboratory.

In the beginning of 1980s, M/s. BHEL, M/s. Crompton Greaves, M/s. ABB (then it was HBB). GEC TELK, ALIND established EHV switchgear as well as large power transformers manufacturing facility in the country with voltage rating varying 72.5 kV, 132 kV, 220 kV and 400 kV. Similarly, many new manufacturers in private sector also have started lot of manufacturing activities in the field of MV switchgear and Power Transformers rated up to 15 MVA. Further development took place in the LT Switchgear equipment for increased fault currents up to 80 kA. To meet the short circuit test requirements of the above-mentioned equipments, Government wanted to enhance the short circuit test facilities of CPRI. During that period, in CPRI, Bhopal, there was only one 1250 MVA short circuit generator-based test facility available, which could test switchgear rated only up to 33 kV, 20 kA and transformers, other electrical power equipment of lower capacity. The 50 MVA short circuit laboratory in Bangalore was serving for low-voltage switchgear equipment testing up to 50 kA.

It was decided to establish a new high power test facility with three numbers of 14 kV, 2500 MVA short circuit generators totaling to 7500 MVA capacity to be achieved in three stages with synthetic test source to bring thrust in switchgear testing. By adopting the synthetic test method, the short circuit capacity of the laboratory increased by about ten times. In the first stage, the test facility was planned comprising of one short circuit generator, six numbers of single-phase low flux density short circuit testing transformers rated at 14 kV/42–42 kV 1150 MVA. The Laboratory is equipped with fast-acting master circuit breakers, Make switches, bus bar system and other control protection equipment, TRV elements for direct testing of 72.5 kV Circuit Breakers with breaking current of 20 kA and Circuit Breakers rated 36 kV, 40 kA breaking capacity. The Circuit Breakers rated at 72.5 kV with higher fault level, 145 kV, 245 kV, 400 kV Circuit Breakers would be tested using specially designed parallel current injection synthetic test circuit. The high power laboratory was established and commissioned in December 1990 and the commercial testing activities for customers began in January1991.

SHRI R. VASUDEVAN, FORMER SECRETARY, MoP INAUGURATING THE HIGH POWER LABORATORY

EDF high power laboratory in Les Renardieres rendered total consultancy services for the preparation of technical specification for the laboratory equipment, assisted in predespatch inspection and complete supervision in linking the various equipments supply, installation and commissioning of the laboratory. EDF trained the CPRI engineers in operation, maintenance of the laboratory and testing techniques. When the fault level in the system increased due to augmentation of the electrical grid in our country, the laboratory added one more high current testing transformer which can deliver 300 kA for 1 sec. This high current transformer caters testing of Isolated Phase Busducts, Power connectors, Disconnectors, Earthing switches and LT /HT Panels.

The high power laboratory also carries out short-time withstand current test, internal arc tests on MV panels, motor terminal boxes, pressure relief tests on lightning arrestors, short time current tests on high voltage cables, breaking tests on fuses, short time current tests on segregated and non-segregated bus ducts, earthing transformers, line traps, compact substations, ring main units, short time current and making capacity tests

on load break switches and power arc tests on insulator strings. Further, short circuit tests on auto reclosures and line traps, induced current switching tests on earthing switches can be taken up in the laboratory. The laboratory undertakes Short Circuit tests, Switching tests strictly according IEC, IS, ANSI/IEEE and other international standards. The High Power Laboratory of CPRI, Bangalore, is a technical member in the prestigious short circuit testing liaison (STL) of Europe and also the member of the Asian high power laboratories association located in Japan.

VIEW OF THE HIGH POWER LABORATORY

When a Short Circuit test is carried out, apparatus, right from the generator up to the test apparatus the series of equipments like short circuit testing transformer, bus bar and disconnector links, test connection accessories are undergoing huge electro dynamic stress and also thermal stress due to the flow of large amount of short circuit current in the system.

VIEW OF THE SYNTHETIC TEST CIRCUIT ELEMENTS

The short circuit generator is the most vital equipment of the High Power Laboratory, which is extremely special from the conventional

PHOTOGRAPH OF 14 kV, 2500 MVA 50/60 Hz DRIVELESS SHORT CIRCUIT GENERATOR

generator, particularly very low reactance, the windings shall be capable of carrying high short circuit current up to 120 kA for a duration of 1 sec, and the well reinforce end winding termination. When the generator is delivering high current, the foundation of the generator experiences huge couple force. The rotor of a short circuit generator has to be specially designed to withstand repeated large electrodynamic force.

Hence, the rotor of the short circuit generator is fitted with retaining rings and special damper windings. Originally, the short circuit generator in Bangalore was driven by a synchronous motor with coupling shaft between motor and the generator. Due to operational intricacies as mentioned earlier, there were typical problems faced in the coupling shaft between the generator and the driving motor shaft. To mitigate the problems faced in the coupling shaft and driving motor shaft, it was decided to modify the short circuit generator in CPRI, Bangalore, as driveless system.

The schematics of the synchronous motor-driven generator and driveless generator are shown in Figures 1 and 2.

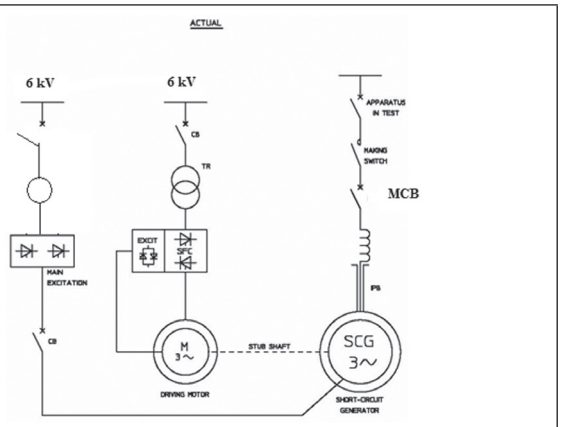

FIG. 1 SCHEMATIC OF THE SYNCHRONOUS MOTOR DRIVEN GENERATOR

The SFC system comprising of two thyristor bridges, viz. network bridge and machine bridge with intermediate reactor, drives either the synchronous motor or will be connected to the stator of short circuit generator with intermediate circuit breaker. These bridges are totally reversible. The network bridge works as a rectifier and the machine bridge work as an inverter during motor mode and these two thyrisor bridges will work totally reverse during generator mode. The bridges are of six pulse graetz bridge configuration. The network and machine bridge configuration are achieved by suitably controlling the firing angle of the thyristors.

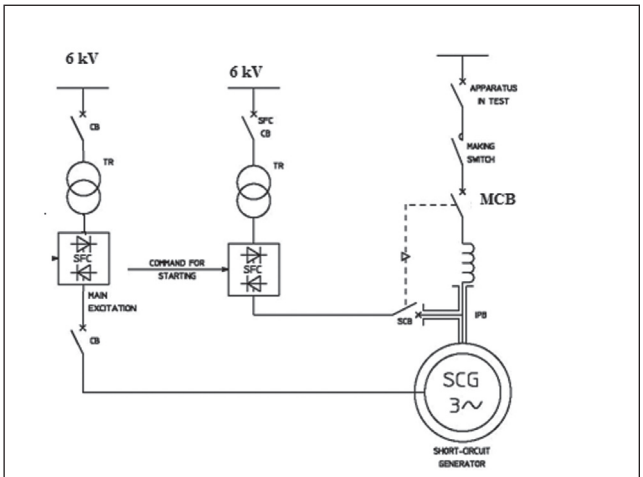

FIG. 2 SCHEMATIC OF THE DRIVELESS GENERATOR

The control system adopted in the excitation as well as the driving system is of the latest technology. By implementing this motorless generator in December 2010, the problems like high bearing temperature and the problems associated with coupling shaft and drive motor shaft have been resolved. After the driveless system was adopted, the power arc test on insulator string, which was earlier suspended due to huge speed drop and subsequent strain coming on the coupling shaft while speeding up of the driving motor, has been resumed in the High Power Lab.

The Laboratory test facilities are not only used by Indian customers but also by customers from other countries, viz. Canada, South Africa, Malaysia,

Sri Lanka, Bangladesh, Indonesia, Philippines, Saudi Arabia and other Middle East countries. From the commissioning date to March 2012,

the total number of equipments tested in high power laboratory is 3600. The testing activities of the laboratories have been beneficial to utilities and end users by way of the assurance of quality and most reliable power equipment. For the manufacturers, the testing has resulted in improvements in design, selection of better material and manufacturing process for the production quality electrical power equipment.

The Laboratory is equipped with the fast-acting master circuit breaker whose arcing time is about half cycle duration. By having this master circuit breaker, it is possible to interrupt the test current within next half cycle when the tested equipment fails to interrupt the current. This helps the manufacturers to enable, understand as well as the analyze the reason for failure of the tested equipment. In case of very longer arcing time, the failure will result in complete damaging of the test equipment.

The fast-acting master circuit breaker equally provides protection to the generator and laboratory's transformers as well as bus bar systems and other equipment like disconnectors bushings, etc. The laboratory is having state-of-the-art technology precise transient recording system with high sampling rate feature for accurate data acquisition.

The laboratory is being augmented with routine test facilities for conducting load loss and no load loss for power transformers rated up to 50 MVA and 220 kV class, and additional MV test cell.

Last 2 years, the laboratory carried out short circuit tests on 400 kV power transformers in the laboratory with a power rating up to 80 MVA in single-phase test circuit. Line to neutral test method is adopted for testing 400 kV transformers, which is in accordance with the IEC-60076-5 standard.

Plan proposal has been put up with government to augment the laboratory facilities with additional short circuit Generator and associated equipment to enhance the installed capacity of the laboratory up to 5000 MVA. With the

400 kV INSULATOR STRING MOUNTED FOR POWER ARC TEST

ISOLATED PHASE BUSDUCT TESTED FOR 300 kA FOR 1 SEC

additional short circuit generator, the laboratory can function as two independent 2500 MVA test stations which will enhance the availability and reliability of the test laboratory for the customers. The augmentation plans of the laboratory will help customers to take up all the tests on their equipment within our country. The new test facility will be a novel R&D centre for Switchgear and Power transformer technology.

Further, there are additional plans to improve the laboratory facility to cater to the testing requirements of the Circuit Breakers for shunt reactor switching, GIS testing and also dead tank CB testing. The facilities will be modernized with additional reignition circuits, and revamping of the shortline fault test facilities.

The laboratory also carried out third-party inspection services during manufacturing of the power transformers, CBs and also witnessed the factory acceptance test and type test of the power transformers and switchgear.

HPL engineers have carried out unique type test inspection of 145 kV GIS manufactured by M/s. Hyundai, South Korea, which was supplied to M/s. TNB, Malaysia. HPL engineers undertook the work of reviewing and approving of the technical specifications pertaining to Power Transformers rated up to 500 MVA/550 kV

800 kV CT TESTED FOR 50 kA FOR 1 SEC

class, earthing transformers and shunt reactors purchased for M/s. TNB, Malaysia. Over the two decades, HPL engineers have presented papers in SWICON, TRAFOTEC Conferences and also INDUCTICA Conference in Berlin. There are plans to take up R&D activities in Switchgear technology and improviz ation on the measurement, control systems of the laboratory.

80 MVA, 400/11.5-11.5 kV POWER TRANSFORMER TESTED AS PER IEC 60076-5

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