Testing of Local Control Cabinet In Gas Insulated Switchgear Using Design of Simulation Kit - Revista

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***Abstract*—In order to keep generation and distribution of power at high priority, two switchgear playing a key role i) Air insulated Substation/Switchgear (AIS) ii) Gas Insulated Substation/Switchgear (GIS). Nowadays, the GIS innovation began with the view of broad essential research and from that point forward the administration encounter together with creative advancement work has presented this system to a sheltered and natural good, a most dependable and accessible component of the power supply. Controllers always play a significant role in the power sector. GIS has low-Local Control Cabinet (LCC) cost and can be utilized for indoor and open-air applications. The local control cabinet is controlling part in Gas Insulated Switchgear. Its task is to follow the logic and interlocks that are set accordingly. The Problem came across while testing LCC panel is studied in this paper and solution to this is found out. In this paper, a test kit for LCC is proposed which will work as a dummy GIS bay. The contact status is found out whether NO or NC by studying connection drawings. This status fed to the relays in the kit through PLC-HMI programming and testing will be done. The proposed test simulation kit allows conducting a full functional assessment of LCC panel, panel wiring, interlock wiring, component functioning etc.**

Keywords—Switchgear, Gas Insulated Substation, Local Control Cabinet, Harting Connector, Circuit Breaker, PLC-HMI programming.

I. Introduction

In expansive urban areas, with the fast advancement of the economy, the power demand is increasing, and the density in the downtown territory day-by-day elevated [1]-[2]. The arranging furthermore, an area of substations is constrained by many factors, for example, land utilization and environmental conditions. The logical inconsistency between power grid development and city development turns out to be increasingly distinctive. This contradiction can be resolved by building switchgear in such a way that there will be a prominent use of land and improvement in the efficiency of land use. The most recent couple of years has seen a colossal change in power generation and distribution [3]-[6]. For the power provider, the most essential part is the transmission and distribution control. Because of the vast power request realized by a developing populace and a vigorous modern division, there is a requirement for the power supply organization to grasp productive strategies. One of the key regions is substation. Substations can be divided into two categories; Air insulated Substation and Gas insulated Substation [7]-[10]. The Gas insulated switchgear has some notable features:

- ✓ Financially viable and Elevated consistency.
- ✓ Secure encapsulation.
- ✓ High degree of gas stiffness and Extended service life.
- ✓ Low life cycle and maintenance charge
- ✓ Superior ease of access and ergonomics.
- ✓ High availability and Safe operation even under extreme environmental conditions.

In Gas Insulated Substation, for each bay, there is the separate control panel called a Local Control Cabinet (LCC). For making operations practicable and convenient as well as trouble-free wiring from Gas Insulated Switchgear (GIS) to the substation control room, a LCC is provided. Even though LCC increases the cost when compared with air-insulated switchgear, it is so well liked attempts to get rid of LCC to trim down cost have not succeeded. The LCC does have the benefit of providing a very clear division of liability between the GIS manufacturer and user in terms of scope of equipment supply. The problem had appeared while testing the LCC during the factory acceptance test (FAT). Every time it is not feasible to have a ready module of GIS for testing LCC as well as quite inconvenient to take every connection from the GIS module to LCC for its testing. There can be swapped of connection because of wiring complexity. This may lead to a further fault. Therefore, in this paper, a simulation kit is proposed that will have NO/NC status for every pin from GIS fed by PLC-HMI programming. This kit will act as a prototype of the GIS module and will test LCC successfully. This paper deals with the study of Gas Insulated Switchgear (GIS), its advantages, Local Control Cabinet (LCC), its importance, logic, interlocks followed, testing of LCC, problem while testing LCC and simulation kit details.

II. Gas Insulated Switchgear

A fundamental feature of Gas Insulated Switchgear is the rising degree of versatility made almost certainly by its modular system. The mechanisms are housed either independent and/or

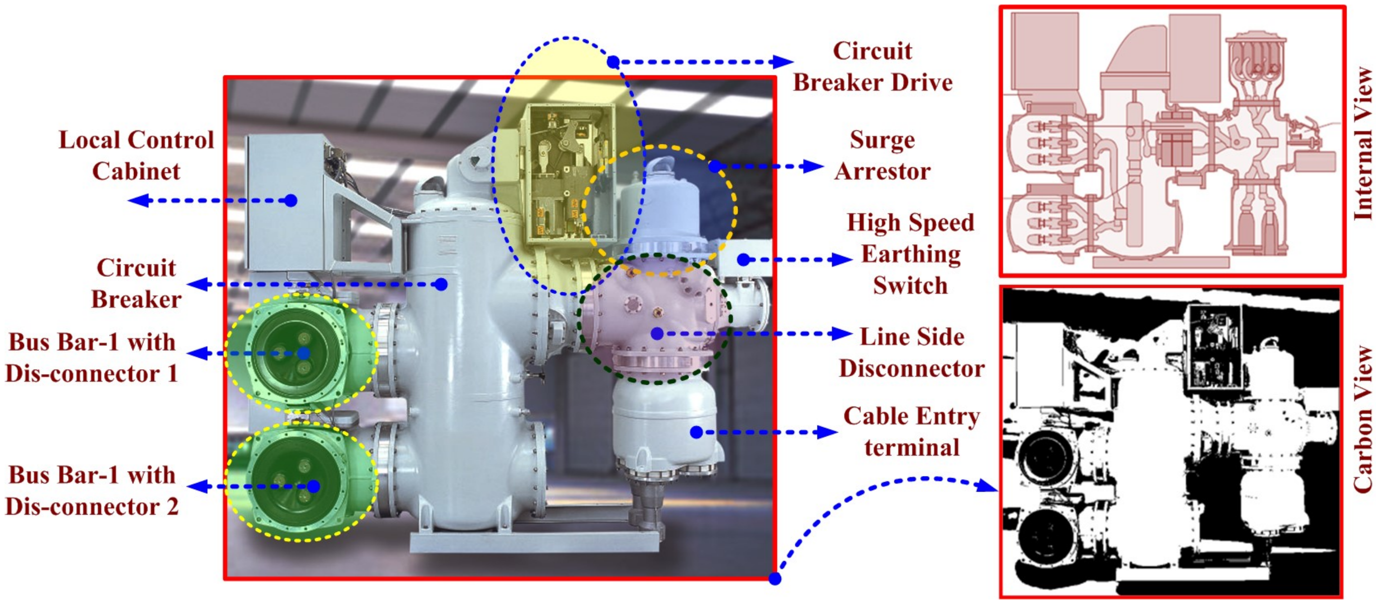

Fig. 1. 145kV Gas Insulated Switchgear (GIS) with carbon view and internal view.

collective in pressure-resistant, gas-tight enclosures depending on their relevant function. Because of the remarkably less number of active and passive modules, every single one customary bus scheme is achievable. Standard adapters ensure compatibility with all predecessor models of the same voltage level. 8DN8, 8DN9, 8DQ1 switchgear for rated voltages of up to 145 kV, 245kV, 420 kV respectively satisfies every single requirement nowadays precisely for recent and advanced switchgear [11]-[12]. This switchgear configuration speaks to a standout amongst the most conservative arrangements accessible in this voltage go. Its space-sparing plan and its low weight add to making this switchgear to a great degree conservative. Since the levels of noise and field discharge/emission (EMC) are amazingly low, it is conceivable to incorporate this switchgear even in delicate conditions, private quarters, and downtown areas. With these attributes, this switchgear meets all prerequisites for naturally perfect high-voltage switchgear.

Low component dimensions can be achieved by enclosing complete structure in three phase enclosures. This gives profitable features like compactness and design that consumes bare minimum space. The control elements are quite easily accessible because of the ergonomic modular principle. This ensures opportunity from erosion and guarantees lightweight hardware. The utilization of present day development strategies and throwing systems makes it conceivable to improve the enclosure's dielectric and mechanical attributes. The need of complex foundations is eliminated as the bay weight has been reduced, which ultimately helps in minimal floor loading. The flanges are the connecting links between all the modules. O-ring seals guarantee the feature of flanges that is gas tightness.

Fig. 1 depicts 145kV GIS bay. The GIS design made of aluminum enclosures had a large impact on the size of the equipment and on the visual appearance [11]. The carbon view and internal view are also as shown in Fig. 1. The following components or parts are described as integrated a local control cabinet

- ✓ Control cabinet support
- ✓ Current Transformer
- ✓ Earthing switch and Bus Bar-I with dis-connector
- ✓ Earthing switch and Bus Bar-II with dis-connector.
- ✓ Interrupter unit of circuit breaker
- ✓ Stored-energy spring mechanism with circuit breaker
- ✓ Voltage transformer.
- ✓ High-speed earthing switch
- ✓ Dis-connector with outgoing feeder module and earthing switch
- ✓ Cable entry terminal.

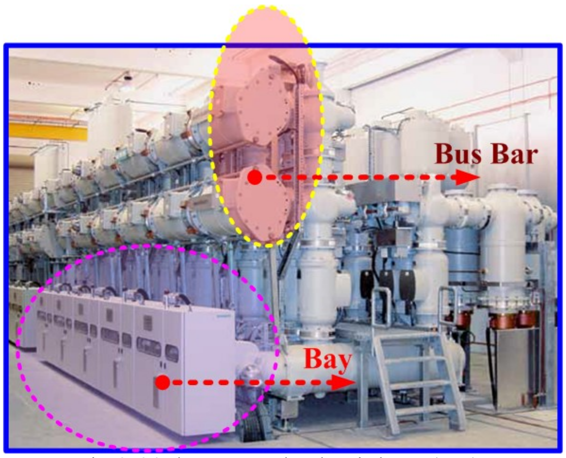

Fig. 2. 245 kV Gas Insulated Switchgear (GIS).

Coupling contacts are one of the methods used to prevent the expansion of the conductor due to temperature. The accessibility to various joints given via openings sealed with gas-tight covers. The insulating and arc-quenching medium used is Sulfur hexafluoride (SF_6). It is filled in the extreme gas-tight enclosure, and thus, it cannot pollute the atmosphere. Compartments included gas is separated and the bay is subdivided into a number of sections with the use of gas-tight bushings. Each compartment is prearranged with their own gas monitoring equipment. Static filters provided to each gas compartment do absorption of moisture and decomposition products. Suddenly buildup of peculiarly high pressure can cause shattering of the enclosure, which is prevented by the use of rupture diaphragms. Rupture diaphragm consisting of a diverter nozzle, which ultimately defines the direction of gas in case of bursting. This ensures the personnel operating nearby are not endangered. Fig. 2 shows switchgear at voltage 245kV. The advantages of GIS is listed [13]-[16] as:

- ✓ Because of the reduction of the distance between life and dead switchgear parts, the space required for installation purpose is reduce than that of air-insulated switchgear (AIS). This is highly preferable in densely populated areas as well as in difficult climatic and seismic conditions.
- ✓ The compartmentalized enclosure of the live parts makes for a very reliable system due to the abridged disruption of the insulation system.
- ✓ The safer working environment for nearby personnel as the metal enclosure earthed, even multiple earthing used in GIS.
- ✓ Sulfur hexafluoride (SF6) gas under scheduled maintenance neither ages nor depletes.
- ✓ Quick installation due to extensive pre-assembly available at factory.

III. Local Control Cabinet

A. *Structure of Local Control Cabinet:*

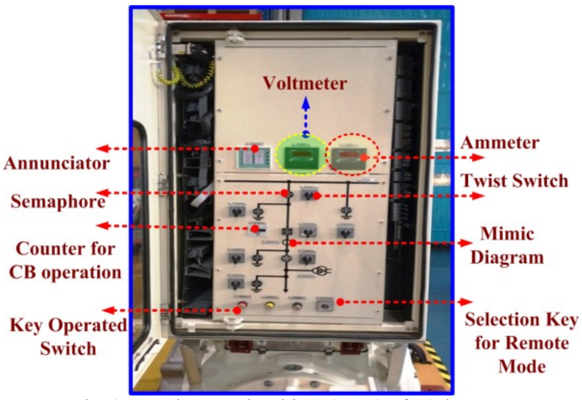

Fig. 3. Local Control Cabinet (LCC) of 145kV GIS.

Allowance to many component options such as switches, terminal blocks, lights, indicators are not provided under user schemes due to the compact and unique design of GIS [14]-[15]. The local control cabinet is incomparable in this case. It is also known as a Marshalling Box (MB), which is ultimately the interfacing link between utility and GIS equipment. The main function of LCC is to follow the logic and check the interlocks set for each compartment or equipment. The client has the choice to introduce control or checking gear inside the cubicle or just utilize the fenced in area as a wiring marshaling point. For instance, numerous clients plan their switchyard offices with the gear control boards in closeness to the control relay panel. Overall disconnect switch and ground switch controls may not be vital in the LCC and the cabinet would be utilized principally to wire terminations with potentially a push button control for Circuit Breaker up keeping purposes. Fig. 3 shows the local control cabinet for 145kV GIS bay.

Indicating lights called as semaphores are also available on the LCC board. A depiction of Single Line Diagram (SLD) on the swing frame behind the acrylic window is known as a mimic diagram. The horizontal main line is bus bar of 10mm width. Other connecting lines are of 7mm width. Various parts over LCC are described as

- ✓ Annunciator.
- ✓ Ammeter.
- ✓ Voltmeter.
- ✓ Semaphore.
- ✓ Twist switch with two Position switches
- ✓ Key operated switches.
- ✓ Twist switch to the local or remote mode operation.
- ✓ Counter for counting CB operation.

Various opportunities to have switches, terminal blocks, heaters, lighting are provided by LCC as the convenience receptacles to be installed that are compliances with the user's standards.

B. *Annunciations by LCC*

In order to operate GIS effectively, the status of equipment needs to be monitored continuously similarly as done in air-insulated switchgear. However, the major factor to be considered is SF6 gas levels, which will be more critical as compared to air-insulated switchgear. Following alarms are utilized for the annunciation on the annunciator:

- ✓ General Lockout (if gas pressure goes down below critical value).
- ✓ Circuit breaker, motor runs time exceeding.
- ✓ Circuit breaker loss of SF6.
- ✓ Circuit breaker zone trip.
- ✓ Voltage transformer MCB trip 14.
- ✓ Spare alarms.
- ✓ Circuit breaker, motor protection.
- ✓ Circuit breaker pole discrepancy.
- ✓ AC distribution MCB trip.
- ✓ DC distribution MCB trip.
- ✓ Circuit breaker, gas refill level.
- ✓ Gas compartment SF6 low level.
- ✓ Gas compartment refill level.
- ✓ Gas compartment zone trip level.

C. *Interlocking Scheme*

- ✓ Interlocks are followed by LCC.
- ✓ No closing of dis-connectors with the earthing switch closed.
- ✓ No closing of dis-connector when a load is connected.
- ✓ No switching of the earthing switch when the bus bar or equipment is energized.
- ✓ No opening of dis-connector under load.
- ✓ No closing of circuit breakers if the associated dis-connectors are in an intermediate state.
- ✓ CB can be connected only one bus at a time.
- ✓ No paralleling of buses by dis-connectors when bus coupler is open.

✓ Only local mode operation for CB when dis-connectors are open.

IV. Testing of Local Control Cabinet and Design of Simulation Kit

A. Various Testing of LCC at the manufacturing site

The electrical panels, used in various kinds of a substation and industrial applications, include all the secondary devices such as control switches, measurement devices, protecting equipment like a differential, over-current, over-voltage relay, etc. To ensure continuity of operation of protecting and controlling device that is LCC, the suitable panel testing is carried out. Panel testing at the manufacturing site, assembling the site, or during maintenance undergoes many qualitative test and inspection test. This covers electrical wiring, polarity continuity, dielectric resistance. Functional testing of relays, protecting schemes and other operational checks is done cautiously.

First, all wiring connections and their terminals are inspected properly to prevent any nonconformity. Components are checked and ensured that they match the bill of materials. Every checking of all labels, screw tightness, wire tight-ness by pulling it out slightly is done before dispatch. Using multimeter point-to-point continuity is checked according to drawing. Whether the contact status is NO or NC is verified using a micrometer. Using a multimeter, perform short circuit testing on all power circuits and PLC outputs.

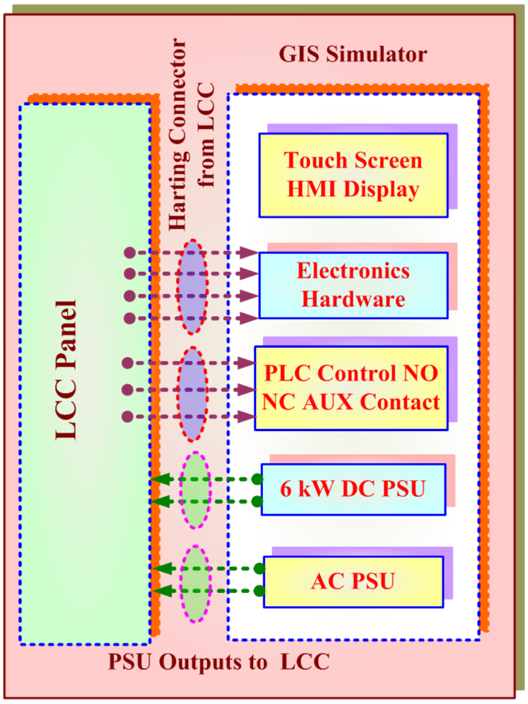

Fig. 6. General Architecture of Simulation Kit.

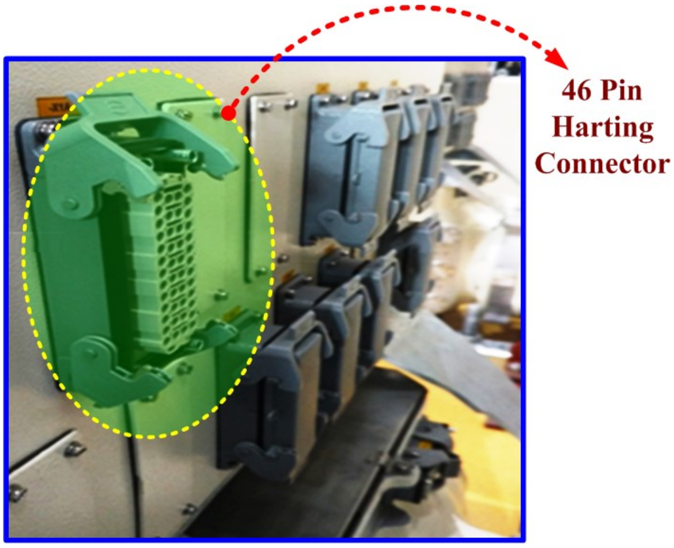

Fig. 4. Harting Connector.

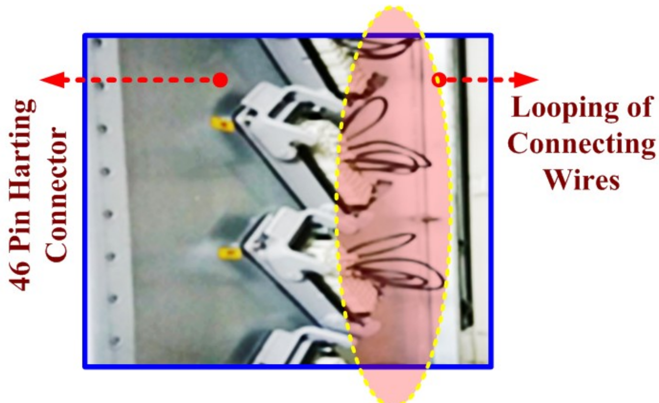

Fig. 5. Looping Technique of connecting wires used in Harting Connectors (HC) and testing panels.

B. Conventional Testing During Factory Acceptance Test (FAT):

During Factory Acceptance Test (FAT), the customer checks all the interlocks from LCC. It is quite easy for 145kV LCC because of the availability of the complete module/bay. However, for 420kV, 245kV testing is done by looping in LCC as the complete bay assembled at the site. Bay is not available at the factory for LCC testing. This looping is obtained by studying LCC schematic. Accordingly, the connections in the Harting pins are done. This increases complexity, as well as some annunciations or function, cannot be performed during the factory acceptance test. Fig. 4 depicts the view of used Harting Connectors (HC). In Fig. 5 the looping technique used for the testing panel is shown. As the lopping method takes quite more time for testing it is directly a factory loss in terms of person-hour. One more inconvenience is, limited personnel who are specified in that work can only check the LCC, and this causes dependency on that particular personnel.

C. Design of Simulation Kit for Testing LCC Panel for Factory Acceptance Test:

To give experience of actual LCC working when coupled with GIS to the customer during inspection is the main objective of this kit. An innovative trolley mounted PLC- HMI based GIS simulator is proposed to test LCC Panels of 145kV, 245kV & 400kV GIS. Various drawings of different projects of GIS with different voltage levels are studied. Every contact used in drawing is considered as a relay and its status, whether NO or NC is noted down. This status is going to feed PLC as its Programming and accordingly with the changing needs and the contact status can be changed from NO to NC and NC to NO. The Simulation kit will work in the following steps:

- ✓ The simulator will act as a GIS model for respective 145kV, 245kV, and 400kV Bays.
- ✓ The Simulator will receive Close and Open command from LCC.
- ✓ Kit will sense those commands and give feedback to LCC in terms of NO-NC contacts. These will show the status of each device on LCC through semaphore indicators.
- ✓ Alarm indication and the customer interface circuit will be simulated through the kit. The general architecture for designing this kit shown in Fig. 6.

As shown in Fig.6, the basic components are electronic hardware such as relays, timers, protecting devices, etc. Various alarm signals as described in annunciation from LCC section are controlled separately through PLC. These alarm signals will be displayed on the HMI screen. Using Touchscreen HMI displays it possible to command for different alarm signals. Relay status is fed by PLC whether NO or NC and according to the command given by LCC twist switch respective relays will change their status. DC supply is required for PLC and relays, Tube lights, fans are given with AC power supply.

V. Conclusion

With this simulation kit, complete functional assessment of LCC panel, panel wiring, interlock wiring, component functioning etc. conducted. Thus, any variations from the norm in LCC recognized in the industrial facility and result in decreased site grumbles. With a simple plug in hurting connection, there is never again required for complex wiring and tedious setup courses of action for LCC testing. Along these lines, a significant measure of man-hour is saved in this Process. In customary LCC testing techniques, the test setup must be changed for various voltage levels of switchgear. Nevertheless, with consideration of PLC in our testing kit, it can be effectively programmed to separate voltage level switchgear without changing the equipment association.

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