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Design and implementation of 220kV Double Main Transfer system switchgear interlocks using PLC programming

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Abstract: With the aid of a Programmable Logic Controller (PLC), the switchgear interlocks of the Double Main Transfer bus were designed in this paper. Here, we primarily concentrate on managing and regulating a bus configuration known as a Double Main Transfer (DMT) type bus in a substation that operates at a 220kV voltage level. Conventional techniques for regulating interlocks are considered dangerous because they involve human interaction in substations that contain transformers, overhead power lines, primary power lines, secondary power lines and other electrical equipment that runs at extremely high voltage. To ensure safe and secure communication between deterministic & non deterministic control applications, programmable automation in control systems offers a scalable solution. This allows for an improvement in productivity, operation optimization and downtime minimization while maintaining safety. The primary goal of this project is to create a prototype model of a 220 kV DMT substation and use ladder logic in a PLC to regulate its operation.

Keywords: Programmable Logic Controller (PLC), Double Main Transfer (DMT), Interlock, Switchgear, Circuit Breaker (CB).

1.INTRODUCTION:

A substation is made up of several pieces of equipment and devices such as transformers, switchgear, circuit breakers, and other components that are essential to the operation of a substation. Switchgear is a broad phrase that refers to a wide range of devices used in the switching, protection, and control of various electrical equipment. The circuit breaker is a form of switchgear that may open or close an electrical circuit in both normal and extraordinary conditions. An isolator, a mechanical switch, separates the problematic section of the substation. It is used to separate a damaged area that has to be fixed from a healthy component in order to prevent the emergence of major faults. It is not recommended that it be opened while the line is carrying current. These are often utilized on both ends of the circuit breaker, making circuit breaker maintenance straightforward and risk-free. An earth switch connects thee line conductor to the earth. Whenever isolation process of opening has been completed and he earth switch has been closed, it is normally open. As a result of this shutdown, the voltage that was trapped on the wire is released to the ground, making operation safe. The earth switch is frequently situated on the frame of the isolator.

Electrical interlocking is used to protect the safety of machinery; it is commonly used in substations and is also used by various firms for industrial safety considerations. Isolators and switch gears are examples of protective devices that would ensure appropriate and efficient power operation. Making the processes of a system interdependent allows one mechanism to operate after another without interfering with the operation of the other. Interlocks are used in electrical systems to avoid erroneous switching. Interlocks with isolators and switch gears are visible to guarantee proper electrical circuit operation. Electrical interlock is used at a substation or during an industrial process to assure the operator's and the machine's safety. We can also prevent potentially harmful activities by interlocking. If a system operator closes the earth switch without first opening the isolator and there is no interlock, a phase-to-earth issue may occur. This is a poor operation, often known as a human mistake, and it endangers both the equipment and the operator. Interlocks are essential in a substation because they allow us to ensure that all disconnectors, earth switches, and circuit breakers are operational. As a consequence, both the people and the equipment in the

vicinity would be safe. The mechanical interlocking is enabled by the lever frames, which are coupled to the signals and locations. This type of interlocking employs plungers, lock bars, locking frames, and other components. The movement of the lever is therefore the fundamental operation of this interlocking, although certain phases will be performed manually.

In this project, we develop several interlocks that must function all of the switchgear equipment utilized in the Double-Main and Transfer bus systems. These interlocks are created with Ladder logic, which is one of the programming languages supported by the TM200CE24R Schneider PLC of the M200 series. The prototype's behavior in relation to the designed model is also monitored and analyzed.

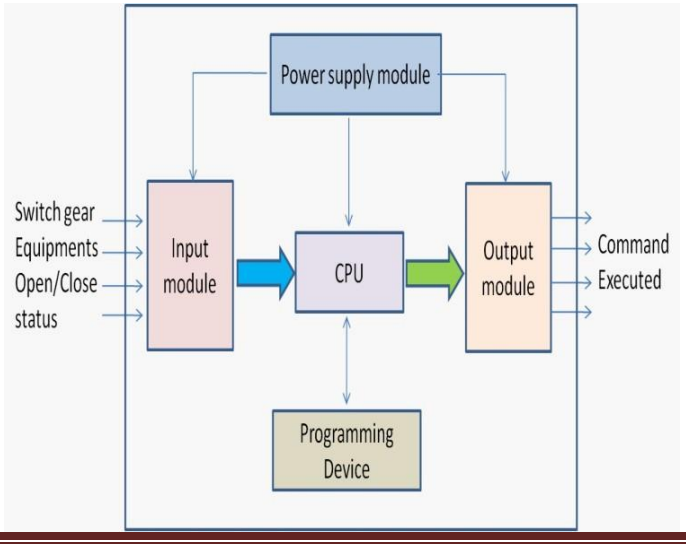
2. METHADOLOGY

Switchgear is an essential component of every electric power system. Fuse, switches, relays, isolators, circuit breakers, potential and current transformers, signaling devices, and lightning arresters are examples of switchgear. This safeguards electrical gear from defective situations. The working state of this switchgear equipment is transmitted to the control panel's input module, as indicated in the above figure. I/O Modules serve as intermediaries between the processor and the input/output devices. The input modules accept signals from switches or sensors and deliver them to the processor, while the output modules send the processor signals back to the control devices. The control module's central processing unit (CPU) accesses the input module's data. The CPU understands processes and executes instructions; it also does programme verification.

The above-mentioned component programming platform denoted a computer or laptop that carries software for programming PLCs in accordance with the interlocks specified for functioning of a 220kV DMT bus bar. Schneider Electric Global's So-machine software is utilized here. Interlocks are controlled by this programme, as we constructed Ladder logic in So machine software. After finishing the logic design, we upload it to the PLC through wires, and we can also replicate the modifications made in hardware to the current design in the system's software via connections. PLC programming should be done in such a way that the user can understand it. PLC programming should take into account standards as well as the unique application. The power supply module is the power source that energizes the entire system so that it can perform its purpose. The power supply module transfers the electricity from the input source into signal level voltage that is utilized by the PLC processor and other modules.

An electrical substation is made up of several incoming and outgoing circuits connected to conventional bus bar systems. Bus bars are conductor bars that connect multiple incoming and outgoing circuits. Circuit breakers, isolators, earth switches, current transformers and voltage transformers will be used in each circuit linked to the bus bar. These components are connected in a specified order so that a circuit can be shut off manually during normal operation and automatically under abnormal conditions such as short circuits. A number of factors must be considered when selecting bus layouts and switching configurations for a substation that meet system and station requirements. As a result, the substation must be trustworthy, economical, secure, and as simple in design as feasible. The layout is critical because it influences the use, upkeep, cost, and security of the substation. These issues are considered when designing the substation layout.

Fig 1: Block diagram of operation through PLC



2.1 DOUBLE MAIN TRANSFER BUS

This sort of Bus bar configuration will include two Main buses and one Transfer bus, as depicted in Fig 2. To link the main bus, bus couplers are needed. Transfer buses are sometimes known as auxiliary and temporary buses. The main bus and the transfer bus are also linked by a transfer bus coupler. This bus bar layout is only useful when one of the circuit breakers is damaged, malfunctioning, or needs to be removed for repair. In general, the auxiliary bus is maintained operating. This bus bar configuration cannot be used if both Circuit Breakers are in operation. The transfer bus system is used here to avoid load shedding difficulties during repair. DMT is used in power evacuation stations. It is also utilized in steel, aluminum and petrochemical heavy industrial stations. It is preferred by several utilities for large 220 kV and 400 kV substations. The main advantage of having two separate bus feeders is improved load management and dependability. In this case, one transfer bay is built in for redundancy of one bay.

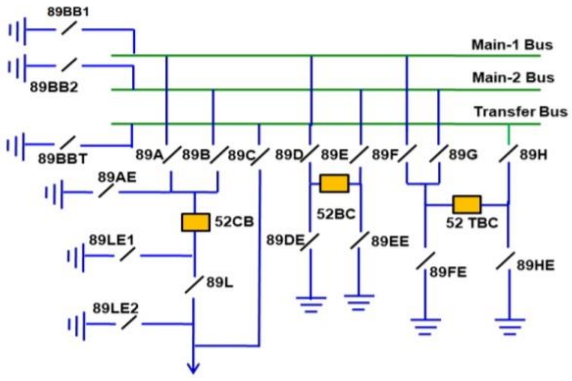


Figure 2:Double Main Transfer Bus

2.2 CONTROLLING THROUGH PLC:

Fig 3: Programming logic controller(TM200CE24R)

PLC is a solid-state control device or computerized industrial controller that performs discrete or sequential logic in the factory or automation environment. Basically, PLC is a combination of software and hardware. It acts as the brain of the machine or system for automation control systems.The M200 Logic Controller as shown in Fig 3 has various powerful features and can service a wide range of applications. Software configuration, programming, and commissioning are accomplished with the So Machine Basic software. The M200 Logic Controller is configured and programmed with the So Machine Basic software, which supports the following programming languages Instruction List(IL) and Ladder Diagram(LD). The power supply of the M200 Logic Controller is 24 Vdc / 100...240 Vac. The M200 Logic Controller includes a Real Time Clock (RTC) system.

3. SO MACHINE SOFTWARE

SoMachine is the OEM solution software for creating, configuring, and commissioning the entire machine, including logic, motion control, HMI, and related network automation tasks, in a single software environment. The simple-to-use SoMachine Basic programming software is designed for working with Modicon 200 Book logic controllers.

So equipment uses a wide range of equipment and installations in the construction, infrastructure, and industrial industries. Material handling, packing, and lifting are some of the application areas. Reduce total machine expenses by using a single environment. It enables one-step installation of all components, as well as a single programme for remote devices, HMI, and controllers. Some of the most essential aspects of software include transparent access to networked devices, one-time cable connection for one-click downloading, and a reduced design cycle. The Fig 4 , 5 and 6 are the designed logic for Main bay, Transfer bus coupler and Bus coupler for the above DMT in Fig 2.

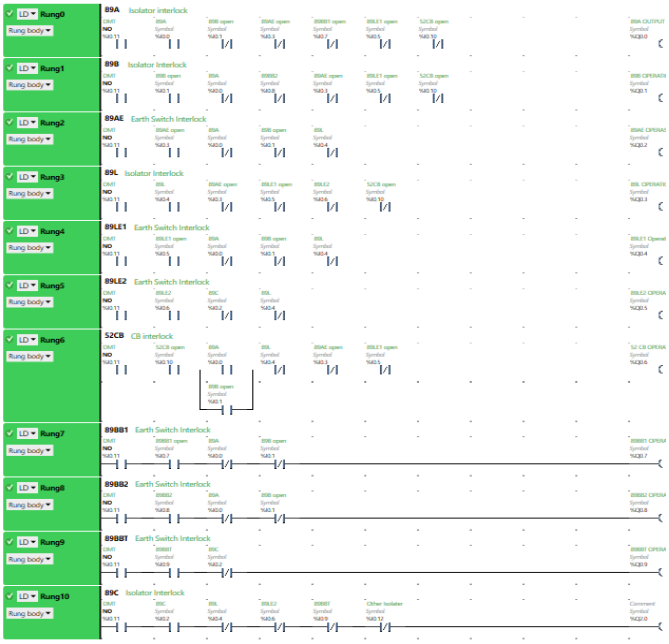


Fig 4: Ladder logic of Main bay of DMT

Fig 6: Ladder logic of Transfer Bus coupler

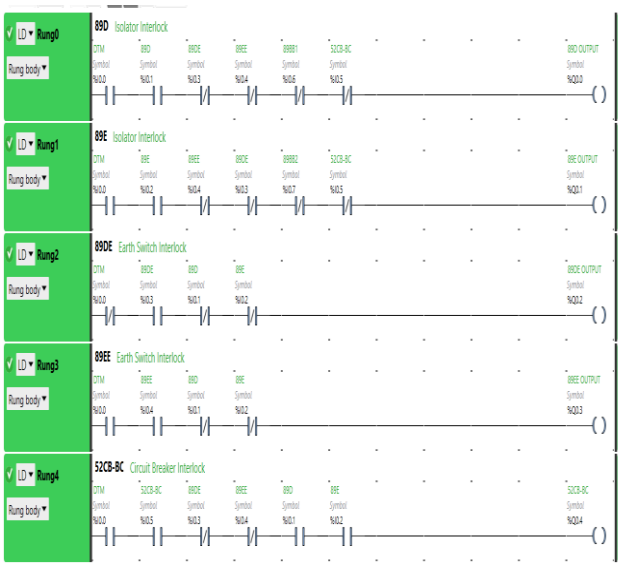


Fig 5: Ladder logic of Bus coupler

4. CONCLUSION

A good electrical power system should provide the continuous availability of electrical power to all loads connected to it. In general, electricity is transported by high voltage transmission lines. Because these lines are exposed, there is a risk of their failing owing to storms, falling exterior items, and damage to the insulators, among other things. These can cause not just mechanical harm but also electrical problems. Electrical equipment breakdowns and failures cause multimillion-dollar losses in institutions, industries, and enterprises throughout the world. A competent maintenance programme may considerably enhance the lifespan and minimise the failure rate of all types of electrical equipment through scheduled regular maintenance. A well-managed maintenance plan will decrease accidents, preserve the lives of workers, and avoid costly failures and unscheduled shutdowns of production equipment. During the maintenance condition, it is required to examine all of the interlocks related with the Busbar's switchgear equipment.

Switchgear interlocks must be satisfied by all switchgears in the substations. Manually operating these interlocks is dangerous; hence, PLCs are employed to automate these interlocks. These switchgear interlocks differ depending on the kind of bus arrangement. Interlocks for a 220Kv DMT system will be created utilising ladder logic in this project. The developed logic is uploaded into the M200 logic controller, which handles DMT. If the intended interlocks fail, switchgear operation fails, and the system is protected. This project is primarily concerned with creating a prototype model of a 220kV DMT substation and managing the switchgear interlocks using PLC programming. The applicability and benefits of PLC interlocks over manual interlock operation are also discussed.

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