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# ACSE GOOSE Messages Deployment for IEC61850 Substation Automation System

Engr. Erum Pathan[1], Engr.Muhammad Asad[2]

PhD Student[P&C], Dept. of E&EE, UTHM, Batu Pahat, Parit Raja, Malysia[1]

Substation Automation Engineer, NG CSD-C, Saudi Electricity Company, Riyadh, Saudia Arabia[2]

**ABSTRACT**: The Automatic changeover switching equipment (ACSE) transfer schemes increase reliability in a power System by automatic switching standby power source when power interruption occurs on the primary source. Traditionally, the large number of physical I/O lines required makes ACSE schemes expensive to design and implement. Using Ethernet-based IEC 61850, these hardwired I/O lines can be removed and replaced with generic object-oriented substation event (GOOSE) messages. Adjustment of the scheme for optimal performance is done via software PCM V2.5 that saves redesign and rewiring times. Special attention is paid to change-of-state GOOSE only; no analog messages are used, making the scheme fast and easy to configure, maintain, and troubleshoot. Applications such as fast automatic transfer of load to standby source like transformer incomer or bus section have been discussed in this paper. Simulation test results recorded GOOSE message latencies on a system configured for an ACSE scheme in PCM software application configuration. This paper presents the detail GOOSE based ACSE scheme logics for power transformer and its latency.

**KEYWORDS:** Generic Object-Oriented Substation Event (GOOSE) messages, Fast Automatic Transfer scheme, Automatic Changeover Switching Equipment (ACSE) scheme.

## I.INTRODUCTION

The IEC 61850 [1] was introduced, and interoperability between different devices became possible, but the next big step in the evolution of substation automation will come with the implementation of the process bus. The process bus interconnects the protection and control devices at bay level, with the instrument transformers and switchgear equipment at process level. With it, conventional copper wires will be replaced by fibre optic cables [2] .IEC 61850 substation automation system standards offering many benefits, although research on protection scheme is going on thereby that is time consuming as well as costly [3]

The IEC 61850 is now being widely used in practical applications. In particular, GOOSE (Generic Object Oriented Substation Events) messaging has been applied not only for SAS (Substation Automation System) control and monitoring of primary equipment and IED status, but also for status interactions between IEDs including protection relays by replacing the conventional method of using binary inputs/outputs and wires with communication by GOOSE messages over Ethernet cables/fibers optics. This is achieved through much simpler engineering based on the multi-vendor interoperability described in the IEC 61850 standard, which enables the easy connection of different IEDs, including relays supplied by different vendors.[ 4] [5].Goose is the model of generic object oriented substation event defined in IEC 61850, it is very crucial for implementing cooperation between IED with the digital substation technology based on IEC 61850 being applied widely, GOOSE has been applied more widely and more thoroughly [6].

Each conventional substation protection and control signalling were designed on only hardwire but IEC 61850 based substation automation system based on communication architecture via Ethernet switches and fiber optics. The generic object oriented Substation event (GOOSE) implementation via software can save re-wiring and redesign time and can easily be modified[7].When any faults occurs transmission line or transformer or even cable, the concern protection IEDs operates its binary output contacts in 10-30ms(depending on function) which further operates its concerned lock out relays contact in 8-10ms and tripped the circuit breaker in 30 to 40ms so the total fault clearance time or tripping time calculated is 80ms but if GOOSE message implemented then this 80ms time can be reduced to 45 to 50ms while

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GOOSE message might be sent one IED to other IED in 4ms.The IEC 61850 ACSE scheme is more secure than conventional methods because traditional copper-wire connection can fail with no notice. IEC 61850 ACSE schemes send immediate alerts because of the loss of generic object-oriented substation event (GOOSE) system health messages [8], [9].

The IEC 61850 ACSE scheme is implemented in PCM software using a substation Ethernet LAN. Thus, the engineering design time, drawing time, number of auxiliary devices, and amount of wiring is reduced, which lowers the initial installation cost. The Device ACSE IED has capable for controlling, monitoring, measuring, and disturbance recording function up to 100 disturbances and communicating with fully IEC61850 compliant. All tripping logics, trip matrix logic and configurable logic blocks and logic gate can easily be done by using PCM software tool.

The rest of this paper is arranged in this manner such as in section 2, briefly describe the concepts of Automatic changeover switching equipment Scheme description. In section 3, Trip on Parallel (TOP) Operation of ACSE scheme. In section 4, Engineering process, In section 5, Testing and Commissioning of ACSE/TOP and finally, in section 6. Present conclusion and future work.

## II. AUTOMATIC CHANGEOVER SWITCHING EQUIPMENT SCHEME DESCRIPTION

Typically Automatic changeover switching equipment (ACSE) scheme consist on 3 parallel incomer power transformer (GT1,GT2 & GT3) feeding to LV side three buses with segregation by 2 bus section circuit breakers (S120 & S320) as shown in fig 1.The purpose of ACSE scheme is to provide continues power supply to 13.8KV LV busses in case of any interruption due to incomers, in this scheme normally 4 Circuit Breakers (52-CBs) out of 5 C.Bs should be closed and 5th C.B will be standby source while complicated scheme is controlled by single IED known as REC670 ABB ACSE mostly used.

Let suppose GT3 is on standby and GT1, 2, BS-1 (S120) & BS-2 (S320) are in service and closed. If fault/interruption occurs on any service C.Bs lets say GT1 then standby GT3 LV CB will be closed automatically (HV CB 805 already closed) and GT1 will be tripped off hence there will not be any interruption on Bus supply because bus section S120 is feeding to bus-A.

The ACSE scheme work both manual called "Trip On Parallel (TOP)" and automatic transfer. The local/remote and Auto/TOP can be selected on ACSE control panel by selector switch or SAS HMI/Remote control centre. The below figure-1 shows the ACSE scheme arrangement suitable for 132/13.8KV Substation Automation system where 132KV bus arrangement is double bus bar single breaker scheme and 13.8KV is single bus scheme in which ACSE scheme plays a vital role and guarantee of healthiness for the power system network.

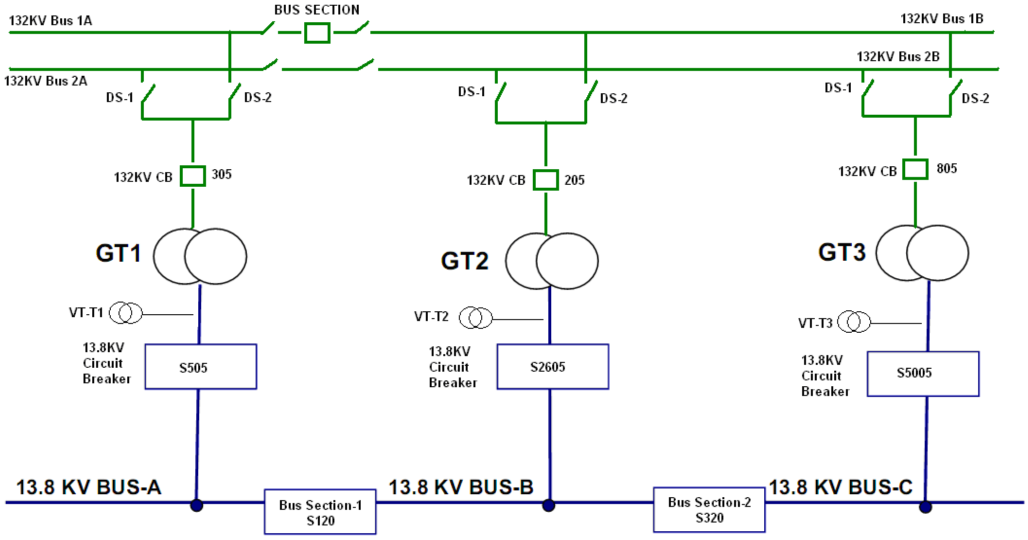


Figure 1.Scheme arrangement for Automatic changeover switching equipment

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An ACSE scheme requires fast communication from and each of the relays and control switches which requires substation LAN bus for the IEC 61850 peer-to-peer protocol.

These LANs can be made very reliable with configuration such dual-ring self-healing arrangements as well as other new ring multicast technologies. This paper assumes that the readers are familiar with the software that publishes and subscribes to data sets and that they are creating and reading the required IEC 61850 files. Typical GOOSE message times are on the order of 4 ms [10].

Let's take case when GT3 is standby mode and ACSE REC670 will decide when GT3 is to be operated or closed. The ACSE output operates for standby source to close if its HV side CB 805 closed, LV CB S-5005 in service (Rack-In not closed condition), all other four CBs closed, and their VT MCB closed and have voltage.
The below fig 2 shows the condition for standby CB to be ready for operation if these given condition are fulfilled.
The standby transformer GT3 (132/13.8KV 160MVA) can be brought in ACSE operation if the following conditions are satisfied.The logics describe for GT3 and similarly concern logics will be used for GT1 and GT2 as shown in fig 2

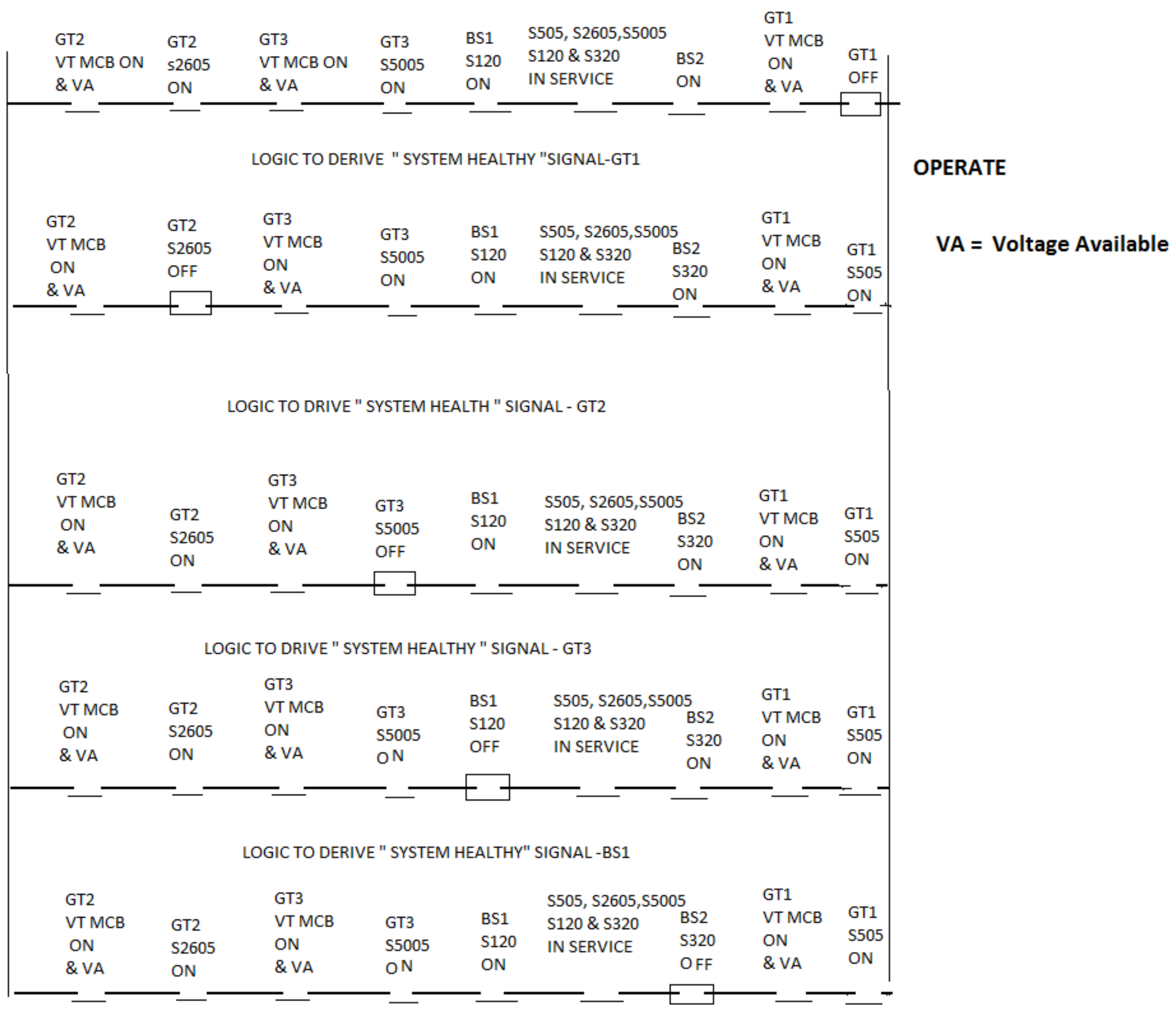

Fig. 2 Proposed ACSE operating Condition

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## III. ENGINEERING PROCESS

The described sequence in figure 3 is a proposal based on practical experience dependencies of the steps. It is possible to do a different sequence based on the available information at the time the project is started. This means that several iterations may be needed to finish the project.

The IEC 61850 standard defines a methodology for engineering a substation automation system in an object-oriented, multi-vendor environment. The data flow for this process is shown in figure 3.

Once the group of IEDs and the system specification has been defined, they can be imported into a system configuration tool. Within the system configuration tool the engineer can define specific instances from the different IED templates and link them to the electrical process. The engineer can then define project-specific addressing and configure the data model by defining the datasets and GOOSE publishing/subscribing amongst the various IEDs. The complete substation description, all IEDs and communications configuration can then be exported to a SCD file. The SCD file can then be imported to various IED native vendor configuration tools to complete the protection, control, and device-specific configuration.

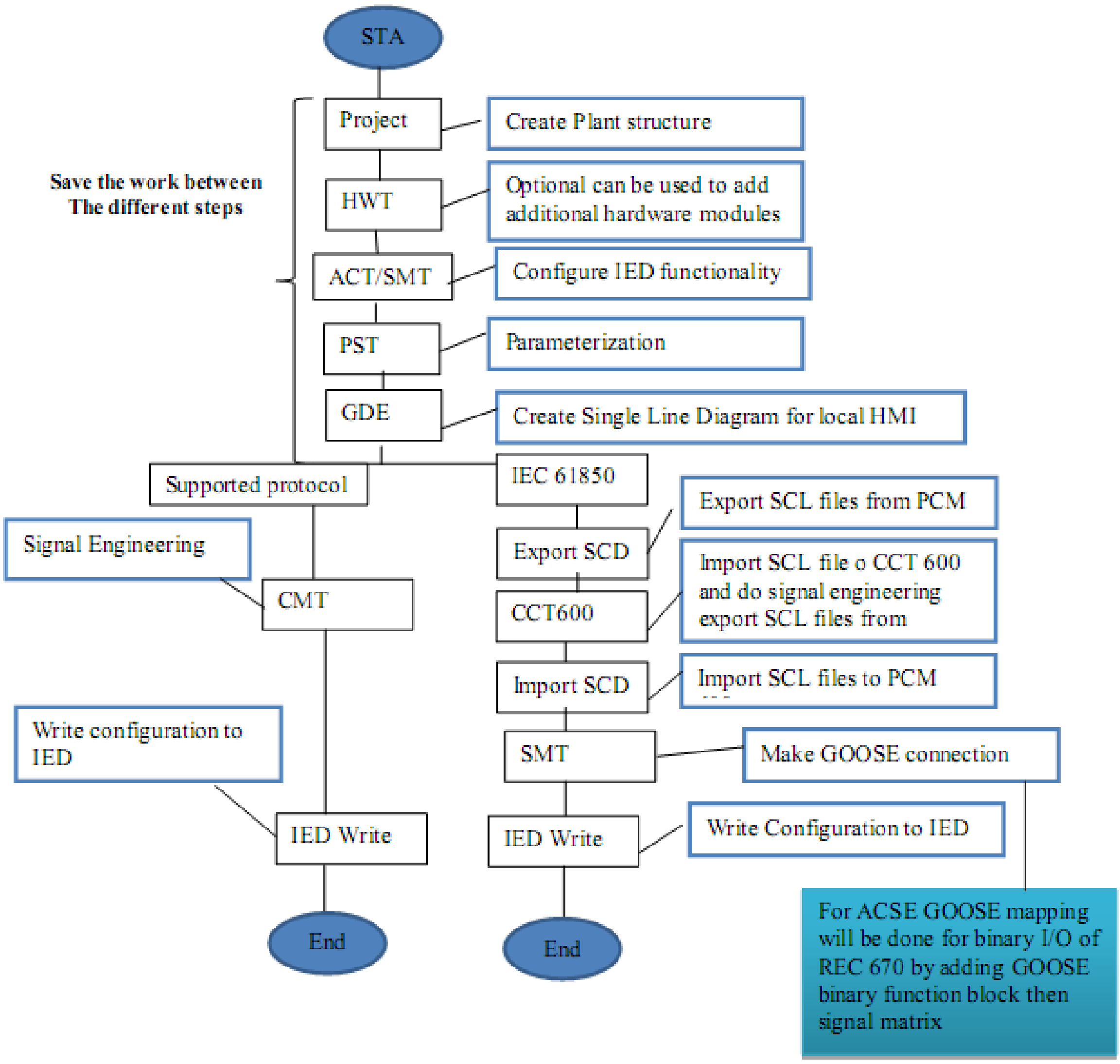


Figure 3 IED Engineering Workflow

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The IEC 61850 protocol supports a method to directly exchange data between two or more IEDs. This method is described in the IEC 61850–7–2 clause 15. The concept is based on sending a multicast over the Ethernet. Whoever needs the information detects the telegram by its source address and will read the telegram and deals with it. The telegrams are multicast sent and not acknowledged by the receiver. When a GOOSE message shall be sent it is defined by configuring the data set with the defined trigger option and the GOOSE control block (GoCB). This engineering process is done in a station configuration tool, for example CCT600. The task involves configuring lists with the signal, value and quality (data attributes) that belong to the GOOSE message dataset. In the opposite direction the standard only defines the IED as a receiver of the GOOSE message. How the GOOSE input signals are handled must be defined in the IED application configuration. The SCD file generated by CCT600 (or any other station configuration tool) contains these GOOSE data sets as input data. The input data must be connected to a GOOSE receive function block (GOOSEBINRCV and GOOSEINTLKRCV) in SMT.

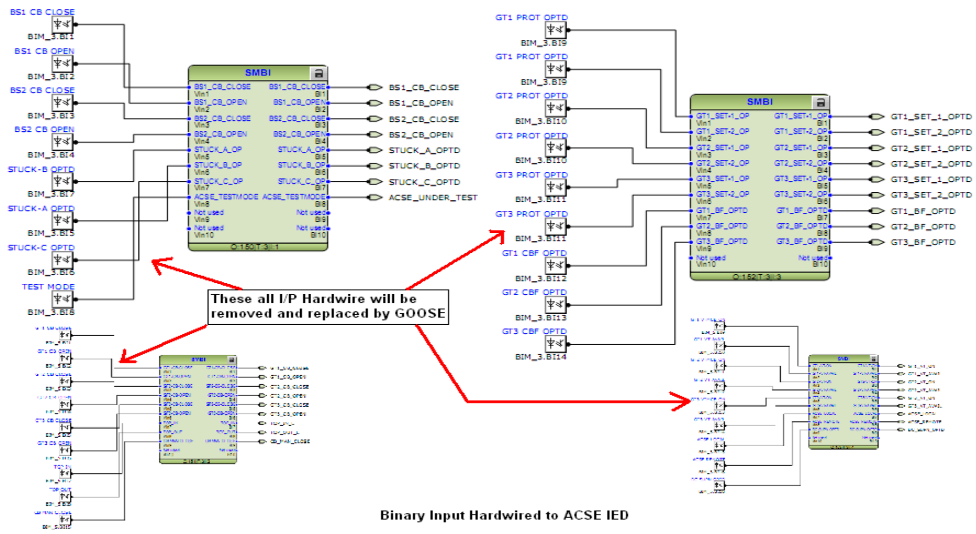


Figure 4 Proposed Binary Inputs to ACSE Control IED

The figure 4 described the logics of binary inputs mentioned in table-1 to the ACSE control IED are hardwired in existing scheme which will be removed and replaced by GOOSE message generates when it change of state as shown in below figure 5 logics. These existing hardwire required more space, cabling and off Corse has the cost and causes mal-functioning.

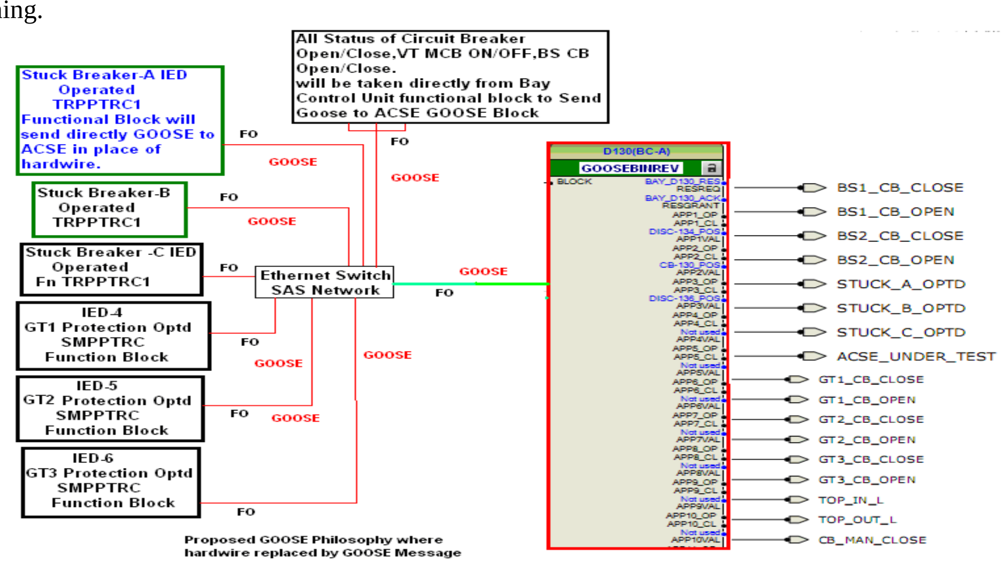


Figure 5 Proposed GOOSE messages logics prepared for REC670 IED.

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The fig. 5 logics are proposed and is the replacement of hardwire where all inputs are directly taken from each concerned IED function by mapping in GOOSE matrix are given to GOOSE receive function block.
The main task is to communicate GOOSE receive function to each IED which might be done in PCM V2.5. To get functionality scheme of GOOSE follow all steps as explained in IED engineering workflow reference figure 3.

The figure 6 described how output contacts are assigned which could be replaced on GOOSE to send directly close command to its concern bay control unit via fiber optics within the substation automation architecture network which will further reduce the closing time and make fast operation and performance of the system.

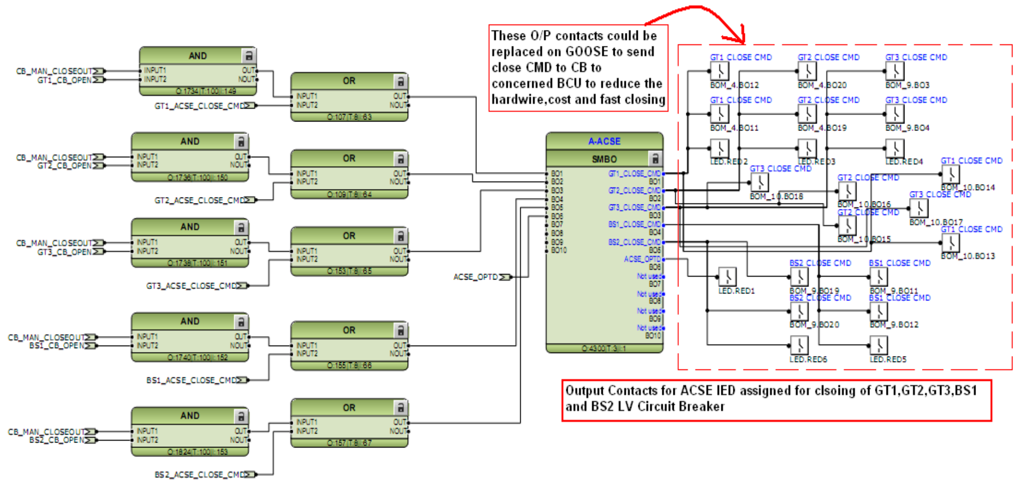


Figure 6 Proposed Output Contacts For ACSE IED To Close Circuit Breaker.

The figure 7 describes Binary outputs and trip on parallel selection software logics prepared for ACSE scheme, ones any GTs or bus section selected for TOP operation the GOOSE message will be sent to concerned bay control IED to trip.

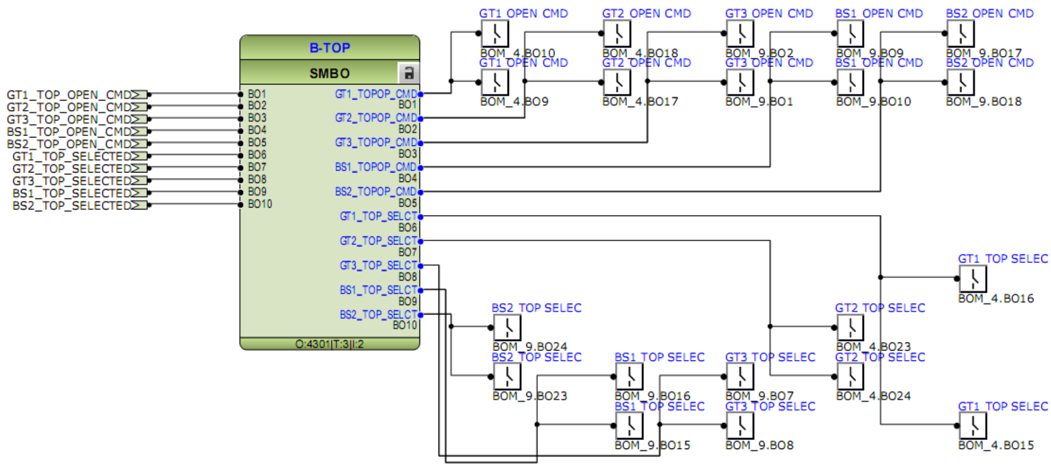


Figure 7 Open/Trip Command And TOP Selection Command For ACSE.

The figure 8 described the input from substation automation system IEC61850 based controlling for ACSE IN/OUT, TOP IN/OUT, Auto manual and all TOP Operation from SAS HMI.

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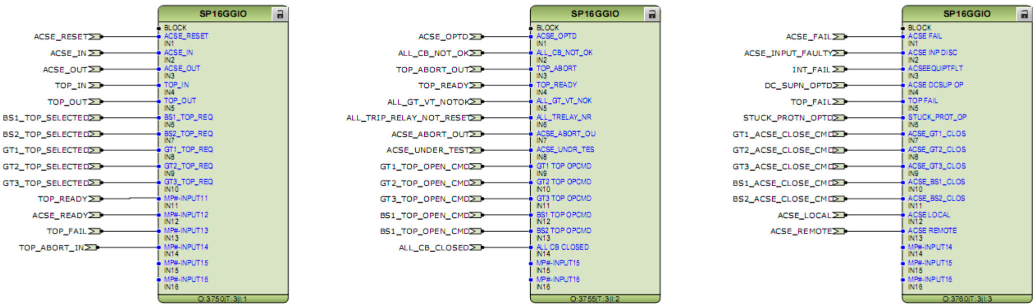


Figure 8 Logic input assigned for Substation Automation System

## VI. CONCLUSION AND FUTURE WORK

The IEC61850 replaces wires/copper among the different IEDs by GOOSE messages which perform better performance, accuracy, relay coordination and makes system compacts for system maintenance.

The IEC 61850 ACSE scheme is more secure and fast because traditional copper wire connections can fail with no notice; however, The IEC 61850 ACSE alerts immediately by internal self-supervision system monitoring to loss of GOOSE system logic fail messages & its abnormality.

Application of GOOSE message in Substation Automation system leads real cost reduction, modification in IEC 61850 ACSE scheme requires no hardwire rewiring, helps maintenance easier. GOOSE messages and publishing/subscriptions are software based required no more hardware changes.

The IEC61850 ACSE scheme provides a continues power supply to LV load busses in case of any interruption to its incomers ,in this scheme normally 4 Circuit Breakers (52-CBs) out of five C.Bs should be closed and $5^{th}$ C.B will be standby source which all are controlled by single IED known as ACSE. The complete ACSE Scheme logics & software implementation has been described in this paper, interfaced GOOSE receive functional blocks enables GOOSE communication among IEDs to ACSE IED replaces copper wires, provides fast communication and compact system. The Trip on parallel manual selection enables easy maintenance when getting outage or maintenance works, TOP can make any CBs standby from local control panels or from IEC61850 SAS HMI.

After successful ACSE GOOSE based logics implemented in system and its Circuit breaker (52) tested by TM1600 CB test analyzer resulting the fault clearance time 86ms can be reduced to 60ms performed in power transformer differential relay 87T benchmark setup by secondary injection Omicron.

The future work might be suggested for GOOSE based IEC 61850 in feeder protection ,transformer protection (87T),Line protection (21/67N & 87U),load shedding ,MTM, Under frequency, switchgear protection, local SAS to remote substation by means cable differential (87C),GSUT overall protection 87U,TEE Protection, Circuit breaker failure protection, low impedance & High impedance bus bar protection, online partial discharge watch system, RPH3,scheme can be brought into IEC61850 SA system.

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## BIOGRAPHY

**Engr.Erum Pathan** was born in Hyderabad, Pakistan; she received the B.E in Electronic Engineering and M.E., degree in Telecommunication & control from Mehran university of Engineering and Technology, Hyderabad, Pakistan in 2004, and 2010 respectively. She was a Lecturer from 2005 to 2009 and an Assistant Professor at QUEST, Pakistan since 2010. She is doing PhD from UTHM, Malaysia in Electrical and Electronic Engineering. She is also member of Pakistan Engineering Council.

**Engr. Muhammad Asad Shaikh** was born in Hyderabad, Pakistan; He received the B.E., & PhD, degrees in Electrical Engineering from, QUEST, Pakistan and Bakerville University in 2006 & 2014 respectively. He was Assistant Manager (Protection and instrument) at NTDC, Pakistan from 2006 to 2010 and site manager (Protection & Substation Automation System) at National Grid, KSA since 2010. He is also member of Pakistan & Saudi Engineering Council.