HOW TO MAKE GOOSE MESSAGES TO SOLVE THE INTEROPERABILITY BETWEEN AREVA AND SEL IEDS

Le Kim Hung[1], Vu Phan Huan[2], Le Thi Minh Chau[3]

[1]The University of Danang, University of Science and Technology; lekimhung@dut.udn.vn
[2]Electrical Testing Central Company Limited, Da Nang, Viet Nam; vuphanhuan@gmail.com
[3]Hanoi University of Science and Technology

Abstract - IEC61850 Goose communication has been used successfully in a lot of different applications in recent years. It is available in IEDs together with software tools which provide new features, and is especially helpful for testing or interoperability. In this paper, we present the applicability of network topology, network media, configuration TCP/IP on PC, PC tools and the challenges of different IED manufacturers when their goose messages are published or subscribed in slightly different ways. In this way, creating a goose message system enables the implementation of substation by software tools of SEL and AREVA such as AcSELerator Quickset, AcSELerator Architect, and MiCOM S1 Agile that are used to configure the IEDs (P445, SEL421 and P643). In addition, ISA DRT66's TDM is used to inject current and voltage signals for testing goose messages on the network. Consequently, the proposed approach helps to perceive interoperability issues, eliminate copper wires and expand the function and the capability of the system.

Key words - Relay Protection; IEC61850; Goose Message; Ethernet; IP Address.

1. Introduction

In Vietnam, substation protection and control systems are typically designed to include devices from different manufacturers, which provide redundancy to ensure no common mode failure in a system and make interchangeability reliability.

The systems are confined to the boundaries of a substation. One of the basic reasons for this is interconnecting wires between protection and control devices that can only reach a certain distance to be economically viable. A mere 10 years ago, a protection panel could consist of over 1000 wires [1] in the fields such as [3]: Substation interlocking; Reverse interlocking; Inter tripping; Load shedding (F81); Breaker failure (50BF);.... This results in a big total cost of building a system for a substation.

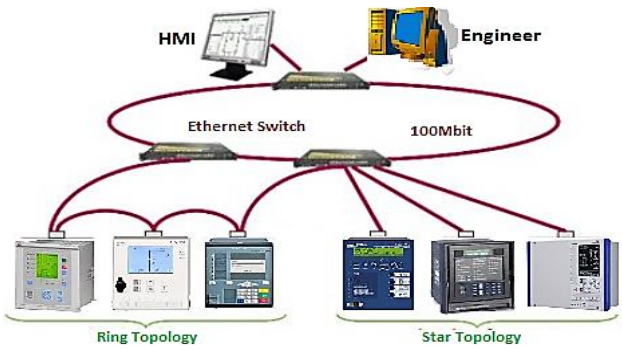

Figure 1. *Mixed ring and star architecture*

Compared to conventional protection and control systems are still based on MODBUS and DNP3 standards, a new substation protocol like IEC 61850 uses only a single LAN cable (Figure 1), has the ability to create virtual wiring between two or more devices across an Ethernet network, using high speed switched Ethernet to obtain the necessary response times of < 4 ms for protective relay by multi-cast goose messages [2]. These replace copper wires for the interconnections between the protection, control devices and primary equipment that use binary inputs/outputs and wires. The goose messages contain quality information and are supervised at all times to monitor strong connections, something a copper wire could never tell us. Now the same application schemes have been reduced to use no more than 200 wires [1].

In addition, goose messages has a common substation configuration language (SCL) which allows the relays from different manufactures to exchange data easily and reuse the user's engineering in the future.

The paper includes 4 sections, in which section 1 is introduction, section 2 is hardware and software tools. Testing relay protection is presented in section 3. Section 4 is the conclusion.

2. Hardware and software tools

In this section, include a list of hardware devices, software tools (with a description of each item) and diagrams showing the connectivity between the devices.

2.1. Networking media

Today, the two most popular physical layer standards for Ethernet are twisted pair copper cable (Category 5 or Cat 5) and fiber optic cable. Ethernet interfaces are identified by the speed (in Megabits per second), the modulation type (Base), and the physical interface (e.g. – T or TX is Twisted Pair, FL or FX is Fiber). Some common copper and fiber interfaces used in the protective relaying industry with the corresponding IEEE 802.3 definitions, distance and power budget are shown in Table 1 [4].

Twisted pair copper (Figure 2) is easier to terminate, has lower installation costs, but is susceptible to electrical noise and a single run of twisted pair cable is distance limited to 100 meters (unshielded) to 150 meters (shielded) in length.

Fiber optic media brings two basic types of solutions, namely, Multi-mode fiber and Single-mode fiber. Both fibers typically can be operated over much longer distances than copper cable, immune to electrical noise, and, while being more difficult to terminate, is usually available as prefabricated cables. Figure 3 shows ST, SC, LC and MTRJ connectors. ST fiber connectors are twist-lock type. SC, LC and MTRJ type connectors are snap-on type. ST, SC and LC based cables have separate cables for transmit and receive signals, whereas on MTRJ based cables, the two fibers are merged into a single connector [4].

Table 1. *Some common coper and fiber interfaces on ethernet switches available to the protection relay*

Port Type	Port Description	Typical Distance
10/100BaseT	10/100 Mbit RJ45 Cooper – unshielded	100m
10/100BaseT	10/100 Mbit RJ45 Cooper – shielded	150m
100BaseFX	100 Mbit Multimode ST Fiber Optic (full-duplex)	2km
100BaseFX	100 Mbit Multimode SC Fiber Optic (full-duplex)	2km
100BaseFX	100 Mbit Singlemode SC Fiber Optic	20km
100BaseFX	100 Mbit Singlemode SC Fiber Optic	40km
100BaseFX	100 Mbit Singlemode SC Fiber Optic	70km
100BaseFX	100 Mbit Multimode LC Fiber Optic	2km
100BaseFX	100 Mbit Singlemode LC Fiber Optic	15km

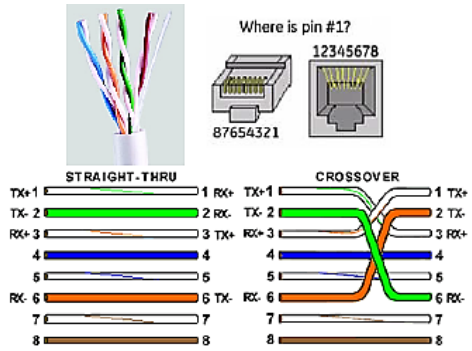

Figure 2. *Twisted pair copper*

Figure 3. *Common fiber optic connectors*

2.2. Network configuration on a PC

IEC 61850 protocol is available with the optional inbuilt Ethernet port. The Ethernet connection uses static IP parameters (Figure 4). Please notice that IP address and netmask must be properly set in reference to devices in order to get the communication to work properly. In LAN network please consultant with IT responsible to obtain proper addresses allowed to be used [5].

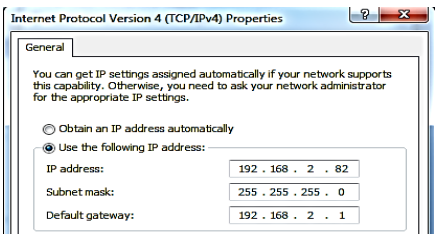

Figure 4. *Internet Protocol (TCP/IP) properties window*

2.3. Standard PC tools

The following tools are always provided with any PC [5]:

Ping 192.168.2.3: the ping tool can be used to test if a device with a given IP address 192.168.2.3 is connected to the network. It runs in a command interface window.

Tracert 192.168.2.5: the tracert tool is used to follow the successive routing path used by a frame along the network. It is therefore useless inside a single subnet.

Ipconfig /all: the Ipconfig tool is used to check the host PC configuration when it cannot establish communication with the network.

2.4. Relay configurator tools

The configuration of the IEC61850 is done with relay tool. The software may be connected to the relay either via serial interface to the front panel connector or via the Ethernet network. Also configuration tool programs are provided by manufactory (Abb, Areva, Siemens, Sel, Ge and Toshiba) to accomplish this process: a relay setting tool, and a tool program designed for creating and editing SCL files for the purpose of building IEC 61850 communication network configurations (Figure 5). Each of the proprietary tools must be able to import the SCL files and extract the information needed for the necessary relays.

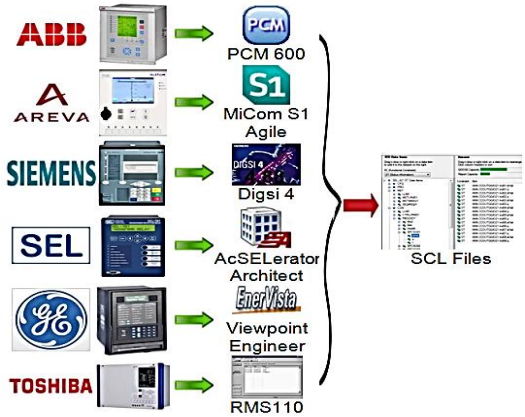

Figure 5. *Tool for creating and editing SCL files*

For more detailed information about the goose message configuration in Sel and Areva relay, see section 3.

2.5. GOOSE Messaging application

With binary input values, protection and control elements, change detect is a False/True or On/Off transition. IEC61850 uses an Ethernet connection as the physical medium of communication between the protective IEDs. This subsection looks at four of these possible applications:

2.5.1. The interlocking system

Information is exchanged with extensive cable and often requires the use of several auxiliary relays to multiply the limited amount of contacts (position) available from the primary equipments.

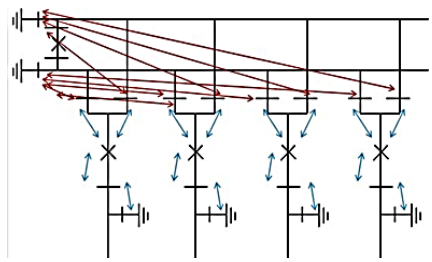

Figure 6. *Interlocking system between disconnector, and earthing switch*

Control/Interlocking in an IEC61850 substation: interlocking signals (CB, disconnector, and earthing switch positions…) are sent through the station bus. Example the interlocking between Earthing Switch and Disconnector shows in Figure 6. We can Open/Close the disconnector only if the earthing switch is Open. If the earthing switch is Close, we cannot operate the disconnecor [6].

2.5.2. Reverse interlocking

One of the common applications of goose messages is to implement a "reverse interlocking" bus protection scheme. In its most basic form (Figure 7) a directional overcurrent relay is installed on the incomer. If a fault is detected towards the bus the incomer relay will trip unless any of the feeder relays send it a blocking signal indicating that the fault is external to the bus [7].

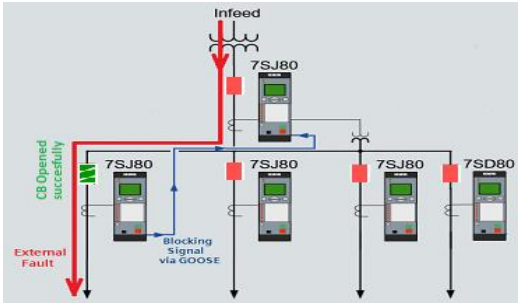

Figure 7. *Bus breaker blocking*

2.5.3. Breaker failure protection

Breaker failure protection can also be implemented as above to monitor the breaker position of downstream breaker i.e. Feeder 1. Once the Breaker Failure Protection function has operated but if the Breaker has not opened at Feeder 1, goose message can be transmitted over existing network to operate the upstream breaker without any need of additional hard wiring to clear the fault as shown in Figure 8 [8].

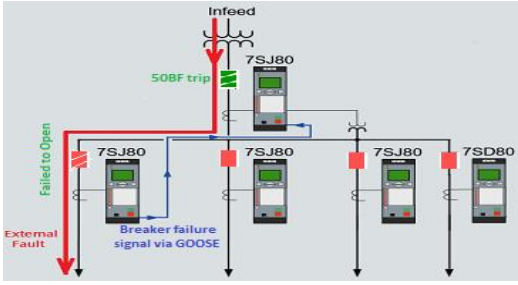

Figure 8. *Breaker failure protection*

2.5.4. Load shedding

Typical load shedding applications in a substation require the addition of a separate under frequency relay followed by wiring from the load shed relay to any breakers to be tripped under an under-frequency condition. Reality is that most breakers in a substation are connected to the tripping output of at least one relay in a substation. Connecting these relays via an Ethernet network, load shed becomes a goose message to trip the appropriate breaker (Figure 9). With some additional logic, the engineer could actually create a rotating schedule of loads to shed. Clearly, a restoration scheme could be created in similar manner. Since this scheme could be loaded into any relay, redundancy is also easy to implement [9], [10].

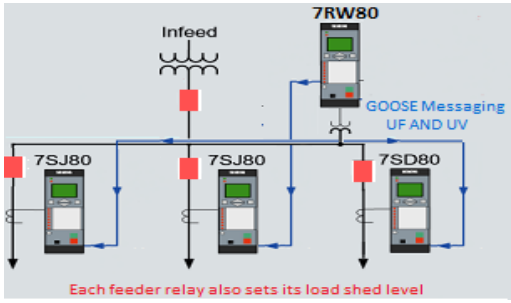

Figure 9. *Load shedding scheme*

3. Testing relay protection

The objective of this section guides you how to create the goose messages for SEL 421 (S/N: 2007134228), P445 (S/N: 32923364/05/14), and P643 (S/N: 911853U) to exchange appropriate information as the following scheme.

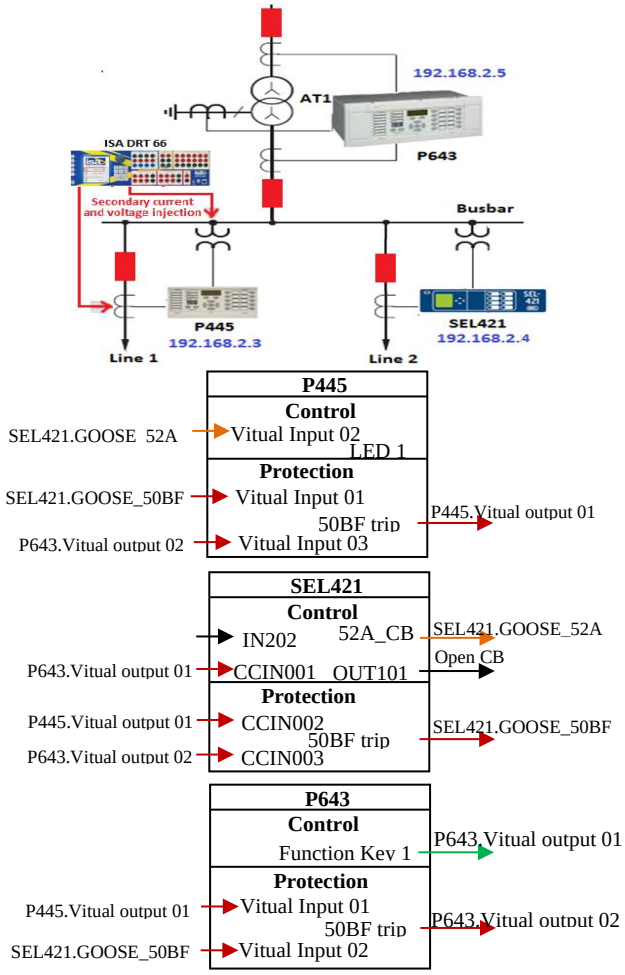

Figure 10. *Substation protection requirements*

The substation protection requirements for the system to be developed:

The circuit breaker connected to the SEL421 will generate a SEL421.GOOSE_52A signal if the circuit breaker is closed (IN202 activate). The P445 displays breaker status on LED 1 from SEL421 using Virtual Input 2.

SEL 421 resets the leds using P643. Virtual output 01 from P643 by push Function key 1.

SEL 421 opens CB if 50BF trip from P445 or P643 is active by using CCIN002, or CCIN003.

P445 opens CB if 50BF trip from SEL421 or P643 is active by using Virtual Input 1, Virtual Input 3.

In the same way, P643 opens CB if 50BF trip from P445 and SEL421 is active by using Virtual Input 1, Virtual Input 2.

3.1. Setup physical connections

Before carrying out the tests please ensure that the connections are set as the requirements.

Apply power to the auxiliary power supply inputs of the relays.

Connect a Cat 5E cable from each relay to unmanaged ethernet switch and apply power to the switch.

Connect a serial cable from your PC to SEL421, P445, P643 and configure the appropriate COM port that is being used so that it is compatible with the relay front port parameters.

Injecting current and voltage directly into relay terminal by ISA DRT 66.

3.2. Configuring goose

3.2.1. Configuring goose in Architect

This subsection is going to provide step by step procedures on how to make a goose message in SEL421.

Step 1: Before you start making goose messages, you need to define the variables and add them to setting file by AcSELerator QuickSet in the following order:

Breaker Monitor/Breaker 1: IN202 connect to 52A of Breaker, it will look like Figure 11.

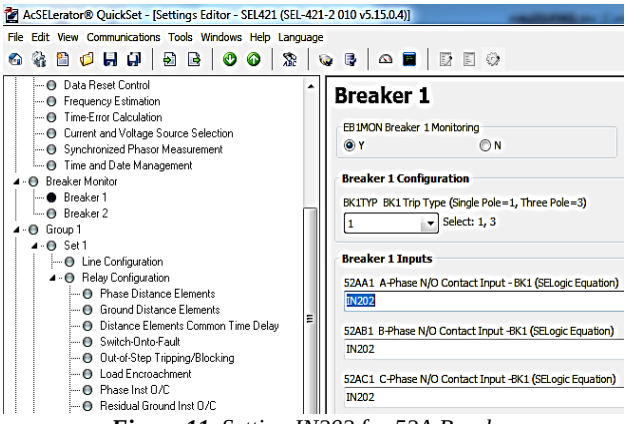

Figure 11. *Setting IN202 for 52A Breaker*

Global/Data Reset Control: Select EDRSTC:= Y and RSTTRGT:= CCIN001.

Outputs/Main Board: select OUT101 = CCIN002 OR CCIN003.

Step 2: When you have completed the step 1, open Architect tool, you can see their current setup and modify it.

Changes to the 'Properties' tab must also be made to the port settings of the SEL421 with IP address is 192.168.2.4.

A goose message contains a single dataset, which can be modified or created under the 'Datasets' tab. "Dataset SEL421_Send" consist IN202 status and 50BF trip command, which are defined in IEC 61850 (Figure 12).

To transmit a dataset, click on the 'GOOSE Transmit' tab and create a new message. Give it a name "GOOSEMgs_Send" and a description, but do not edit the MAC Address and APP ID unless you know what you're doing and know the relevant 61850 specifications. Click on the dropdown menu to change the dataset to the one you previously set up.

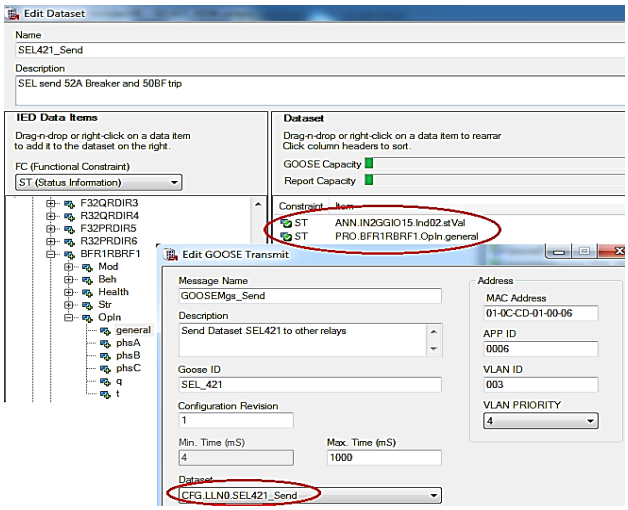

Figure 12. *Edit dataset and GOOSE transmit*

Once the proper message is set up to transmit, select the desired recipient device from the menu on the left. Click on 'GOOSE Receive', and navigate to the device which is transmitting the message you want to receive. By expanding this tree, you can get to the individual values being transmitted. By clicking and dragging variables to the right, they can be mapped to CCIN inside the recipient device [11]. This is shown in Figure 13.

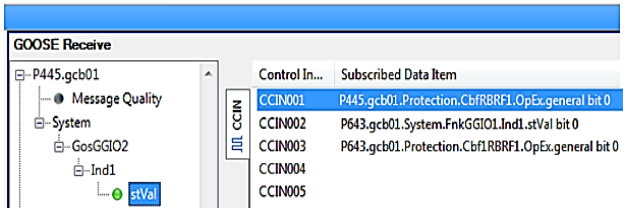

Figure 13. *Edit goose receive*

After that we start sending goose messages. Right click on the device SEL421, and click 'Send CID'. Enter username is '2AC'. The password is 'TAIIL'.

3.2.2. Configuring goose in MiCom S1 Studio

This subsection provides a description how to make a goose message in P445 and P643.

Step 1: goose control block.

The goose control block specifies the parameters for publishing a Dataset over the Ethernet LAN. In the Version 2 implementation of IEC 61850 we can link Datasets to a maximum of eight different goose control blocks. At least one goose control block within the IED must be enabled for goose messages to work. If the other goose blocks are not being used, it is best practice to leave them disabled. For this paper, we will ensure **IED CONFIGURATOR/GoEna** is enabled by checking the bit position corresponding to gcb01 is set to 1 [12].

Step 2: Configure programmable scheme logic for P445 and P643 such as:

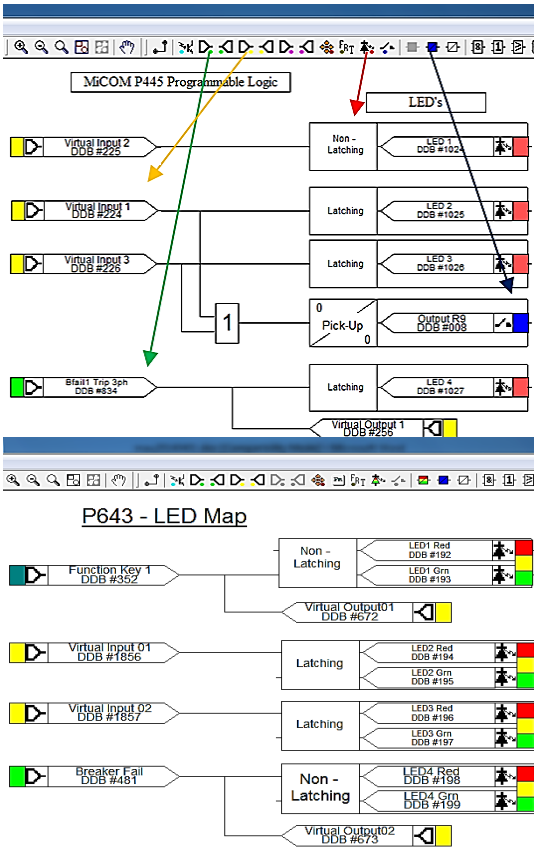

Figure 14. *Configure PSL files*

Step 3: Configure goose messages

There are a few major parameters that need to be completed in order to configure goose messages:

Configure Communications: Set IP address 192.168.2.3 for P445 and 192.168.2.5 for P643.

Create Dataset Definitions: Create a dataset by specifying it's location within the IED and then select which data object will be contained within the dataset.

For P643, we will add the Protection/Cbf1RBRF1.ST. OpEx.general and System/FnkGGIO1.ST.Ind1.stVal to the dataset and store that dataset in the System\LLN0\ Dataset1 location of the IED data model (Figure 15).

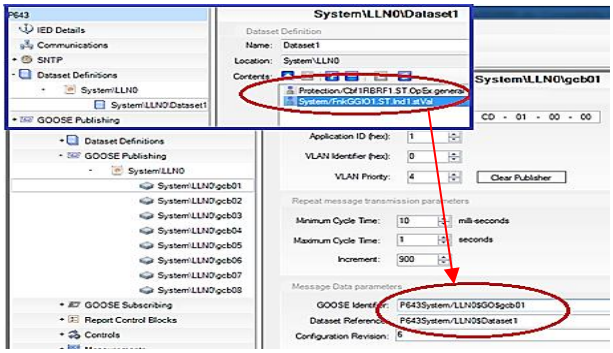

Figure 15. *Edit dataset and goose transmit in P643*

Repeat the step with Protection/Cbf1RBRF1.ST. OpEx.general for P445.

Configure goose publishing: Configure goose publishing by linking, the dataset that was created in the previous step, to goose control block gcb01. This particular data object represents a goose output signal which is mapped internally to the Virtual Output 1 element relays.

Configure goose subscribing: The final part in the configuration of goose message is to subscribe to the goose message published by the other IED. The end result will have the subscribed goose message linked to the IED's Virtual Input as follows:

IED	Virtual Input in PSL	Data object
P445	1	SEL_421\ANN\IN2GGIO15\Ind02.stVal
	2	SEL_421\PRO\BFR1RBRF1\Opln
	3	P643\PRO\Cbf1RBR1\ST\OpEx.General
P643	1	SEL_421\PRO\BFR1RBRF1\Opln. General
	2	P445\PRO\Cbf1RBR1\ST\OpEx.General

After that we start sending goose messages. Right click on the device P445 or P643, and click 'Send". Enter password is AAAA.

3.3. Result and discuss

In order to verify the properties described above, the experimental results base on SEL421, P643 and P445 include:

Check 52A breaker status from SEL421 send to P445:

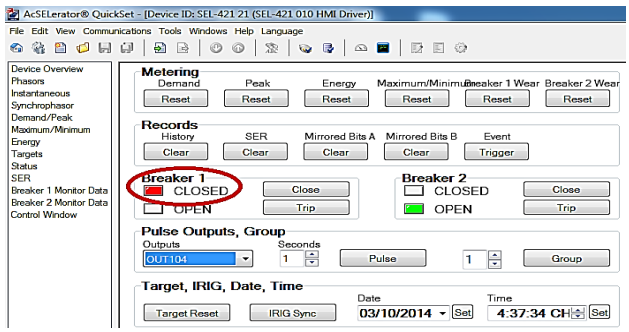

Figure 16a. *CB close status on SEL421*

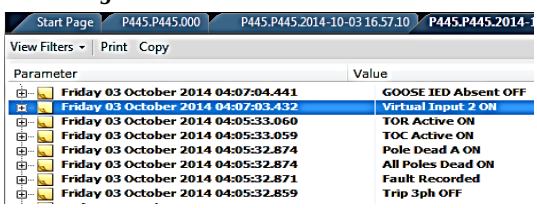

Figure 16b. *CB status on P445*

Checking 50BF trip from P445 send to SEL421:

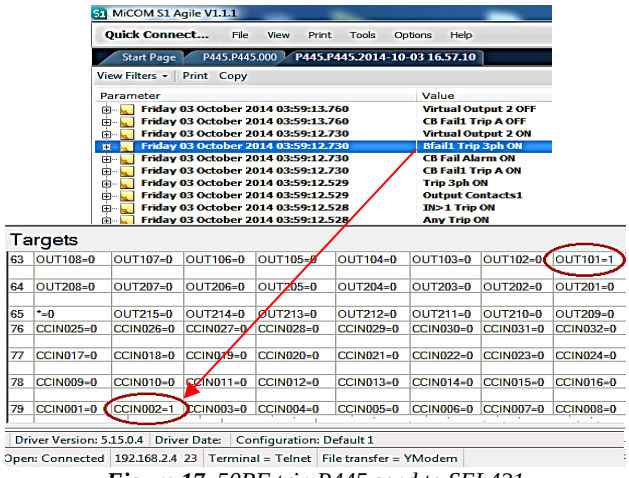

Figure 17. *50BF trip P445 send to SEL421*

Reset LEDs: the LEDs on SEL421 blinks when the Trip signal occurs. After trip signal off, LEDs remain latched until the Function Key 1 of P643 is pushed.

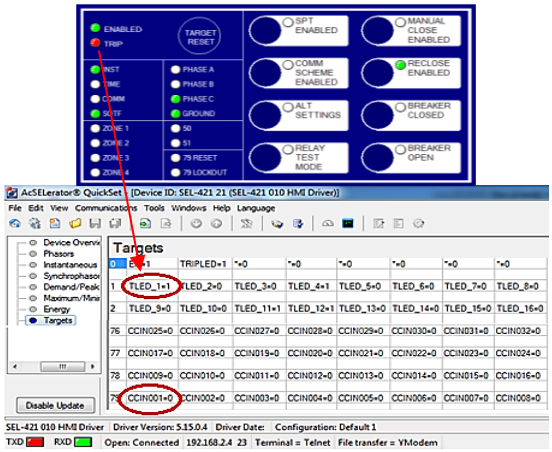

Figure 18a. *Trip led blink with F50/51 trip on SEL421*

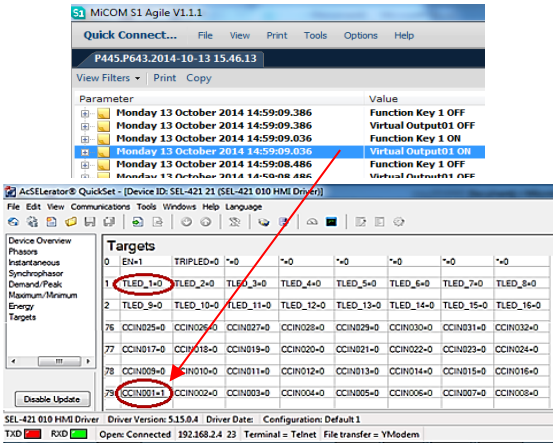

Figure 18b. *SEL421's trip led is reset with Functiom Key 1 on P643*

From these results, the interoperability of devices from SEL and AREVA was successfully demonstrated in the use of goose messages for implementing control and protection systems. We can conclude that this solution is better than tradition connection cables. This is also a target for us to research more than with other IEDs in the future.

4. Conclusion

The objective of this paper was not to discuss the benefits of IEC 61850. We presented all steps of configuration and testing goose messages communication in IEDs (SEL421, P445, and P643) for exchanging information with each other devices on a substation LAN. The obtained results clearly show that the goose messages help to solve the interoperability of IEDs from different manufacturers easily and reduce cost building substation. We hope that making information above will assist researchers working in this area to have the most appropriate platform for their purposes.

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