IEC61850-Based Remote Control System of Pole-Mounted 69/115kV Switches on MEA's Distribution System

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***Abstract*—Metropolitan Electricity Authority (MEA) is a power distribution utility in Thailand distributed at the following voltage levels: 230kV; 115kV; 69kV; 24kV; 12kV, and 380/220 Volts. Almost 21,115 km together with 159 substations deliver 53,282 gigawatt-hours of electricity annually from the Electricity Generation Authority of Thailand (EGAT). In the distribution system, the transmission line is one of the critical parts. The transmission line has to have good maintenance and switching plan for reaching the highest reliability. Nowadays, the environment of MEA's distribution area has changed, such as severe traffic jam, a high number of high constructions, and a high number of high advertising boards resulting in a higher chance of overhead-transmission-line faults than before. In the metropolitan area of Thailand, there is a significant problem with switching operations on transmission line due to severe traffic jam cause prolonged outage duration in wide-area especially industrial area, making higher cost. This paper presents an efficient method for improving the electrical distribution system's reliability by implementing a remote-control system using IEC61850 standard (MMS and GOOSE messaging) to operate pole-mounted 69/115kV switches in transmission lines from SCADA instead of a local control operation and proprietary remote-control system. The paper presents several practical techniques to implement the IEC61850-based remote control system to support both old RTUs (by GOOSE method) and modern RTUs (by MMS method) for utilizing data and reducing procurement cost. Finally, the IEC61850-based remote control system can reduce an outage duration from 30-60 minutes to 3-5 minutes if switchable loads make satisfactory**

Keywords—Remote control system, load break switch, remote I/O device, power distribution

I. INTRODUCTION

Metropolitan Electricity Authority (MEA) is a power distribution utility in Thailand distributed at the following voltage levels: 230kV; 115kV; 69kV; 24kV; 12kV, and 380/220 Volts. Almost 21,115 km together with 159 substations deliver 53,282 gigawatt-hours of electricity annually from the Electricity Generation Authority of Thailand (EGAT). In the distribution system, the transmission line is one of the critical parts. The transmission line has to have good maintenance and switching plan for reaching the highest reliability. Nowadays, the environment of MEA's distribution area has changed, such as severe traffic jam, a high number of high constructions, and a high number of high advertising boards resulting in a higher chance of overhead-transmission-line faults than before. In the metropolitan area of Thailand, there is a significant problem with switching operations on transmission line due to severe traffic jam cause prolonged outage duration in wide-area especially industrial area, making higher cost. So, MEA has to find out the best solution to deal with the problems.

II. DEVELOPMENT OF EQUIPMENT AND SYSTEMS

In the past, some large customers that receive power from transmission lines have been interrupted for long time due to slow restoration service. Major causes are traffic jam and none of remote-control system of transmission line. So, MEA had tried several remote-control solutions for coping the problems. three major areas of development are communication media, remote control circuits for existing high-voltage load break switch and remote I/O devices. A series of trial plans are initiated to identify the most suitable equipment and its fitness for purpose.

A. Communication Media

There are various communication media available for distribution systems, i.e., optical fiber, power line communication (PLC) and radio communication, etc. The type of communication media for distribution system is different depending on the required speed for applications and customers' density. Advantage of the optical fiber is the high-speed communication [1], and its disadvantage is the high cost of installation works. Advantage of PLC is the low cost of installation works due to the line is not necessarily installed in this application. Disadvantage of PLC is the security of information and noise interference to neighbor equipment. Advantage of radio is also the low cost for the installation. And its disadvantage is noise interference and security. In this project, the communication media is optic fiber (see Figure 1). Additionally, 6-core single mode type of optic fiber is selected for more effective and reliable. For the other reason, length of optic fiber is not too long due to allocating a nearby substation as data concentrator using an existing RTU instead of direct SCADA connection from transmission line switches at any electrical pole. Therefore, cost of fiber optic cable is not quite high.

Fig. 1. Optical Fiber Cubicle

B. Control Circuits of Pole-Mounted 69/115kV Switches

For remote monitor and control of a 69/115kV switch (see Figure 2), MEA has to modified control circuits and terminals on the switch. MEA control center (SCADA) has specified alarms and point controls.

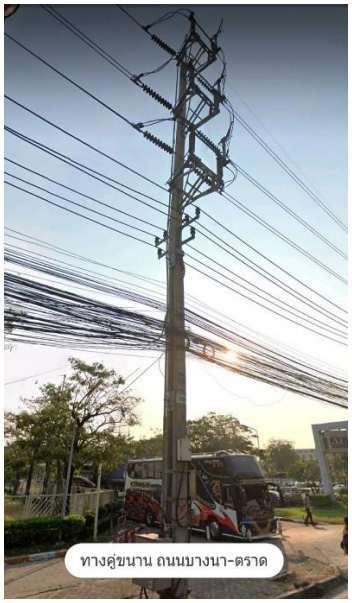

Fig. 2. Load Break Switch

Thus, the switch cubicle has to have many auxiliary relays for providing alarm and control contacts (see Figure 3). By means of the digital inputs and outputs of control system (Remote Terminal Unit/Substation Automation) at substation, the status of the switches (open/closed) is detected and the operations of opening or closing the switches may be performed. Also, alarm inputs are connected to the sensors in order to inform what wrong of the transmission line switch. Importantly the power supply includes a battery that allows the proper working of the system in the event of no low-voltage supply. So, alarms associated with the power supply have to send to the control center. The table 1 shows the main signals used in the remote-control system of the transmission line switch.

Fig. 3. Load Break Switch Cubicle

TABLE 1. Remote Control System

Type	Description
Switch Control	Load-Switch Status (Open/Closed/Error)
	Load-Switch Command (Open/Close)
General Alarms	Switch Trouble
	AC Loss
	DC Loss
	Cubicle Door Opened
Remote I/O Alarms	Remote I/O Failed
	Local I/O Failed
	Communication Error

C. Remote I/O Devices in the Beginning

In the beginning of the project, there were 3 types of devices acting as paired remote I/O devices for transferring data, i.e., tailor-made PLCs (Programmable Logic Controller), in-house microcontroller boards and mirrored remote I/O. The first choice is a microcontroller board (see Figure 4).

Fig. 4. MEA Microcontroller Board

The microcontroller board has been designed by MEA personals. Thus, its cost is quite cheap and able to implement a high complex work without extra cost, but the microcontroller board is not standardized. The second choice is PLC. It can be implemented faster and more reliable due to PLC is approved by industrial standard (see Figure 5).

Fig. 5. Tailor-Made Programmable Logic Controller

However, its disadvantage is the cost for its installation works quite high, especially when system is more sophisticate such as MMI (Man Machine Interface) required. So, MEA preferred to use a PLC as a remote I/O device for a few years. However, PLC is needed to be programmed that make some troubles on our technicians for maintaining. MEA have changed to use non-programming required device instead that is a mirrored remote I/O device (see Figure 6) for solving the problem.

Fig. 6. Tailor-Made Programmable Logic Controller

Fig. 7. Cubicle of Remote I/O Device

The configuration of beginning Remote Control System is designed as Figure 8. There are 3 places where can control a transmission line switch. The first place is local control panel at an electric pole that installs a transmission line switch. The second place is remote control panel at a substation that is selected as data concentrator and the final place is the power system control center (SCADA) where control via RTU/CSCS. Due to many controllable places, it has more reliability to operate a transmission line switch. Moreover, if the microcontroller board is being use as a remote I/O device, then the remote-control system is able to have a MMI that is used to monitor and control in a substation and spending a little extra cost. Due to there is no communication protocol between Remote I/O devices and RTU/CSCS, MEA has to use two remote I/O devices between remote and local locations and use hardwiring between Remote I/O devices and RTU/CSCS. Additionally, the beginning remote control system used serial communication resulting in lack of peer-to-peer ability.er, its disadvantage is the cost for its installation works quite high, especially when system is more sophisticate such as MMI (Man Machine Interface) required. So, MEA preferred to use a PLC as a remote I/O device for a few years. However, PLC is needed to be programmed that make some troubles on our technicians for maintaining. MEA have changed to use non-programming required device instead that is a mirrored remote I/O device (see Figure 6) for solving the problem. The configuration of beginning Remote Control System is designed as Figure 8. There are 3 places where can control a transmission line switch. The first place is local control panel at an electric pole that installs a transmission line switch. The second place is remote control panel at a substation that is selected as data concentrator and the final place is the power system control center (SCADA) where control via RTU/CSCS. Due to many controllable places, it has more reliability to operate a transmission line switch. Moreover, if the microcontroller board is being use as a remote I/O device, then the remote-control system is able to have a MMI that is used to monitor and control in a substation and spending a little extra cost. Due to there is no communication protocol between Remote I/O devices and RTU/CSCS, MEA has to use two remote I/O devices between remote and local locations and use hardwiring between Remote I/O devices and RTU/CSCS. Additionally, the beginning remote control system used serial communication resulting in lack of peer-to-peer ability.

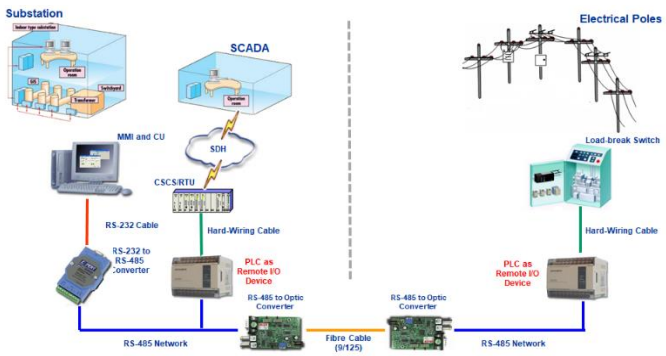

Fig. 8. Configuration of Beginning Remote Control System

III. Configuration of IEC61850-Based Remote Control System

After 5 years of the project, MEA have a difficulty due to some remote I/O devices are getting not work resulting in high cost of maintenance. Due to MEA has not specified a communication standard for remote I/O device making MEA has a few options to select a spared remote I/O device. So, MEA has considered to use IEC61850 IED as the remote I/O device on an IP network instead. Then MEA can use bidding procurements for installation and maintenance. The IEC61850 IED also can support both old and modern technology RTU including CCU/CGW. About the old technology RTU, it does not support IEC61850 protocol making use a pair/1:m of remote I/O device among IEDs as beginning method. So, IEC61850 GOOSE [2] has been use to send/receive as mirror bit between local and remote I/O device for an old technology RTU (see Figure 9).

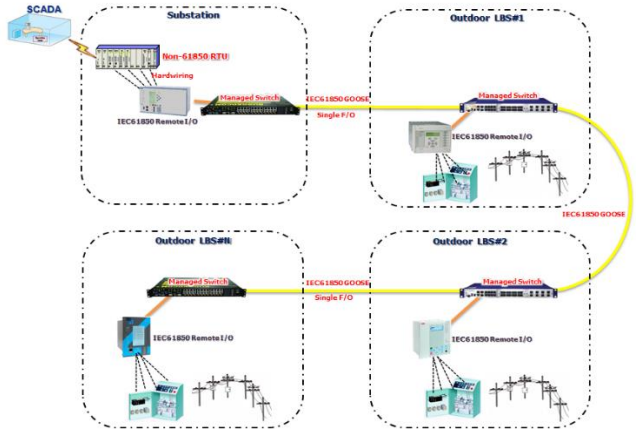

Fig. 9. Use of IEC61850 GOOSE for Old RTU

About modern technology IEDs (RTU, CGW, CCU) for connecting to MEA SCADA, they support IEC61850 MMS [3] then they can directly connect with IEC61850 remote I/O device without hardwiring (see Figure 10). Comparing with the old method, MEA can use IEC61850 MMS to remove a lot of connection points to make the remote-control system increasing a system reliability.

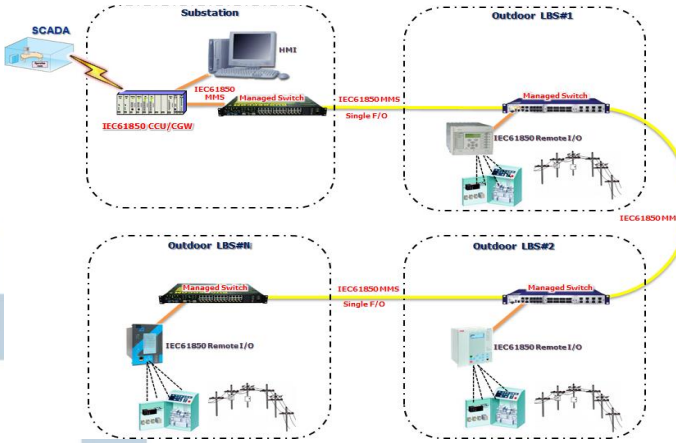

Fig. 10. Use of IEC61850 MMS for IEC61850-based Substation

The advantage of IEC61850 method also give MEA can replace any I/O device by other manufacturer, So MEA does not need to spare several types of IED. However, MEA has to upgrade skill of our technician about communication technology for getting an efficiency maintenance.

IV. Conclusions

Business-oriented management of distribution process has been greatly enhanced. Reliability based network is essentially required for customer satisfaction. Effective remote-control system of sub-transmission line switch on the 69/115 kV network will become increasingly important to maintain and improve the availability of supply to customers at an acceptable cost. The paper presents practical techniques to implement the IEC61850-based remote control system to support both old RTUs (by GOOSE method) and modern RTU/CCU/CGW (by MMS method) for utilizing data and reducing procurement cost. Finally, use the IEC61850-based remote control system can reduce maintenance cost and an outage duration from 30-60 minutes to 3-5 minutes if switchable loads make satisfactory. Finally, MEA will continue improve its network to the best quality of service.

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