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# PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON SCIENCE AND ENGINEERING

*Volume - 1*

**Electronics**
**Electrical Power**
**Information Technology**
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# ELECTRICAL POWER ENGINEERING

# SCADA-Based Control System for Distribution Substation

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*Abstract*— **SCADA (Supervisory Control and Data Acquisition) distribution is an integrated system which accepts for the digital automation of distribution substation, feeder and user functions. It includes control, monitoring and protection of the distribution system, load management and remote metering of consumer load. The main function of distribution system is to receive electric power from large, bulk power sources and to distribute electric power to consumer at various levels with acceptable degrees of reliability. This distribution system is analyzed to develop a secure, reliable and convenient management tool which can use remote terminal units (RTUs). This research work aims to apply SCADA-based control technique for distribution substation. In order to accomplish that purpose, necessary graphic designs are created and input/output devices of PLC are assigned to communicate Citect HML and PLCs. Afterwards, PLCs ladder diagram is developed for network of distribution substation. In addition, Ethernet System is established using SCADA design in which four clients and one supervisory computer are involved for control purpose. Each of four process control station connects with PLC by means of RS 232 system. However, this thesis mainly focuses on distribution substation process control system using SCADA. In that case, graphic design for distribution substation is created using graphic builder and dynamic pictures are controlled by each tag using the Citect (HML) programming including tags function. Various performance tests have been carried out in order to demonstrate the desirable features of SCADA application. The significant advantages of SCADA design implemented in this thesis are to provide safe energy efficiency and minimize damage possibilities. This tag development system is able to fulfil all tasks of power load management, and can be upgraded easily, and satisfy the continuously developing requirements. By using this system, the continuously developing requirements would be satisfied.**

## I. Introduction

The electric power system is one of the tools for converting and transporting energy which is playing an important role in meeting this challenge. Development of sources of energy to accomplish useful work is the key to the industrial progress which is essential to the continuous improvement in the standard of people everywhere. An electric power system consists of three principal components: the generating stations, the transmission lines, and the distribution systems. The transmission is the connecting links between the generating stations and the distribution systems and led to other systems over interconnections. A distribution system connects all the individual loads in a given locality to the transmission lines. Electricity power utilities world wide are increasingly adopting the computer aided monitoring, control and management of electric power distribution system to provide better services to customers. SCADA control distribution systems benefit customers: reducing unnecessary power outages, getting maximum demands. By using control unit in power distribution network, it reduces the labour costs, system maintenance, maximum on-peak and off-peak time, etc. The architecture of a SCADA system changed with the philosophy of computing in organization, from mainframe dominated, centralized computing system to network-based distributed computing in the early 1990s. Great progress in computer and communication technologies has lead to the innovation in SCADA system. In particular, the widespread availability of internet technology provides a fundamental support for developers in their approach to a new generation of SCADA system.

## II. METHODOLOGY

There are four main components of SCADA system.

(1) Hardware
(2) Software
(3) Communication
(4) PLC Program

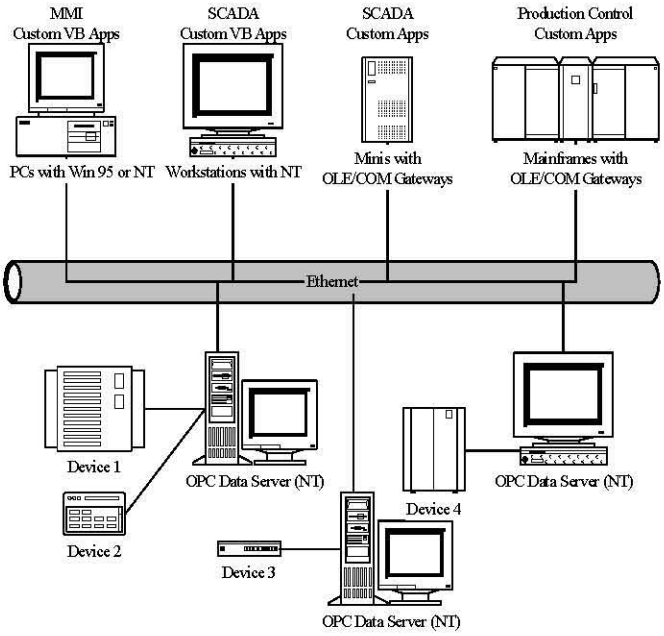


Fig. 1 System Configuration of SCADA

*B. Citect SCADA Topologies*

Citect is easily scalable, so that it is possible to use it as a SCADA package of a small system, and then upgrade the system size at a later date. Citect's data redundancy and client server techniques may well be advantageous in later years. Citect is designed to operate under network architecture. This enables many Citect terminals (clients) to be used around a large plant, all getting the data from PLCs around the plant. Citect is a Client/Server distributed processing package, which means that it is possible to use a server that collects data from PLCs around the plant. Thus the client asks the server computer for data, rather than the PLCs themselves. This means that only small packets of data are sent across the network. Citect even includes data redundancy options, allowing two or more Citect servers on either the same or different local area networks (LAN). Using full LAN and data path redundancy, input/output (I/O) devices are connected to servers via two or more data paths, and the servers then run on two independent LANs. The Citect client systems are connected to both LANs in such a way that if a fault occurs in the primary data path from the I/O device to the server, or even during a total LAN malfunction, the system will switch to the standby data path or to the standby server. Citect is a SCADA package which provides a complete set of software tools to build a communications database, complex (or simple) display graphics, reports, historical and real-time trending, and programs. A user-friendly, real-time interface allows the plant personnel to interact easily with live plant-floor data. High-performance device drivers, written down to the protocol level for PLCs, loop controllers, I/O modules, and similar devices, ensure reliable plant-floor data. Choice of Citect software provides users with substantial benefits.

There are many requirements of a SCADA package in order to be suitable for industry use. Citect meets all of these requirements and is widely used because of its connectivity to other automation equipment in a factory and also because it is easy to upgrade. The Citect software is designed in such a way as to make the automation process scalable. This means that a company can start with a small system, and expand the automation process to any size by upgrading the software license.

The Citect software supports intelligent redundancy. This means that backup equipment can be installed, ensuring that there is continued operation in the event of any single hardware or software failure in the system.

*C. Distribution with Automation*

Distribution Automation is an integrated system concept for the digital automation distribution substation, feeder and user functions. It includes control, monitoring and protection of the distribution system, load management system, load management and remote metering of consumer loads. The distribution automation contains:

(1) Computer Hardware
(2) Computer Software
(3) Remoter Terminal Units (RTUs)
(4) Communication Systems
(5) Consumer Metering Devices

The distribution automation system provides automation system provides automatic reclosing of relays, automatic feeder switching and provides remote monitoring and controlling of distribution equipment (transformers, capacitors, breakers, sectionalizers, communication nodes etc.) from substation up to and including the consumer interface. It affords the utility in minimizing outage time and ultimately, better consumer service and lowering of the total delivered cost of electricity. It allows operation of the system with less capacity margin.

*D. Automation Communication System*

There are many communication methods available. Evaluation of different communication systems for data communication between Distribution Control Centre (DCC) and any point on the distribution network is required at the planning stage. The fundamental requirements for communication infrastructure are:

(1) Determination of system average message rate;
(2) Handling the requisite amount of data and multitasking;
(3) Determining data and system response to meet various application requirements
(4) Allowing for network growth and added applications

The communication methods may be used individually or may be combined. They are;

1. Public Telephone Communication (PTC)
2. Power-Line Carrier (PLC)
3. Radio communication

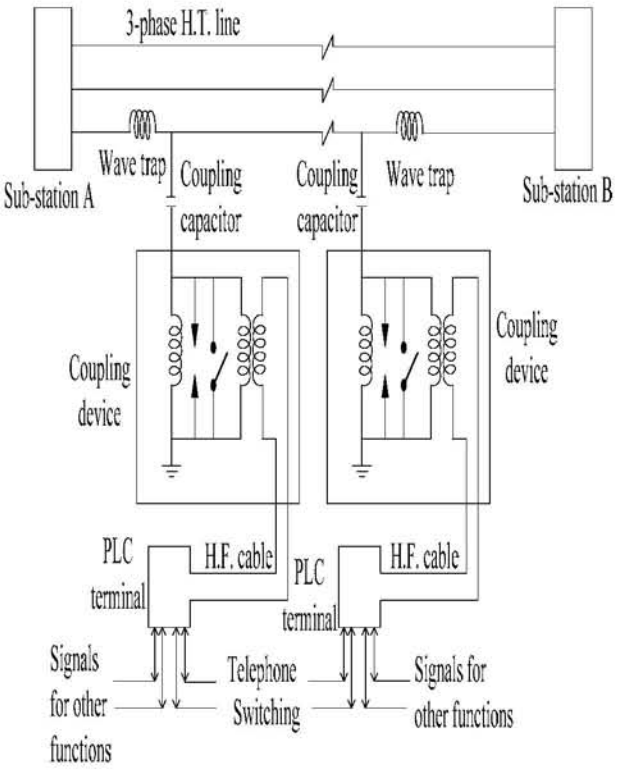


Fig. 2 Radio Communication

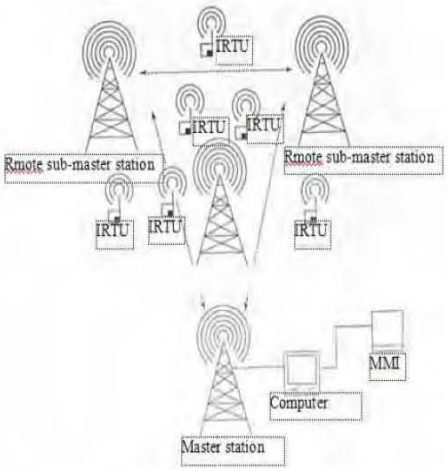


Fig. 3 UHF Multi Address System Radio

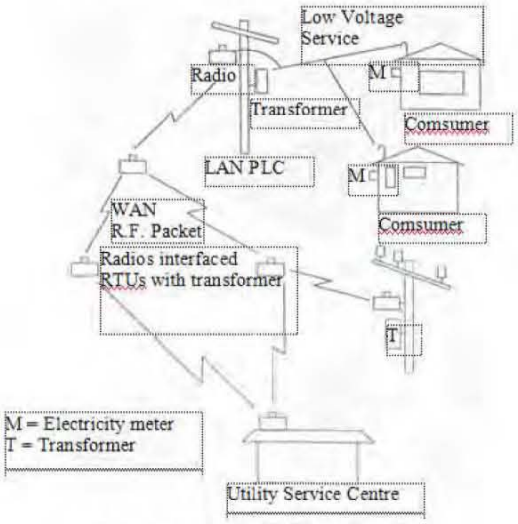


Fig. 4 Packet Switchin Network (PSN)

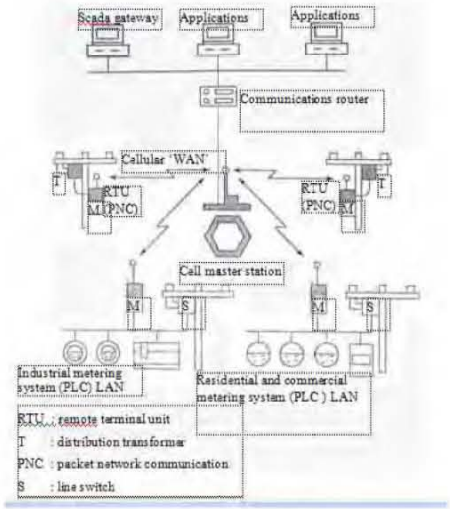


Fig. 5 Cellular Radio

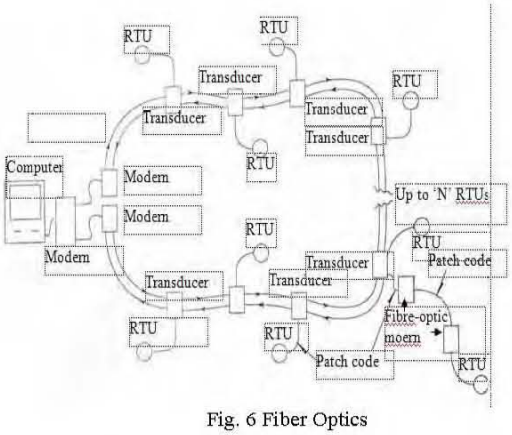


Fig. 6 Fiber Optics

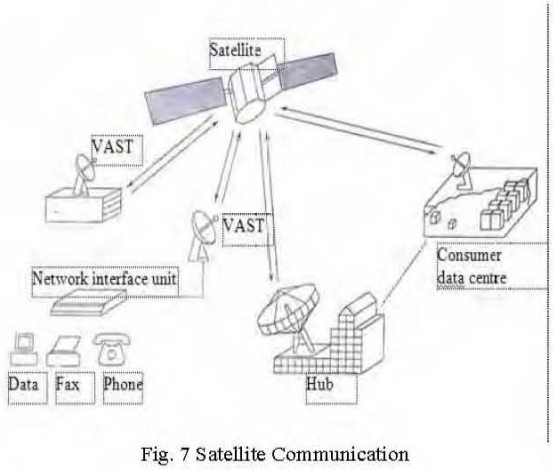


Fig. 7 Satellite Communication

## III. TEST AND PERFORMANCE RESULTS OF SCADA DESIGN ETHERNET SYSTEM USING SCADA DESIGN

There are four stations and Host station in this Ethernet system. Host station is Supervisory control with IP 120.100.11.5. It is the main station in this project. The four stations are substations or clients.

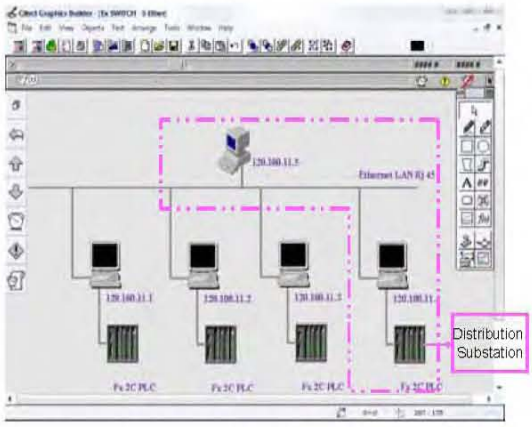


Fig. 8 Graphic Design for Distribution Substation

(a)The DAM process control with IP 120.100.11.1
(b)The Generation process control with IP 120.100.11.2

(c)The Switching process control with IP 120.100.11.3

(d)The Distribution Substation process control with IP 120.100.11.4

Each of four process control station connects with PLC by means of Serial communication RS 232 system. This thesis mainly emphasizes on Substation Distribution process control system using SCADA.

This section expresses the communication of the Ethernet system. The supervisory computer can communicate with each client computer and operate each process of client computer.


Fig. 9 Graphic View of Main Page

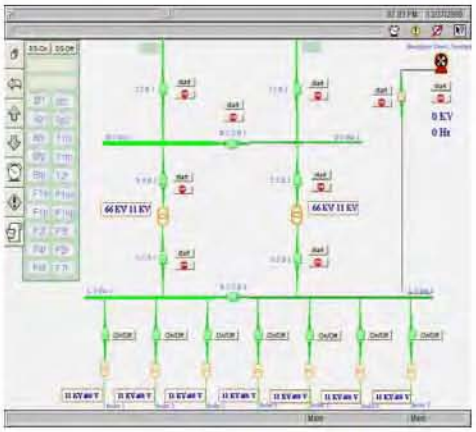

Fig. 10 Operation View of Instrument

This section illustrates the operation of substation distribution system. Firstly, a designer must close the DS (disconnection switch) 'ON' position. At this time, all circuit breakers are in 'OPEN' position. If source 1 or high voltage line-1 is alive, the I.C.B-1 (incoming circuit breaker-1) will be closed. If source 2 or high voltage line-2 is alive, the I.C.B-2 will be closed. If source 1 and 2 are synchronized, synchronizing detector meter will send tripping signal to the circuit breaker B.C.B-1 (bus coupling circuit breaker – 1), the circuit breaker B.C.B-1 must be tripped. Circuit breaker T.C.B-1 (transformer circuit breaker – 1) and T.C.B-2, O.C.B-1 (outgoing circuit breaker – 1) and O.C.B-2, and B.C.B-2 are automatically closed within time delay.

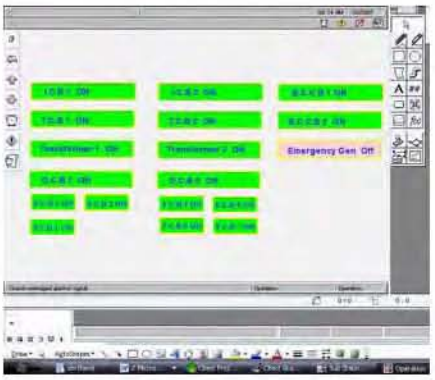

Fig. 11 Performance Test of Feeder-1 Fault Condition

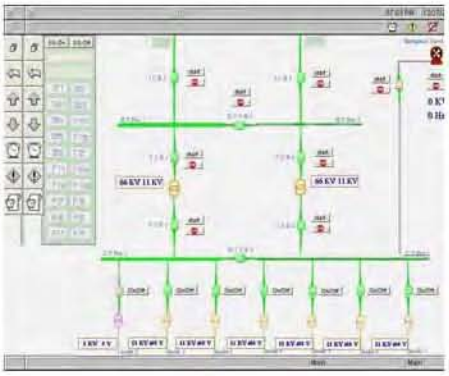

Fig. 12 Performance Test of Source -1 Failure Condition

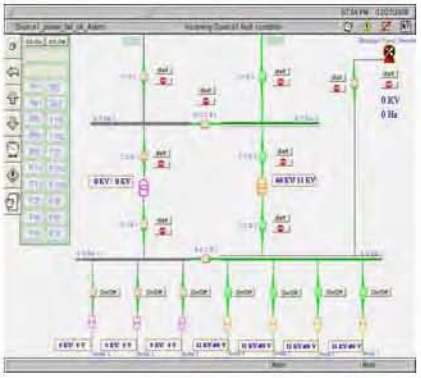

Fig. 13 Performance Test of Source -1 Failure Condition

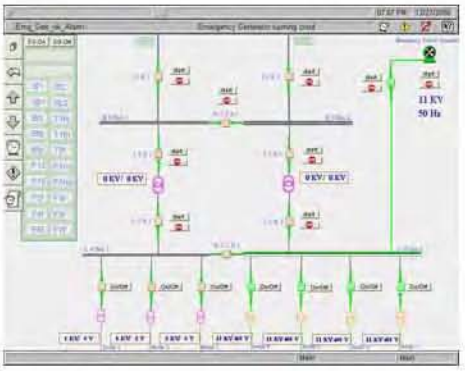

Fig. 14 Performance Test of Source 1 and 2 Failure Condition

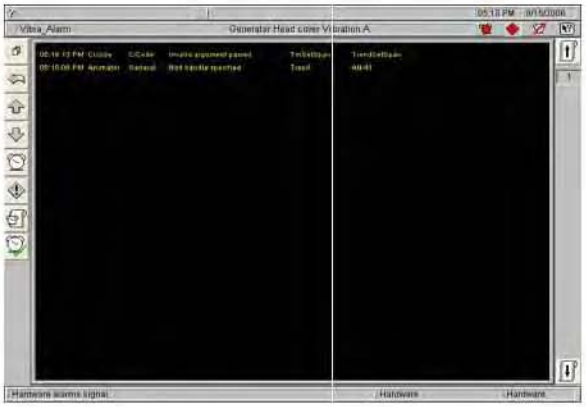

Fig. 15 Hardware Alarm Condition

When a system error occurs, that is a malfunction in CitectSCADA operation and CitectSCADA generates a hardware alarm. Hardware alarms are usually displayed on a dedicated Hardware Alarm page, which is available as a standard template. The hardware alarm page is our primary indicator of what is happening in our CitectSCADA system. If a communication fault occurs, if Cicode can't execute, if a graphics page is not updating correctly, or if a server fails, this page shows operator. The hardware alarms do not have detailed information, but serve to point operator in the right direction.

## IV. CONCLUSION

The application of SCADA control system for distribution substation conducts outdoor busbars, circuit breakers, transformers, auxiliary and earthing transformers, current and potential transformer, isolating switches as incoming line data and transfers sufficient data to control rooms with geographical information, energy management information which includes load managements information and operational managements information.

The use of SCADA control system for the distribution system is advanced and advanced and also very feasible. Therefore, the security of the power system operation can be improved, the distribution fault in substation distribution system can be prevented and the human error can be avoided. The study here is just for a small power distribution system. The further study should be made for the large power system and others. The exact available data from the system can be made more helpful and useful design of SCADA system.

## V. RECOMMENDATION

A little or no knowledge of SCADA and telemetry systems and incomplete pre-system assessment decisions can be costly and can cause a lot of mistakes. Graphic design created by graphic builder and dynamic picture control by each tags are essential not only for distribution substation design but also for any other control process control system controlling by SCADA design. Citect HMI programming including tags function and other programming tags function are available for SCADA application. To get the significant advantages for SCADA design, control system designer must have knowledge in PLC programming language tag function, graphic design and dynamic picture. This thesis delivers just a bit knowledge to beginner who contacts the SCADA system with PLC programming. In further study, remote sensing program can be improved by using SCADA system.

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