DESIGN OF AUTOMATIC BY-PASS SWITCH FOR DISTRIBUTION AUTOMATION SYSTEM (DAS)

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November 2005

I admit that I have read this report and in my point of view this report achieved the scope and quality for the purpose of graduation in Bachelor of Electrical Engineering.
(Industrial Power)

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DECLARATION

"It is hereby declared that all materials in this thesis are the effort of my own work and materials which are not the effort of my own work has been clearly acknowledged."

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Date : **18 November 2005**

Specially dedicated to
My beloved parent, Rahimin B. Ismail & Norhayati Bt. Lop Ahmad and my younger sister Nazatul Ajirah who have encouraged, guided and inspired me throughout my journey of education

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In the name of Allah, the Most Compassionate, Most Merciful. I am most thankful to Him, for it is with His permission that I could complete this project. Praise be upon the prophet Muhammad S.A.W, his family, friends and followers

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ABSTRACT

Automatic By-pass Switch (ABS) is a mechanical device used in the Distribution Automation System (DAS). The function of ABS is to cut of the faulted main power line and at the other side to reclose the reserve power line to supply to the load. In the conventional distribution system, the only protection available at the distribution side is circuit breakers placed at substation. However, this scheme of protection will produce complete isolate to the large distribution network due to the operation of circuit breaker when the fault occurs. . By utilizing ABS as part of the DAS, the distribution network can be further divided into smaller sections and the area of blackout can be significantly reduced. The Distribution Automation System (DAS) will allow automatic response to maintain continuous supply to loads when fault occurs. The ABS is design to receive trip signal from RTU to operate and send it status signal to RTU for monitoring purpose. The complete system of DAS need 2 type of ABS, normally open and normally close located at strategic pole position to perform it function as a part of DAS. At the end of this project, the ABS was able to perform in desired operation and also communicate with RTU as expected.

ABSTRAK

Automatic By-pass Switch (ABS) merupakan sejenis peranti mekanikal yang digunakan sebahagian daripada Sistem Pengautomasian Pengagihan (DAS). ABS berfungsi adalah untuk memutuskan talian kuasa pengagihan utama yang mengalami kerosakan "fault" dan juga menyabung litar kuasa pengagihan simpanan untuk membekalakan kuasa kepada beban. Di dalam sistem pengagihan sediada, skim perlindungan ini akan mengakibatkan pengasinggan kepada jaringgan penggagihan yang besar yang diakibatkan oleh pemutus litar terpelantik yang beroperasi apabila berlakunya kerosakan. Dengan penggunaan ABS sebagai sebahagian daripada DAS, jaringan pengagihan ini dapt dibahagikan kepada seksyen-seksyen yang lebih kecil dan kawasan yang mengalami pemutusan bekalan elektrik dapat dikurangkan dengan signifikan. Sistem DAS akan membenarkan tindakbalas automatic terhadak kerosakan talian bagi memastikan bekalan kuasa yang berterusan kepada pengguna. Rekabentuknya ABS direka supaya membolehkan ia menerima isyarat *"trip"* dari RTU untuk beroperasi dan juga menghantar isyarat status kepada RTU. Untuk membangunkan satu sistem DAS yang lengkap memerlukan dua jenis ABS, iaitu sedia buka atau sedia tutup yang diletakkan di lokasi *"pole-mounted"* yang strategicbagi membolehkan ianya berfugsi sebagai sebahagian dari DAS. Di akhir projek, didapati ABS telah berjaya melakukan operasi seperti yag dikehendaki serta berkomunikasi dengan RTU seperti yang dijangkakan.

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CHAPTER 1

PROJECT OVERVIEW

1.1 Introduction

Real power losses in distribution systems in general are quite appreciable, constituting major portion of the overall power system losses. The main cause of distribution losses are non-availability of real-time loading information and lack of proper monitoring and coordinated controls. Within the enormously extended distribution networks due to meet the rapidly growing demand, the solution to overcome power losses and power reliability in distribution are highly demanding. [1]

In today's engineering research, Distribution automation system (DAS) is getting attention to overcome these problems. Distribution automation systems (DAS) can improve the operation of distribution system and the quality of power supply. DAS aims at conservation of energy, including reduction of consumption and losses in the distribution and transmission circuits, reduction of peak load, improvement in the reliability and quality of service, deferral of new construction, and recovery of lost area. [1]

Within the increasing use of machinery in industries and domestics area, electric customers are more concerned about the electric power reliability. When any the power supply outage has taken place there is a loss of money and productivity. To avoid this situation to happen, the power utility company need to provide alternative healthy line that will takeover the fault affected line to supply power to the load. In the event to exchange or swap the lines, a high intensity of by-pass

switch is needed to avoid damage to equipment by surge current and other transient problems.

1.2 Objectives

The main objective of this project is to design and develop Automatic By-pass Switch (ABS) schematics and circuit diagrams for Distribution Automation System (DAS). The background study of the present distribution used by electrical utility company in Malaysia is necessary to understand. The load and structure of distribution system in Malaysia will be studied and the design requirement for this project will be based on the TNB system. This can be done by studying the automatic switching techniques, the design mechanism and the hardware parts of vacuum by-pass switches development in particular and other similar switches used for the same purpose.

The ABS is basically a device to exchange power supply of two lines when the fault occurs to the line. With its main function, ABS design characteristics must meet the design requirement such as maintaining the rated voltage, line loading rates and maximum inrush current to protect internal equipment. In order to achieve secure level of protection for the pole-mounted equipment, the correct and most suitable characteristics and design of the ABS must be used. This is also an objective in this project to find the most suitable characteristics and the design of ABS for pole-mounted system.

This Automatic By-pass Switch must also be able to communicate correctly with the devices that involve in its operation, namely the remote terminal unit (RTU) and the supervisory control and data acquisition (SCADA) system. This involves proper and accurate processing of information to and from the ABS. To do this, a standardized programming and communication protocol will be used.

1.3 Work Scope

The scope of this project will be the low voltage (LV) side (11 KV and 415 V) in local distribution network. However the study of automatic by-pass switch implementation in DAS will be done in 415V. This study will come out with the most suitable ABS to be implemented to the system. The main aim is the studying operation and switching mechanism, the design of operational ABS for 415V system and its development. This design will be tested in the lab to simulate the operation of DAS with other DAS equipments, SCADA and RTU.

In the by-pass system, there are four main equipments that need to be considered, by-pass switch, remote terminal unit (RTU) and communication unit. The by-pass switch will mechanically swap the line between the main line and the by-pass line when it receives a signal to operate from the RTU. The RTU acts as a control unit to the by-pass switch to control the whole switching behavior. RTU also collects the line characteristics (current, voltage) and send it to the control center (SCADA) along with the switch current condition (ON/OFF).

The other scope in this project is to understand the basic communication network between DAS equipment in the network Communication which is important to the system to make sure all components in DAS execute the same task and understand the situation happen in the distribution network.

1.4 Project Contribution

The completion of this project is expected to add an improvement to the power distribution efficiency and provide a reliable distribution automation system to local domestic and industrial power consumers. With the implementation of the Automatic By-pass Switch (ABS) to the existing distribution system could help local power utility company in planning to improve the power management and contribute to the work of minimizing the fault effect and upgrading the quality of power supply by saving cost and time.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter overview

This chapter explains the research and literature review related to Distribution Automation System, conventional distribution network and Automatic By-pass switch available. The principle ideas are established before the design of the automatic by-pass switch is continued. This will increase deeper understanding of DAS.

2.2 Conventional Distribution System

The present structure of distribution system, the 33KV substation supplies power to the downstream area of the system and later branches further into several subsidiary of 11 KV substations to supply power close to the load points, where it is further stepped down to 415 and 240V. This type of distribution system shown in Figure 1 doesn't support quick fault detection, isolation of fault region and restoration of power supply to the maximum outage area, which is healthy area.

2.2.1 Loop System

The loop/ring distribution networks are widely used for distributing power to customers. This system allows load to be supplied from several feeders. The changing of these feeders are controlled at 33/11 kV substations which control the

load supplied by the feeders. In doing this, some characteristics of distribution system must be taken into consideration such as voltage drop limits, the line capacity limits, transformer capacity limits and load calculations. The Figure 2.1 below showed the example of loop/ring distribution network system.

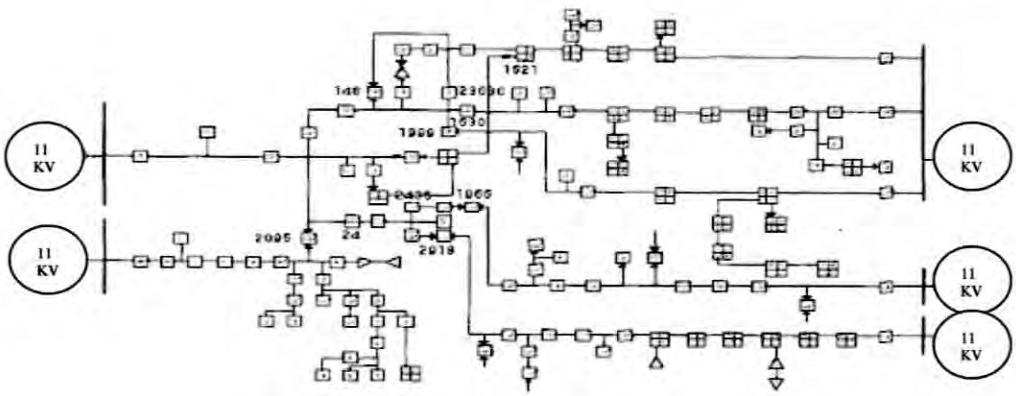


Figure 2.1: conventional loop distribution system. [2]

By adding switches at different points in the distribution network, it is possible to isolate certain load from load shedding as required. The only option available in present distribution system is the circuit breaker (one each for every main 11KV feeder) at the 33KV substation [1]. However this breaker operation is to provide protection for large area, which can completely isolate one downstream network in the event of fault. If the faulty section could be precisely identified, it would be possible to substantially reduce the blackout area, by re-routing the power to the healthy section through the operation of by-pass (sectionalizing) switches, placed at strategic locations on distribution system.

2.3 Introduction of DAS

The demand to reduce outage rates (both quantity and duration) has led most electric companies to reconfigure their networks from radial to normally opened loop, so that once a faulted section is isolated, power can be restored to the rest of the network from an alternative source. This task is economically achieved by introducing pole mounted distribution automation (DA) switches, which are remotely controlled from a central control room. In this manner, quality and continuity of service to the customers are vastly improved as users' convenience. [3]

The Distribution Automation Distribution (DAS) is a system to provide remote control and supervising switches on a distribution line for switching load current to the line either automatically or manually. As shown in figure 2.3, DAS can be developed in three stages. The first stage is automation by pole-mounted equipment such as Automatic By-pass Switch (ABS), Fault Detecting Relay (FDR) and Switch Power Supply (SPS). The second stage is an automation with manual-remote-control and supervisory function such as Remote Terminal Unit (RTU). The third stage is computer-based DAS (SCADA) [4]. The interconnection between equipment in all stages for automation distribution is shown in figure 2.2 below.

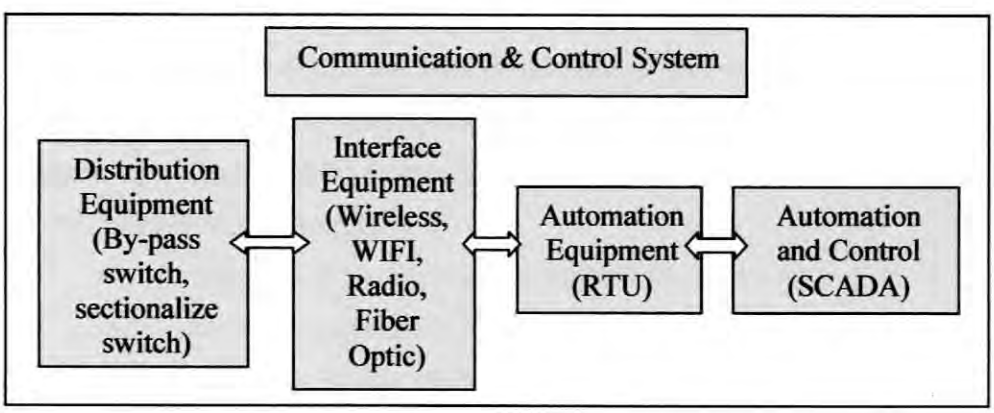
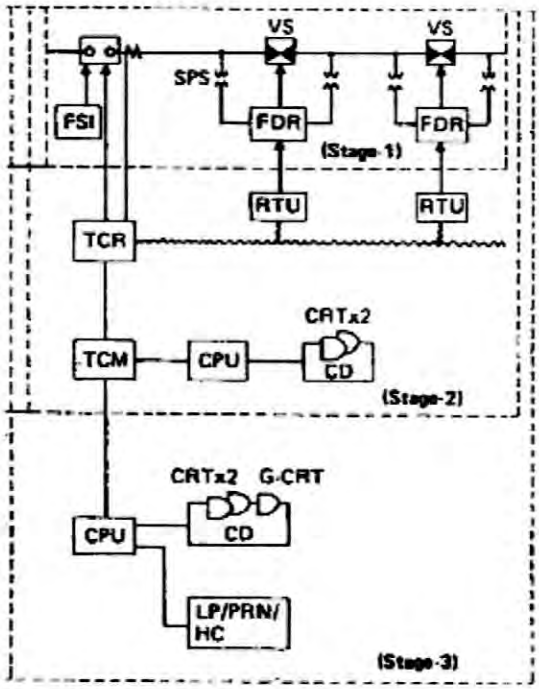


Figure 2.2: Interconnection of distribution, control and communication system. [1]



Legend

CPU : Central Processing Unit
LP : Line Printer
HC : Hard Copier (hard disc/ storage)
FSI : Fault Section Indicator
CB : Circuit Breaker
VS : Vacuum Switch
FDR : Fault Detection Relay
SPS : Switch Power Supply
RTU : Remote Terminal Unit
TCM : Telecontrol Master Unit
CD : Control Desk

Figure 2.3: Configuration of DAS [4].

2.4 Main component of DAS

As mentioned before, the Distribution Automation system is developed using combination of electric and electronic components and also communication components. Among these components, there are three most important components in the DAS which are listed below:

i) supervisory control and data acquisition (SCADA)
ii) remote terminal unit (RTU)
iii) automatic by-pass switch (ABS)

2.4.1 Supervisory control and data acquisition (SCADA)

Supervisory control and data acquisition (SCADA) system is mainly a computer based system usually using Visual Basic (VB) programming software. This program is used in the system as a human-machine interface to control overall operation of the DAS. SCADA also records all the changing in operation into database for further analysis. The SCADA collects the data such as line voltage, line current and frequency, which are transferred from RTU at pole mounted location using communication line.

In Malaysian power utility system, SCADA is only implemented at generation side and transmission side. This SCADA are used to as a data acquisition and control for every power plant generator in Malaysia [5]. The SCADA applied here allow the power utility company to organize the power generated accordingly to the demand in real-time operation. All this observation is done at TNB's National Load Dispatch Center (NLDC) located at TNB Bangsar, Kuala Lumpur. The interface of the NLDC SCADA is shown in figure 2.4. The SCADA that will be implement in the DAS is the extended of it application in the power system.

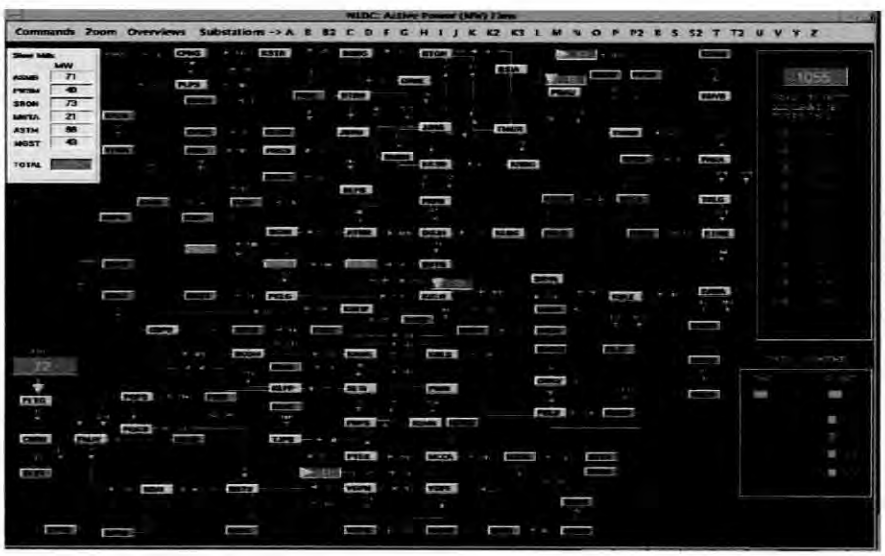


Figure 2.4: NLDC's SCADA interface [5]

2.4.2 Remote terminal unit (RTU)

The function of the RTU is; supervision and control of the switches according to instruction from the master station (SCADA), data acquisitions and fault detection using the line sensor, and communication with the master, the master station and other RTU's. RTU basically is the middle-man between SCADA and Automatic By-pass Switch. The RTU will be installed with other equipment mounted at poled. This RTU will collect all the needed distribution line information such as line voltage, current, frequency and others from the line. RTU processes the data and will detect if there is a fault at the line. The information of distribution line gathered by RTU also transmits to the SCADA.

2.4.3 Automatic by-pass switch (ABS)

The Automatic By-pass Switch is the line breaking mechanism that cuts off the line or connect the line. Due to this operation, the type of this switch must be seriously selected. There are few types of Automatic By-pass Switch which are available and those usually used in DAS as show in the list below.

i) SF6 gas switch.
ii) Oil switch
iii) Vacuum switch

This ABS is poled mounted equipment that are usually placed at a strategic locations in the distribution system, as the distribution system is divided into a smaller areas. Each one is placed ABS, along with other pole mounted equipment that needed to be installed to ensure the optimum operation of the DAS system. The complete pole mounted equipment needed in DAS is shown in figure 2.5.