SYSTEM-WIDE POWER QUALITY MONITORING IN MALAYSIA

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INTRODUCTION

Tenaga Nasional Berhad (TNB) began installation of its system-wide power quality monitoring project in October 2004. The project involved installation of 60 power quality (PQ) recorders throughout Malaysia at selected critical feeders in important substations to monitor the quality of power provided to important Large Power Customers (LPC). This included monitoring at 132 kV, 33 kV, 22 kV and 11 kV levels supplied to the LPC.

Utilizing the latest monitoring technology and software, TNB put its fiber optic communication at its substations to good use to enable power quality information to be polled from the remote recorders and displayed on the company's intranet. The polling is done by the Central Server that also compiles different level of reports on a regular basis. The monitoring system is also equipped with an early warning system that automatically alerts selected people when disturbances are detected according to the threshold settings that have been violated. Hence, only high-level officers are alerted through emails (or SMS in future) when a severe disturbance occurs on a critical feeder.

With the wealth of power quality information that is gathered from the system, TNB has engaged professors and engineers from its university, University Tenaga Nasional (UNITEN) to analyse the data and to classify generic scenarios with its most probable cause of faults. In doing so, TNB would be able to respond faster to complaints by LPC and identify problem conditions before they cause more concerns, or worse, cause wider damage to neighboring customers in the system.

POWER QUALITY MONITORING – SYSTEM DESIGN

According to Malaysia's topographical locations of substations, the system is divided into four regions – Northern, Eastern, Central and Southern, as depicted in Figure 1. Each region has a regional server that is connected to PQ recorders in that region through a wide-area network of fibre optic communication. The main purposes of these regional servers are to download data from the PQ recorders throughout the day and to receive any warning messages from the PQ recorders. Thus, operators of these servers can view real-time disturbance data and take appropriate action to address the fault.

Data from the four regional servers are subsequently polled by the Central Server once a day to update the main PQ database. It is here that data is analysed, stored and displayed on the company's intranet. The software on the Central Server also compiles statistical data and produce monthly reports for high-level TNB officers as well as reports for submission to the energy regulator.

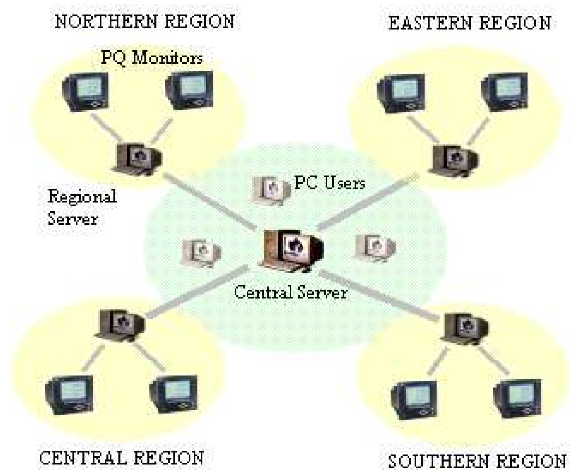

Figure 1 : Design of Power Quality Monitoring System in Malaysia

POWER QUALITY MONITORING – HARDWARE

The PQ recorder that TNB has employed in its substation is the ION 7600 manufactured by Power Measurement Ltd. Measurements of power, energy and power quality parameters are recorded all the time. Alike other power quality recorders at the higher end, it comes with many capabilities and functions such as high sampling rate, cross triggering on all voltage and current channels, high dynamic and static storage, multiple communications ports, GPS time synchronization, automatic call back feature[1] and compliance with the latest IEC, IEEE and EN standards related to power quality monitoring.

More importantly, the ION 7600 has the ability to export recorded PQ data into the standard PQ Data Interchange Format (PQDIF) and can be configured to communicate smoothly with the routers in TNB's existing fiber communication system.

1 The Automatic Call Back feature is the ability of the PQ recorder to remotely send disturbance data to the regional server at any time of the day.

POWER QUALITY MONITORING – SOFTWARE

The system has been designed to assimilate data from the propriety software of the PQ recorder with an ODBC (Open DataBase Connectivity) database running on SQL Server. The importance of this is to relieve any dependence on the propriety software for analysing and processing the data so that future addition of PQ recorders will not be limited to the same brand or company. Thus, the propriety software must be able to export all data into the PQDIF format, which is used by our own developed software to analyse the data.

The propriety software, which is located on the four regional servers, is used mainly for operational tasks such as gathering and downloading data from remote PQ recorders, converting them into PQDIF format and then storing them in appropriate folders on the regional servers. The propriety software also has a "SCADA-like" programme where real-time data of voltage, current, harmonics, disturbance events and alarm events are displayed. Users of this software are the selected operators at the regional control centre who are responsible for checking alarm events, re-establishing disconnected sites and creating backups of archived PQ data. The software also sends out email (or SMS in future) to designated people when a disturbance happens. The priority level of the event will determine who receives the alarm notification.

The software on the Central Server however polls the PQDIF data from the regional servers and format the data into reports and display them on the intranet website. The purpose of the intranet website is to provide all TNB staffs on the company network with statistical data, event records and other PQ information of the system. This data is updated once everyday.

POWER QUALITY MONITORING - COMMUNICATION

TNB has a wide coverage of fibre optic communication network that connects all of its substations. Each substation has a Main Distribution Frame (MDF) where equipment in the building can be connected to the fibre optic line. However, not all substations are equipped with a router, which enables the equipment to "see" a whole network of routers. Substations that do not have routers are connected to the nearest substation with a router via point-to-point serial connection to the router's asynchronous port.

We can imagine that a substation without a router is like a house situated at a dead-end road. To get to your destination, you must first follow one road until you meet a junction. From there, you will have a network of roads to choose from to reach your destination. Similarly, the fibre optic connection from the substation without a router to the substation with a router is a point-to-point connection. Once at the router, only then are you connected to a network of routers to choose different routes to the destination.

Therefore, the PQ recorder is connected to the MDF in the substation with a serial connection. Data from the PQ recorder will be sent over a dedicated fibre optic line from the MDF to the nearest router. From that router, data is sent through the wide-area network (WAN) until it reaches the regional server. (See Figure 2 at bottom of page).

This posed two challenges to the project. Firstly, there is a limitation to the length of a serial connection from the PQ recorder to the MDF. In practice, a serial connection cable should not exceed 15.2 meters (50 feet). However, the average distance at site is 50 meters. Secondly, the PQ recorder software must be able to configure a serial connection from the PQ recorder to a port on the router keeping in mind that the regional server is connected through Ethernet. The biggest problem here is getting the PQ recorder software to "talk" to the port on the router.

In addressing both challenges, multiple tests were carried out in office as well as out in the field under real working conditions. The tests concluded that by using a high quality screened CAT5 cable for the serial connection, data can be sent from the PQ recorder to the MDF without any loss of information up to a tested distance of 305 meters. Although CAT5 cables have 4 pairs of twisted wires, we currently make use of 3 wires, i.e. Ground, Transmit and Receive for serial connection. Using CAT5 cables instead of serial cables increases the performance of the line and does not involve re-laying of cables in future when we plan to convert the serial connection to Ethernet connection. Secondly, after many trials of different configuration settings with the router and PQ recorder software, a suitable configuration was found to establish communication with insignificant error. This involved adjusting timeout duration and port settings on the router.

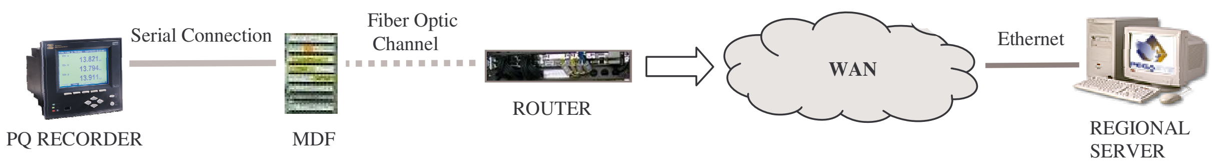

Figure 2 : Communication Path

POWER QUALITY RECORDER AT SITE

At of the writing of this paper, 32 of the 60 PQ recorders have been installed at site. The target date for complete installation and commissioning of the 60 sites is by end of April 2005. Each PQ recorder installed will monitor a selected outgoing feeder in the substation.

The placement of the PQ recorder at the selected feeder was decided based on a couple of considerations. The maximum recommended length by the manufacturer for the current clamp wires was 3 meters. Any extension to this length would cause a loss of accuracy in current readings and more severely to current harmonic readings. Therefore, the only possible place to put the PQ recorder was either at the front of the panel or on top of the panel. The latter position was chosen due to most of the substation panels being fully occupied at the front panel. (See Image 1).

Image 1 : Location of PQ Recorder

The position on top of the panel is less convenient and harder to reach. However, there should be a minimal need for this since all setting changes are made remotely from the regional server and all data can viewed on the intranet. The exception to this is if the PQ recorder becomes faulty and need to be serviced, then it would need to be removed.

It is also important to note that the time on all PQ recorders at site are synchronised to the regional servers every day. These regional servers are regularly synchronised with the Central Server time. This ensures that all time tagging by the PQ recorders are using the same reference point.

POWER QUALITY MONITORING - ONLINE

One of the most important aspects of this project is providing an online resource for power quality information about the system. The aim is to have power quality data readily available online for power quality engineers and coordinators to use. This will also enable TNB to respond faster to customers' inquiry on power quality issues.

The web server is located at the Central Server which also houses the main PQ database. Access to the online data is done through Internet browsers from any PC within TNB's intranet. This eliminates the need for additional software installation or training at the user-end. The website is password protected to keep unauthorised people from viewing confidential data.

The main screen for the online Power Quality Monitoring System (PQMS) website is as illustrated in Image 2.

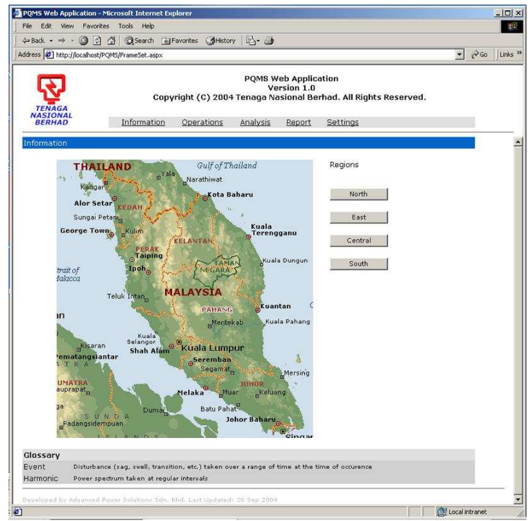

Image 2 : Main Screen of PQMS Website

This website allows users to check for the latest power quality events up till a day before. The disturbance analysis feature allows the user to view all aspects of an event. There are RMS summaries in table format, SEMI 47 plots of the events and waveform captures up to 256 samples per cycle for disturbance analysis and event tracing. Voltages and currents for Red, Yellow and Blue phases can be toggled on or of as depicted in Image 3 below.

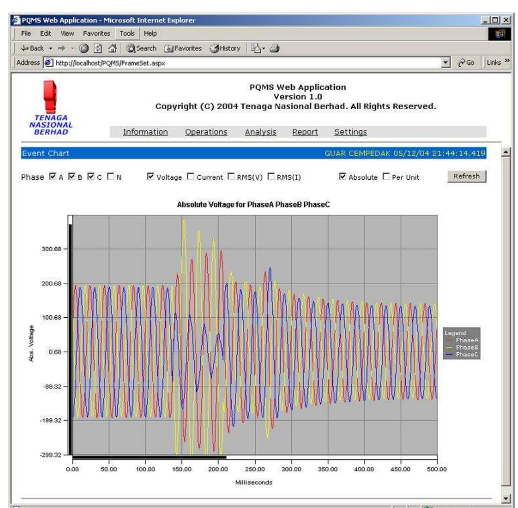

Image 3 : Waveform of Disturbance

The report feature of the website has two different type of formats. The first type is used for reporting to State Managers on power quality disturbances and number of customers affected. The second type of report is for submission to Energy Commission (EC), the energy regulator in Malaysia. This report details the type of power quality disturbance that occurred in the system according to the category that has been defined by EC. (See Image 4).

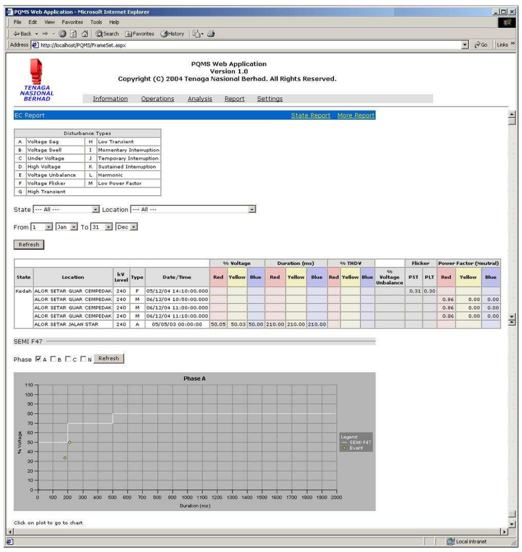

Image 4 : Energy Commission Report

UTILISING THE DATA

The power quality monitoring system explained so far does an excellent job of monitoring various elements of power quality, transferring and managing the data, creating custom reports, archiving and backing up data regularly, and displaying disturbance data on the intranet website, all automatically. Naturally, the next step is to utilise the abundant power quality data of the system to enhance the power quality information and performance of the system.

Firstly, with 60 PQ recorders continuously monitoring power quality performance in the system, TNB can study power quality disturbances and strive to locate the fault that caused the phenomena. Professors and scholars in University Tenaga Nasional are working towards creating a catalogue of common power quality disturbance in the system and their most probable cause. With such information, engineers will be able to use pattern recognition to match waveforms of PQ disturbances with similar waveforms in the catalogue. This will make it easier to determine or locate the cause of fault so that the problem can be addressed quickly without causing more disturbances in the system.

Next, ample power quality data can be used to create a baseline for the power quality performance of the system over a certain period. This baseline can be used as a benchmark for TNB to improve the standard of power quality in the system year after year. This will also enable TNB to benchmark their performance with other utility companies around the world.

Equally important is to share some information from the power quality monitoring system with customers, especially new customers. By analysing power quality performance of an area for the past years and conducting stochastic analysis, customers can be well informed of the level of power quality that they can expect. In other words, TNB would be able to inform customers the expected frequency of voltage sags and their depth in a year based on statistics. This will lead to better understanding between TNB and LPC in tackling power quality issues.

CONCLUSION

This paper has described the Power Quality Monitoring System that has been put in place by TNB in Malaysia. The design of the system and details of the project implementation were presented to share our experience in implementing the best and most suitable power quality monitoring system in Malaysia. With a stable system in place, TNB can focus on utilising the data to improve the power quality performance of the system and working with customers to minimise their exposure to power quality issues.

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