PMU를 통한 개발도상국 전력 시스템의 안정성 및 회복력 개선

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Improvement to Power Systems Reliability and Resiliency in Developing Countries Using PMU

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Abstract - The Phasor Measurement Unit (PMU) is the most important measurement device for monitoring, protection, and control power system. It is capable to provide the synchronized voltage and current phasors from dispersed locations in electric power network with high accuracy and high precision. The high performance of PMU technology for improving the power network reliability and resiliency over the Supervisory Control and Data Acquisition (SCADA) system is discussed. The case study presents the power system unreliability using SCADA. This paper shows the possibilities to improve power systems reliability and resiliency using PMU.

1. Introduction

Currently, the power systems in developing countries are still monitored and controlled by a Conventional Supervisory Control and Data Acquisition (SCADA) system. Typically, the SCADA system receives the data from Remote Terminal Units (RTUs) installed in dispersed locations of the power network. RTUs record the unsynchronized voltage and current magnitude, active and reactive power with low accuracy [1]. Due to its low resolution, the SCADA system is unable to monitor the dynamic state of the network.

The Phasor Measurement Unit (PMU) was developed for monitoring and control power system to improve the grid reliability and resiliency. It was mainly developed for monitoring and control transmission network applications. PMU has the capability to provide the synchronized voltage and current phasors (Magnitude and phase angle) from dispersed locations of power network with high accuracy and high sampling rate [2]. With PMU, the operators can monitor and control a wide area network in real-time.

The objective of this paper is to provide the improvements to power system reliability and resiliency using PMU and to describe how the PMU technology has proved its potential superiority over conventional SCADA system for monitoring and control power system.

The rest of this paper is organized as follows. Section 2 presents the limitations of the SCADA system, it shows the case study of unreliability power system using the SCADA system and the features of PMU technology. Section 3 describes the improvements to power system reliability and resiliency using PMU. Finally, Section 4 concludes the paper.

2. SCADA system

In this section, we investigate the limitations of the SCADA system for monitoring and control the power system through a Rwanda case study.

2.1. The limitations of the SCADA system

SCADA system has a low resolution of 1Hz, it can observe the network conditions every 2 to 4 seconds (1 sample per 2 or 4 seconds) which is very slow to track the dynamic states of the network [3]. It does not monitor the voltage and current phase angles, and the data are not consistently time-synchronized and not shared across the network. It does not enable the operators to monitor the network in real-time.

2.2. Case study of power system using SCADA

In this subsection, we show the number and the duration of outages of one of the developing countries still using the SCADA system for monitoring and control power system.

Table 1 shows the number of planned and unplanned power outages occurred in Rwanda power network from 1st January to 31st December 2018 and their corresponding durations. The planned power outages are caused by utility operators when there are maintenance works in the power system. For the unplanned outages in power network, however, the utility operators do not have any intervention to cause these outages.

The unplanned outages in Rwanda power network were caused by emergency works, load-shedding, under frequency, emergency load-shedding, earth fault, overcurrent, overvoltage, undervoltage, overload, loss of supply and other causes were not identified. Their number and duration are shown in Table 2.

Due to the limitations of SCADA system for monitoring and control the dynamic state of the power system, some outages took a long time for searching fault location and fixing the problem such as outages caused by emergency works and earth fault. The other outages were caused by the problem in the power network such as generation, overload, and others.

<Table 1> The planned and unplanned power outages in Rwanda power network, 2018.

Outages	Number	Duration (minutes)
Planned	189	18,504
Unplanned	10,128	92,205
Total	**10,317**	**110,709**

3. Phasor Measurement Unit

We briefly review the PMU and the qualities of using PMU for enhancing the power system resiliency and reliability.

3.1. The features of PMU technology

PMU is capable of measuring the synchronized measurements with high accuracy and high precision. It has a high sampling rate of 30 up to 60 samples per second at 60 Hz and Total Vector Error (TVE) of ±1%. The measurements from PMU are obtained to widely dispersed locations, the time stamping of PMU phasor is performed using Global Positioning System (GPS) satellite which has an accuracy of less than 1μs. Due to the applications of PMU, it gives the grid operators a deep insight into what is happening to the power network in real-time [4].

<Table 2> The causes of unplanned power outages, their number, and duration in the power network.

Cause of outages	Number	Duration (minutes)
Emergency works	334	9,118
Earth fault	4,018	36,119
Unidentified	16	35
Load-shedding	150	647
Emergency load-shedding	7	17
Under frequency	2,195	16,874
Undervoltage	2	25
Overvoltage	1	10
Overcurrent	3,186	28,894
Overload	213	315
Loss of supply	6	151
Total	**10,128**	**92,205**

3.2 Improvements to power system reliability and resiliency using PMU

In this section, we describe the improvements of using PMU technology to enhance the network operations and planning for improving the power system resiliency and reliability. Due to the high accuracy and precision of PMU, it can detect and record the events that SCADA misses. Thus, it enables much better visibility into network conditions and performance of specific assets.

PMU with high accuracy data networks, high-quality data analytics, and active network management can provide improved power network reliability and resiliency. PMU improves power system reliability and resiliency by reducing the duration of outages, as well as the number of customers affected by the outages [5]. It can enable early event detection and analysis of potential dangerous network conditions, and it can early identify their causes. The time required to restore the service is decreased through the faster line reclosing, faster black-start restoration and synchronization and faster island restoration due to the faster event identification and fault location [6]. The oscillation detection and actions to restore network stability can reduce interruptions. The interruption reductions also occur by identifying the potential equipment failures and fixing them before they occur.

Using the PMU in Rwanda power network for the case study in Section 2, some unplanned power outages duration can be reduced. The causes of these outages are emergency works, earth fault, and unidentified. The total number of these unplanned power outages is 4,368 and their duration is 45,272 minutes by using SCADA. By using PMU, however, these outages can take 754 minutes due to the high performance of PMU for fault detection and fault location for service restoration, this means that 44,517 minutes can be reduced. For the other causes of outages, their duration cannot be reduced by using PMU such as overload, loss of supply and others. Therefore, the total unplanned power outages duration is reduced to 47,687 minutes with PMU, i.e., it is reduced to 51.7%.

4. Conclusion

The Phasor Measurement Unit (PMU) was developed for monitoring, protection and control the power system. It is capable of measuring the synchronized voltage and current phasors at the transmission network with high accuracy. The improvements to power systems reliability and resiliency using PMU in developing countries. are presented in this work. The SCADA data from Rwanda power network are analyzed and showed that power system using a SCADA system the outages took a long time for service restoration because of the SCADA system. With PMU, the duration of unplanned outages can be reduced to 51.7%.

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