Monitoring of Isolated Standalone Renewable Energy Systems

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Abstract. For many areas, powering their homes or small businesses using a small renewable energy system that is not connected to the electricity grid. The monitoring system is essential for isolated areas; with existing monitoring systems the cost of returning is very expensive and difficult to install. In this work we have proposed a monitoring technique based on PMU technology this technology allows to measure the parameters important for the monitoring and send them by a communication system based on the GSP to PDC platform, and using isolated standalone renewable energy systems for reduce oscillations of interconnection power system. To validate the proposed approach, the developed PMU based monitoring system is implemented using Simulink/Matlab. Then, its performance is tested by power system Simulink model under different operating conditions.

Keywords: PMU · Renewable · Monitoring · Oscillation · PDC

1 Introduction

THE development of renewable energy systems always improving, several techniques which are used in order to convert natural resources towards a suitable electric energy in order to reduce pollution and protect nature. The use of renewable energy either for integration into the main energy system or for the electrical supply of isolated areas. In energy production systems there is always an operational monitoring system, but for the isolated areas this system of monitoring almost does not exist because of difficult of installation and the very important cost. In this work we propose a solution of a monitoring of isolated standalone renewable energy systems based on a PMU technology and for the validation of this system we use a simulation of the isolated hybrid system. Then we have proposed isolated standalone renewable energy systems for damping of oscillations in interconnection power systems, our application is for the Algeria and Tunisia interconnection line.

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2 Description of Stand-Alone Hybrid Energy Systems

Renewable energy comes from natural, like sunlight or wind keep shining and blowing, even if their availability depends on time and weather. And may be powered by:

- Solar energy, wind energy, Biofuels, Geothermal energy; Hydroelectric power; Wave power

Renewable energy can be used to supply some or all of your electricity needs, using technologies like: Small solar electric systems, Small wind electric systems, Micro-hydropower systems, Small hybrid electric systems (solar and wind).

At present, the path generating the bulk of electricity worldwide is shown by the bold lines that lead through combustion from chemical to thermal, from thermal to mechanical and finally to electrical power conversion (Fig. 1).

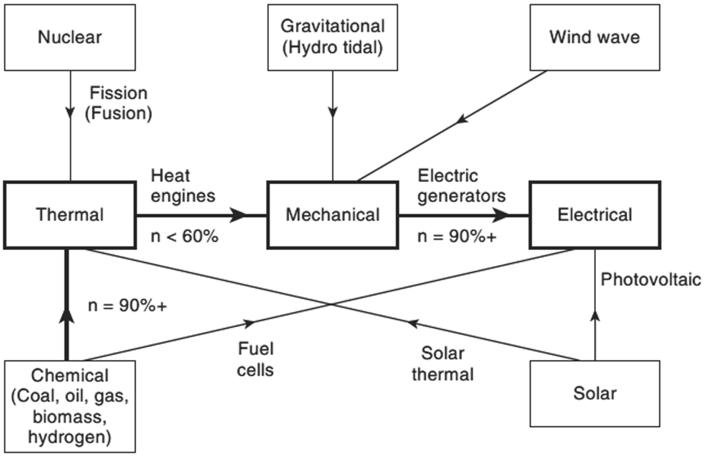

Fig. 1. Conversion from a variety of energy forms into electricity

The energy produced will be used for isolated areas or will be injected into existing electrical networks, but in this work we are just interested in the electrical supply of isolated areas which are not connected to the main electrical networks

The (Fig. 2) show the presentation of isolated Standalone Renewable Energy Systems

Use of stand-alone hybrid energy systems will allow consumers in isolate areas to ensure the availability of energy.

The management and monitoring of isolated areas is essential to ensure the availability of energy and make a remote control, but the problem of remoteness make the situation difficult to manage, our work has been devoted to find a better solution to this problem.

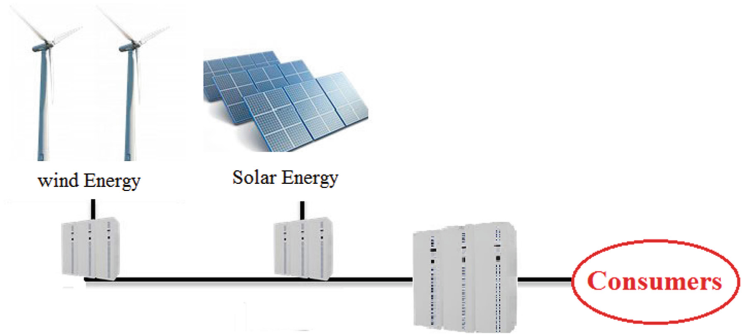

Fig. 2. General layout of a stand-alone hybrid energy system

3 Monitoring of Stand-Alone Hybrid Energy Systems

The monitoring system offers a deeper understanding of the operational parameters of the facility's electrical system.

3.1 Benefit of Monitoring Power System

- Real-time alarm is displayed on the monitoring screen
- Identifying the location of a fault
- Display of several parameters such as voltage current power
- Evaluating the monitoring system data can reveal existing problems that can adversely affect the operation and product in a facility.
- Data trends can predict and inform people who can be selected when equipment parameters can be exceeded,
- Monitoring systems can limit personnel exposure to potentially hazardous electrical environments from a distance and equipment operating parameters in hazardous areas

3.2 Monitoring System Components

Power monitoring system contains three primary components:

1) Discrete metering devices to record data,
2) Software to accumulate, manage, and display the data,
3) Communications interface between the software and metering devices.

For the third component concerning communication is a problem for isolated areas. The proposed solution is to use the PMU technology based on GPS communication, to ensure communication between isolated areas and supervision.

Stand-alone hybrid energy systems consist of several solar panels and wind turbines; the whole system connect to a transformer which supplies the consumers, in order to properly monitor the hybrid energy systems, the voltage and current sensors will be installed upstream of the transformer and the measured values are considered PMU inputs. The (Fig. 3) show the illustration of a monitoring system integrated in the isolated hybrid power system.

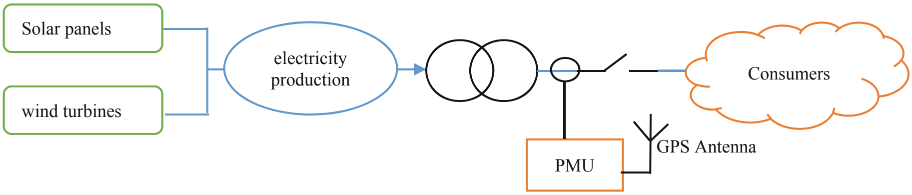

Fig. 3. Illustration of a monitoring hybrid power system

4 Integration of PMU Technology in Stand-Alone Hybrid Energy Systems

Synchrophasor technology uses monitoring devices, called phasor measurement units, which take high-speed measurements of phase angles, voltage and frequency that are time stamped with high-precision clocks.

This makes valuable new energy management applications possible, including electric model validation, wide area network monitoring, and oscillation and islanding detection (Fig. 4).

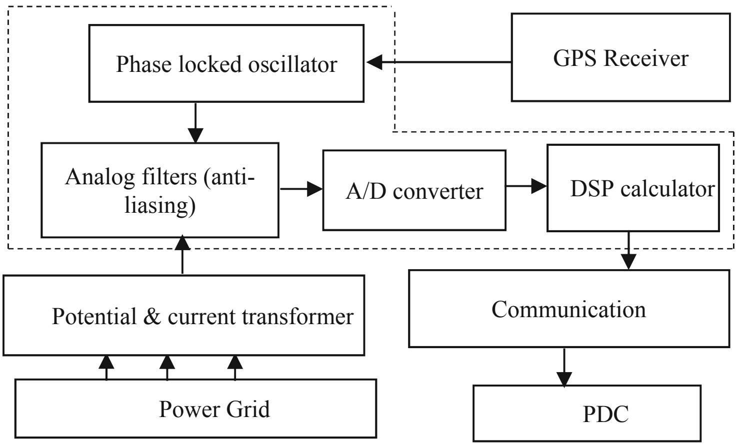

Fig. 4. General architecture of a PMU.

PMU technology provides phasor information (both magnitude and phase angle) about current and voltage in real time. The classical mathematical definition of the phasor relies on a generic AC signal(t), that is, a cosinusoidal signal with constant frequency and magnitude, as follows:

$$x(t) = X_m \cos(\omega \cdot t + \varphi)$$

where Xm is the signal peak value, ω = 2πf is the system angular frequency, and φ is the initial phase of the signal, which depends on the definition of the time scale.

The phasor representation of this sinusoidal signal is given by

$$x(t) = \frac{X_m}{\sqrt{2}} e^{j\varphi} = \frac{X_m}{\sqrt{2}} (\cos\varphi + j\sin\varphi)$$

Extracting a single frequency component is often done with a Fourier transform calculation. In sampled data systems, this becomes the discrete Fourier transform (DFT) or the fast Fourier transform (FFT) The PMU could be exchanged with the supervision station by using the standard data format including the timestamp of the synchronized GPS time. The model of PMU is developed using Matlab/Simulink (Fig. 5).

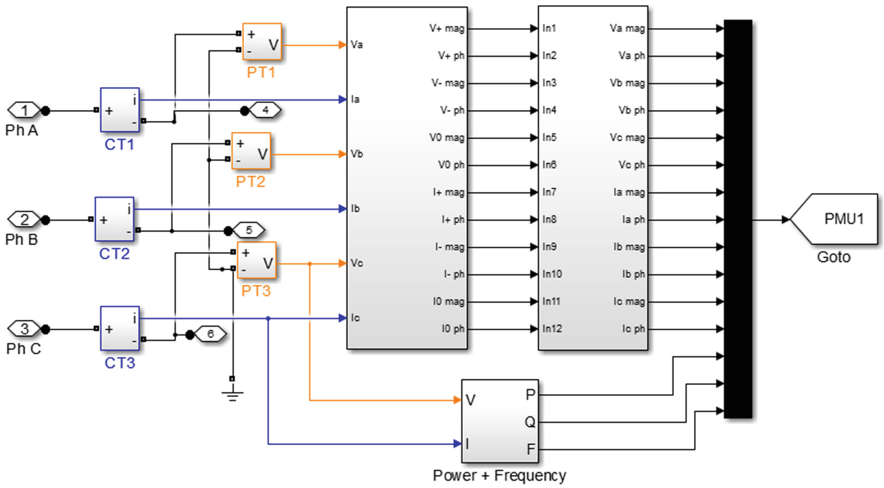

Fig. 5. The model of PMU

5 Simulation of the Monitoring Stand-Alone Hybrid Energy Systems and PMU

The system considered is composed of three isolated areas, for each area equipped with a PMU to measure the following parameters: voltage, current; power and frequency.

The measured values will be sent to a PDC (Phasor Data Concentrators) platform for storage and analysis of data.

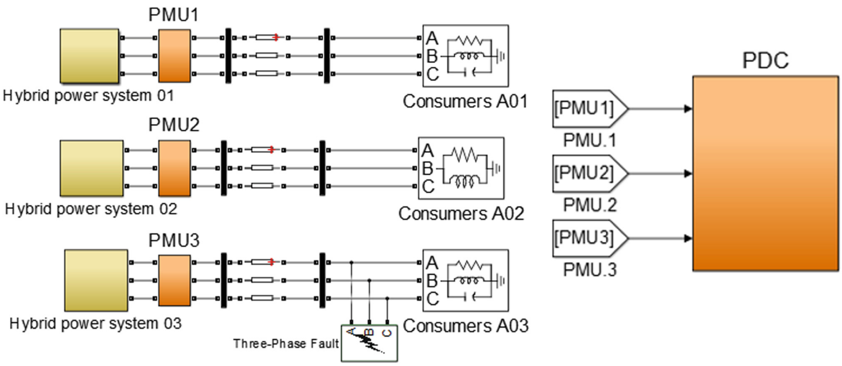

Fig. 6. Simulation of monitoring isolated Standalone Renewable Energy Systems

For the first area we will simulate the system under normal operating conditions (Fig. 6).

For the second area the lines between consumers and hybrid power system disconnection and connection at interval of time 1 s and 1 + 1/50 s.

For the third area we simulate the fault at interval of time 1 + 1/60 s and 1 + 5/60 s. The PMU measures the following parameters: current, voltage and frequency (Figs. 7, 8, 9).

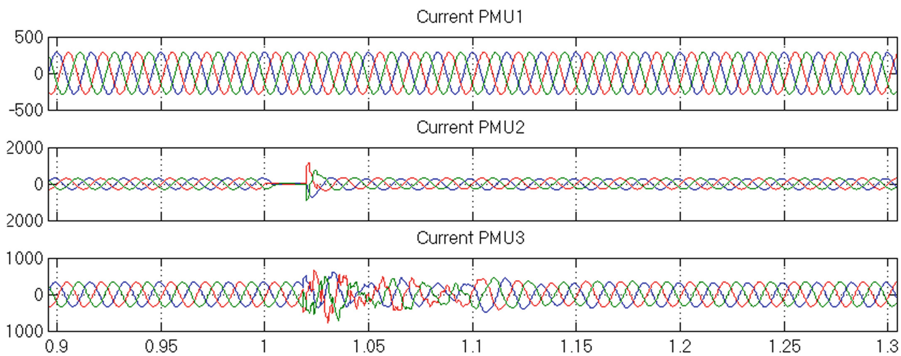

Fig. 7. Current profiles measured by the three PMUs

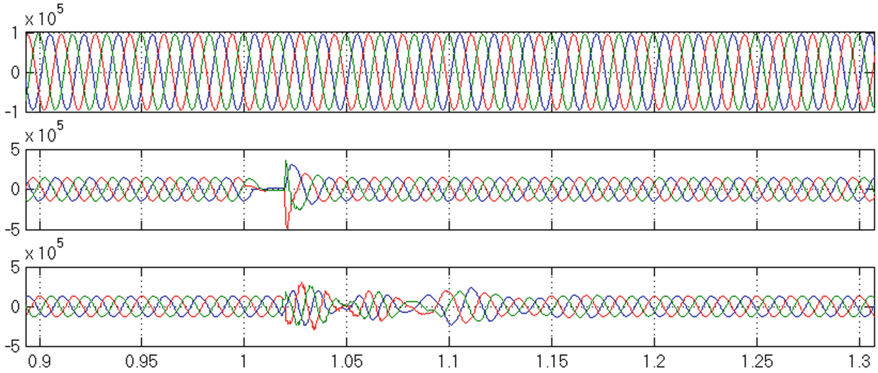

Fig. 8. Voltage profiles measured by the three PMUs

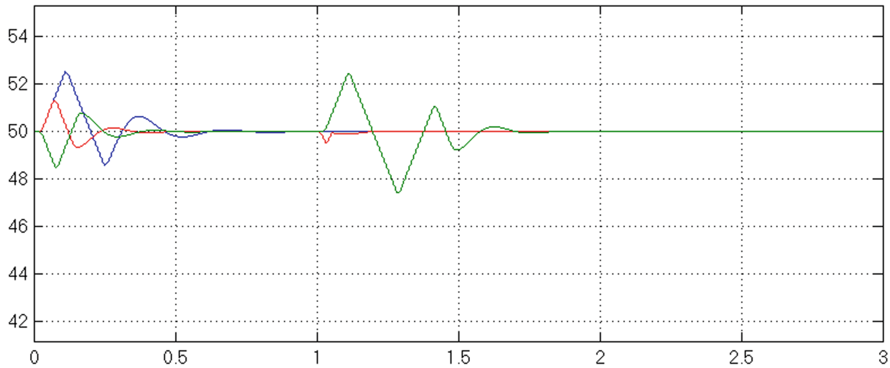

Fig. 9. Frequency profiles measured by the three PMUs

6 Integration of Isolated Standalone Renewable Energy in Interconnected Power System

The phenomenon of oscillation in interconnection power system is a subject of current research, several solutions have been proposed in order to reduce oscillations and improve the quality of energy, among these solutions is the use of energy storage in order to damp oscillations. Based on the results of our research, we propose to use isolated standalone renewable energy to reduce interconnection oscillation. In our case, we are proposed the interconnection line between Algeria and Tunisia power system. When oscillations appear in the interconnected line, the PMU1 detects and measures oscillations, then the data will be sent directly to the PDC platform. A command information will be sent to PMU2 to order the closing of the circuit breaker connecting the interconnection line and isolated standalone renewable energy. The stability of the energy injected into the interconnection line will reduce oscillations (Fig. 10).

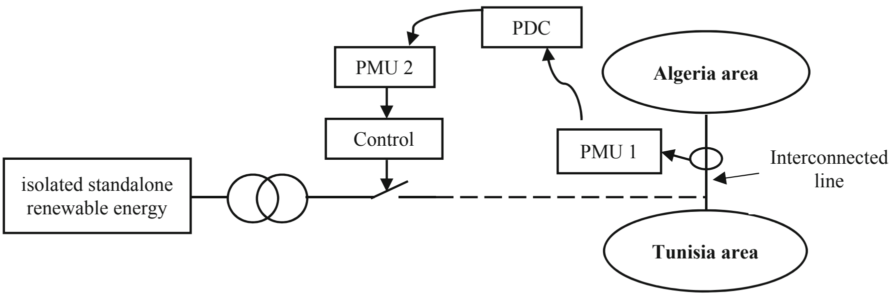

Fig. 10. Damping oscillation using isolated standalone renewable energy

7 Conclusion

In this research work, the Monitoring of isolated standalone renewable energy systems has been studied and simulated using Simulink/Matlab under different operation conditions. The proposed approach integrates the PMUs and PDC for real time measurement. The obtained simulation results show that the advantage of new approach by integrating the PMUs associated with PDC in the Monitoring of isolated standalone renewable energy systems. It is also possible to use this solution for the integration system of renewable energies in the main network.

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