Energy Conversion and Management 89 (2015) 615–625

Contents lists available at ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

Modeling and control of hybrid photovoltaic wind power system with battery storage

S. Aissou [a], D. Rekioua [a,*], N. Mezzai [a], T. Rekioua [a], S. Bacha [b]

[a] Laboratoire LTII, Universite de Bejaia, 06000, Algeria
[b] G2elab Laboratory, INPG Grenoble, France

ARTICLE INFO

Article history:
Received 8 March 2014
Accepted 13 October 2014
Available online 31 October 2014

Keywords:
Photovoltaic power systems
Wind power system
Modeling
Storage
Control
LabVIEW Software
Data acquisition

ABSTRACT

In this paper, the model and the control of hybrid power system is presented. It comprises wind and photovoltaic sources with battery storage supplying a load via an inverter. First, the design and the identification of the hybrid power system components has been made, then the proposed system is modeled and simulated under Matlab/Simulink Package. Finally, the power control of the hybrid system is introduced, by using LabVIEW Software. The proposed control strategy has been experimentally implemented and practical results are presented to show the effectiveness of the proposed hybrid system.

1. Introduction

Hybrid systems with wind and photovoltaic energy sources have received considerable attention for last decades [1–25]. In addition to energy sources, a hybrid system may also include DC or AC converters, a storage system, filters and a control system for load management. All these components can be connected in different architectures [1,2,16]. Data-acquisition systems are widely used in renewable energy source applications in order to collect data regarding the installed system performance and for evaluation purposes. The collected data is first conditioned using exact electronic circuits and then interfaced to a PC using a data-acquisition card [1,2]. LabVIEW is an environmental development program, developed by National Instruments (NI). It is similar to C and BASIC's environment development. There is an obvious difference between LabVIEW and other computer languages: Other computer languages are used to generate based code on the language of the text, whereas LabVIEW uses a graphical editing language G. The resulting program is the form of block diagram [19,20].

A control and a power management of a standalone hybrid renewable energy system comprising wind and photovoltaic sources with battery storage are introduced. The development of a data acquisition system for electrical hybrid systems parameters is described. The LabVIEW program is used for further process, display and storage of the collected data in a hard disk PC. The sizing of the proposed system is detailed. It depends mainly on the site location that dictates the average wind speed, the turbine orientation, the solar irradiance and the average energy consumption of the application. An identification of all components of the proposed system has been made. The obtained results using LabVIEW Software are presented to demonstrate the effectiveness of the proposed system.

2. Hybrid system description

The studied system consists of six photovoltaic panels (with 175 W_c for each panel) connected in parallel, and wind turbine of 1 kW, batteries bank, inverter, and sensors measurement (Fig. 1).

2.1. Photovoltaic power system

2.1.1. Measured sensors

The block diagram of the climatic measurement card consists of a sensor solar radiation, a temperature sensor and a symmetrical power supplying (Fig. 2). We opted for a temperature sensor LM35-type semiconductor, the sensor has a sensitivity of 10 mV/°C. To avoid transmission losses, it is proposed to amplify the output voltage with a amplifier:

* Corresponding author.
E-mail address: dja_rekioua@yahoo.fr (D. Rekioua).

http://dx.doi.org/10.1016/j.enconman.2014.10.034
0196-8904/

Nomenclature

A	ideality factor of the junction
$C_p(\lambda)$	power coefficient
C_{10}	rated capacity
E_{batt}	voltage source
E_s	insolation in the panel plane
E_{sref}	reference insolation (1000 W/m^2)
f	viscous frictions
f_r	frequency 50 Hz
I_{batt}	battery current
I_{ph}	photocurrent of the PV generator
I_{pv}	photovoltaic current
I_s	cell reverse saturation current
J	total inertia
K	Boltzman's constant
G	gearbox
n_{batt}	battery cells
N_p	number of parallel modules
Ns	number of series modules
PV	photovoltaic
P_{pv}	photovoltaic power
q	elementary charge
R	turbine radius
R_{batt}	internal battery resistance
R_{se}	series resistor
R_{sh}	shunt resistor
SOC	state of charge
t	discharging time
T_{aero}	aerodynamic torque
T_j	junction temperature of the modules
T_{jref}	reference module temperature (25 °C)
T_g	machine torque shaft
T_{visq}	torque due to frictions
U_{batt}	battery voltage
V_{pv}	photovoltaic voltage
v_{wind}	wind velocity
X_{batt}	battery reactance
Z_{batt}	battery impedance
ρ	air density
ρ_{batt}	phase-shift between current and voltage battery
Ω_{mec}	mechanical speed
$\Omega_{mec\text{-}ref}$	reference mechanical speed
$\Omega_{turbine}$	turbine speed
λ	tip speed ratio

$$G_{voltage} = \frac{U_{out}}{U_{in}} = \frac{R_9 + R_7}{R_9} \quad (1)$$

The key component is the electronic circuit for the photodiode under the influence of light, the photodiode generates a very low order of micro current, we had to convert current to voltage and amplified more, using a LM358 amplifier with:

$$G_{LM358} = \frac{R_1 * R_3}{R_2} \quad (2)$$

The realized solar radiation and temperature sensors are represented in Fig. 3.

The output measure is given in Fig. 4.

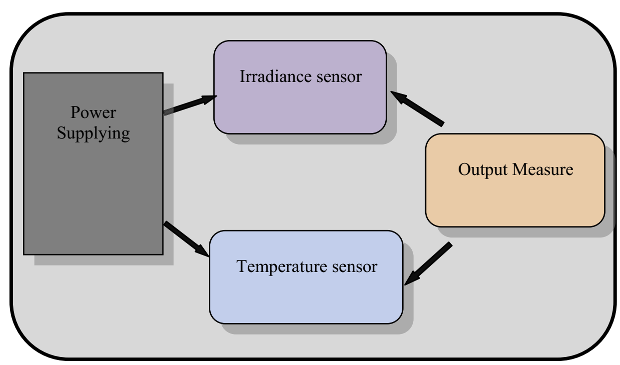

Fig. 2. Climatic measurement card.

2.1.2. Photovoltaic panel model

A photovoltaic (PV) power system consists of six solar panels (NT175E1) of 175 W_c (Fig. 5). The parameters of PV panels are given in Table 1.

The model studied in this work is represented by an equivalent circuit. This one consists of a single diode for the cell polarization function and two resistors (series and shunt) for the losses (Fig. 6). Thus, it can be named "one diode model". This model runs under the technical characteristics of the solar cells given by the manufacturers (data sheets).

The $I_{pv}(V_{pv})$ characteristic of this model is given by the following equation [1,4,9,13]:

Fig. 1. Installed hybrid wind-photovoltaic system.

Fig. 3. Realized solar radiation and temperature sensors.