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ScienceDirect

Energy Procedia 57 (2014) 168 – 177

Energy Procedia

2013 ISES Solar World Congress

Computational Tool for Sizing and Assessment of Grid-Connected Photovoltaic Systems

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Abstract

This work presents the utilization of mathematical models which represent the energy processing on Grid-Connected Photovoltaic Systems. Such models are part present on literature and part proposed by the authors. All models are implemented in MATLAB GUIDE code which allows the analysis, helps on the design and permits the operational behavior and energy contribution simulation of GCPV with different sizes. The work also presents comparison between the data generated by the program and some measured data from installed Grid-Connected Photovoltaic Systems.

Keywords: Gri-Connected Photovoltaic Systems, Computational Tool, Energy Forecasting

1. Introduction

The interest in simulating the behavior of Grid-Connected Photovoltaic Systems (GCPV) accurately is related to the fact that solar energy is particularly different from conventional forms of Distributed Generation (DG), such as diesel. That said, using models which are able to show the performance of GCPV in distinct climatic conditions as close as possible to reality becomes a necessity.

The mathematical models used in the software presented on this paper are further shown. The modeling includes the Photovoltaic (PV) generation and DC to AC conversion stage which comprises the representative models of Maximum Power Point Tracking (MPPT), DC to AC conversion efficiency and the power limitation due to power and/or temperature. Electrical losses are also estimated.

doi:10.1016/j.egypro.2014.10.021

Nomenclature

P_{mp}	Power at the maximum power point (MPP)	I	Generator current
P_{PV}^{0}	Generator peak power	I_L	Photo generated current
H_{plane}	Irradiance level at generator's plane	V_{oc}	Open circuit voltage
γ_{mp}	MPP Temperature coefficient	V	Generator voltage
T_c	Cell temperature	R_s	Series resistance
a	IxV curve shape factor	η_{MPPT}	Maximum power point tracking efficiency
p_{cc}	Normalized PV power	M_0, M_1	MPPT model power factors
V_{max}	Maximum input voltage	$V_{initial}$	Start-up MPPT voltage
P_{cc-max}^{inv}	Maximum inverter input power	P_{inv}^{0}	Inverter nominal power
p_{out}	Normalized inverter output power	p_{PV}	Normalized PV power
V_{mp}	Voltage at MPP	k_{0V}, k_{1V}, e k_{2V}	Losses linear coefficients
s_{0V}, s_{1V} e s_{2V}	Losses angular coefficients	P_{max}^{inv}	Maximum inverter output power
η_{Inv}	Inverter efficiency	T_{inv2}, T_{inv1}	Inverter temperatures at t_1 and t_2
F_{cap}	Inverter thermal capacity factor	F_D	Inverter dissipation factor
T_{amb}	Ambient temperature	Δt	Time interval
η_{max}	Maximum inverter efficiency	T_{max}	Maximum inverter operational temperature
$step$	Temperature limitation process counter	P_{init_lim}	Power level just before the limitation
L_{DC}, L_{AC}	Inverter electrical losses (input and output)	ISF	Inverter's sizing factor

2. Mathematical Models

2.1. Photovoltaic Generation

The PV generator converts the energy contained in photons of sunlight into DC electricity. The correct sizing of the PV generator in means of power capacity and configuration to be installed is essential for the safe and efficient operation of the system.

The computational tool developed in this paper allows the evaluation of the PV generator operation in two ways: first using a model that considers the power loss coefficient by temperature. In this part the software returns to the user graphical information about the relationship between global efficiency and annual yield of the system related to the ratio between the inverter installed power and PV peak power. This factor is called Inverter Sizing Factor – ISF (As the interface was made in Portuguese, such variable will appear in the figures as FDI).

The temperature of the module is almost never maintained at the value set by the Standard Test Conditions (STC) during of the PV generator operation so it is important that modeling considers this