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Investigation and analysis of high performance green energy induction motor drive with intelligent estimator

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ABSTRACT

This paper attempts to enhance the performance of a green energy induction motor drive. The electronic power converters become indispensable part of the renewable energy systems (RES). The solar photovoltaic (PV) system is efficiently operated with artificial neural network (ANN) based maximum power point tracking (MPPT) algorithm. The inverter topologies for the green drive scheme are analyzed. To improve the drive performance a reduced switch multilevel inverter (RSMLI) is employed. As indirect field oriented control (IFOC) is used, the drive demands on-line estimation of rotor resistance. A neural learning model reference adaptive scheme (NL-MRAS) based rotor resistance estimator is found to exhibit good dynamic performance. This work also investigates the performance of the green drive with an intelligent estimator. The performance enhancement of the green energy drive obtained by ANN based MPPT for the PV system, a reduced switch MLI and an intelligent estimator is presented.

1. Introduction

Nowadays the major energy supplier in the worldwide economy is the fossil fuels. A fossil-fueled power station can be built almost anywhere, so long as large quantities of fuel are available. Fossil fuels are not a renewable energy resource. Once it is burnt, there isn't any more. So at one point of time they may get depleted, which leads to the shutdown of major power stations. In view of latest worldwide green and clean energy mission, the solar energy is a promising source of alternate energy. Solar power is renewable, as the sun will keep on shining and will not get depleted. PV cell is the current technology used to produce direct electricity from sunlight.

PV system with MPPT is employed for increased system efficiency. There are many conventional MPPT techniques such as perturb and observe, incremental conductance (IC), hill climbing method, etc. Recently artificial intelligence based MPPT techniques are gaining momentum due to their superior performance [1–7]. In this work an ANN based MPPT is developed for the PV system and its results are compared with the conventional IC based MPPT.

The optimal performance of the PV system is mainly influenced by the power electronics converter topology and its modulation strategy. Recently, multilevel inverters (MLI) has gained attention in high power applications due their superior performance when compared to conventional two level pulse width modulated (PWM) inverters. MLI outperforms in terms of reduced total harmonic distortion (THD) and elimination of bulky and dissipative passive filter requirements [8]. Hence, they have been gaining popularity in the field of RES. Thus the investigation of suitable inverter topology and the switching techniques attain significance [9–12]. In this work a RSMLI proposed by the authors is employed.

A PV based system can be optimized to drive a typical load such as induction motor. Due to the maintenance issues in DC drives, they have been replaced by AC drives. Among the AC drives, the induction motor drives are quite popular due their own advantages of being robust, cheap and maintenance free. Thus these induction motors have become the workhorses in many industries. Nearly 75% of the electrical load in India comprise of induction motors, hence the overall power system efficiency is centrally dependent on the drive performance [13–19]. In order to meet the energy requirements, an efficient green energy drive is to be developed. The performance of the green energy drive system can be optimized with suitable inverter topology operated with optimal modulation strategy. The next issue is the control scheme employed for the drive system which may be scalar or

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vector control method.

With the advancements in power electronics, the AC drives are more widely used. The main principle involved in IFOC is that the torque and flux components are controlled independently similar to that of a DC motor. The performance of IFOC mainly requires the correct alignment of dq reference frame with the rotor flux vector. This demands the accurate knowledge of the machine parameters such as rotor resistance [20–25]. An IFOC drive with the on-line tuning of the rotor resistance can assure better torque and speed dynamics than a typical DC drive [26–30]. NL-MRAS based rotor resistance estimator makes the green drive system intelligent.

2. PV system with ANN based MPPT

This section deals with MPPT techniques for the PV system. The PV panel is modeled using one diode model and the characteristics are studied for varying irradiations and temperature. The converter used along with the PV is the conventional boost converter which is designed for the desired output voltage. A number of conventional algorithms are available in literature [3]. The neural network (NN) based approach is also promising as the NN is capable of learning highly nonlinear functions [4]. In this paper the NN based approach is explored and the results obtained are presented.

The block diagram is shown in Fig. 1. The control strategy used in this work involves a conventional PI controller which generates a duty cycle (D2) for the boost converter. Also from the ANN based MPPT output, which is the voltage at the maximum power point (VMPP), a duty cycle (D1) can be generated. Now if the power required by the load (Pload) is less than or equal to the power supplied by the PV system (PPV), then the converter will be operated in tracking mode, where Duty = D1 will come into play. When the PPV is greater than the Pload, then the converter has to change from MPPT mode to precise DC bus voltage regulation mode, where Duty = D2 will come into picture.

The inputs to the neural network are temperature and irradiance and outputs are voltage at the maximum power point (V_{MPP}) and current at the maximum power point (I_{MPP}). Numerous data for varying irradiation in the range of 250–1000 w/m^2 and temperature in the range of 10 °C–50 °C is generated using MATLAB simulation. Seventy percent of the data is used for training and 30% for testing. The hidden layer neurons use tan sigmoid activation function and the output neurons use pure linear activation function. The neural network is generated off line using *trainlm* of MATLAB. The input data employed for training the ANN is presented in three dimensional and two dimensional graphs. Figs. 2 and 3 show the training data as PV and IV curves with varying temperature. Similarly Figs. 4 and 5 portrays the training data as PV and IV curves with varying irradiation.

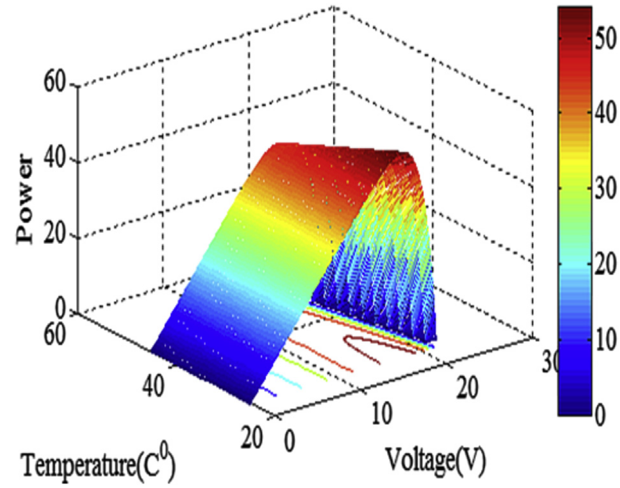

Fig. 2. Input data as PV curves for varying temperature.

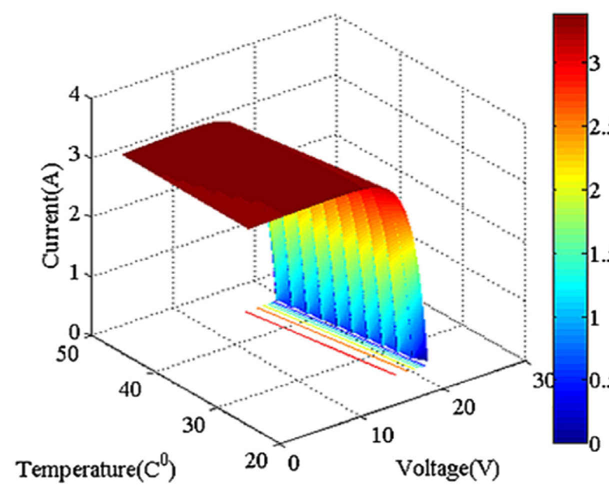

Fig. 3. Input data as IV curves for varying temperature.

The variation in power is presented as a contour plot for changing irradiation and temperature in Fig. 6. The training set generated for the ANN training is shown in Fig. 7. The number of hidden neurons is obtained by increasing the number of neurons in

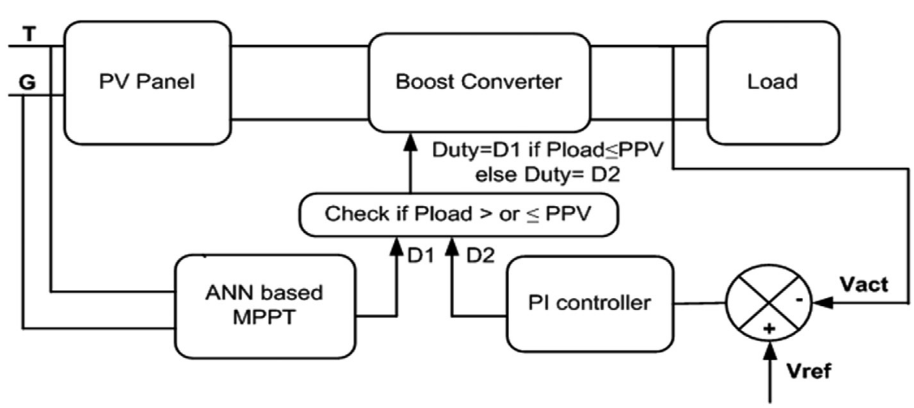

Fig. 1. PV system with ANN based MPPT.