Chapter (1)

Introduction

(1.1) General

The use of squirrel-cage induction motors in drive systems has many advantages; since this type of motors is rugged and inexpensive. Inverter-driven induction motors are used in many industrial applications over a wide range and their operation is economical and the motor speed in these systems can be controlled in applications that require variable speed [1].

Studying of PV array applications in the field of electrical power engineering is receiving a lot of attention by several authors [2-13]. The PV array, as a source of electrical energy, is quiet, clean and reliable. It does not cause pollution and can be installed easily. Its maintenance cost is low, but its capital cost of installation is relatively high and its efficiency of power conversion is low [14].

(1.2) Previous Work

Surveying the previous investigations in which the conventional DC supply is used to feed the VSI / induction motor system, showed that there are a lot of investigations that had dealt with this system. These investigations are mentioned briefly as follows.

In most of these investigations the induction motor dq model in the stationary reference frame was used. In reference [15] the induction motor dq model in the stationary reference frame was presented. In this model the inversion of the inductance matrix is avoided. In reference [16] the design of the DC link filter elements in a VSI / induction motor system was presented. In reference [17] a method of obtaining the transient performance of a six-step VSI / induction motor system when fed from a pure DC supply was presented.

A method of analysis for obtaining the harmonic line currents produced by the variable speed induction motor drives was presented in reference [18]. A pulse width modulator based on voltage space vector technique was presented in reference [19]. This modulator is suitable for the field oriented control of the VSI / induction motor system. In reference [20] a method of modeling and simulation of a three phase fully-controlled rectifier bridge / six-step VSI / induction motor system was presented. In reference [21] a neural network based a space vector modulator was proposed for controlling the VSI / induction motor system.

Surveying the previous investigations in which the PV array is used to supply the VSI / induction motor system, showed that there are a lot of investigations that had dealt with this system. These investigations are mentioned briefly as follows.

The optimization of the performance of a system which is composed of a PV array, a DC-DC chopper, a six-step VSI, an induction motor and a pump was presented in reference [22]. The optimization of this system was accomplished by obtaining an optimum voltage – frequency relationship which is used to control the motor and the PV array is operated at maximum power point by controlling the chopper duty ratio.

The improvement of the efficiency of the six-step VSI / induction motor system fed from a PV array was presented in reference [23]. This improvement was achieved by a frequency control strategy. In reference [24] a comparison was achieved between two control strategies for the VSI / induction motor system driven pump when fed from a PV array via DC-DC chopper. The first control strategy is to operate the system on a maximum power line of the PV array with variable water flow rate. The second control strategy is to operate the system for the maximum efficiency of the induction motor.

In reference [25] a system which is composed of a PV array, six-step VSI, induction motor and water pump was analyzed. In this system the inverter is operated as maximum power point tracker by controlling its frequency as the insolation level varies. In reference [26] comparisons were achieved between three types of drive systems when fed from a PV array. The object of these comparisons is to select the most suitable one for an aerospace application integrated with a reliable power system. These types are the induction motor drive, switched reluctance motor drive and brushless DC motor drive systems. It was found that the induction motor drive system is the most suitable one. In reference [27] a method of analysis of the performance of a PV array feeding a VSI / induction motor system was presented. Also, the effect of the system on the PV array performance was investigated.

In reference [28] the vector control of the VSI / induction motor system fed from a PV array via DC-DC chopper was proposed. In reference [29] the performance optimization of a PWM-VSI / induction motor system when fed from a PV array was presented. The optimization includes improving the motor efficiency by a proper adjustment of the frequency and the modulation index of the inverter. The values of the frequency and modulation index are obtained based on the nonlinear optimization.

In reference [30] the design and analysis of a system which is composed of a PV array, a PWM-VSI, an induction motor and a multistage centrifugal submersible pump was presented. In reference [31] a method by which the six-step VSI / induction motor system is matched to the PV array via a DC-DC chopper was presented.

(1.3) Scope of the Thesis

In this thesis the performance of the VSI / induction motor system is investigated when fed from either a conventional DC supply or a PV array.

Performance characteristics of such systems that have been investigated include currents, voltages, motor torque and speed. The different characteristics are obtained using MATLAB language programming and using MATLAB / SIMULINK software package.

The thesis includes eight chapters. These chapters are, briefly, explained as follows:

Chapter (1)

In this chapter the previous work, which includes investigations achieved in the subject of the thesis, and the scope of the thesis are presented.

Chapter (2)

In this chapter, dynamic models for the induction motor and the six-step VSI are presented to obtain the transient performance of the six-step VSI / induction motor system when fed from a pure DC supply.

Chapter (3)

In this chapter, a model for a three-phase fully-controlled rectifier bridge is presented and a method of designing a DC-link, obtaining the filter inductance and capacitance, is explained. Analytical expressions for the DC-link model are presented. The performance results of the three-phase fully-controlled rectifier bridge / DC-link / six-step VSI / induction motor system are obtained when the DC-link consists of either an L-C filter or a C filter.

Chapter (4)

In this chapter, models for a sinusoidal pulse-width-modulated (SPWM) VSI and an uncontrolled rectifier bridge are presented. The performance results of the uncontrolled rectifier bridge / DC-link / SPWM-VSI / induction motor system are obtained when the DC-link consists of either an L-C filter or a C filter.

Chapter (5)

In this chapter, a model for the space vector pulse-width-modulated (SVPWM) VSI is presented. Various modulation schemes used with the SVPWM-VSI are also explained. Performance results of a SVPWM-VSI feeding an inductive load via an LC filter system are obtained.

Performance results of a SVPWM-VSI / induction motor system when fed from a pure DC supply are also presented.

Performance results of an uncontrolled rectifier bridge / DC-link / SVPWM-VSI / induction motor system are obtained and compared to those obtained when the SPWM-VSI is used instead of the SVPWM-VSI.

Chapter (6)

In this chapter the performance of photovoltaic arrays are explained and a method for determining the PV module equivalent circuit parameters from the data given by the manufacturer is presented. Also, various types of back-up batteries used in the PV systems are explained and methods of sizing the PV array, when used in a certain application, and the back-up batteries, if used, are explained too.

Chapter (7)

In this chapter, steady-state models for the induction motor, six-step VSI and DC-DC chopper are mentioned. The steady-state performance of a six-step VSI / induction motor system when fed from a pure DC supply is presented. Also, the steady-state performance of a PV array / DC-DC chopper / six-step VSI / induction motor system is presented.

The steady-state performance of a PV array / six-step VSI / induction motor system is also presented. Some of these results are speed / frequency / insolation level characteristics, inverter input voltage / frequency / insolation level characteristics, inverter input current / frequency / insolation level characteristics and inverter input power / frequency / insolation level characteristics.

Chapter (8)

In this chapter conclusions of the thesis and recommendations for future work are presented.