A Review on Speed Control of Renewable Fed Induction Motor

[1]Nauf Nissa, [2]Sushma Gupta
[1]Student, [2]Assistant Professor
[1, 2] Electrical Engineering
[1]Swami Devi Dayal Institute of Engineering and Technology, Haryana, India

***Abstract* - There has been a growing demand for variable speed operation in the electrical drives. The induction motor is one of the most popular machines which are known for its robustness, reliability, high efficiency and much more. There are various methods to control the speed of the induction motor. Some of them are namely; change in applied voltage, rotor resistance change, pole changing, etc. Recently, Field oriented control has gained a lot of popularity as it can produce full torque at zero speeds and has a capability of faster response which make it suitable for many applications. Also, renewable fed induction motors have drawn the interests of a lot of researchers all around the world. Among those, PV cells forms the most reliable one due to the advancement in this field. Multi-Junction solar cells are said to perform better than their traditional counterparts and hence can be utilized for improved performance. This paper provides an extensive analysis of all the works related to this field that has been done in the recent past.**

***Keywords* - PV nodule, MPPT, induction motor, FOC.**

I. INTRODUCTION

Low cost, high reliability, high robustness, self-starting capability, and high efficiency have made induction motor the most attractive in industry. Induction motor is coupled and has complex multivariable structure. So the implementation of induction motor needs a fast-acting processor. Induction motor control is highly challenging due to very fast motor dynamics and highly nonlinear motor model. Therefore, an adequate motor mode should be selected, depending on the application. Induction motor is spotted as the best candidate for variable speed applications. Even under variable load conditions, variable speed drives offer wide range of speed and fast torque response. This invokes the necessity of advanced methods for control. As such there are many methods of speed control of induction motor.

Nowadays, renewable energy is getting very much concern in various applications. So far there are many types of renewable sources. Out of which solar energy is gaining more attention. Earlier a single junction solar cell was used. But today multi-junction solar cell is being employed in many areas. This has further extended the uses of photo-voltaic systems. The most important thing to keep in mind while working with the solar modules is its efficiency that can be maximized using various MPPT techniques. The various MPPT techniques are perturbation and observer, incremental conductance, etc. Each of the techniques is granted with merits and demerits. Despite of various merits of PV system, it has demerits also. One of them is the low out-put power which can be further boosted by using a converter. But the out-put of the converter will be DC which can be further converted to an AC by using a suitable inverter. Then this AC power can be utilized in many fields especially in induction motor drives.

II. RELATED WORK:

Multi-Junction Pv System

Nowadays**,** solar energy is one of the promising sources of energy that is gaining a lot of attention worldwide. Owing to its high efficiency, eco-friendly behavior, low maintenance, etc it is bridging gap between supply and demand very rapidly. Moreover, multi-junction solar cells have received a lot of interest in concentrated PV systems [1] [2]. This is the main reason that these types of cells are having the ability to convert an enormous solar energy into some useful form of energy with much higher efficiency. It has been estimated that the conversion efficiency of these types of cells is more than 40% [1]. In addition, it has been seen that multi-junction solar cells can be used to attain its maximum performance compared with the conventional silicon PV cell [3]. The results show that the multi-junction solar cells can offer nearly three times more power when compared to the conventional PV cell. Consequently, the multi-junction solar cells can produce superior power all the way through the clear days due to the higher tracking capability [3].

Multi-junction solar cells can be modeled using matlab. A widespread simulation model of multi-junction solar cell has been presented. A mathematical procedure has been used to examine the cell description curves, power curves and current density curves in reference with the functional voltage. Moreover, material properties, no. of junctions and dissimilar concentration levels have been taken into consideration [2]. Thereby, the out come of the simulation write out the performance of the multi-junction solar cell [2].

Maximum Power Tracking Techniques

It is a well-known fact that the efficiency of the solar modules can be increased using various MPPT techniques. Several researches had been taken place in order to study the solar photovoltaic power conversion techniques and different algorithm for tracking the maximum power to make the efficient use of the technology. A unique maximum power tracking method has been projected for matching the solar module to the batteries and load [4]. The planned method is based on the purpose of the derivative of the module output power with respect to the module current while the module current is described as a decaying exponential sweep function. In this method, analog multipliers are not utilized to calculate the maximum power point. The projected method is implemented on a 250 W photovoltaic solar panel successfully [4]. A detailed comparison and investigation of several MPPT techniques has been conducted. For the tracking of MPP's of the solar array a simple method of proportional integrator compensator and DTC is used [5]. The converter system based on a DSP is constructed and the experimental tests are carried out. One of the renowned techniques of MPPT is based on the measurement of incremental conductance. The MPPT algorithm is called Incremental conductance Method. By using this method the efficiency can be maximized by 44% [6]. This method calculates the utmost power and controls directly the captured power from the PV. This method offers diverse advantages that are: good tracking efficiency, higher response and sound control for the extracted power [6]. . For the maximum power point tracking (MPPT) incremental conductance method can be modeled with a DC-DC cuk converter. The solar module used is KC85T . For the improvement of PV system complete analysis and simulation of KC85T solar module has been performed [7]. Also, the various environmental factors on the PV system have been investigated. Another MPPT algorithm namely perturbation and observer method can also be used to track the maximum power point. This algorithm is based on the variable iteration step-size with which maximum power point tracking in PV systems can be obtained quickly. In this algorithm the operating point is bought close to the original MPP in little iteration [8]. Further, to track exact MPP incremental conductance or Hill-climbing methods with improved steps can then be used. The fast convergence rate and accurate tracking of MPP has made the proposed algorithm very beneficial [8]. The output voltage of the photo-voltaic cells depends on atmospheric conditions like temperature and sunlight. So, far P&O algorithm is the most easy MPPT technique , which changes the operating point close to the maximum power point[8][9]. However, sometimes diverges from the maximum operating point. A modified fixed algorithm can be used to design the photo voltaic system, boost converter and IP&O. The algorithm involuntarily adjusts the hysteresis bandwidth and reference step size for power transfer [9].

The attainment of maximum power point of PV systems has made it necessary to have an efficient MPPT algorithm [10]. The original perturbation and observer algorithm faces many difficulties in acquiring the maximum power point. Moreover, the original values of n and Io are not found while using this method [10]. So, a new combined perturbation and observer method is used in order to determine actual values of n and Io. Thus, with the actual values of n and Io the tracking bound is decreased while, the tracking speed is increased which is further compared with the original perturbation and observer method [10]. A new control strategy, which is based on the positive feedback of a MPPT converter output current, is introduced [11]. With this simplified positive feedback control strategy maximum power point tracking for relatively small photovoltaic (PV) systems, having battery back-up, is achieved by increasing the output current to the battery. This new control strategy uses Buck converter topology for the analysis and for the practical tests [11]. Moreover, it can also be used to know the converter topologies for PV systems and other renewable energy sources with single power maxima.

Pv Fed Induction Motor

Because of the low cost and high reliability, induction motor is very popular in industrial and consumer applications. A low cost photovoltaic (PV) fed 3 phases Induction motor drive serves for pumping applications in rural areas [12]. In general in a standalone system, the PV module will charge the battery and then the battery set up will in turn serve as a source for the inverter. An improved single stage battery less transfer is implemented by MPPT method that is implanted with a boost converter [12]. By using an embedded boost converter the overall cost of the setup goes considerably down. Presently, multi-level inverters are becoming very conventional for various industrial applications [13]. The hybrid inverter scheme gets the improved sinusoidal output when compared with low level inverters. The asymmetrical multilevel inverter obtains a high resolution. The hybrid multilevel inverter procedure is used to advance the level of inverter, extends the design flexibility and reduces the harmonics [13]. Nowadays, more emphasis is being made on low cost PV three phase Induction motor drive which can be used in many rural pumping applications. In a standalone system, the solar cells produce direct current energy which is stored in batteries and then the battery serves as a source of inverter. However, at present a new single stage battery-less power transfer is engaged by MPPT set in with a boost converter which changes the present tradition and makes the overall cost of the setup to go down significantly [14]. A prototype consisting of PV module of 500watts, a 3 phase squirrel cage induction drive of 357 watts, a MPPT set in with a boost converter and a 3 phase inverter has been modeled [14]. A capable and low rate micro controller dspic4011 is used to code and execute the well-known P and O MPPT method [14].

Control Techniques for Solar Fed Induction Motor

Induction motors can be described as self-starting constant speed AC motors because these motors possess a steady speed depending on the no of windings and the frequency of the supply. Earlier it was very difficult to control the speed of induction motors, and hence there use was limited despite of having many advantages over DC motors. However, with the availability of power electronic devices like IGBTs, power transistors, thyristors and GTOs the changeable speed induction motor drives have been made-up. Despite of their high cost, the induction motor drives are being used increasingly and replacing DC motors because of their numerous advantages. Speed control of induction motor can be made by several methods. Some of them are: pole changing, supply frequency control, stator voltage control, slip-power recovery, rotor resistance control, eddy-current coupling, etc. The speed control of induction motor can also be done by using Proportional Integral Derivative controller that is based on Genetic Algorithm. The characteristic feature of Proportional Integral Derivative controller is that it combines the uniqueness of

Proportional Integral and Proportional Derivative controller thereby giving quick settling time, optimum overshoot, and minimizing the steady state error [15]. The principle of Genetic Algorithm is based on Darwin's theory of evolution which includes a lesser part of artificial intelligence and evolutionary computing. The genetic algorithm is used to determine the gain parameters of PID controller [15]. The output of GA is then used to control the voltage which is further applied to the induction motor thereby controlling its speed.

A unique speed control method for wide speed control of single-phase induction motor is proposed these days [16]. The method is employing the renewable energy such as solar power. This method inhibits 2 levels of power transfer. The foremost level is the boost converter having Maximum Power Point Tracking capability and the next level comprises of load which is a single phase induction motor fed from a inverter that is connected in parallel[16]. The volt/hertz (v/f) control technique is used for the Wide speed operation of the induction motor. The characteristics of the motor load are determined for different operating conditions and are then compared with the existing methods of speed control [16]. Also, another induction motor control method that optimizes both torque response and efficiency is in use at present. The control is unlike from the usual field oriented control because it depends on the concept of the instantaneous slip frequency control, rather than on electromagnetic force [17]. For a consistent active system and considerable amount of savings in energy handling, adjustable speed drives (ASD) play a fundamental role [18]. The appropriate control of induction motor drives provide an excellent system response and also add to the efficiency of the drive. Newly, the direct torque control approach has drawn enormous significance for induction motor drives due to its ease, insensitivity to the motor parameters, high consistency and enhanced dynamic response [18]. Many control strategies have come into practice for the development of conventional DTC drives aiming exclusively on flux and torque. Numeral methods have been formulated and effectively implemented for the widespread control of induction motors [18].

Field-Oriented Control of Induction Motor Drives

The simple construction of the induction motor makes it very popular among the industrial and the consumer areas. But, at the same time because of the complexity of torque-speed characteristic curve there is decoupling between the field power and the armature power. For this purpose a most efficient type of vector control scheme called Field Oriented Control is in use at present. The main aim of this Field Oriented Control is that it treats the induction motor as a DC machine wherein the field flux and the armature current are two independent control variables that control the electromagnetic torque. With this the torque can be controlled either by maximizing the armature current or field current. Moreover, the speed can also be maximized by reducing the field current or by increasing the armature current. The excellent reliability, low cost, high robustness, and great efficiency of Induction motors have necessitated there use in industrial sector. The speed control of induction motor can be done by using a unique field oriented control approach which has many applications in hybrid electric vehicles [19]. For the current and speed control loops the PID based controllers have been developed. This assures the increased phase margin by employing the symmetrical optimum method [19].

The field oriented control approach can also be implemented in stator flux coordinates with a salient pole synchronous machine [20]. For the purpose of stator flux oriented control the current controller design is modeled. A new sensorless control is adopted with the view of torque angle in stator flux coordinates and by employing stator flux closed loop observer [20]. A unique approach of field oriented control has also been used to drive a three phase induction motor with a two phase inverter[21] .The FOC can produce full torque at zero speeds and it has a capability of fast response which make it suitable for many applications. This strategy is also applicable during inverter failure [21].

While design of induction motor drives which employ field-oriented control has reached a quite mature state, little effort has been spent on civilizing the reliability of induction motor drives [22]. At present a new improved induction motor drive topology and control approach has been developed which allows for uninterrupted, trouble free operation of the drive even with entire loss of one leg of the inverter or motor phase [22].

III. CONCLUSION:

An extensive review of some of the important works relating to this field is done in this paper. The paper describes the main techniques utilized by each author along with a brief summary of their results and the limitations. It is found that a lot of work is being done in control of induction motors. Recently, people have started working towards field oriented control. Also it is found that the renewable sources have drawn the attention of a lot of researchers all around the world. Some of the works prove that multi-junction solar cells perform better than single junction solar cell. In future, work can be done regarding FOC control of renewable fed induction motors. Also, the concept of MJSC can be utilized for improvement in efficiency.

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