Application of DSP for Speed Control of Induction Motor

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Abstract—This paper gives a high speed digital signal processor (DSP) based system for speed control of single phase induction motor. The system achieves fast speed control by using the Tiva\textsuperscript{\textregistered} C Series DSP-EXP430G2 and specialized digital hardware. The peripheral hardware has been designed for easy interface to many types of motor drive systems, to make the system generally applicable in the motion control field. The controller in the circuit consists of faster generation of the voltage and frequency inputs of sine wave in PWM. The creation of pulse width modulation outputs had to be implemented in hardware, since the use of the DSP for this task would consume a majority of the processing time at the desired repetition frequencies. The inner sine generation using the voltage and frequency components, the speed control of a single phase induction motor can be handled accurately and a smoother control can be obtained. This paper attempts a new speed control technique for the single-phase a.c. induction motor. It presents a design of a low-cost; high-efficiency drive capable of supplying a single-phase a.c. induction motor with a PWM modulated sinusoidal voltage.

Keywords—Digital Signal Processor, Pulse Width Modulation, Insulated Gate Bipolar Transistor, Single Phase Induction Motor, Universal Serial Bus

I. INTRODUCTION

The Motor Control industry is a strong aggressive sector. Each industry to remain competitive must reduce costs but also has to answer to power consumption reduction and EMI radiation reduction issues imposed by governments and power plant lobbies\cite{1}\cite{2}\cite{5}. The results of these constraining factors are the need of enhanced algorithms. DSP technology allows achieving both, a high level of performance as well as a system cost reduction\cite{1}\cite{3}. Texas Instruments launches a new DSP, referenced TM4C123G, specifically designed for the Digital Motor Control segment. This device combining a 16 bit fixed-point DSP core with microcontroller peripherals in a single chip solution is part of a new generation of DSPs called the DSP controllers.

Digital controller systems are used extensively in the field of motion control. High performance digital control systems usually require the fast execution of control algorithms. Many existing controllers are designed around a microprocessor or a microcontroller which typically runs at a moderate clock frequency and uses multiple instruction cycles for each processing step. These systems lack the ability to execute advanced algorithms fast enough for real-time control. Recently the use of a Digital Signal processor (DSP) as the heart of the controller has been explored. DSPs are designed for signal processing and have hardware optimizations which are directly applicable to digital control. Some of these desirable features are short instruction cycle duration, DSP technology allows to achieve both, a high level of performance as well as a system cost reduction. The Induction Motor (IM) has dominated over a number of fixed-speed applications because of its reliability and low maintenance operation compared to DC motors.

But speed control has been one of the obvious shortcomings which impeded IM applications in some industrial fields, such as hydraulics. Controlling the speed of a brushed DC motor is simple. This relationship is linear to the motor's maximum speed. In addition, most industrial DC motors will operate reliably over a speed range of about 20:1 down to about 5-7% of base speed\cite{4}. This is much better performance than comparable AC motors. However, in the last two decades, with the evolution of power semiconductor devices and power electronic converters, the Induction DSP Based Speed Control of Induction Motor (IM) is also well established in the controlled-speed area.
High performance Digital Signal processor (DSP)’s introduction makes complicated control algorithms, such as flux vector control available and flexible, which means that Alternating Current (AC) motors can be applied to accurate motor speed control as DC motor. Meanwhile, an AC induction motor, compared with a DC motor, is relatively inexpensive, since the windings consist of metal bars which are cast into steel laminations that make up the remainder of the rotor and the stator windings can easily be inserted in slots in stator laminations. An asynchronous motor, at least the cage variety, has no brushes, no moving parts other than the rotor, and virtually no maintenance. As a result, AC motors are progressively replacing DC machines in variable-speed applications. PWM modulated sinusoidal voltage during start. Circuit operation is controlled achieve soft start control technique for a single-phase A.C. induction motor. It presents design of a low-cost; high-efficiency drive capable of supplying single-phase a.c. induction motor[1][6].

For the speed control of single phase induction motor we have only one method called as “stator voltage control of single phase induction motor” as shown in figure 1. In speed control by stator voltage control, the stator voltage is reduced from base value of rated speed to a lower value. As torque is proportional to voltage square, the torque speed characteristics goes down proportional to voltage square. With shifting of torque characteristics the operating point will also move to give reduce motor speed. For a well-designed machine with low value of .slip the reduction in speed with reduced voltage is very small. Therefore if a large drop in speed I required with reduction in stator voltage, the motor is specially designed with high full load slip.

The literature reveals that DSP is very popular tool for many applications in digital world such as it usually to measure, filter and/or compress continuous real-world analog signals. Most general-purpose microprocessors can also execute digital signal processing algorithms successfully, but dedicated DSPs usually have better power efficiency thus they are more suitable in portable devices such as mobile phones because of power consumption constraints[2][7][8]. DSPs often use special memory architectures that are able to fetch multiple data and/or instructions at the same time.

II. OBJECTIVE

The basic objective of this paper is to present speed control of single phase induction motor. Many existing controllers are designed around a microprocessor or a microcontroller which typically runs at a moderate clock frequency and uses multiple instruction cycles for each processing step. These systems lack the ability to execute advanced algorithms fast enough for real-time control. Recently the use of a Digital Signal Processor (DSP) as the heart of the controller has been explored, therefore we are doing the project based on Digital Signal Processor (DSP) PWM modulated sinusoidal voltage during start Circuit operation is controlled by an This project goal is to achieve soft start control technique for a single-phase A.C. induction motor. It presents design of a low-cost; high-efficiency drive capable of supplying single-phase a.c. induction motor
III. BLOCK DIAGRAM

Initially single phase A.C. supply is given to the single phase transformer. This transformer is a step down transformer; it will step down the 230volt A.C supply into 12volt A.C supply. So this 12volt A.C. supply is given to the rectifier, rectifier will convert this 12volt A.C. supply into 12volt D.C. supply and this D.C. supply is given to the voltage regulator. Now the function of voltage regulator (7805) is designed to automatically maintain a constant voltage level. It gives required voltage to the digital signal processor i.e. 5volt dc supply. The Tiva™ C Series TM4C123GH6PM is a 32-bit ARM Cortex-M4-based with 256-kb Flash memory, 32kB SRAM, and 80-MHz operation; USB host, device, and OTG connectivity; a Hibernation module and PWM; and a wide range of other peripherals and a reset button. This DSP is used to generate pulse width modulation (PWM) to control the speed of induction motor Opto-couplers are made up of a LED and a light sensitive device, all wrapped up in one package[4][9].

No electrical connection between the two devices. The light sensitive device may be a photodiode, phototransistor, or more esoteric devices such as thyristors. Now to achieve a continuous voltage out of the alternative input signal, a single phase input bridge with tank capacitor is needed represented as the rectifier block to generate the phase voltage with variable amplitude and frequency a single phase inverter is used based on IGBT technology. So we are using IGBT as inverter. This inverted supply is given to the single phase induction motor.

After getting supply from IGBT inverter motor will start rotating. Now we need to control the speed of induction motor. This will achieve by controlling the width of PWM technique[10][11].
The input filter block includes the hardware protections, EMI filter and an optional power factor correction (PFC). The PFC may be active or passive, in the case of active it can be entirely handled by the DSP. To achieve a continuous voltage out of the alternative input signal, a single phase input bridge with tank capacitor is needed represented as the rectifier block. To generate the phase voltages with variable amplitude and frequency a 3 phase inverter is used, based on an IGBT technology. The system is controlled by the DSP TMS320C240. The inputs are, a tacho generator to measure the speed, a resistor divider to sense the voltage bus (VBUS), a resistor sensor on the line (IBUS) to estimate the phase currents, and a temperature sensor. The controller uses a serial link to communicate. The auxiliary supply feeds the inverter driver and the logic circuitry.[12]

**IV. CONTROL STRATEGY**

The control uses a space-vector PWM modulator. The voltage controller implements a closed-loop scheme for the motor field-weakening at high speeds. The DC bus voltage controller with iq limitation for the reference of the q-axis current enables the use of the motor as a brake, keeping the DC bus voltage under a maximum limit. The speed, flux and current controllers are all implemented using a standard PI regulator block, with double precision for integral part. The speed regulator has also a cutting frequency to avoid wind-up of the integral action[1][4]. The flux model block uses the values for α & β axis currents and the current electrical speed of the rotor to calculate.
the angle of rotor flux and the value of the equivalent magnetizing current of the motor. The coordinate transformation block is standard and uses the rotor flux angle to transform the stator phase currents values in the d-q axis frame. A software protection against high temperature is also implemented. To reduce the number of sensors, the phase currents are calculated from the DC bus current with the current estimator block.

V. Hardware Setup

VI. CONCLUSION

Digital signal processing is one of the core technologies, in rapidly growing application areas, such as wireless communications, audio and video processing and industrial control. This presents a new controller architecture the DSP controller. The DSP Controller Tiva C Series TM4C123G combines the performance of a DSP architecture with the optimized peripherals of a Microcontroller in a single chip solutions for the control of an induction motor. With the DSP controller an intelligent control approach is possible to reduce the overall system costs and to improve the reliability of the drive system.

REFERENCES