MULTILEVEL CONVERTER FOR SINGLE PHASE INDUCTION MOTOR USING IGBT

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Abstract: -
This study describes a five-level inverter for three-phase induction motors that is based on a microcontroller and is field-oriented. IGBT serves as the power source. Since its introduction three decades ago, pulse width modulation (PWM) techniques have been the most widely used means of controlling the voltage and frequency supplied to electrical AC machines. A flexible and affordable solution is made possible by a scheme based on a 5-level PWM inverter that controls a high performance 8-bit standard microcontroller with a gate driver circuit and additional hardware. There is a wide range and good resolution for changing the output voltage. We'll present experimental results from an induction motor drive.

Keywords: - Microcontroller, FOC, PWM, multilevel inverter, and induction motor.

INTRODUCTION

Over the past ten years, numerous studies have been conducted with the aim of enhancing the efficiency of induction motors. The foundation of the different approaches is the field-oriented control of the rotor flux model reference condition system. The induction motor's unique benefits of low cost and simple construction make it a suitable choice for variable speed drives. Certain internal components of the asynchronous machine require upkeep or replacement. The asynchronous machine's electromagnetic torque expression can be practically translated into the torque of a D.C. machine through field-oriented control of the rotor flux of voltage applied to the machine.

This work sharpens the suggestions of decoupling the dependent excited D.C. motor by decoupling Vds and Vqs to control the flux, specifically in the course of the component Ids and Iqs. The couple, the junction temperature, the rotor flux, and the stator pulsation are all determined by the estimators. The expression of electromagnetic torque can be transformed by controlling an induction motor to almost equal the torque of a DC machine. An implementation of a 5-level PWM inverter-based vector-oriented control of the rotor flux of an asynchronous machine using an induction motor. Furthermore, the voltage applied to the IM requests a modulator stage with field-oriented control of rotor flux and multi-level inverter PWM. This step lengthens the time required for signal processing (orders IGBTs of the type H inverter), which in turn restricts the control system's responses and, in turn, the torque and speed response times. Additionally, a hardware implementation of the field-oriented control of the five-level inverter-fed induction motor system, as well as the programming and coding of that control within the real-time operating system.[5]

MULTI LEVEL PWM INVERTER

A variety of power semiconductors and capacitor voltage sources are used in the multilevel PWM inverters, and their output produces voltages with stepped waveforms. While the power semiconductors can only withstand lower voltages, the switches' ability to commutate permits the addition of capacitor voltages that reach high levels at the output. An ideal switch with multiple positions represents the action of the power semiconductors in a single phase leg of an inverter with varying levels. An output voltage with five values (levels) in relation to the capacitor's negative terminal is produced by a five-level PWM inverter..

The number of steps in the voltage between the two phases of the load, k, is defined by: Taking into account that m is the number of steps of the phase voltage with respect to the negative terminal of the inverter.

$K = 2m + 1$ (1)

The number of steps p in the phase voltage of a threephase load in wyes connection is given by:

$p = 2k+1$ (2)

The three-level inverter is where the term "multilevel" originates. Harmonic distortion is reduced when the inverter's number of levels is increased because the output voltages have more steps and produce staircase waveforms. Nevertheless, a large number of levels leads to an increase in complexity and the introduction of issues with voltage imbalance.[1] For multilevel inverters, three distinct topologies have been proposed: cascaded multicell with independent dc sources, capacitor-clamped (flying capacitors), and diode-clamped (neutral-clamped). Furthermore, a number of modulation and control techniques, such as space-vector modulation (SVM), multilevel sinusoidal pulse width modulation (PWM), and multilevel selective harmonic elimination, have been developed or implemented for multilevel inverters.

The following are multilevel inverters' most alluring features:

1) It has a very low distortion in its output voltage generation.

2) It has very little distortion when drawing input current.

3) It lessens the stress on the motor bearings by producing a lower common-mode (CM) voltage. Additionally, CM voltages can be removed by employing advanced modulation techniques [8].

4) The switching frequency at which they operate can be lowered.

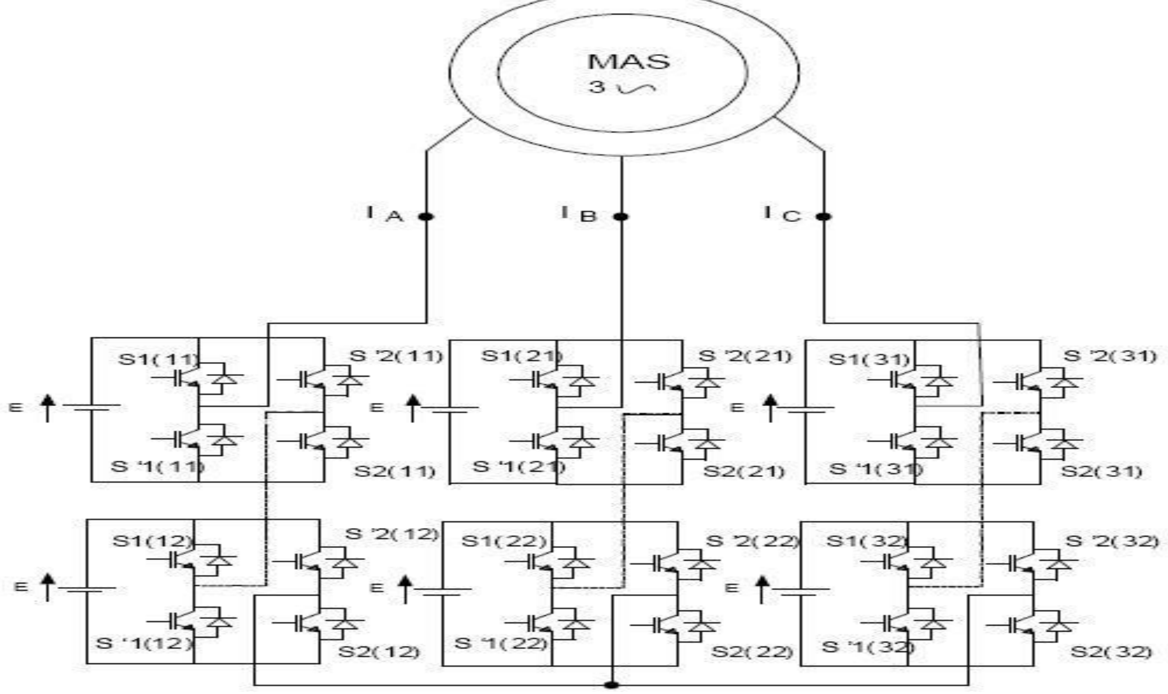


Fig.1 *Three-phase cascaded multilevel inverter PWM of the type H*

The fundamental buck converter, which converts a DC signal into a square wave by using a power semiconductor, is the basis for early DC to AC conversion techniques (Square Wave Inverter). When power storage elements like capacitors and inductors are added, this square wave will start to resemble a rough sinusoidal wave. The semiconductors' logic control can be used to further optimize the intended sinusoidal output. By producing a zero level, it allows the square wave's positive and negative peaks to be delayed (Phase Shifted Square Wave inverters). All of these adjustments were done to help reduce the Total Harmonic Distortion (THD) and create a perfect sinusoidal output.

The DC input to AC output conversion is further improved by the PWM inverter. Prior to recent developments in semiconductor technology, this inverter advancement was not possible. High power rating and high switching frequency semiconductors are required for this specific project. PWM inverters get their name from using high-speed semiconductor switches to switch the DC signal at different intervals, which results in different pulse widths[5–6].

S1	S2	S3	S4	S5	S6	S7	S8	OUTPUT
1	0	0	1	0	0	1	1	$0.5V_{DC}$
0	0	1	1	1	0	0	1	VDC
1	0	0	1	1	0	0	1	$1.5\ V_{DC}$
0	0	1	1	1	0	0	1	VDC
1	0	0	1	0	0	1	1	$0.5\ V_{DC}$
0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	1	1	$-0.5\ V_{DC}$
0	0	1	1	0	1	1	0	$-\ V_{DC}$
0	1	1	0	0	1	1	0	$-1.5\ V_{DC}$
0	0	1	1	0	1	1	0	$-\ V_{DC}$
0	1	1	0	0	0	1	1	$-0.5\ V_{DC}$
0	0	0	0	0	0	0	0	$-\ V_{DC}$

Table 1:- Conduction Sequence for Asymmetric CascadedMultilevel Inverter

With two voltage sources and two H bridges, three voltage levels can be achieved. Second h bride h2 receives 0.5 of Vdc if first h bride h1's voltage is Vdc. The proper IGBTs are turned on to obtain a different voltage level. Vdc, 1.5 Vdc, 0.5 Vdc, and 0. which, for negative values, are inverted IGBT sequence and repeated continuity.

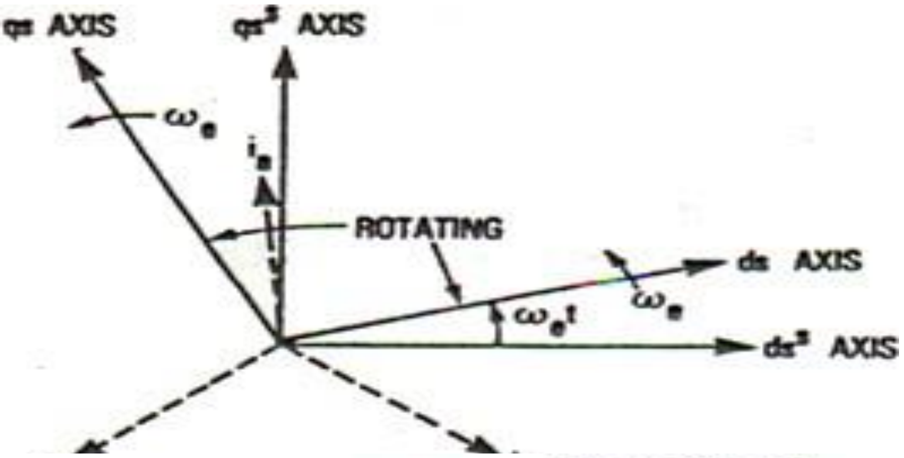
FIELD ORIENTATED CONTROL

By adjusting the angle and amplitude components of the stator field, field-oriented control provides exact controllability over an induction motor fed by a multilevel PWM inverter. In order to convert a three-phase, time- and speed-dependent system into a two-coordinate, time-invariant system, a simplified model of an induction motor must undergo a number of intricate transformations. In essence, it makes it possible to control an induction motor in a manner akin to that of a dc motor by isolating and streamlining the variables required for controlling torque and speed. The torque (q) and flux components (d) of the stator current are aligned with respect to a synchronously rotating frame, providing instantaneous controllability, and this forms the basis of the control system. An ideal vector system for field-oriented control is shown below:

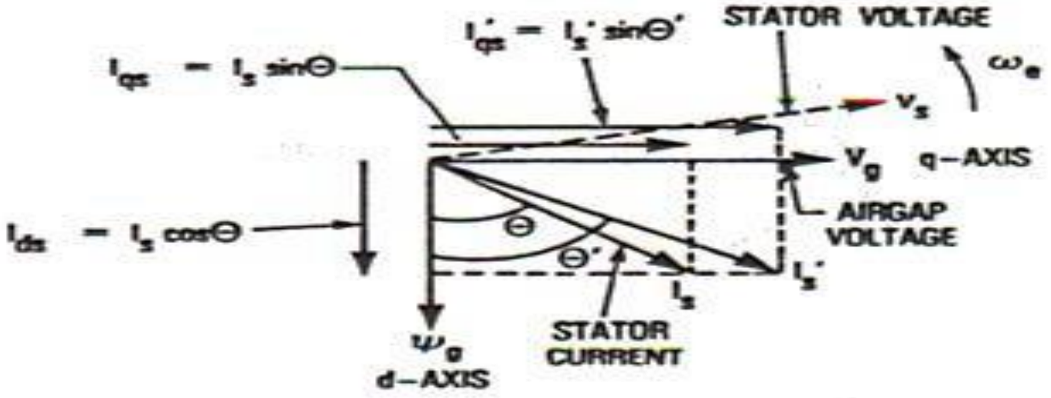
$$\psi R\ isq$$

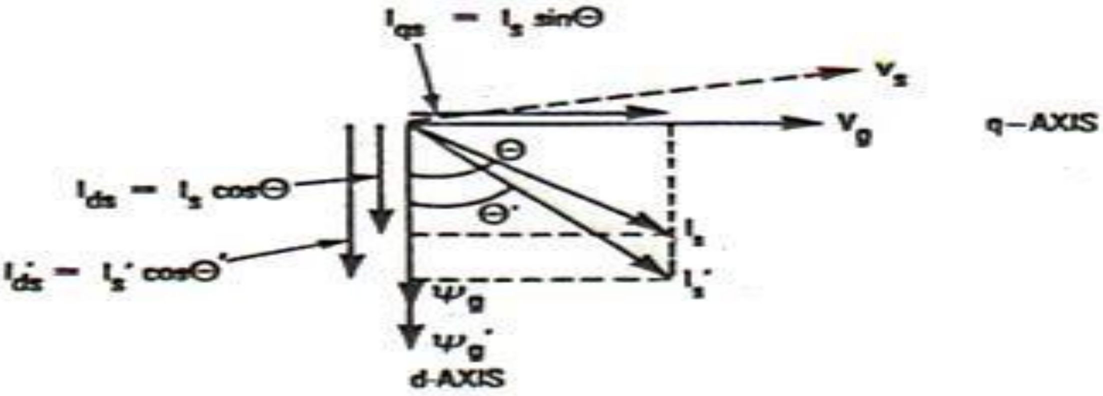
Where m = Torque
ψ_R = Rotor flux
i_{Sq} = Stator current vector

The relationship presented above essentially indicates that m and φR iSq are directly proportional to one another. As a result, by controlling the torque component of the stator current vector, keeping the rotor flux constant will result in a direct linear relationship between the torque and torque component (iSq). This will enable precise control. [4-5]



HARDWARE I





To Capture and Compare the PWM modules a version of the modulator suitable for the field oriented control, accepts as:

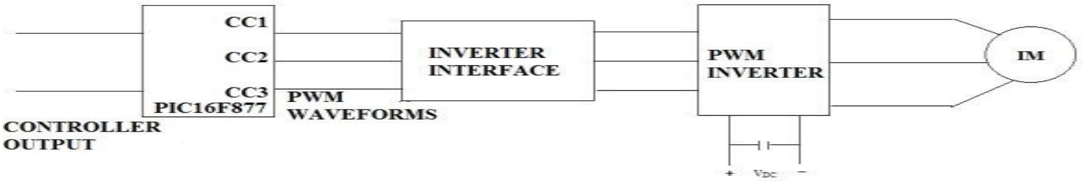
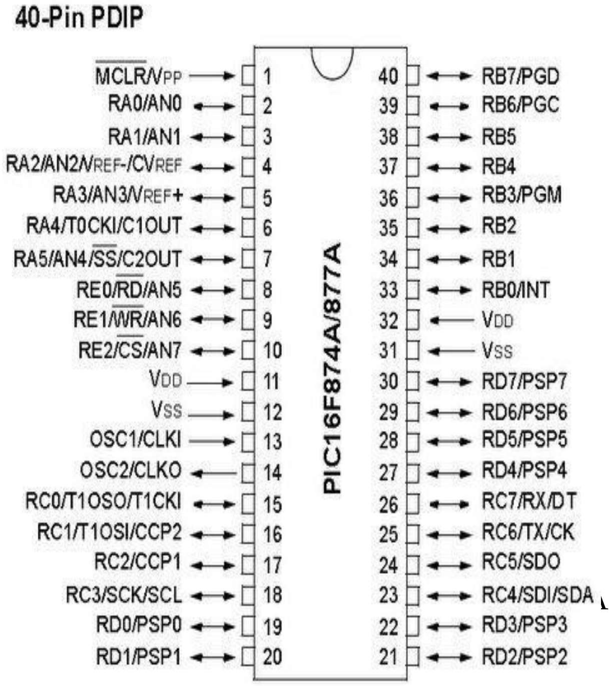


Fig 4:- Block diagram of the used system to test themodulator.

It produces the digital waveforms that drive the power stages when the voltage demand is input in the dq stator coordinates (U, and U). The modulator hardware in the suggested solution is essentially an 8-bit microcontroller with very little additional logic, which serves as the power stage interface.The microcontroller, a 16F877A, was created specifically for sophisticated, real-time control applications.It has a single register-based architecture core that allows for quick context switching and gets rid of the accumulator bottleneck. All of the devices have bit, byte, word, and 8-bit operations even though the 16F877A microcontrollers have an 8-bit architecture. Peripherals from the Motion Control family are designed with power inverter and three-phase AC induction motor control in mind. These devices have a special peripheral called the capture and compare module (CCM), which makes control over external hardware used to generate three-phase pulse width modulation waveforms and a 5 level PWM inverter gate driver circuit much simpler. Three complementary are produced by the capture and compare module (CCM).

PWM pulses that don't overlap and have a 250 ns resolution (using an oscillator at 16 MHz). After initialization, the CCM needs to adjust the PWM duty cycles. The CCM has dead time, duty cycle, and programmable switching (or carrier) frequency up to 1 kHz. To prevent a short circuit in one leg of the power inverter, the dead time generator (part of the CCM peripheral) stops the complementary outputs from being turned on simultaneously. Additionally, every phase of this peripheral has programmable high drive capability outputs. The outputs can be forced high or low or have their polarity programmed. The PWM waveforms are produced by the CCM, as seen in Fig. The switching frequency is set by the CC-COUNTER register. Every state machine clocks the 8-bit counter in the CC-COUNTER register. The counter constantly counts up and down from OOOlH to the CC-RELOAD value while it is operating. This register sets the pulse width when the counter equals the Capture and Compare Modules (CCMs)—three CCMs, one for each phase—because the outputs are complemented. A PI-Interrupt is generated each time the CC-COUNTER register reaches the CC-RELOAD value. The CC-COMP register values can be changed with this interrupt (if needed). [2]

Specification of capture and campare module
- Capture is 16-bit, max. resolution is 12.5 ns
- Compare is 16-bit, max. resolution is 200 ns
- PWM max. resolution is 10-bit



SOFTWARE IMPLEMENTATION

Fig. 7 displays the general flowchart of the modulator software design. ISR (Intrrupt Service Routine) Fig. and the primary routine are essentially the two ongoing tasks. The IGBT combination to be switched ON is first determined, and values are then output to the corresponding port C that is connected to the gate driver circuit. This is how the main routine uses port C, which is an input to the

IGBT gate driver circuit produced by the controller. The subsequent combination is turned ON after each PWM counter. For the motor, all combinations are thus output along with a multi-level wave form.

Another 120 phase-shifted output is produced for the other two phases. 250 ns is the minimum pulse width resolution, regardless of the CC-RELOAD value. The chosen carrier frequency determines the actual resolution; the lower the pulse width resolution, the higher the carrier frequency. About 1 kHz was the carrier frequency used in the experiments, allowing for a pulse width resolution of 1/256, which is more than sufficient for the majority of applications. The switching times are updated in a single carrier period when using this frequency. Between 0 and 70 Hz is the frequency range that the modulator synthesizes. [3]

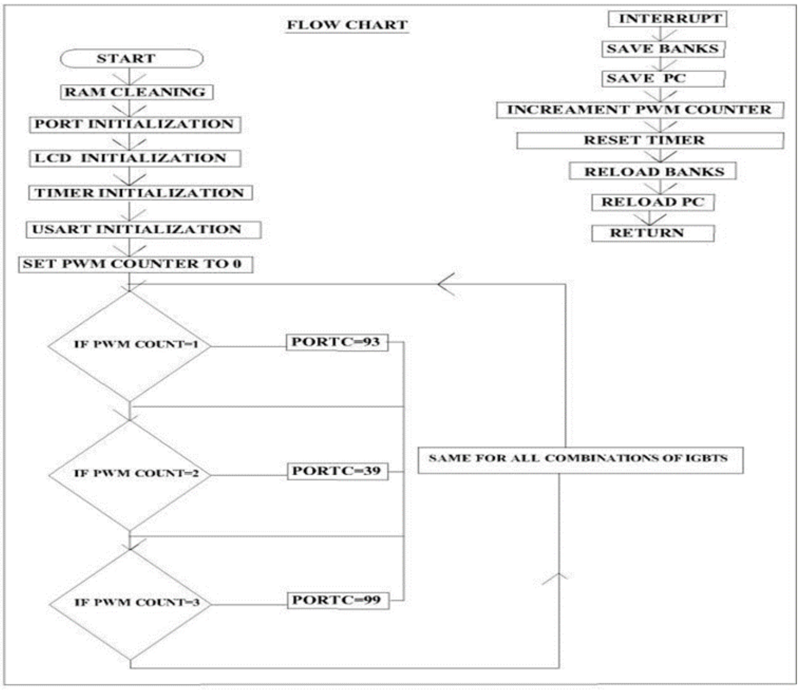


Fig 6: flowchart of software deign

EXPERIMENTAL RESULTS

Using 5 level inverter techniques, a 0.5 horsepower induction motor is successfully operated when connected to the system.The maximum supply voltage that is being used is 100V. The motor is tested without any load. In both an ordinary and an industrial setting, the hardware and power components operate at room temperature. In order to ensure that the motor operates suitably when using solar power as an input source in the future, various input voltages are applied.

Fig 7:- experimental generated 5-level wave form ofPWM inverter

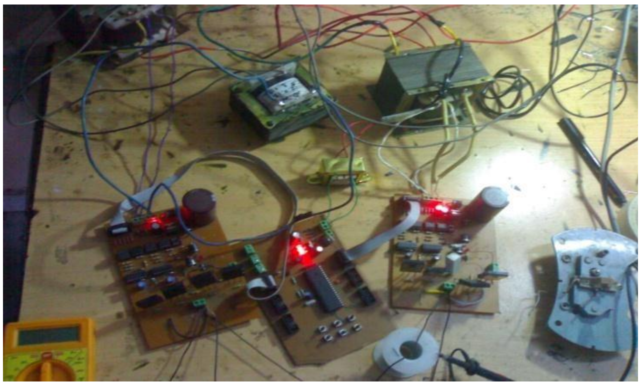


Fig 8: Hardware Setup of Proposed Design

CONCLUSION

An IGBT 5-level PWM inverter fed a 0.5 horsepower three-phase induction motor was used to demonstrate and test a voltage space vector PWM modulator appropriate for field-oriented control. A high performance 8-bit microcontroller with a gate driver circuit and extra hardware served as the foundation for the suggested solution. Because of the high efficiency of the implemented algorithm, there is ample time to use the same microcontroller for other tasks, such as basic motor control schemes. Fine resolutions at high switching frequencies are achievable over a wide range of output frequencies.

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