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Variable Frequency Inverter Using DSPIC

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ABSTRACT

Induction motors are being used in greater numbers throughout a wide variety of industrial and commercial applications because it provides many benefits and reliable device to convert the electrical energy into mechanical motion. In some applications, it's desired to control the speed of the induction motor. In recent years, with the microcontroller incorporated into an appliance, it becomes possible to use it to generate the variable frequency AC voltage to control the speed of the induction motor.
This study investigates the microcontroller based variable frequency power inverter. The microcontroller provides the variable frequency pulse width modulation (PWM) signal that controls the applied voltage on the gate drive, which provides the required PWM frequency with fewer harmonic at the output of the power inverter. The fully controlled bridge voltage source inverter has been implemented with semiconductors power devices isolated gate bipolar transistor (IGBT), and the PWM technique has been employed in this inverter to supply the motor with AC voltage. From the result, a stable variable frequency inverter over wide range has been obtained.

Keywords: V/F Control, Speed Control, Variable Frequency, PWM.

I. INTRODUCTION

In the various industrial applications the induction motor is widely used. The loads on induction motor most of the time varies as per its application need, but speed of induction motor remains unchanged & does not match with the demand from load. If load on induction motor changed, the speed of induction motor does not change as per the load. Hence it takes rated power from supply so the energy consume by the motor is same. Hence there is energy consumption is same during load varying condition also. This problem can be addressed using a VFD method industrial application to save the energy consumption and electricity billing. Variable frequency drive (VFD) usage has increased dramatically in industrial applications. This device uses power electronics to vary the frequency of input power to the motor, thereby controlling motor speed. Variable Speed Drive (VSD) This more generic term applies to devices that control the speed of either the motor or the equipment driven by the motor (fan, pump, compressor, etc.). This device can be either electronic or electro-mechanical.

Design microcontroller based variable frequency power inverter is presented in [1]. The microcontroller unit (MCU) provides the adjustable frequency pulse width modulation (PWM) which controls the voltage applied to the gate drive. This provides the necessary PWM pulse with minimum harmonics at the output stage. The proposed driver for 3-ϕ&1-ϕ power inverter is simulated using Matlab/Simulink. The simulation results of the proposed system achieved with different SPWM. Author found a stable adjustable frequency for inverter over wide range. In [2] author uses basic principle of variable frequency where, the speed of the AC motor is controlled using PWM pulses produce by PIC 16F873Microcontroller. The wireless technology is helpful to handicapped, paralysed and elder people. In [3] author implement variable speed drive for regulating the speed of 3-ϕAC motor as batching system needs constant speed. The synchronization is important in between batching system and weaving machine. This can be done by using variable voltage variable frequency method with the help of AC drive. Work in [4] presents variable speed control application of induction motor using v/f method. In this work the speed of the induction motor is adjusted to required speed. The actual speed & reference speed is compared. The difference of speed is achieved by changing the firing angles of IGBTs. The system is tested & experimental results are recorded for variable speed under various load conditions.

In early days, the variable speed drives (VFD) had various limitations such as larger space, poor efficiencies, lower speed, etc. But, now with new techniques and invention in power electronics semiconductor devices has changed the situation. Now days, variable speed drives (VFDs) can be constructed in smaller size with high efficiency and reliability. One of mostly control scheme is variable voltage – variable frequency. With this method one can control speed of motor working under any circumstances.

The organization of this document is as follows. In Section 2, detail of method used to implement this work is presented. In Section 3, Results and findings are presented. Finally conclusion is discussed in Section 4.

II. DESIGN AND IMPLEMENTATION

Induction motors generate torque from an electric current flowing through a rotating magnetic field. If the current is held constant, the motor can generate torque at full load. Below the base speed, this is achieved by maintaining the voltage-to-frequency ratio applied to the motor when the frequency is changed to the controlled speed. For 460 and 230V motors, the ratio is 440/50 = 8.8 and 230/50 = 4.6. As the frequency decreases and the motor speed decreases, increasing this ratio increases the motor current and may be too high. As the frequency increases, the torque capacity of the motor decreases. There are exceptions to this rule, which are described below.

The main speed of the motor is proportional to the supply frequency and inversely proportional to the number of poles. So we can change the motor speed by changing the frequency on the display. Above the base speed, this ratio decreases when a constant voltage is applied to the motor. In this case, the motor output torque is lower than the base speed. Below about 30 Hz, the volt/Hz ratio is not always constant. Depending on the load type, the voltage can be increased to a higher gear ratio so that the motor can generate sufficient torque, especially when stopped. This parameter is commonly referred to as overvoltage [2].

Advances in semiconductor manufacturing technology have significantly reduced the quantity and price of semiconductors. This means motor users can replace their low-power machine control systems with frequency converters (VFDs). VFD can not only control the motor speed, but also improve the dynamic and static characteristics of the motor[5] . VFDs can also reduce the average power consumption of the system. Although several induction motor control techniques are currently used, the most common control technique is to create a variable frequency source with a constant voltage/frequency ratio. This method is commonly known as VF control. VF control is widely used in open loop systems and is suitable for a variety of applications where changing the motor speed is a critical requirement to effectively control the motor[5]. It is also easy to implement and inexpensive.

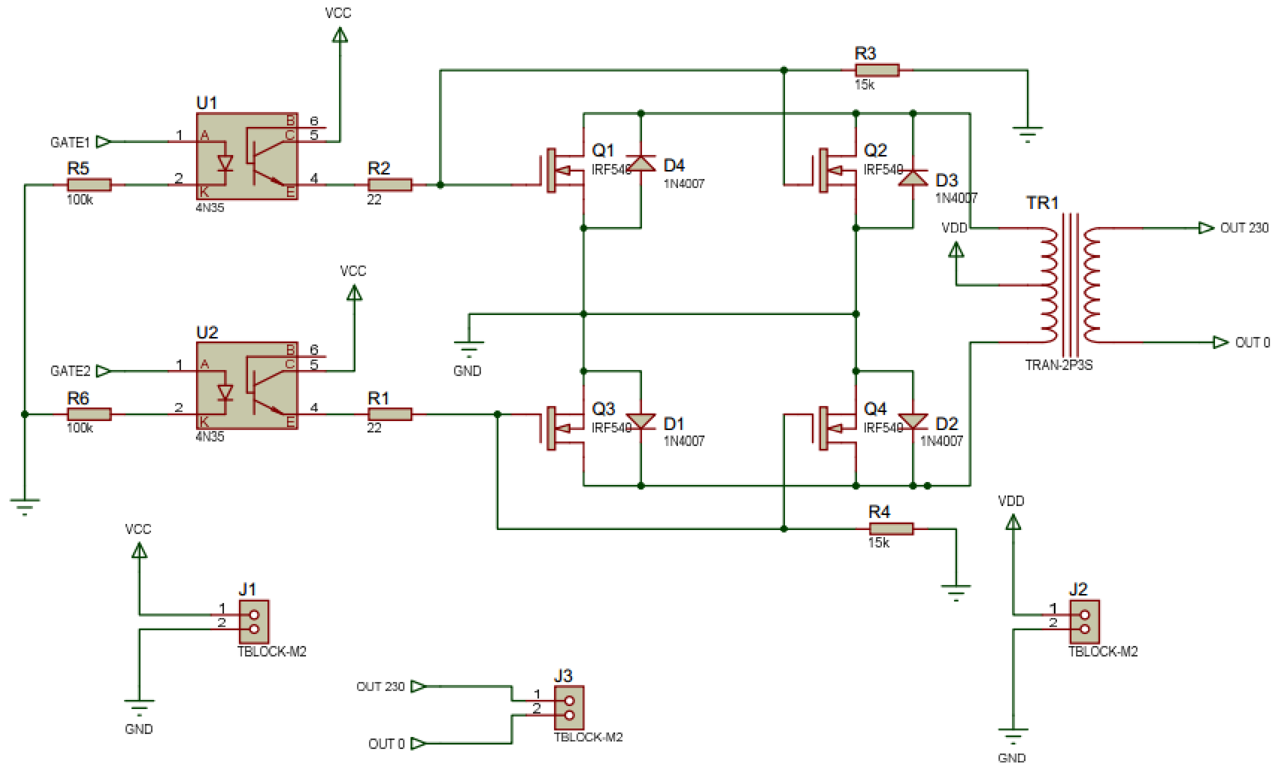

Figure 1: Circuit Diagram

At base speed and low speed, the volt/hertz ratio can be lowered to reduce the motor current when the motor is under light load. Low Motor Voltage This setting reduces the motor solenoid current. So the motor has less torque for transportation. This control is more common in the industry and is commonly referred to as static V/F control.

Variable Frequency and speed control

Many applications require variable speed operation. This is especially true in applications where the input power is directly proportional to the cube of the motor. For applications such as centrifugal pumps based on induction motors, a reduction of up to 20% in speed can result in savings of around 50%. A major concern in todays energy world is the efficient drive and control of induction motors.

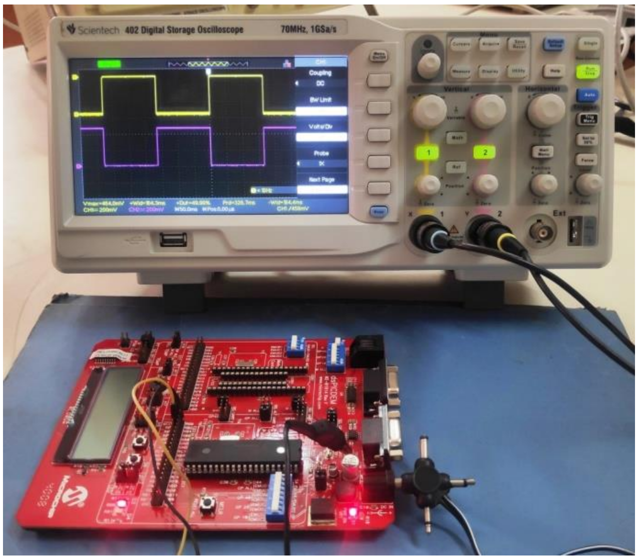

Figure 2: Hardware Setup

Algorithm and flow Chart

Figure 3 is frequency control flow chart. The speed of motor is directly proportional to frequency of applied signal. The advanced sinusoidal PWM generation is used. The sine table is saved in memory. The width of unit pulse and decided by table value and input frequency. Use of sinusoidal PWM technique will reduce harmonics and coil heating of induction motor.The first step in the flowchart is to initialize the input parameters. They are responsible for cold start and motor protection. Gate control for MOSFET banks are kept LOW to protect bank from short circuit.

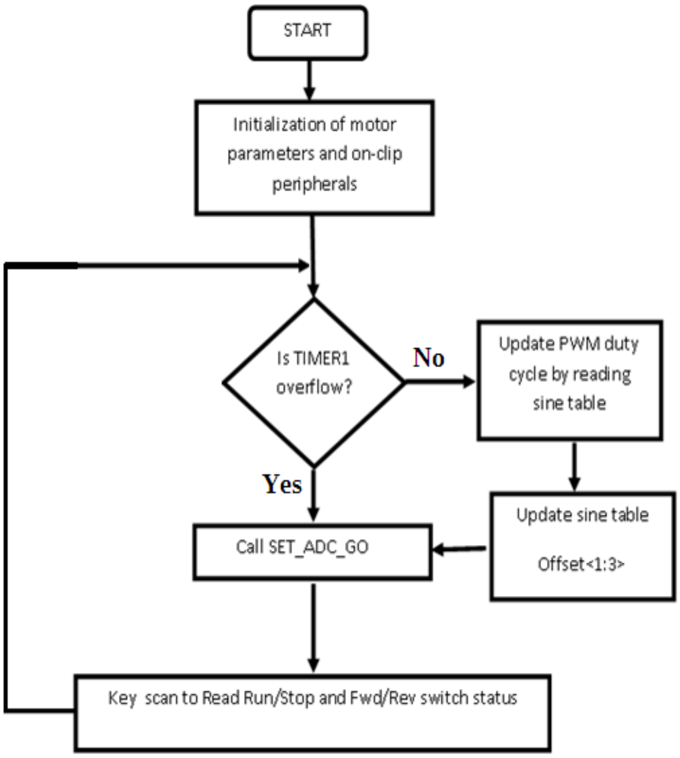

Figure 3: Algorithm Flow Chart

Timer is initialized and compared to ADC value for controlling the pulse width of the waveform. The sine table is read and corresponding proportional value is calculated based on required frequency. This value is loaded in to the timer preset value. Timer runs for presented value and again the cycle repeats for next value in sine table.

Status of input switches is scanned and control parameters are updated. The switches are RUN, STOP. Three phase induction motors includes forward and reverse switches. In every call of sinusoidal adjustment call for ADC scan and switch matrix scan is generated.

Figure 4 displays the ADC scan routine. The time interval for ADC scan is 4ms. The ADC call is initiated. The timer value is updated and system returns to main control loop. The ADC resolution is 10 bit and maximum count is 1023. ADC buffer is read and compared with previous value. If it is differs the process for new frequency setup is initiate. This new value is used to update the timer value and it will change the frequency of waveform. Change in the timer value will.

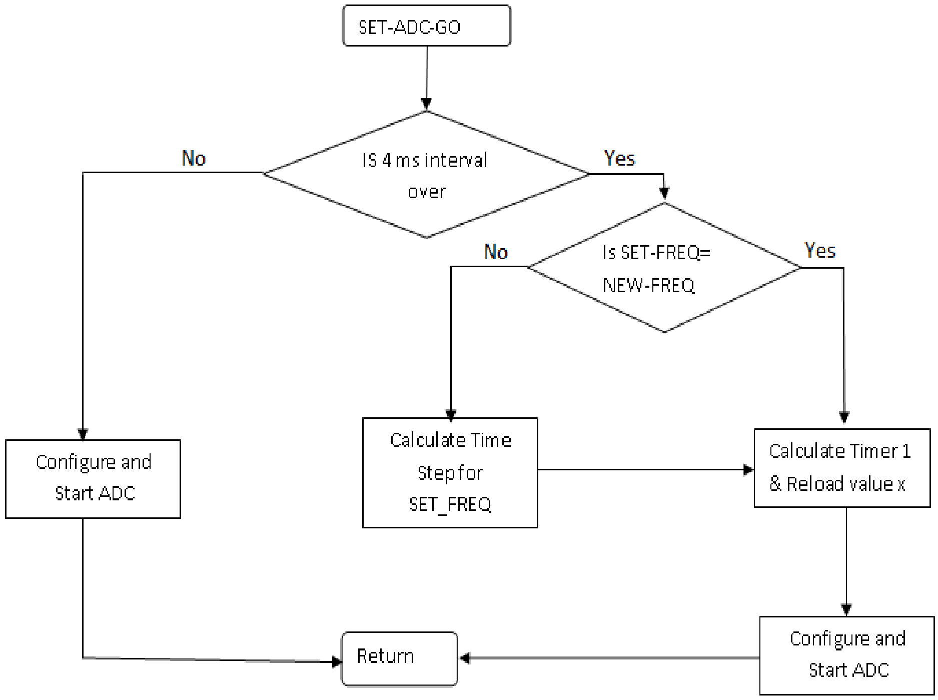

Figure 4: Algorithm Flow Chart

change the step size and hence the overall time period of sine wave. Frequency is reciprocal of time period. Hence the frequency of generated waveform will change

III. RESULTS AND DISCUSSION

With the help of DSPIC DEM development board we get PWM pulses at the output port. These pulses are as per our expiations. Algorithm for PWM pulses shows that response time is much less and it appears in suitable form.

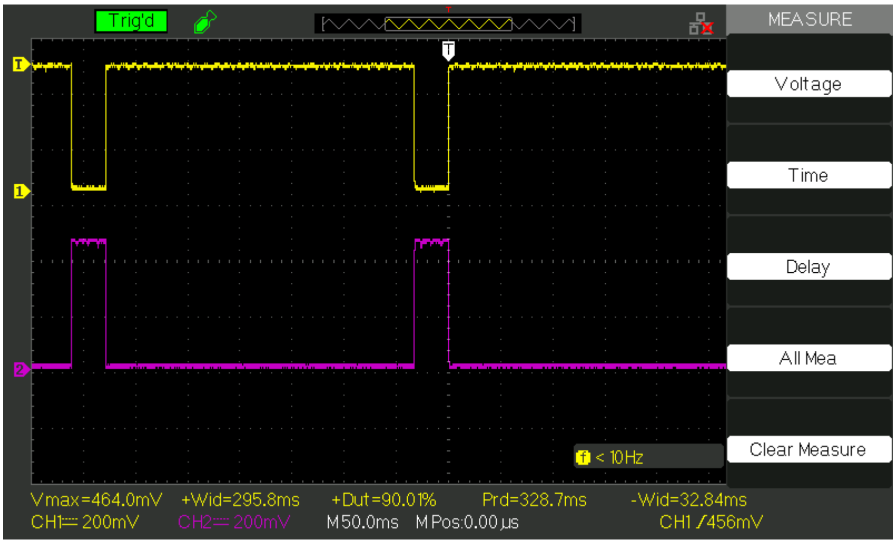

Figure 5: PWM output at 90% Duty Cycle

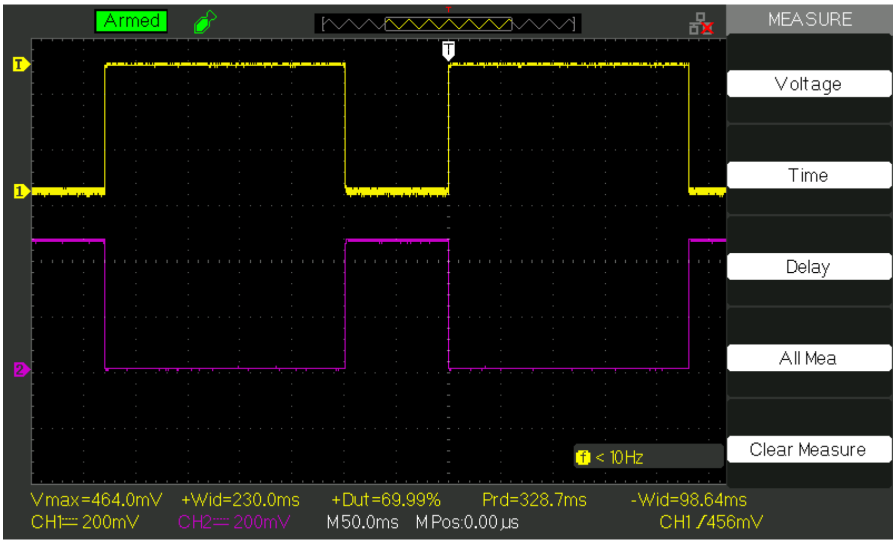

Figure 6: PWM output at 70% Duty Cycle

It is observed that at output port on board LEDs intensity is constant and LEDs switching time is changing with respect to change in frequency of V/F ration. MOSFET driver circuit ON-OFF is observed satisfactorily. Figure 5 to 8 Shows PWM output at different Duty cycle.

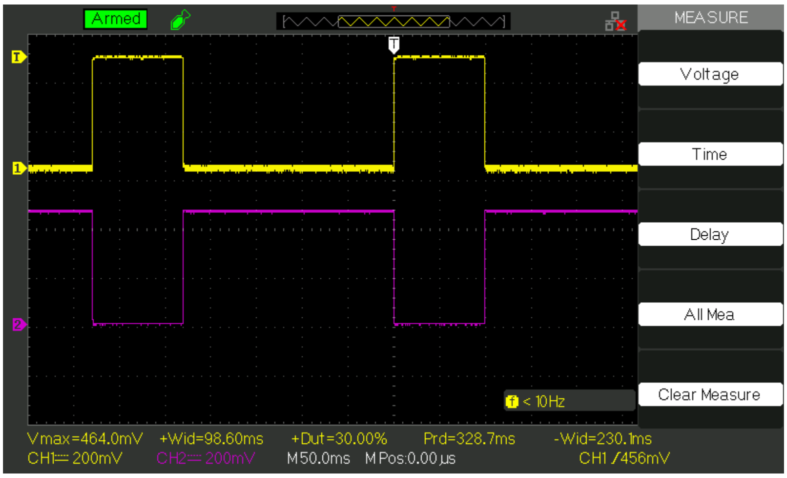

Figure 7: PWM output at 30% Duty Cycle

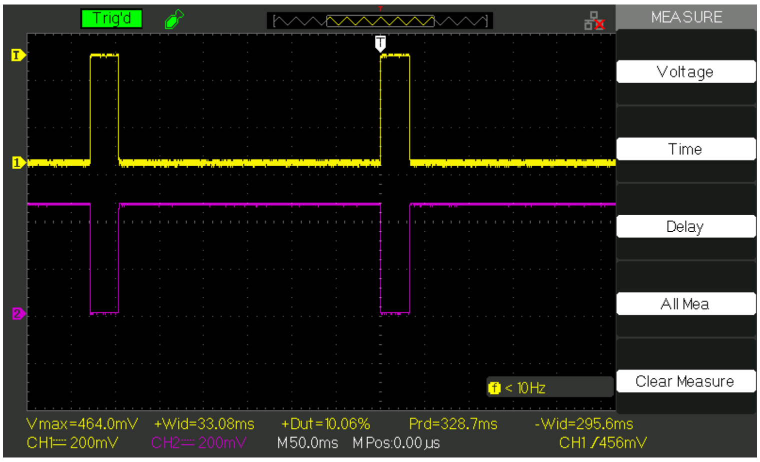

Figure 8: PWM output at 10% Duty Cycle

Following observations made during experimental setup.

% Duty Cycle	Output Voltage (in Volt)	
	Observed	Calculated
10	0.481	0.5
30	1.443	1.5
70	3.367	3.5
90	4.329	4.5

Table 1: Output voltage vs Duty Cycle

IV. CONCLUSION

This work presents implementation of speed and torque control of induction motor using DSPIC. We developed algorithm for generation of PWM to maintain torque at required level for variable speed application. To do this effectively we have adapted method of V/F control. Our Results shows the use of

DSPIC gives better torque stability and quick response as compare with other MCUs. We have successfully able to maintain required torque at low and high speed of AC motor.

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