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# V/f Control of Induction Motor Using Space Vector Modulation

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***Abstract*— This paper presents a V/f control technique of three phase induction motor using space vector PWM. The three phase induction motor is driven using one of the most commonly used speed control techniques. The three phase inverter is driven by space vector modulation.**

***Index Terms*—Space vector modulation, three phase induction motor, V/f control technique.**

## I. INTRODUCTION

The work here presents a commonly used speed control technique of three phase induction motor using space vector modulation. The dc supply or the battery is fed to three phase induction motor through a three phase inverter. The inverter is driven by space vector modulation.

## II. THE PROPOSED SYSTEM

### *A. Three Phase Inverter*

A three phase inverter carries six switches where each switch is composed of a controllable device and a uncontrollable device, connected in anti-parallel.

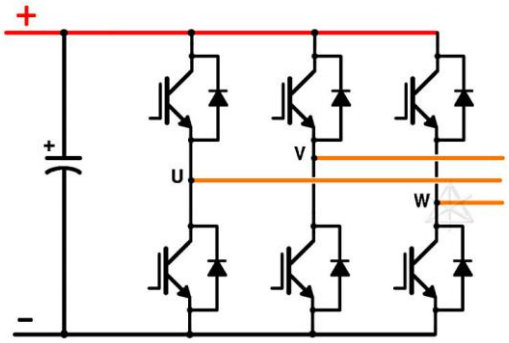


**Fig.1.Three phase inverter**

### *Space Vector Modulation*

The method of controlling the ON and OFF time periods of six switches of the inverter so as to generate ac voltage from the input dc source is actually the method of modulation. Here are different types of modulation techniques. Among them the most commonly used technique is sinusoidal modulation. But nowadays the space vector modulation technique is found to offer better features compared to conventional modulation techniques. A three-phase VSI generates eight switching states which include six active states and two zero states. These vectors form a hexagon which may be considered as consisting of six sectors spanning 60° each.

**Table 1: Eight on-off states of the inverter**

| Inverter State | $S_A S_B S_C$ | $\frac{V_A}{V_{dc}}$ | $\frac{V_B}{V_{dc}}$ | $\frac{V_C}{V_{dc}}$ |
|---|---|---|---|---|
| 0 | 000 | 0 | 0 | 0 |
| 1 | 001 | -1/3 | -1/3 | 2/3 |
| 2 | 010 | -1/3 | 2/3 | -1/3 |
| 3 | 011 | -2/3 | 1/3 | 1/3 |
| 4 | 100 | 2/3 | -1/3 | -1/3 |
| 5 | 101 | 1/3 | -2/3 | 1/3 |
| 6 | 110 | 1/3 | 1/3 | -2/3 |
| 7 | 111 | 0 | 0 | 0 |

The reference vector which represents three-phase sinusoidal voltage is generated by switching between two nearest active vectors and a zero vector. This is the method behind space vector modulation.

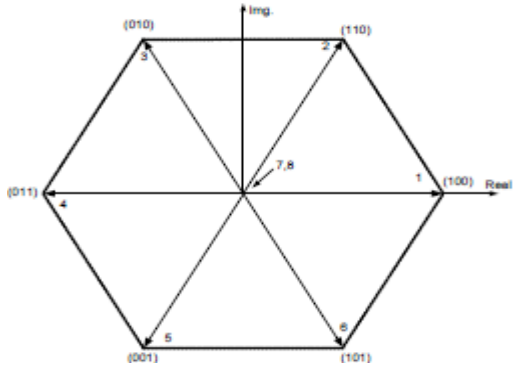


**Fig.2. Phase voltage space vectors**

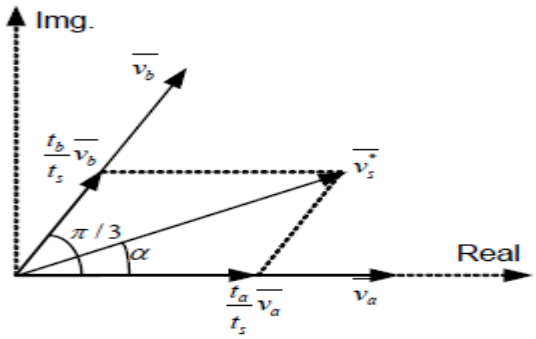


**Fig.3. Principle of space vector calculation**

The time of application of active voltage space vectors is found from the above figure. The important feature of space vector modulation is that each leg changes its state only once in a switching period. The time of application of active voltage space vectors may be as below.

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$$t_a = \frac{|v_s^*|\sin(\pi/3-\propto)}{|v_a|\sin(2\pi/3)}$$

$$t_b = \frac{|v_s^*|\sin(\propto)}{|v_b|\sin(2\pi/3)}$$

and

$$t_0 = t_s - t_a - t_b$$

Where

$$v_a = v_b = \frac{2}{3} * v_{dc}$$

In order to have optimum harmonic reduction, any switch should change its state only once in a switching period in SVPWM. Here, the switching period is divided as follows. ie., in one half of the switching cycle, zero vector is applied for 1/4$^{th}$ of its time of application. Then, it is followed by the active vectors, which is applied for half of its time of application. Next it is again followed by the zero vector periods which comprises of 1/4$^{th}$ of its time of application. The next half cycle is a mirror image of the first one.

### *B. V/f Speed Control*

The torque developed by the motor is directly proportional to the magnetic field produced by the stator. So, the voltage applied to the stator is directly proportional to the product of stator flux and angular velocity. This makes the flux produced by the stator proportional to the ratio of applied voltage and frequency of supply.

$$V \propto \Phi f$$

$$\Phi \propto V/f$$

Therefore by varying the voltage and frequency by the same ratio, the torque can be kept constant throughout the speed range. This makes constant V/f is the most common speed control of an induction motor.

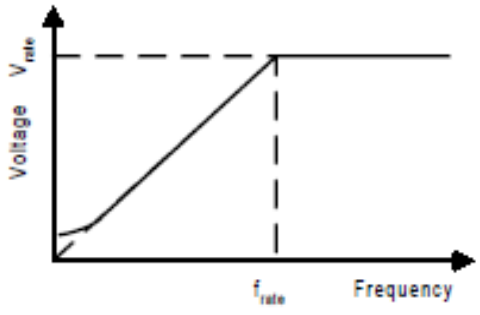


**Fig.4. Voltage- frequency under constant V/f principle**

## III. SIMULINK MODEL

Simulation of the proposed system, i.e., the V/f control of the three phase induction motor using space vector modulation is done in the software MATLAB-SIMULINK R2010A. The dc source is directly connected across a three phase inverter, which feeds the three phase induction motor. The three phase inverter is driven by space vector modulation technique. An open loop speed control based on constant V/f ratio technique is tried for a 5.4HP, 400V, 50 Hz asynchronous machine.

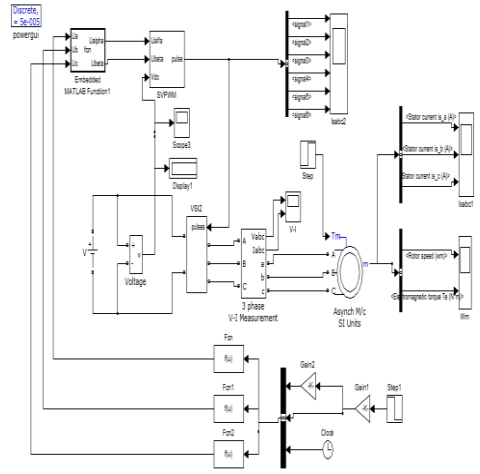

**Fig.5.Simulink model**

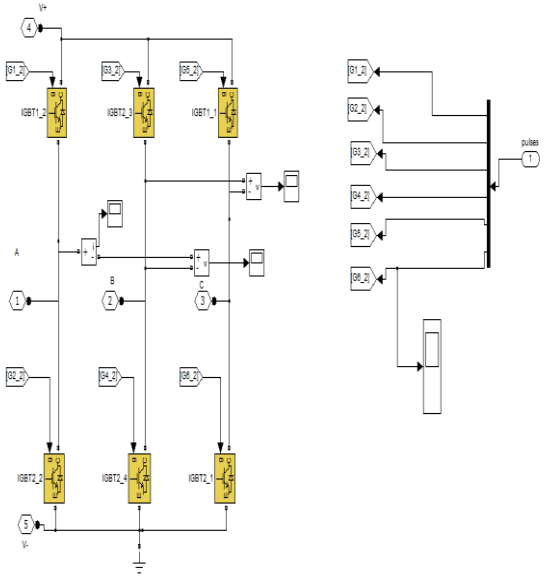

**Fig.6.three phase inverter block**

## IV. RESULTS

In the proposed system, the space vector modulation technique is used to control the three phase inverter. An open loop speed control based on constant V/f ratio technique is tried for a 5.4HP, 400V, 50 Hz asynchronous machine. The rated torque was applied after a delay of 0.5 seconds and the speed was found to be settling from the initial value to the final value, once the mechanical input was applied. The results are as shown below.

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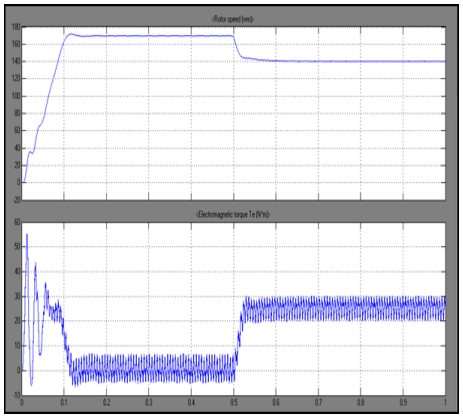

**Fig.7.Speed control and torque**

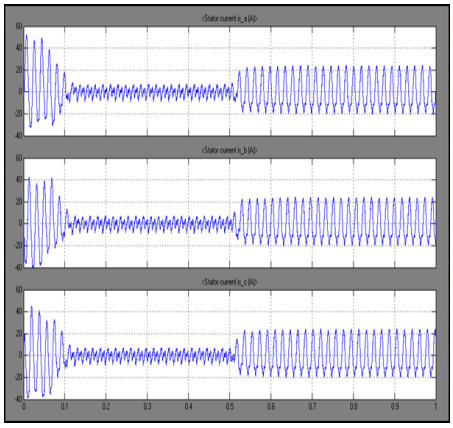

**Fig.8.Stator currents**

## V. CONCLUSION

This paper deals with the open loop V/f control of three phase induction motor using space vector modulation technique. The SVPWM technique, compared to other techniques, offer better harmonic reduction.

## ACKNOWLEDGMENT

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