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Simulation of V/F control of induction motor drive

Tirth N. Patel[1], Saunak K. Bhalsod[2]

[1]*PG student, Electrical Engineering, LDCE, Ahmedabad*
[2]*PG student, Electrical Engineering, Nirma, Ahmedabad*

Abstract* — *This paper presents the basic V/f control of 3 phase induction motor drive with the help of computer simulation. The speed control of induction motor can be achieved by varying the applied voltage magnitude or changing the frequency of the excitation. Out of the various methods of controlling the speed of Induction motors, V/f Control has proven to be the most versatile.The V/f Control Method requires the Pulse Width Modulated Controlled Inverter. The rectifier is also required for the conversion of fixed frequency AC into the DC voltage. In this paper the open loop V/f Simulink Model is developed and analyzed. The uncontrolled transient and steady state response of the Induction Motor has been obtained and analyzed.

Keywords- V/f control,Induction motor drive.

I. INTRODUCTION

Induction Machines, the most widely used motor in industry, have been traditionally used in open-loop control applications, for reasons of cost, size, reliability, ruggedness, simplicity, efficiency, less maintenance, ease of manufacture and its ability to operate in dirty or explosive conditions. However, because the induction machine requires more complex control methods, the dc machine has predominated in high performance applications. With developments in Micro-processors/DSPs, power electronics and control theory, the induction machine can now be used in high performance variable-speed applications.

II. V/F CONTROL

The induction motor speed variation can be easily achieved for a short range by either stator voltage control or rotor resistance control. But both of these schemes result in very low efficiencies at lower speeds. The most efficient scheme for speed control of induction motor is by varying supply frequency. This not only results in scheme with wide speed range but also improves the starting performance.

If the machine is operating at speed below base speed, then v/f ratio is to be kept constant so that flux remains constant. This retains the torque capability of the machine at the same value. But at lower frequencies, the torque capability decrease and this drop-in torque has to be compensated for increasing the applied voltage.

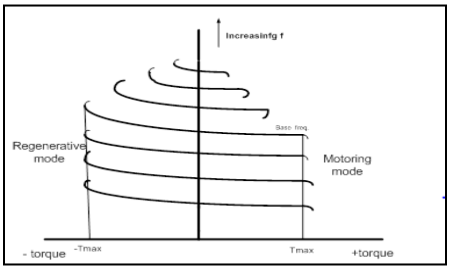

Figure 1.Speed Torque Characteristics of Induction Motor with frequency variation

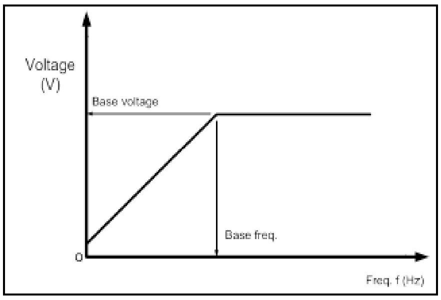

Figure 2. voltage and frequency variation in VSI fed Induction motor

The above curve suggests that the speed control and braking operation are available from nearly zero speed to above synchronous speed.
it is noted that V is kept constant above base speed and freq. is increasing. The variable frequency control provides good running and transient performance because of the following features:

(a) Speed control and braking operation are possible from zero to above base speed.
(b) During transients (starting, braking and speed reversal), the operation can be carried out at the maximum torque with reduced current giving good dynamic response.
(c) Copper losses are reduced; efficiency and power factor are high as the operation is in between synch. speed and max. torque point at all frequencies.
(d) Drop in speed from no load to full load is small.
Fig. 3 shows the block diagram of a V/f control of VSI fed three phase induction motor drive. In this according to the reference speed input command (Nr*) the reference frequency (f*) and reference voltage (V*) commands are calculated such that V/f ratio maintained to be constant. The reference commands V* and f* are given to the SPWM generator to generate 6-PWM pulses to the three-phase voltage source inverter which drives the three-phase induction motor.

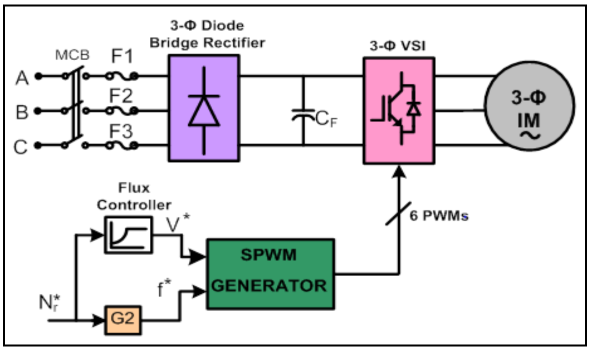

Figure 3. Block Diagram Schematic of V/f control of VSI fed 3-phase Induction Motor drive

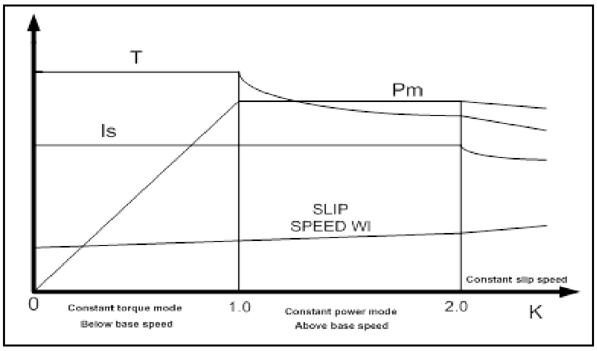

Figure 4. Modes of operation and variation of i_s, ω_{sl},, T and P_m with per unit frequency K

III. SINUSOIDAL-PULSE-WIDTH-MODULATION (SPWM)

In sinusoidal pulse width modulation, there are multiple pulses per half-cycle and the width of each pulse is varied with respect to the sine wave magnitude corresponding to that duration. In this scheme, the switches in the two legs of the full-bridge inverter are not switched simultaneously, as in the bi-polar scheme. In this unipolar scheme the legs R, Y and B of the full-bridge inverter are controlled separately by comparing carrier triangular wave with the three control sinusoidal signals which are displaced by 120 degrees. This SPWM is generally used in industrial applications. The number of pulses per half-cycle depends upon the ratio of the frequency of carrier signal to the modulating sinusoidal signal. The frequency of control signal or the modulating signal sets the inverter output frequency and the peak magnitude of control signal controls the modulation index ma which in turn controls the rms output voltage.

IV. SIMULATION RESULTS

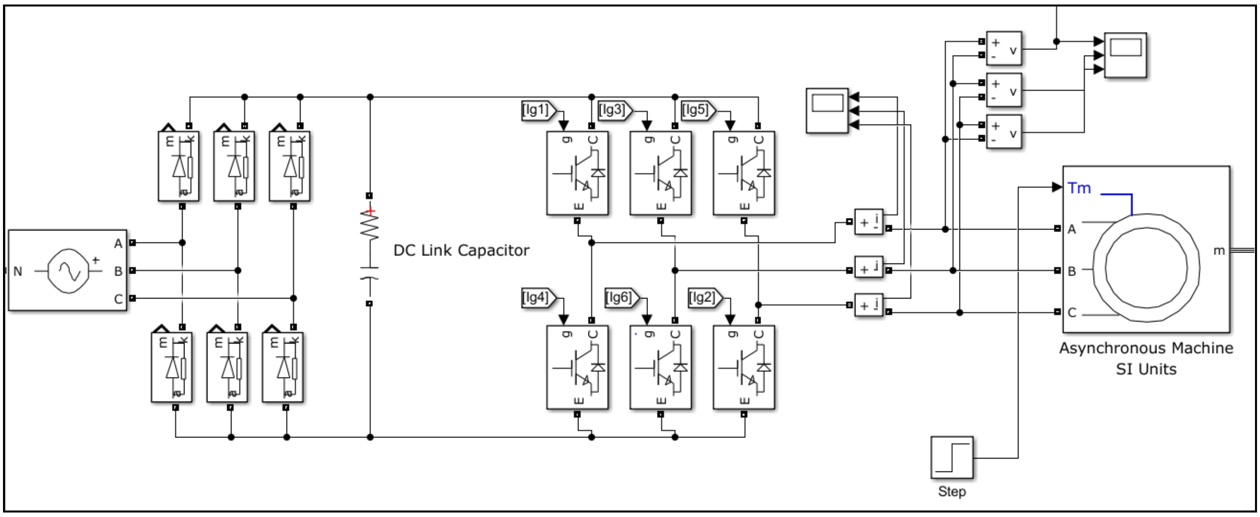

Figure 5. Power Circuit: 3 Phase Rectifier, DC Link Capacitor, 3 Phase PWM Inverter and Asynchronous Machine.

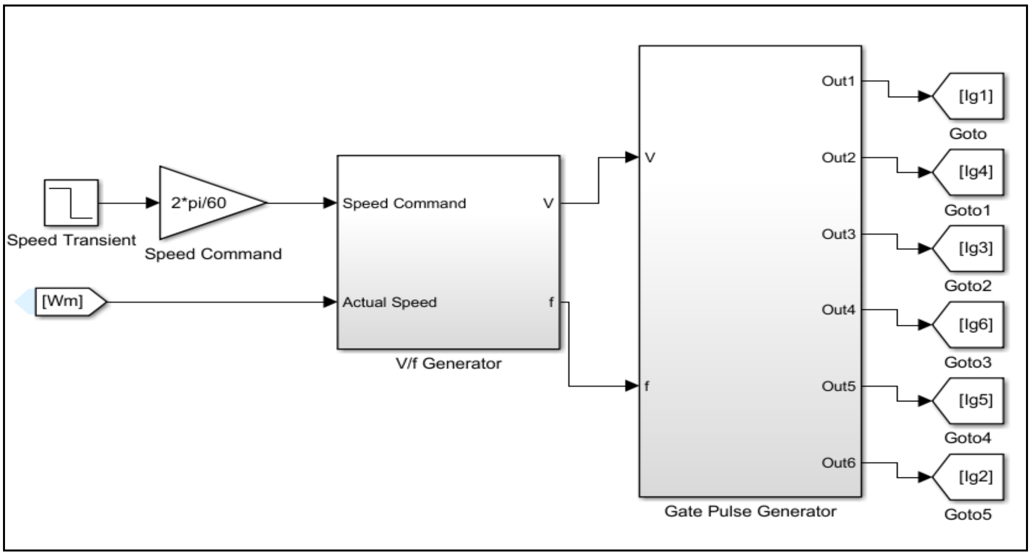

Figure 6. Control Circuit: V/f Generator and Pulse Frequency Modulator

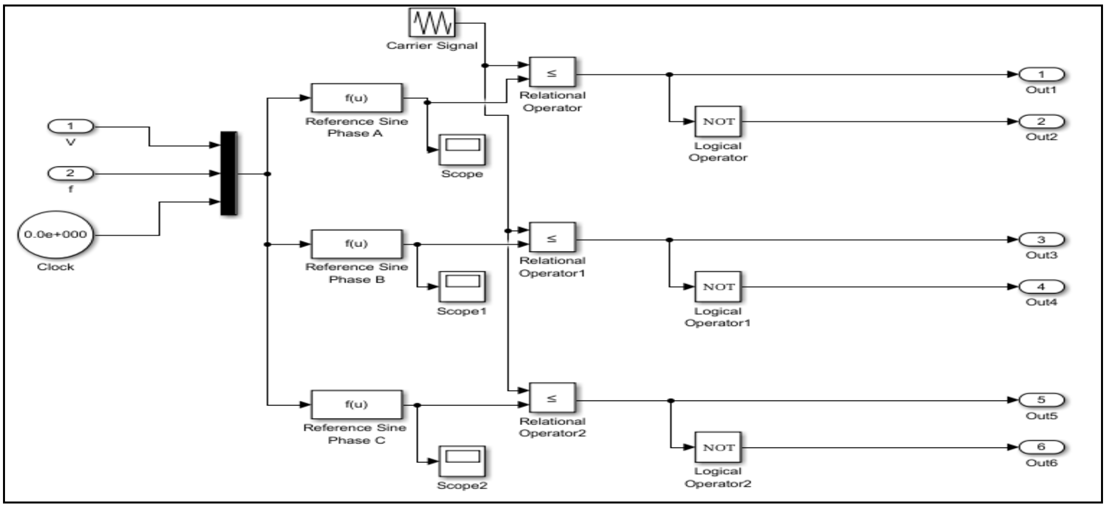

Figure 7. Sine Pulse Width Modulation logic.

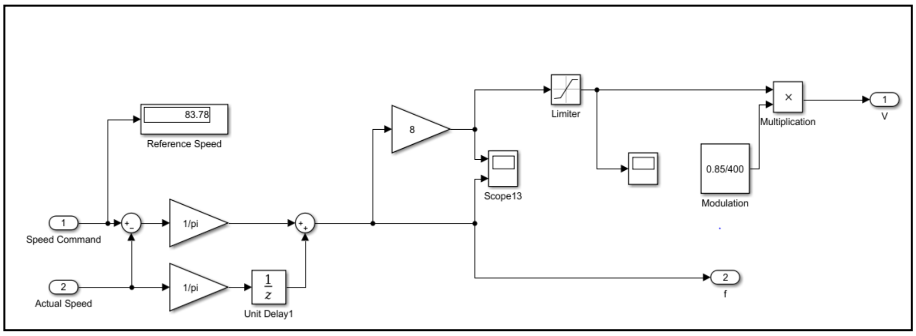

Figure 8 V/f Generator Logic.

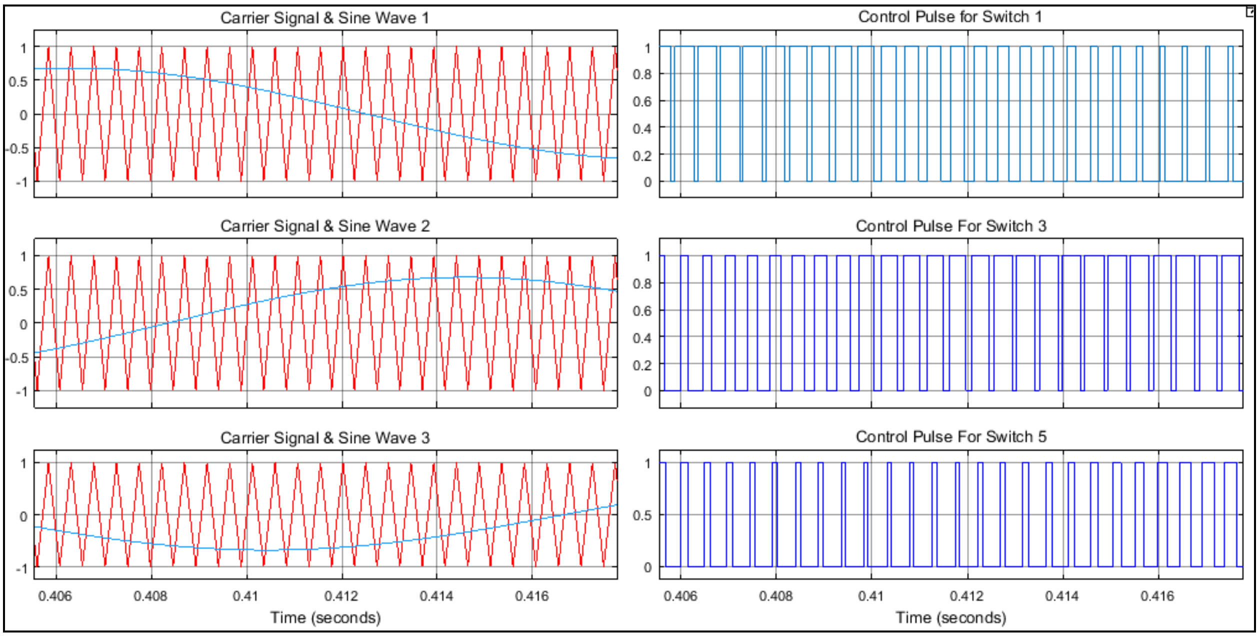

Figure 9: Simulated SPWM Waveforms

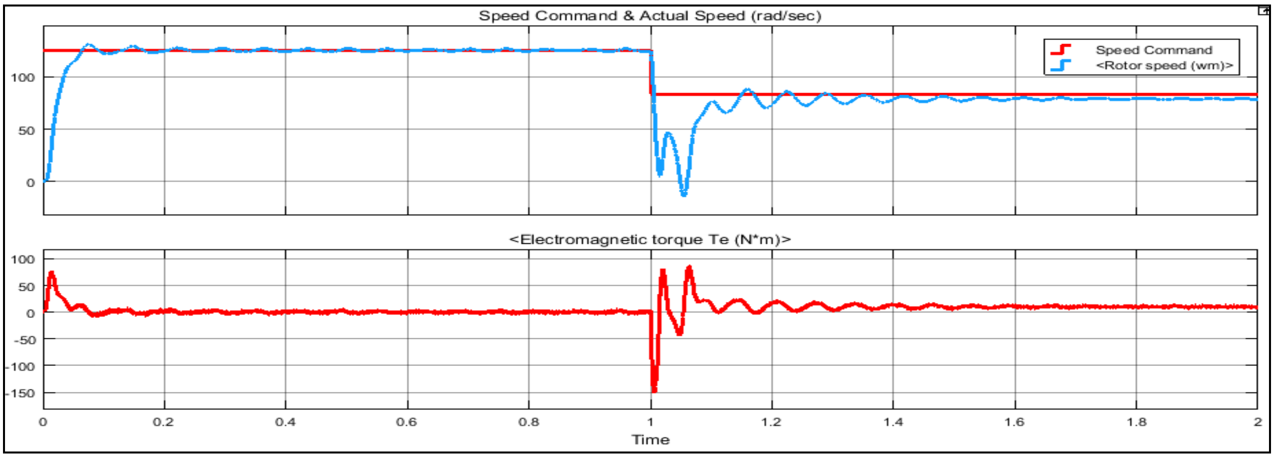

Figure 10. Transient response of the V/f Controlled 3 phase induction motor with speed command variation.

Here the Q1:Q4, Q3:Q6, Q5:Q2 are pair complementary switches. The gate pulse of Q4, Q6 and Q2 are derived from the gate pulse of Q1, Q3 and Q5 by implementing the NOT logic.
The transient behavior and steady state behavior of the V/f fed induction motor drive can be obtained by applying speed command and analyzing the speed and torque waveform of the induction motor.
From the above waveform, it can be seen that the V/f control maintain the speed of the rotor to the command speed.

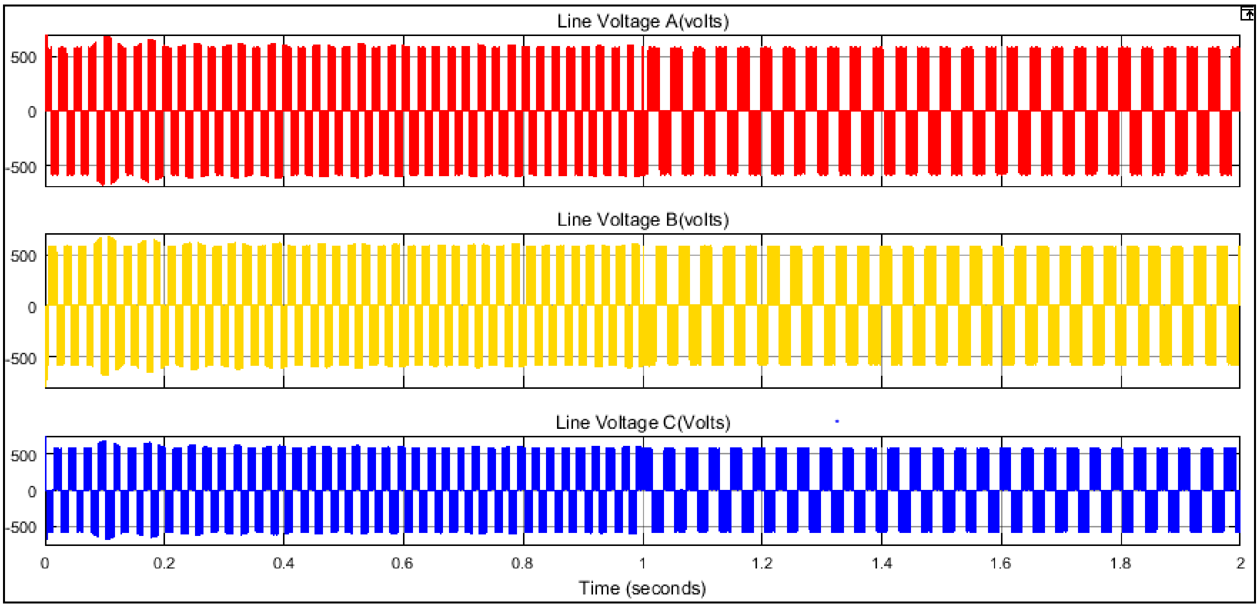

Figure 11. Transient Response of the PWM inverter

From the above waveforms, it can be verified that inorder to maintain the speed of the rotor to the command speed V/f generator change the frequency and voltage.

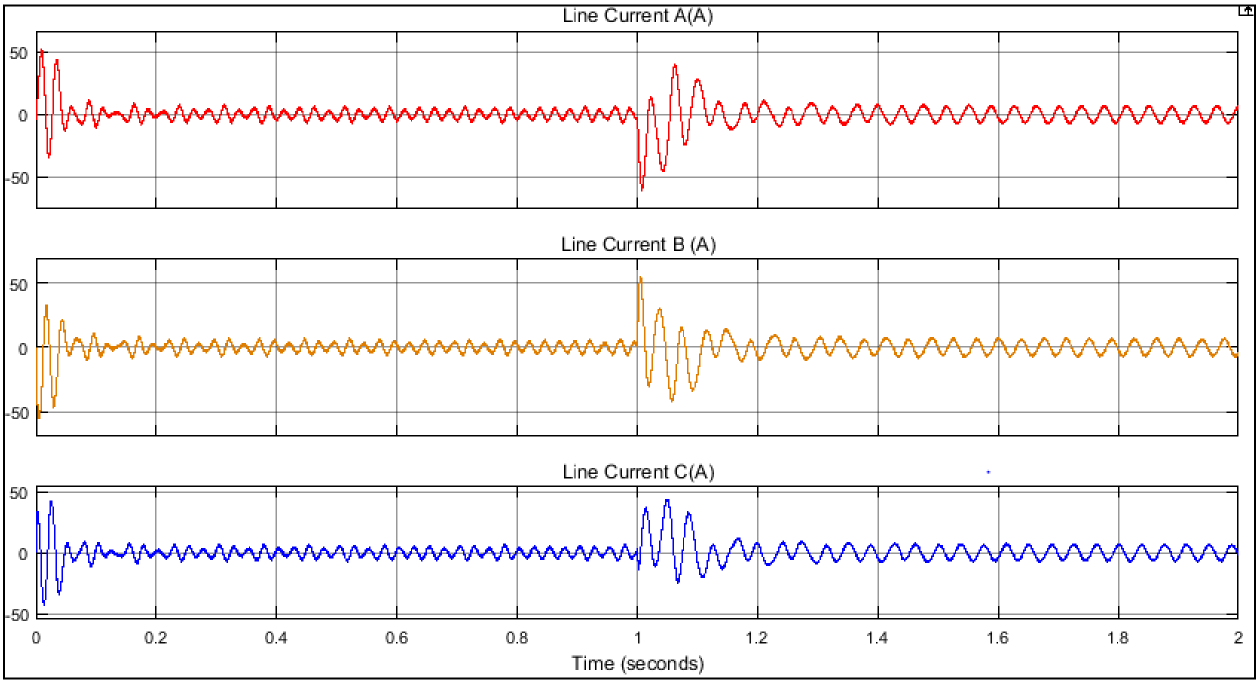

Figure 12. Line Currents waveform

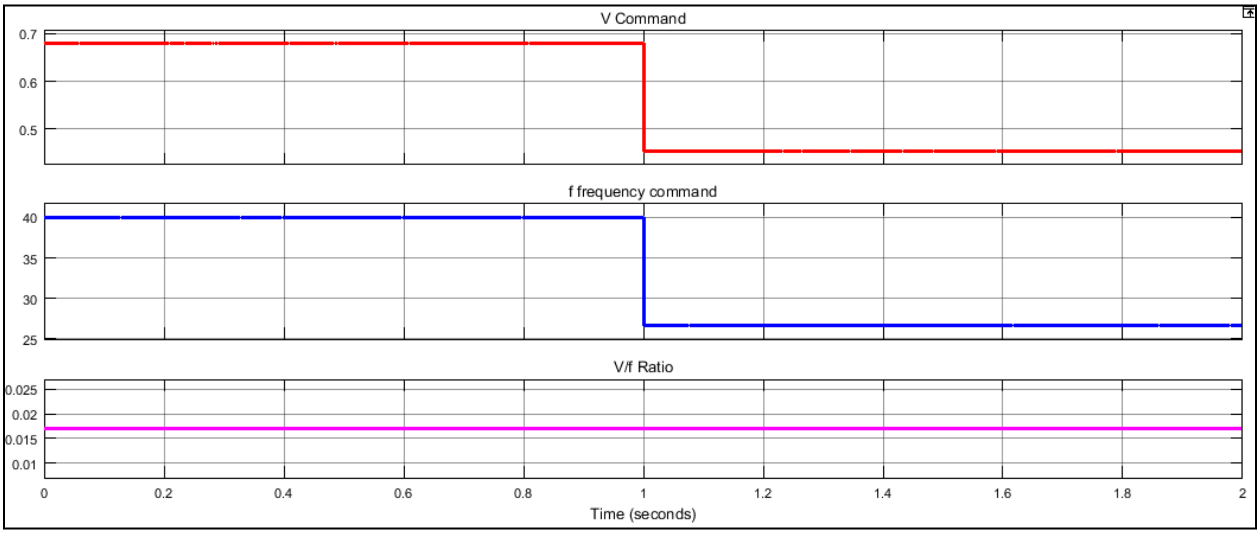

Figure 13. V/f Command Waveform.

VI. CONCLUSION

Open-loop V/f Control was implemented using MATLAB and it was observed that by varying the supply frequency and terminal voltage such that the V/f ratio remains the same, the flux produced by the stator remained constant. As a result, the maximum torque of the motor remained constant across the speed range.

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