ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Frequency Variable Three Phase Inverter Connected to PWM to Control the Induction Motor

[1]Ms.R.Indu Poornima, [2]V Sindu, [3]K.Senthil Kumar

[1,2]Assistant Professor, Dept. of Information and Technology, Karpagam College of Engineering, Coimbatore, India

3PG Scholar, Department of ECE, Karpagam College of Engineering, Coimbatore, India

ABSTRACT: In this paper, the three phase frequency variable inverter is designed in Matlab/Simulink. The overall two level three phase inverter circuit consisting of six IGBTs is controlled using Pulse width modulation (PWM) signal. PWM signal controls the applied voltage on the gate drive of six IGBTs. Each IGBT is maintained at different phase delay to produce three phase pure sine wave. The frequency of inverter is initially set to 50 Hz, the rotor speed, electromagnetic torque and rotor angle of an asynchronous machine is measured. When the rotor speed increases a particular limit (1450 RPM), the inverter frequency is automatically reduced to 30Hz by the use of feedback.

KEYWORDS – Frequency Variable Inverter, IGBT, Pulse Width Modulation, Electromagnetic Torque, Rotor Speed, Power, Phase delay, Frequency, Gain.

I. INTRODUCTION

Frequency variable inverter is widely used in three phase induction motor drive traction and especially in many high power industrial applications, such as speed and torque control. Various researches on the control of the variable frequency inverter are in progress as low-cost, high-performance, and the development was made in several areas, such as: microelectronics, SOPC [1], allowing the use of software instead of hardware to solve complex control problems, which control the inverter output and reduce the harmonic. Another application is in the aerospace and airline industries. Often airplanes use 400 Hz power, so 50/60 Hz to 400 Hz frequency converter is needed for use in the ground power unit to power the airplane while it is on;, the ground. Frequency variable inverter is also used in super heterodyne receiver that converts the radio frequency signals from one frequency to other frequency.

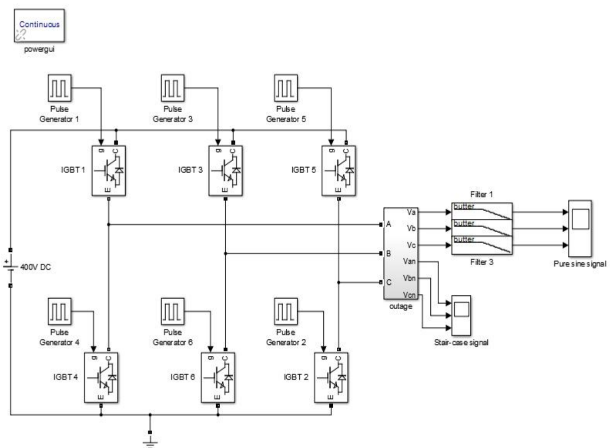

Fig.1. Three phase inverter using IGBT.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

With the increasing demands for high-quality power sources, and harmonic distortion, a PWM inverter has been used as a key element for a high-performance power conversion system for critical loads such as computers, medical equipment and communication systems [2].At the same time, in the power system, the inverters are mainly applied in the power controllers, which are used in flexible ac transmission systems [3].

Recently, microcontrollers and digital signal processors (DSP) are used as advanced control techniques. Researchers developed the software for the control system, the high quality of the control based on microcontroller techniques is confirmed [4] and to provide additional real time processing throughput in an inverter operation, microcontrollers and features of DSP minimize the CPU's overhead in an interrupt intensive application [5]. The variable speed operation of a single phase induction motor suffers from large harmonic and limited speed, therefore the system using voltage control method with semiconductor power device IGBT.

Pulse generator	Time(sec)	Pulse width (% of time)	Phase delay
1	0.02	50	0
2	0.02	50	0.0033
3	0.02	50	0.0066
4	0.02	50	0.01
5	0.02	50	0.013
6	0.02	50	0.016

Table 1. Phase delay for IGBT's at 50Hz frequencies.

PWM techniques have been implemented to avoid large harmonics. The inverter circuit is simulated using Matlab/Simulink. The main circuit is shown in Fig.1. Pulse generator produces high (1) and low (0) pulse which is connected to gate of IGBT makes the transistor ON and OFF respectively. To obtain a pure sine wave as shown in Fig.3, the connected six pulse generator pass each IGBT should have phase delay as shown in Table.1.

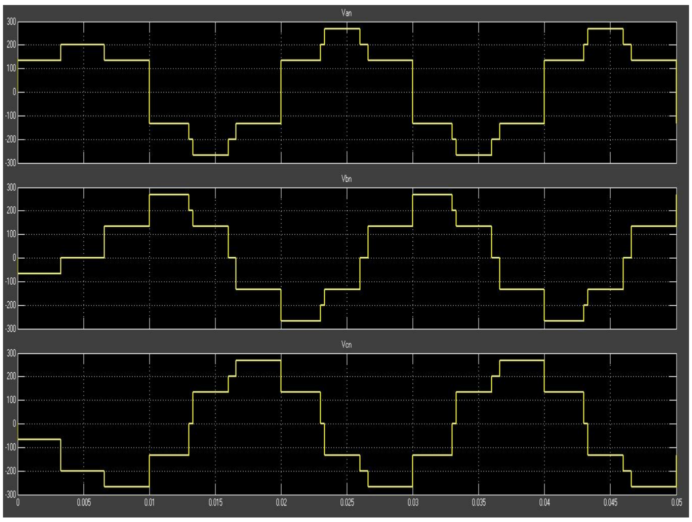

Fig.2. Stair case signal from inverter.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

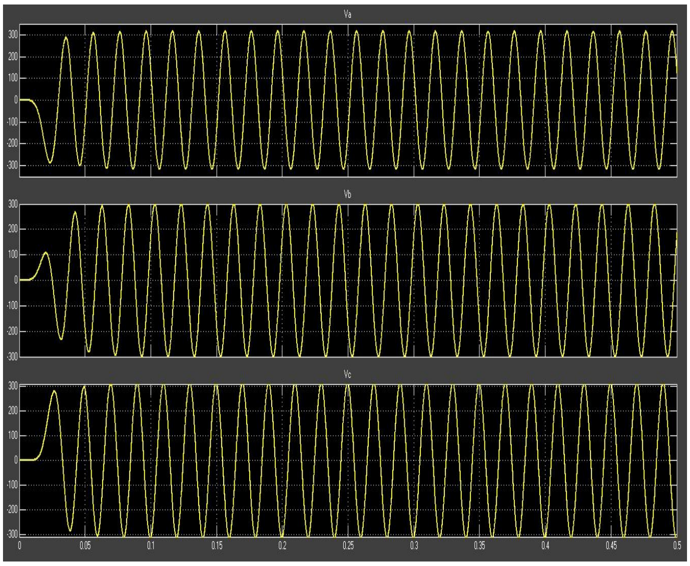

Fig.3. Pure three phase sine wave obtained from filter.

The inverter converts the 400V DC to 300V AC of 50Hz by using IGBT. The butterworth filter is used for producing pure sine wave from the stair-case signal shown in Fig.3, obtained from the inverter.

II. SIMULINK MODEL OF THREE PHASE FREQUENCY VARIABLE INVERTER

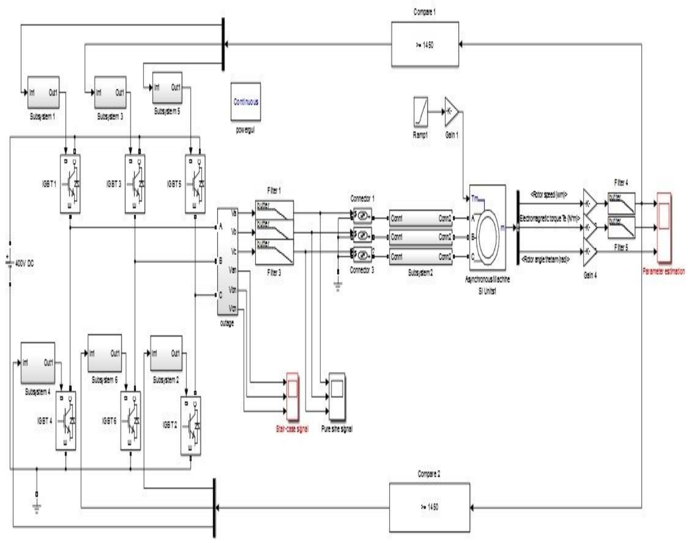

Fig.4. Three phase frequency variable inverter.

The switching states of the three phase inverter are the main cause to produce pure three phase sine wave [6]. Six IGBT connected to individual PWM with each having different phase delay which is responsible for proper switching.

The phase delay applied for each IGBT is shown in Table.1. Phase delay differs for each IGBT at different frequency.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

The asynchronous machine connected to the three phase frequency variable inverter is shown in Fig. 4. From the machine the electromagnetic torque, rotor speed [7] and rotor angle is estimated for 50Hz frequency. From the Table.2 it is clear that the rotor speed is directly proportional to the frequency.

Speed = (120*Frequency)/P (1)

Where P is number of motor winding poles. Speed is calculated in revolution per minute (RPM). Electromagnetic torque is inversely proportional to the frequency.
Torque = (5252*HP)/RPM (2)

Where HP is the horse-power and 5252 is constant. Rotor speed (n_r) can also be calculated from synchronous speed (n_s) and slip (s).

$n_r = (1\text{-}s)*n_s$ (3)

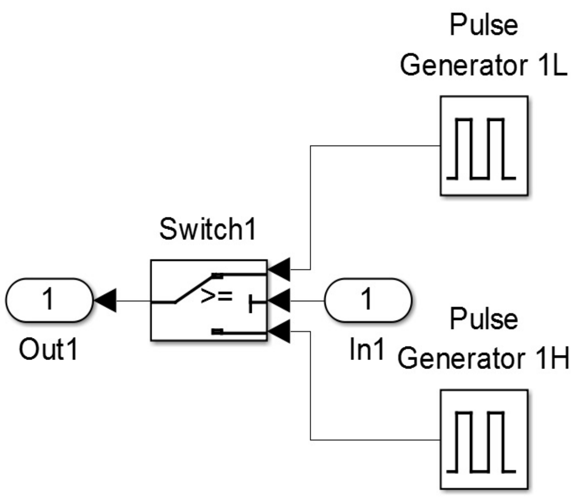

Fig.5. 50Hz – 30 Hz frequency conversions.

The output (rotor speed) of the machine is given to the input of the IGBT gate. When the rotor speed increases a particular limit (1450 rpm) the frequency of the inverter is reduced by means of feedback. The inverter frequency is varied from 50Hz to 30Hz. The output from the inverter is stair-case signal shown in Fig.2. But the asynchronous machine requires pure sine wave to be driven.

So the stair-case signal needed to be converted to pure sine wave shown in Fig.3, which is made possible by the use of Analog filter (Butterworth).

III. SIMULATION RESULTS

The rotor speed is directly proportional to the frequency. So when the rotor speed is increased beyond the limit, then the frequency is automatically varied. In this model the initial frequency is 50Hz and based on rotor speed limit the frequency is varied to 30Hz. The Frequency variable sub-block shown in Fig.5 is given as input to the gate of the IGBT. Generator 1H produces 50Hz frequency initially, when the rotor speed increases beyond 1450 rpm the generator 1L (30Hz) is switched to the IGBT.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Three phase inverter		Electro-magnetic torque (N*m)	Rotor speed (rpm)	Rotor angle (rad)
Volt (V)	Freq (Hz)			
400	30	1954.75	847.5	6862.56
400	50	885.71	1498.88	6326.73

Table.2. Asynchronous machine parameter estimation for 50Hz and 30Hz frequencies.

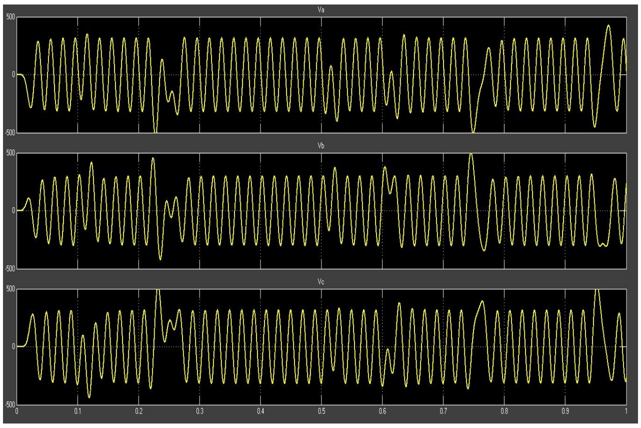

Fig.6. 50Hz – 30Hz varying pure sine wave.

The pure sine wave frequency variation of 50Hz and 30Hz is shown in Fig.6. When the speed of motor increases beyond 1450 rpm. The sine wave changes from 50Hz to 30Hz. From equation (1) it is clear that the speed is directly proportional to the frequency applied to asynchronous machine. The frequency variable inverter output of 50Hz/30Hz is applied to the asynchronous machine and the parameter is measured. It is shown in Fig.7.

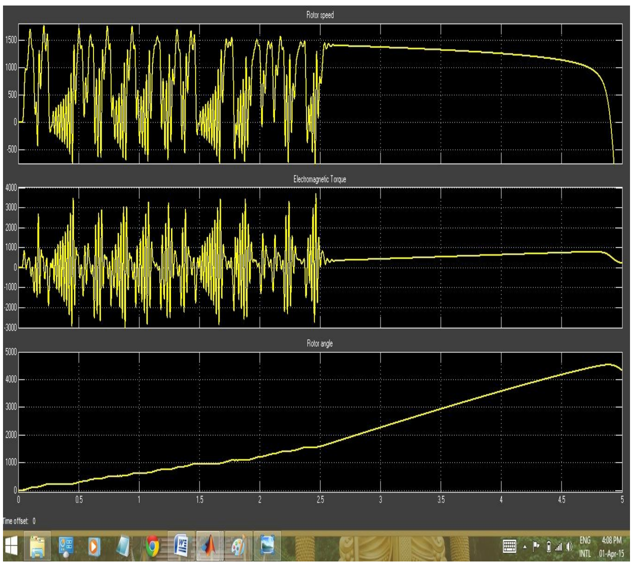

Fig.7. 50Hz – 30Hz varying asynchronous machine parameter estimation.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

IV. CONCLUSION AND FUTURE WORK

In this paper, the asynchronous machine is controlled using PWM which is effectively useful in the estimation of different parameters. All the output is measured for constant voltage of 400V and varying frequencies of 50Hz and 30Hz. The relationship between electromagnetic torque (N*m), rotor speed (rpm) and rotor angle (rad) are tabulated in Table. 2.

This project can be further improved with less harmonic distortion by using Sinusoidal Pulse Width Modulation (SPWM) [9]. The feedback loop from the asynchronous motor can also be used to measure the rapid changes in machine parameter, then based on its change the frequency can be automatically varied using fuzzy logic [10].

REFERENCES

[1] He-Jin Liu, Ke-Jun Li, Member, IEEE, Wei-Jen Lee, Fellow, IEEE, Hongxia Gao, and Ying Sun " Development of Frequency Variable Inverter Based on SOPC and Nios II ", IEEE Transactions on Industry Applications, Vol. 49, No. 5, September/October 2013.

[2] S. K. Chung, H. B. Shin and H. W. Lee, " Precision Control of Single-Phase PWM Inverter Using PLL Compensation ", in Proceedings of the 2005 Electric Power Applications, IEE, Vol. 152, pp. 429 - 436.

[3] M. Mohseni and S. M. Islam, " A New Vector-Based Hysteresis Current Control Scheme For Three-Phase PWM Voltage-Source Inverters ", IEEE Trans. Power Electron., Vol. 25, no. 9, pp. 2299–2309, Sep. 2010.

[4] W. Bacharowski, " Microcontrollers in Variable Frequency Inverters ", WESCON95, Maintain View, CA, Conference Record, Microelectronics Communications Technology Producing Quality Products Mobile and Portable Power Emerging Technologies, 1995, pp. 13-15.

[5] A. S. Ba-thunya, R.Khopkar, K. Wei and H. A. Toliyat, " Single Phase Induction Motor Drives–A Literature Survey ", Electric Machines and Drives Conference. IEMDC 2001, College Statias, Texas, IEEE International 2001, pp. 911 – 916.

[6] M. Mohseni and S. M. Islam, " A New Vector-Based Hysteresis Current Control Scheme For Three-Phase PWM Voltage-Source Inverters ", IEEE Trans. Power Electron., vol. 25, no. 9, pp. 2299–2309, Sep. 2010.

[7] Pedro Nuno da Costa Neves and Joao L.Afonso, " Development of a Variable Frequency Power Electronics Inverter to Control the Speed of a Three-Phase Induction Motor ", HSCI'2006 – 3rd International Conference on Hands-on Science – Science Education and Sustainable Development.

[8] Fernando Botterón and Humberto Pinheiro, " A Three-Phase UPS That Complies With the Standard IEC 62040-3 ", IEEE Transactions On Industrial Electronics, VOL. 54, NO. 4, AUGUST 2007.

[9] Despande, V.; Chaudhari, J.G.; Jagtap, P.P., "Development and Simulation of SPWM and SVPWM Control Induction Motor Drive", ICETET'2009 – 2nd International Conference on Emerging Trends in Engineering and Technology.

[10] Abdalla, T.Y. ; Dept. of Comput. Eng., Univ. of Basrah, Basrah, Iraq ; Hairik, H.A. ; Dakhil, A.M., " Direct Torque Control System for a Three-phase Induction Motor with Fuzzy Logic based Speed Controller ", EPC-IQ'2010 – 1st International Conference on Energy, Power and Control.