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**Submission date:** 21-Oct-2022 12:24PM (UTC+0700)

**Submission ID:** 1931293161

**File name:** I\_Ketut\_Wiryajati\_IJEEET\_Speed\_drive\_strategy\_for\_CBPWM.pdf (991.33K)

**Word count:** 1874

**Character count:** 9364

# Speed Control Strategy for Three Phase Induction Machine Fed Inverter Base on Carrier Base Pulse Width Modulation (CBPWM).

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**Abstract**— An induction motors in many industries is used because it has several advantages, such as a very simple and strong construction, the price is relatively cheap, has good efficiency, power factor is quite good, and maintenance is easier. Besides the advantages of induction motors also have disadvantages, one disadvantage of induction motors is not being able to maintain a constant speed when there is a change in load. If the load changes, the speed of the induction motor will decrease. One method of regulating the speed of an induction motor presented in this study is the regulation of an induction motor using an Carrier Base PWM based inverter with the Field Oriented Control technique. The estimation of rotor rotation, torque and flux is done by Carrier Base PWM technique which is given input voltage and stator current. To achieve the desired flux and torque, estimation is used as feedback in the control system. In this study, it will be simulated the induction motor speed regulation with a carrier base-based inverter using Matlab.

The results obtained through simulation show the length of time to reach the reference speed for speeds of 1500 rpm and 1450 rpm is around 0.45 seconds. And THD average 2,675%.

Keywords: *Induction Motor, Carrier base PWM, Mat lab.*

## I. INTRODUCTION

The Field Oriented Control (FOC) technique on an induction motor is a separation between field and torque technique that was first published in 1971 by F. Blaschke. The basic concept of this separation is to use a vector control model so that it can also be called a vector control. Since this invention the speed control strategy of the induction motor is very good, so too the development of the performance and reliability of the induction motor is getting better.

In recent industrial development, induction motor is broadly used for variable speed control system, which needs a precise and quick torque response [1]. An enhancement of the drive performance can be obtained using a field oriented control algorithm based on the application of the carrier base PWM modulation. The performance of the output voltage of inverter that fed induction motor system is mostly determined by pulse width modulation (PWM) strategy. The plain implementation is use current control based on hysteresis current controller.[3] With this method, fast response current loop will be attained and information of load parameter is not required. However, this method can cause variable switching frequency of inverter and produce undesirable harmonic generation. Another method of PWM that have become popular and obtained big interest by researcher is Carrier base Pulse Width Modulation (CBPWM). This technique have better DC bus exploitation and easy for digital implementation [2].

## II. RESEARCH STUDY

Field Oriented Control : The Field Orientated Control (FOC) consists of controlling the stator currents represented by a vector. This control is based on protrusions which transform a three phase time and speed dependent system into a two coordinate (d and q co-ordinates) time invariant system. These protrusions lead to a structure similar to that of a DC machine control. Field oriented controlled machines require two constants as input references: the torque component (aligned with the q co-ordinate) and the flux component (aligned with d co-ordinate). As Field Orientated Control is merely based on projections the control structure holds instantaneous electrical quantities. This makes the control accurate in every working operation (steady state and transient) and independent of the limited

bandwidth mathematical model. In order to estimate the rotor flux vector is possible to utilize FOC.[3-5]

Mathematical modeling is required for simulation and analysis of drive system. IM equations are presented in d-q reference frame.

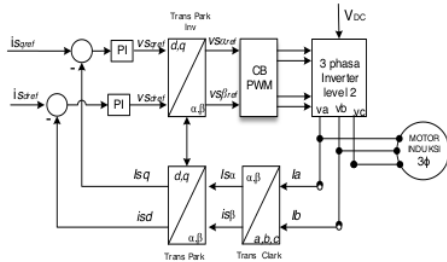


Figure 1. Basic concept of Field oriented control

In Figure 1 explains the concept of an induction motor model by starting with the transformation process from abc to dq with park transform, then the results of the transformation are entered as a reference signal on the inverter, in this case using the CBPWM concept, the output current signal from the inverter is processed again with the back transformation. Transformation of park is dq to abc then made feedback with the addition of a PI controller (Proportional integrator) even using Fuzzy Logic Control to get better output [6].

### III. RESEARCH METHOD

In this study the FOC method is used by using a inverter to induction motor, an inverter with a carrier base based CBPWM modulation scheme is used using matlab and simulink. The principle of the CBPWM method is the generation of pulses obtained by comparing reference sinusoidal waves (Vref) with triangular waves or high frequency sawtooth waves. A triangle wave or a sawtooth is also called a carrier wave (Vc). The pulse generation from the CBPWM method is similar to the Sinus PMW or SPWM by using very simple logic as governed by equation (3-1). Equation (3-1) means that if the reference sine wave (Vref) is greater than the carrier wave (Vc) then the pulse is one (high) and vice versa if the sine wave (Vref) is smaller than the carrier wave (Vc) then the pulse is zero (low). It is called CBPWM because the dominant carrier wave becomes a modulation wave because the fundamental wave is summed with all the harmonic waves produced. Carrier waves usually have a frequency of at least 20 times faster than sine wave frequencies so that they can shift the harmonics low enough far from the fundamental components of the inverter output voltage. This is needed to improve the control quality of the three-phase[7, 8].

$$V_{ref} > V_c \quad M_x = 1 \text{ (high)} \quad \dots\dots\dots(3.1)$$

$$V_{ref} < V_c \quad M_x = 0 \text{ (low)}$$

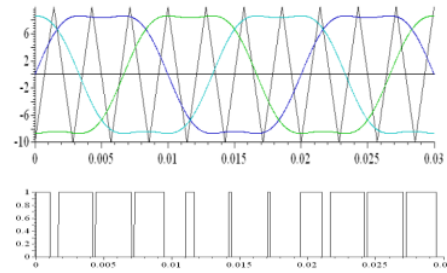


Figure 2. Sinyal triger pada phase A dari CBPWM

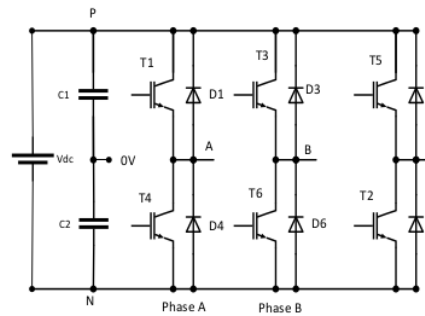


Figure 3 Topologi Inverter With CB PWM

### IV. SIMULATION , RESULT AND DISCUSSION

This section describes the experimental results with the method of Carrier base Pulse width modulation method and Field oriented control method.

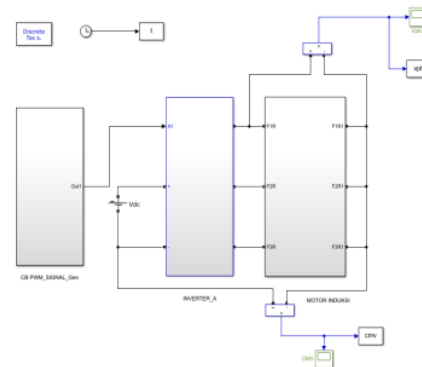


Figure 4 Model control strategy for induction Motor with CB PWM

Figure 4 illustrates the scheme consisting of three main schemes, namely the engineering module with CBPWM as the modulation signal, the inverter module with six switches /power electronic as a three-phase inverter, and the induction motor module that has been modeled with the FOC technique. This scheme becomes one unit to carry out control techniques on induction motors with a rating like in table 1 and table 2 to show parameter of switch power electronic.

Tabel 1 Parameter of induction machine

No	Parameter	Value
1	Rs (Stator resistor)	10 Ohm
2	Rr (Rotor resistor)	6.3 Ohm
3	Lls ( Stator inductance )	0.004 Henry
4	Llr ( Rotor inductance )	0.004 Henry
5	Lm ( Stator reactance )	0.42 Henry
6	J ( Moment inertia )	0.01 N-m
7	P ( number of pole in pair )	2 pai
7	V ( voltage rate )	220 vphase
8	f ( frequency )	50 hz
9	P ( power )	5 hp
10	I ( Current )	1.2 A
11	Rpm	1500 rpm

Tabel 2 Parameter of Power electronic switch

No	Parameter	Value
1	IgbtRon	0.001
2	IgbtInductance	0
3	IgbtVf	1.2
4	IgbtTf	1e-6
5	IgbtTt	2e-6
6	IgbtRs	inf
7	DiodeRon	0.01
7	DiodeLon	0
8	DiodeVf	1.2V
9	DiodeRs	500e6
10	DiodeCs	250e-9

The basic concept of CBPWM modulation is as illustrated in Figure 5. The reference signal which is adjusted to the gain compared to the carrier signal which is 20 times the reference signal will be made for three switches and the three switches below are the complement. This signal will used to refrigerate the switch so that the inverter can work to flow current to the load

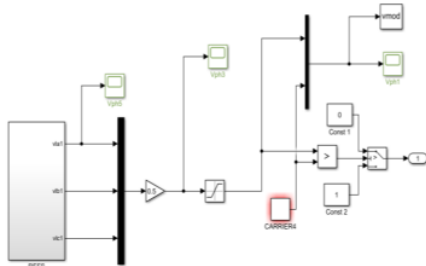


Figure 5 CB PWM

Carrier Base can be created by adding a zero sequence calculator in schema CBPWM which has the function of adding all harmonics components with fundamental signals. So we get the modulation signal as shown in Figure 6 and figure 7 illustrate how to get signal reference with three phase voltage sources.

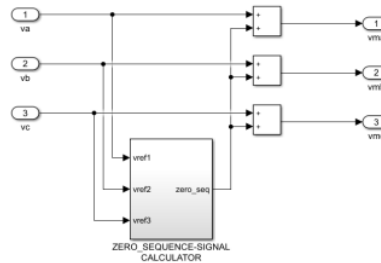


Figure 6 Carrier Base model

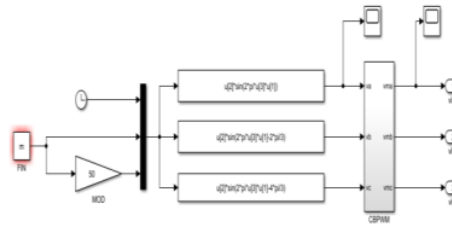


Figure 7 Signal referency

The experimental results, in Figure 8, show that the current, voltage with simetrical componen with TDH as below.

Phase "a" Load Current CBPWM single Supply Schemes. = 47.5Hz (M= 0.95)

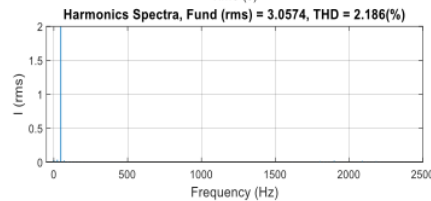
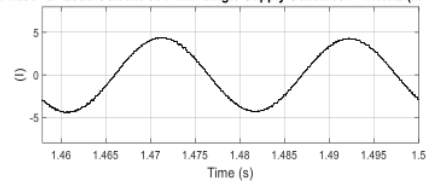


Figure 8 Load current CBPWM

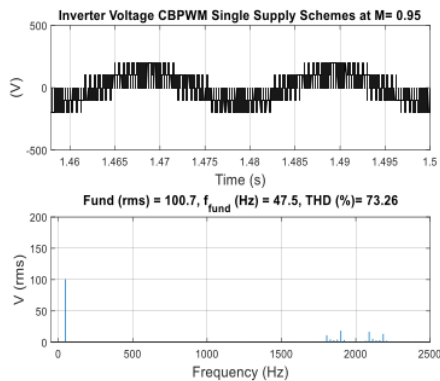


Figure 9 Voltage inverter CBPWM

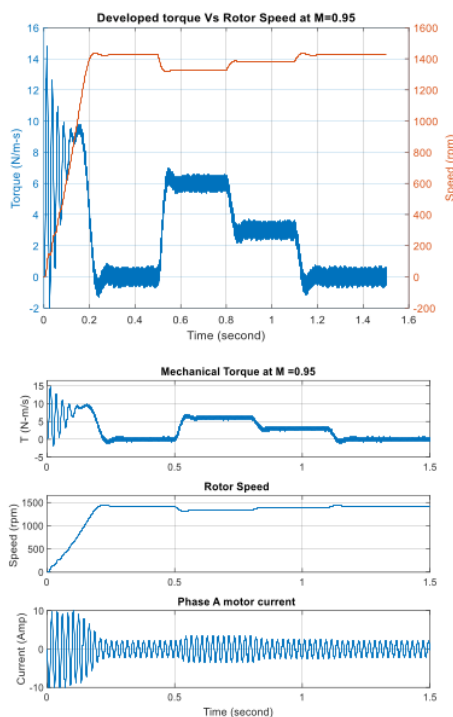


Figure 10 Torque and Speed induction Motor with CBPWM

The results of this technique can be seen in Figure 8 showing the symmetry waveforms in phase a phase current on the induction motor and THD of 2.86% at the modulation index of 0.95, while the resulting voltage form is symmetry like in figure 9. In Figure 10 shows the performance of an induction motor with a speed of 1450 rpm with the highest torque at 15 and the load given to the motor is worth 5 N at 0.45 seconds.

## V. CONCLUSION

Performance of Inverter Three phase using CBPWM with induction motor in this study obtain an average Total Harmonic Distortion (THD) and indeks modulation (M) from 0.1 to 1.15 and the average value of THD is 2.67%. the method of Carrier Base Pulse width modulation with induction motor can be used to improve thd and performance of induction motor.

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