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Single-phase Induction motor Drive CircuitBased on SPWM and SVPWM Techniques

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***Abstract*— Single phase induction motor drive circuit based on sinusoidal and space vector pulse width modulation inverter is presented in this paper. The control system is analyzed theoretically and built depending on MATLAB/SIMULINK. The simulation results illustrated that the speed response of the induction motor for both control types are almost same. But for power quality improvement, space vector type gives THD lessthan sinusoidal type. The control system is built based on V/F control method. The system is tested under different speed and load torque conditions. The overall results are good.**

***Keywords*— single phase H-bridge inverter, single phase induction motor, sinusoidal pulse width modulation (SPWM), space vector pulse width modulation (SVPWM), V/F control.**

I. INTRODUCTION

Developments in electrical power systems lead to converter a large amount of energy into mechanical energy depending on motors especially in industrial applications. Single phase induction motors are one of these machines which widely used in applications need speed adjustment [1]. The speed control of induction motors is done by varying input AC voltages and/or frequencies of induction motor using sinusoidal (SPWM) and space vector pulse width modulation (SVPWM) techniques with inverter circuits.

In 2011 [2], single phase induction motor (SPIM) was controlled using SVPWM inverter. The system is investigated theoretically and modeled by MATLAB program to study the transient performance of Smith SPIM. The speed is controlled based on constant V/f control.

Usually SVPWM technique is used in three phase power inverter circuits. In this paper, single-phase SVPWM and SPWM bridge inverter is used to drive SPIM to study the transient and steady-state performance.

II. DRIVE SYSTEM

The AC drive circuit shown in Fig.1 consists of single-phase H-bridge inverter as illustrated in Fig.2, SPIM, and control system. The SPIM based on capacitor start-run type is selected; this type of motors gives high starting torque and stability in running and good performance more than the other types. The closed-loop control system is designed using fuzzy-PI controller based on SPWM and SVPWM techniques. The fuzzy logic controller is trained to select the desired frequency and PI is designed to select and tune the desired voltage in order to get V/f constant during speed and load torque changing at steady-state and transient conditions.

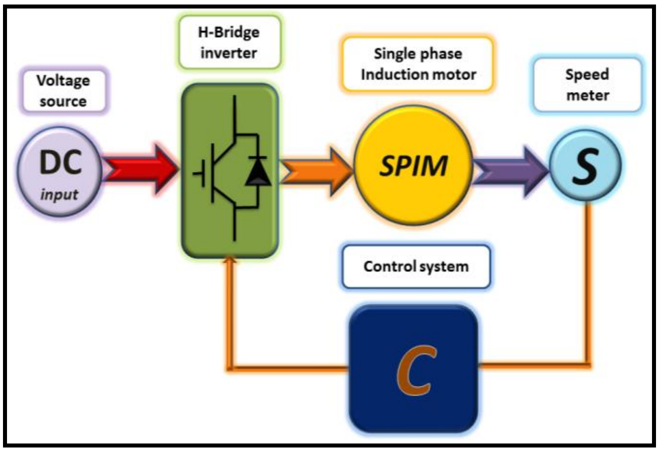

Fig.1 main parts of the drive system

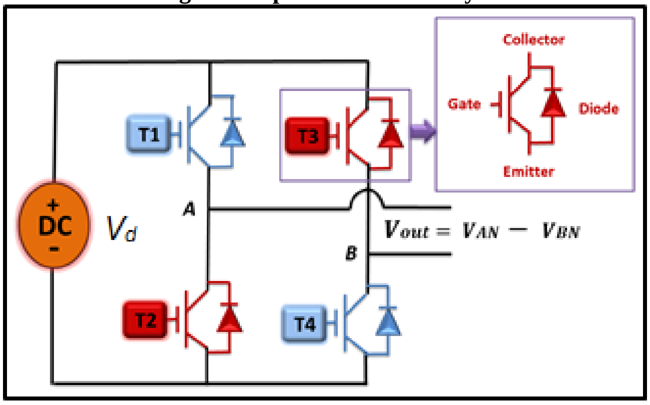

Fig.2 single-phase H-bridge inverter

III. MATHEMATICAL REPRESENTATION

In this paper, two PWM techniques are used to control power switches of the H-bridge inverter. The output voltage of the unipolar SPWM is given as:

$$m_i = \frac{V_{control}}{V_{carreir}} \quad (1)$$

$$V_{out} = m_i * V_d \quad (2)$$

The switching operation conditions of the inverter IGBTs are illustrated in Table (1).The SVPWM technique consists of four sectors. The output voltage of each sector depending on IGBTs switching states is indicatedas v0, v1, v2 and v3 as illustrated in Table (2). The voltage vector (Vout) consists of two null (v0and v3) and two active (v1 andv2) space voltage vectors as illustrated in Fig.3 [3].

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Table (1) switching state conditions of SPWM

T_1	T_2	T_3	T_4	V_{out}
1	0	1	0	0
1	0	0	1	V_d
0	1	1	0	$-V_d$
0	1	0	1	0

Table (2) switching state patterns and corresponding output voltage vectors

T_1	T_2	T_3	T_4	V_{out}	Vectors
1	0	1	0	0	v_0
0	1	1	0	$-V_d$	v_1
1	0	0	1	V_d	v_2
0	1	0	1	0	v_3

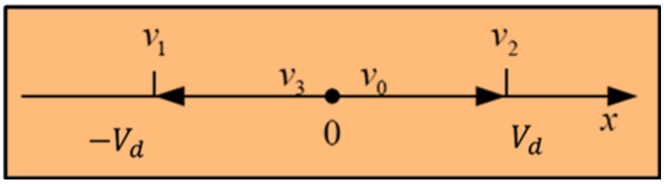

Fig.3 space-vector of the single-phase inverter output voltage

To get sinusoidal output inverter voltage, suppose:

$$V_{out}=V_m \sin(wt) \quad (3)$$

and

$$M = \frac{V_m}{V_d} \leq 1 \quad (4)$$

Where *M* is the modulation index ratio.

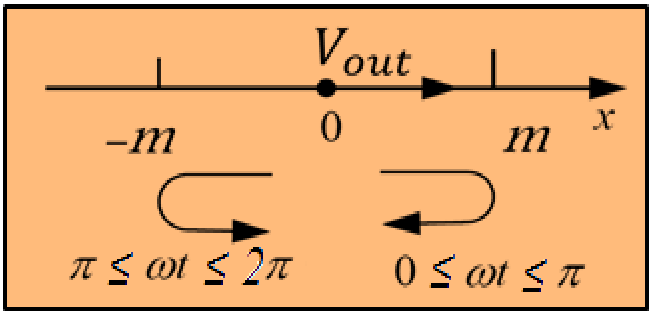

Fig. 4 space vector of sinusoidal inverter voltage

The vector v_2 is active within ($0 \leq wt \leq \pi$) and the inverter output voltage is (V_d). While vector v_1 is active within period ($\pi \leq wt \leq 2\pi$). Theactive and null vectors timesare obtained as [3]:

$$T_v = \frac{V_{out}}{V_{dc}} T_c \quad (5)$$

$$T_0 = T_c - T_v \quad (6)$$

Where T_v and T_0 are ON-time of active and null vectors, and T_c is carrier cycle time. The time of null vectors is ($T_0/2$).The single phase induction motorcapacitor start-run type as shown in Fig.(5) is used. This type of motor employed two capacitors, capacitor start and capacitor run. These capacitorsare used to start uptorque of the SPIM. Capacitor start is switched out at approximately 75% of full load speed. While capacitor runis left in circuit during motor running. Usually capacitor start value is larger than capacitor run [4].

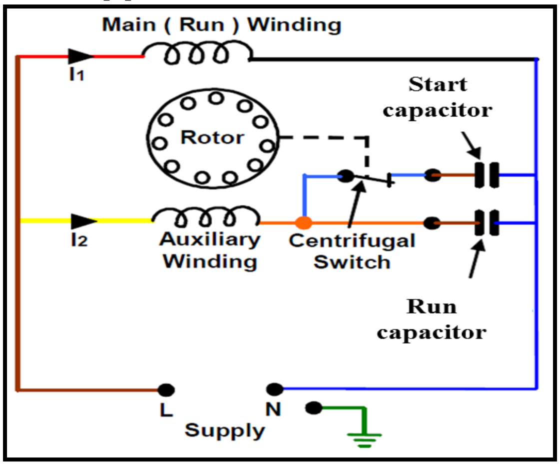

Fig.5 single phase induction motor diagram

IV. SIMULATION RESULTS OF THE DRIVE SYSTEM

The drive system is modeled by Matlab/Simulink as illustrated in Fig. (6). The SPIM capacitor start-run type with 0.5HP and 1500rpm is used. The SPWM and SVPWM is built and modeled as illustrated in Fig.(7) and Fig.(8)

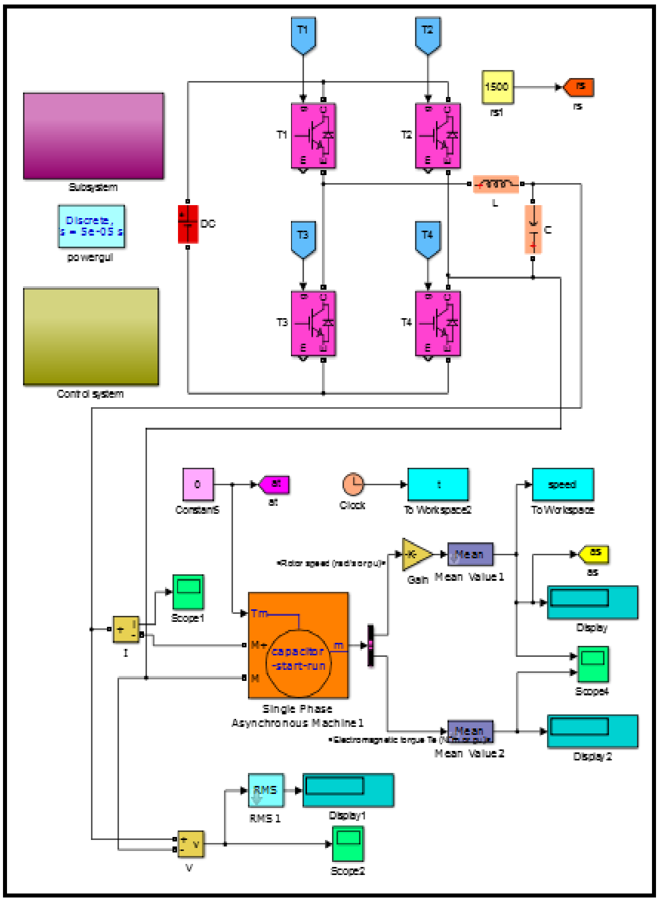

Fig.6 SPIM drive circuit model

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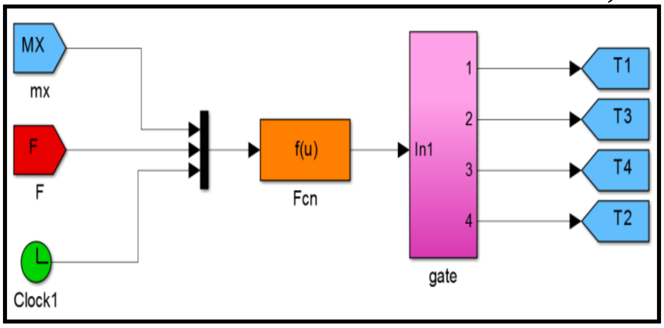


Fig.7 Simulation model of the SPWM pulses generation

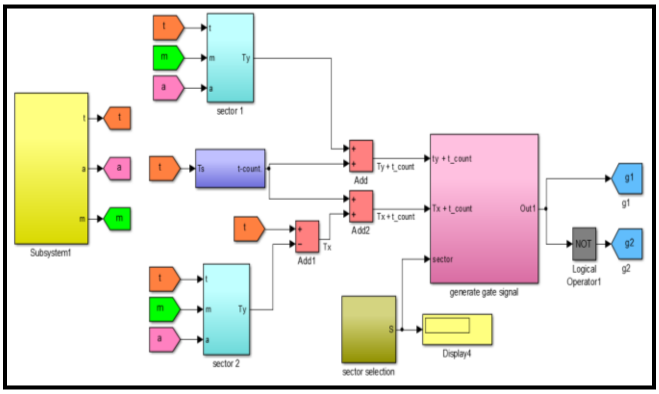
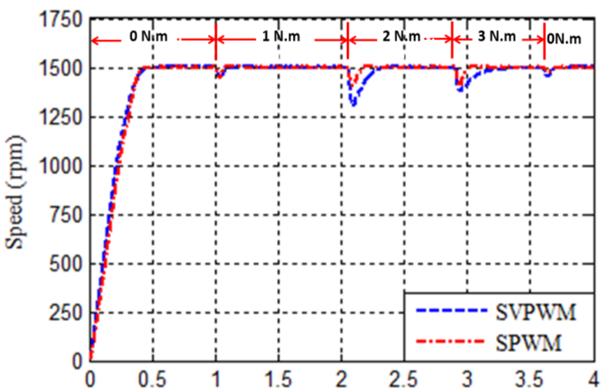


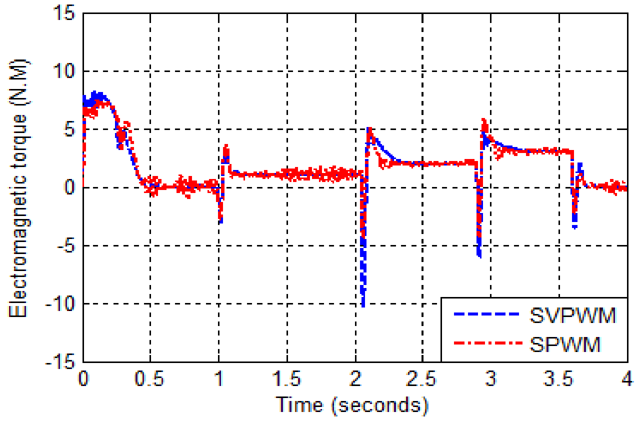
Fig.8 Simulation model circuit of the SVPWM pulses generation

The speed and electromagnetic torqueresponses of the drive circuit at different load torque values are shown in Fig.(9).Figure (10) illustrates the system responses at different speed and load torque values. While Fig.(11) shows system responses of SPIM at differences speed values and constant load torque. The overall system has good responses based on SPWM and SVPWM techniques. On the other hand, the SPWM technique gives better responses than SVPWM technique during load torque changing.

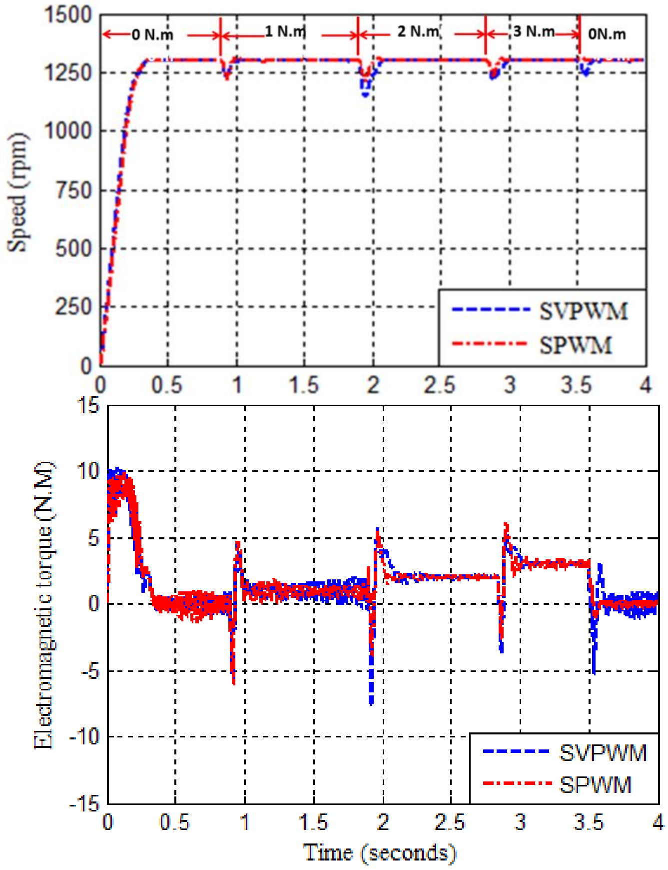
The output inverter voltage and current using SPWM and SVPWM techniques are demonstrated in Fig. (12). The FFT analysis illustrated in Fig.(13) explain that the THD results are within acceptable standards. The FFT analysis proves that the power quality produced by SVPWM is better than SPWM type.

As a results, SPIM drive circuit based on SVPWM technique is more preferable than SPWM control technique. Also, all these results have been done depending on V/f constant.



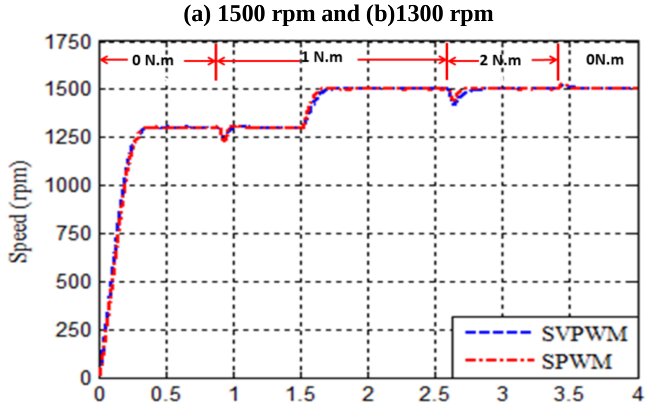


(a)



(b)

Fig.10 speed and electromagnetic torque responses at (a) 1500 rpm and (b)1300 rpm



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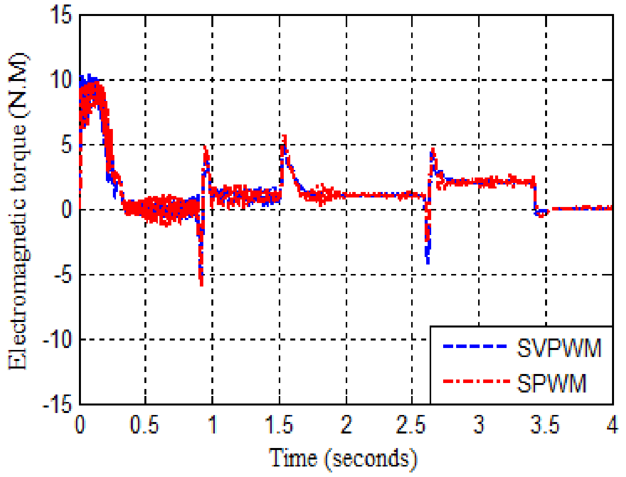


Fig.11 speed and electromagnetic torque responses at different speed and load torque

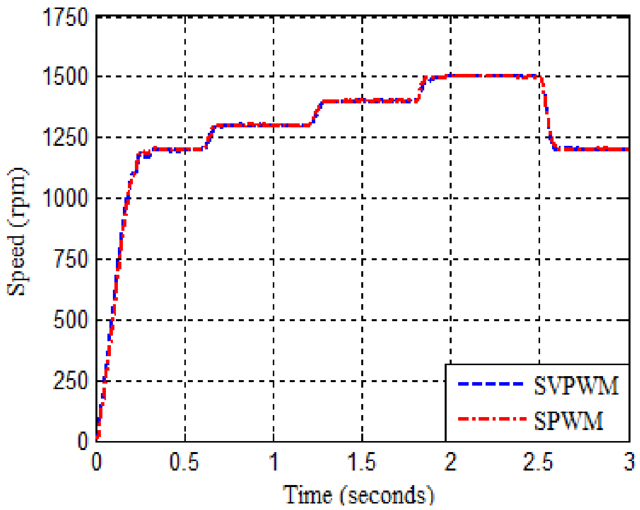
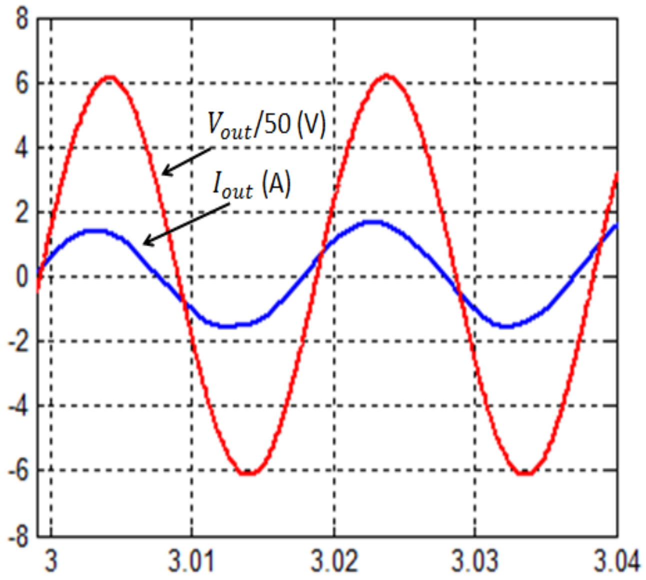
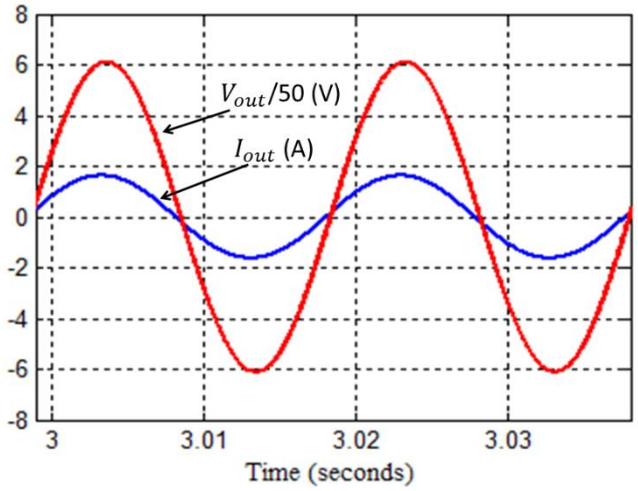


Fig.12 SPIM speed response at constant load torque

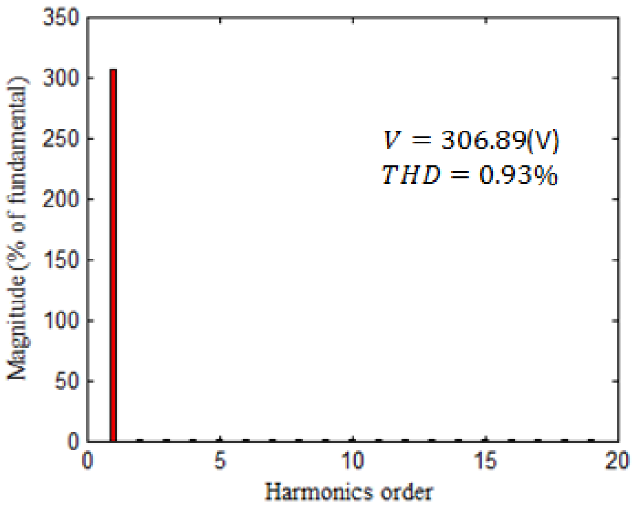


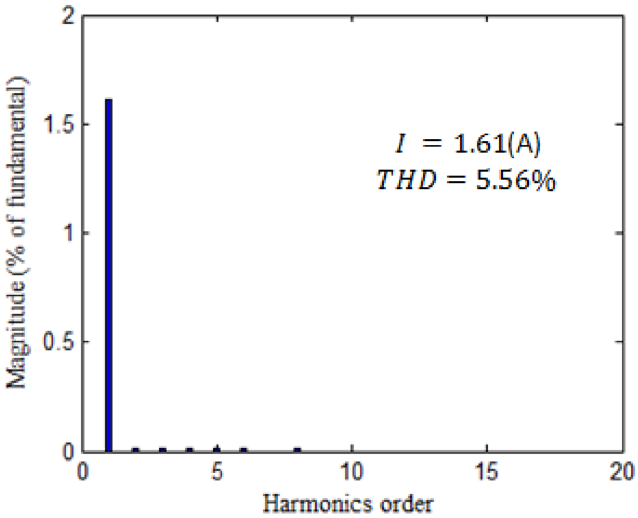
(a)



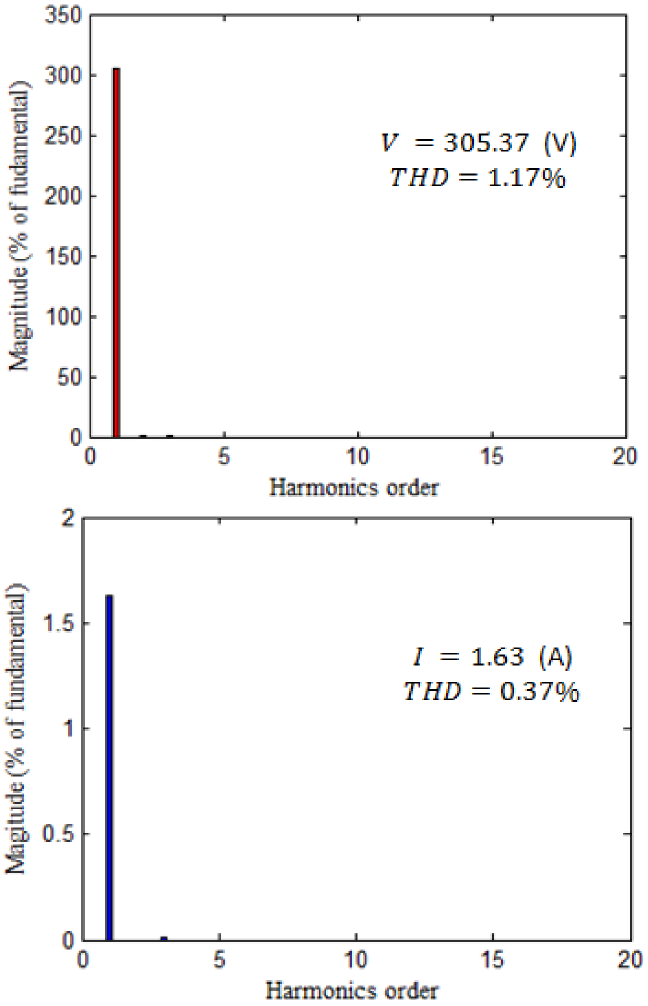
(b)

Fig.13 The output voltage and currentwaveforms using: (a) SPWM and(b) SVPWM techniques





(a)



(b)

Fig.14 FFT analysis of single-phase H-bridge inverter using: (a) SPWM and (b) SVPWM techniques

V. CONCLUSION AND FUTURE ENHANCEMENT

This paper presents a drivecircuit to control speed of SPIM. Single-phase H-bridge invertercircuit had been achieved depended on SPWM and SVPWM techniques.The control circuit is designed to control voltage and frequency of the inverter circuit to control speed of the SPIM and get acceptable THD. The SPWM inverter circuitproduces faster speed response than SVPWM inverter circuit especially during load torque changing.While SVPWM inverter circuit gives THD less than SPWM type. The overall results proves that SVPWM inverter is more efficient and better than SPWM inverter. The future enhancement, implementation drive system practically and compare which of two techniques give a better response of the induction motor.

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