Single-Phase to Three-Phases Sinusoidal Waveform Converter for driving 3 Phase induction motor based on SPWM Inverter

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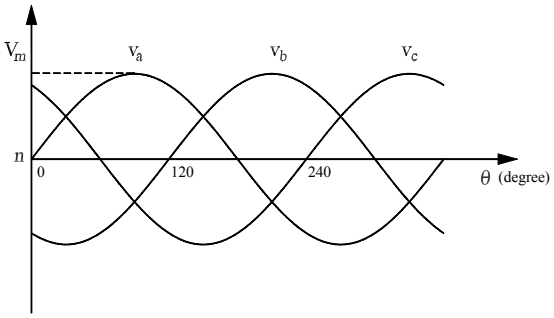
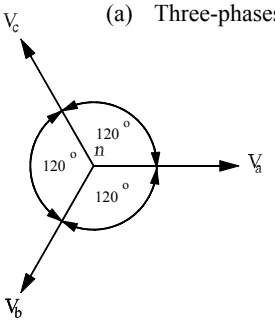
1 Introduction

The 3-phases induction motor might be used for powerful more than single-phase induction motor, because it can be given the high power when comparison with single phase induction motor as the same size. But the three phase induction motor must be connected to the three phase supply which have phase voltage waveform are difference and phasor diagram that shown in Fig.1(a),(b) and can be written in the equation (1) [1].



(a) Three-phases voltage waveform



(b) Phasor diagram

Fig.1 Three-phase voltage waveform and phasor diagram

$$v_a = V_m \sin(\omega t + 0°)$$
$$v_b = V_m \sin(\omega t - 120°) \quad (1)$$
$$v_c = V_m \sin(\omega t + 120°)$$

So that, if you want to drive three-phase induction motor by using single-phase waveform, you must be shift the phase voltage into two-phase waveform by connect a capacitor that shown in Fig. 3 with this connection, its look like split phase induction motor, the motor will continue turning on the single phase supply but the performance of a motor is fairy poor. [2]

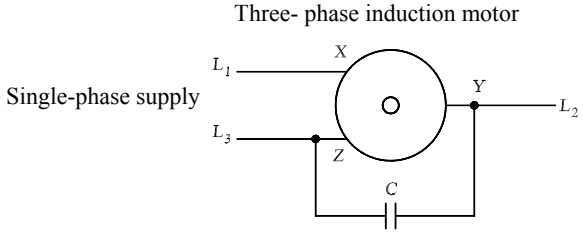
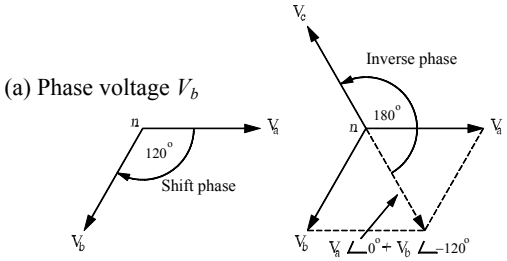


Fig.2 Three-phase induction motor in single phase supply

2 Single phase to three phase converter

Fig. 3 is the concept for convert single phase to three phases sinusoidal waveform; start from phase voltage V_a is shift to 120° lagging for generated phase voltage V_b. After that summing V_a , V_b together and inverse phase for generated phase voltage V_c



(b) Phase voltage V_c

Fig.3 Single-phase voltage converts to three-phase voltage

2.1 Sine wave pulse width modulation inverter (SPWM)

Fig. 4 is the block diagram of the SPWM inverter [3] for driving three-phase induction motor by using switching frequency about 5kHz. The function of switch S_1 is start/stop for smooth increasing and decreasing the spindle speed of motor.

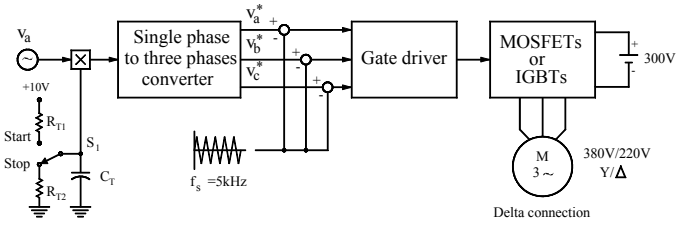


Fig.4 block diagram of the SPWM inverter for driving three-phase induction motor

The principle of softly start/stop is using the percentage of modulation between command reference sinusoidal waveform and triangle waveform carrier frequency that shown in Fig.5 [4].

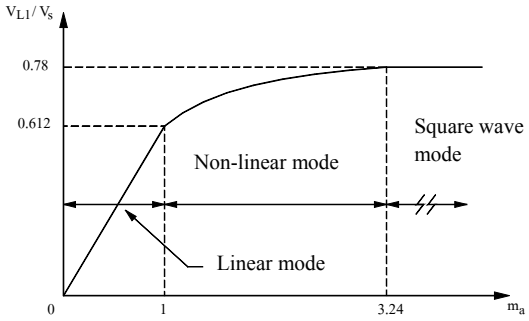


Fig.5 rms line voltage VS percentage modulation

3. Simulation result

This paper used the Proteus release 7.2 SP6 computer program for simulation the circuits design and the result as shown below

3.1 Single-phase to three-phase converter

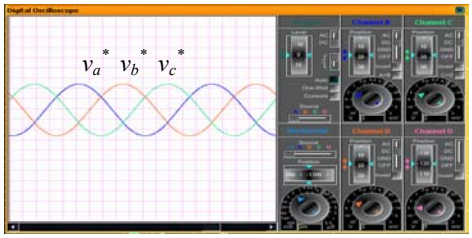


Fig.6 Single phase to three-phase sinusoidal waveform

3.2 Line voltage of SPWM inverter

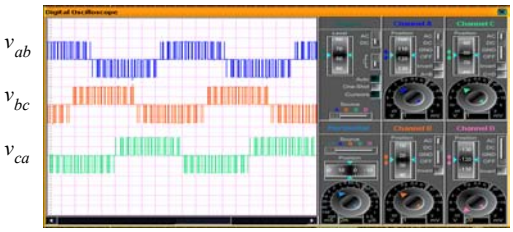


Fig. 7 The line voltage for three-phase induction motor

3.3 Soft-start when S_1 change from stop to start position

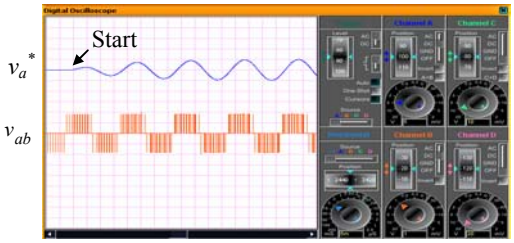


Fig. 8 The magnitude of v_a^* and modulation percentage of v_{ab} are increase smoothly.

3.4 Soft-stop when S_1 change from start to stop position

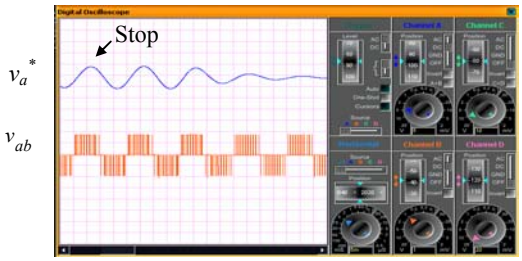


Fig. 9 The magnitude of v_a^* and modulation percentage of v_{ab} are decrease smoothly.

Fig.6 that show the sinusoidal waveform of three-phase which converted from the single-phase v_a by using the principle in Fig.3

Fig.7 that show the line voltage for supply to three-phase induction motor from the SPWM inverter by the circuits which made from the block diagram in Fig.4

Fig.8 that show the command of phase voltage v_a^* and the line voltage v_{ab} for three-phase induction motor when switch S_1 change from stop to start position. The magnitude of v_a^* and modulation percentage of v_{ab} are smooth increasing. That mean the rms of line voltage for driving motor and spindle speed is smooth increasing follow.

Fig.9 that show the reverse operation when switch S_1 change from start to stop position. The magnitude of v_a^* and modulation percentage of v_{ab} are smooth decreasing. That mean the rms of line voltage for driving motor and spindle speed is smooth decreasing follow.

4. Conclusion

According to circuits design and simulation result that shown the operation is work well and can be applied to drive the three-phase induction motor by using only single-phase sinusoidal waveform for only synchronous spindle speed which dependence on the frequency of single phase line voltage before convert to three phase sinusoidal waveform. The rating of power element such as gate driver, power MOSFETs or power IGBTs and dc bus power supply must be in line with the rating power of three phases induction motor.

References

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