Current and Speed Characteristic of Linear Induction Motor according to Reference Scenario and Voltage/Frequency Ratio

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Abstract — This paper deals with the operating characteristic of Linear Induction Motor (LIM) driven by SVPWM inverter according to reference modulation for speed control. Since the speed of LIM can be controlled by voltage and frequency variation, this paper constructed VVVF (Variable Voltage Variable Frequency) controller based on DSP (Digital Signal Processor) with SVPWM (Space Vector Pulse Width Modulation) principle. With suitable algorithm, the reference is modulated to control speed, and its related operating characteristics are analyzed.

I. Introduction

Since linear induction motor (LIM) has durable structure, and its maintenance is simple, it is widely employed to various applications. Since LIM is introduced in 1800s, its related researches are actively performed[1]-[5], and they are mostly based on the analytical method to analyzed the static characteristics of LIM. Recently, thanks to the development of computer technology, the researches by finite element method(FEM) is widely performed as well. However, when the LIM is applied to real system, although the dynamic characteristic analysis is essential, its related researches are not sufficiently performed. The Speed of LIM can be controlled by frequency and input voltage modulation. For the stable acceleration and deceleration operating characteristics, the ratio of voltage and frequency should be constant. This constant ratio can be realized by suitable reference modeling. To minimize switching loss of inverter and to use maximum DC link voltage, this paper applied space vector pulse width modulation (SVPWM) to controller based on DSP. To confirm the operating characteristics in high speed and low speed, the reference modeling is performed to control the speed of LIM.

II. Operating Characteristic by Reference Modulation for Speed Control of LIM

A. VVVF Control

The electromagnetic propulsion force of LIM tends to decrease as frequency increases at constant voltage, and it has the constant value with constant V/F (Voltage/Frequency) ratio. Although its speed can be controlled by pole pitch or frequency, the frequency variation changes the amount of flux density in air-gap, the electromagnetic propulsion force does not remain constant. For the stable acceleration of LIM, the constant electromagnetic propulsion force is very essential.

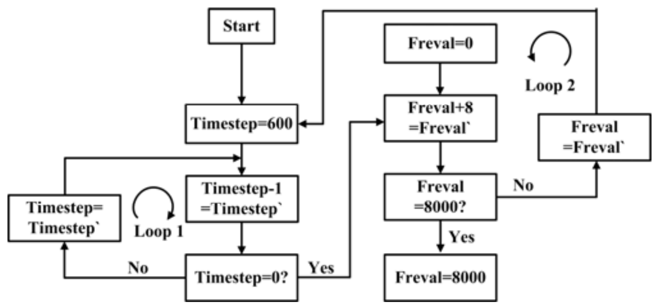

Fig. 1. Reference generating procedure for 60[sec] acceleration.

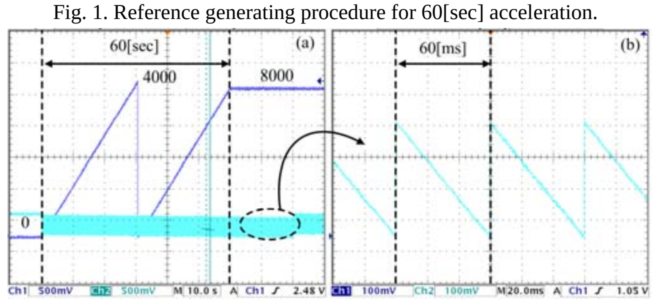

Fig. 2. 60[sec] acceleration reference : (a) Freval, (b) Timestep.

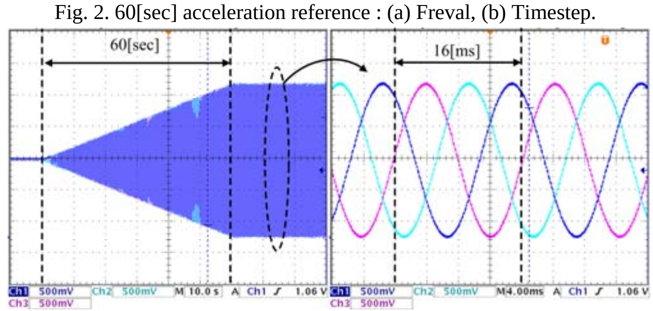

Fig. 3. d-q transformed 60[sec] acceleration reference.

Therefore, the inverter with Various Voltage Various Frequency function is suitable choice. In this paper, the experiment is performed with maximum frequency 20[Hz] with 100[Vdc] considering experimental safety condition. The V/F ratio is determined by the value of DC link Voltage, which are 100[vdc], 75[vdc] and 50[vdc] with 60[sec] acceleration time. The VVVF control will be performed with V/F ratio reference and SVPWM inverter. The algorithm of 60[sec] acceleration reference is obtained from the procedure shown in Fig.1. Since the interrupt of DSP is set as 10[kHz], it takes 0.0001[sec] for one interrupt generation. Here, The variable "Timestep" is set as 600, and it is creased by 1 until the variable becomes zero. This is the first loop of reference modeling. When "Timestep" is zero, and if another variable "Freval" is increased by 8, the

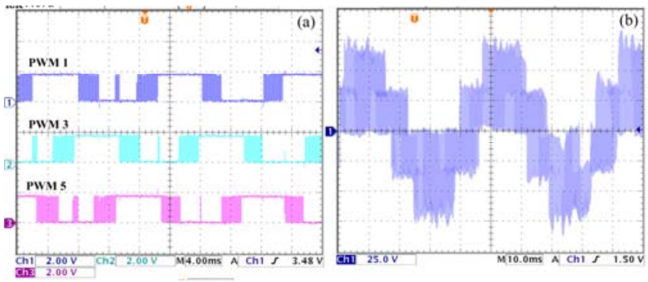

Fig. 4. SVPWM inverter output : (a) PWM, (b) phase voltage(100[Vdc]).

acceleration reference in 60[sec] can be obtained when "Freval" becomes 8000. This is the second loop of the procedure. In that, to increase "Freval" by 8, the loop 1 takes 0.06[sec] (600*0.0001[sec]), and the loop 2 takes 60[sec] (600*0.0001*(8000/8)) to make "Freval" 8000. The reference "Freval" is presented in Fig. 2, and it is integrated to be the angle of d-q transformation. With similar procedure, the reference can be modulated to control the speed of LIM, the entire reference scenario consists of eight regions including acceleration, deceleration and constant speed.

B. Space Vector Pulse Width Modulation

For decades, space vector pulse width modulation (SVPWM) technique has been employed to operate induction motors since it presents higher output voltage for the identical DC link voltage, lower switching losses and better harmonic performance in comparison with the carrier-based sine-triangle PWM (SPWM) generating PWM outputs based on the principle of comparing a triangular carrier signal with a sinusoidal reference waveform [6]. Therefore this paper employed SVPWM principal to generate PWM signals, and Fig. 4 shows the generated PWM signal and inverter output voltage.

C. Operating Characteristic according to V/F ratio

The LIM model for experiment is manufactured as arc type considering spatial limitation and continuous experiment. Table I presents the design specifications, and Fig. 5 shows the experimental set with constructed SVPWM inverter. Fig.6(a) shows the current characteristic according to the scenario and V/F ratio. When the reference accelerates in region I and VII, its value increases, and it keeps constant value during constant reference in region II, IV and VIII. Besides, during deceleration in region III and V, it shows decreasing current characteristics as anticipated.

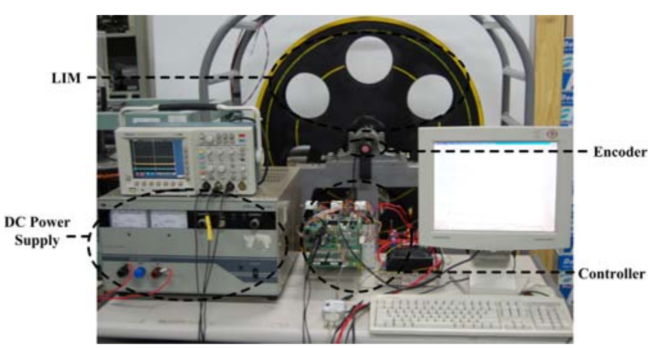

Fig. 5. Experimental Set with SVPWM inverter.

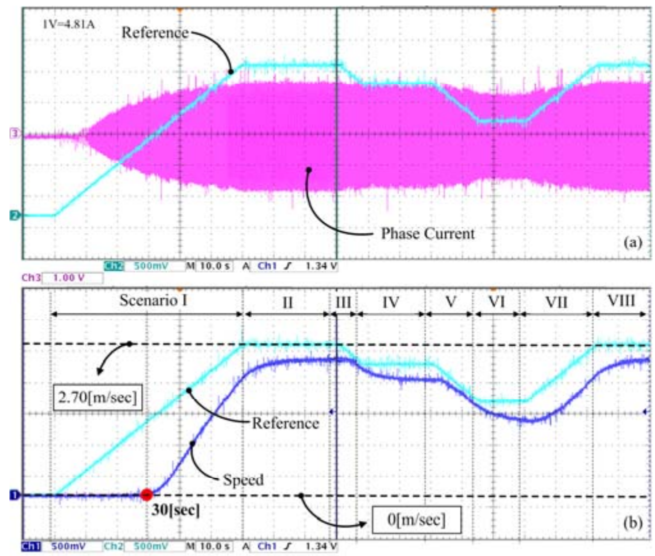

Fig. 6. Operating Characteristic with reference modulation: (a) speed characteristic, (b) current characteristic.

In each ratio, they shows similar trend, and it is noticed that the speed should be decreased to reduce the current value. Fig.6(b) shows the speed characteristic according to the scenario and V/F ratio. The Maximum value of reference represents 2.7[m/sec], and when the DC link voltage is 100[Vdc], its maximum speed shows 2.3[m/sec]. Besides, the starting time shows difference according to V/F ratio, and it is delayed as the ratio decreased. In comparison with both current and speed characteristics, it is noticed that maximum current value 5[A] is required to operated this arc type LIM.

III. CONCLUSION

This paper evaluates the operating characteristic of LIM driven by SVPWM inverter with constant V/F ratio. Based on DSP, the VVVF controller is constructed, and the current characteristic and speed characteristic are analyzed. In later full paper, the operating characteristic according to V/F ratio will have been presented, and more specific operating data will have been offered as well.

IV. REFERENCES

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