Induction Motor Drives Fed By Four- Leg Inverter

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ABSTRACT: In this paper we proposed novel method was introduced for driving 2 Independent three phase induction motors by feeding through four- leg inveter(FLI) which can have capability of driving three phase AC motos also. It basically consists of four legs two capacitors connected in series and similarly U and V phases of both motors are connected to each leg on the other hand W phase of both motors is connected over to neutral point of two spirit capacitors.For the sake of modulation to phases only PWM method os not directly applied here. We observed that results are verified with Matlab Simulink.

I. INTRODUCTION

The independent control of two motor drives using a single inverter offers cost reductions by decreasing the number of power electronic switches, only one DC bus supply and one controller. In addition, it consumes less space and has lower complexity. The independent control of two three phase motors can be realized by using a Four Leg Inverter, a FLI or a Nine Switched Inverter . Analysis of the FLI inverter mainly focuses on the capability of the motors to work independently with FLI performance, together with switching pattern and DC voltage utilization. This paper will thoroughly compare the individual motor performances using FLI and TLI. Indirect FOC methods using TLIs are well established and used in high performance speed drive in various industries. They are used to control one motor with three a leg inverter system. Meanwhile, a FLI two motor drives system consists of the FLI, two induction motors and separated FOC schemes for the individual motors. The system only used one five leg inverter to supply to two three phase motors. The principle of independent control for two induction motors by using a FLI voltage source inverter has been investigated and research focused on the operation of the carrier based or space vector based PWM modulation methods, two motor performance, switching pattern, DC utilization and total harmonic distortion (THD). Meanwhile, this study performed a direct comparison of the motor performances based on FLI and TLI systems with the same equipment, vector control scheme, motor parameters and Proportional Integral (PI) controller. The indirect field oriented control (FOC) scheme is used for the motor control drives.

Fig. 1 illustrates a block diagram of two induction motors applying the indirect FOC schemes fed by a FLI system. By referring to the control for motor M1, the torque component and the flux component of the stator, current goes through a coordinated transformation to supply the voltage amplitude, phase, and frequency. this paper also analyzes about potential in the neutral point of two-sprit capacitors and inverter output voltage. This paper presents the experimental test results of the independent driving characteristics of two induction motors (IMs) fed by the FLI, the PWM technique, and the validity of those analytic results.

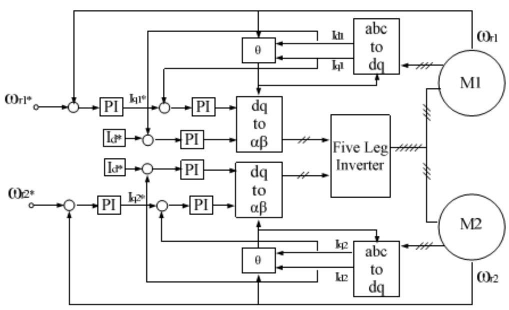


Fig.1. Two induction motor drive vector control block diagram.

II. PROPOSED SYSTEM CONFIGURATION (CHARACTERISTICS OF FLI)

A. Neutral Point Potential of Two-Sprit Capacitors

The fluctuated component depends on the fundamental wave frequency and peak value of both motor currents. Able to decrease when the motors are driven at lighter load and higher speed condition and be also decreased by the capacitor with larger capacitance.

B. Inverter Output Voltage

The FLI is fed by voltage source and connects inductive loads (for example,RLloads, ac motors, and so on).

U-V line voltage	v_{UVi}	$-E$, 0, E 3level
V-W line voltage	v_{VWi}	$-E/2 - \Delta v_{WO}$, $E/2 - \Delta v_{WO}$ 2level (*superposition of* Δv_{WO})
W-U line voltage	v_{WUi}	$-E/2 + \Delta v_{WO}$, $E/2 + \Delta v_{WO}$ 2level (*superposition of* Δv_{WO})

Table I. Output voltage level

The switches of one leg must not be simultaneously closed or opened. the output voltage level in both motors is obtained as Table I.

III. PWM TECHNIQUE OF FLI

A. ETAM

Here inverter W phase is constructed in the two-sprit capacitors, the modulation in the phase is impossible. Therefore, the PWM technique in three-phase VSI is not directly applicable for the FLI. To obtain a balanced three-phase ac voltage, only the U and V phases must be modulated in the FLI. Then, we apply an expanded two-arm modulation (ETAM) known as a modulation method of a five-leg inverter.

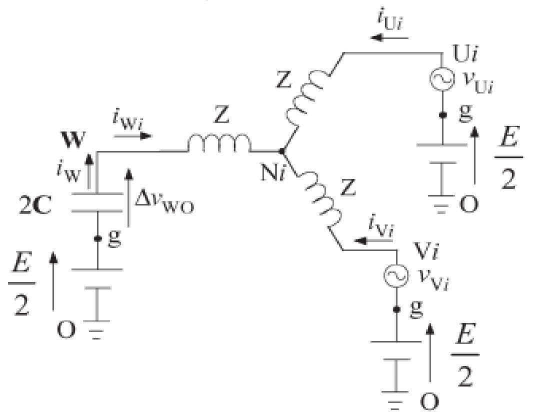


Fig. 2. Equivalent circuits for the four-switch inverter.

The connection method in the FLI is equivalent to the V-connection of a transformer for one motor. In the V-connection of a transformer, if the phase differences of each phase voltage command are$\pi/3$each other, we get a balanced three-phase voltage.

B. Neutral Point Potential of Two-Sprit Capacitor Compensation

When we analyze the FLI, we had to better consider one motor to understand it easily. For one motor, it is possible to think that the FLI connecting two motors is equivalent to the four-switch inverter as shown in Fig. 2.

Because only the output voltages of the motors are remarkable values to be analyzed, each phase of the motor can approximate to a load having impedance Z.Ni is the neutral point of the load. Employing the ETAM, the phase current in the IMi becomes unbalanced three-phase current. To obtain unbalanced threephase current, it is necessary to compensate.

C. Neutral Point Potential of Two-Sprit Capacitor Compensation

Fig. 3 shows the block diagram of PWM technique in FLI. The PWM strategy may apply carrier-based PWM. It is noted that the amplitude of carrier signal is often chosen as one in the carrier-based PWM. In the FLI, defining the reference signal of U (V) phase voltage in the IMicompared with the carrier signal. To obtain a balanced three-phase current,ΔvWO must be added to reference signals in each phase (“unbalanced compensation” in Fig. 3). Fig. 3 shows the control block diagram to restrain the drift of ΔvWO in steady state. Zero command is given because the drift must be restrained to zero. The error between the command andΔvWO is inputted to proportional–integral (PI) controller. Δvdrift_Comp, which is the output value of PI controller, is the value to compensate the drift. The drift is compensated with the addition ofΔVdrift_Compto reference signal .It must be noted that the drift will be able to compensate with only the PI controller because it has a dc component in steady state. If the drift is not compensated, overmodulation may be caused in consideration thatΔvWO is added to each reference signal. As a result, the VUF will be reduced, and it will be necessary to restrain the drift.

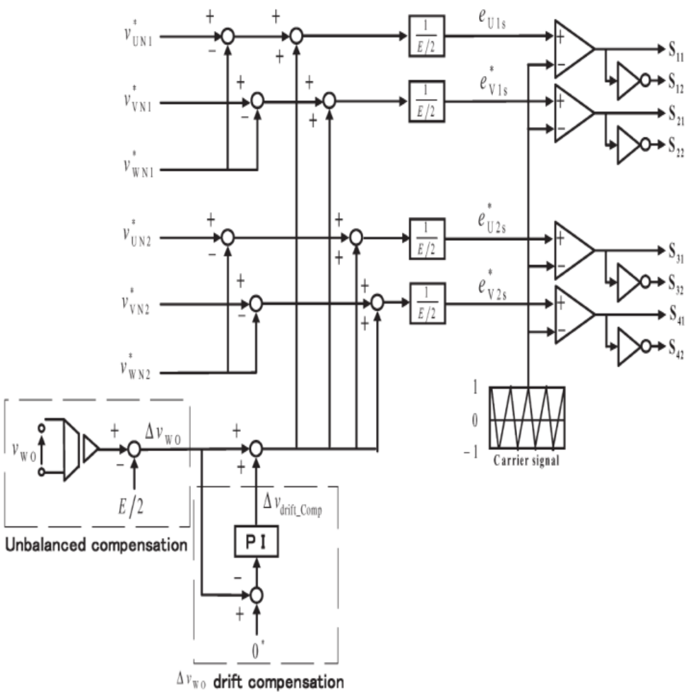


Fig. 3. Block diagram of carrier-based PWM

IV. D C - BUSVUF

To evaluate the inverter capacity, it is important to calculate the VUF. The VUF is defined as the ratio of the maximum output voltage to the inverter and the dc-bus voltage. In the carrier-based sinusoidal PWM, this way, defining the VUF with the maximum modulation index has the advantage that can investigate the VUF more easily. To connect two motors in the FLI, it should be noted that the VUF must be defined for each motor.

V. INDEPENDENT CONSTANT VOLTS PER HERTZ CONTROL

Fig. 4 shows the independent constant volts per hertz (V/f) control system of the FLI. AnotherV/fcontroller for each IM is employed to realize two IM independent control. Fig. 5 shows the block diagram ofV/fcontrol. TheV/f control system is the system to control the frequencyf_i in the IMi.

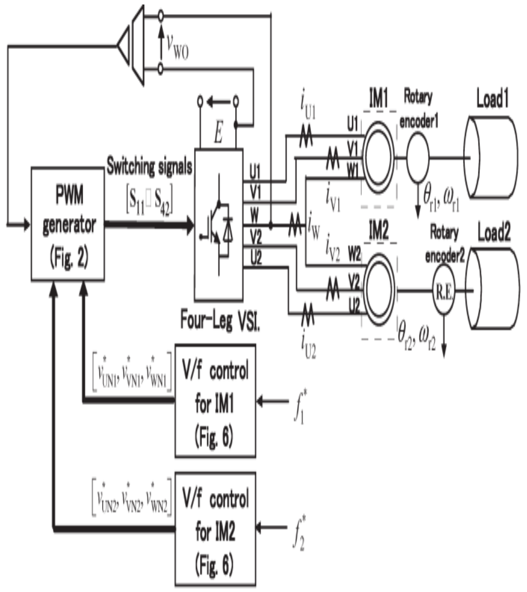


Fig. 4. IndependentV/f control system in the FLI.

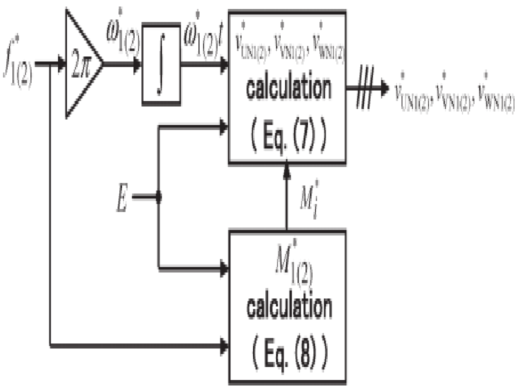


Fig. 5. Block diagram ofV/fcontrol

Fig. 6 shows the equivalent circuit of IM without a load, whereVis the phase voltage in IM.Iois the excitation current, Rsis the stator resistance,lsis the stator inductance,E1is the internal induced voltage, andMis the mutual inductance.

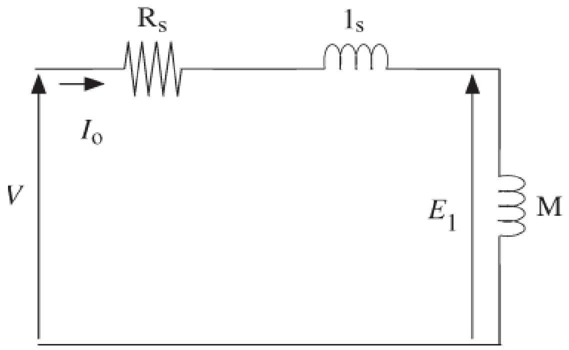
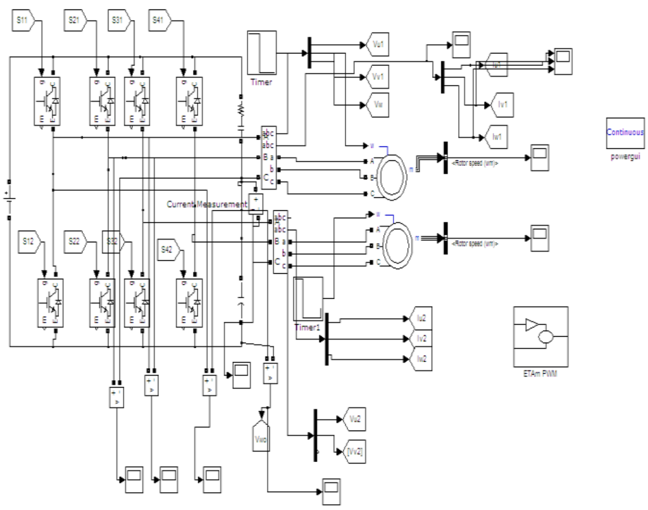


Fig. 6. Equivalent circuit of IM without a load.

VI. SIMULATION RESULTS



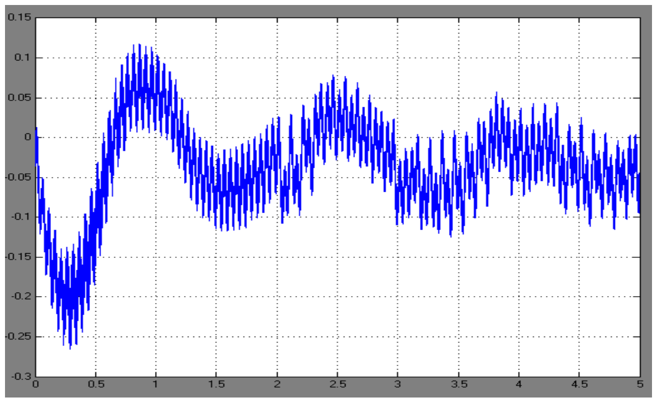


Fig. 7. Neutral point potential of two capacitors (compensation; simulation result)

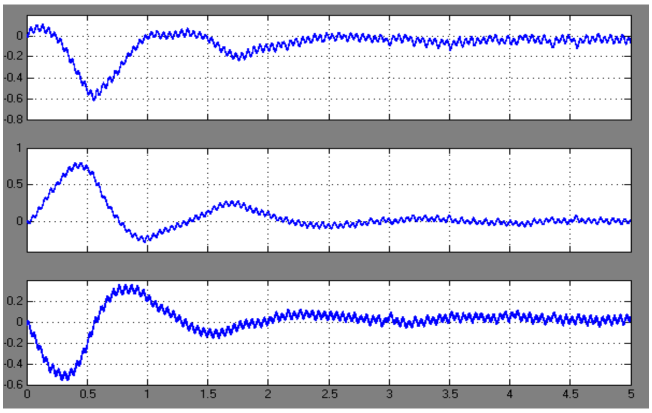


Fig 8 Three-phase current waveforms of the IM1 (simulation result)

Fig. 7 shows the neutral point potential waveform of twosprit capacitors with compensation. The drift phenomenon of vWO cannot be almost observed at starting time and load change compared with no compensation.

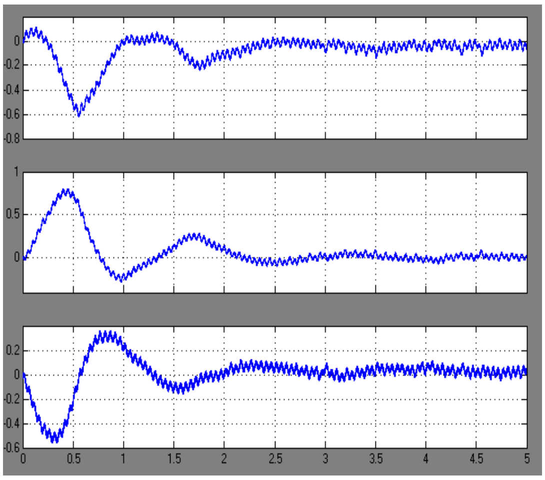


Fig. 9. Three-phase current waveforms of the IM1 (simulation result)

Figs. 8 and 9 show the three-phase current waveforms of the IM1 and IM2. It can be confirmed that the balanced threephase current can be obtained in both IMs.

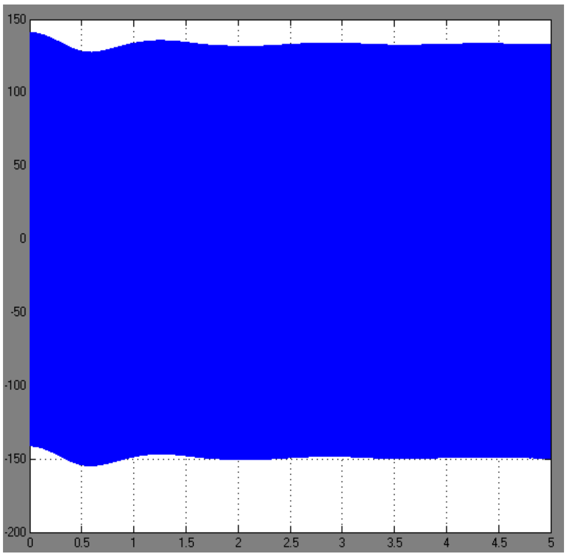


Fig. 10. W–U phase line voltage of the IMl simulation result).

CONCLUSION

This paper has also analyzed about the neutral point potential of two-sprit capacitors and inverter output voltage. Next, a modulation technique in the FLI has been also shown. The experimental results demonstrated the characteristics of two IM independent drives and the validity of those analytic results.

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