

VELOCITY CONTROL APPARATUS FOR ELEVATOR SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an elevator system, and more particularly to a velocity control apparatus for an elevator system which appropriately restricts a torque ripple of an induction motor, thereby improving comfortableness of passengers aboard an elevator car.

2. Description of the Background Art

An elevator system has adopted an inverter for its induction motor since the late 1980's, and accordingly a vector control theory has been applied to a velocity control for the induction motor so as to obtain an equivalent characteristic to that of a direct current motor, thereby improving comfortableness for passengers aboard an elevator car which employs an alternating current. Also, the application of an inverter to such an alternating current elevator car has resulted in a power reduction.

In order to control a velocity of an induction motor by use of a vector control method, there is essentially required a current controller. A velocity controller transmits a current command having a torque element to the current controller so that an angular velocity of the induction motor may follow a velocity command. Here, a practical current that flows in the induction current should be detected for the current control. At this time, there are detected two phase currents from three phase currents for the induction motor, and then the remaining

one phase current is obtained therefrom and fed back to the current controller which in turn generates a voltage command to allow the detected current to follow the current command.

However, the thusly controlled induction motor incurs a torque ripple due to a variety of reasons, such as an offset of a current detection device, a parameter imbalance of an induction motor and a torque ripple caused by dead-time. Consequently, when a frequency with regard to the torque ripple corresponds or approximates to a nature frequency for a mechanical system, the comfortableness for passengers aboard an elevator car tends to be deteriorated.

Figure 1 is a block diagram illustrating a general velocity control apparatus for an elevator system. As shown therein, the velocity control apparatus includes: a converter 11 for converting a three-phase alternating current input voltage AC to a direct voltage; an inverter 12 for converting the converted direct voltage an alternating current voltage in type of variable voltage and variable frequency; an induction motor 14 for generating a driving force to drive an elevator car 15 by use of the converted alternating current voltage; current detectors 13A, 13B for detecting two phase currents i_a , i_b from three phase currents which flow in the induction motor 14; the elevator car 15 for driving along respective floors in accordance with the induction motor 14; a velocity detector 16 for detecting an angular velocity of the induction motor 14; a drive control unit 17 for generating a drive command and a velocity command W_d for the induction motor 14 so as to drive the elevator car 15 to a required floor in correspondence to a hall call or a cage call; a velocity control unit 18 for executing a current control or a velocity control of the induction motor 14; and an amplifier 19 for amplifying a velocity control signal outputted from the velocity control unit 18 and transmitting the

amplified velocity control signal to a base of a power transistor provided in the inverter 12.

As shown in Figure 2 detailing the velocity control unit 18 in Fig. 1, the velocity control unit 18 includes: a first subtractor 21 for operating a difference between an angular velocity W_r of the induction motor 14 and velocity command W_d received from the drive control unit 17; a velocity controller 22 for generating a torque element current command T_d in accordance with an operated value of the first subtractor 21; a C-phase current operator 26 for operating a remaining signal phase current i_c by use of the two phase currents i_a , i_b selected from three phase currents received from the induction motor 14; a frequency operator 27 for operating a frequency that is to be applied to the induction motor 14, using the torque element current command T_d generated from the velocity controller 22 and the angular velocity W_r of the induction motor 14; a 2-phase synchronous coordinate converter 28 for converting the three phase currents i_a , i_b , i_c to a torque current T_r and a magnetized current; a second subtractor 23 for operation a difference between a torque current T_r generated from the 2-phase synchronous coordinate converter 28 and the torque element current command T_d generated from the velocity controller 22; a current controller 24 for generating a voltage command of the induction motor in accordance with a value operated by the second subtractor 23; and a PWM (Pulse Width Modulation) signal generator 25 for converting a voltage command generated from the current controller 24 to a PWM signal.

The control steps of the thusly constituted velocity control apparatus for an elevator system according to the conventional art will now be described.

First, the three-phase alternating current input voltage AC is inputted to the

converter 11, converted to a predetermined level of current voltage, filtered by condenser C, and released to the inverter 12.

The inverter 12 converts the direct voltage released thereto to a variable voltage and variable frequency, and the converted value is supplied to the induction motor 14.

Meanwhile, the drive control unit 17 inputs the velocity command W_d for driving the elevator car 15 to the velocity control unit 18 which serves to control a velocity of the induction motor 14 in order for the elevator car 15 to be driven in accordance with the velocity command W_d applied thereto.

Specifically, in the first subtractor 21 of the velocity control unit 18, when there is operated a difference between the velocity command W_d received from the drive control unit 17 and the practical velocity W_r detected by the velocity detector 16, the velocity controller 22 generates the torque element current command T_d which serves to control the induction motor 14.

When two phase currents i_a , i_b selected from the three phase currents which flow in the induction motor 14 are detected through the current detectors 13A, 13B and the detected values are applied to the C-phase current operator 26, the remaining one phase current i_c is operated in accordance with the detected currents i_a , i_b .

The three phase currents i_a , i_b , i_c are inputted to the 2-phase synchronous coordinate converter 28 and converted to the torque current T_r and a magnetized current. At this time, a synchronous frequency during a synchronous coordinate conversion is operated using a velocity W_r detected from the velocity detector 16 and the torque element current command T_d generated from the velocity controller 22.

Then, when the difference between the torque current T_r generated by the 2-phase synchronous coordinate converter 28 and the torque element current command T_d generated from the velocity controller 22 is operated in the second subtractor 23, the current controller 24 generates a voltage command that is to be applied to the induction motor 14.

The voltage command generated from the current controller 24 is converted to PWM signal in accordance with the PWM signal generator 25.

The thusly generated PWM signal is amplified to a predetermined level by the amplifier 19 and fed back to the inverter 12 and then the PWM signal is applied to the inverter 12 to serve as a base drive signal of the power transistor in the inverter 12, whereby the power transistor becomes switched and accordingly a variable type of alternating current voltage is supplied to the induction motor 14.

In the conventional velocity control apparatus for an elevator system, the C-phase current operation by the C-phase current operator 26 is feasible under a condition in which the induction motor 14 has its parameter in three-phase balance, or under another condition in which relevant current detection circuits are identical in gain. However, the parameter of the induction 14 is not in an accurate three-phase balance, neither are the respective gains of the current detection circuits precisely identical.

However, the induction motor 14 may experience a zero phase current flow and accordingly generate a torque ripple with regard to frequency, and when such a torque ripple corresponds to a mechanical secondary nature frequency in a predetermined velocity during an acceleration of an elevator car, it is amplified and transferred to the elevator car 15, thereby deteriorating a comfortableness of

passengers aboard the elevator car.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a velocity control apparatus for an elevator system capable of restraining a torque ripple of frequency which occurs due to a parameter imbalance of an induction motor or gain errors of respective phase current detection circuits, thereby improving comfortableness for passengers aboard an elevator car.

To achieve the above-described object, there is provided a velocity control apparatus for an elevator system according to the present invention which includes a plurality of current detectors for detecting three phase currents i_a , i_b , i_c which flow in an induction motor, and a current compensator for generating compensation currents i_a' , i_b' , i_c' wherein a zero phase current i_0 is offset from the detected three phase currents i_a , i_b , i_c .

The object and advantages of the present invention will become more readily apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific example, while indicating a preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become better understood with reference to the accompanying drawings which are given only by way of illustration and thus are not limitative of the present invention, wherein:

Figure 1 is a block diagram illustrating a velocity control apparatus for an elevator system according to a conventional art;

Figure 2 is a block diagram detailing a velocity control unit in the circuit of Fig. 1;

Figure 3 is a block diagram illustrating a velocity control apparatus for an elevator system according to the present invention;

Figure 4 is a block diagram detailing a velocity control unit in the circuit of Fig. 3; and

Figure 5 is a block diagram detailing a current compensator in the circuit of Fig. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 3 is a block diagram illustrating a velocity control apparatus for an elevator system according to the present invention, and Figure 4 is a block diagram detailing a velocity control unit in the circuit of Fig. 3.

As shown therein, the velocity control apparatus for an elevator system according to the present invention includes current detectors 33A, 33B, 33C for respectively detecting three phase currents i_a , i_b , i_c of the induction motor 34, and a current compensator 34 for converting three phase currents i_a , i_b , i_c applied to the induction motor 34 to compensation currents i_a' , i_b' , i_c' compensated to thus offset a zero phase current. Here, the other blocks shown in Figures 3 and 4 are

identical to those of the conventional art and accordingly their description will be omitted.

Figure 5 is a block diagram detailing a current compensator 46 in Fig. 4. As shown therein, the current compensator 46 includes: a zero phase current operator 51 for adding up three phase currents i_a , i_b , i_c of the induction motor 34 and operating a zero phase current i_0 ; a gain multiplier 52 for multiplying the zero phase current i_0 by a gain k and generating a zero phase distribution current i_0' for distributing the multiplied value to the respective phases; and adders 53A, 53B, 53C for adding the zero phase distribution current i_0' to the detected three phase currents i_a , i_b , i_c and generating compensation currents i_a' , i_b' , i_c' .

The control steps of the velocity control apparatus for an elevator system according to the present invention will now be described.

First, the three-phase alternating current input voltage AC is inputted to the converter 31, converted to a predetermined level of current voltage, filtered by condenser C, and released to the inverter 32.

The inverter 32 converts the direct voltage released thereto to variable voltage and variable frequency, and the converted value is supplied to the induction motor 34.

Meanwhile, the drive control unit 37 inputs the velocity command W_d for driving the elevator car 35 to the velocity control unit 38 which serves to control a velocity of the induction motor 34 in order for the elevator car 35 to be driven in accordance with the velocity command W_d applied thereto.

That is, in the first subtractor 41 of the velocity control unit 38, when there is operated a difference between the velocity command W_d received from the drive control unit 37 and the practical velocity W_r detected by the velocity detector

16, the velocity controller 42 generates the torque element current command T_d which serves to control the induction motor 34.

When the three phase currents i_a , i_b , i_c which flow in the induction motor 34 are detected through the current detectors 33A, 33B, 33C and the detected values are applied to the current compensator 46, the three phase currents i_a , i_b , i_c are converted to compensation currents i_a' , i_b' , i_c' in which the zero phase current is offset.

Specifically, the three phase currents i_a , i_b , i_c which are detected by the current detectors 33A, 33B, 33C are added up in the zero phase current operator 51 of the current compensator 46 for thereby operating the zero phase current i_0 .

The gain amplifier 52 amplifies a gain k by the zero phase current i_0 and generates a zero phase distribution current i_0' which is to be distributed to respective phases, and the zero phase distribution current i_0' is added to the three phase currents i_a , i_b , i_c by the adders 53A, 53B, 53C, thereby being converted to compensation currents i_a' , i_b' , i_c' in which the zero phase current provided in the respective phase currents is offset. Here, the gain k is desirable to be $-\frac{1}{3}$.

The thusly compensated three phase currents i_a' , i_b' , i_c' are inputted to the 2-phase synchronous coordinate converter 48 and converted to the torque current T_r and a magnetized current. At this time, a synchronous frequency during a synchronous coordinate conversion is operated using a velocity W_r detected from the velocity detector 36 and the torque element current command T_d generated from the velocity controller 42.

Then, when the difference between the torque current T_r generated by the 2-phase synchronous coordinate converter 48 and the torque element current

command T_d generated from the velocity controller 42 is operated in the second subtractor 33, the current controller 44 generates a voltage command that is to be applied to the induction motor 34.

The voltage command generated from the current controller 44 is converted to PWM signal in accordance with the PWM signal generator 45.

The thusly generated PWM signal is amplified to a predetermined level by the amplifier 39 and fed back to the inverter 32 and then the PWM signal is applied to the inverter 32 to serve as a base drive signal of the power transistor in the inverter 32, whereby the zero phase current is offset and a three phase balanced current flows in the induction motor 34.

As described above, the velocity control apparatus for an elevator system according to the present invention obtains the zero phase current by detecting the three phase input currents of the induction motor, and the three phase input currents are converted to a compensation current so that the zero phase current provided in the respective phase currents is offset accordingly, thereby feeding back the converted value to the induction motor. As a result, the parameter of the induction motor becomes balanced in three phases, thereby preventing a torque ripple of the input frequency from occurring and improving a comfortableness of passengers aboard an elevator car.

As the present invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within meets and

bounds of the claims, or equivalences of such meets and bounds are therefore intended to embrace the appended claims.

What is claimed is:



1. A velocity control apparatus for an elevator system, comprising:
 a plurality of current detectors for detecting three phase currents i_a , i_b , i_c which flow in an induction motor; and
 a current compensator for generating compensation currents i_a' , i_b' , i_c' wherein a zero phase current i_0 is offset from the detected three phase currents i_a , i_b , i_c .

2. The apparatus according to claim 1, wherein the current compensator comprises:

a zero phase current operator for adding the three phase currents i_a , i_b , i_c of the induction motor and operating the zero phase current i_0 ;

a gain multiplier for multiplying the zero phase current i_0 by a gain k and generating a zero phase distribution current i_0' for thereby distributing the multiplied value to the respective phases; and

a plurality of adders for adding the zero phase distribution current i_0' to the detected three phase currents i_a , i_b , i_c and generating compensation currents i_a' , i_b' , i_c' .

3. The apparatus according to claim 2, wherein the gain k is $-\frac{1}{3}$.

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