

"A.C. ELEVATOR CONTROL SYSTEM".

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1 This invention relates to a system for controlling an AC elevator car driven by an induction motor.

 The operation of an elevator car is classified into a normal operation mode and an emergency operation
5 mode. In the normal operation mode, the elevator car is driven under control of a normal-operation control apparatus controlling the acceleration and deceleration of the elevator car in usual manner, while, in the
10 emergency operation mode, the elevator car is driven under control of an emergency-operation control apparatus provided to deal with an emergency such as sudden service interruption.

 In an AC elevator system including an elevator car driven by a three-phase induction motor, such a
15 normal-operation control apparatus and such an emergency-operation control apparatus have been separately provided so that the former can be switched over to the latter in the case of an emergency.

 An example of an AC elevator control system
20 including the former apparatus is disclosed in U.S. Patent No. 3,876,918 (issued April 8, 1975). In the disclosed system, a controller composed of control elements such as thyristors is provided for controlling the elevator car in the normal operation mode so that,
25 depending on the error between the speed command signal

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1 and the speed feedback signal, the primary voltage
of an induction motor can be controlled when the
elevator car is accelerated or running at the rated
speed, while the DC braking current supplied to the
5 primary winding of the induction motor can be controlled
when the elevator car is decelerated, whereby both of the
motoring torque and the DC braking torque can be control-
led to satisfactorily control the acceleration and
deceleration of the elevator car.

10 In such an elevator control system, the opera-
tion mode is switched over to an emergency operation
mode as described below in the case of an emergency,
such as sudden service interruption.

(a) An emergency DC power source such as a battery
15 and an inverter unit converting DC power into three-
phase AC power are provided so as to drive the induction
motor by the inverter unit.

(b) As proposed in British Patent No. 2,020,926
(issued August 25, 1982), an emergency DC power source
20 such as a battery and a small-sized DC motor supplied
from the DC power source are provided so as to drive the
elevator car by the small-sized DC motor.

However, in each of (a) and (b) above des-
cribed, a battery and an inverter unit or a small-sized
25 DC motor have been required besides the aforementioned
normal-operation control apparatus, resulting in a bulky
and expensive system.

On the other hand, in the normal operation mode,
the induction motor is controlled to operate in the range

1 of large slip during both of acceleration and decelera-
tion. Therefore, a large rotor loss and large power
consumption have been inevitable.

5 A method solving these problems is known from,
for example, British Patent No. 2,081,534 (issued
February 17, 1982). According to the cited British
patent, an inverter unit is used to control an induction
motor driving an elevator car. This inverter unit
controls the induction motor in such a manner as to
10 maintain constant the relation between the voltage and
the frequency applied to the induction motor, as is
commonly known. For example, the pulse-width modulation
(PWM) control is well known as this type of control.
In this case, the induction motor can be controlled to
15 operate in the range of small slip so that efficient
operation can be ensured.

Further, since this inverter unit operates
with DC power, this DC power can be obtained by con-
verting AC power from an AC power source by a converter
20 in the normal operation mode, while DC power supplied
from a DC power source such as a battery can be directly
used in the emergency operation mode. That is, in the
case of an emergency, the emergency operation can be
effected by merely connecting the inverter unit to a DC
25 power source such as a battery.

Also, as is commonly known, the inverter
unit which controls the induction motor is primarily
designed to operate on the DC voltage provided by

1 rectifying the AC voltage supplied from the AC power
source. Therefore, when the inverter unit is connected to
the battery or like DC power source supplying a low DC
voltage, the torque generated by the induction motor is
5 inevitably lowered. On the other hand, a torque (an
unbalance torque) determined by the difference between
the weight of the elevator car and that of the counter-
weight is imposed as a load of the induction motor, and
this load varies greatly depending on the number of
10 passengers in the elevator car. That is, a great
unbalance torque is applied in the down direction
when the elevator car is full loaded, while such a
torque is applied in the up direction when the number
of passengers in the elevator car is small. Therefore,
15 when the torque generated by the induction motor is
small, the unbalance torque becomes dominant to such an
extent that the control of the elevator car becomes
impossible resulting in a great danger.

In order to avoid a dangerous situation as
20 above described, the emergency DC power source such as
the battery is required to supply a very high voltage
of the value close to that of the DC voltage obtained
by rectifying the AC voltage supplied from the AC power
source. Because of the above requirement, the in-
25 crease in the cost and scale has been unavoidable
in the prior art control system.

It is therefore a first object of the present
invention to provide an AC elevator control system in

which an emergency DC power source of a low voltage can be used to simply drive an elevator car in the case of an emergency.

A second object of the present invention is to
5 provide an AC elevator control system which can improve the reliability of the emergency operation.

A third object of the present invention is to provide an AC elevator system which can improve the comfortableness to ride and the accuracy of landing at
10 stopping floors even in the case of an emergency.

According to the present invention there is provided an AC elevator control system including an AC power source, an induction motor driving an elevator car, an inverter unit receiving DC power obtained by converting
15 the AC power as its input and supplying an output of a variable voltage and a variable frequency to said induction motor, speed commanding means for commanding the speed of said elevator car, speed detecting means for detecting the speed of said elevator car, and normal-operation switching
20 signal generating means for generating a switching signal for controlling the frequency and duty factor of the output of said inverter unit depending on the error between the speed command and the detected speed of said elevator car in a normal operation mode, said AC elevator
25 control system comprising an emergency DC power source, abnormal-condition detecting means for detecting occurrence of an abnormal condition in said AC elevator control system, and emergency-operation

switching signal generating means for generating such a switching signal in an emergency operation mode that the duty factor relative to the same frequency, of the output of said inverter unit in the emergency operation mode
5 differs from that in the normal operation mode, whereby, when occurrence of said abnormal condition is detected, said emergency DC power source supplies DC power to the DC input terminals of said inverter unit, and said emergency-operation switching signal generating means controls the
10 output of said inverter unit.

The present invention will now be described in greater detail by way of examples with reference to the accompanying drawings, in which:

Fig. 1 to 12 illustrate a preferred embodiment of
15 the present invention wherein:

Fig. 1 is a block diagram showing the general structure of the AC elevator control system;

Fig. 2 is a circuit diagram showing the structure of the main circuit of the inverter unit shown in Fig. 1;

20 Fig. 3 is a graph showing the relation between the voltage and the frequency applied to the induction motor from the inverter unit;

Fig. 4 shows the waveform of the output voltage generated from the inverter unit in a high frequency range;

25 Fig. 5 shows the waveform of the output voltage generated from the inverter unit in a low frequency range;

Fig. 6 shows the torque characteristic of the induction motor controlled by the inverter unit;

Fig. 7 is a block diagram showing the structure

of the normal-operation switching signal generating unit generating the switching signal in the normal operation mode;

5 FIG. 8 is a signal waveform diagram for illustrating the operation of various parts of the switching signal generating unit shown in FIG. 7;

FIG. 9 shows the waveform of the output voltage generated from the inverter unit in the normal operation mode;

10 FIG. 10 shows the waveform of the output voltage generated from the inverter unit in the emergency operation mode;

FIG. 11 is a block diagram showing the structure of the emergency-operation switching signal generating unit generating the switching signal in the emergency operation mode; and

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FIG. 12 is a signal waveform diagram for illustrating the operation of various parts of the switching signal generating unit shown in FIG. 11, and

20 FIG. 13 is a block diagram showing the general structure of another preferred embodiment of the AC elevator control system according to the present invention.

Preferred embodiments of the present invention will now be described in detail with reference to the

25 drawings.

The present invention is applicable to all of the cases in which an elevator car must be driven by DC power supplied from a DC power source since it is no more

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1 capable of normal operation under control of an elevator
control unit due to occurrence of abnormal situations
including sudden service interruption, accidental
stoppage of the elevator car between floors for some
5 unidentified reason and operational failure of the
elevator control unit. Such abnormal situations are
detected by individual abnormality detecting means, and
it is apparent that such means are constructed to detect
corresponding abnormal conditions respectively. In the
10 following description, preferred embodiments of the
present invention are adapted to deal with occurrence of
sudden service interruption, by way of example.

FIG. 1 is a block diagram showing the general
structure of a preferred embodiment of the AC elevator
15 control system according to the present invention.

Referring to FIG. 1, an elevator car 9 and a
counterweight 10 are suspended from the both ends
respectively of a rope 6 trained around a traction sheave
7. The elevator car 9 is driven by a three-phase AC
20 induction motor 4 through an electromagnetic brake 5
and a reduction gearing 6. A service interruption
detecting unit 19 detects sudden interruption of AC
power supply from a three-phase AC power source 1 func-
tioning as a power source in the normal operation mode.
25 The output signal from this service interruption detect-
ing unit 19 is applied to an elevator sequence control-
ler unit 22 which functions to turn on-off main circuit
contacts 20, 21 and control circuit contacts $20a_1$, $20a_2$

1 and 21a₁, 21a₂ depending on the presence or absence of service interruption detected by the service interruption detecting unit 19.

In the normal operation mode, the contacts 20,
5 20a₁ and 20a₂ are in their closed position, while the contacts 21, 21a₁ and 21a₂ are in their open position. A converter unit 2 converts the three-phase AC voltage into a DC voltage V_{DC} which is applied to an inverter unit 3. This inverter unit 3 has a known structure as
10 shown in FIG. 2 and is composed of transistors T_{r1} to T_{r6} and diodes D_1 to D_6 . The transistors T_{r1} to T_{r6} are subject to switching control to convert the DC voltage V_{DC} into a three-phase AC voltage which is applied to the induction motor 4.

15 In response to the application of an elevator-car operation start signal from the sequence controller unit 22, the electromagnetic brake 5 is released, and a speed commanding unit 13 generates a speed command signal whose level rises with time. The speed command
20 signal from the speed commanding unit 13 is applied to a comparator 14 together with the detected speed signal applied from a tachometer generator 12 coupled to the three-phase induction motor 4 driving the elevator car 9. The comparator 14 compares the detected speed signal with
25 the speed command signal to find the difference or error therebetween, and the error signal is applied from the comparator 14 to a normal-operation switching signal generating unit 15 which generates a switching signal

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1 used for the PWM control of the inverter output in the normal operation mode.

This switching signal generating unit 15 is provided for controlling the transistors T_{r1} to T_{r6} shown in FIG. 2 so that the ratio between the voltage and the frequency applied to the induction motor 4 can be maintained constant. The number of switching and duty factor of the output of the inverter unit 3 are controlled depending on the error between the speed command
10 signal and the detected speed signal.

For the purpose of ensuring efficient operation of the elevator car 9, it is necessary to control the voltage V and frequency f applied to the induction motor 4 so that the ratio V/f therebetween can be maintained
15 constant as shown in FIG. 3. Therefore, in a low frequency range in which the period is long, the output of the inverter unit 3 is controlled in a manner as shown in FIG. 4. It will be seen in FIG. 4 that the number of switching (referred to hereinafter as the number of
20 pulses N) in the half cycle is large, and the duty factor T_p/T of the pulses is small, where T is the half cycle time and T_p is the pulse width. On the contrary, in a high frequency range in which the period is short, the output of the inverter unit 3 is controlled in a
25 manner as shown in FIG. 5. It will be seen in FIG. 5. that the number of pulses N is small, and the duty factor T_p/T of pulses is large. This manner of control is called the pulse-width modulation (PWM) control.

1 When the voltage applied to the induction motor 4 is
controlled in the manner above described, the torque
characteristic of the induction motor 4 will be as shown
in FIG. 6. By controlling the speed of the elevator car
5 9 by driving it by the induction motor 4 having the
torque characteristic shown in FIG. 6, the elevator car
9 can be efficiently driven since the induction motor
4 operates in the range of small slip.

FIG. 7 shows one form of the practical struc-
10 ture of the switching signal generating unit 15.
Referring to FIG. 7, the switching signal generating
unit 15 includes an oscillator 31, a $1/2$ frequency
divider 32, a sexenary ring counter 33, a PWM signal
producing circuit 34, a pulse number changer 35, a dif-
15 ferentiator 36, a sawtooth waveform generating circuit
37 and a comparator 38. This switching signal generat-
ing unit 15 is constructed so that the number of pulses
in the half cycle is changed over between the three
values, N_1 , N_2 and 1, depending on the frequency of the
20 output from the inverter unit 3.

FIG. 8 shows waveforms appearing from the
various parts of the switching signal generating circuit
15 when the number of pulses N_1 in FIG. 7 is selected to
be $N_1 = 8$.

25 A frequency command signal d_2 which is a con-
trol input to the switching signal generating unit 15 is
provided generally by adding the error between the speed
command signal and the speed feedback signal to the

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1 speed command signal or the speed feedback signal.

Therefore, the oscillator 31 generates a pulse signal a having a frequency proportional to the frequency command signal d_2 as shown in FIG. 8. This pulse signal a is applied through the pulse number changer 35 to the differentiator 36 to produce a pulse signal c as shown in FIG. 8. The pulse signal c thus obtained is applied to the sawtooth waveform generating circuit 37 to produce a sawtooth pulse signal d_1 , and, then, this pulse signal d_1 is compared with the frequency command signal d_2 in the comparator 38 to produce a pulse signal e as shown in FIG. 8.

In the meantime, the output pulse signal a from the oscillator 31 is applied to the 1/2 frequency divider 32 to produce a pulse signal a_1 which is frequency-divided by the factor of 2 as shown in FIG. 8, and this pulse signal a_1 is applied to the sexenary ring counter 33 to produce pulse signals b_0 to b_5 which are different in phase by 60° from each other. These pulse signals b_0 to b_5 are applied together with the pulse signal e and its inverted signal $\bar{e}$ to the PWM signal producing circuit 34 which carries out the AND and OR operations on the signals b_0 to b_5 , e and $\bar{e}$ to produce pulse signals $g_1 = b_0 + b_1 \cdot \bar{e} + b_2 + b_4 \cdot e$, $g_2 = b_2 + b_0 \cdot e + b_4 + b_3 \cdot \bar{e}$, and $g_3 = b_0 + b_2 \cdot e + b_4 + b_5 \cdot \bar{e}$, as shown in FIG. 8. These pulse signals g_1 , g_2 , g_3 and their inverted signals $\bar{g}_1$, $\bar{g}_2$, $\bar{g}_3$ (not shown) are used as the switching signals (pulse signals)

1 for the PWM control.

The pulse signals g_1 to g_3 and $\overline{g_1}$ to $\overline{g_3}$ above described are amplified by a pulse amplifier unit 17 shown in FIG. 1. The pulse signals G_1 and $\overline{G_1}$ obtained by amplifying the pulse signals g_1 and $\overline{g_1}$ are applied to the bases of the transistors T_{r1} and T_{r2} shown in FIG. 2 respectively. Similarly, the pulse signals G_2 and $\overline{G_2}$ obtained by amplifying the pulse signals g_2 and $\overline{g_2}$ are applied to the bases of the transistors T_{r3} and T_{r4} respectively, and the pulse signals G_3 and $\overline{G_3}$ obtained by amplifying the pulse signals g_3 and $\overline{g_3}$ are applied to the bases of the transistors T_{r5} and T_{r6} respectively. Thus, depending on the error between the speed command signal and the detected speed signal, the frequency is progressively increased to control the motoring torque of the induction motor 4 so as to control the acceleration of the elevator car 9 through the reduction gearing 6, sheave 7 and rope 8.

As soon as the elevator car 9 accelerated in the manner above described reaches a predetermined position short of the floor landing point after having travelled a predetermined distance, a position detector 11 mounted on the elevator car 9 detects the position of the elevator car 9 from the floor landing point and applies a signal indicative of the detected position to the speed commanding unit 13.

The speed commanding unit 13 generates a speed command signal decreasing depending on the position of

1 deceleration of the elevator car 9, and the frequency
command signal d_2 corresponding to the error between
this speed command signal and the speed feedback signal
from the tachometer generator 12 is applied to the
5 switching signal generating unit 15 as described with
reference to FIG. 7.

Therefore, by the function of the switching
signal generating unit 15 above described, the frequency
is progressively decreased as commanded by the frequency
10 command signal d_2 while maintaining constant the re-
lation between the voltage V and the frequency f , and
the regenerative braking torque of the induction motor
4 is controlled to control the deceleration of the ele-
vator car 9.

15 The regenerative power in this case may be
returned to the power source or consumed by an external
resistor as is customarily done in this field.

As soon as the elevator car 9 being decelerated
reaches the floor landing point, a signal indicative of
20 arrival of the elevator car 9 at the floor landing point
is applied to the sequence controller unit 22, and a
stop signal is generated from the sequence controller
unit 22 to activate the electromagnetic brake 5 thereby
stopping and holding the elevator car 9 at the target
25 floor.

When service interruption occurs in the AC
power source 1 in such an elevator control system, the
elevator car 9 is operated in a manner as will be

1 described now.

When service interruption occurs while the elevator car 9 is situated within the door open zone in which the door of the elevator car 9 can be opened
5 because the elevator car 9 is situated at one of the floors, the elevator car 9 is not operated until power supply is restored. On the other hand, only when service interruption occurs while the elevator car 9 is running, and the elevator car 9 is stopped outside of
10 the door open zone, rescue operation is done to avoid confinement of passengers in the elevator car 9. In such a case, it is advantageous from the aspects of economy and safety to run the elevator car 9 at a speed considerably lower than the rated speed.

15 Referring to FIG. 1 again, in the event of occurrence of sudden service interruption in the AC power source 1, the service interruption detecting unit 19 detects occurrence of service interruption and acts to open the contacts 20, 20a₁ and 20a₂ and close the
20 contacts 21, 21a₁ and 21a₂.

As a consequence, an emergency DC power source 18 such as a battery is connected to the DC input terminals of the inverter unit 3. At the same time, this emergency DC power source 18 is connected to the input
25 terminals of an emergency-operation switching signal generating unit 16, pulse amplifier unit 17, sequence controller unit 22 and service interruption detector unit 19. Thus, the DC power source 18 supplies power now to

1 the individual units, and the emergency-operation switch-
ing signal generating circuit 16 operates now in lieu of
the normal-operation switching signal generating circuit
15 thereby completing or establishing an emergency
5 operation circuit.

Let f_a and V_a be the output frequency and
output voltage respectively of the inverter unit 3 cor-
responding to the running speed of the elevator car 9
in the emergency operation mode. Then, the emergency-
10 operation switching signal generating unit 16 is re-
quired to generate such pulse signals that the relation
 V_a/f_a satisfies the f - V characteristic shown in FIG. 3.

Therefore, in order that the power supply
voltage V_{a1} of the inverter unit 3 in the emergency
15 operation mode can be set to be lower than the power
supply voltage V_{n1} in the normal operation mode, the
output voltage of the inverter unit 3 relative to the
same frequency is preferably controlled in such a manner
that the number of pulses in the normal operation mode
20 is, for example, 9 as shown in FIG. 9 and the number
of pulses in the emergency operation mode is, for
example, 2 as shown in FIG. 10, so that the effective
voltage is equal in both of these cases.

That is, the number and duty factor of pulses
25 in the output generated from the inverter unit 3 under
control of the switching signals applied from the normal-
operation and emergency-operation switching signal
generating units 15 and 16 are selected to satisfy the

(24)

1 following relations:

Number of pulses: normal operation

> emergency operation

Duty factor of pulses: normal operation

5 < emergency operation

Further, when the effective output voltage relative to the same frequency is set to be equal in both of these cases, the induction motor 4 generates torques as shown in FIG. 6 thereby satisfactorily driving the elevator car 9 in the emergency operation mode.

FIG. 11 shows one form of the practical structure of the emergency-operation switching signal generating unit 16. The emergency-operation switching signal generating unit 16 includes an oscillator 40, a sexenary ring counter 41, a PWM signal producing circuit 42, a differentiator 43, a sawtooth waveform generating circuit 44 and a comparator 45. The operating principle of this unit 16 is substantially the same as that of the normal-operation switching signal generating unit 15 shown in FIG. 7.

FIG. 12 shows the waveforms appearing from the various parts of the emergency-operation switching signal generating unit 16 when it is adapted to generate two PWM control pulses in the half cycle. Referring to FIGs. 11 and 12, an emergency-operation speed command signal (frequency signal) k_2 for driving the elevator car 9 at a low speed is applied from the sequence controller unit 22 to the oscillator 40, and a pulse signal

(35)

1 h having a frequency proportional to that of the speed
command signal k_2 as shown in FIG. 12 is generated from
the oscillator 40. This pulse signal h is differentiated
by the differentiator 43 to produce a pulse signal j
5 as shown in FIG. 12, and this pulse signal j is applied
to the sawtooth waveform generating circuit 44 to pro-
duce a sawtooth pulse signal k_1 as shown in FIG. 12.
This signal k_1 is compared with the speed command signal
 k_2 in the comparator 45 to produce a pulse signal l as
10 shown in FIG. 12.

In the meantime, the output pulse signal h
from the oscillator 40 is applied to the sexenary ring
counter 41 to produce pulse signals m_0 to m_5 which are
different in phase by 60° from each other. These pulse
15 signals m_0 to m_5 are applied together with the pulse
signal l and its inverted signal $\bar{l}$ to the PWM signal
producing circuit 42 which carries out the AND and OR
operations on the signals m_0 to m_5 , $\dot{l}$ and $\bar{l}$ to produce
pulse signals $q_1 = m_0 + m_1 \cdot \bar{l} + m_2 + m_4 \cdot l$, $q_2 =$
20 $m_2 + m_0 \cdot l + m_4 + m_3 \cdot \bar{l}$, and $q_3 = m_0 + m_2 \cdot l + m_4 + m_5 \cdot \bar{l}$
as shown in FIG. 12. These pulse signals q_1 , q_2 , q_3 and
their inverted signals $\bar{q}_1$, $\bar{q}_2$, $\bar{q}_3$ (not shown) are used
as the PWM switching signals in the emergency operation
mode.

25 The pulse signals q_1 to q_3 and $\bar{q}_1$ to $\bar{q}_3$ above
described are amplified by the pulse amplifier unit 17
shown in FIG. 1, and the output pulse signals from the
unit 17 are applied to the bases of the transistors

- 1 T_{r1} to T_{r6} respectively in the inverter unit 3 as described already with reference to FIG. 7.

In response to the appearance of an emergency-operation starting signal from the sequence controller
5 unit 22, the emergency-operation switching signal generating unit 16 generates the pulse signals corresponding to the running speed of the elevator car 9 in the emergency operation mode, and these pulse signals are applied through the pulse amplifier unit 17 to the in-
10 verter unit 3 to drive the elevator car 9.

As soon as the running elevator car 9 reaches the floor landing point, a stop signal is generated from the sequence controller unit 22 to deactivate the in-
verter unit 3 and activate the electromagnetic brake 5
15 thereby stopping and holding the elevator car 9 at the target floor.

In the embodiment of the present invention shown in FIG. 1, an emergency power source such as a battery is connected, in the case of an emergency such
20 as sudden service interruption, to the DC terminals of the inverter unit provided for the control of the induction motor driving the elevator car in the normal operation mode, and switching signal generating means for the PWM control of the inverter unit in the emergency
25 operation mode is provided separately from the switching signal generating means provided for the PWM control of the inverter unit in the normal operation mode. Further, the switching signals generated from the emergency-

1 operation switching signal generating means are such
that, when the frequency applied from the inverter unit
to the induction motor is the same for both of the normal
and emergency operation modes, the number of pulses in
5 the inverter output is smaller than that generated in
the normal operation mode, and the duty factor of the
pulses is larger than that of the pulses generated in the
normal operation mode. Therefore, the DC power supply
voltage of the inverter unit can be reduced in the
10 emergency operation mode.

Therefore, the size and cost of the emergency
power source can be greatly reduced to provide an econo-
mical AC elevator control system.

FIG. 13 shows another embodiment of the pres-
15 ent invention in which the speed feedback control is
also applied during acceleration and deceleration of the
elevator car in the emergency operation mode.

In FIG. 13 showing a modification of the AC
elevator control system shown in FIG. 1, reference num-
20 erals 23 and 24 designate an emergency-operation speed
commanding unit and a comparator respectively, and the
same reference numerals are used to designate the same
parts shown in FIG. 1. Since the operation of the
system in the normal operation mode is the same as that
25 described with reference to FIG. 1, any description
thereof is unnecessary.

In the emergency operation mode, the speed
commanding unit 23 generates a speed command signal which

1 is a function of time when the elevator car 9 is being
accelerated, while it generates a speed command signal
which is a function of the position of the elevator car
9 when the elevator car 9 is being decelerated. The
5 comparator 24 detects the difference or error between
the speed command signal from the speed commanding unit
23 and the speed feedback signal from the tachometer
generator 12, and the emergency-operation switching
signal generating unit 16 generates PWM-control switch-
10 ing signals corresponding to the speed control error
detected by the comparator 24 to control the speed of
the elevator car 9 in the emergency operation mode.

The embodiment shown in FIG. 13 is advantageous
in that the capacity of the battery 18 can be further
15 reduced since the current of smaller value flows through
the induction motor 4 during acceleration and deceler-
ation of the elevator car 9 in the emergency operation
mode.

The second embodiment is further advantageous
20 in that the application of the speed feedback control
during acceleration and deceleration of the elevator car
9 can also greatly improve the accuracy of floor landing.

When the elevator car 9 is run at a very low
speed, the floor landing error is expected to be un-
25 appreciable.

In such a case, therefore, the speed feedback
control may not be done, and a speed command signal
increasing or decreasing with a substantially constant

1 acceleration or deceleration may be generated to control
the inverter unit 3 for suppressing the current flowing
through the induction motor 4 thereby reducing the
capacity of the battery 18.

5 In the embodiments shown in FIGs. 1 and 13,
the PWM-control signals are described to include equal
pulses having the same pulse width. However, known
unequal pulses having different pulse widths may be used
in lieu of the equal pulses. In such a case, the wave-
10 form of the output voltage of the inverter unit 3 be-
comes closer to the sinusoidal waveform, and such a wave-
form provides the advantage that the noise and heat
generated from the induction motor 4 can be reduced.

The switching signal generating units 15 and
15 16 shown in FIGs. 1 and 13 may be replaced by a micro-
computer having both of the normal-operation switching
signal generating function and the emergency-operation
switching signal generating function, and these functions
may be switched over to generate the required switching
20 signals. By the use of such a microcomputer, the system
can be made smaller in size, and the switching signals
can make more delicate control of the speed of the
elevator car.

Further, the normal-operation switching signal
25 generating unit 15 only may be replaced by an elevator-
control microcomputer, and the emergency-operation
switching signal generating unit 16 may be left to serve
exclusively its scheduled function. In such a case, the

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- 1 emergency operation of the system can be reliably performed even when the microcomputer is disabled, and the safety can be more reliably ensured.

It will be understood from the foregoing

- 5 detailed description of the present invention that, in the case of an emergency such as sudden service interruption of AC power supply from the AC power source, a DC power supply voltage from an emergency DC power source is applied to the inverter unit provided for the
- 10 control of the elevator car in the normal operation mode, and the inverter unit is controlled by switching signals so that its output includes pulses having a duty factor larger than in the case of the normal operation mode, when the frequency applied to the induction motor from
- 15 the inverter unit in both of the normal and emergency operation modes is the same. Therefore, the DC power supply voltage to be applied to the inverter unit in the emergency operation mode can be reduced, and the small-capacity and economical DC power source can be used to
- 20 safely run the AC elevator car in the emergency operation mode. When, for example, a battery is used as this emergency DC power source, the effect becomes more marked considering the fact that the battery must be periodically inspected and replaced.

CLAIMS

1. An AC elevator control system including an AC power source, an induction motor driving an elevator car, an inverter unit receiving DC power obtained by converting the AC power as its input and supplying an output of a variable voltage and a variable frequency to said induction motor, speed commanding means for commanding the speed of said elevator car, speed detecting means for detecting the speed of said elevator car, and normal-operation switching signal generating means for generating a switching signal for controlling the frequency and duty factor of the output of said inverter unit depending on the error between the speed command and the detected speed of said elevator car in a normal operation mode, said AC elevator control system comprising an emergency DC power source, abnormal-condition detecting means for detecting occurrence of an abnormal condition in said AC elevator control system, and emergency-operation switching signal generating means for generating such a switching signal in an emergency operation mode that the duty factor relative to the same frequency, of the output of said inverter unit in the emergency operation mode differs from that in the normal operation mode, whereby, when occurrence of said abnormal condition is detected, said emergency DC power source supplies DC power to the DC input terminals of said inverter unit, and said emergency-operation switching signal generating means controls the output of



42

said inverter unit.

2. An AC elevator control system as claimed in claim 1, wherein said emergency-operation switching signal generating means generates such a switching signal that, for the same frequency, the number of switching pulses per one cycle or half cycle is smaller than that in the normal operation mode, and the duty factor per unit switching pulse or per one cycle is larger than that in the normal operation mode.

3. An AC elevator control system as claimed in claim 1, wherein said abnormal-condition detecting means includes means for detecting an interruption of said AC power source.

4. An AC elevator control system as claimed in claim 1, wherein said abnormal-condition detecting means includes means for detecting accidental stoppage of said elevator car between the floors.

5. An AC elevator control system as claimed in claim 1, wherein said abnormal-condition detecting means includes means for detecting an operational failure of said elevator control system.

6. An AC elevator control system as claimed in claim 1, further comprising emergency-operation speed command generating means, so that said emergency-operation switching signal generating means generates a switching signal corresponding to the speed command generated from said emergency-operation speed command generating means.



43

- 26 -

7. An AC elevator control system as claimed in claim 6, further comprising means for detecting the error between said emergency-operation speed command and said detected speed so that said emergency-operation switching
5 signal generating means generates a switching signal corresponding to said error.

8. An AC elevator control system as claimed in claim 6, wherein said emergency-operation speed command is so set that the acceleration and deceleration are
10 substantially constant.

9. An AC elevator control system as claimed in claim 1, wherein said emergency DC power source supplies DC power to other units in addition to said inverter unit.

10. An AC elevator control system as claimed in
15 claim 1, wherein said emergency-operation switching signal generating means is provided separately from said normal-operation switching signal generating means.

11. An AC elevator control system as claimed in claim 10, further comprising switch-over means for
20 disconnecting said normal-operation switching signal generating means from said inverter unit when occurrence of said abnormal condition is detected and connecting said emergency-operation switching signal generating means to said inverter unit in an emergency operation
25 mode.



44

- 27 -

12. An AC elevator control system as claimed in claim 10, further comprising speed commanding means for emergency-operation in addition to said speed commanding means for controlling the elevator car, 5 wherein said emergency-operation switching signal generating means is adapted to generate a switching signal in accordance with said speed commanding means for emergency-operation.

13. An AC elevator control system as claimed in 10 claim 1, wherein said AC power source is a three-phase AC power source.

14. An AC elevator control system constructed and arranged to operate substantially as herein described with reference to and as illustrated in the 15 accompanying drawings.

