

Motor Driven Door Device

5       The present invention relates to a door device using an induction motor, and, in particular, relates to a motor driven door device suitable for an elevator door which is provided with a door closer.

10       A conventional motor driven elevator door device such as disclosed in JP-A-55-89182(1980) includes a circuit in which a DC motor is connected in parallel with a resistor and is constituted to initiate a braking force on the door by means of a regenerative braking of the DC motor in the event of an interruption of the motor power source.       Further,  
15       JP(U)-B-53-12033(1978) discloses a motor driven door device wherein an induction motor (condenser motor) is connected to an independent DC source for a predetermined time in the event of power service interruption in order to prevent such as a passenger from being caught by the door and the door  
20       from being destroyed.

      The first mentioned conventional motor driven elevator door device using a DC motor is suitable for preventing an elevator door free run and for securing safety for the passengers of the elevator in the event of power service  
25       interruption.

      However, DC motors are desirable with regard to their control properties but undesirable with regard to their

maintenance properties because it is necessary to replace the brushes of DC motors due to their wear. Therefore, in association with the recent development in inverter control technology applicable to an  
5 induction motor it is desired to use a strong and maintenance free induction motor for such motor driven elevator door device.

Further, the second mentioned conventional motor driven door device uses the separate DC power source  
10 (battery) other than the purchasing power source which causes a drawback of maintenance of the battery.

The present invention seeks to provide an easily maintained door free run preventing device during power service interruption for a motor driven door  
15 device using an induction motor.

According to the present invention, there is provided a motor driven door device comprising:

an alternating current power source;

a converter for converting the alternating  
20 current to a direct current;

a filtering capacitor connected to the direct current output side of the converter for smoothing the output of the converter;

an inverter for inverting the direct current to  
25 a three-phase alternating current;

a three-phase induction motor for driving a door, the motor being powered by the inverter; and

means for connecting the filtering capacitor

between input terminals of the induction motor in the event of interruption of the power source, so that the electric charge stored in the filtering capacitor is discharged through the connecting means into the  
5 three-phase induction motor.

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which;

Fig.1 is a constitutional diagram of one embodiment of the motor driven door devices according to the present invention ;

Fig.2 is a view of a mechanical structure of an elevator door seen from the floor side in the motor driven door devices ;

Fig.3 is a view of the same seen from the upper side ;

Fig.4 is a characteristic diagram of a door closing force of a door closer in the motor driven door devices ;

Fig.5 is a flowchart showing a part of program in a microcomputer for the door control of the one embodiment according to the present invention ;

Fig.6 is waveforms of DC braking currents flowing into the induction motor in the motor driven door devices ; and

Fig.7 is a constitutional diagram showing another embodiment of the motor driven door devices according to the present invention.

Fig.1 is a constitutional diagram of one embodiment of the present invention which is applied to an elevator door device.

The AC of a three phase power source 1 is converted to a DC by a converter 2. The rectified output is fed to an inverter 4 after being smoothed by a filtering capacitor 3. The inverter 4 supplies a three phase AC of variable voltage and variable frequency to a three phase induction motor 5.

A control unit 6 controls such as the inverter 4 and is provided with a microcomputer including such as a microprocessing unit (MPU) 601, a random access memory (RAM) 602, a read only memory (ROM) 603 and an input and output interface (I/O) 604, and is further provided with a MPU monitoring circuit 605 including such as a watch dog timer monitoring the MPU 601, a power service interruption detecting circuit 606 and a base drive circuit 607 for driving such as transistors 41 and 42 in the inverter 4.

A relay 7 is controlled by the control unit 6 and includes break contacts 7b1-7b3. The filtering capacitor 3 is connected between two input lines of the induction motor 5 via the contacts 7b1 and 7b2 and a resistor 8.

An elevator door which is driven by the induction motor 5 is explained with reference to Fig.2 and Fig.3.

Fig.2 is a view of the internal mechanical structure of the elevator door seen from the front thereof and Fig.3 is a view of the same seen from the above.

Through the revolution of the three phase induction

motor 5 an endless chain extending between prockets 11 and 12  
moved via a chain 10 to open and close elevator cage side  
doors 14 and 15. When an elevator cage 16 arrives within a  
predetermined landing zone, the cage side doors 14 and 15 and  
5 floor side doors 18 and 19 open and close together through an  
engagement device 17. In the present embodiment, a door  
closer spring 20 is attached to one of the floor side doors  
18 and 19 and a door closing force is provided to the door  
which varies dependent on the position of the door as shown  
10 in Fig.4. The door closer spring 20 is an indispensable  
device which serves to reliably close the floor side doors  
when no cage 16 is at the floor in order to prevent  
passengers on the floor from falling into the elevator moving  
duct.

15 In such elevator door device wherein the door closing  
force is always acting on the floor side doors 18 and 19,  
when a power service interruption happens and the driving  
torque from the induction motor 5 disappears at the moment  
when the doors are on the way of closing, the door is  
20 accelerated and collides to the end of the other door by the  
tensile force of the door closer spring 20. Thereby a large  
door collision sound is generated which frightens the  
passengers and further because the door safety is rendered  
inoperative the impact when a passenger is caught between the  
25 door becomes large and dangerous.

For the above problems, according to one embodiment of  
the present invention as shown in Fig.1, a DC braking is

acted on the motor 5 to limit the door closing speed.

Fig.5 shows a flow chart with regard to an operating program in the microcomputer as shown in Fig.1.

At first, via a timer interruption which is very frequently executed, at step 501 the program starts, at step 502 it is judged whether or not there is a power service interruption and when it is judged that there exists a power service interruption it is determined at step 503 whether the MPU 601 is normal or not and when the MPU 601 is determined normal the process moves to step 504 to energize the relay 7. Subsequently, it is determined at step 505 whether or not the relay 7 and the contacts 7b1-7b3 are normal. Namely, when the relay 7 is energized the break contact 7b3 must have been opened so that the opening and closing conditions of the contact 7b3 are taken in to determine the normality thereof. When it is determined normal and if a failure signal TB of the relay 7 is outputted, the signal output is stopped at step 506 to complete the processing at step 507.

At this moment in response to the arrival of the elevator cage 16 at a predetermined floor, a door opening command is provided in accordance with a processing flow (not shown) and a PWM signal from the MPU 601 is supplied to the inverter 4 via the base drive circuit 607. Thereby, the inverter 4 speed-controls the induction motor 5 via a predetermined PWM control and the door is opened smoothly against the force of the door closer spring 20. Further, when a door closing command is provided after a predetermined

time has passed or through the operation of a door closing button the door begins to close smoothly via the speed control of the induction motor 5.

Assuming that a power service interruption occurs at the moment when the door is on the way of closing. The power service interruption detecting circuit 606 as shown in Fig.1 generates a signal and such is sensed at the step 502 in Fig.5, then the process moves to step 508 to deenergize the relay 7 and at step 509 a gate suppress signal is outputted to such as the transistors 41 and 42 constituting the inverter 4 to stop the operation of the inverter 4. Thereby the operation of the inverter 4 is stopped and at the same time, the contacts 7b1 and 7b2 are closed to constitute a closed circuit routing through the filtering capacitor 3, resistor 8, contact 7b1, induction motor 5, contact 7b2 and the filtering capacitor 3 in Fig.1 and the charged electricity in the filtering capacitor 3 is discharged through the induction motor, in that for the filtering capacitor 3 a discharge current  $i_b$  flows and for the induction motor a DC braking current  $i_b$  flows.

Fig.6 shows variations of the DC braking current with respect to time. The magnitude of the DC braking current varies dependent upon the time constant determined by the capacitance of the capacitor 3 and the resistance of the resistor 8, and by selecting a proper amount of capacitance of the filtering capacitor 3 and a proper amount of resistance of the resistor 8, currents such as shown by

curves ib1 and ib2 are obtained. In an actual application, the duration of a DC braking current of about 1 sec. was satisfactory when the door opening or closing time was about 2 sec., in that the DC braking current indicated by curve ib1 was preferable.

Now, returning to Fig.5, when an abnormality of such as the MPU 601 is detected at step 503 by sensing the output of the monitoring circuit 605, in the same manner as the above the process moves to steps 508 and 509 and the operation of the inverter 4 is stopped as well as the DC braking is applied to the motor 5 to secure safety.

Subsequently, when an abnormality of the operating mode of the contact 7b3 such as caused by fusing of the contacts 7b3 is detected at step 505, the operation of the inverter 4 is stopped at step 510 as well as the failure signal TB of the relay 7 is outputted to an elevator control unit 9 at step 511. Thereby, the failure signal of the relay 7 is stored in the elevator control unit 9 and the cause of the elevator failure is promptly analyzed so that a reliable door device with a good maintenance property is obtained.

According to the above embodiment, generation of the DC braking torque to the door driving induction motor 5 in the event of a power service interruption is realized without providing a separate emergency use power source such as battery other than the purchased AC power source 1, thereby a motor driven door device having a good maintenance property as well as simple structure and economical production cost

is obtained.

Further, in addition to such advantages indicated above that the provision of the separate emergency use power source is eliminated by discharging the charged electricity in the  
5 filtering capacitor 3, which smoothes the rectified output from the converter 2, to the induction motor 5 in the event of power service interruption, by making use of advantageously the charged electricity in the filtering capacitor 3 which has to be discharged in the event of power  
10 service interruption in view of safety during the maintenance a remarkable advantage that no independent discharge circuit is needed is achieved.

Fig. 7 is another embodiment of the present invention.

In the drawing, only the portions different from those in the embodiment shown in Fig.1 are explained. All of the transistors 41-46 and diodes 411-461 which constitute the inverter 4 are illustrated and wherein a thyristor 24 which short-circuits one positive arm of one phase in the inverter circuit and another thyristor 25 which short-circuits one negative arm of a different phase therein are added.

Those thyristors 24 and 25 are fired by a firing circuit 608 which is added in the control circuit 6. The firing circuit 608 generates a firing pulse in response to the output from the power service interruption detecting circuit 606. Accordingly, when a power service interruption occurs, with the same timing as in the previous timing, a discharge current from the filtering capacitor 3, in other words the DC braking current  $i_b$  for the induction motor 5 flows through the closed circuit formed by the filtering capacitor 3, resistor 8, thyristor 24, induction motor 5, and thyristor 25. The thyristors 24 and 25 are fired by a single pulse and extinguish by themselves after the electricity in the filtering capacitor 3 is substantially discharged. Since only one single pulse is enough to fire the thyristors, the thyristors 24 and 25 are reliably fired by an electricity charged in a capacitor (not shown) contained in the firing circuit 608 even after the detection of a power service

interruption and the discharge current is serving the braking current is surely caused to flow into the induction motor 5.

It therefore becomes possible that, a motor driven door device with an induction motor as its driving source is provided which includes a door over speed preventing device in the event of a power service interruption having a simple constitution, economical production cost and good maintenance property.

**CLAIMS**

1. A motor driven door device comprising:  
an alternating current power source;  
a converter for converting the alternating  
5 current to a direct current;  
a filtering capacitor connected to the direct  
current output side of the converter for smoothing the  
output of the converter;  
an inverter for inverting the direct current to  
10 a three-phase alternating current;  
a three-phase induction motor for driving a door,  
the motor being powered by the inverter; and  
means for connecting the filtering capacitor  
between input terminals of the induction motor in the  
15 event of interruption of the power source, so that the  
electric charge stored in the filtering capacitor is  
discharged through the connecting means into the  
three-phase induction motor.
2. A motor driven door device according to claim 1,  
20 wherein the connecting means comprises a discharge  
circuit connected in parallel with the inverter.
3. A motor driven door device according to claim 1,  
wherein the inverter has a pair of switching elements  
for each of the three phases, the elements of each  
25 pair forming positive and negative arms respectively,  
signal input terminals for the switching  
elements, means for short-circuiting a positive arm of  
one phase and a negative arm of another phase, and an



input terminal for actuating the short-circuiting means.

4. A motor driven door device according to any one of the preceding claims, having means for stopping the
  - 5 inverter in response to a predetermined condition other than interruption of the power source and connecting the filtering capacitor to the three-phase induction motor.
  5. A motor driven door device according to any one
  - 10 of the preceding claims, wherein the connecting means includes a resistor.
  6. A motor driven door device substantially as herein described, with reference to the accompanying drawings.
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