

Electric Motor Drive Circuit

The present invention relates to an electric motor circuit wherein A.C. motors of different rated voltages are provided with an emergency A.C. supply, and
5 the invention has application to an elevator to operate an A.C. traction motor and an A.C. door opening motor in the event of a breakdown of the normal A.C. supplies to the motors.

When an elevator stops between floors due to a
10 breakdown of its normal power supply, it is desirable to move the elevator to the nearest floor and open the elevator door to allow the passengers to disembark.

It has been proposed to use a battery as an emergency power supply, with the A.C. traction motor and
15 the A.C. door opening motor being driven via respective inverters from the D.C. battery supply. The traction and door opening motors have different ratings with the result that separate inverters have had to be used to derive suitable A.C. emergency supplies for motors.

20 In accordance with the present invention there is provided an electric motor circuit comprising first and second A.C. electric motors of different rated voltages, means for providing to the motors respective A.C. supplies for normally driving the motors, and an emergency drive

circuit comprising an inverter for producing an emergency A.C. supply from a D.C. supply, the inverter being selectively operable in a first or a second mode, wherein in said first mode the inverter supplies to the first
5 motor an emergency A.C. supply for driving the first motor and in said second mode the inverter supplies to the second motor an emergency A.C. supply for driving the second motor.

Thus in accordance with the invention a single
10 inverter can be used to provide an emergency A.C. supply for both of the motors.

In order that the invention may be more fully understood embodiments thereof in an elevator will be described by way of example with reference to the accom-
15 panying drawings and by way of contrast with a prior proposal for an emergency A.C. motor supply for an elevator. In the accompanying drawings:

Figure 1 is a circuit diagram of a prior proposal for providing emergency power to an elevator traction
20 motor;

Figure 2 is a circuit diagram of a first embodiment of a motor circuit according to the invention, for an elevator;

Figure 3 illustrates the waveforms produced
25 by the oscillator circuit 7 of Figure 2;

Figure 4 is a circuit diagram of an inverter circuit used in a second embodiment of the invention, together with an oscillator and turn-on circuit;

Figure 5 shows timing of the turn-on of the inverter device wherein Figure 5(a) shows the timing of the "H" level of a command signal and Figure 5(b) shows the timing of the "L" level of a command signal;

Figure 6 is a timing chart showing the states of the parts of the inverter device and the turn-on circuit shown in Figure 4: and

Figure 7 is a schematic view of the other embodiment of the present invention.

Referring firstly to the prior proposal shown in Figure 1, the references R, S, T designate a three phase D.C. 400V power source for driving an elevator traction motor 3. The motor 3 drives an elevator cage (not shown). Two sets of control contactors 1 and 2 are provided. When the contactors 1a-c are closed the motor 3 is driven forwardly to make the elevator ascend, whereas when and alternatively the contactors 2a-c are closed, the motor 3 is driven in reverse to cause the elevator to descend. The arrangement of the contactors 1 and 2 is such that when the contactors 1 are open, contactors 2 are closed or vice versa, (this is referred to as interlock) so that the elevator is never simultan-

ously driven up and down. An emergency D.C. power source 4 such as a D.C. battery drives, via a contact 5 which is closed for emergency operation, an inverter 6 comprising semiconductor devices for converting the D.C. battery power into an A.C. emergency supply for the motor 3. The inverter 6 is driven by an oscillator 7 via a turn-on circuit 8 for generating a turn-on signal for sequentially turning on elements of the inverter device 6 in response to the oscillatory output of the oscillator 7. Contacts 9a-c of a contactor 9 are closed for making the elevator ascend under the emergency power from the battery 4 whereas contacts 10a-c are alternatively closed when it is desired to make the elevator descend under the emergency power from the battery. The contactors 9 and 10 are interlocked with one another and are also interlocked with the contactors 1 and 2. An A.C. motor of a different voltage rating for door-opening and closing (not shown) is provided. In the normal state, the A.C. power of the three phase A.C. power source R, S, T is fed through the contacts 1a to 1c or 2a to 2c to the traction motor 3 whereby the cage is driven to ascend or descend. In an emergency, the emergency contact 5 is closed whereby the A.C. power having a specific frequency produced by the inverter 6 is fed through the contacts 9a to 9c or 10a

to 10c, to the traction motor 3 whereby the cage is driven upwardly or downwardly depending upon which of the contactors 9 or 10 is closed.

When the induction motor is driven by the inverter 6, the following equation relates the voltage and frequency of the applied A.C. power to the voltage and frequency of the emergency power produced by the inverter 6:

$$\frac{V}{f} = \frac{V'}{f'}$$

10 wherein V : voltage of the power source in the normal state;

f : frequency of the power source;

V' : output voltage of the inverter device 6;

f' : output frequency of the inverter device 6.

15 Therefore, when the traction motor 3 is driven, the output frequency f' and voltage of the battery are set to suitable values taking into account the desired motor speed required for the emergency operation, and the expense of the standby circuits for emergency operation.

20 When an induction motor is used for a motor for door-opening and closing of the cage, usually the rated voltage of the traction motor 3 is different from the rated voltage of the motor for door-opening and closing. The voltage of the power source for the traction motor 3

is 400 V in three phase whereas the voltage of the power source for the motor for door-opening and closing is 100 V in three phase. In view of the above equation and the revolution speed of the motor for door-opening and closing, it is necessary to use a separate inverter circuit for the motor for door-opening and closing to that shown in Figure 1. This is disadvantageous as it undesirably complicates the circuit, increases the cost and decreases the reliability.

10 An embodiment of the present invention will now be described with reference to Figures 2 and 3. The circuit arrangement shown in Figure 2 is generally similar to that of Figure 1 and like parts are shown with the same reference numerals as used in Figure 1.

15 As in Figure 1, the traction motor 3 is driven by a usual three phase A.C. supply RST or from an emergency supply developed by the battery 4 and the inverter 6.

 Additionally, the door opening motor 15, which
20 is rated at a lower voltage than the traction motor 3, is driven from a three phase A.C. power source (100 V) R_1 , S_1 , T_1 . Contacts 11a-11c of contactor 11 are closed to open the door, whereas contacts 12a-c of contactor 12 are alternatively closed to close the door. In an
25 emergency, when power from the source R_1 , S_1 , T_1 , is lost, power is derived from the battery 4 via the inverter 6.

In the emergency situation, contactor 13 is closed to open the door, whereas contactor 14 is closed to close the door.

An input terminal 16 receives a driving command
5 signal which is a logic signal that when in a logical high or "H" level instructs the inverter 6 to drive the traction motor 3, but when the command signal is at a logical low or "L" level instructs the inverter to drive the door motor 15. The oscillator circuit 7 in Fig. 2
10 differs from Fig. 1 in that it includes two oscillators 17, 18 which operate at different frequencies. The oscillator 17 produces rectangular pulses as shown at 17a in Figure 3 whereas the oscillator 18 generates the pulse waveform 18a (Fig. 3) having a frequency higher
15 than the frequency of the pulses 17a. An inverter or NOT gate 19 and NAND gates 20 and 22 comprise a logic circuit 100 for selecting the output of oscillator 17 or 18 in dependence upon whether the input at 16 is at a "H" or "L" level. The output of the circuit 100 is either
20 as shown at 22a or 22b of Figure 3 and is applied to the turn-on circuit 8.

The contacts 11a to 11c are interlocked with the contacts 12a to 12c, and the contacts 13a to 13c are interlocked with the contacts 14a to 14c. The contacts
25 1a to 1c are interlocked with the contacts 2a to 2c and

the contacts 9a to 9c are interlocked with the contacts 10a to 10c.

The operation of the embodiment of Figure 2 will now be described in detail.

5 The driving of the traction motor in the normal state has been described with reference to Figure 1. The door motor 15 is normally driven from the supply R_1 , S_1 , T_1 and can be driven in a forward or reverse direction to open and close the door under the control
10 of contactors 11 and 12.

In an emergency condition when the normal power supplies R, S, T and R_1 , S_1 , T_1 are interrupted, the elevator cage may stop between floors. The automatic emergency braking is then released by a circuit (not shown).
15 When the safety is confirmed by a circuit (not shown), the driving command signal 16 assumes the "H" level, whereby the output of the NAND gate 20 is in a reverse phase to the pulse waveform 17a of the oscillator 17. The output of the NOT gate 19 assumes the "L" level,
20 whereby the output of the NAND gate 21 is kept in "H" level regardless of the pulse waveform 18a of the oscillator 18. Therefore, the output 22a of the NAND gate 22 is the same phase as that of the pulse waveform 17a. The inverter 6 therefore generates A.C. emergency power at a
25 frequency corresponding to the frequency of the pulse

waveform 17a to feed emergency power through the contacts 9a to 9c or 10a to 10c (depending upon whether the elevator is set to ascend or descend), to the traction motor 3, whereby the cage runs to reach the door openable section of the nearest floor. Then, the contacts 9a to 9c or the contacts 10a to 10c are opened to actuate electromagnetic braking to stop the cage.

Then the driving command signal 16 assumes the "L" level. The output of the NAND gate 20 is consequently held at the "H" level. The output of the NOT gate 19 assumes the "H" level whereby the output of the NAND gate 21 has the reverse phase to the pulse waveform 18a of the oscillator 18 and the output 22b of the NAND gate 22 has the same phase as that of the pulse waveform 18a. The output frequency of the inverter device 6 thus becomes four times the frequency supplied to the traction motor 3 and is fed through the contacts 13a to 13c of the contactor for door-opening, to the door opening motor 15 whereby the motor 15 opens the door. When the door is opened, the contacts 13a to 13c are opened. The contacts 14a to 14c for door closing are closed after a specific period from the door-opening, whereby the motor 15 is reversed to close the door. When the door closes, the contacts 14a to 14c are opened. In such emergency operation of the door, the speed of door-opening and

closing is slower than the speed in the normal state but is acceptable in view of the pertaining emergency situation.

In this embodiment, the ratio of the output voltage of the inverter device 6 to the voltage of the power source in the normal state is substantially the same as the ratio of the frequency of the output of the inverter device 6 to the frequency of the power source in the normal state whereby in accordance with the previously mentioned equation the developed motor torque in the emergency state is substantially the same as the torque in the normal state.

Thus, the frequency of the output of the inverter 6 in the emergency condition is different from the A.C. frequency in the normal state so as to give the same motor torque with the reduced voltage of the emergency power supply. By use of the two oscillators 17, 18 operating at different frequencies, optimum emergency supply frequencies can be selected for the different rated motors 3, 15, thus enabling a single inverter 6 to be used for both of the motors.

If the frequency of the output in the emergency condition is the same as the frequency in the normal state, the torques of the motors 3, 15 are lower than the torques in the normal state. When the motors 3, 15

can be driven by such lower torques, this feature can be applied in the practical operation.

The inverter 6 need not be a semiconductor type inverter device and can be the rotary type inverter device which can control frequency of the output by varying its revolution speed, or an inverter device which opens and closes a contactor in a varied time interval to control frequency of the output.

In the embodiment just described, separate electromagnetic contactors 13, 14 are provided for door-opening and door-closing and separate electromagnetic contactors 9 and 10 are provided for ascending operation and descending operation. It is however possible in accordance with the invention to provide only one electromagnetic contactor for both door-opening and closing and only one electromagnetic contactor for both ascending and descending operation, and additionally to invert selectively the order of phases produced by the inverter. Such an arrangement is shown in Figure 7, and will now be described in detail with additional reference to Figures 4 to 6.

In Figure 4, the inverter 6 comprises transistors T_1 to T_6 and diodes D_1 to D_6 . The turn-on circuit 8 comprises hexagonary up/down counter 23, an up/down terminal U/D which switches the counter 23, to count up

or down depending upon level "H" or "L" of the command signal, output terminals A to F of the counter 23, NOR elements 24A to 24F, resistors R_{A1} , T_{A2} , transistors T_A , resistors R_{F1} , R_{F2} and transistor T_F . The counter
5 23 is formed to be hexagonary counter corresponding to the number of the transistors T_1 to T_6 and receives as its input the clock signal of the oscillation circuit 7. When the outputs of the NOR elements 24A, 24B, 24C, 24D, 24E, 24F are in "L" level, the corresponding
10 transistors T_1 , T_2 , T_3 , T_4 , T_5 , T_6 are respectively connected to be in turned-on state. The NOR elements 24A to 24F form a logical circuit connected to the output of the counter 23.

Figure 5 is a timing chart showing the relation
15 of the levels of the signals received at the U/D terminals, and the ON state of the transistors T_1 to T_6 . When the level of the signal is in "H", the transistors T_1 to T_6 are in ON state in the combination shown in Figure 5(a). In Figure 5, the arrow line t shows the time to
20 the arrow line and the references T_1 to T_6 designate the transistors in ON state. On the other hand, when the level of the signal is in "L", the transistors T_1 to T_6 repeat ON-OFF state in the combination shown in Figure 5(b). As it is clear from Figures 5(a) and 5(b), the phase
25 rotation is reversed between the two Figures.

Figure 6 shows the states of various parts shown in Figure 4. In Figure 6, the arrow line t shows the time and the references "H", "L" designate levels of the signals; the references "ON", "OFF" designate states of the operations. The left side from the dotted chain line shows the states in the "H" level of the signal at the U/D terminals and the right side from the dotted chain line shows the states in the "L" level of the signal at the U/D terminals. As it is clear from Figures 4-6, the ON-OFF timing modes of the transistors T_1 to T_6 is reversed and accordingly the phase rotation of the output of the inverter device 6 is reversed depending upon the level of the signals at the U/D terminals (level of the command signal).

Figure 7 shows the structure of the apparatus using the inverter devices shown in Figures 4 to 6. In Figure 7, the references Ma-Mc designate contacts for motor driving; and Da - Dc designate contacts for door-opening and closing. That is, when the inverter 6 whose phase rotation can be switched as shown in Figures 4 to 6 is used, the contacts 9a - 9c, 10a - 10c, 13a - 13c and 14a - 14c shown in Figure 2 need not be used. Only one set of the contacts Ma - Mc for being closed to establish the motor driving condition and one set of the contacts Da - Dc for being closed for establishing a door-opening or closing condition can be

used instead of the contacts 9a - 9c and 13a - 13c.
Therefore, only one pair of contacts is used. The
contacts for motor driving Ma - Mc and the contacts
for door-opening and closing Da - Dc should be
5 interlocked.



CLAIMS:

1. An electric motor circuit comprising first and second A.C. electric motors of different rated voltages, means for providing to the motors respective A.C. supplies for normally driving the motors, and
5 an emergency drive circuit comprising an inverter for producing an emergency A.C. supply from a D.C. supply, the inverter being selectively operable in a first or a second mode, wherein in said first mode the inverter supplies to the first motor an emergency A.C. supply
10 for driving the first motor and in said second mode the inverter supplies to the second motor an emergency A.C. supply for driving the second motor.

2. An electric motor circuit according to
15 claim 1, wherein the inverter is driven by oscillator circuit means and in the first and second modes the oscillator circuit means drives the inverter at respective different frequencies.

20 3. An electric motor circuit according to claim 2, wherein the oscillator circuit means includes first and second oscillators which in use oscillate at said different frequencies respectively, and logic



circuit means for selectively operating the first or the second oscillator.

4. An electric motor circuit according to
5 any preceding claim, wherein the motors are multi-phase motors and the inverter is adapted to produce a multi-phase emergency A.C. supply.

5. An electric motor circuit according to
10 claim 4, including means for selecting the direction of rotation of the motors produced by the emergency A.C. supply.

6. An electric motor circuit according to
15 claim 5, including electrical contactors connected in the emergency supply and arranged to reverse the phases of the emergency supply to the motors.

7. An electric motor circuit according to
20 claim 6, including logic circuit means associated with the inverter and arranged to alter selectively the sequence of the phases of the emergency supply produced by the inverter.



8. An electric motor circuit according to any preceding claim and incorporated in an elevator, wherein one of the motors comprises a traction motor for the elevator and the other motor is arranged
5 to open and close the door of the elevator.

9. An electric motor circuit substantially as hereinbefore described with reference to Figures 2 and 3 or Figures 4 to 7 of the accompanying drawings.

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