

TITLE OF THE INVENTION

ELEVATOR WITH ELECTRONIC SAFETY SYSTEM

FIELD OF THE INVENTION

5 The present invention relates to an elevator with an electronic safety system and is particularly suitable for application to an elevator with an electronic safety system that implements safety control by an electronic safety controller, less relying on mechanical safety devices.

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BACKGROUND OF THE INVENTION

Heretofore, elevators are provided with a safety system including diverse devices to ensure safe movement of an elevator car (hereinafter referred to as the car). When an abnormal
15 behavior of the car is detected by any of detecting devices, the safety system makes the car transit into a safe state. The detecting devices are arranged to detect, for example, whether the car is moved at a specified moving speed or whether the car is within a moving range in a hoistway. The detecting devices
20 include, for example, a final limit switch, a governor, a rotary encoder installed on a shaft or the like of the governor for acquiring information on the speed and position of the car, and a door switch. If any of the detecting devices has detected an abnormal behavior of the elevator, it sends a signal to a
25 controller, thus triggering a predetermined operation for

making the car transit into a safe state is performed, for example, power shutoff to shut off the power supply to a drive motor and stop the operation of a traction machine or emergency stop to directly stop the movement of the car.

5 It is known that an electronic safety controller that electronically controls the safety system adopts dual CPUs to enhance its reliability and facilitate the detection of abnormality, compares the computational processing results of the CPUs, and executes transition of the elevator into a safe
10 state and emergency stop of the car upon detecting overspeed or positional aberration.

Furthermore, an electronic safety controller using dual CPUs is known, in which a two-port RAM is connected to the CPUs as a shared memory for data transfer between both the CPUs in
15 order to compute the position and speed of the car without incorrect interpretation of data. Dual pulse signals that are output from the rotary encoder are input to the CPUs respectively. Computation results of the CPUs are compared with each other via the shared memory and then compared to a reference value
20 for abnormality judgment. Such electronic safety controller is described, e.g., in PCT International Application WO 2006/033153.

SUMMARY OF THE INVENTION

25 In the related art mentioned above, because the CPUs

compute the speed by counting pulse signals that are input within a certain period of time, complete clock synchronization is required to synchronize processing timing of both the CPUs. Besides, it is needed to monitor for an abnormal clock frequency and this complicates structure and requires a watchdog timer as dedicated hardware.

In a case where clock synchronization is hard to attain, an allowable error range has to be broaden to increase availability, i.e., to improve availability. Sufficient speed data and position data needed for mutual comparison are as much as eight bytes, whereas the shared memory has a capacity of several kilobytes; this is wasteful.

With the air of solving the problems of the related art discussed above, an object of the present invention is to provide a system that is capable of ensuring high safety, the system which dispenses with dedicated hardware, which is simple and has high availability, and in which software processing load is reduced.

To achieve the foregoing object, the present invention resides in an elevator with an electronic safety system including a rotary encoder that outputs pulse signals corresponding with movement of a car as encoder signals and an electronic safety controller having a first CPU and a second CPU to which the encoder signals are input respectively. The first and second CPUs compute speed and position data of the car and their

computation results are compared with each other and,
accordingly, the electronic safety controller decides whether
abnormality occurs. Car speed and position data computed in
multiple cycles are transferred between the first and second
5 CPUs by serial communication and compared. If such data is
beyond an allowable error range set beforehand, the electronic
safety controller decides that abnormality occurs.

According to the present invention, since car speed and
position data computed in multiple cycles are transferred
10 between the first and second CPUs by serial communication and
compared, reliability is enhanced and it is possible to improve
availability without broadening an allowable error range. Thus,
there is no need to completely synchronize processing timing
of each microcomputer and, without complexity of software design,
15 it is possible to provide a system capable of ensuring high
safety, which is simple and in which software processing load
is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

20 Fig. 1 is an overall structural diagram of an elevator
with an electronic safety system according to an embodiment
of the present invention;

Fig. 2 is a block diagram depicting a controller according
to an embodiment;

25 Fig. 3 depicts a format of data which is communicated

between CPUs according to an embodiment;

Fig. 4 is a flowchart illustrating operation according to an embodiment; and

Fig. 5 is a flowchart illustrating a booting operation according to an embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 depicts an overall structure of an elevator 1 with an electronic safety system in which a traction machine and a control panel are installed beside a hoistway. The elevator 1 with an electronic safety system is the elevator whose safety system is electronically controlled by an electronic safety controller 42. It includes a car 10, a traction machine 20, a main rope 30, and a controller 40. The car 10 is a cage that carries people, luggage, or the like and moves within the hoistway 50 by drive force that is supplied from a motor 21 via the main rope 30.

On the inside of the car 10, an in-car operation panel 11 and a car door switch 12 are provided. The in-car operation panel 11 includes a control part (not depicted) that is operated by a passenger to specify a floor to which the car 10 should go or to open/close the door and a display part (not depicted) that displays the indication of a floor or floors to which the car 10 should go, the state of the car 10, etc. The car door switch 12 is a switch that detects opening and closing of the

door of the car 10.

On the outside of the car 10, an emergency stop device 13 and a position detection sensor 14 are provided. The emergency stop device 13 is a device that is fixed to the car 10 and immediately stops the car 10 by grasping the rail in case of emergency. The position detection sensor 14 is a sensor that senses a distance between the car 10 and a shield plate 81 to 83 provided on every floor at which the car 10 stops.

Final limit switches 51, 52 are provided in the vicinity of the upper and lower ends of the hoistway 50 in which the car goes up and down. The final limit switches 51, 52 are switches that turn on when the car 10 has moved beyond a prescribed moving range, thus detecting an abnormal behavior of the car.

Besides, a buffer 53 is provided at the lower end of the hoistway 50. The buffer 53 is a physical stoppage device that stops the car 10 by coming into direct contact with the car 10 and absorbing impact if it is unable to stop the car 10 completely by braking force produced by the traction machine 20 and the emergency stop device 13.

In every floor at which the elevator 1 with an electronic safety system stops, there are provided a landing door switch 64 to 66 that detects opening and closing of a landing door 61 to 63 and a hall button panel 67 to 69 that is operated by a user.

The traction machine 20 is a device that moves the car

10 within the hoistway 50 by supplying drive force produced by revolution of the motor 21 to the main rope 30. It includes the motor 21, a traction brake 22, an inverter 23, a shutoff circuit 24, and an AC power supply 25.

5 One end of the main rope 30 is connected to the car 10 and a counterweight 31 is connected to the main rope 30 in the vicinity of the other end of the main rope 30. A path of the main rope 30 is formed by one or more sheaves 33 to 35.

 A governor rope 36 that moves in conjunction with the
10 movement of the car 10 is connected to the car 10. A governor 37 rotates, following the movement of the governor rope 36. The governor 37 includes a rotary encoder 38 and a gripping device 39 that grips the governor rope 36. A path of the governor rope 36 is formed by a sheave 32.

15 The rotary encoder 38 rotates with the rotation of the governor 37 and outputs dual pulse signals as encoder signals to the electronic safety controller 42. The electronic safety controller 42 computes the speed and position of the car 10 by counting the pulse signals that are input within a certain
20 period of time.

 The controller 40 includes an elevator controller 41 and an electronic safety controller 42. The elevator controller 41 mainly controls the operations of mechanical parts and electronic parts of the elevator 1 with an electronic safety
25 system. The electronic safety controller 42 electronically

controls the operations of diverse devices of the safety system. The electronic safety controller 42 uses dual microcomputers (CPUs) for enhanced reliability, in which output signals of the CPUs are input to each other and their computational
5 processing results are compared.

Fig. 2 depicts relation between the controller 40 and each part of the elevator 1 with an electronic safety system. The motor 21 is supplied with power from the AC power supply 25 via the inverter 23 to which a power supply interrupter 241
10 is connected. The power supply interrupter 241 operates by power that is supplied from POWER 224 via drive current shutoff devices 242a, 242b for the electronic safety controller and a drive current shutoff device 243 for the elevator controller. Unless the drive current shutoff devices 242a, 242b and the
15 drive current shutoff device 243 are both closed, no current is conducted to the power supply interrupter 241.

When the elevator 1 with an electronic safety system operates normally, the power supply interrupter 241 is put in a conducting state and makes a connection between the AC power
20 supply 25 and the inverter 23, and the power is supplied from the AC power supply 25 to the inverter 23. In case there is a need for emergency stop of the car, the power supply interrupter 241 is put in a non-conducting state and opens the connection between the AC power supply 25 and the inverter 23, and shuts
25 off the power supply from the AC power supply 25 to the inverter

23. Alternatively, while the power supply interrupter 241 is put in a conducting state, it may also be implemented that the AC power supply 25 and the inverter 23 are connected so that the AC power supply 25 and the inverter 23 are opened and
5 non-conducting.

In the vicinity of the motor 21, a traction brake 22 is provided. The traction brake 22 is supplied with power from POWER 223 via brake shutoff devices 221a, 221b for the electronic safety controller and a brake shutoff device 222 for the elevator
10 controller. Unless the brake shutoff devices 221a, 221b and the brake shutoff device 222 are both closed, no current is conducted to the traction brake 22.

When the elevator 1 with an electronic safety system operates normally, the traction brake 22 is put in a conducting
15 state and remains in a state in which it does not exert braking force on the motor 21. In case of stopping the car, the traction brake 22 is put in a non-conducting state and exerts braking force on the motor 21 to decelerate the revolution of the motor 21. Note that the power supply interrupter 241, the drive
20 current shutoff devices 242a, 242b, and the drive current shutoff device 243 are arranged inside the shutoff circuit 24 depicted in Fig. 1.

The elevator controller 41 controls the drive power produced by the motor 21 and supplied to the main rope 30 by
25 controlling electric power supplied from the AC power supply

25 to the motor 21, while exchanging signals with the inverter
23. The elevator controller 41 also controls current
conduction to the power supply interrupter 241 and the traction
brake 22, respectively, by sending a control signal to the drive
5 current shutoff device 243 and the brake shutoff device 222.

The electronic safety controller 42 takes input of signals
from the rotary encoders 38a, 38b, position detection sensor
14, and various safety switches 270. The safety switches are
the car door switch 12, landing door switches 64 to 66, final
10 limit switches 51, 52, or signals equivalent to them.

The electronic safety controller 42 controls current
conduction to the power supply interrupter 241 and the traction
brake 22, respectively, by sending a control signal to the drive
current shutoff devices 242a, 242b and the brake shutoff devices
15 221a, 221b, based on the input signals. Besides, the electronic
safety controller 42 sends information indicating a result of
its control to the elevator controller 41 as log information.

In a situation where platform repositioning control
occurs less often, as only a small number of passengers who
20 use the elevator 1 with an electronic safety system and luggage
pieces or the like enter and leave the car, the electronic safety
controller 42 disables the execution of the platform
repositioning control for an interval between opening and
complete closing of the door of the car 10 and executes an
25 operation test (which may, hereinafter, also be referred to

as a device diagnosis) of the brake shutoff devices 221a, 221b and the drive current shutoff devices 242a, 242b.

Dual encoder signals from the rotary encoders 38a, 38b are input respectively to the CPU 1 and CPU 2 in the electronic safety controller 42. The two CPUs are connected by a communication line through a serial interface (serial I/F) within each CPU to make an abnormality decision after comparing their computation results with each other. Car speed and position data computed by each CPU are transferred between the CPUs by serial communication. Moreover, car speed and position data computed in at least a plurality of cycles are compared with each other. When having determined that such data is beyond an allowable error range set beforehand, the electronic safety controller regards it as abnormality and decides to make emergency stop of the elevator.

Fig. 3 depicts a format of data detail which is communicated between the CPUs. This data format is comprised of communication header data HDATA which is prepended to the beginning of communication data, acceptance signal data ADATA, sequential number data SQNDATA, car speed data SPDDATA, car position data POSDATA, spare data SPRDATA, and communication footer FDATA which is appended to the tail of communication data.

A case in which data is transmitted from the CPU 1 to the CPU 2 is described. When the CPU 2 has received data from

the CPU 1, it copies car speed and position data as of one cycle ago to the area for data as of two cycles ago, copies car speed and position data held as current data to the area for data as of one cycle ago, and stores the received data into the current data area. Moreover, each CPU uses three sets of data computed by the other CPU and held as the current data, data as of one cycle ago, and data as of two cycles ago and compares these sets of data with the corresponding sets of data computed by itself. Thereby, the CPU determines whether or not there is abnormality in computation results of car speed and position data which is serial data. Thus, data equalization and reliability are enhanced and it is possible to improve availability without broadening an allowable error range.

The acceptance signal data ADATA is an area in which data signifying whether or not initialization has finished in each CPU is set. The value of the sequential number data SQNDATA is incremented each time data is transmitted, so that the receiving side can determine whether or not the data is updated by referring to it.

Fig. 4 is a flowchart illustrating basic operation of the safety controller. At step 401, a determination is made as to whether or not initialization (which is also called booting) has finished. If initialization has not finished, initialization such as setting a CPU timer cycle period is executed at step 402. Fig. 5 is a flowchart illustrating a

booting operation. At step 501, rated speed data is read from a storage area (ROM DATA) stored within the CPU.

At step 502, depending on the rated speed data, a cycle period is set as CPU timer time suited for predefined positional
5 precision. For example, under the condition of a positional precision of ± 10 mm, if the rated speed data is 150 m/min, a cycle period of 4 ms is set.

After setting an initialization finished flag ON at step S503, the microcomputer executing this operation sends its
10 computed data to be shared between the CPUs to the other microcomputer (step 504).

At step 505, the microcomputer determines whether or not initialization has finished, based on data to be shared between the CPUs received from the other microcomputer. Upon making
15 sure that initialization has finished, the microcomputer terminates the flow. If initialization has not finished, the microcomputer returns to step S504.

In Fig. 4, when initialization has finished, it is determined at step 403 whether or not a predetermined period
20 of the CPU timer has elapsed. If the period has not elapsed, the process goes to steps 411, 412 in which the temporary storage areas for data as of one cycle ago and data as of two cycles ago are updated. When the period has elapsed, the electronic safety controller 42 updates at step 404 input information which
25 is input from the position detection sensor 14 and various safety

switches 270 and computes speed and position data of the car 10, based on the input signals.

Besides, the controller stores car position data as of two cycles ago in a temporary storage area in order to indicate
5 a floor at which the car emergency-stopped to users (passengers). This stored data is used to indicate it, for example, on the hall button panel in a lobby floor. If the car speed is at or more than a predefined speed in a position where forced deceleration is required, e.g., in the vicinity of an uppermost
10 or lowermost floor, it is determined at step 408 that the car position is not abnormal, but the car speed is abnormal. In that event, after making emergency stop of the elevator at step 409 and then, at step 413, the elevator controller computes the floor at which the car stopped from the data stored at step
15 S404 and indicates it on the hall button panel in the lobby floor.

At steps 405 to 407 of the process illustrated, determination is made as to whether the current car speed data, same data as of one cycle ago, and same data as of two cycles
20 ago held in the CPU 1 and the CPU 2 fall, respectively, within first, second, and third allowable speed error ranges which may be, e.g., $\pm 5\%$ (first), $\pm 10\%$ (second), and $\pm 15\%$ (third). When such data falls within the range, the process goes to steps 411, 412 in which the temporary storage areas for data as of
25 one cycle ago and data as of two cycles ago are updated.

At step 408, if the car position is not abnormal, but the car speed is abnormal, and if a maximum value of speed data with respect to each cycle, received from the other microcomputer and computed by the microcomputer itself, is less than the
5 predefined speed, then the car is stopped at the nearest floor at step 410.

WHAT IS CLAIMED IS:

1. An elevator with an electronic safety system comprising a rotary encoder that outputs pulse signals corresponding with movement of a car as encoder signals and an electronic safety controller having a first CPU and a second CPU to which the encoder signals are input respectively, wherein the first and second CPUs compute speed and position data of the car and their computation results are compared with each other and, accordingly, the electronic safety controller decides whether abnormality occurs,

wherein car speed and position data computed in a plurality of cycles are transferred between the first and second CPUs by serial communication and compared and, if such data is beyond an allowable error range set beforehand, the electronic safety controller decides that abnormality occurs.

2. The elevator with an electronic safety system according to claim 1, wherein the first and second CPUs compute speed data for each cycle and determination is made as to whether current speed data, speed data as of one cycle ago, and speed data as of two cycles ago fall within respective allowable error ranges.

3. The elevator with an electronic safety system according

to claim 1, wherein, if the speed data is beyond the allowable error range set beforehand and if a maximum value of the speed data computed in a plurality of cycles is at or more than a predefined speed, the electronic safety system makes emergency
5 stop of the car.

4. The elevator with an electronic safety system according to claim 1, wherein, if the speed data is beyond the allowable error range set beforehand and if a maximum value of the speed
10 data computed in a plurality of cycles is less than a predefined speed, the electronic safety system stops the car at the nearest floor.

5. The elevator with an electronic safety system according
15 to claim 1, wherein a period of the cycle is determined from rated speed data during booting.

6. The elevator with an electronic safety system according to claim 1, wherein car speed and position data as of two cycles
20 ago is stored and the electronic safety system stops the car when it has been decided that abnormality occurs and indicates a floor at which the car stopped to users (passengers), based on the stored data.

25 7. The elevator with an electronic safety system according

to claim 1, wherein acceptance signal data signifying whether or not initialization has finished in each CPU is added to data that is communicated between the first and second CPUs by serial communication.

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8. The elevator with an electronic safety system according to claim 1, wherein sequential number data that is incremented each time data is transmitted, so that the receiving side can determine whether or not the data is updated by referring to
10 it, is added to data that is communicated between the first and second CPUs by serial communication.
