

DESCRIPTION

Title of Invention: ELEVATOR INVERTER SYSTEM, METHOD FOR DETERMINING ABNORMALITY IN ELEVATOR INVERTER, SERVER, AND MOBILE TERMINAL

TECHNICAL FIELD

[0001]

The present invention relates to an elevator inverter system, a method for determining an abnormality in an elevator inverter, a server, and a mobile terminal.

BACKGROUND ART

[0002]

There has been known an elevator that includes a motor that raises and lowers a car, a motor control circuit that controls the motor, and a host controller that controls the motor control circuit based on an operation input by a passenger to an operation panel in the car (for example, see Patent Literature 1).

CITATION LIST

PATENT LITERATURE

[0003]

Patent Literature 1: JP 2016-166071 A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004]

If setting parameters of a motor control circuit are inappropriate or changed due to aging of an elevator or the like, the ride quality of the elevator may be degraded. Such a state may also cause a failure of the elevator itself.

[0005]

Consequently, an object of the present invention is to provide an elevator inverter system, a method for determining an abnormality in an elevator inverter, a server, and a mobile terminal that can detect an abnormal operation of a motor control circuit.

SOLUTION TO PROBLEM

[0006]

An elevator inverter system according to the first aspect includes: a motor control circuit that supplies power to a motor that raises and lowers a car of an elevator in order to control the motor; a normal waveform storage unit that stores normal waveform information indicating an operation waveform in the motor control circuit when the elevator is operated under a predetermined operating condition; and an abnormality determination unit that, based on the normal waveform information stored in the normal waveform storage unit, compares operating waveform information indicating an operation waveform in the motor control circuit when the elevator, which is operating, is operated under the predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit is operated normally.

[0007]

A method for determining an abnormality in an elevator inverter according to the second aspect includes: causing a motor control circuit to supply power to a motor that raises and lowers a car of an elevator in order to control the motor; storing normal waveform information indicating an operation waveform in the motor control circuit when the elevator is operated under a predetermined operating condition; and based on the normal waveform information, comparing operating waveform information indicating an operation waveform in the motor

control circuit when the elevator, which is operating, is operated under the predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit is operated normally.

[0008]

A server according to the third aspect is a server capable of communicating with a mobile terminal. The server includes: an abnormal waveform acquisition unit that acquires abnormal waveform information indicating an operation waveform in the motor control circuit when it is determined that the motor control circuit included in an inverter is not operated normally from the mobile terminal; and an adjustment information generating unit that generates adjustment information about adjustment of the motor control circuit based on the abnormal waveform information acquired by the abnormal waveform acquisition unit.

[0009]

A mobile terminal according the fourth aspect includes: a position information storage unit that stores connection destination position information indicating a position corresponding to an inverter including a motor control circuit that supplies power to a motor in order to control the motor and a communication unit having a communication function; a position information acquisition unit that acquires terminal position information indicating a current position of the mobile terminal; a connection destination determination unit that determines a communication unit corresponding to an inverter to be connected based on the connection destination position information and the terminal position information; and a radio communication unit that performs radio communication with a communication unit determined by the connection destination determination unit.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010]

According to the present invention, it is possible to provide an elevator inverter system, a method for determining an abnormality in an elevator inverter, a server, and a mobile terminal that can detect an abnormal operation of a motor control circuit.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a diagram illustrating an overall configuration of an elevator inverter system according to an embodiment.

Fig. 2 is a diagram illustrating a hardware configuration of an elevator according to the embodiment.

Fig. 3 is a diagram illustrating a hardware configuration of a mobile terminal and a server according to the embodiment.

Fig. 4 is a diagram illustrating a functional block configuration of the elevator inverter system according to the embodiment.

Fig. 5 is a flowchart illustrating an operation of an inverter according to the embodiment.

Fig. 6 is a flowchart illustrating an operation of a mobile terminal according to the embodiment.

Fig. 7 is a flowchart illustrating an operation of a server according to the embodiment.

DESCRIPTION OF EMBODIMENTS

[0012]

An embodiment will be described with reference to the drawings. In the following description of the drawings, the same or similar parts are denoted by the same or similar reference numerals.

[0013]

(1) Overall configuration of elevator inverter system

[0014]

Fig. 1 is a diagram illustrating an overall configuration of an elevator inverter system 1 according to an embodiment.

[0015]

As illustrated in Fig. 1, the elevator inverter system 1 according to the embodiment includes a motor 100, an inverter 200, a host controller 300, a mobile terminal 400, and a server 500.

[0016]

The motor 100 is an AC motor driven by the inverter 200. In the embodiment, the motor 100 is a synchronous motor, for example, a synchronous reluctance motor, a surface magnet synchronous motor or a built-in magnet type synchronous motor. However, the motor 100 is not limited to the synchronous motor, and other types of motors such as an induction motor can be used. The motor 100 is connected via a power line to the inverter 200, and the inverter 200 controls an operation/stop and a rotation speed of the motor 100 during an operation. The motor 100 raises and lowers a car 14 (see Fig. 2) of an elevator 2.

[0017]

The inverter 200 is a device that converts power such as frequency, current, and voltage by switching a semiconductor switch. The inverter 200 converts a commercial AC power supply or a DC power supply into a variable frequency three-phase AC, supplies AC power to the motor 100, and controls the rotation speed of a rotating shaft of the motor 100. The inverter 200 has an operation unit 220. The operation unit 220 is connected to a main body of the inverter 200, and allows a user (operator) to perform various operations on the inverter 200 and display an internal state of the inverter 200.

The operation unit 220 may be a removable keypad.

[0018]

The host controller 300 is a device that gives a command to the inverter 200 to cause the inverter 200 to perform a predetermined operation. The host controller 300 may be a PLC (Programmable Logic Controller). The host controller 300 changes a set value of the inverter 200 and controls the inverter 200 by executing a preset program. The inverter 200 controls the motor 100 based on a command from the host controller 300.

[0019]

The mobile terminal 400 is a portable terminal that can communicate with the inverter 200 and the server 500. In Fig. 1, a smartphone is illustrated as the mobile terminal 400. The mobile terminal 400 may be a terminal other than the smartphone, for example, a PDA terminal, a tablet terminal, a notebook PC, or the like. The mobile terminal 400 establishes a radio connection with the inverter 200, and executes an application for displaying information about the inverter 200 and instructing the inverter 200 to perform various operations. As a result, the mobile terminal 400 can remotely instruct the inverter 200 to perform various operations and display information.

[0020]

The server 500 is a network device connected to a communication network 10. The communication network 10 may be a public communication line such as the Internet. The communication network 10 includes a wide area radio communication network. The server 500 communicates indirectly with the inverter 200 through the communication network 10 and the mobile terminal 400. In the embodiment, communication between the server 500 and the inverter 200 does not pass through the host controller 300. The server 500 may collect information from many inverters 200, accumulate the information as big data, and perform

machine learning on the big data.

[0021]

(2) Hardware configuration of elevator inverter system

[0022]

A hardware configuration of the elevator inverter system 1 will be described. Fig. 2 is a diagram illustrating a hardware configuration of the elevator 2 in the elevator inverter system 1.

[0023]

As illustrated in Fig. 2, the elevator 2 includes an encoder 13, the car 14, a counterweight 15, a wire rope 16, and a hoist 17, in addition to the motor 100 and the inverter 200.

[0024]

The encoder 13 is attached to the rotating shaft of the motor 100. The encoder 13 detects at least one of the rotation speed and magnetic pole position of the motor 100, and outputs a detection value to the inverter 200. The encoder 13 is not always necessary as long as an elevator can be operated. It is needless to mention that a pulse generator or the like may be used instead of the encoder 13.

[0025]

The car 14 and the counterweight 15 are connected to the wire rope 16 wrapped around the hoist 17. The hoist 17 is driven by the motor 100 to raise and lower the car 14. The elevator 2 may include a load sensor that detects a load of the car 14 and outputs a detection value to the inverter 200. The elevator 2 may also include a brake for braking the rotation of the rotating shaft of the motor 100.

[0026]

The inverter 200 includes a motor control circuit 210, the operation unit 220, a communication unit 230, a

processor 240, and a storage unit 250.

[0027]

The motor control circuit 210 supplies power to the motor 100 in order to control the motor 100 that raises and lowers the car 14 of the elevator 2. The motor control circuit 210 converts the power from a power supply 20 (commercial AC power supply or DC power supply) into a variable frequency three-phase AC by switching a semiconductor switch. The motor control circuit 210 may include a converter unit that converts AC into DC, a smoothing circuit unit that smooths DC, an inverter unit that converts smoothed DC to AC, and a drive unit that drives the inverter unit. The operation of the motor control circuit 210 is controlled by the processor 240. The motor control circuit 210 includes a plurality of sensors that detect an output current/voltage of the converter unit, an output current/voltage of the smoothing circuit unit, an output current/voltage of the inverter unit (phase current/phase voltage to motor 100), and an output current/voltage of the drive unit, and the like and output detection values to the processor 240.

[0028]

The operation unit 220 includes an operation switch 221 that receives various operations on the inverter 200 from a user and a display 222 that outputs video images. The operation switch 221 may be integrated with the display 222 such that a touch panel display is configured. The operation unit 220 may include a speaker 223 that outputs sound.

[0029]

The communication unit 230 is configured by an antenna, a communication controller, and the like. The communication unit 230 establishes a radio connection with the mobile terminal 400 to perform radio communication with the mobile terminal 400. The communication unit 230

performs radio communication with the mobile terminal 400 according to a short-range radio communication standard such as Bluetooth (registered trademark) or Wi-Fi (registered trademark). The communication unit 230 may be incorporated in the operation unit 220.

[0030]

The processor 240 is connected to the motor control circuit 210, the operation unit 220, the communication unit 230, and the storage unit 250 to control an overall operation of the inverter 200. The processor 240 may be an MPU (Micro Processing Unit). The processor 240 performs various processes by executing a program stored in the storage unit 250. For example, when receiving a rotation speed command from the host controller 300, the processor 240 controls the motor control circuit 210 to rotate the rotating shaft of the motor 100 at a specified rotation speed based on a detection value of the encoder 13. A detection value of the load sensor may be input to the processor 240.

[0031]

The storage unit 250 stores a program executed by the processor 240 and information used for processes performed by the processor 240. The storage unit 250 includes a volatile memory and a non-volatile memory. The volatile memory may be a RAM (Random Access Memory). The non-volatile memory may be a ROM (Read Only Memory) or an EEPROM (Electrically Erasable Programmable Read Only Memory).

[0032]

Fig. 3 is a diagram illustrating a hardware configuration of the mobile terminal 400 and the server 500.

[0033]

As illustrated in Fig. 3, the mobile terminal 400 includes a first radio communication unit 410, a second

radio communication unit 420, a user interface 430, a storage unit 440, and a processor 450. The first radio communication unit 410 establishes a radio connection with the communication network 10 to perform radio communication according to a wide area radio communication standard. The second radio communication unit 420 establishes a radio connection with the inverter 200 to perform radio communication according to a short-range radio communication standard. The first radio communication unit 410 and the second radio communication unit 420 configure a radio communication unit 460 (see Fig. 4). The user interface 430 includes an operation switch that receives various operations from a user, a display that outputs video images, a speaker that outputs sound, a microphone that inputs sound, and the like. The operation switch may be integrated with the display such that a touch panel display is configured. The storage unit 440 stores a program executed by the processor 450 and information used for processes performed by the processor 450. The processor 450 performs various processes by executing a program stored in the storage unit 440.

[0034]

The server 500 includes a communication unit 510, a storage unit 520, and a processor 530. The communication unit 510 is connected to the communication network 10. The storage unit 520 stores a program executed by the processor 530 and information used for processes performed by the processor 530. The processor 530 performs various processes by executing a program stored in the storage unit 520.

[0035]

(3) Functional block configuration of elevator inverter system

[0036]

A functional block configuration of the elevator

inverter system 1 will be described. FIG. 4 is a diagram illustrating the functional block configuration of the elevator inverter system 1. As illustrated in Fig. 4, the elevator inverter system 1 includes the inverter 200, the mobile terminal 400, and the server 500. The elevator inverter system 1 includes the motor control circuit 210 that supplies power to the motor 100 that raises and lowers the car 14 of the elevator 2 in order to control the motor 100, a normal waveform storage unit 251 that stores normal waveform information indicating an operation waveform in the motor control circuit 210 when the elevator 2 is operated under a predetermined operating condition, and an abnormality determination unit 244 that, based on the normal waveform information stored in the normal waveform storage unit 251, compares operating waveform information indicating an operation waveform in the motor control circuit 210 when the operating elevator 2 is operated under the predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit 210 is operated normally. The elevator inverter system 1 may be a system configured by the inverter 200 including the motor control circuit 210, the normal waveform storage unit 251, and the abnormality determination unit 244. Alternatively, the elevator inverter system may be a system configured by the inverter 200 and devices other than the inverter 200. In this case, at least one of the normal waveform storage unit 252 and the abnormality determination unit 244 may be disposed outside the inverter 200 (for example, disposed in server 500).

[0037]

(3.1) Functional block configuration of inverter

[0038]

The inverter 200 includes, in addition to the motor control circuit 210, a normal waveform registration unit

242, the normal waveform storage unit 251, a determination start unit 243, the abnormality determination unit 244, an abnormal waveform storage unit 252, an abnormal waveform transmission unit 245, a registration start unit 246, and the communication unit 230.

[0039]

The normal waveform registration unit 242 stores an operation waveform in the motor control circuit 210 when the elevator 2 is operated based on a user operation, which is normal waveform information, in the normal waveform storage unit 251 in association with condition information indicating a predetermined operating condition in the operation. For example, at a time of installation or maintenance of the elevator 2, a user (operator) performs a registration operation on the operation unit 220. Alternatively, the user may perform the registration operation remotely using the mobile terminal 400. In response to the registration operation, the normal waveform registration unit 242 causes the normal waveform storage unit 251 to store a set of normal waveform information and condition information.

[0040]

Here, the operation waveform in the motor control circuit 210 is at least one waveform of an output current/voltage of the converter unit in the motor control circuit 210, an output current/voltage of the smoothing circuit unit in the motor control circuit 210, an output current/voltage (phase current/phase voltage to motor 100) of the inverter unit in the motor control circuit 210, and an output current/voltage of the drive unit in the motor control circuit 210. The waveform information may be configured with data obtained by directly sampling such a waveform, or may be configured with data obtained by sampling a waveform obtained by converting such a waveform through signal processing. Further, the processor 240 may

be regarded as a part of the motor control circuit 210. In this case, the operation waveform in the motor control circuit 210 may be, for example, a waveform of various command signals, response signals, control signals, or the like generated or used in the processor 240 or the motor control circuit 210. Examples of the operation waveform include a speed command specifying a motor rotation speed and a speed response to the speed command, a position command specifying a motor rotation position and a position feedback signal, a torque command specifying a motor rotation torque and a torque value generated by a motor, a current command specifying a motor supply current and a current supplied to the motor, and a voltage command specifying a motor supply voltage and a voltage supplied to the motor. The waveform information may be configured with data obtained by directly sampling waveforms of these command signals, or may be configured with data obtained by sampling waveforms obtained by converting these waveforms through signal processing.

[0041]

Various conditions related to the elevator 2 including the motor 200 can be used as the condition information. Examples of the condition information include a motor rotation speed, a motor rotation time, a change amount of a motor rotation position, a torque value generated by a motor, a state of a brake (whether or not brake is operated), a load of the car 14 (that is, a detection value of load sensor), a departure floor and/or arrival floor of the car 14, a scheduled automatic operation of the elevator 2, and an operating time zone of the elevator 2. The condition information may be one of these conditions or may be a combination of two or more conditions. However, the condition information is not limited thereto, and may be any information as long as the information affects the operation waveform in the motor

control circuit 210. The condition information may further include a time zone, a season, weather, and the like when the elevator 2 is operated. The normal waveform registration unit 242 may acquire the condition information from a user input or from the host controller 300.

[0042]

The normal waveform storage unit 251 stores normal waveform information indicating an operation waveform in the motor control circuit 210 when the elevator 2 is operated under a predetermined operating condition. In the embodiment, the normal waveform storage unit 251 stores the normal waveform information and the condition information registered by the normal waveform registration unit 242. As a result, the condition information indicating the predetermined operating condition is stored in the normal waveform storage unit 251 in association with the corresponding normal waveform information. The normal waveform storage unit 251 may store a plurality of sets of condition information and normal waveform information.

[0043]

The determination start unit 243 causes the abnormality determination unit 244 to start a determination based on condition information. For example, the determination start unit 243 monitors the current operating condition of the operating elevator 2 (for example, motor rotation speed, motor rotation time, load of car 14, and the like), determines whether or not the current operating condition matches condition information stored in the normal waveform storage unit 251, and if the current operating condition matches the condition information, determines that the abnormality determination unit 244 may start a determination. The determination start unit 243 can automatically start a

determination by using various conditions such as a specific command from the host controller 300, an operating time, and an operation content, which are condition information, as a trigger.

[0044]

When the normal waveform storage unit 251 stores a plurality of sets of the condition information and the normal waveform information, the determination start unit 243 may extract one piece of the normal waveform information to be used for comparison based on a plurality of pieces of the condition information stored in the normal waveform storage unit 251. For example, the determination start unit 243 monitors the current operating condition of the operating elevator 2, determines whether or not the current operating condition matches any of the plurality of pieces of the condition information stored in the normal waveform storage unit 251, extracts the normal waveform information associated with the matching condition information from the normal waveform storage unit 251, and outputs the extracted normal waveform information to the abnormality determination unit 244.

[0045]

The abnormality determination unit 244 compares operating waveform information indicating an operation waveform in the motor control circuit 210 when the operating elevator 2 is operated under a predetermined operating condition with the normal waveform information based on the normal waveform information stored in the normal waveform storage unit 251 to determine whether or not the motor control circuit 210 is operated normally. For example, when the normal waveform information is output from the determination start unit 243, the determination start unit 243 acquires the operating waveform information indicating the operation waveform in

the motor control circuit 210 and compares the acquired operating waveform information with the normal waveform information output from the determination start unit 243.

[0046]

When the operating waveform information does not match the normal waveform information, the abnormality determination unit 244 determines that the motor control circuit 210 is not operated normally. Alternatively, the abnormality determination unit 244 may determine that the motor control circuit 210 is not operated normally when a difference (deviation) between the operating waveform information and the normal waveform information is larger than a threshold. For example, a difference value between the operating waveform information and the normal waveform information is calculated for each sample value and added up, and an add-up value is compared with a threshold. When the add-up value exceeds the threshold, it may be determined that the motor control circuit 210 is not operated normally. When determining that the motor control circuit 210 is not operated normally, the abnormality determination unit 244 outputs the operating waveform information at that time to the abnormal waveform storage unit 252 as abnormal waveform information.

[0047]

The abnormal waveform storage unit 252 stores the operating waveform information when the abnormality determination unit 244 determines that the motor control circuit 210 is not operated normally as the abnormal waveform information.

[0048]

The communication unit 230 has a function to communicate with the mobile terminal 400. In the embodiment, the communication unit 230 establishes a radio connection with the mobile terminal 400 to perform radio communication with the mobile terminal 400. Alternatively,

the communication unit 230 of the inverter 200 may perform wired communication by establishing a wired connection with the mobile terminal 400. The wired connection may be a USB connection.

[0049]

When the communication between the communication unit 230 and the mobile terminal 400 is established, the abnormal waveform transmission unit 245 transmits the abnormal waveform information stored in the abnormal waveform storage unit 252 to the mobile terminal 400.

[0050]

Parameters of the inverter 200 (motor control circuit 210) may be changed based on a user operation. The parameters are various values set by the user for controlling an operation of the inverter 200. Examples of the parameters include, but are not limited to, environment setting parameters, operation mode setting parameters, parameters for a motor acceleration/deceleration time, parameters for motor torque compensation, speed control (ASR) setting parameters, frequency command setting parameters, and V/f characteristic setting parameters. Various parameters can be used as long as the parameters are used for controlling the operation of the inverter 200. These setting parameters are changed by the user performing an operation on the operation unit 220 or by the user remotely performing an operation with the mobile terminal 400.

[0051]

When the parameters of the motor control circuit 210 are changed, the registration start unit 246 causes the normal waveform registration unit 242 to start storing at least normal waveform information in the normal waveform storage unit 251. When the parameters are changed, the operation waveform is also changed. Consequently, the registration start unit 246 updates the content of the

normal waveform storage unit 251 to the latest state according to the change in parameters of the motor control circuit 210. For example, the registration start unit 246 may acquire waveform information from the motor control circuit 210 when an operation that matches condition information is detected after the parameters are changed, and automatically update the content of the normal waveform storage unit 251 based on the waveform information acquired. Alternatively, the registration start unit 246 may acquire waveform information from the motor control circuit 210 by causing the motor control circuit 210 (inverter 200) to start an operation that matches the condition information stored in the normal waveform storage unit 251 and automatically update the content of the normal waveform storage unit 251 based on the waveform information acquired. Alternatively, the registration start unit 246 may cause the motor control circuit 210 (inverter 200) to newly perform a predetermined operation to update the condition information stored in the normal waveform storage unit 251 together with a waveform.

[0052]

(3.2) Functional block configuration of mobile terminal

[0053]

The mobile terminal 400 includes a position information storage unit 441, a position information acquisition unit 451, a connection destination determination unit 452, an adjustment information acquisition unit 453, and the radio communication unit 460.

[0054]

The position information storage unit 441 stores connection destination position information indicating a position corresponding to the elevator 2. The connection destination position information may be registered in the

position information storage unit 441 by a user operation. Connection destination position information indicating a position corresponding to the elevator 2 (inverter 200) to which the mobile terminal 400 has been connected in the past may be automatically registered in the position information storage unit 441. The connection destination position information includes latitude and longitude information. The connection destination position information may further include altitude information. However, the connection destination position information is not limited to these pieces of information, and may be any information as long as the information indicates a position corresponding to the elevator 2.

[0055]

The position information acquisition unit 451 acquires terminal position information indicating the current position of the mobile terminal 400. The position information acquisition unit 451 is configured using, for example, a GPS (Global Positioning System) receiver. The position information acquisition unit 451 acquires terminal position information based on a GPS signal transmitted from a GPS satellite. The terminal position information includes latitude and longitude information. The terminal position information may further include altitude information. The terminal position information may be information indicating a current position obtained by triangulation using a plurality of base stations, or may be information indicating a current position calculated through a network based on signal reception levels from the base stations. However, the terminal position information is not limited to these pieces of information, and may be any information as long as the information indicates the current position of the mobile terminal 400.

[0056]

The connection destination determination unit 452 determines a communication unit (communication unit 230) corresponding to the elevator 2 to be connected, based on connection destination position information and terminal position information. For example, when the difference between a position indicated by the connection destination position information and a position indicated by the terminal position information is less than a threshold, the connection destination determination unit 452 determines the communication unit corresponding to the elevator 2 (communication unit 230) as a connection destination. After the connection destination is determined, the radio communication unit 460 may automatically transmit a connection request to the communication unit (communication unit 230) corresponding to the elevator 2. Consequently, when the mobile terminal 400 approaches the target elevator 2, the radio communication unit 460 can automatically start connecting to the inverter 200 of the target elevator 2. For example, when the mobile terminal 400 enters the car 14, the connection destination determination unit 452 determines the communication unit (communication unit 230) corresponding to the car 14 as the connection destination. As a result, setting parameters of the inverter 200 can be adjusted while a user (operator) is in the car 14.

[0057]

The radio communication unit 460 performs radio communication with the communication unit (communication unit 230) determined by the connection destination determination unit 452. The radio communication unit 460 establishes a radio connection with the inverter 200 (communication unit 230) to perform radio communication according to a short-range radio communication standard. The radio communication unit 460 acquires abnormal waveform information through radio communication with

inverter 200 (communication unit 230), and transfers the acquired abnormal waveform information to the server 500. The radio communication unit 460 may also acquire normal waveform information, condition information, mechanical information such as elevator specifications, and results of parameter adjustment performed in order to correct an abnormality, and transfer the acquired information to the server 500.

[0058]

The adjustment information acquisition unit 453 then acquires, from the server 500, adjustment information about adjustment of the motor control circuit 210. The adjustment information acquisition unit 453 may output the acquired adjustment information through the user interface 430 (display). An operator having the mobile terminal 400 can thus easily adjust the inverter 200. For example, the mobile terminal 400 remotely changes parameters of the inverter 200 based on a user input through radio communication. Details of the adjustment information will be described later.

[0059]

(3.3) Functional block configuration of server

The server 500 includes a communication unit 510, an accumulation unit 521, an abnormal waveform acquisition unit 531, a derived information generating unit 532, an adjustment information generating unit 533, and an adjustment information transmission unit 534.

[0060]

The communication unit 510 performs communication with the mobile terminal 400 through the communication network 10.

[0061]

The abnormal waveform acquisition unit 531 acquires abnormal waveform information transmitted to the mobile terminal 400. The abnormal waveform acquisition unit 531

acquires not only the abnormal waveform information but also normal waveform information, condition information, mechanical information such as elevator specifications, and results of adjustment performed in order to correct an abnormality. However, it is not always necessary to acquire information other than the abnormal waveform information unless the information is necessary at a time of generating adjustment information.

[0062]

The adjustment information generating unit 533 generates adjustment information about adjustment of the motor control circuit 210 based on the abnormal waveform information acquired by the abnormal waveform acquisition unit 531. The adjustment information generating unit 533 may generate the adjustment information further based on derived information generated by the derived information generating unit 532. Alternatively, the adjustment information generating unit 533 may generate the adjustment information without being based on the derived information. For example, the adjustment information generating unit 533 may display an abnormal waveform based on abnormal waveform information, and generate the adjustment information based on an input from an operator or the like who has seen the abnormal waveform. The adjustment information may be an adjusted parameter itself. Alternatively, the adjustment information may be information specifying a parameter to be adjusted or information suggesting an adjustment method.

[0063]

The accumulation unit 521 accumulates at least a plurality of sets of condition information and abnormal waveform information. The accumulation unit 521 may also accumulate normal waveform information, mechanical information such as elevator specifications, and parameter sets after adjustment performed in order to correct an

abnormality.

[0064]

The derived information generating unit 532 generates derived information for deriving parameters of the motor control circuit 210 based on at least a plurality of sets of condition information and abnormal waveform information accumulated in the accumulation unit 521. The derived information generating unit 532 performs machine learning by using the condition information, abnormal waveform information, normal waveform information, and mechanical information such as elevator specifications accumulated in the accumulation unit 521 as input parameters, and using parameter sets after adjustment performed in order to correct an abnormality as correct answer data to generate the derived information. The derived information is a parameter set of an algorithm or a neural network constructed by machine learning, or the like. The adjustment information generating unit 533 generates adjustment information about adjustment of the motor control circuit 210 based on at least the derived information generated by the derived information generating unit 532 and the abnormal waveform information acquired by the abnormal waveform acquisition unit 531.

[0065]

The adjustment information transmission unit 534 transmits the adjustment information generated by the adjustment information generating unit 533 to the mobile terminal 400.

[0066]

(4) Operation of elevator inverter system

[0067]

An operation of an elevator inverter system will be described.

[0068]

Fig. 5 is a flowchart illustrating an operation of

the inverter 200.

[0069]

As illustrated in Fig. 5, at step S101, the normal waveform storage unit 251 stores normal waveform information indicating an operation waveform in the motor control circuit 210 when the elevator 2 is operated under a predetermined operating condition. The normal waveform storage unit 251 stores condition information indicating the predetermined operating condition in association with the corresponding normal waveform information.

[0070]

At step S102, the determination start unit 243 determines whether or not to cause the abnormality determination unit 244 to start a determination. The determination start unit 243 monitors an operating condition of the operating elevator 2 and, when the current operating condition matches the condition information stored in the normal waveform storage unit 251, causes the abnormality determination unit 244 to start a determination.

[0071]

If it is determined that the abnormality determination unit 244 should start a determination (YES at step S102), at step S103, the abnormality determination unit 244 compares the operating waveform information indicating the operation waveform in the motor control circuit 210 when the operating elevator 2 is operated under the predetermined operating condition with the normal waveform information based on the normal waveform information stored in the normal waveform storage unit 251. The abnormality determination unit 244 thus determines whether or not the motor control circuit 210 is operated normally (step S104). If it is determined that the motor control circuit 210 is operated normally (YES at step S104), the process returns to step S102.

[0072]

When it is determined that the motor control circuit 210 is not operated normally (NO at step S104), at step S105, the abnormal waveform storage unit 252 stores the operating waveform information when the abnormality determination unit 244 determines that the motor control circuit 210 is not operated normally as abnormal waveform information.

[0073]

Thereafter, when the communication unit 230 establishes a radio connection with the mobile terminal 400 (YES at step S106), at step S107, the abnormal waveform transmission unit 245 transmits the abnormal waveform information stored in the abnormal waveform storage unit 252 to the mobile terminal 400.

[0074]

Next, when parameters of the motor control circuit 210 are changed (YES at step S108), the process returns to step S101, and the normal waveform information stored in the normal waveform storage unit 251 is updated to new normal waveform information that is the operation waveform in the motor control circuit 210 when the elevator 2 is operated.

[0075]

Fig. 6 is a flowchart illustrating an operation of the mobile terminal 400.

[0076]

As illustrated in Fig. 6, at step S201, the position information acquisition unit 451 acquires terminal position information indicating the current position of the mobile terminal 400.

[0077]

At step S202, the connection destination determination unit 452 determines a communication unit (communication unit 230) corresponding to the elevator 2

to be connected based on connection destination position information and the terminal position information.

[0078]

At step S203, the radio communication unit 460 performs radio communication with the communication unit (communication unit 230) determined by the connection destination determination unit 452.

[0079]

At step S204, the radio communication unit 460 acquires abnormal waveform information through the radio communication with the inverter 200 (communication unit 230), and transfers the acquired abnormal waveform information to the server 500.

[0080]

At step S205, the adjustment information acquisition unit 453 acquires, from the server 500, adjustment information about adjustment of the motor control circuit 210.

[0081]

Fig. 7 is a flowchart illustrating an operation of the server 500.

[0082]

As illustrated in Fig. 7, at step S301, the derived information generating unit 532 generates derived information for deriving parameters of the motor control circuit 210 based on at least a plurality of sets of condition information and abnormal waveform information accumulated in the accumulation unit 521.

[0083]

At step S302, the abnormal waveform acquisition unit 531 acquires the abnormal waveform information transmitted to the mobile terminal 400.

[0084]

At step S303, the adjustment information generating unit 533 generates adjustment information about adjustment

of the motor control circuit 210 based on at least the derived information generated by the derived information generating unit 532 and the abnormal waveform information acquired by the abnormal waveform acquisition unit 531.

[0085]

At step S304, the adjustment information generated by the adjustment information generating unit 533 is transmitted to the mobile terminal 400.

(5) Summary of embodiment

[0086]

The elevator inverter system 1 includes the motor control circuit 210 that supplies power to the motor 100 that raises and lowers the car 14 of the elevator 2 in order to control the motor 100, the normal waveform storage unit 251 that stores normal waveform information indicating an operation waveform in an inverter when the elevator 2 is operated under a predetermined operating condition, and the abnormality determination unit 244 that, based on the normal waveform information stored in the normal waveform storage unit 251, compares operating waveform information indicating an operation waveform in the motor control circuit 210 when the operating elevator 2 is operated under a predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit 210 is operated normally. According to such a configuration, the operating condition of the elevator 2 for the operating waveform information is the same as the operating condition of the elevator 2 for the normal waveform information, and thus the operating condition information can be appropriately compared with the normal waveform information. By comparing the operating waveform information with the normal waveform information, it is possible to automatically determine whether or not the motor control circuit 210 (inverter 200) is operated normally.

Consequently, setting parameters of the motor control circuit 210 can be adjusted efficiently. Before a serious abnormality occurs in the host controller 300 that affects an operation of an elevator, an abnormality of a waveform in the motor control circuit 210 (deviation from normal operation, which is outside allowable range) can be detected. Consequently, by re-adjusting the motor control circuit 210 due to aging or the like at an early stage, it is possible to prevent a serious abnormality beforehand. If parts need to be replaced, it is possible to secure the parts in stock in advance. As a result, it is possible to reduce the possibility that the elevator 2 will stop in the future. The normal or abnormal state of the motor control circuit 210 may indicate a normal or abnormal operation of the motor control circuit 210 itself, but is not limited thereto. The normal or abnormal state of the motor control circuit 210 includes a normal or abnormal state of the entire system or components included in the system, which appears in the operation of the motor control circuit 210. Examples of the components include various components such as the motor 100, a brake, the car 14, the wire rope 16, and a rail.

[0087]

In the embodiment, the condition information indicating a predetermined operating condition is stored in the normal waveform storage unit 251 in association with the corresponding normal waveform information. The elevator inverter system 1 further includes the determination start unit 243 that causes the abnormality determination unit 244 to start a determination based on condition information. According to such a configuration, the determination start unit 243 can automatically start a determination based on the operating waveform information and the condition information. Consequently, a periodic abnormality determination can be

easily performed.

[0088]

In the embodiment, the normal waveform storage unit 251 stores a plurality of sets of condition information and normal waveform information. The determination start unit 243 extracts one piece of the normal waveform information used for comparison, based on a plurality of pieces of the condition information. According to such a configuration, a plurality of conditions can be registered, and thus, for example, an abnormality determination can be performed using different waveforms in different weather or seasons. It is thus possible to easily perform a more reliable determination.

[0089]

In the embodiment, the elevator inverter system 1 further includes the normal waveform registration unit 242 that stores an operation waveform in the motor control circuit 210 when the elevator 2 is operated, as the normal waveform information, in the normal waveform storage unit 251 in association with condition information indicating a predetermined operating condition in the operation. According to such a configuration, for example, by operating the elevator 2 at the time of installation or maintenance of the elevator 2, the waveform and condition at that time can be easily registered for an abnormality determination.

[0090]

In the embodiment, the elevator inverter system 1 includes the registration start unit 246 that, when parameters of the motor control circuit 210 are changed, causes the normal waveform registration unit 242 to start storing at least the normal waveform information in the normal waveform storage unit 251. According to such a configuration, when the parameters are changed, the operation waveform is also changed, and thus the operation

waveform can be reliably updated to the latest waveform.

[0091]

In the embodiment, the elevator inverter system 1 includes the abnormal waveform storage unit 252 that stores operating waveform information when the abnormality determination unit 244 determines that the motor control circuit 210 is not operated normally as abnormal waveform information, the communication unit 230 that has a function to communicate with the mobile terminal 400, and the abnormality waveform transmission unit 245 that, when communication between the communication unit and the mobile terminal is established, transmits the abnormal waveform information stored in the abnormal waveform storage unit 252 to the mobile terminal 400. According to such a configuration, when the mobile terminal 400 is connected to the communication unit, an abnormal waveform is acquired. Consequently, it is easy to determine maintenance or measures for abnormalities based on the abnormal waveform.

[0092]

In the embodiment, the elevator inverter system 1 further includes the mobile terminal 400. The mobile terminal 400 includes the position information storage unit 441 that stores connection destination position information indicating a position corresponding to the elevator 2, the position information acquisition unit 451 that acquires terminal position information indicating the current position of the mobile terminal 400, the connection destination determination unit 452 that determines a communication unit corresponding to the elevator 2 to be connected based on the connection destination position information and the terminal position information, and the radio communication unit 460 that performs radio communication with the communication unit determined by the connection destination determination

unit 452. According to such a configuration, when the mobile terminal 400 approaches the target elevator 2, the mobile terminal 400 can be automatically connected to the inverter 200 of the target elevator 2. Consequently, the time and effort required to connect to the inverter 200 can be reduced, and setting parameters of the inverter 200 can be adjusted efficiently.

[0093]

In the embodiment, when the mobile terminal 400 enters the car 14, the connection destination determination unit 452 determines the communication unit corresponding to the car 14 as the connection destination. According to such a configuration, setting parameters of the inverter 200 can be adjusted while an operator is in the car 14. Consequently, the setting parameters of the inverter 200 can be remotely adjusted while the actual ride quality of the car 14 is actually checked. As a result, the setting parameters of the inverter 200 can be adjusted more efficiently.

[0094]

In the embodiment, the elevator inverter system 1 further includes the server 500 capable of communicating with the mobile terminal 400. The server 500 includes the abnormal waveform acquisition unit 531 that acquires the abnormal waveform information transmitted to the mobile terminal 400 and the adjustment information generating unit 533 that generates adjustment information about adjustment of the motor control circuit 210 based on the abnormal waveform information acquired by the abnormal waveform acquisition unit 531. According to such a configuration, as the adjustment information is generated based on an abnormal waveform, the adjustment can be performed easily.

[0095]

In the embodiment, the server 500 includes the

adjustment information transmission unit 534 that transmits the adjustment information generated by the adjustment information generating unit 533 to the mobile terminal 400. According to such a configuration, setting parameters that enable the inverter 200 to be operated normally can be notified to an operator through the mobile terminal 400. Consequently, the time and effort required for the operator to adjust the setting parameters can be reduced, and the setting parameters of the inverter 200 can be adjusted more efficiently. As the adjustment information is transmitted to the mobile terminal 400, the operator can easily adjust the inverter 200.

[0096]

In the embodiment, the adjustment information includes parameters of the motor control circuit 210 itself. According to such a configuration, the adjustment information includes parameters after adjustment. Consequently, it is only required to set the parameters in the motor control circuit 210, and thus the adjustment is performed more easily.

[0097]

In the embodiment, the server 500 further includes the accumulation unit 521 that accumulates at least a plurality of sets of condition information and abnormal waveform information and the derived information generating unit 532 that generates derived information for deriving parameters of the motor control circuit 210 based on at least the sets of condition information and abnormal waveform information accumulated in the accumulation unit 521. The adjustment information generating unit 533 generates adjustment information about adjustment of the motor control circuit 210 based on at least the derived information generated by the derived information generating unit 532 and the abnormal waveform information acquired by the abnormal waveform acquisition unit 531.

According to such a configuration, setting parameters that enable the inverter 200 to be operated normally can be automatically derived. Consequently, the time and effort for an operator to actually go to the elevator 2 and adjust the setting parameters through trial and error can be reduced. As a result, the setting parameters of the inverter 200 can be adjusted more efficiently.

[0098]

(6) Other embodiments

As described above, the present invention has been described by way of embodiment. However, it should not be understood that the description and drawings forming a part of this disclosure limit the present invention. From this disclosure, various alternative embodiments, examples and operational techniques will be apparent to those skilled in the art.

[0099]

In the embodiment described above, an example has been described in which the elevator inverter system 1 includes not only the inverter 200 but also the mobile terminal 400, the server 500, and the like. However, the elevator inverter system 1 does not always necessary to include the mobile terminal 400, the server 500, and the like.

[0100]

In the embodiment described above, an example has been described in which the inverter 200 includes the normal waveform registration unit 242, the normal waveform storage unit 251, the determination start unit 243, the abnormality determination unit 244, the abnormal waveform storage unit 252, the abnormal waveform transmission unit 245, and the registration start unit 246. However, at least one of the normal waveform registration unit 242, the normal waveform storage unit 251, the determination start unit 243, the abnormality determination unit 244,

the abnormal waveform storage unit 252, the abnormal waveform transmission unit 245, and the registration start unit 246 may be disposed outside the inverter 200, for example, disposed in the mobile terminal 400 or the server 500 in a distributed manner.

[0101]

In the embodiment described above, the mobile terminal 400 and the server 500 can be used in a system different from the elevator inverter system 1. That is, the configuration and operation of the mobile terminal 400 and the server 500 described above may be applied to a system in which the inverter 200 is used for an application other than an elevator.

[0102]

The server 500, which is also used for an application other than an elevator, includes the abnormal waveform acquisition unit 531 that acquires abnormal waveform information indicating an operation waveform in the motor control circuit 210 when it is determined that the motor control circuit 210 included in the inverter 200 is not operated normally from the mobile terminal 400 and the adjustment information generating unit 533 that generates adjustment information about adjustment of the motor control circuit 210 based on the abnormal waveform information acquired by the abnormal waveform acquisition unit 531. According to such a configuration, as the adjustment information is generated based on an abnormal waveform, the adjustment can be performed easily.

[0103]

The mobile terminal 400 used for an application other than an elevator includes the position information storage unit 441 that stores connection destination position information indicating a position corresponding to the inverter 200 including the motor control circuit 210 that supplies power to the motor 100 in order to

control the motor 100 and the communication unit 230 having a communication function, the position information acquisition unit 451 that acquires terminal position information indicating the current position of the mobile terminal 400, the connection destination determination unit 452 that determines the communication unit 230 corresponding to the inverter 200 to be connected based on the connection destination position information and the terminal position information, and the radio communication unit 460 that performs radio communication with the communication unit 230 determined by the connection destination determination unit 452. According to such a configuration, when the mobile terminal 400 approaches the target inverter 200, the mobile terminal 400 can be automatically connected to the target inverter 200. Consequently, the time and effort required to connect to the inverter 200 can be reduced, and setting parameters of the inverter 200 can be adjusted efficiently.

REFERENCE SIGNS LIST

[0104]

- 1 elevator inverter system
- 2 elevator
- 10 communication network
- 13 encoder
- 14 car
- 15 counterweight
- 16 wire rope
- 17 hoist
- 2 power supply
- 100 motor
- 200 inverter
- 210 motor control circuit
- 220 operation unit
- 221 operation switch

222 display
223 speaker
230 communication unit
240 processor
242 normal waveform registration unit
243 determination start unit
244 abnormality determination unit
245 abnormal waveform transmission unit
246 registration start unit
250 storage unit
251 normal waveform storage unit
252 abnormal waveform storage unit
300 host controller
400 mobile terminal
410 first radio communication unit
420 second radio communication unit
430 user interface
440 storage unit
441 position information storage unit
450 processor
451 position information acquisition unit
452 connection destination determination unit
453 adjustment information acquisition unit
460 radio communication unit
500 server
510 communication unit
520 storage unit
521 accumulation unit
530 processor
531 abnormal waveform acquisition unit
532 derived information generating unit
533 adjustment information generating unit
534 adjustment information transmission unit

CLAIMS

1. An elevator inverter system comprising:

a motor control circuit that supplies power to a motor that raises and lowers a car of an elevator in order to control the motor;

a normal waveform storage unit that stores normal waveform information indicating an operation waveform in the motor control circuit when the elevator is operated under a predetermined operating condition; and

an abnormality determination unit that, based on the normal waveform information stored in the normal waveform storage unit, compares operating waveform information indicating an operation waveform in the motor control circuit when the elevator, which is operating, is operated under the predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit is operated normally, wherein

the normal waveform storage unit stores condition information indicating the predetermined operating condition in association with the normal waveform information corresponding to the condition information, and

the elevator inverter system further comprises a determination start unit that causes the abnormality determination unit to start the determination based on the condition information.

2. The elevator inverter system according to claim 1, wherein

the normal waveform storage unit stores a plurality of sets of the condition information and the normal waveform information, and

the determination start unit extracts one piece of the normal waveform information to be used for comparison based on a plurality of pieces of the condition information.

3. The elevator inverter system according to claim 1 or 2 further comprising a normal waveform registration unit that stores an operation waveform in the motor control circuit when the elevator is operated, as the normal waveform information, in the normal waveform storage unit in association with condition information indicating a predetermined operating condition in the operation.

4. The elevator inverter system according to claim 3 further comprising a registration start unit that, when a parameter of the motor control circuit is changed, causes the normal waveform registration unit to start storing at least the normal waveform information in the normal waveform storage unit.

5. The elevator inverter system according to any one of claims 1 to 4, further comprising:

an abnormal waveform storage unit that stores the operating waveform information when the abnormality determination unit determines that the motor control circuit is not operated normally as abnormal waveform information;

a communication unit that has a function to communicate with a mobile terminal; and

an abnormality waveform transmission unit that, when communication between the communication unit and the mobile terminal is established, transmits the abnormal waveform information stored in the abnormal waveform storage unit to the mobile terminal.

6. The elevator inverter system according to claim 5 further comprising the mobile terminal, wherein

the mobile terminal includes:

a position information storage unit that stores connection destination position information indicating a position corresponding to the elevator,

a position information acquisition unit that acquires terminal position information indicating a current position of the mobile terminal,

a connection destination determination unit that determines a communication unit corresponding to an elevator to be connected based on the connection destination position information and the terminal position information, and

a radio communication unit that performs radio communication with the communication unit determined by the connection destination determination unit.

7. The elevator inverter system according to claim 6, wherein

when the mobile terminal enters the car, the connection destination determination unit determines a communication unit corresponding to the car as a connection destination.

8. The elevator inverter system according to any one of claims 5 to 7, further comprising a server capable of communicating with the mobile terminal, wherein

the server includes:

an abnormal waveform acquisition unit that acquires the abnormal waveform information transmitted to the mobile terminal, and

an adjustment information generating unit that generates adjustment information about adjustment of the motor control circuit based on the abnormal waveform information acquired by the abnormal waveform acquisition unit.

9. The elevator inverter system according to claim 8, wherein

the server further includes an adjustment information transmission unit that transmits the adjustment information generated by the adjustment information generating unit to the mobile terminal.

10. The elevator inverter system according to claim 8 or 9, wherein

the adjustment information includes a parameter of the motor control circuit itself.

11. An elevator inverter system comprising:

a motor control circuit that supplies power to a motor that raises and lowers a car of an elevator in order to control the motor;

a normal waveform storage unit that stores normal waveform information indicating an operation waveform in the motor control circuit when the elevator is operated under a predetermined operating condition; and

an abnormality determination unit that, based on the normal waveform information stored in the normal waveform storage unit, compares operating waveform information indicating an operation waveform in the motor control circuit when the elevator, which is operating, is operated under the predetermined operating condition with the normal waveform information to determine whether or not the motor control circuit is operated normally

an abnormal waveform storage unit that stores the operating waveform information when the abnormality determination unit determines that the motor control circuit is not operated normally as abnormal waveform information;

a communication unit that has a function to communicate with a mobile terminal; and

an abnormality waveform transmission unit that, when communication between the communication unit and the mobile terminal is established, transmits the abnormal waveform information stored in the abnormal waveform storage unit to the mobile terminal; and

a server capable of communicating with the mobile terminal, wherein

the server includes:

an abnormal waveform acquisition unit that acquires the abnormal waveform information transmitted to the mobile terminal,

an accumulation unit that accumulates at least a plurality of sets of condition information indicating the

predetermined operating condition and the abnormal waveform information,

a derived information generating unit that generates derived information for deriving a parameter of the motor control circuit based on at least the sets of the condition information and the abnormal waveform information accumulated in the accumulation unit,

an adjustment information generating unit that generates adjustment information about adjustment of the motor control circuit based on at least derived information generated by the derived information generating unit and the abnormal waveform information acquired by the abnormal waveform acquisition unit, and

an adjustment information transmission unit that transmits the adjustment information generated by the adjustment information generating unit to the mobile terminal.

12. A method for determining an abnormality in an elevator inverter comprising:

causing a motor control circuit to supply power to a motor that raises and lowers a car of an elevator in order to control the motor;

storing normal waveform information indicating an operation waveform in the motor control circuit when the elevator is operated under a predetermined operating condition;

based on the normal waveform information, comparing operating waveform information indicating an operation waveform in the motor control circuit when the elevator, which is operating, is operated under the predetermined operating

condition with the normal waveform information to determine whether or not the motor control circuit is operated normally;

storing condition information indicating the predetermined operating condition in association with the normal waveform information corresponding to the condition information; and

starting the determination based on the condition information.

13. A server capable of communicating with a mobile terminal, the server comprising:

an abnormal waveform acquisition unit that acquires abnormal waveform information indicating an operation waveform in the motor control circuit when it is determined that the motor control circuit included in an inverter, which operates under a predetermined operating condition, is not operated normally from the mobile terminal;

an accumulation unit that accumulates a plurality of sets of condition information indicating the predetermined operating condition and the abnormal waveform information;

a derived information generating unit that generates derived information for deriving a parameter of the motor control circuit based on at least the sets of the condition information and the abnormal waveform information accumulated in the accumulation unit;

an adjustment information generating unit that generates adjustment information about adjustment of the motor control circuit based on at least derived information generated by the derived information generating unit and the abnormal waveform information acquired by the abnormal waveform acquisition unit; and

an adjustment information transmission unit that transmits the adjustment information generated by the adjustment information generating unit to the mobile terminal.