

Method and system for managing the electric network of a railway network

The present invention relates to a method for managing an electric network of a railway network, comprising a step consisting of receiving a plurality of measured data, the measured data comprising the current intensity and/or a voltage value supplied to and/or received from a current supply means of a railway line of at least one power supply substation.

For example, KR 101437350 and CN 104578399 respectively disclose a smart measurement system for measuring the current and voltage in a railway network.

During the operation of an electric network of a railway network, the electrical equipment may slowly deteriorate or unknown events may destroy or damage the electrical equipment.

The object of the application is to propose a method and a system allowing more effective management of an electric network of a railway network.

This object is achieved, according to the invention, by a method for managing an electric network of a railway network, the electric network comprising at least one central unit and a plurality of power supply substations, the power supply substations being connected to a current supply means of one or several railway vehicles, the power supply substations being adapted to convert a first electric current having a transport voltage, into a second electric current adapted to circulate on the current supply means and having a usage voltage, or vice versa, the method comprising the following steps:

receiving, by the central unit, a plurality of measured data, the measured data comprising the intensity of a current and/or a voltage value supplied to and/or received from the current supply means;

storing, by the central unit, the measured data, the stored measured data being associated with a measurement time;

receiving, by the central unit, one or several instantaneous measured values of the intensity of the current and/or of the voltage supplied to and/or received from the current supply means;

calculating, by the central unit, of at least one estimated value of the instantaneous measured value(s), from the stored measured data;

comparing, at the central unit, the instantaneous measured value(s) with the estimated value(s); and

activating, at the central unit, an alarm, as a function of the comparison of the instantaneous value(s) with the estimated value(s), and/or

sending, by the central unit, a command signal to the power supply substation, as a function of the comparison of the instantaneous value(s) with the estimated value(s).

According to advantageous features:

- the alarm indicates a maintenance operation to be performed;
- upon receiving the command signal, the power supply substation controls at least one electric equipment of the power supply substation as a function of the command signal;
- the measured data comprise one or several temperature values associated with at least one electrical equipment and/or with one or more rooms of the power supply substation and/or maneuvering counters of an electric connection switch associated with at least one electrical equipment of the power supply substation; and/or
- the method further comprises the following step: measuring, at the power supply substation, measured data and/or one or several temperature values associated with at least one electrical equipment or with one or more rooms of the power supply substation.

According to another aspect of the invention, this object is achieved, by a system for managing an electric network of a railway network, the electric network comprising at least one central unit and a plurality of substations, the power supply substations being connected to a current supply means of one or several railway vehicles, the power supply substations being adapted to convert a first electric current having a transport voltage, into a second electric current adapted to circulate on the current supply means and having a usage voltage, or vice versa, the central unit being adapted to:

receive a plurality of measured data, the measured data comprising the intensity of a current and/or a voltage value supplied to and/or received from the current supply means;

store the measured data, the stored measured data being associated with a measurement time;

receive one or several instantaneous measured values of the intensity of the current and/or of the voltage supplied to and/or received from the current supply means;

compute at least one estimated value of the instantaneous measured value(s), from the stored measured data;

compare the instantaneous measured value(s) with the estimated value(s);

activate an alarm, as a function of the comparison of the instantaneous value(s) with the estimated value(s), and/or send a command signal to the power supply

substation, as a function of the comparison of the instantaneous value(s) with the estimated value(s).

According to advantageous features:

- the alarm indicates a maintenance operation to be performed;
- the power supply substation comprises one or more electrical equipments, the power supply substation being adapted, upon receiving the command signal, to control at least one of the electrical equipments as a function of the command signal;
- the measured data comprise one or several temperature values associated with at least one electrical equipment and/or with one or more rooms of the power supply substation and/or maneuvering counters of an electric connection switch associated with at least one electrical equipment of the power supply substation;
- the power supply substation is adapted to measure data and/or one or several temperature values associated with at least one electrical equipment or with a room of the power supply substation; and/or
- the system comprises a computer network for the connection between the substations and the central unit and for communication of the substations with one another.

Other features and advantages of the present invention will emerge from the description below, done with reference to the drawings, which illustrate a non-limiting embodiment in which:

- figure 1 is a schematic view of a segment of a railway track;
- figure 2 is a schematic illustration of a system according to the invention;
- figure 3 is a schematic illustration of a system according to the invention;
- figure 4 shows a flowchart of the method according to the invention.

Figure 1 schematically shows a segment of a railway track 1 on which an electric railway vehicle 3 travels. The railway vehicle 3 is for example a tram, train, subway, etc. The railway vehicle 3 can operate in a driving mode, where the railway vehicle 3 consumes electrical energy supplied by a current supply means 5, or in a braking energy collection mode, in which the railway vehicle 3 generates an electric energy that it transmits to the current supply means 5.

The current supply means 5 for the vehicle runs alongside the railway track 1. For example, the current supply means 5 is a catenary or a conducting rail.

The electric energy management system of a railway network comprises a plurality of power supply substations 7. The power supply substations 7 are connected on one side to the current supply means 5 and on another side to a high-voltage distribution grid 9.

The power supply substations 7 are adapted to convert a first electric current having a transport voltage, for example received from the high-voltage distribution grid 9, into a second current having a usage voltage and adapted to circulate in the current supply means 5, or vice versa when the railway vehicle 3 is operating in the braking energy collection mode.

To that end, the power supply substations 7 comprise items of electrical equipment, for example one or several transformers, one or several inverters, one or several rectifiers, one or several circuit breakers, one or several contactors, and/or one or several disconnecting switches.

Figure 2 is a schematic view of the system. The power supply substations 7 each comprise one or several current and/or voltage sensors 11 adapted to measure the current and/or the voltage supplied to and/or received from the current supply means 5. In one embodiment, the current supplied to the current supply means 5 is the current used by the railway vehicle 3 during driving and the current received from the railway vehicle 3, when the railway vehicle 3 is in a braking energy collection mode.

The supply current is for example a direct current or an alternating current.

Advantageously, the power supply substations 7 also comprises counting sensors adapted to count the number of maneuvers, i.e., to determine a maneuvering counter of an electrical connection switch associated with at least one electrical equipment of the power supply substation 7. The number of maneuvers is for example a number of openings and/or closings of the switch.

Furthermore, the power supply substations 7 comprise, in one embodiment, one or several temperature sensors 12. The temperature sensor(s) are adapted to measure the temperature of the electrical equipment of the respective power supply substation 7, and/or the temperature of the room(s) of the respective power supply substation 7.

The sensor(s) are connected to one or several local computing units 13, for example a programmed circuit and/or a processor. Each local computing unit 13 is adapted to be connected to a computer network 15. In one embodiment, the computer network 15 is a virtual network.

The computer network 15 allows communication between each power supply substation 7 and one or several central units 19. One central unit 19 is associated with several power supply substations 7. The central unit(s) 19 are arranged at a distance from the power supply substations 7.

For example, the local computing unit(s) 13 send to the central unit(s) 19 the measured data. The measured data comprise an intensity of the current and/or a voltage value supplied to and/or received from the current supply means 5. Furthermore, in one embodiment, the local computing units 13 send one or several temperature values to the central unit(s) 19 as measured data and/or the maneuver counters. The sent measured data are associated with a time value or are time-stamped. In other examples, all of the electrical data coming from the local computing units 13 of the power supply substations 7 are sent to the central unit 19. In another example, the local computing unit(s) 13 are adapted to send the operating state of one or more electrical equipments, an event, an alarm, etc. In one embodiment, an event is a change in operating state of an equipment, for example a circuit breaker switches from the open position to the closed position and/or the temperature of a transformer rises from a normal value to an abnormal value (too hot).

The computer network 15 also allows communication between power supply substations 7, in particular between the local computing units 13 of the power supply substations. For example, a first local computing unit 13 of a first power supply substation 7 needs one or several data from a second local computing unit 13 in a second power supply substation 7, in particular without consulting a central unit 19.

In one embodiment, the local computing units 13 are adapted to control the electrical equipment located in the respective power supply substation. For example, the local computing unit(s) 13 are adapted to command, activate and/or stop one or several pieces of electrical equipment of the power supply substation 7. In one embodiment, the local computing units 13 control the piece(s) of electrical equipment in response to a command signal received from one of the central units 19.

In one example, the local computing units 13 do not include any sophisticated local man-machine interface to analyze or display the values of the sensors 11, 12. A man-machine interface is for example provided by a computer or a portable device 23 that is connected to the computer network 15 to receive this information from the central unit 19.

The central unit 19 is for example a server that is adapted to prepare information readable by clients on other computers, for example a computer 21 located on the site of the central unit or by the portable device 23. In one embodiment, the server is adapted to generate HTML (hypertext markup language) pages that are readable by a web browser installed on the computer 21 and/or the portable device 23.

In one embodiment, the central unit 19 is adapted to enrich the raw data using algorithms, thresholds, counters, etc. The enriched data are made available by the central unit 19 to the various operators, for example the portable device 23 and/or the computer 21, as information. The readable information made available to the other computers 21 or

portable devices 23 are the current or historical values of the sensors 11, 12 or information based on the current or historical values of the sensors 11, 12.

Furthermore, the central unit 19 is adapted to send command signals to the local computing units 13 to control them or to control the piece(s) of electrical equipment of the respective power supply substation 7, for example in response to a command from a user or a computation from received data.

Figure 3 is a schematic view of a portion of the system according to the invention showing the central unit 19 in greater detail. The central unit 19 comprises a first communication module 30 adapted to be connected to the local computing units 13 via the computer network 15. The local computing units 13 are adapted to send the data to the central unit 19 at their own initiative. For example, the local computing units 13 can send the measured data when the value changes, periodically, and/or upon request by a user.

The communication module 30 sends the data measured by the sensors 11, 12 of the power supply substations 7 to a database management module 32. The database management module 32 is adapted to store the measured data in a database 34, to perform a synchronization with another external database 36 and make a backup copy of the database 34. In particular, all of the numerical values, the events and the alarms of the power supply substations are stored in the database 34. In one embodiment, the site or location of the power supply substations 7 is also associated with the data.

The module for creating a graphic 42 uses the data from the database 34 to create a graphic depicting the data. The graphic is provided to a server module 44 that provides access to the remote computers 21, 23.

In one embodiment, the central unit 19 comprises an alarm management module 46 and a mathematical module 48. The alarm management module 46 makes it possible, depending on the state of the alarms and the various actions performed by the operator, to establish different values for each alarm, for example: alarm present not acknowledged, alarm acknowledged, alarm disappeared not acknowledged, and/or alarm hidden. The mathematical module 48 develops computations on the data from the database 34 to create new data or to have a depiction thereof in the graphic, such as a computation of a time average, a cumulative total over a day, a statistic over a year, etc.

The server module 44 is adapted to receive commands from a remote computer 21, 23, for example to make it possible to filter the data by category, for example: date, degree of severity and/or importance; type of equipment; voltage level and/or measuring location.

For example, in one embodiment, the operator can, by using a remote computer, view general power supply diagrams, detailed diagrams of the power substations (unit for connecting to the electric network; driving substation; auxiliary substation, etc.), and/or diagrams of the computer architecture as information.

In one embodiment, the central unit 19 is adapted to generate information, for example in the form of dashboard tables, regarding the general state of the electrical equipment of the railway track 1, the detailed state of the electrical equipment of each substation 7, the general state of the pieces of equipment making up the computer architecture of the system, for example the local computing unit 13, the detailed state of the automatons of each electrical substation, the operating time of the electrical equipment, and/or usage temperatures of the electrical equipment. The state of an electrical equipment includes whether this equipment is running or stopped.

The computer architecture of the system comprises the local computing unit(s) 13, the computer network 15, the central unit 19 and the viewing unit(s), for example one or several computers 21 and 23.

In one embodiment, the central unit 19 comprises a function 38 for replaying measured data by using a replay database 40. To that end, the replay function 38 is adapted to read the data from the database 34 to store them in its replay database 40. The function 38 is adapted to generate a sequence of data and provide them to a module for creating a graphic 42.

The central unit 19 makes it possible to replay data, for example step by step, to relaunch a defective sequence. A finer analysis of failures is therefore possible.

This information in particular allows effective maintenance of the energy system, and in particular, of one or several power supply substations 7. For example, the central unit 19, in particular the mathematical module 48, is adapted to issue alarms for the maintenance staff in order to schedule maintenance operations for the electrical equipment, in particular in accordance with the instructions from the manufacturer of the electrical equipment.

In one embodiment, the user can send command signals to the power supply substations 7 to control the electrical equipment, via the central unit 19. In another example, the central unit 19 can send command signals to the power supply substations 7 as a function of one or several received measured values.

In another embodiment, the central unit 19 is adapted to generate information, for example in the form of dashboards, for example relative to current electric measurements of current or voltage and minimum, maximum, average and/or effective values; energy consumption and identification of deviations with respect to a statistical model or a

historical average; the power required by the power supply substation 7, for example in kVA, kW, kVAR, and/or the power factor; the power drawn by the power supply substation 7, for example the power for driving and/or power, in particular in kVA, kW, kVAR, and/or the power factor, for the auxiliaries; the power collected toward high voltage and/or the power collected toward direct current for the reversible power supply substations 7; and/or a performance of the power supply substation 7 (with and without inclusion of the auxiliary power supply substations). For example, this information makes it possible to predict the consumption and standard profiles, show anomalies and optimize the energy subscription. In another example, the central unit 19 is adapted to compute estimated load profiles, for example daily, monthly or yearly, to compare them with current consumption to analyze or anticipate deviations.

A reversible power supply substation 7 operates in both directions either by supplying driving energy to the railway vehicle 3, or by collecting braking energy from the railway vehicle 3 to return it upstream, as explained above. An auxiliary power supply substation 7 is a substation that does not provide driving energy to the railway vehicle 3, but that provides energy to traveler stations for lighting, ventilation, air conditioning or heating, etc. This information allows effective energy management.

In another embodiment, the central unit 19 is adapted to execute different sequences to power on the high-voltage energy, stop the high-voltage energy, power on or stop the driving energy; power electrical section on or off from different commands by the operator from a remote computer 21, 23.

To that end, the central unit 19, in response to a command from a user or automatically, sends one or several command signals to a local computing unit 13. In response to receiving this or these command signal(s), the local computing unit 13 executes the command(s), for example activates the circuit breaker to power on the power supply substation 7. For example, if the central unit 19 detects, during a comparison of an instantaneous current and/or voltage value, that an error has occurred, it can execute a sequence to place the current supply means 5 in a downgraded mode.

These operations make it possible to manage the electrical infrastructure of a railway track and can be requested by remote computer 21, 23 via the server module 44. Figure 4 shows a flowchart of the method according to the invention.

In a step 100, the local computing units 13 receive measured data from the sensors 11, 12 and send this measured data to the central unit 19. The central unit 19 receives the measured data. The measured data comprise the intensity of a current, a voltage value supplied to and/or received from the current supply means 5, and/or one or

several temperature values associated with at least one electrical equipment and/or with one or more rooms of the power supply substation 7.

Advantageously, the measured data comprise maneuver counters of an electrical connection switch associated with at least one electrical equipment of the power supply substation.

In one embodiment, the measured data are associated with a measurement time by the local computing unit 13 and/or by the sensor 11, 12 that is also sent by the respective local computing unit 13 to the central unit 19.

In a step 102, the central unit 19 stores the measured data in the database 34, the stored measured data being associated with a measurement time.

The central unit 19 next receives, in step 104, one or several instantaneous measured values of the intensity of the current and/or of the voltage supplied to and/or received from the current supply means 5. In one embodiment, the central unit 19 receives, from one or several local computing units 13, other instantaneous measured values, for example one or several temperature values associated with at least one electrical equipment and/or with one or more rooms of the respective power supply substation 7.

In step 106, the central unit 19 computes, for example with the mathematical module 48, at least one estimated value of the instantaneous measured value(s), from the stored measured data. For example, the estimated value corresponds to an estimated current intensity or an estimated voltage value for the measurement moment of the instantaneous measured value(s) of the intensity of the current and/or the voltage supplied to and/or received from the current supply means 5.

Next, in step 108, the instantaneous measured value(s) are compared with the estimated value(s), for example by the central unit 19.

In step 110, the central unit 19 actuates an alarm, as a function of the comparison of the measured instantaneous value(s) with the estimated value(s). For example, if the instantaneous measured value(s) have a difference greater than a predetermined value, the central unit 19 actuates the alarm. In one embodiment, the alarm indicates maintenance to be performed. Alternatively or additionally, the central unit 19 sends a command signal to the power supply substation 7, as a function of the comparison of the measured instantaneous value(s) with the estimated value(s). Upon receiving the command signal, the power supply substation 7 controls at least one electric equipment of the power supply substation 7 as a function of the command signal. For example, the command signal can command the power supply substation 7 to power on or stop the driving energy, to power an electrical section on or off, and/or to perform other operations.

CLAIMS

1.- A method for managing an electric network of a railway network, the electric
5 network comprising at least one central unit (19) and a plurality of power supply
substations (7), the power supply substations being connected to a current supply means
(5) of one or several railway vehicles (3), the power supply substations (7) being adapted
to convert a first electric current having a transport voltage, into a second electric current
adapted to circulate on the current supply means (5) and having a usage voltage, or vice
10 versa, the method comprising the following steps:

receiving (100), by the central unit (19), a plurality of measured data, the measured data
comprising the intensity of a current and/or a voltage value supplied to and/or received
from the current supply means (5);

storing (102), by the central unit (19), the measured data, the stored measured data being
15 associated with a measurement time;

receiving (104), by the central unit (19), one or several instantaneous measured values of
the intensity of the current and/or of the voltage supplied to and/or received from the
current supply means (5);

computing (106), by the central unit (19), at least one estimated value of the
20 instantaneous measured value(s), from the stored measured data;

comparing (108), at the central unit (19), the instantaneous measured value(s) with the
estimated value(s); and

activating (110), by the central unit (19), an alarm, as a function of the comparison of the
instantaneous value(s) with the estimated value(s), and/or

25 sending (110), by the central unit (19), a command signal to the power supply substation
(7), as a function of the comparison of the instantaneous value(s) with the estimated
value(s).

2.- The method according to claim 1, characterized in that the alarm indicates a
30 maintenance operation to be performed.

3.- The method according to claim 1 or 2, characterized in that, upon receiving the
command signal, the power supply substation (7) controls at least one electric equipment
of the power supply substation (7) as a function of the command signal.

4.- The method according to one of the preceding claims, characterized in that the measured data comprise one or several temperature values associated with at least one electrical equipment and/or with one or more rooms of the power supply substation (7) and/or maneuvering counters of an electric connection switch associated with at least one electrical equipment of the power supply substation.

5.- The method according to one of the preceding claims, characterized in that the method further comprises the following step:
measuring, at the power supply substation (7), measured data and/or one or several temperature values associated with at least one piece of electrical equipment or with one or more rooms of the power supply substation (7).

6.- A system for managing an electric network of a railway network, the electric network comprising at least one central unit (19) and a plurality of power supply substations (7), the power supply substations being connected to a current supply means (5) of one or several railway vehicles (3), the power supply substations (7) being adapted to convert a first electric current having a transport voltage, into a second electric current adapted to circulate on the current supply means (5) and having a usage voltage, or vice versa, the central unit (19) being adapted to:

receive a plurality of measured data, the measured data comprising the intensity of a current and/or a voltage value supplied to and/or received from the current supply means (5);

store the measured data, the stored measured data being associated with a measurement time;

receive one or several instantaneous measured values of the intensity of the current and/or of the voltage supplied to and/or received from the current supply means (5);

compute at least one estimated value of the instantaneous measured value(s), from the stored measured data;

compare the instantaneous measured value(s) with the estimated value(s);

activate an alarm, as a function of the comparison of the instantaneous value(s) with the estimated value(s), and/or send a command signal to the power supply substation (7), as a function of the comparison of the instantaneous value(s) with the estimated value(s).

7.- The system according to claim 6, characterized in that the alarm indicates a maintenance operation to be performed.

5 8.- The system according to claim 6 or 7, characterized in that the power supply substation (7) comprises one or more electrical equipments, the power supply substation (7) being adapted, upon receiving the command signal, to control at least one of the electrical equipments as a function of the command signal.

10 9.- The system according to one of claims 6 to 8, characterized in that the measured data comprise one or several temperature values associated with at least one electrical equipment and/or with one or more rooms of the power supply substation (7) and/or maneuvering counters of an electric connection switch associated with at least one electrical equipment of the power supply substation.

15 10.- The system according to one of claims 6 to 9, characterized in that the power supply substation (7) is adapted to measure data and/or one or several temperature values associated with at least one electrical equipment or with a room of the power supply substation (7).

20 11.- The system according to one of claims 6 to 10, characterized in that the system comprises a computer network for the connection between the substations and the central unit and for communication of the substations with one another.