



- (51) International Patent Classification:  
H02J 13/00 (2006.01)
- (21) International Application Number:  
PCT/EP2009/051004
- (22) International Filing Date:  
29 January 2009 (29.01.2009)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
08151039.8 4 February 2008 (04.02.2008) EP
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

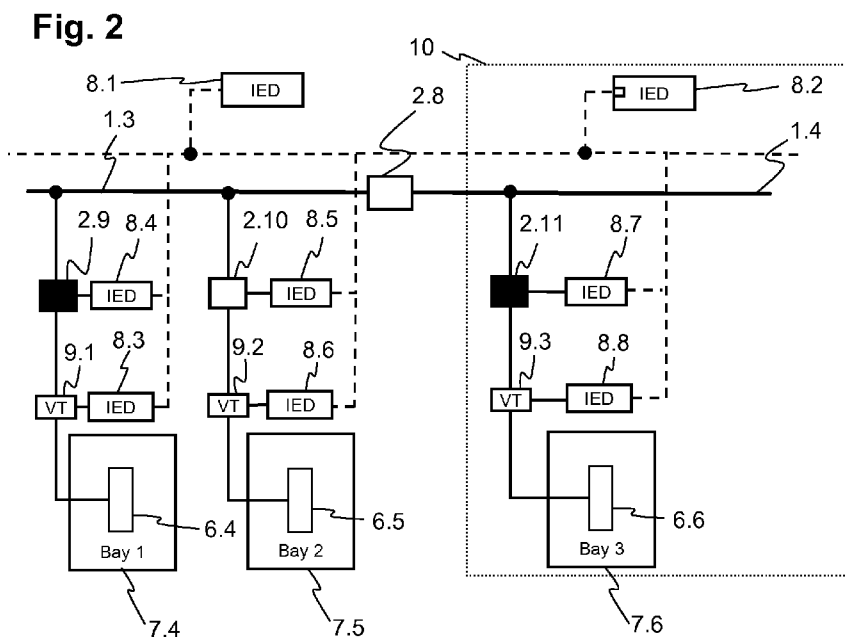
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(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: DETERMINING A BUS BAR VOLTAGE



(57) Abstract: The present invention is concerned with Substation Automation (SA) system in high or medium voltage power networks, in particular for determining a bus bar voltage at a first node (1.3). The invention replaces a 'real' voltage transformer with an IED (8.1) or a 'virtual' VT, which determines the bus bar voltage at the first node from a first bay (7.4) connected to the first node. The IED receives network message from a second IED (8.3) of the SA system, indicating the bay voltage of the first bay connected to the first node. The IED also receives switch status of the switching device (2.9), arranged between the first bay and the first node, from a third IED (8.4). Depending upon the switch status, the IED establishes the bay voltage as the bus bar voltage at the first node.



## DESCRIPTION

### DETERMINING A BUS BAR VOLTAGE

5

#### FIELD OF THE INVENTION

The invention relates to the field of Substation Automation (SA) systems for substations in high and medium voltage power networks.

#### 10 BACKGROUND OF THE INVENTION

Substations in high and medium-voltage power networks include primary devices such as electrical cables, lines, bus bars, switches, power transformers and instrument transformers, which are generally arranged in switch yards and/or bays. These primary devices are operated in an automated way via a Substation Automation (SA) system. The SA system comprises microprocessor based, programmable secondary devices, so-called  
15 Intelligent Electronic Devices (IEDs) responsible for protection, control and monitoring of the primary devices. The IEDs are generally assigned to one of three hierarchical levels, i.e. the station level, the bay or application level, and the process level being separated from the bay level by a process interface. The station level of the SA system includes an  
20 Operator Work Station (OWS) with a Human-Machine Interface (HMI) and a gateway to a Network Control Centre (NCC). IEDs on the bay level, also termed bay units, in turn are connected to each other and to the IEDs on the station level via an optical inter-bay or station bus.

IEDs on the process-level comprise e.g. non-conventional or electronic sensors for  
25 voltage, current and gas density measurements, contact probes for sensing switch and transformer tap changer positions, or intelligent actuators for controlling switchgear like circuit breakers or disconnectors. Breaker-IEDs, if shielded against electromagnetic disturbances, may even be directly integrated into the switchgear or respective intelligent primary equipment. Such process-level IEDs are connected to the bay units via a process  
30 bus, preferably optical, which can be considered as the process interface replacing the hard-wired process-interface that conventionally connects the switchyard to the bay level equipment.

A communication standard for communication between the secondary devices of a substation has been introduced by the International Electrotechnical Committee (IEC) as part of the standard IEC 61850 entitled “communication networks and systems in substations”. For non-time critical messages, the communication between the IEDs is  
5 handled via a Manufacturing Message Specification (MMS) application level protocol and a reduced Open Systems Interconnection (OSI) protocol stack with the Transmission Control Protocol (TCP) and Internet Protocol (IP) in the transport and network layer, respectively, and Ethernet and/or RS-232C as physical media. On the other hand, time critical messages, so-called Generic Object Oriented Substation Events (GOOSE, part IEC  
10 61850-8-1 of the standard) build directly on the Ethernet link layer of the communication stack. Very time-critical signals at the process level such as trip commands and measured analogue voltages or currents use a simplified variant of GOOSE known as Sampled Values (SV, part IEC 61850-9-2 of the standard) that also builds directly on the Ethernet link layer.

15 Conventionally, a Voltage Transformer (VT) is connected to a bus bar of a substation and provides instantaneous values of the bus bar voltage, which are then distributed to all the bays connected to the bus bar. However, VTs are costly and if they have to be maintained or replaced, the concerned part of the switch yard is required to be put out of operation for a long time. In addition, a VT used for synchrocheck function at a bus bar  
20 represents a single point of failure, because no bay can anymore be connected to the bus bar if this bus VT fails.

To avoid making a bus bar VT a single point of failure, a bay VT of a bay currently connected to the bus bar is selected and switched to a dedicated cable or voltage bus of an SA system. The central cable then distributes this bay voltage as the bus bar voltage to all  
25 the bays needing it. Such SA systems use a relay or wiring logic to determine which bay VT is connected to the bus bar. However, this solution of bus bar voltage determination has electrical problems as well as danger, if the logic does not work correctly or with some time delays. For example, if two VTs are accidentally connected to the central cable at the same time, it would destroy them both, causing possible danger to life and limbs of human  
30 beings near them. Also, in this case, the common relay or wiring logic becomes the single point of failure.

The advent of digital controllers rectified the logic problem and enhanced its reliability by expressing the selection logic as Boolean formulas calculated in the controllers.

However, all the VTs have to be switched with some relay contacts to the bus bar related cable. Therefore, the danger of connecting them erroneously still persists, especially if the de-centrally implemented selection logic is too simple. A solution to this problem is centrally implemented selection logic on a controller IED, which assures that only one VT  
5 is switched to the voltage bus cable. But, like the VT and the relay logic, the centrally implemented selection logic also becomes a single point of failure. In addition, these solutions also need a dedicated cable for the voltage running through all the bays, and A/D converters at all the bays needing the bus bar voltage.

## 10 DESCRIPTION OF THE INVENTION

The limitations of the aforementioned electrical solutions for bus bar voltage determination are solved to some extent by a serial process bus with sampled values, as introduced by IEC61850. In this solution, no voltage transformer (VT) outputs have to be physically switched onto a dedicated cable or voltage bus, as the voltage samples are  
15 distributed via the serial bus. The IEDs of the bays connected to the serial bus then use some logic to select the needed voltage sample from the stream of samples on the serial bus. However, the architecture for this solution is quite complex, because similar logic has to be placed in each receiving IED, with relatively complex logic in case of complex switch yard configuration, for example, with several bus bars and bus bar segments or  
20 bypass bus bars. Also, the high amount of samples on the serial bus may result in high load on the bus. This restricts the size of the bus bar because in the worst case all the samples have to be distributed to all the bays connected to the bus bar.

It is therefore an objective of the invention to improve the reliability of a bus bar node voltage determination in an electrical power substation. This objective is achieved by a  
25 method and an IED according to the claims 1 and 6. Further preferred embodiments are evident from the dependent patent claims.

According to the invention, a high or medium voltage substation is controlled by a Substation Automation (SA) system comprising a number of Intelligent Electronic Devices (IEDs) connected to a communication network or serial process bus. The substation has a  
30 first node or segment of a bus bar, to which, via a first switching device, a first bay may be connected. In order to determine a bus bar voltage at the first node, a first IED is provided as a virtual voltage transformer, in place of a real, conventional or non-conventional voltage transformer, i.e. in place of a dedicated primary device connected to the first node.

The first IED receives and reads network messages transmitted over the communication network, and indicative of a bay voltage of the first bay, as well as indicative of a switch status of the switching device connecting the first bay to the first node. If the switch status indicates that the first bay is actually connected to the first node, the bay voltage of the first bay is established or defined as the bus bar voltage of the first node. Optionally, this node voltage is then distributed or broadcasted, via further network messages.

Advantageously, the first IED is given a standardized description of a static substation topology representative of at least a first part of the substation comprising the first node and neighbouring or adjacent sections such as the first bay. The description may be provided to the first IED as part of an engineering process of the IEDs, and in terms of the substation communication standard IEC 61850, is a Substation Configuration Description (SCD) file. Accordingly, the relevant network messages that are intercepted by the first IED are Generic Object Oriented Substation Events (GOOSE) for the switch status and Sampled Values (SV) for the bay voltage. A comparison or evaluation of the static substation topology and the switch status indication allows identifying the first bay as actually being connected to the first node.

In case the switch status indicates that the first bay is not connected to the first node or sends no valid voltage samples, the first IED, according to a preferred variant of the invention, sequentially takes into consideration a second or further bay connectable to the first node, and any bus bar section neighbouring the first bus bar node. This process terminates as soon as a valid voltage can be unambiguously identified as originating from a voltage transformer monitoring a part of the substation, i.e. the second or further bay or the neighbouring bus bar section, which is actually connected, via closed switching devices, to the first node. The sequential nature of this procedure eliminates the single point of failure that is constituted by a dedicated real voltage transformer permanently connected to the first node.

An IED transmitting the network message indicative of the voltage may be assigned to a real voltage transformer, or may itself be a virtual voltage transformer. However, as neighbouring bus bar node connections are checked last, 'real' voltages are given preference over 'virtual' voltages from other virtual voltage transformers. Likewise, if more than two connected neighbouring bus bar nodes are found, the higher voltage is preferred, and if no connected bay or bus bar node is found, a 'preconfigured' zero voltage message is distributed.

In a preferred embodiment of the invention, a first communication network section or Virtual Large Area Network (VLAN), comprising and/or interconnecting secondary equipment assigned to the first node or bus bar section, is delimited or defined within the SA communication system. The GOOSE and the SV network messages are then  
5 constrained to the VLAN, i.e. they are not distributed beyond a boundary of the VLAN. This ultimately reduces network traffic in the SA communication system. It is achieved, for instance, by means of switches in the SA communication network which are arranged at, and define, the boundaries of the VLAN, and which only selectively forward network messages originating from within the VLAN.

10 If all incoming voltage messages are based on the same sampling rate, then the first IED selects, based on some logical conditions, one of the incoming or received messages for output or distribution as a node voltage message, and simply replaces its source identification parameters. However, if different sampling rates exist, then due to the IEC 61850 standard rules the first IED needs to perform a re-sampling of the voltage indicated  
15 by the received SV message to the prescribed fixed sampling rate.

The first IED is either a dedicated process device physically placed in the vicinity of the assigned first node in the switchyard, or it is one physical part or a functionality of a central or station controller located in a central location. In the latter case, the requirements regarding electromagnetic shielding of the first IED are less stringent, due to the larger  
20 distance to the primary equipment and the shielding provided at the central location.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter of the invention will be explained in more detail in the following text with reference to preferred exemplary embodiments which are illustrated in the attached  
25 drawings, in which:

Fig.1 shows a single-line electrical power distribution diagram of a switchyard with a double bus bar topology;

Fig.2 shows a first node of a bus bar with a connected bay;

Fig.3 shows a first node of a bus bar without any connected bay; and

30 Fig.4 is a flowchart illustrating a preferred method for determining a bus bar voltage at a first node of a bus bar.

The reference symbols used in the drawings, and their meanings, are listed in summary form in the list of reference symbols. In principle, identical parts are provided with the same reference symbols in the figures.

## 5 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig.1 depicts a single-line electrical power distribution diagram of a switchyard with a double bus bar topology. The switchyard comprises various primary devices, such as bus bars 1, circuit breakers 2, disconnectors 3, line infeed and outgoing conductors 4, nodes 5, and load or generators 6. The diagram further shows bays 7, which comprises the load or generators 6. Devices of the same kind are distinguished via a continued decimal digit, for example 5.1 and 5.2 denote two nodes. The icons representative of open state of switches (circuit breakers 2 and disconnectors 3) are shown outlined, and those of closed state are shown as filled icons. For example, a closed/open disconnector 3 is depicted by a black/white rhombus. It is apparent that other topologies are conceivable, with or without any bypass buses, and the topologies may comprise other primary devices, such as power transformers, generators, earthing isolators and instrument transformers, without limiting the applicability of the present invention.

In Fig.1, the topology depicted comprises two bus bars 1.1 and 1.2, separated by two circuit breakers 2.1 and 2.2. Each of the bus bars 1.1 and 1.2 is further separated into two bus bar sections by section circuit breakers 2.3 and 2.4. Further, three bays 7.1, 7.2 and 7.3 are depicted in the topology, each comprising a bay circuit breaker 2.5, 2.6, 2.7 connected via conductors 4.1, 4.2, 4.3 to distant loads 6.1, 6.2 or generator 6.3. The bay circuit breakers 2.5, 2.6, 2.7 are each connected to the two bus bars 1.1 and 1.2 via two disconnectors 3.1, 3.2; 3.3, 3.4 and 3.5, 3.6 respectively. The disconnectors 3.1, 3.3 and 3.5 are connected to the bus bar 1.2 through nodes 5.1, 5.4 and 5.7, and to the bay circuit breakers 2.5, 2.6 and 2.7 through nodes 5.2, 5.5 and 5.8. Similarly, the disconnectors 3.2, 3.4 and 3.6 are connected to the bus bar 1.1 through nodes 5.3, 5.6 and 5.9. Further, the topology depicted in Fig.1 shows the disconnectors 3.1, 3.3 and 3.6 in open state and the disconnectors 3.2, 3.4 and 3.5 in closed state. Hence, the bays 7.1, 7.2 and 7.3 are connected to the bus bar 1.1, 1.1 and 1.2 respectively.

Fig.2 shows a first node or bus bar segment 1.3 of a bus bar of a high or medium voltage substation controlled by a SA system, to which a first Intelligent Electronic Device (IED) 8.1 is assigned. A first bay 7.4 and a second bay 7.5 are connected to the first node

1.3. The bays 7.4 and 7.5 include loads 6.4 and 6.5 respectively. The bays 7.4 and 7.5 are connected to the first node 1.3 by switching devices 2.9 and 2.10 respectively. The switching devices 2.9 and 2.10 can be, for example, circuit breakers or connectors/disconnectors. A voltage transformer (VT) 9.1 is arranged between the first bay 7.4 and the switching device 2.9, and a second IED 8.3 is assigned to the VT 9.1. The switching device 2.9 is arranged between the first bay 7.4 and the first node 1.3, and is assigned a third IED 8.4. The black square icon in the switching device 2.9 shows that the switching device 2.9 is in the 'closed-switch' state and the first bay 7.4 is connected to the first node 1.3. Similar to the first bay 7.4, the bay 7.5 is connected to a VT 9.2 and an IED 8.6 is assigned to the VT 9.2. The switching device 2.10 is arranged between the bay 7.5 and the first node 1.3, and is assigned an IED 8.5. The outlined square icon in the switching device 2.10 shows that the switching device 2.10 is in the 'open-switch' state and the bay 7.5 is not connected to the first node 1.3.

Further, the first node 1.3 is separated from a neighbouring bus bar section 10 by a circuit breaker 2.8. The neighbouring bus bar section 10 includes the primary devices connected to the bus bar segment 1.4. Additionally, the neighbouring bus bar section 10 includes an IED 8.2 assigned to a bay 7.6. Similar to the bays 7.4 and 7.5, the bay 7.6 also includes a load 6.6. A switching device 2.11 is arranged between the bay 7.6 and the node 1.4. Similar to the bays 7.4 and 7.5, the bay 7.6 comprises a VT 9.3, and an IED 8.8 assigned to the VT 9.3. Also, the switching device 2.11 is assigned an IED 8.7. The IEDs, 8.1 and 8.2, are part of the station level.

The topology depicted in Fig. 2 shows a case when the first IED 8.1 acts as a virtual VT for the first node 1.3, delivering the bus bar voltage as sample telegrams based on bay level process bus data instead of measurement with a 'real' VT. The first IED 8.1 selects the samples of one (e.g. the first detected) healthy and connected bay having voltage above zero, and communicates these voltage samples as bus bar voltage to the other bus bar segments, as this would have been done by an IED serving a 'real' VT. The basis for the voltage source selection logic at the first IED 8.1 is the state of the switches in the bays 7.4 and 7.5, as communicated in IEC 61850 systems via GOOSE messages for interlocking reasons, to avoid any additional communication load. To select a bay VT as source for the bus bar segment, a series of switches of this bay to the virtual VT's bus bar segment must be in ON state, the samples must provide a non zero voltage (if at all a non zero voltage is connected), and the sample quality must be good. In case, the first bay 7.4 is not connected

to the first node 1.3, the first IED 8.1 is configured to determine the bus bar voltage at the first node 1.3 from the second bay 7.5, in case it is connected to the first node 1.3. Similarly, the first IED 8.1 continues to look for a 'healthy' bay connected to the first node 1.3 to determine the bust bar voltage at the first node 1.3. In case no bay is selected, the first IED 8.1 sends a preconfigured 'zero voltage' telegram.

The first IED 8.1 is provided with a standardized description of a substation topology, for example, the configuration of the bays and the switching devices of a bus bar section. Thereafter, the first IED 8.1 identifies whether the first bay 7.4 is connected to the first node 1.3, by using the switch status of the switching device 2.9 along with the standardized topology description. The first IED 8.1 receives network messages from the third IED 8.4, indicating the switch status of the switching device 2.9. When the switching device 2.9 is in the closed state, the third IED 8.4 sends out a network message that the first bay 7.4 is connected to the first node 1.3. Further, the first IED 8.1 receives network messages from the second IED 8.3, indicating the bay voltage of the first bay 7.4. The second IED 8.3 receives the voltage values from the VT 9.1. When the first IED 8.1 receives the bay voltage of the first bay 7.4, it establishes the received bay voltage as the bus bar voltage at the first node 1.3, depending on the switch status. Once the first IED 8.1 establishes the bus bar voltage at the first node 1.3, it provides this voltage as samples on the bus bar, for example, according to IEC 61850-9-2 standards.

When all bay level VTs provide the same sample rate, the first IED 8.1 routes the selected samples of the first bay connected to the first node 1.3, providing healthy data with its own identification back to the communication bus. When the bay VTs provide different sample rates, the first IED 8.1 interpolates the samples to its own preconfigured, fixed sample rate. Further, the first IED 8.1 can additionally provide a voltage RMS calculation, for example, as IEC 61850 DATA MMXN1.Volt, either with GOOSE or even with a MMS report.

Additionally, the logic to select a bay VT as source for the bus bar voltage ensures that only one bus bar segment and its connection to other segments have to be considered for voltage selection, and not the connections within the other segments. This selection logic can be configured into the virtual VT, for example, the first IED 8.1, thus making it independent from changes in other parts of the switch yard, or could reside in some central controller, which communicates the selection result to the virtual VT, making the virtual VT simpler and allowing a 'one place change' on switch yard configuration changes. The

selection logic further ensures that all healthy real VTs of the bays connected to the segment are used as voltage source. Also, the voltage selection logic at the bays requires the bays to read the samples provided by the virtual VT at the bus bar segment they want to connect to. Switches in the SA communication network delimit a first communication  
5 network section interconnecting IEDs of the SA system that are assigned or related to the first bus bar node 1.3, constraining e.g. the network messages from the second and third IEDs 8.3 and 8.4, as well as from the IEDs 8.5, 8.6 of the second bay 7.5, to this communication network section, by forming a Virtual LAN (VLAN).

Fig.3 depicts the IEDs 8.1, 8.2 connected to the two bus bar segments (nodes) 1.3 and  
10 1.4, without any bay connected to the first node 1.3. The switching devices 2.9 and 2.10 are in 'open switch' state (as shown by outlined icons), disconnecting the first bay 7.4 and the second bay 7.5 from the first node 1.3. Further, the circuit breaker 2.8 connecting the nodes 1.3 and 1.4, is in 'closed switch' state. The first IED 8.1 can communicate with the devices of the bus bar section 1.4, for example the IED 8.1 can communicate with the IED  
15 8.2 of the bus bar segment 1.4. In this case, the first IED 8.1 can be configured to determine the bus bar voltage at the first node 1.3 from the neighbouring bus bar section 10. The first IED 8.1 is configured with the switch positions to be closed in series to select the samples from a specific bay VT. Any neighbouring bus bar segment (which might also contain a VVT) must get lower priority than 'real' bays in the selection process. Further, a  
20 central selection logic, based on the known switch yard topology and switch state, can determine the source VT(s) for each VVT, and configure it appropriately. This introduces a central point of failure needing some redundancy / backup, however allows maintenance of the selection logic for complex switch yard configurations at one place. The VVT can further receive the selected state of circuit breakers together (in the same GOOSE  
25 message) with the switch states, and send its voltage samples only, if a CB is really selected.

For example, when the first IED 8.1 determines that none of the bays 7.4 and 7.5 is connected to the first node 1.3, it establishes the bus bar voltage of the first node 1.3 by using voltage samples from the neighbouring bus bar section 10. Further, in the present  
30 configuration, the voltage value provided by the 'real' VT 9.3 to the IED 8.1 via the IED 8.8 is given preference over the voltage value that the IED 8.2 might provide to the IED 8.1. In case the first IED 8.1 is not able to establish the bus bar voltage at the first node 1.3 by either the bays connected to the first node 1.3 or the neighbouring bus bar section 10, it

sends a preconfigured 'zero voltage' network message to all the bus bar sections of the SA system.

Fig.4 is a flowchart illustrating a preferred method for determining a bus bar voltage at the first node 1.3 of a bus bar of a high or medium voltage substation controlled by an SA system. At step 11, network messages are received by the first IED 8.1 from the second IED 8.3, indicating the bay voltage of the first bay 7.4, connectable to the first node 1.3. At step 12, network messages, indicating a switch status of the switching device 2.9, arranged between the first node 1.3 and the first bay 7.4, are received by the first IED 8.1, from the third IED 8.4. At step 13, the bay voltage of the first bay 7.4 is established as the bus bar voltage at the first node 1.3 by the first IED 8.1, depending on the switch status of the switching device 2.9. Thereafter, this voltage is made available to all the bays connected to the bus bar, and they can use it to connect to the first node 1.3.

LIST OF DESIGNATIONS

- 15 1 bus bar segments
- 2 circuit breakers, switching devices
- 3 disconnectors
- 4 line infeed and outgoing conductors
- 5 nodes
- 20 6 load or generators
- 7 bays
- 8 IEDs
- 9 voltage transformer
- 10 bus bar section
- 25 11 first flowchart step
- 12 second flowchart step
- 13 third flowchart step

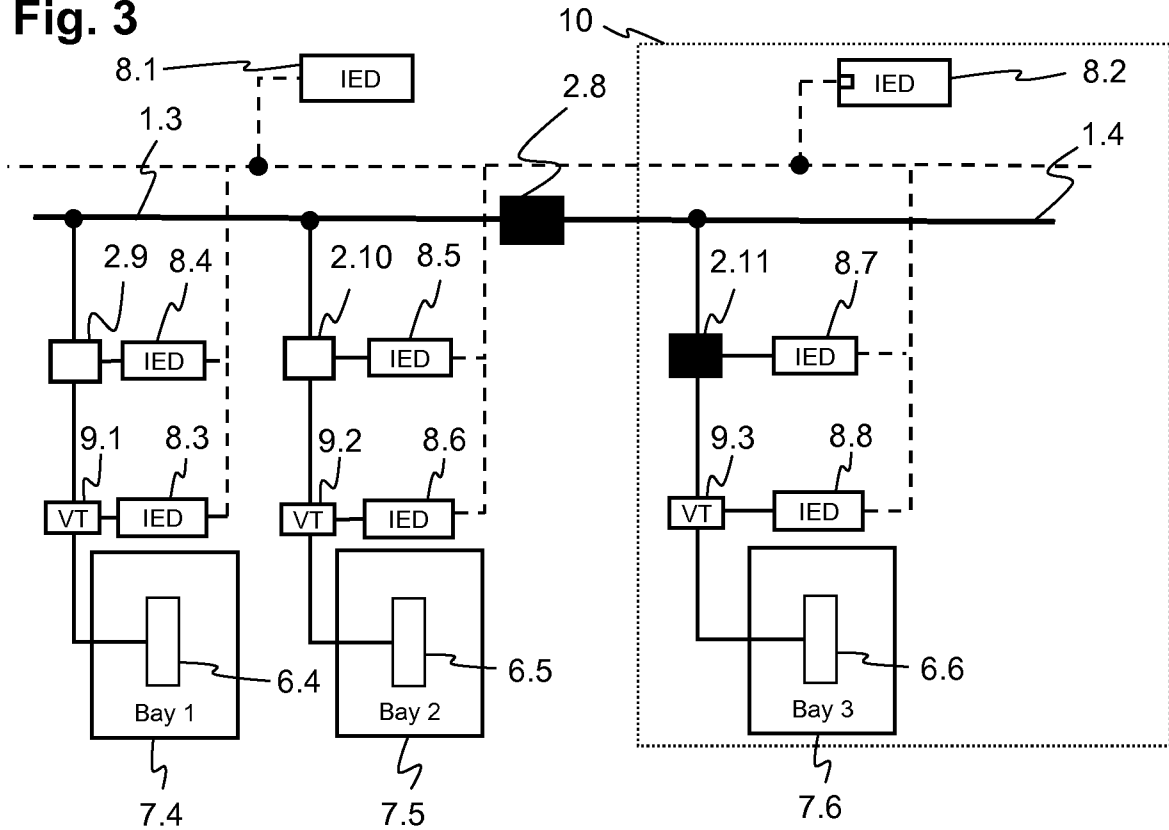
**PATENT CLAIMS**

1. A method of determining a bus bar voltage at a first node (1.3) of a bus bar of a high or  
5 medium voltage substation controlled by a Substation Automation (SA) system,  
comprising, by a first Intelligent Electronic Device (IED) (8.1) of the SA system,
  - receiving network messages from a second IED (8.3) of the SA system and indicative  
of a bay voltage of a first bay (7.4) connectable to the first node (1.3),
  - receiving network messages from a third IED (8.4) of the SA system and indicative of  
10 a switch status of a switching device (2.9) arranged between the first bay (7.4) and the  
first node (1.3), and
  - establishing, depending on the switch status, the bay voltage as the bus bar voltage at  
the first node (1.3).
  
2. The method according to claim 1, characterized in that it comprises  
15
  - providing the first IED (8.1) with a standardized description of a substation topology,  
and
  - identifying the first bay (7.4) as being connected to the first node (1.3) by comparing,  
by the first IED (8.1), the switch status indication with the standardized topology  
description.
  
- 20 3. The method according to claim 1, characterized in that it comprises
  - establishing a voltage from a second bay (7.5) connected to the first node (1.3), or  
from a bus bar section (10) neighbouring the first node (1.3), as the bus bar voltage at  
the first node (1.3).
  
4. The method according to claim 1, characterized in that it comprises  
25
  - delimiting a first communication network section interconnecting IEDs of the SA  
system that are assigned to the first bus bar node (1.3), and
  - constraining the network messages from the second and third IED (8.3, 8.4) to this  
communication network section.
  
5. The method according to claim 1, characterized in that it comprises  
30
  - re-sampling, by the first IED (8.1), the bay voltage established as the bus bar voltage  
at the first node (1.3).

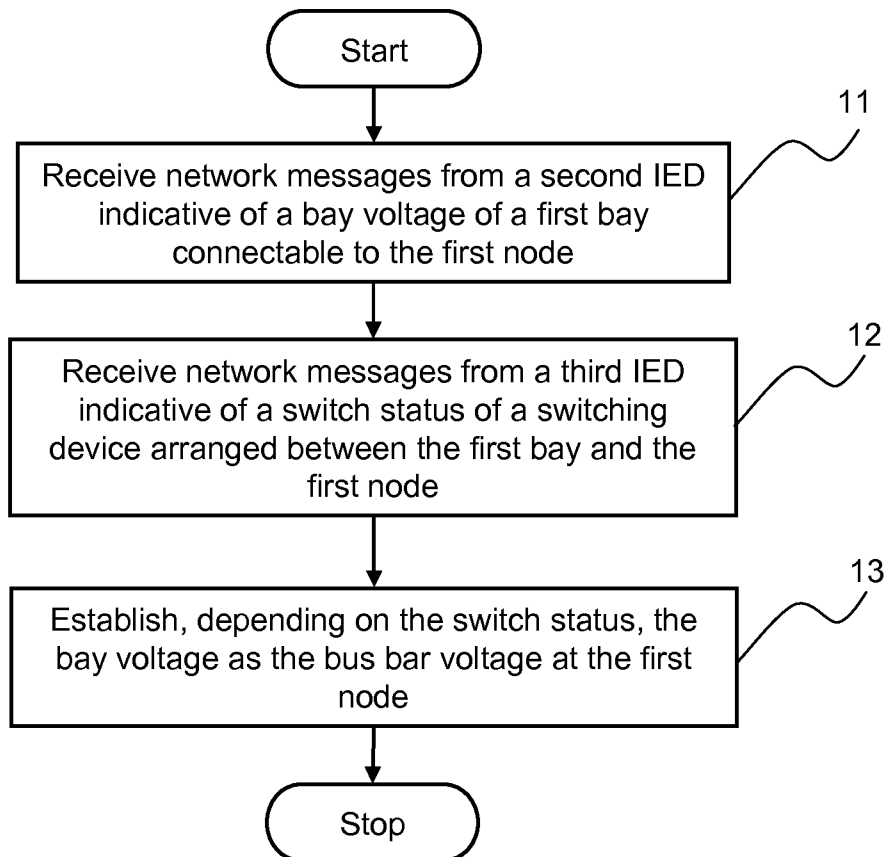
6. An Intelligent Electronic Device (IED) (8.1) connectable to a SA communication network and assignable to a first node (1.3) of a bus bar of a high or medium voltage substation controlled by a Substation Automation (SA) system, and adapted to receive network messages from a second IED (8.3) of the SA system and indicative of a bay voltage of a first bay (7.4) connectable to the first node (1.3), and adapted to receive network messages from a third IED (8.4) of the SA system and indicative of a switch status of a switching device (2.9) arranged between the first bay (1.3) and the first node (1.3), characterized in that the IED (8.1) is adapted to establish, depending on the switch status, the bay voltage as the bus bar voltage at the first node (1.3).
7. The IED (8.1) according to claim 6, characterised in that it is part of a station level IED.
8. A Substation Automation (SA) with an Intelligent Electronic Device (IED) (8.1) according to claim 6 and adapted to execute the method of determining a bus bar voltage at a first node (1.3) of a bus bar of a high or medium voltage substation controlled by the Substation Automation (SA) system according to one of the claims 1 to 5.



**Fig. 3**



**Fig. 4**



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/EP2009/051004

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. H02J13/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 655 669 A (ABB TECHNOLOGY AG [CH]) 10 May 2006 (2006-05-10) abstract paragraphs [0002] - [0009] figures 1,2	1
X	FOLEY M ET AL: "OBJECT-ORIENTED ON-LINE NETWORK ANALYSIS" IEEE TRANSACTIONS ON POWER SYSTEMS, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 10, no. 1, 1 February 1995 (1995-02-01), pages 125-132, XP000513227 ISSN: 0885-8950 the whole document	1

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

26 June 2009

Date of mailing of the international search report

07/07/2009

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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2009/051004

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/064010 A1 (NELSON WILLIAM CHRISTIAN TRACY [US] ET AL) 30 May 2002 (2002-05-30) abstract paragraphs [0036] - [0040], [0060], [0061], [0081], [0119], [0147] figures 1,2,9,10 -----	1-8
A	EP 1 850 447 A (ABB RESEARCH LTD [CH]) 31 October 2007 (2007-10-31) abstract figure 1 -----	1-8
A	EP 1 819 022 A (ABB TECHNOLOGY AG [CH]) 15 August 2007 (2007-08-15) abstract figures 1-3 -----	1-8

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/051004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1655669	A	US 2006108871 A1	25-05-2006
US 2002064010	A1	NONE	
EP 1850447	A	CN 101432947 A	13-05-2009
		WO 2007122196 A1	01-11-2007
		US 2009076762 A1	19-03-2009
EP 1819022	A	WO 2007090302 A2	16-08-2007
		CN 101385213 A	11-03-2009
		US 2009005915 A1	01-01-2009