

## TRANSPORTATION SYSTEM WITH GUIDES FOR GUIDED TRANSPORTATION VEHICLES AND METHOD FOR OPERATING SAID TRANSPORTATION SYSTEM

The invention relates to a transportation system with guides for guided transportation  
5 vehicles, wherein the transportation vehicles are supplied with electric current via a  
contact line, and relates to a corresponding operating method.

From EP 1 254 852 B1 a storage and transportation system is known having  
transportation vehicles which can travel on railway tracks, so-called satellite vehicles  
10 or shuttles which are controlled by a control computer via a wireless connection  
(WLAN). The vehicles are supplied with current either via contact lines or by induction.

The use of WLAN technology has the advantage that absolutely no hardware has to  
be installed on the railway tracks themselves and the constantly moving satellite  
15 vehicles can always be reached or can communicate wirelessly. However, for this  
purpose each vehicle must carry a WLAN adaptor.

However, WLAN communication suffers from the system-imposed disadvantage that it  
is dependent on the topology of the site. This leads to a reduction in the availability of  
20 the site and makes projects more expensive. Furthermore, a WLAN system must  
always be planned and commissioned anew from site to site. A plug & play solution is  
not readily possible with WLAN technology.

Although the construction of large WLANs with a plurality of base stations and  
25 uninterrupted switching of the clients between the different base stations is provided  
as standard, in practice there are problems. The frequency ranges of the base  
stations overlap and lead to interference. Since - in contrast to mobile telephone  
networks - the "intelligence" resides entirely within the client, there is no true handover  
between different base stations. In normal operation a client will seek a new base  
30 station only when contact with the previous one has already been broken off. Owing to  
the limited number of freely available WLAN channels, the size of sites has thus far  
been limited because replication of a channel has a negative effect on the site  
availability and causes interference. In addition there are limitations, depending on the  
country concerned, on the number of free WLAN channels. Moreover, site operators  
35 themselves very often use WLAN technology in their stores, which then renders use

more difficult or impossible.

Although power rail-bound data transmissions exist, this technology always suffers from interference.

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Thus from DE 100 59 072 A1 a device for transmitting binary data between two participants, which can move relative to each other, via a contact line is known, wherein transmission data of a transmitting participant reach the contact line via an energy-amplifying line coupler and the contact line is open at its ends, wherein the  
10 frequency content of the transmission data reaching the contact line is limited to a degree which is permissible in dependence upon a preset maximum data transmission rate and the contact line is formed as an electrically short line in relation to the limited frequency content of the transmission data. This contact line, however, is used only for data transmission.

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It is also known to use power lines in private households for data transmission for computers. This technology, also called PowerLAN or Powerline communication (PLC), designates a local area network which also uses lines intended for supplying conventional network voltage for data transmission. This is a carrier frequency system  
20 which is produced by adaptors for Schuko sockets. By means of a carrier frequency system (CFS) a plurality of signals are each additionally modulated on the line to a carrier frequency (frequency division multiplex process) and distributed on the line. By means of a band pass filter the frequencies are then separated from the carrier frequencies at the receiving adapter.

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Furthermore, this is a matter of communication in which the network is measured prior to the beginning of the transmission of data by modem tuning. Only in this way is it possible to have any success at all in using the open domestic network, to which a wide variety of consumers are connected at a wide variety of locations.

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Conductors through which current is flowing, however, act as antennas and emit the CFS signals into the surrounding area. Since a power line without shielding also receives signals from the surrounding area and from connected devices, there is a problem that in order to maintain a good connection, high transmission levels of the  
35 CFS modems are required. High transmission levels of the modems, however, lead to

higher emitted signals.

In contrast, the object of the present invention consists of providing a simple way of transmitting data between rail-bound transportation vehicles and a (central) control  
5 computer. In particular, a current supply and secure data transmission at the same time should easily be possible.

This object is achieved by the transportation system described in claim 1 and by the method described in claim 11.

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Owing to the fact that the transportation vehicles are also supplied with data from a control unit via the same contact line, a particularly simple data transmission or supply of data is possible without additional installations on the contact lines or guides etc. Each vehicle and the central control merely have to be provided with a corresponding  
15 interface adapter.

It is particularly preferred if the contact line is divided into sections for the supply of data, wherein only one or a plurality of transportation vehicles are located in each section at one time and each section is supplied only with the data for the respective  
20 transportation vehicles, it is possible, in spite of brush arcing during "collection" of the current or of the data from the contact line, to provide successful and secure data transmission between a plurality of rail-bound transportation vehicles and a central control computer.

25 It is thus possible for the transportation vehicles to share sections or to change sections. Thus provision can be made for the transportation vehicles to use lifts or points in order to leave sections and to change to other sections. The addressing of the data to the contact lines of the corresponding lifts, points etc for a group of transportation vehicles can then take place so that these sections are ready with the  
30 corresponding data as soon as a transportation vehicle uses them.

A particularly simple and reliable embodiment includes only one individual transportation vehicle per contact line section at one time.

35 The division of the contact line into sections means that, in spite of the moving

vehicles and therefore the changing line length and thus changing network topology, virtual point-to-point communication is made possible.

5 A contact line is in this case understood to be a power rail as a supply line for the electric current for the electric drive of the transportation vehicles. The current supply from the power rail to the transportation vehicle is effected via so-called contact shoes or current collectors.

10 Electric current is in this case understood to be the electric current for supplying the electric travel drives of the transportation vehicles, e.g. electric motors. This is preferably alternating current and in particular in the range between 40 V to 220 V, particularly preferably in the range between 40 V and 110 V. It is also possible to use direct current.

15 In spite of the division of the contact line into a plurality of sections, it is possible for a plurality of sections to have a parallel feed from the same current source. The division into sections relates only to the data feed which is effected in a targeted/addressed manner into the respective contact line section. The supply of current can thus be effected in a centralised or grouped manner.

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In order to prevent undesired crosstalk of the data - addressed in a targeted manner - from the data transmission from one contact line section into other non-addressed contact line sections, it is useful if a filter device is connected between the current feed and the data feed of each contact line section to prevent crosstalk of the data signals into the power network. In a preferred manner the filter has, for this purpose, an inductor and/or a capacitor or only an inductor. The filter device thus filters the data signals out of the current supply.

25 In a preferred embodiment the transportation system includes a device for targeted modulation of the data to the current supply for the supply of a specific transportation vehicle in a contact line section and in each vehicle a device is provided for demodulation of the data from the supply current. The data for the respective transportation vehicle are thus sent (modulated) in an addressed or targeted manner via the device to the respective contact line section, on which the corresponding  
35 transportation vehicle is located. The device for targeted modulation functions in a

similar manner to a switch from conventional Ethernet technology.

The device for targeted modulation thus stores the respective stopover place of a transportation vehicle, i.e. the contact line section. This can be effected in a self-learning and automatic manner or can be programmed. The communication from the device for targeted modulation then takes place directly via the respective contact line sections. The back-communication from the transportation vehicle is correspondingly "simpler" since only one path, namely the respective contact line section, is available.

Of course, it is possible, however, to carry out a data transmission simultaneously into all sections or section groups etc in the manner of a broadcast signal.

The guides are preferably railway tracks and the transportation vehicles are preferably rail-bound transportation vehicles. However, within the scope of the invention other guides can also be used. Thus e.g. laterally limited travel paths for the transportation vehicles can also be used as guides. Even the contact line itself could be used as a guide.

In order to increase the security and redundancy of the data transmission, the transmitted net data transmission rate of the contact line is so low that the required gross data transmission rate is high enough to transmit the required quantity of data. Therefore, in spite of the considerable interference, e.g. owing to brush arcing, secure transmission can be ensured.

The net data transmission rate is preferably between 20 and 50 kBaud.

Thus, contrary to the prevailing manner of progressing to ever more high-performance and higher transmission rates, the opposite path towards lower transmission rates has been deliberately selected.

The transmission properties (speed and redundancy) selected for secure data transmission during transportation can be changed for so-called offline operation (no communication to the control computer) e.g. program download. If it is assumed that, for example, the program download is carried out when the transportation vehicle is at a standstill, it is not necessary to take account of expected interference owing to brush

arcings. Therefore the transmission redundancy of the protocol can be reduced, which would bring with it an increase in the net data transmission speed. Therefore, when the transportation vehicles are at a standstill, it is possible also to transmit larger quantities of data, e.g. during an update of the firmware of the transportation vehicles,  
5 to the transportation vehicles.

Therefore the method in accordance with the invention can also be used in offline operation with reduced transmission redundancy and/or an increased data transmission rate in order to effect an increase in the net data transmission speed to  
10 the stationary transportation vehicles.

The data transmission method can be used not only for pure data transmission but also as a method for measuring the quality of the current collectors. If the transmission quality deteriorates owing to increased brush arc formation, the data  
15 transmission speed is also reduced which means that many data packets must be transmitted repeatedly. Therefore the data rate which can therefore be used as a measuring variable for the quality of the current transmission is reduced. The method in accordance with the invention can therefore also be used as a method for measuring the quality of the current collectors of the transportation vehicles, wherein  
20 the transmission quality is monitored and deterioration therein serves as a measurement for the wearing out of the current collectors.

It is particularly preferred if the transportation system is provided with railway tracks and rail-bound transportation vehicles are used.  
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The system and method in accordance with the invention can be used particularly in in-house logistics applications. Particularly preferred is the use in storage and transportation systems having one or a plurality of levels with associated conveyor technology, racks, workstations etc.  
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In such storage and transportation systems, a rail-bound transportation vehicle in the rack, for example, serves the whole storage system. The system design is based on autonomous, rail-guided vehicles for transportation of pallets, containers, trays, cardboard boxes, packing drums or other goods, including direct transportation of  
35 goods without loading aids, which operate inside and outside the storage system.

A special load-receiving means permits short load-change times and simultaneous loading and unloading. The system has travel rails which can be installed on each level of the store or standing upright or suspended in the preliminary zone. By means of highly dynamic lifts the vehicles or levels change. Both the power and also the  
5 "orders" are received by the transportation vehicles via the contact line-related current and data transmission in accordance with the invention.

However, the transportation vehicles can also be racking storage and retrieval vehicles, racking serving devices, distribution and travelling trucks and other rail-  
10 bound conveying systems.

Further details, features and advantages of the invention will become clear from the following description of an exemplified embodiment with the aid of the single drawing (Figure 1) which shows a block diagram of a transportation system with guided  
15 transportation vehicles and their current and data supply via a contact line.

In Figure 1 the transportation system is designated as a whole by 1. It includes central control and current supply electronics 2 which are integrated into a control cabinet. This has a central control 3 for control of the transportation vehicles and a central  
20 current feed 4 for supplying the system with electric power.

The transportation vehicles 10 are rail-bound satellite vehicles which travel on a respective level I, II, III, IV of an aisle of a rack on travel rails 11, disposed at that location between the sides of the rack, and are guided by these.  
25

In the region of the travel rails 11 contact lines 12 are disposed which are contacted by the transportation vehicles 10 by means of collectors in order to receive current and data. In the present example, 24 V of direct current are fed to the contact lines 12, meaning that these have two cores 12a, b.  
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The transportation vehicles 10 have, in addition to the wheels 14 and the current collector, not shown for the sake of clarity, a unit 15 for data extraction from the tapped current and an intelligent programmable control 16 which converts the "orders", travel commands etc obtained from the extracted data. It will be understood  
35 that the unit 15, in addition to the demodulation of the data from the current, can also

modulate data in order to transmit data from the transportation vehicle 10 to the central control 3.

The intelligent programmable control 16 is supplied in parallel directly with the tapped  
5 current in order to supply, for example, on-board electronics and the travel drives.

The current supply to the individual sections of the contact lines of the respective levels I, II, III, IV takes place in pairs via network parts 7 which are supplied from the central current feed 4 and are disposed in a sub-distributor 6.

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A single section-wise current supply to the contact line sections or even a common current supply are also feasible. This depends on the respective circumstances, e.g. length of the sections, type of transportation vehicles etc.

15 In the sub-distributor 6 a device 8 is also provided which, on the one hand, is connected via an Ethernet switch 5, which uses known technology, to the central control 3 and, on the other hand, divides the contact line into sections I, II, III, IV for the purpose of the targeted transmission of data to a specific transportation vehicle 10, wherein only one transportation vehicle 10 is located in each section I, II, III, IV at  
20 one time and each section I, II, III, IV is supplied only with the data for the respective transportation vehicle 10.

The unit 8 is, for this purpose, connected to the respective contact lines 12a, b of a section I, II, III, IV via dedicated lines and addresses these lines in a targeted manner  
25 by reason of the address of each transportation vehicle 10 analogously to a computer network. Therefore the data are transmitted from the central control 3 via the switch 5 to the unit 8 by means of the Ethernet protocol and at that location are converted into the protocol used to communicate via the contact line 12 and, by reason of the address of the transportation vehicle 10 intended to receive the data, are fed in a  
30 targeted manner into the contact line 12 of the respective section I, II, III, IV or modulated to the current. It will be understood that the reverse path is also possible.

The data are then extracted or demodulated from the tapped current by the respective transportation vehicle 10 of the corresponding section I, II, III, IV by means of the unit  
35 15. These data are then passed to the intelligent programmable control 16. It will

again be understood that the reverse path is also possible.

The unit 8 for targeted modulation thus stores the respective stopover place of a transportation vehicle 10, i.e. the contact line section I, II, III, IV. This can be carried  
 5 out in a self-learning and automatic manner or can be programmed. The communication from the unit 8 then takes place directly via the respective contact line sections. The back-communication from the transportation vehicle 10 is correspondingly "simpler" since only one path, namely the respective contact line section, is available.

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Of course, it is also possible, however, to carry out the data transmission simultaneously into all sections I, II, III, IV or section groups etc in the manner of a broadcast signal.

15 In order to increase the security and redundancy of the data transmission the transmitted net data transmission rate of the contact line is so low that the required gross data transmission rate is high enough to transmit the required quantity of data. Therefore, in spite of the considerable interference, e.g. owing to brush arcing, a secure transmission can be ensured. The net data transmission rate is between 20  
 20 and 30 kBaud (higher in offline operation). The use of this data transmission rate, which is very low by today's standards, is possible because, amongst other things, the transportation vehicles 10 include the intelligent programmable control 16 which only has to be supplied with orders but monitors and carries out low operational functions independently. The intelligent programmable control 16 also contains e.g. a type of  
 25 system map so that the transportation vehicle 10 knows where it is located and where it must travel to in order to carry out an order.

In order to prevent undesired crosstalk of the data - addressed in a targeted manner - from the data transmission from the contact line 12 of one section I, II, III, IV into other  
 30 non-addressed contact line sections, a filter device 9 is connected between the current feed via the network parts 7 and the data feed of each contact line section via the unit 8. The filter device includes, for this purpose, one inductor per core 12a, b or phase and one capacitor connecting the cores 12a, b. The filter device 9 thus filters the data signals out of the current so that they cannot be propagated via the "open"  
 35 current supply.

## Reference list

|    |                |                                        |
|----|----------------|----------------------------------------|
|    | 1              | transportation system                  |
|    | 2              | control and current supply electronics |
| 5  | 3              | central control                        |
|    | 4              | central current feed                   |
|    | 5              | switch                                 |
|    | 6              | sub-distributor                        |
|    | 7              | network part                           |
| 10 | 8              | unit                                   |
|    | 9              | filter device                          |
|    | 10             | transportation vehicle                 |
|    | 11             | travel rail                            |
|    | 12             | contact line                           |
| 15 | 12a, b         | core                                   |
|    | 14             | wheels                                 |
|    | 15             | unit                                   |
|    | 16             | intelligent programmable control       |
|    | I, II, III, IV | section                                |

## Claims

- 1     Transportation system with guides for guided transportation vehicles (10),  
       wherein the transportation vehicles (10) are supplied with electric current via a  
 5     contact line (12),  
       characterised in that the transportation vehicles (10) are also supplied with data  
       from a control unit (3) via the same contact line (12).
  
- 2     Transportation system as claimed in claim 1, characterised in that the contact  
 10    line (12) is divided into sections (I, II, III, IV) for data supply purposes, wherein  
       one or a plurality of transportation vehicles (10) are located in each section (I, II,  
       III, IV) at one time and each section (I, II, III, IV) is supplied only with the data for  
       the respective transportation vehicles (10).
  
- 15    3     Transportation system as claimed in claim 1 or 2, characterised in that the  
       contact line (12) is divided into sections (I, II, III, IV) for data supply purposes,  
       wherein only one transportation vehicle (10) is located in each section (I, II, III,  
       IV) at one time and each section (I, II, III, IV) is supplied only with the data for  
       the respective transportation vehicle (10).
  
- 20    4     Transportation system as claimed in any one of the preceding claims,  
       characterised in that a plurality of sections (I, II, III, IV) have a parallel feed from  
       the same current source (4, 7).
  
- 25    5     Transportation system as claimed in any one of the preceding claims,  
       characterised in that a filter device (9) is connected between the current feed  
       and the data feed of each contact line section (I, II, III, IV) to prevent the data  
       signals skipping over into the power network.
  
- 30    6     Transportation system as claimed in claim 5, characterised in that the filter  
       device (9) has an inductor and/or a capacitor or only an inductor.
  
- 7     Transportation system as claimed in any one of the preceding claims,  
       characterised in that a device (8) is provided for targeted modulation of the data  
 35    to the current for the supply to a specific transportation vehicle (10) in a contact

line section (I, II, III, IV) and in each vehicle (10) a device (15) is provided for demodulation of the data from the current.

- 8      Transportation system as claimed in any one of the preceding claims,  
5      characterised in that the guides are railway tracks (11) and the transportation vehicles are rail-bound transportation vehicles (10).
- 9      Transportation system as claimed in any one of the preceding claims,  
10      characterised in that the transmitted net data transmission rate of the contact line (12) is so low that the required gross data transmission rate is high enough to transmit the required quantity of data.
- 10      Transportation system as claimed in claim 9, characterised in that the net data transmission rate is between 10 and 50 kBaud, preferably between 20 and 30  
15      kBaud.
- 11      Method for operating and controlling a transportation system with guides for guided transportation vehicles (10), wherein the transportation vehicles (10) are supplied with electric current via a contact line (12), characterised in that the  
20      transportation vehicles are also supplied with data from a control unit (3) via the same contact line.
- 12      Method as claimed in claim 11, characterised in that the contact line is divided into sections (I, II, III, IV) for data supply purposes, wherein one or a plurality of  
25      transportation vehicles (10) are located in each section at one time and each section (I, II, III, IV) is addressed only with the data for the respective transportation vehicles (10).
- 13      Method as claimed in claim 11 or 12, characterised in that the contact line is divided into sections (I, II, III, IV) for data supply purposes, wherein only one  
30      transportation vehicle (10) is located in each section at one time and each section (I, II, III, IV) is addressed only with the data for the respective transportation vehicle (10).

- 14     Method as claimed in any one of the preceding claims 11 to 13, characterised in that one or a plurality of sections (I, II, III, IV) are supplied from the same current source (4, 7).
- 5     15     Method as claimed in any one of the preceding claims 11 to 14, characterised in that the data transmission is effected by means of targeted modulation of the data to the current for the supply to a specific transportation vehicle (10) in an addressed contact line section (I, II, III, IV) and demodulation of the data from the current is effected in each vehicle (10).
- 10     16     Method as claimed in any one of the preceding claims 9 *[sic]* to 15, characterised in that the used net data transmission rate is so low that the required gross data transmission rate is high enough to transmit the required quantity of data.
- 15     17     Method as claimed in claim 16, characterised in that the net data transmission rate is between 10 and 50 kBaud, preferably between 20 and 30 kBaud.
- 20     18     Method as claimed in any one of the preceding claims 11 to 17, characterised in that crosstalk of the data transmission from one addressed contact line section to a non-addressed contact line section is prevented by means of a filter device (9).
- 25     19     Use of the system as claimed in any one of claims 1 to 10 and/or of the method as claimed in any one of claims 11 to 18 in a storage and transportation system having one or a plurality of levels with associated conveyor technology, racks and workstations.
- 30     20     Use of the system as claimed in any one of claims 1 to 10 and/or of the method as claimed in any one of claims 11 to 18 in a storage and transportation system having at least one rack with rack bays disposed on both sides of an aisle on a plurality of levels, and rails, extending along the levels of the rack in the aisles, for rail-bound transportation vehicles for supplying goods to, and removing them from, the rack bays.

- 21 Use of the method as claimed in any one of claims 11 to 18 in offline operation with reduced transmission redundancy and/or an increased data transmission rate in order to effect an increase in the net data transmission speed to the stationary transportation vehicles.

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- 22 Use of the method as claimed in any one of claims 11 to 18 as a method for measuring the quality of the current collectors of the transportation vehicles, wherein the transmission quality is monitored and deterioration therein serves as a measurement for the wearing out of the current collectors.