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Hartwich

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(54) **METHOD FOR TRANSMITTING DATA AMONG SUBSCRIBER STATIONS OF A BUS SYSTEM**

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H04L 12/413	(2006.01)
H04L 12/417	(2006.01)
H04L 12/707	(2013.01)
H04L 12/803	(2013.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC H04L 12/66
USPC 370/423–464
See application file for complete search history.

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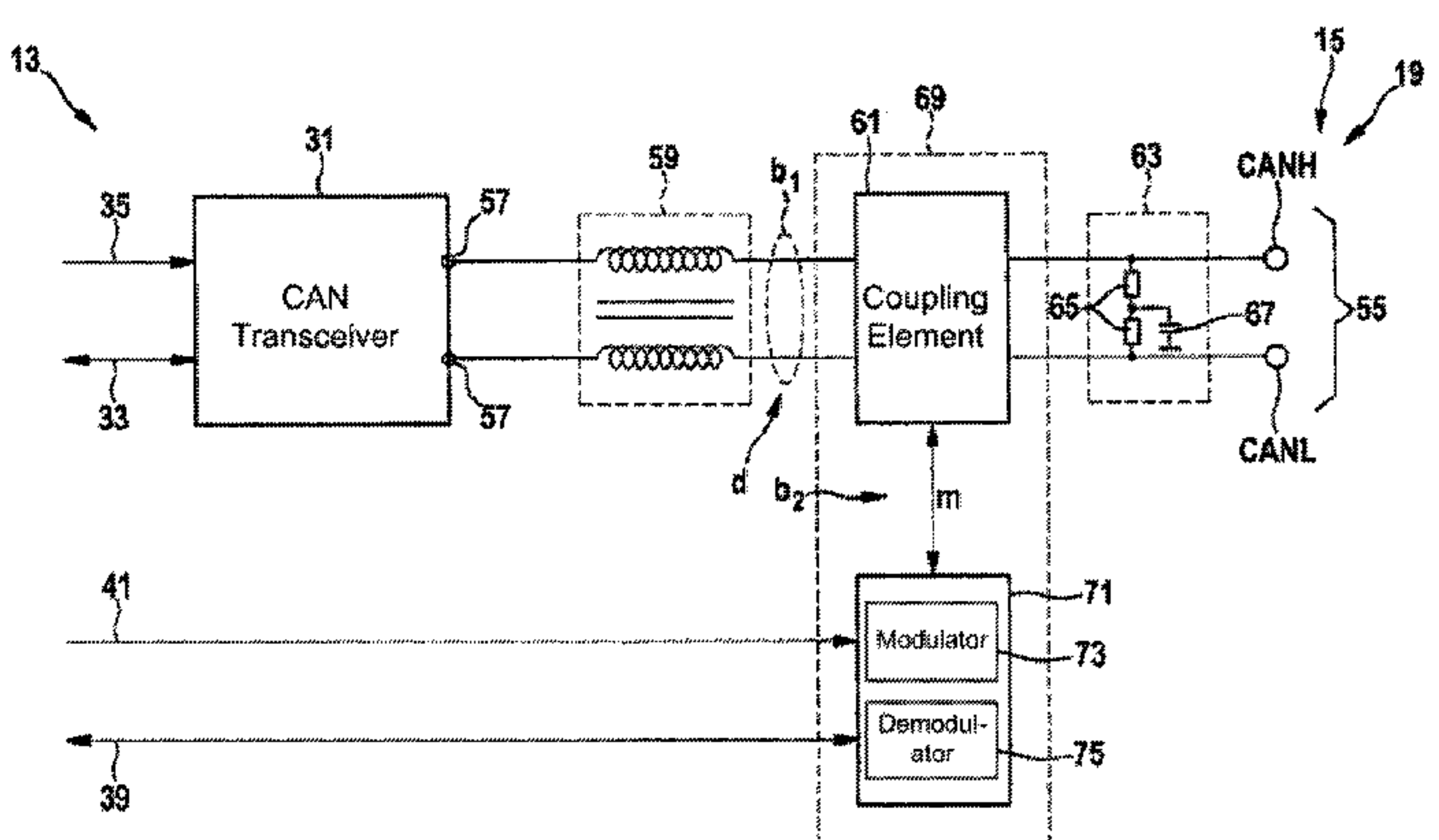
(57) **ABSTRACT**

A method for transmitting data among subscriber stations of a bus system over a first channel of the bus system that is jointly used by a plurality of subscriber stations. To provide a method for the access by a subscriber station of the bus channel to a second channel of the bus system in parallel to a first channel that is jointly used by a plurality of subscriber stations; besides over the first channel, data are also transmitted over a second channel that is used by a plurality of subscriber stations, the access to the second channel being controlled by any given access method, and first data to be transmitted over the first channel and second data to be transmitted over the second channel being transmitted over a shared signal line.

10 Claims, 5 Drawing Sheets



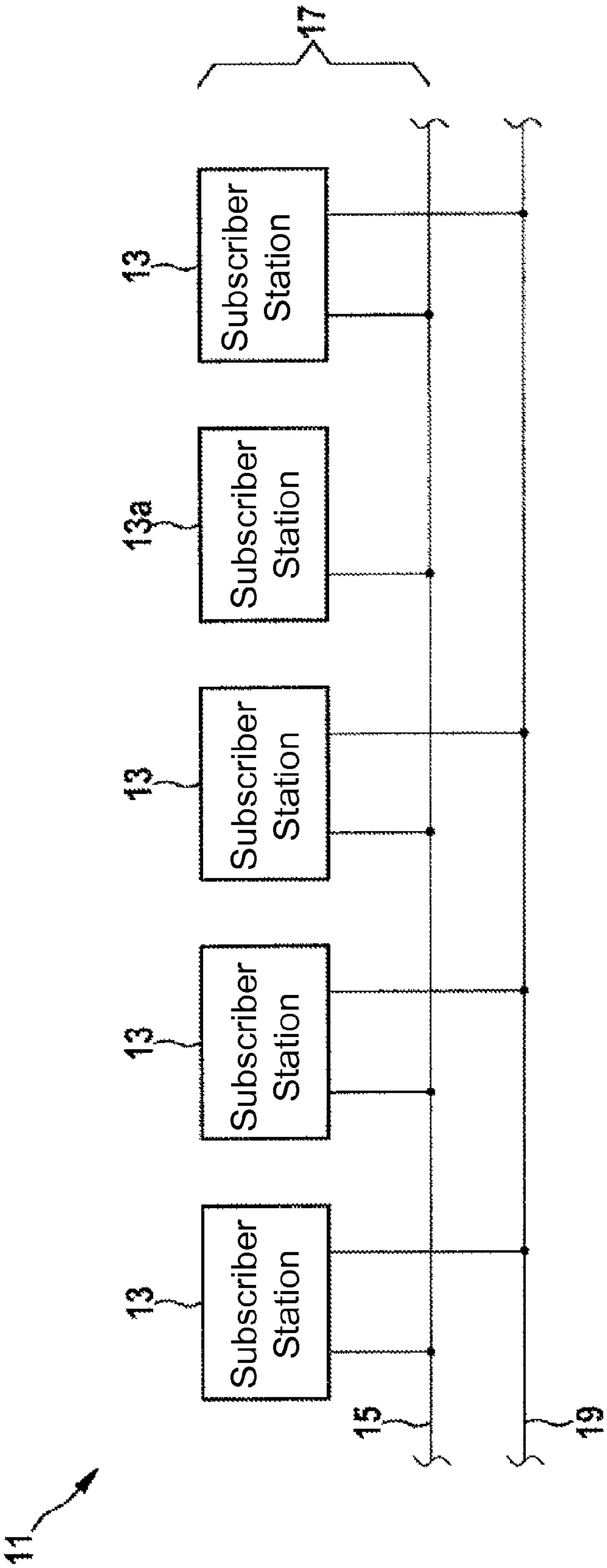
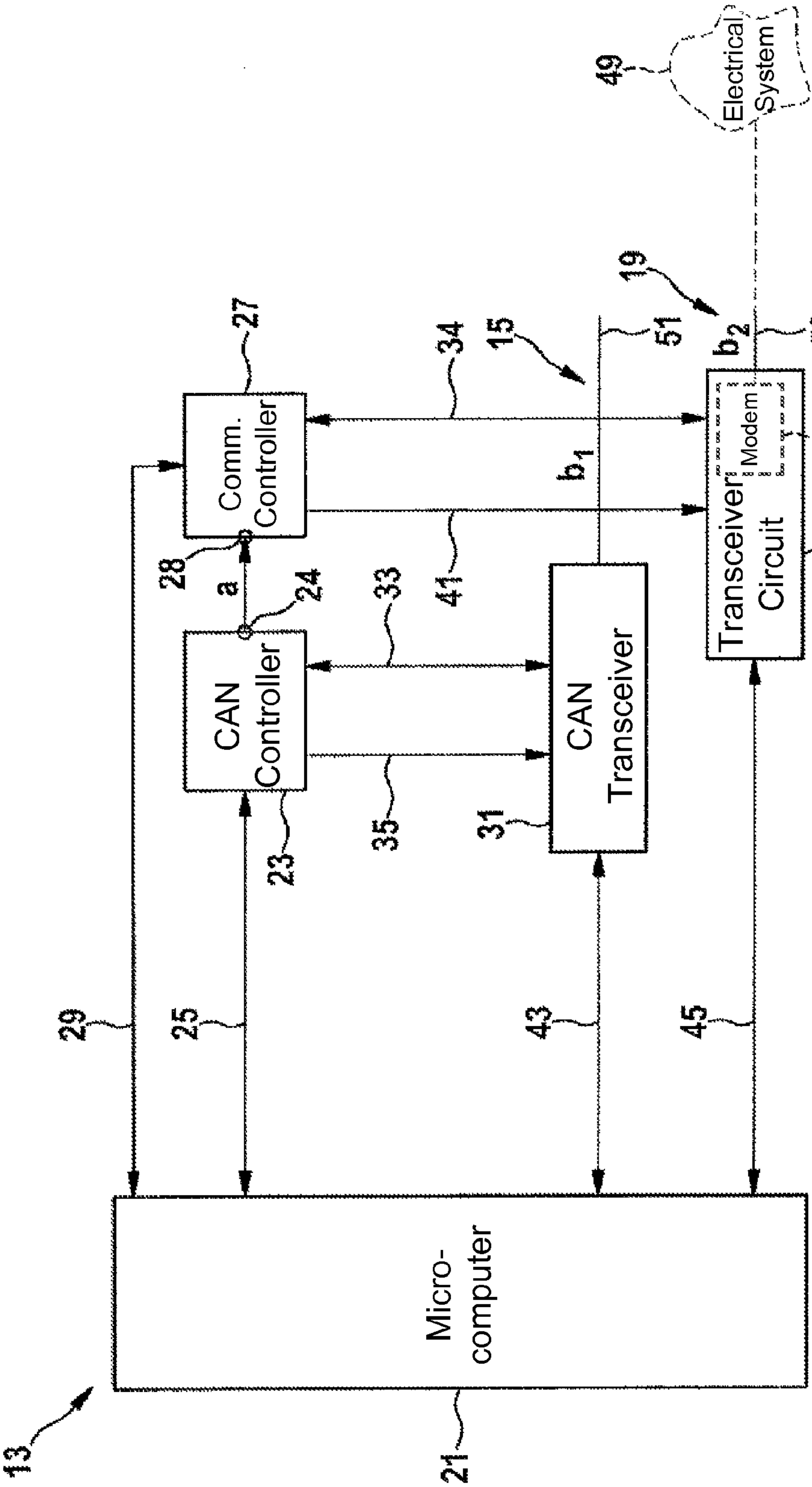

11
13
13a
15
17
19
Subscriber Station
Subscriber Station
Subscriber Station
Subscriber Station
Subscriber Station

Fig. 1


Micro-
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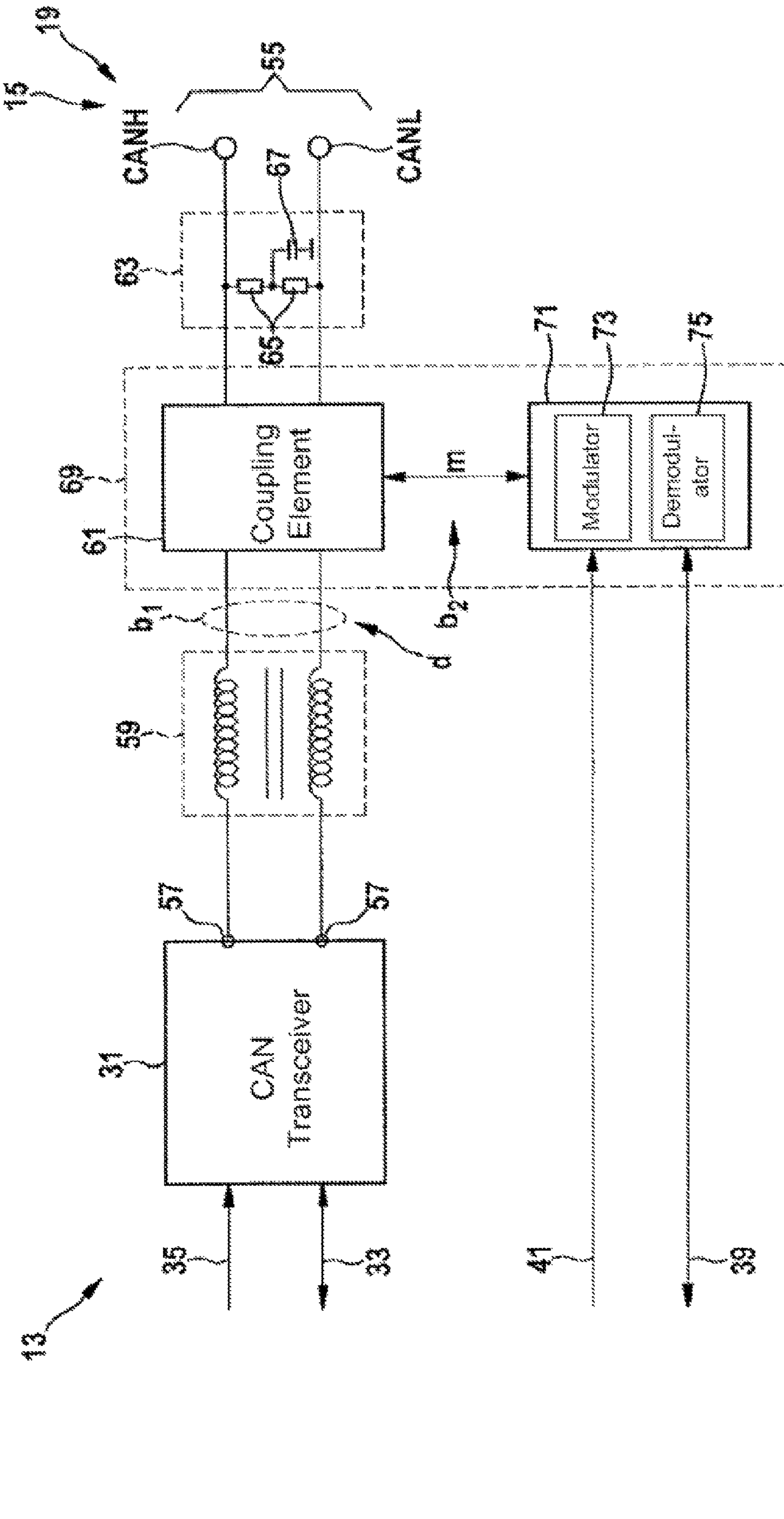
CAN
Controller
CAN
Transceiver
Comm.
Controller
Transceiver
Circuit
Modem
Electrical
System
a
b_1
b_2
13
15
19
21
23
24
25
27
28
29
31
33
34
35
37
41
43
45
47
49
51
53

Fig. 2


19
15
55
CANH
CANL
67
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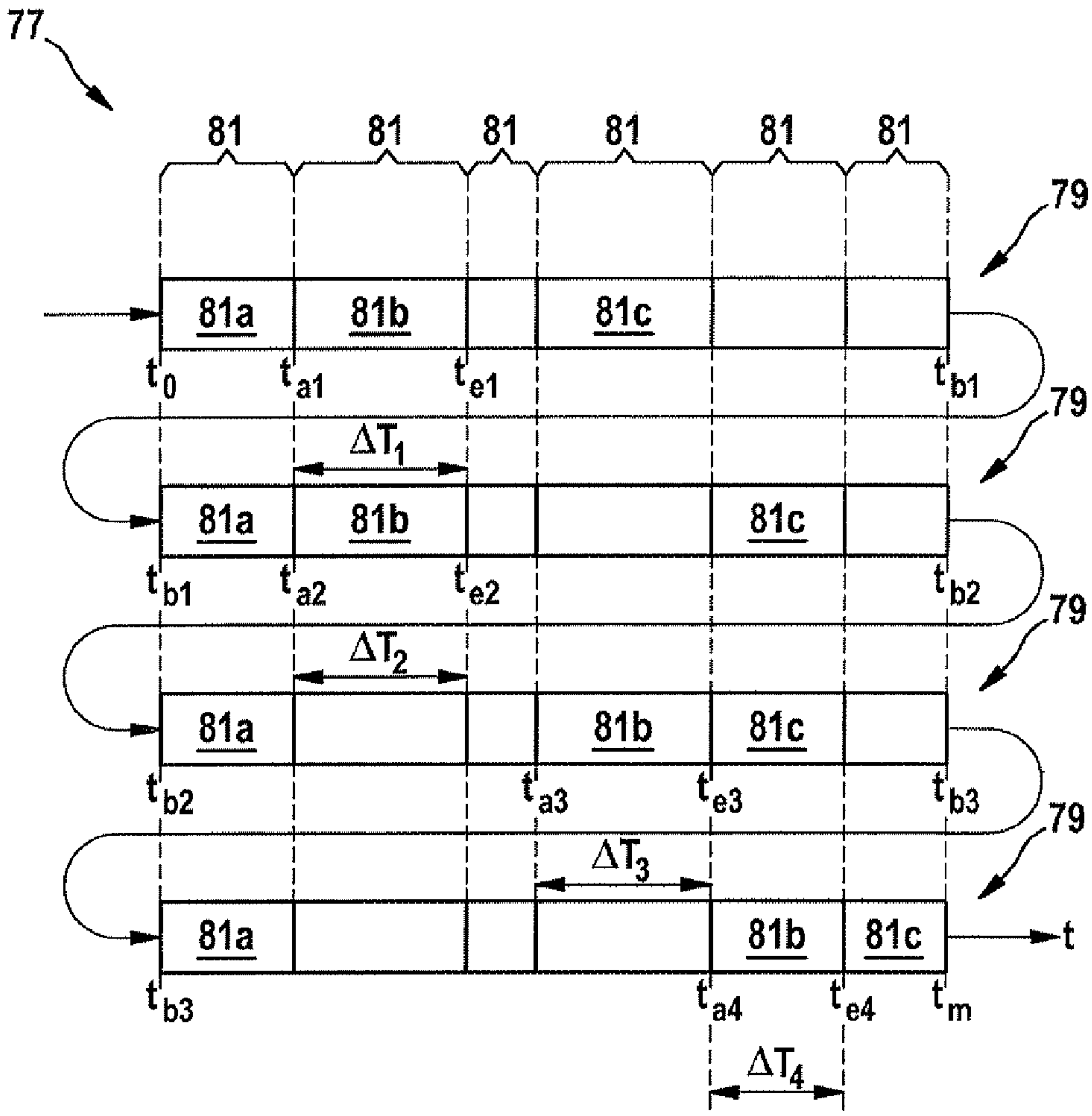
65
69
61
Coupling Element
m
71
73
75
Modulator
Demodul-ator
b_1
b_2
d
59
57
57
31
CAN Transceiver
35
33
41
39
13

Fig. 3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81
81
81
81
81
81
79
81a
81b
81c
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79
ΔT_2
81a
81b
81c
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t_{a3}
t_{e3}
t_{b3}
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t_m
ΔT_4

Fig. 4

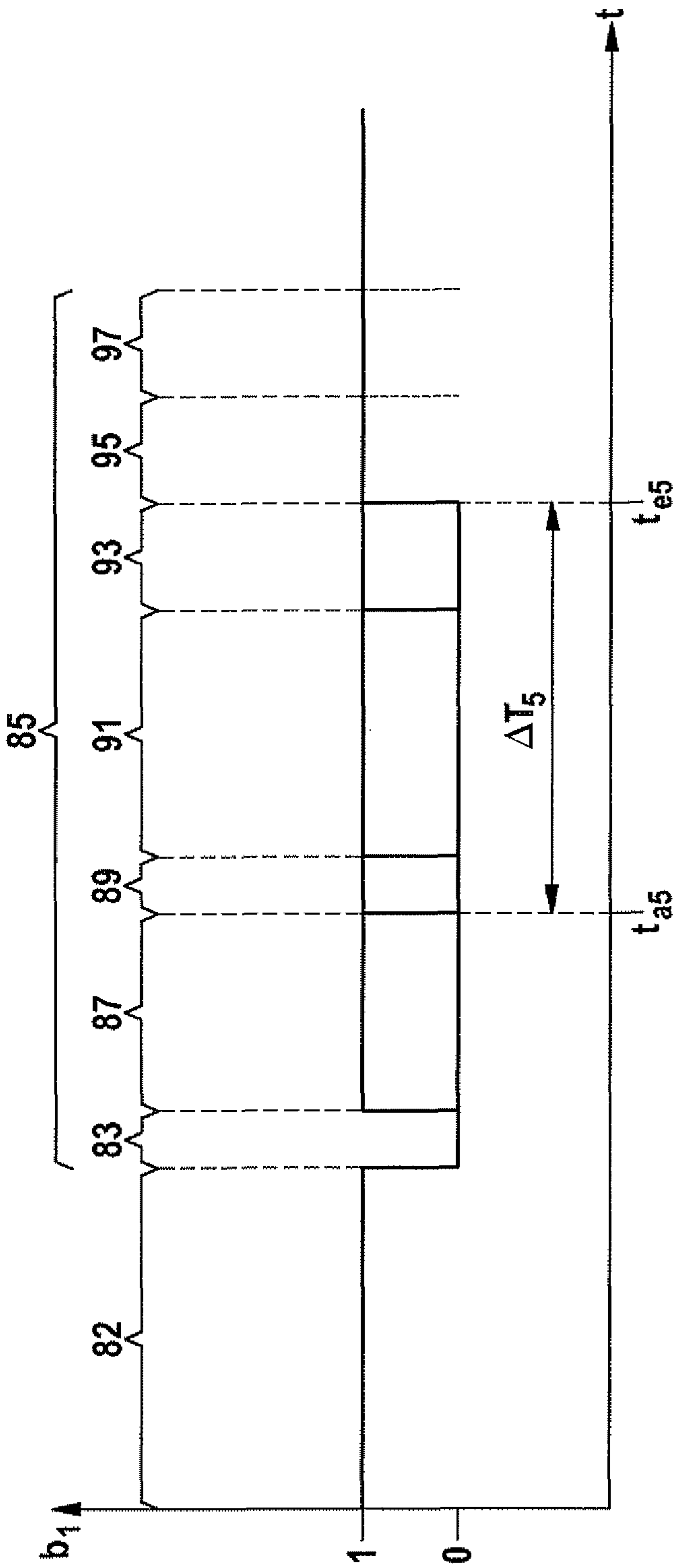

Fig. 5

METHOD FOR TRANSMITTING DATA AMONG SUBSCRIBER STATIONS OF A BUS SYSTEM

FIELD OF THE INVENTION

The present invention relates to a method for transmitting data among subscriber stations of a bus system over a first channel of the bus system that is jointly used by a plurality of subscriber stations. The present invention also relates to a subscriber station of a bus system having a first control element for controlling an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations.

BACKGROUND INFORMATION

The "Controller Area Network" (CAN), as well as an extension of the CAN, referred to as a "Time Triggered CAN" (TTCAN), are known, for example, from German Published Patent Application No. 100 00 305. The media access control method used by the CAN is based on a bitwise arbitration. Bitwise arbitration allows a plurality of subscriber stations to simultaneously transmit data over the channel of the bus system, without any interference to the data transmission in the process. In addition, when transmitting a bit over the channel, the subscriber stations can determine the logic state (0 or 1) of the channel. If a value of the transmitted bit does not correspond to the ascertained logic state of the channel, the subscriber station then terminates the access to the channel. In the case of the CAN, the bitwise arbitration is usually performed in an arbitration field within a data frame to be transmitted over the channel. Once a subscriber station has completed transmission of the arbitration field to the channel, it knows that it has exclusive access to the channel. Thus, the end of the arbitration field transmission corresponds to a beginning of an enable interval during which the subscriber station has exclusive use of the channel. In accordance with the protocol specification of the CAN, other subscriber stations are not permitted to access the channel, i.e., transmit data to the channel, until the transmitting subscriber station has transmitted a checksum (CRC field) of the data frame. Thus, an end time point of transmission of the CRC field corresponds to an end of the enable interval.

A nondestructive transmission of the data frame over the channel is accomplished by the bitwise arbitration. Good real-time properties of the CAN are thereby obtained, whereas media access control methods where the data frame transmitted by a subscriber station can be destroyed during the transmission over the channel due to a collision with another data frame transmitted by a different station, are characterized by a distinctly less favorable real-time behavior since the collision and the thereby necessitated re-transmission of the data frame delay the data transmission.

A further improvement in the real-time behavior of the CAN is attained by the TTCAN extension. In accordance with the TTCAN protocol specification, a time window structure is defined which includes a plurality of successive time windows (often referred to as time slots) and which is regularly repeated. In this context, a specific message type and thus a specific subscriber station can have a specific time window assigned thereto, during which messages of this message type can be transmitted. Thus, in the case of the TTCAN, predetermined time windows are provided during which a specific station has exclusive access to the channel of a CAN domain. In the case of the TTCAN, the access to the channel

is at least partially coordinated in accordance with the time based multiple access (Time Division Multiple Access, TDMA) principle.

The protocols of the CAN, respectively of the TTCAN extension thereof, are particularly suited for transmitting short messages under real-time conditions. However, if larger data blocks need to be transmitted over a CAN domain, then the relatively low bit rate of the channel is perceived as interference. To ensure the correct functioning of the bitwise arbitration, a bit transmission requires that a minimum duration be observed that is dependent, in particular, on the extent of the bus system and the signal propagation speed on the channel. Thus, the bit rate cannot be readily increased by reducing the duration of the individual bits.

To nevertheless be able to rapidly transmit a relatively large data block required for programming a control unit via a communication interface actually provided for the connection to a CAN domain, German Published Patent Application 101 53 085 discusses temporarily switching the communication interface for transmitting the data block to a different communication mode in which no bitwise arbitration is performed, so that a relatively high bit rate is possible. In this case, however, it is necessary to interrupt the communication with the CAN protocols for a certain time period. For example, if it is no longer possible to begin the bus system operation in accordance with the CAN protocols due to an error, then the result is bus system failure. Moreover, transmitting a relatively large data block causes a considerable delay in the subsequent transmissions to be undertaken in accordance with the CAN protocols, thereby degrading the real-time properties of the CAN. Thus, using this method to not only program the control unit at the end of a production process for a motor vehicle or the control unit, but also during operation of the motor vehicle, is impractical.

SUMMARY

Example embodiments of the present invention provide a method for a subscriber station of a bus system to access a second channel of a bus system in parallel to the first channel jointly used by a plurality of subscriber stations, where large quantities of data will be able to be transmitted relatively quickly, and real-time conditions will be able to be observed during transmission of the messages over the bus.

The realization of the method according to example embodiments of the present invention provides for a high-frequency (HF) communication to be implemented over any given bus system, such as a CAN bus, using any given access protocol. Any given access method may be employed to control access to the second channel used by a plurality of subscriber stations for HF communication. First data to be transmitted over the first channel and second data to be transmitted over the second channel are transmitted over a shared signal line. Thus, it suffices to provide one single signal line, for example in the form of a shared bus line, among the individual subscriber stations. It is possible that it be a bus line of the known bus system, in particular of the CAN, over which the data of the first channel are transmitted in accordance with the CAN protocols. Here, the advantage is derived that conventional subscriber stations, which control the known CAN protocols, for example, may be readily connected to the bus system that is operated using the method according to the present invention. In this respect, the method provided here relates to a CAN protocol extension that is compatible to the known protocols and devices of the CAN.

In this case, it is preferred that a data signal and a signal modulated by the second data be generated as a function of the first data, and that the modulated signal be superimposed on the data signal. This prevents the simultaneously occurring transmission of the second data over the second channel from interfering with the transmission of the first data over the second channel. A frequency modulation, in particular a frequency shift keying may be used as a modulation method for producing the modulated signal as a function of a logic state (0 or 1) of the second channel. It is also possible to provide a phase modulation, for example a binary phase modulation (Binary Phase Shift Keying, BPSK).

One especially preferred example embodiment provides that the bitwise arbitration, which limits a bit rate of the first channel, be used to control the access to the first channel, whereas no special arbitration is needed for the second channel. A subscriber station has exclusive access to the first channel during the enable interval, and it accesses the second channel only if it has exclusive access to the first channel. Thus, the second channel may feature a considerably higher bit rate than the first channel. The subscriber station is able to transmit a relatively large data block over the second channel while it has exclusive access to the first channel. The bus system preferably has a CAN domain.

Moreover, it is especially preferred that a time window or a portion thereof be predefined as the at least one enable interval within a regularly repeating time window structure. For the case that the bus system has a CAN domain, the enable interval, respectively the time window is preferably predefined by the TTCAN protocols. In this connection, the time window may be a segment of a basic cycle that is repeated several times within one total cycle. Since, in the case of the TTCAN, a time window is usually assigned to one specific message type, one single subscriber station often has a plurality of time windows and, thus, a plurality of enable intervals within the time window structure preassigned thereto. This is especially the case when this subscriber station is responsible for sending different types of messages, i.e., when it constitutes an information source for a plurality of message types. Using the TTCAN not only makes it possible to ensure an interference-free communication among a plurality of subscriber stations over the second channel without thereby requiring a special arbitration method for the second channel, but allows a specific proportion of the capacity of the second channel to be allocated to individual subscriber stations. Thus, a specific average bit rate may be hereby predefined or assured for transmissions between two specific subscriber stations for transmissions of specific types of messages.

Alternatively or additionally, it may also be provided for a beginning of the enable interval to be ascertained by the subscriber station by a bitwise arbitration of the first channel, and for an end of the enable interval to be specified as soon as the subscriber station re-enables it following a successful arbitration of the first channel. It is thereby accomplished that the access to the second channel is controlled by the bitwise arbitration provided for the first channel. In the case of a CAN domain, it may be provided that the beginning of the enable interval correspond to the end of the transmission of an arbitration field of a frame, and that the end of the enable interval correspond to an end of the transmission of a checksum field of this frame (CRC field).

Using a suitable access method, it is ensured during operation of the bus system that the data to be transmitted over the second channel are not destroyed by collisions thereon. The subscriber station features a second control element for controlling the access to the second channel. The second control element may be any type of communications controller that is not required to execute any protocol for controlling the access to the second channel. The communications controller may be simply realized as a controller for transmitting and receiving an asynchronous serial data stream. The subscriber station features a coupling element which connects the two control elements to a shared signal line in such a way that the first data and the second data are transmissible over the shared signal line between different subscriber stations. This makes possible a simple wire routing among the subscriber stations of the bus system.

Any given media access control method or protocol may be provided to prevent the data to be transmitted over the second channel from being destroyed by a collision on the second channel. However, it is preferable that the access to the second channel be controlled in a way that allows the second channel to be enabled only within the enable interval of the first channel for access by the subscriber station. Every subscriber station that is linked to the bus system is thereby able to ensure that no more than one subscriber station accesses the second channel at any point in time. The subscriber station may be an electronic component of a motor vehicle, for example, in particular, a control unit of a motor vehicle.

To be able to coordinate the access to the second channel without using a separate media access control method or protocol, it is especially preferred that the second control element be coupled to the first control element in a way that makes the second control element controllable, preferably by an access control signal generated by the first control element, to enable the access to the second channel. It may be provided here for the first control element to feature an output for outputting the access control signal, and for the second control element to feature a corresponding control input for communicating with the output.

The subscriber station is preferably configured to implement the method as described herein in order to realize the advantages thereof.

Further features and advantages of example embodiments of the present invention are derived from the following description in which exemplary embodiments are explained in greater detail with reference to the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic representation of a bus system having a plurality of subscriber stations;

FIG. **2** shows a schematic representation of one of the subscriber stations from FIG. **1**;

FIG. **3** is a schematic representation of a section of a subscriber station from FIG. **1** in accordance with an example embodiment of the present invention;

FIG. **4** illustrates a time characteristic of an allocation of a bus system channel; and

FIG. **5** shows a time characteristic of the channel allocation during transmission of a frame over the channel.

DETAILED DESCRIPTION

FIG. **1** shows an overview of a bus system **11** of a motor vehicle which encompasses a plurality of subscriber stations **13**, **13***a* and a first channel **15** jointly used by these subscriber stations **13**, **13***a*. In the illustrated exemplary embodiments, subscriber stations **13**, **13***a* and first channel **15** make up a CAN domain **17**. However, example embodiments of the present invention are not only applicable to the CAN, but also to other types of communications networks. In this context, it is beneficial, but not a necessary condition that a station's exclusive, collision-free access to a shared channel be ensured at least for certain time periods in the communications networks being used. Subscriber stations **13**, **13a** may, for example, be control units or display devices of the motor vehicle.

A portion of subscriber stations **13** is linked to a second channel **19** jointly used by this portion of subscriber stations **13**. In the illustrated exemplary embodiment, all subscriber stations **13**, except for subscriber station **13a**, are linked to both channels **15**, **19**. This subscriber station **13a** is a conventional subscriber station, which, in fact, controls the protocols of the CAN, but is not configured for implementing a method according to example embodiments of the present invention. In accordance with example embodiments of the present invention, the other subscriber stations **13** are expanded to include additional functions, allowing them to additionally communicate over second channel **19**. Thus, in the case of bus system **11** shown in FIG. **1**, conventional subscriber stations **13a** and expanded subscriber stations **13** may be interconnected. A plurality of conventional subscriber stations **13a** may also be provided in the bus system; however, it is also possible in bus system **11** for merely expanded subscriber stations **13** to be provided that are linked to both channels **15**, **19**.

Example embodiments of the present invention are clarified in the following with reference to a media access control method, respectively protocol used in the CAN bus. However, it is self-evident that example embodiments of the present invention is not restricted to such access methods, but rather may be carried out using any given media access control methods and protocols.

FIG. **2** shows an expanded subscriber station **13** in detail. This subscriber station **13** features a microcomputer **21** which may be configured as a microcontroller, for example. A first control element of the subscriber station in the form of a CAN controller **23** is linked via a first coupling device **25** to microcomputer **21**. Moreover, subscriber station **13** features a second control element in the form of a communications controller **27** which is connected via a second coupling device **29** to microcomputer **21**. The two coupling devices **25**, **29** are configured for exchanging data to be transmitted via bus system **11**, as well as configuration, control and status information among microcomputer **21** and the two control elements **23**, **27**. Communications controller **27** is coupled to CAN controller **23** in a way that allows CAN controller to control communications controller **27** via an access control signal a generated by the same. For this purpose, a control input **28** of communications controller **27** is linked to a control output **24** of CAN controller **23**.

Moreover, a subscriber station **13** features a first transceiver circuit which is configured as a CAN transceiver **31**. CAN transceiver **31** communicates with CAN controller **23** in a way that allows the exchange (arrow **33**) of first data to be transmitted via CAN domain **17**, i.e., first channel **15**, between CAN controller **23** and CAN transceiver **31**. Moreover, CAN transceiver **31** is linked to CAN controller **23** in a way that allows CAN controller **23** to transmit control signals to CAN transceiver **31** (arrow **35**). CAN transceiver **31** is linked to first channel **15**.

In addition, subscriber station **13** features a second transceiver circuit **37** which communicates with communications controller **27** for transmitting first data (arrow **39**) to be exchanged via CAN domain **17**, as well as for transmitting control signals (arrow **41**) between communications controller **27** and second transceiver circuit **37**. Second transceiver circuit **37** is linked to second channel **19**.

Moreover, the two transceiver circuits **31**, **37** may be connected to microcomputer **21**, thereby allowing microcomputer **21** to control the two transceiver circuits **31**, **37** and to read out status information therefrom (see arrows **43** and **45**). Such a connection of microcomputer **21** to transceiver circuits **31**, **37** is optional, however. Example embodiments of the present invention may also be realized without such a connection.

Inherent in the precise design of communications controller **27** and second transceiver circuit **37** are considerable degrees of freedom. It is merely necessary that communications controller **27** and second transceiver circuit **37** be provided with a transmitting device for transmitting second data among expanded subscriber stations **13**. A protocol for controlling the media access to the second channel (Media Access Control Protocol, MAC protocol) does not necessarily need to be executed over second channel **19**. In the case of the specific embodiment shown here, communications controller **27** is configured for transmitting and receiving an asynchronous serial data stream. A transceiver circuit, which is actually provided for the CAN, may be used as second transceiver circuit **37**, for example. Since there is no need to perform any bitwise arbitration over second channel **19**, nor therefore any bitwise arbitration of the CAN, second transceiver circuit **37** may be operated at a bit rate higher than that which is permissible for the operation of the second transceiver circuit in accordance with the CAN protocols. If the two transceiver circuits **31**, **37** are identically designed as CAN transceivers, second channel **19** may then be operated at a higher bit rate than first channel **15**. The bit rate of second channel **19** may be 3 to 4 Mbit/s, for example.

If an even higher bit rate is to be provided for data transmissions over second channel **19**, then a transceiver circuit for the "FlexRay" communications system or for local computer networks, such as "Ethernets," for example, may be used as second transceiver circuit **37**. A bit rate of 10 Mbit/s or 100 Mbit/s may be hereby realized on second channel **19**, for example. Second channel **19** may be designed as an electrical and/or optical connection between second transceiver circuits **37** of subscriber stations **13**.

In addition, the second channel may also be constituted of an electrical system **49** of a motor vehicle in which bus system **11** is installed ("Powerline Communications," PLC). In this case, second transceiver circuit **37** features a PLC modem **47** that is coupled to electrical system **49** of the motor vehicle for transmitting the second data over electrical system **49**.

In the exemplary embodiment shown in FIG. **2**, first channel **15** is constituted of a first signal line **51**. Second channel **19** is composed of second signal line **53** that is separate from first signal line **51**. In this respect, the exemplary embodiment illustrated in FIG. **2** is not included in the subject matter of the claims, since, in accordance with example embodiments of the present invention, first channel **15** and second channel **19** are formed by a shared signal line **55** (compare FIG. **3**). Except for this distinction from the present invention, the explanations pertaining to the exemplary embodiment from FIG. **2** also apply to example embodiments of the present invention, however.

For example, in the case of first signal line **51**, it is a question of a two-wire line commonly used in CANs for the differential transmission of first data (depicted in FIG. **2** as first bitstream b_1) to be transmitted over first channel **15**.

Second signal line **53** is configured for transmitting data to be transmitted over second channel **19**, i.e., for transmitting a second bitstream b_2. Second signal line **53** may have the form of another two-wire line used for the differential transmission of second data b_2, respectively of second bitstream b_2, or have some other type of configuration.

FIG. **3** illustrates an example embodiment of the present invention where a shared signal line **55** is provided for the two channels **15**, **19**. Shared signal line **55** encompasses a wire pair composed of a first wire CANH and a second wire CANL. In the illustrated example embodiment, shared signal line **55** is a conventional bus line suited for a CAN-based bus system.

As is apparent from FIG. **3**, CAN transceiver **31** is also present in the case of a subscriber station **13** designed for connection to shared signal line **55**. It is connected via lines **33**, **35** to CAN controller **23**. A common-mode choke **59** is configured at two bus connections **57** of CAN transceiver **31**. Located between common-mode choke **59** and wire pair CANH, CANL of shared signal line **55** is a coupling element **61**. Coupling element **61** may also be combined with common-mode choke **59** to enable high-frequency signals to be inductively coupled in and out, and the high-frequency section of subscriber **13** to be galvanically decoupled from CAN bus **55**. Configured moreover between first wire CANH and second wire CANL is a bus-termination circuit **63** which features two series connected terminal resistors **65**, the outer ends of this series circuit being connected to wires CANH, CANL, and a center tap of this series circuit being connected via a capacitor **67** to ground. In one specific embodiment (not shown), common-mode choke **59** and/or bus-termination circuit **63** are not provided.

Coupling element **61** belongs to a connection circuit **69** of subscriber station **13** that, in the specific embodiment shown in FIG. **3**, is provided instead of second transceiver circuit **37**. On the one hand, a modem **71** of connection circuit **69** may be connected to microcomputer **21**; on the other hand, it is linked to coupling element **61**. Modem **71** features a modulator **73** for producing a signal m that is modulated as a function of second bitstream b_2. In addition, modem **71** features a demodulator **75** for demodulating modulated signal m that has been transmitted by another subscriber station **13** over shared signal line **55**.

In the following, the operating principle of subscriber stations **13** and of bus system **11** are clarified in greater detail with reference to FIG. **4** in **5**. During operation of bus system **11**, microcomputers **21** of individual subscriber stations **13** control individual CAN controllers **23** and CAN transceivers **31**, thereby allowing messages to be exchanged between subscriber stations **13**, **13***a* in accordance with the CAN protocols, in that frames containing the messages are transmitted over first channel **15**.

In the illustrated example embodiment, individual subscriber stations **13** support the TTCAN extension. In accordance with the TTCAN, the time is subdivided into regularly repeating total cycles. Such a total cycle **77** is shown schematically in FIG. **4**. Total cycle **77** begins at time point t_0 and ends at time point t_m. It is discernible that total cycle **77**, in turn, is subdivided into a plurality of basic cycles **79**. In the illustrated example embodiment, total cycle **77** is subdivided into four basic cycles **79**. First basic cycle **79** (drawn at the top in FIG. **4**) begins at time point t_0 and ends at time point t_{b1}. Second basic cycle **79**, which follows first basic cycle **79**, also begins at this time point t_{b1} and ends at a time point t_{b2}. Correspondingly, third basic cycle begins at time point t_{b2} and ends at time point t_{b3}. Fourth basic cycle begins at time point t_{b3} and ends at time point t_m and thus ends total cycle **77**.

Individual basic cycles **79** are subdivided into a plurality of, in the illustrated example embodiment six, time windows **81**, the subdivision of basic cycles **79** into time windows **81** being identical for each basic cycle **79**. Total cycles **77** define a regularly repeating time window structure which, due to the identical subdivision of individual basic cycles **79** into time windows **81**, features a matrix-type structure and, thus, is usually referred to as a communications matrix.

A first time window **81***a* is provided for transmitting reference messages over first channel **15**. The reference messages are used, in particular, for synchronizing individual subscriber stations **13** among themselves, so that, from the perspective of individual subscriber stations **13**, the temporal position of individual time windows **81** is at least substantially identical. A portion of time windows **81** is assigned to a specific message type, i.e., within this time window **81**, exclusively data frames having a specific identifier are transmitted. For example, it may be provided that time windows **81** denoted by **81***b* are reserved for transmitting the message of the specific type.

Since, in the case of the CAN, a message of a specific type, i.e., having a specific identifier, may only be generated by a subscriber station **13**, time windows **81***b* are exclusively assigned to this subscriber station **13**. This means that at a beginning time point t_{a1}, t_{a2}, t_{a3}, respectively t_{a4}, an enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 begins within which these subscriber stations **13** have exclusive access to first channel **15**. Enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 ends in each case at the end of corresponding time window **81***b*, i.e., at time point t_{e1}, t_{e2}, t_{e3}, respectively t_{te4}. In the illustrated specific embodiment, enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 corresponds to particular time window **81***b* of the total cycle. Deviating herefrom, it may also be provided, however, that enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 merely correspond to a portion of particular time window **81***b*. Important for the functioning of the method according to example embodiments of the present invention is that enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 be completely covered with respect to time by a time window **81***b* or by a plurality of directly successive time windows **81***b*.

Each subscriber station **13** records time points t_0, t_{b1}, t_{b2}, t_{b3} when the individual reference messages are received and calculates the temporal position of at least those time windows **81** within which it intends to access the bus. Subscriber station **13**, which is responsible for sending those messages to which time window **81***b* is assigned, calculates the position of enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4 drawn in FIG. **4**. In the illustrated example embodiment, CAN controller **23** performs these calculations. It may also be provided, however, for these calculations to be performed by microcomputer **21**. In addition, CAN controller **23** generates access control signal a and transmits it to communications controller **27** (see FIG. **2**). Access control signal a is always active within enable interval ΔT_1, ΔT_2, ΔT_3, respectively ΔT_4. Communications controller **27** evaluates access control signal a and only accesses second channel **19** when access control signal a is active. If access control signal a is not active, then communications controller **27** keeps second channel **19** free, thereby allowing other subscriber stations **13** to access it. Thus, subscriber stations **13** are configured to allow CAN controller **23** to control communications controller **27** as a function of access control method executed in the CAN domain in such a way that communications controller **27** accesses second channel **19** only when an access to first channel **15** is also permitted in accordance with media access control method of CAN domain **17**.

In addition, within total cycle **77**, other time windows **81***c* are provided within which messages of any given type may be transmitted. Exclusive access of a specific station to the first channel is not ensured within these time windows **81***c*. For that reason, a bitwise arbitration is performed within time windows **81***c* in accordance with the protocols of the CAN. The bitwise arbitration is based on the fact that a bit having one specific value is always received by all stations when a plurality of subscriber stations **13** simultaneously access first channel **15** and transmit bits having different values. The value of this bit is referred to as "dominant bit" and, in the illustrated example, corresponds to the value 0. In addition, first signal line **51** is configured to allow each subscriber station **13** to receive via its CAN transceiver **31** while it accesses first channel **15**. Thus, while accessing first channel **15** in order to transmit a bit, each subscriber station **13** is able to read the momentary state of first channel **15** in order to ascertain whether this state corresponds to the transmitted bit.

FIG. **5** shows a detail of a time characteristic of the logic state (value 0 or 1) of first channel **15** within time window **81***c*. Following an open-circuit time **82** during which first channel **15** was not assigned by a subscriber station **13**, a subscriber station **13** under consideration begins to transmit a start bit **83** of a frame **85**. Following transmission of start bit **83**, subscriber station **13** transmits an arbitration field **87** which, in particular, contains the identifier of the message that indicates the type of message. During the transmission of arbitration field **87**, subscriber station **13** compares the logic state of first channel **15** to the particular transmitted bit of arbitration field **87**. If, during the transmission of arbitration field **87**, subscriber station **13** determines that the detected state of the first channel does not correspond to the transmitted bit, then subscriber station **13** terminates the transmission of frame **85**. It is thus ensured that, following transmission of arbitration field **87** at a time point t_{a5}, a subscriber station **13** has exclusive access to first channel **15**. All other stations, which have simultaneous access to first channel **15** in order to transmit a frame **85**, have terminated their transmission and thus their access to first channel **15** at time point t_{a5}. Thus, time point t_{a5} corresponds to the beginning of another enable interval ΔT_5. Once arbitration field **87** has been transmitted, subscriber station **13** transmits a control field **89** of frame **85**, a data field **91** of frame **85**, as well as a check field **93** (what is generally referred to as a CRC field).

In an acknowledgement field **95** that follows check field **93**, other subscriber stations **13** may transmit an acknowledgement bit over first channel **15**, i.e., access first channel **15**. Thus, enable interval ΔT_5, within which subscriber station **13** under consideration has exclusive access to first channel **15**, ends at the end of the transmission of check field **93**, i.e., at a time point t_{e5}. Acknowledgement field **95** is followed by a field having stop bits **97**. Deviating from the illustrated specific embodiment, enable interval may also be selected to be shorter; however, it must reside within interval ΔT_5 in which subscriber station **13** has exclusive access to first channel **15**.

During time windows **81***c*, CAN controller **23** ensures that access control signal a is only active during enable interval ΔT_5, so that, within time window **81***c*, communications controller **27** only accesses second channel **19** during enable interval ΔT_5.

Deviating from the illustrated specific embodiment, it may also be provided that CAN controller **23** releases enable signal a for enabling the access to second channel **19** only within such time window **81** that enables transmission of messages of a certain type, i.e., within time window **81***b*, for example, while those time windows (for example, time windows **81***c*), which are used for transmitting messages of a different type, i.e., within which the bitwise arbitration takes place, are not used in this specific embodiment of second channel **19**. It is also conceivable that an access to second channel during interval ΔT_5 is only enabled when TTCAN is not available due to an error in CAN domain **17**, for example. This makes possible an emergency operation of bus system **11**, in particular of second channel **19** given a TTCAN that is not available, i.e., in the case of a missing time window structure **77**.

In addition, it may be provided that the present invention be used on a CAN domain **17** that does not support the TTCAN extension. In the case of such a CAN domain **17**, time window structure **77** is missing. Thus, a bitwise arbitration always takes place in such a case. In the case of such a CAN domain **17**, the access to second channel **19** is enabled during enable interval ΔT_5 indicated in FIG. **5**.

If access control signal a is active, i.e., the access to second channel **19** is enabled, then, in the case of the specific embodiment illustrated in FIG. **2**, second transceiver circuit **37** outputs second bitstream b_2. If second signal line **53** is constituted of electrical system **49**, then, in the case of transmitting subscriber station **13**, PLC modem **47** modulates bitstream b_2 and transmits a correspondingly modulated signal to electrical system **49**. In the case of receiving subscriber stations **13**, PLC modem **47** demodulates the modulated signal emitted by a transmitting subscriber station **13** and thereby reconstructs transmitted bitstream b_2 and relays the second data contained in second bitstream b_2 to communications controller **27**.

In the example embodiment illustrated in FIG. **3**, modulator **73** of modem **71** of transmitting subscriber station **13** produces modulated signal m as a function of second data b_2 that communications controller **27** had communicated to connection circuit **69**. Coupling element **61** superimposes a signal m, that has been modulated as a function of second bitstream b_2, on data signal d generated by CAN transceiver **31** as a function of first bitstream b_1 and outputs it to both CANH and CANL wires of shared signal line **55**. In the case of receiving subscriber stations **13**, coupling element **61** relays a signal, which is received via the two wires CANH and CANL, over optionally present common-mode choke **59** to CAN transceiver **31** and transmits it to demodulator **75** of modem **71**. From the received signal, CAN transceiver **31** extracts first bitstream b_1 and relays it to CAN controller **23**. Correspondingly, demodulator **75** ascertains second bitstream b_2 from the received signal. By configuring optionally present common-mode choke **59** between CAN transceiver **31** and coupling element **61**, common-mode choke **59** is prevented from attenuating modulated signal m within a signal path between modem **71** of two subscriber stations linked to shared signal line **55**.

As a modulation method in the illustrated example embodiment, modem **71** employs a frequency shift keying as a function of the value of the individual temporally successive bits of second bitstream b_2. Deviating herefrom, in place of the frequency shift keying, a phase modulation or any other modulation method may also be used.

In the simplest case, coupling element **61** may also be configured as a resistor network. However, coupling element **61** may also feature one or a plurality of filters for separating data signal d to be fed to CAN transceiver **31** from modulated signal m. Moreover, it would be conceivable for coupling element **61** to be combined with common-mode choke **59**; thus, instead of a simple inductor having four connections, for common-mode choke **59** to use an inductor having six or more connections. In this manner, high-frequency signal may be inductively coupled in and out; and the high-frequency section is galvanically decoupled from the CAN bus. Moreover, cost advantages are thereby derived.

Overall, therefore, example embodiments of the present invention provide a method and a subscriber station **13** which make it possible to substantially increase the useful bit rate of CAN domain **17** using additional, second channel **19**, thereby enabling larger data blocks to be readily transmitted over bus system **11**. Since the access to second channel **19** may be controlled as a function of the media access control of CAN domain **17**, it is possible to prevent collisions, i.e., inference caused by a plurality of subscriber stations **13** unintentionally accessing second channel **19** simultaneously. Therefore, a bus system **11** is obtained that is able to satisfy the real-time conditions that arise in automotive technology, render possible transmissions at relatively high bit rates and, nevertheless, be realized at low cost.

What is claimed is:

1. A method for transmitting data among subscriber stations of a bus system over a first channel of the bus system that is jointly used by a plurality of subscriber stations, comprising:

besides over the first channel, transmitting data over a second channel that is used by the plurality of subscriber stations;

controlling access to the second channel by an access method; and

transmitting first data to be transmitted over the first channel and second data to be transmitted over the second channel over a shared signal line;

wherein:

the transmitting of the first data includes generating a data signal as a function of the first data, generating a modulated signal as a function of the second data, superimposing the modulated signal on the data signal, and transmitting the superimposed signals over the shared signal line;

the access to the second channel by any particular subscriber station is controlled in a manner that allows the second channel to only be enabled for the particular subscriber station within an enable interval;

the enable interval is an interval during which the particular subscriber station has exclusive access to the first channel;

a beginning of the enable interval is ascertained by the subscriber station by a bitwise arbitration of the first channel; and

an end of the enable interval is specified as soon as the subscriber station re-enables the first channel following a successful arbitration of the first channel.

2. The method according to claim **1**, wherein a time window or a portion thereof is predefined as the at least one enable interval within a regularly repeating time window structure.

3. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by the plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first processing circuitry and the second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

the subscriber station is configured to generate a data signal as a function of the first data, generate a modulated signal as a function of the second data, superimpose the modulated signal on the data signal, and transmit the superimposed signals over the shared signal line;

the access to the second channel by the subscriber station is controlled in a manner that allows the second channel to only be enabled for the subscriber station within an enable interval;

the enable interval is an interval during which the subscriber station has exclusive access to the first channel;

a beginning of the enable interval is ascertained by the subscriber station by a bitwise arbitration of the first channel; and

an end of the enable interval is specified as soon as the subscriber station re-enables the first channel following a successful arbitration of the first channel.

4. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by the plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first processing circuitry and the second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

the second processing circuitry is coupled to the first processing circuitry in a manner that makes the second processing circuitry controllable, by an access control signal generated by the first processing circuitry, to enable the access to the second channel;

the coupling element is combined with a common mode choke in a manner that allows a high-frequency signal encompassing the first and the second data to be inductively coupled in and out;

the first processing circuitry is configured for controlling an access of the subscriber station to the second channel in a manner that allows the second channel to only be enabled for the subscriber station within an enable interval; and

the enable interval is an interval during which the subscriber station has exclusive access to the first channel.

5. The subscriber station according to claim **4**, wherein a time window or a portion thereof is predefined as the at least one enable interval within a regularly repeating time window structure.

6. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by the plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first processing circuitry and the second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

the subscriber station is configured to generate a data signal as a function of the first data, generate a modulated signal as a function of the second data, superimpose the modulated signal on the data signal, and transmit the superimposed signals over the shared signal line; and

the first processing circuitry is configured for controlling an access of the subscriber station to the second channel in a manner that allows the second channel to only be enabled for the subscriber station within an enable interval, and the enable interval is an interval during which the subscriber station has exclusive access to the first channel.

7. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by the plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first processing circuitry and the second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

the subscriber station is configured to generate a data signal as a function of the first data, generate a modulated signal as a function of the second data, superimpose the modulated signal on the data signal, and transmit the superimposed signals over the shared signal line; and

the second processing circuitry is coupled to the first processing circuitry in a manner that makes the second processing circuitry controllable, by an access control signal generated by the first processing circuitry, to enable the access to the second channel by the subscriber station only within an enable interval, and the enable interval is an interval during which the subscriber station has exclusive access to the first channel.

8. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by a plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first and second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

data is transmitted among the subscriber stations of the bus system over the first channel of the bus system that is jointly used by the plurality of subscriber stations;

besides over the first channel, data is transmitted over the second channel that is used by the plurality of subscriber stations;

access to the second channel is controlled by an access process;

first data is transmitted over the first channel and second data is transmitted over the second channel over the shared signal line; and

the subscriber station is configured to:

generate a data signal as a function of the first data;

generate a modulated signal as a function of the second data;

superimpose the modulated signal on the data signal; and

transmit the superimposed signals over the shared signal line.

9. A subscriber station of a bus system, comprising:

first processing circuitry adapted to control an access by the subscriber station to a first channel of the bus system jointly used by a plurality of subscriber stations;

second processing circuitry adapted to control an access of the subscriber station to a second channel used by the plurality of subscriber stations, in accordance with an access method; and

a coupling element which connects the first processing circuitry and the second processing circuitry to a shared signal line such that first data to be transmitted over the first channel and second data to be transmitted over the second channel are transmissible over the shared signal line among different subscriber stations;

wherein:

the coupling element is combined with a common mode choke in a manner that allows a high-frequency signal encompassing the first and the second data to be inductively coupled in and out;

the second processing circuitry is coupled to the first processing circuitry in a manner that makes the second processing circuitry controllable, by an access control signal generated by the first processing circuitry, to enable the access to the second channel;

the first processing circuitry is configured for controlling an access of the subscriber station to the second channel in a manner that allows the second channel to only be enabled for the subscriber station within an enable interval; and

the enable interval is an interval during which the subscriber station has exclusive access to the first channel.

10. The subscriber station according to claim **9**, wherein a time window or a portion thereof is predefined as the at least one enable interval within a regularly repeating time window structure.

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