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(54) **DALI CONTROL DEVICE**

(57) A DALI control device (10) comprises a DALI interface (21) adapted to receive and/or transmit DALI signals. Additionally, the DALI interface (21) is adapted to utilize a signal level of the DALI signals.

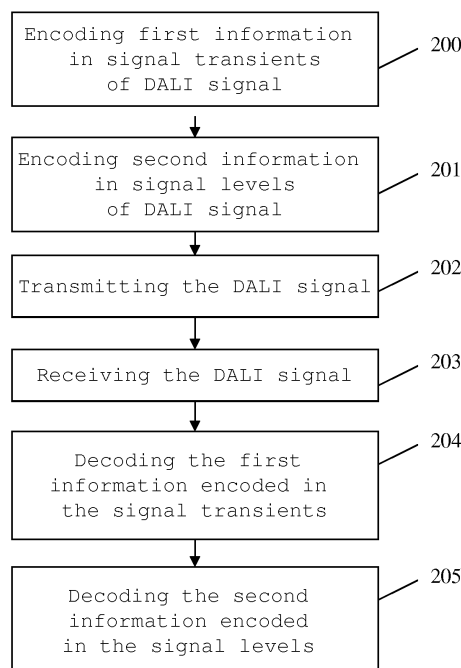


Fig. 9

Description

[0001] The invention relates to an improvement of the DALI communications standard.

[0002] As of now, the DALI communications standard allows for up to 64 devices and additional 64 sensors connected to a single DALI bus system. The current drawn by each connected element is limited to 2 mA. While using such a large number of devices on a single DALI bus though, bus congestion can occur, leading to unacceptably high reaction times of the connected devices due to a long waiting time until the respective DALI command can be transmitted.

[0003] A conventional DALI bus communication system is for example shown by the document WO 2013/113888.

[0004] Accordingly, the object of the invention is to increase the information transmission capacity while preferably retaining compatibility to legacy devices.

[0005] The object solved by the features of claim 1 for the device and claim 14 for the method. Further it is solved by the features of claim 15 for the associated computer program. The dependent claims contain further developments.

[0006] The inventive DALI control device comprises a DALI interface adapted to receive and/or transmit DALI signals. Additionally, the DALI interface is adapted to utilize a signal level of the DALI signals. By using not only the signal transitions according to the Manchester coding employed by regular DALI signals, but by additionally utilizing the signal levels of the DALI signals, the information carrying capacity of the DALI signals can be increased, without increasing the necessary bandwidth or clock rate.

[0007] Preferably, the DALI control device is adapted to transmit DALI signals. In this case, the DALI interface comprises an encoder, adapted to encode a first information based on Manchester coding, and encode a second information based on a signal level of HIGH and/or LOW pulses of the Manchester coding. This allows for a very efficient spectral use.

[0008] More preferably, the encoder is adapted to encode the second information using amplitude modulation, e.g. amplitude shift keying, with at least two, preferably at least three, most preferably at least four signal levels. Additionally or alternatively, the encoder is adapted to encode the second information using frequency modulation, e.g. frequency shift keying, with at least two, preferably at least three, most preferably at least four signal frequencies within the HIGH and/or LOW pulses of the Manchester coding. Using amplitude modulation allows for a very simple coding and decoding, while using frequency modulation allows for a more robust signal transmission.

[0009] Preferably, the DALI control device is adapted to receive DALI signals. The DALI interface then comprises a decoder, which is adapted to decode a first information based on Manchester coding and decode a

second information based on a signal level of HIGH and/or LOW pulses of the Manchester coding. This allows for an especially efficient spectral use.

[0010] Preferably, the decoder is adapted to decode the second information using amplitude modulation with at least two, preferably at least three, most preferably at least four signal levels. Additionally or alternatively, the decoder is adapted to decode the second information using frequency modulation with at least two, preferably at least three, most preferably at least four signal frequencies within the HIGH and/or LOW pulses of the Manchester coding. Using amplitude modulation allows for a very simple coding and decoding, while using frequency modulation allows for a more robust signal transmission.

[0011] Preferably, the DALI interface moreover comprises a galvanic decoupler, adapted to perform a galvanic decoupling of the DALI control device and a connection port to a secondary DALI line. This effectively prevents interferences.

[0012] More preferably, the galvanic decoupler is a high frequency clocked DC-DC converter comprising a transformer. This type of galvanic decoupler is especially suitable for conveying different signal levels of the DALI signals.

[0013] Preferably, the high frequency clocked DC-DC converter comprising a transformer is adapted to transmit a load modulation of a secondary side to a primary side, forming a reverse channel. This allows for 2-way communications.

[0014] Preferably, the DALI interface is adapted to set the clocking of the high frequency clocked DC-DC converted so as to perform an amplitude modulation and/or a frequency modulation of the HIGH and/or LOW pulses of the DALI signal at a secondary side of the transformer. This allows for an especially simple signal generation.

[0015] Preferably, the high frequency clocked DC-DC converter comprises at least one primary side switch. An amplitude of a signal of a secondary side of the transformer may be set by a duty factor or switching frequency selection of the primary side switch of the DC-DC converter. This allows for an especially simple signal generation.

[0016] In an alternative embodiment, the primary side switch of the DC-DC converter may be clocked at a fixed frequency and a fixed duty cycle and thereby may transfer the level of the amplitude of the primary side voltage to the secondary side in a "feed-forward" operation.

[0017] Preferably, the DALI interface is adapted to be compatible to legacy DALI devices, especially to DALI control devices employing only Manchester coding. This allows for an especially flexible use of the DALI control device.

[0018] Preferably, the DALI interface is adapted to utilize additional signal levels between 10 V and 30 V, preferably between 11 V and 15 V, most preferably between 11,5 V and 12,5 V. This allows for a clear distinguishing from the regular DALI high voltage of 10 V.

[0019] Moreover, an inventive DALI system is present-

ed. The inventive DALI system comprises a first DALI control device as explained earlier and a second DALI control explained earlier. Moreover, the system comprises a primary DALI line connecting the first DALI control device and the second DALI control device. The system allows for an especially high information transmission rate between the devices.

[0020] Moreover, a method for communicating using a DALI interface is provided. The method comprises receiving and/or transmitting DALI signals, additionally utilizing a signal level of the DALI signals. This allows for an especially efficient communication with a high transmission rate.

[0021] Moreover, a computer program is provided. The computer program comprises program code for performing the previously shown method, when the computer program runs on a computer.

[0022] An exemplary embodiment of the invention is now further explained with respect to the drawings, in which

Fig. 1 shows a first embodiment of the DALI system along with a first embodiment of the DALI control device in a block diagram;

Fig. 2 shows a second embodiment of the DALI system along with a second embodiment of the DALI control device in a block diagram;

Fig. 3 shows a detail of a third embodiment of the DALI control device in a block diagram;

Fig. 4 shows an exemplary DALI signal using Manchester coding;

Fig. 5 shows an exemplary DALI signal as used by a fourth embodiment of the DALI control device;

Fig. 6 shows a detail of a fifth embodiment of the DALI control device in a circuit diagram;

Fig. 7 shows a detail of a sixth embodiment of the DALI control device in a circuit diagram;

Fig. 8 shows a first embodiment of the inventive method in a flow diagram, and

Fig. 9 shows a second embodiment of the inventive method in a flow diagram.

[0023] First we demonstrate the construction and function of different embodiments of the inventive DALI system and DALI control device along Fig. 1-7, before we show the detailed function of the different embodiments of the method along Fig. 8 and Fig. 9. Similar entities and reference numbers in different figures have been partially omitted.

[0024] In Fig. 1, a first embodiment of the DALI system

1 is shown. The DALI system 1 comprises a first DALI control device 10 connected by a primary DALI line 13 to a second DALI control device 11. For example, the first DALI control device 10 is a central DALI controller, while the second DALI control device 11 is a DALI compatible lighting device. According to the legacy DALI protocol, Manchester coding is used for encoding communications between the first DALI control device 10 and the second DALI control device 11.

[0025] The second DALI control device 11 may comprise an internal control unit which is designed to control a load element like a lamp depending on the communication received from primary DALI line 13. At least the second DALI control device 11 may comprise a galvanic decoupler, like an opto-coupler, which provides galvanic isolation from the primary DALI line 13 to the internal control unit.

[0026] An example of a Manchester coding is for example shown in Fig. 4. The information is therein encoded in the transitions between a low signal level and a high signal level. The actual signal level of the LOW signal level and the HIGH signal level though is conventionally not used for information transmission.

[0027] According to the present invention, as shown in Fig. 5, the signal level of the DALI signal is used for encoding additional information. Here, four different signal levels $\frac{1}{4}$ low, $\frac{1}{2}$ low, $\frac{3}{4}$ low, low are employed. A different number of signal levels still can be used. Especially, also different HIGH levels can be used. Advantageously, at least two, preferably at least three, most preferably at least four signal levels are used for encoding the second information.

[0028] At the same time though, the Manchester encoding, as shown in Fig. 4 though is still used. This means that a first information is encoded using the Manchester encoding, while a second information is encoded utilizing the signal levels. In the embodiment shown in Fig. 5, an amplitude modulation, for example an amplitude shift keying, between the different signal levels is used. Alternatively, though, also a frequency modulation, for example a frequency shift keying, can be used. In this case, different signal frequencies within the LOW and HIGH pulses of the Manchester encoding can be used to encode the second information.

[0029] In Fig. 2, a detail of a DALI system 1 with the first DALI control device 10 and the second DALI control device 11, as shown in Fig. 1, is shown. The first DALI control device 10 comprises a controller 20. The second DALI control device 11 comprises a DALI interface 21. The controller 20 of the first DALI control device 10 and the DALI interface 21 of second DALI control device 11 are connected by a primary DALI line 13. The controller 20 provides the information to be transmitted over the primary DALI line 13, while the DALI interface 21 encodes the information for transmission through a secondary DALI line 12, which is connected to an internal control unit 15 of the second DALI control device 11. The internal control unit 15 is designed to control a load element, like

a lamp, depending on the communication received from first DALI control device 10 via primary DALI line 13 and transferred over the DALI interface 21 to the secondary DALI line 12.

[0030] Also, the DALI interface 21 receives DALI signals through the secondary DALI line 12 from the internal control unit 15, decodes them, and provides the received information to the controller 20.

[0031] In Fig. 3, further details of the DALI interface 21 of Fig. 2 are shown. The DALI Interface 21 here comprises an encoder 30 and a decoder 31, connected over the primary DALI line 13 to the controller 20 of Fig. 2, and also connected to a galvanic decoupler 32, which again is connected to the secondary DALI line 12.

[0032] The encoder 30 receives information to be transmitted from the controller 20 of Fig. 2 and encodes it. As described along Fig. 4 and Fig. 5, a first piece of information is encoded using the Manchester encoding, while a second piece of information is encoded utilizing the signal levels, as especially shown in Fig. 5.

[0033] When receiving a DALI signal through the primary DALI line 13, the galvanic decoupler 32 performs a decoupling of the received signal together with performing a galvanic isolation. The encoder 30 therefore provides a coding signal to the galvanic decoupler 32, which performs a galvanic decoupling generated a DALI signal to be transmitted through the secondary DALI line 12.

[0034] When receiving a DALI signal through the secondary DALI line 12, the galvanic decoupler 32 performs a galvanic decoupling and provides the received signal to the decoder 31. The decoder 31 decodes the received DALI signal and provides the decoded information through the controller 20 of Fig. 2. Especially, the decoder 31 performs a Manchester decoding of a first piece of information and performs a decoding taking the signal levels into account, resulting into a second piece of information.

[0035] The decoder 31 may for instance adjust the signal level on the primary DALI line 13 depending on the second information which can be decoded by decoder 31.

[0036] It is important to note that the resulting DALI control device is compatible to legacy DALI control devices in that the first piece of information encoded using Manchester encoding can still be transmitted to and received from legacy DALI control devices. Only the second piece of information encoded utilizing the signal levels cannot be processed by legacy DALI control devices. Knowing which devices within the DALI system are legacy DALI control devices and which devices are inventive DALI control devices, it is possible to decide, if to transmit the second piece of information, or not. Also, when receiving information from a legacy DALI control device, it is not necessary to decode the signal levels, since legacy DALI control devices cannot transmit any information within the signal levels.

[0037] Advantageously, in order to accommodate leg-

acy DALI control devices, the additional signal levels used are outside of the signal level range of the Manchester encoding. While in legacy DALI communication standard, a voltage of 10V for the low signal are used, an additional voltage the additional amplitude values could be around 12V.

[0038] In Fig. 6, a further detail of an embodiment of the DALI control device is shown. Especially here, the inner workings of the galvanic decoupler 32 are shown. Since opto-couplers are often not very accurate with regard to the signal level, the use of opto-couplers is disadvantageous. Therefore here, a clocked DC-DC converter comprising a transformer is suggested. The DC-DC converter may be formed by a flyback converter or forward converter.

[0039] The galvanic decoupler 32 formed by a clocked DC-DC converter comprises a transformer 61, connected to a source 60. The source 60 may be formed by the supplying primary DALI line 13, which is provided to the input terminals of the galvanic decoupler 32. There might be an additional constant current source in series connection with the primary side of the transformer 61. The primary side of the transformer 61 is connected to a switch 62, which is controlled by the encoder 30. The switch 62 either leaves the primary side of the transformer 61 open or connects it to ground 63. The secondary side of the transformer 61 is connected to the secondary DALI line 12. The switch 62 is clocked with a high frequency signal by the encoder 30. The frequency and / or the duty cycle of the high frequency signal sets the signal level of the resulting DALI signal. The encoder 30 may detect the amplitude of the signal applied by the primary DALI line 13 and may set the frequency and / or the duty cycle of the high frequency signal depending on the amplitude of the signal applied by the primary DALI line 13 which is provided to the galvanic decoupler 32. Thereby an amplitude of a signal at the secondary side of the transformer 61 is set by a duty factor and / or switching frequency of the primary side switch 62 of the DC-DC converter 32. By deliberately using a switching signal, which is of a sufficiently low frequency that the switching pulses are transferred to the secondary side, the previously described frequency modulation, e.g. frequency shift keying, the resulting DALI signal to encode the second information can be achieved.

[0040] Preferably, during the HIGH pulses of the Manchester encoding, the switching is deactivated, while the different signal levels are set during the LOW pulses of the Manchester encoding, as for example showing in Fig. 5. Also a coding scheme employing switching during all pulses, resulting in utilizing the HIGH and LOW pulse values for coding is possible.

[0041] When performing frequency modulation, e.g. frequency shift keying, the information is transmitted to the secondary side and can be decoded on the receiver side as different frequencies within the low pulses of the Manchester encoded signal.

[0042] In a further embodiment, the primary side switch

62 of the DC-DC converter 32 may be clocked at a fixed frequency and fixed duty cycle and thereby may transfer the level of the amplitude of the primary side voltage to the secondary side in a "feed-forward" operation. In such case there is no need that the encoder 30 detects the amplitude of the signal applied by the primary DALI line 13. The primary side switch 62 just has to be clocked at a given fixed frequency and given fixed duty cycle. As soon as there is a change in the amplitude of the signal applied by the primary DALI line 13 the resulting voltage on the secondary side of the transformer 61 will change proportional to the signal on primary DALI line 13. By such operation there will be an "automatic" forwarding of the information provided by the signal on primary DALI line 13 to the secondary side of the DC-DC-converter feeding the secondary DALI line 12. The embodiment described by this example is one example for the usage of amplitude modulation to encode the second information.

[0043] In a further embodiment, shown in Fig. 7, a back channel is shown. Here, on the secondary side of the transformer 61, the secondary DALI line 12 is connected. On a receiver side of the secondary DALI line 12, a secondary side switch 70 is shown. The secondary side switch 70 may be connected in series with a load element, e.g. a resistance, which is not shown here. This secondary side switch 70 may perform a load modulation depending on signals or information received on the secondary DALI line 12 from the internal control unit 15. This load modulation is transformed by the transformer 61 to the primary side and can be read out there by a decoder 31, e.g. by monitoring of the resulting duty cycle of primary side switch 62 or by monitoring the current flowing through the primary side of transformer 61 or primary side switch 62.

[0044] This is symbolized by an arrow pointing to the reference number 31, referring to the decoder of Fig. 3.

[0045] The decoder 31 then decodes the received DALI signal and provides the decoded information onto the primary DALI line 13, e.g. by switching a switching element (not shown) onto the primary DALI line 13. Especially, the decoder 31 switches the switching element depending on the decoded first information and second information into account. Thereby a DALI signal will be generated on the primary DALI line 13 comprising first information and second information, whereby the Manchester coding comprises a first piece of information and the signal level comprises the second piece of information.

[0046] The decoder 31 may for instance adjust the signal level on the primary DALI line 13 depending on the first and second information which can be decoded by decoder 31.

[0047] Furthermore, in Fig. 8, a first embodiment of the inventive method is shown. In a first step 100, DALI signals are received and or transmitted. In addition to the Manchester encoding regularly employed when transmitting or receiving DALI signals, in a second step 101,

the signal level of the DALI signals is additionally utilized.

[0048] In Fig. 9, in more detail embodiment of the inventive method is shown. In a first step 200, first information is encoded in signal transitions of a DALI signal. In a second step 201 second information is encoded in signal levels of a DALI signal. In a third step 202 the DALI signal is transmitted. Any fourth step 203, the DALI signal is received. In a fifth step 204 the first information, encoded in the signal transitions, is decoded. In a sixth step 205, the second information, encoded in the signal levels, is decoded.

[0049] The invention is not limited to the examples and especially not to a specific type of encoding or decoding scheme. Also it is not limited to a specific number of used signal levels for the encoding. The characteristics of the exemplary embodiments can be used in any advantageous combination.

Claims

1. DALI control device (10) comprising a DALI interface (21), wherein the DALI interface (21) is adapted to receive and/or transmit DALI signals, **characterized in that** the DALI interface (21) is adapted to additionally utilize a signal level of the DALI signals.
2. DALI control device (10) according to claim 1, wherein the DALI control device (10) is adapted to transmit DALI signals, wherein the DALI interface (21) comprises an encoder (30), adapted to
 - encode a first information based on Manchester coding, and
 - encode a second information based on a signal level of HIGH and/or LOW pulses of the Manchester coding.
3. DALI control device (10) according to claim 2, wherein the encoder (30) is adapted to encode the second information using amplitude modulation with at least two, preferably at least three, most preferably at least 4 signal levels, and/or wherein the encoder (30) is adapted to encode the second information using frequency modulation with at least two, preferably at least three, most preferably at least 4 signal frequencies within the HIGH and/or LOW pulses of the Manchester coding.
4. DALI control device (10) according to any of claims 1 to 3, wherein the DALI control device (10) is adapted to receive DALI signals, wherein the DALI interface (21) comprises a decoder (31), adapted to

- decode a first information based on Manchester coding, and
 - decode a second information based on a signal level of HIGH and/or LOW pulses of the Manchester coding.
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13. DALI system, comprising a first DALI control device (10) according to claim 2, a second DALI control device (10) according to claim 4 and a primary DALI line (13) connecting the first DALI control device (10) and the second DALI control device (10).
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14. Method for communicating using a DALI interface (21), the method comprising:
- receiving (100) and/or transmitting DALI signals,
 - additionally utilizing (101) a signal level of the DALI signals.
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15. A computer program with a program code for performing the method according to claim 14 when the computer program runs on a computer.
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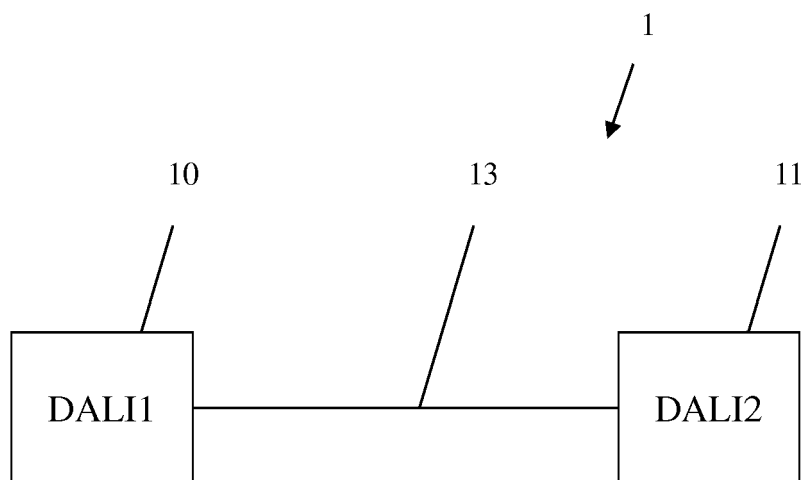


Fig. 1

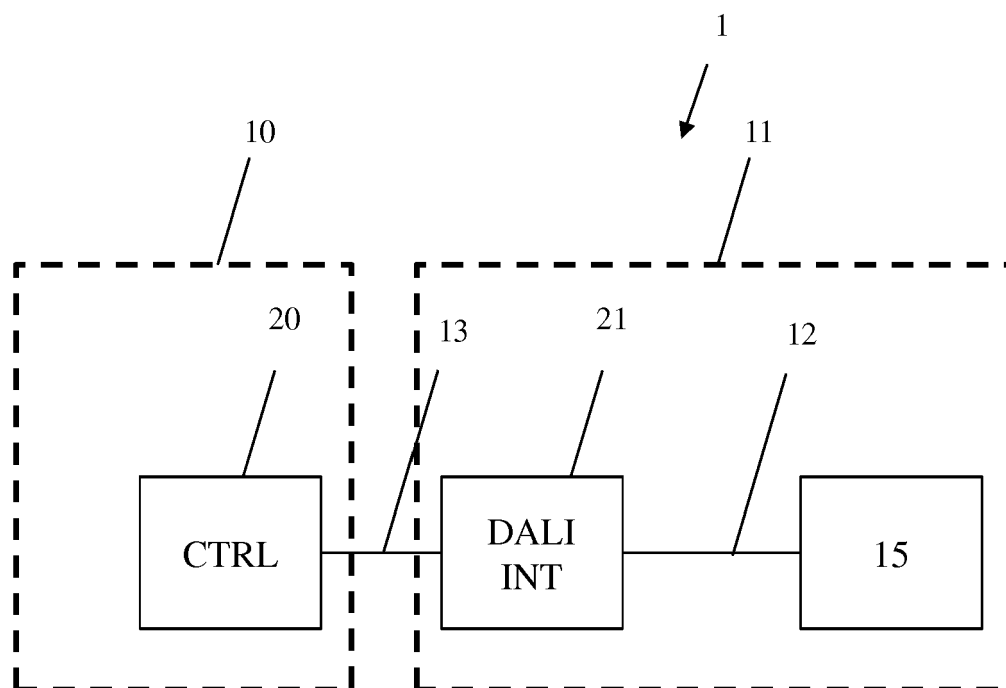


Fig. 2

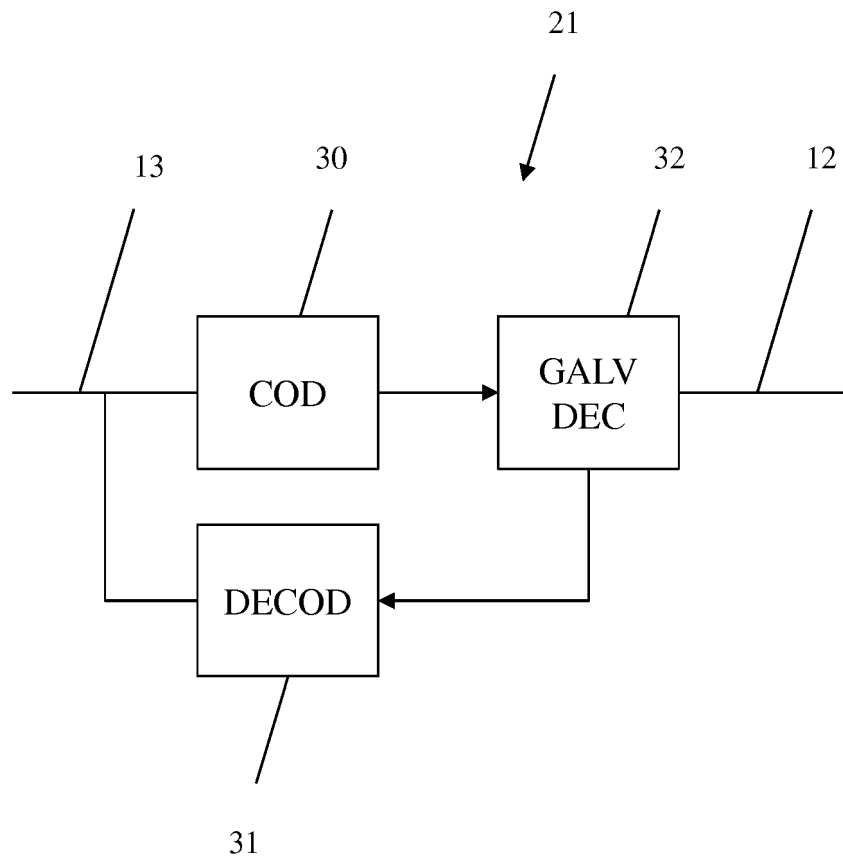


Fig. 3

Fig. 4

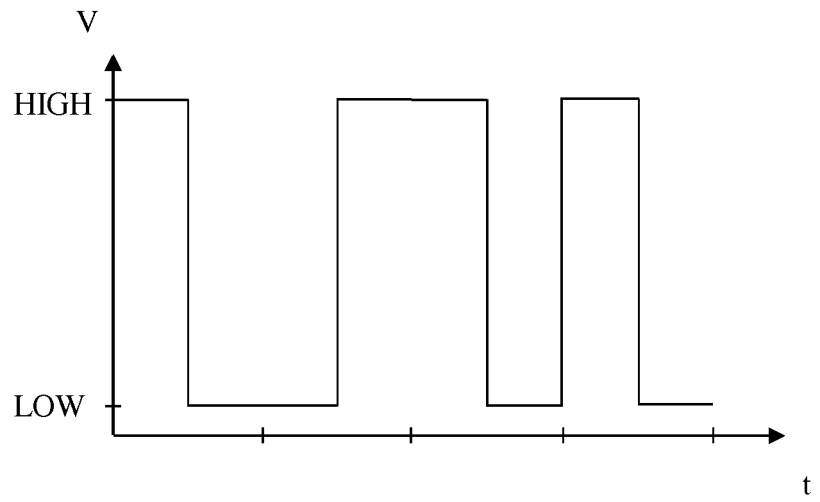
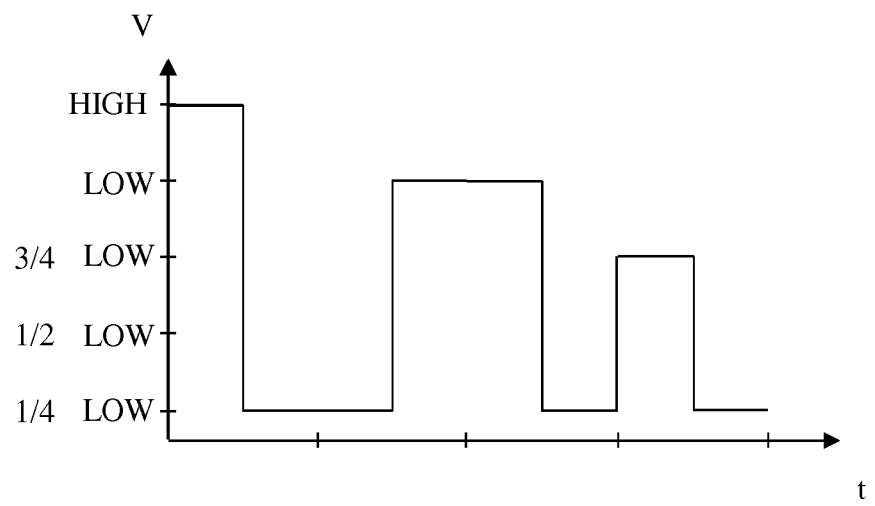


Fig. 5



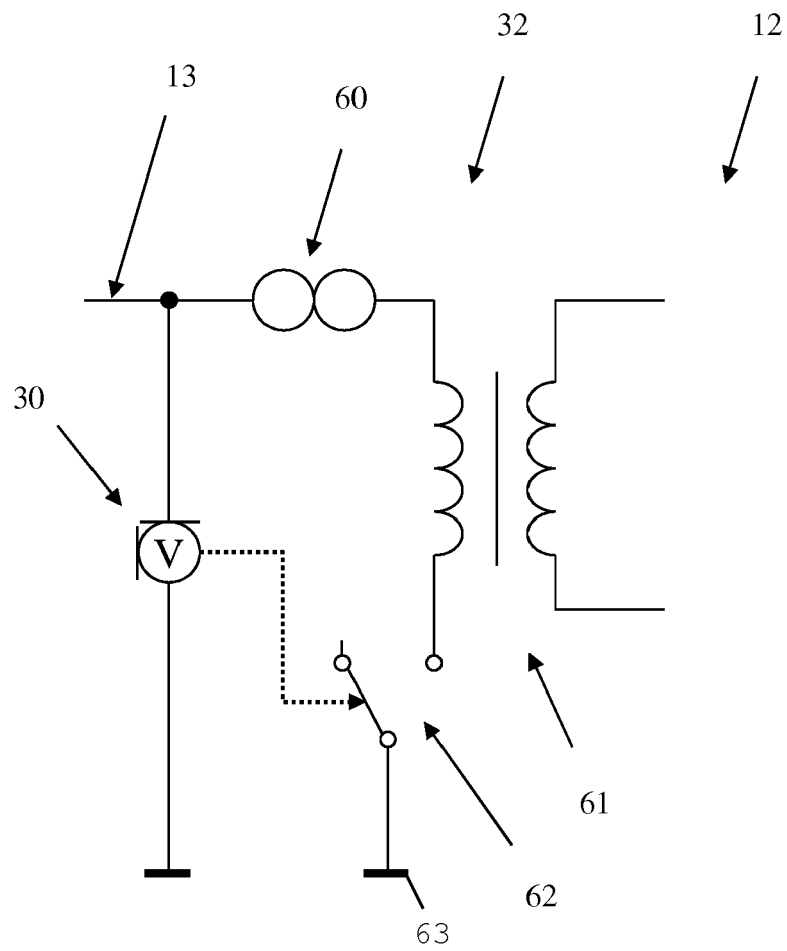


Fig. 6

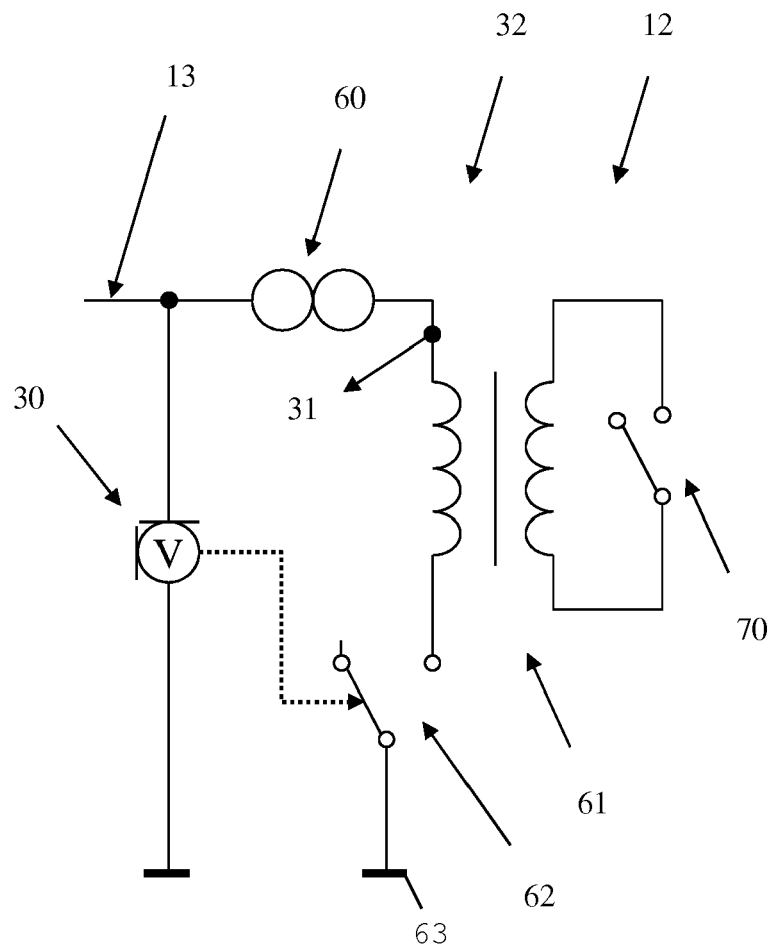


Fig. 7

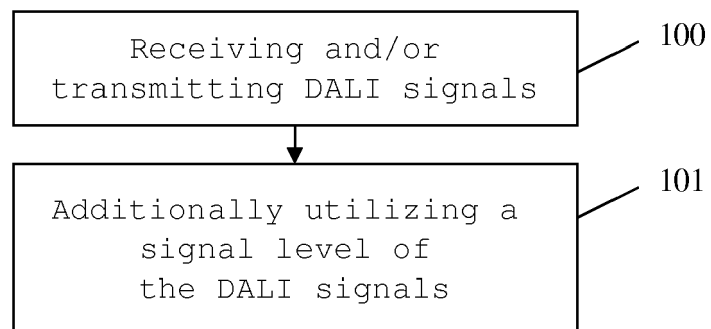


Fig. 8

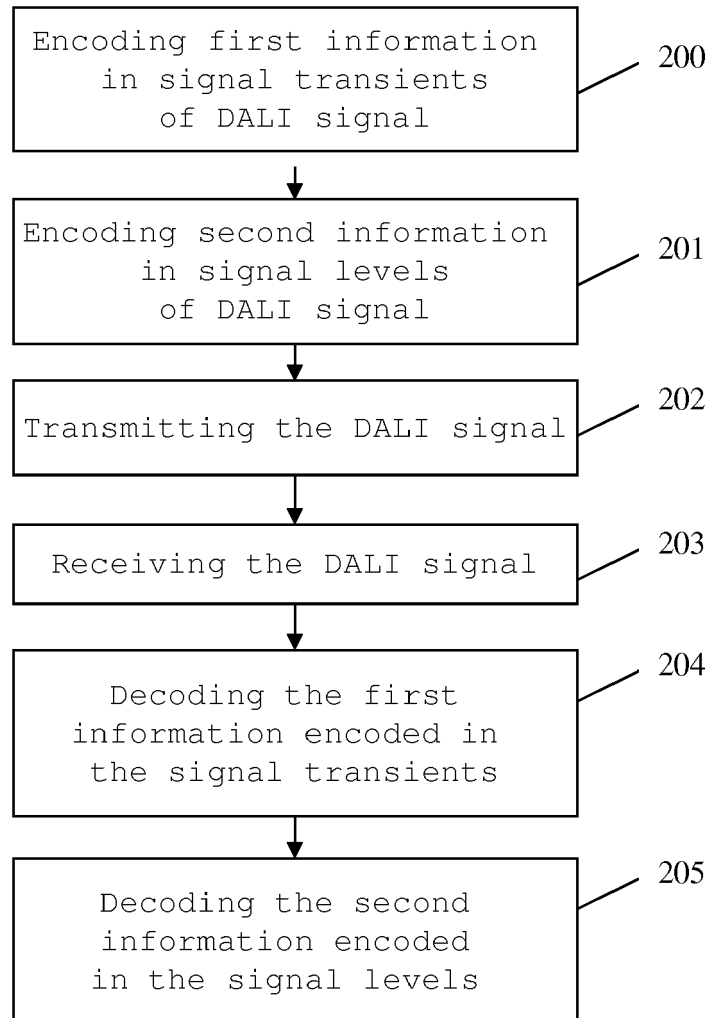


Fig. 9



EUROPEAN SEARCH REPORT

Application Number
EP 18 21 0318

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Place of search Munich		Date of completion of the search 15 May 2019	Examiner Boudet, Joachim
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EP 18 21 0318

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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