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(54) **DYNAMIC CURRENT LIMITATION FOR DALI POWER SUPPLY**

(57) A DALI device (2) comprises a DALI power supply (11). The DALI device (2) is adapted to be connected to a DALI bus (3), which is connected to a plurality of further DALI devices. The DALI power supply (11) is adapted to provide a DALI bus idle current to the DALI

bus (3) during DALI bus idle times, and provide a communication current dependent upon a communication current input signal to the DALI bus (3), during DALI communication times.

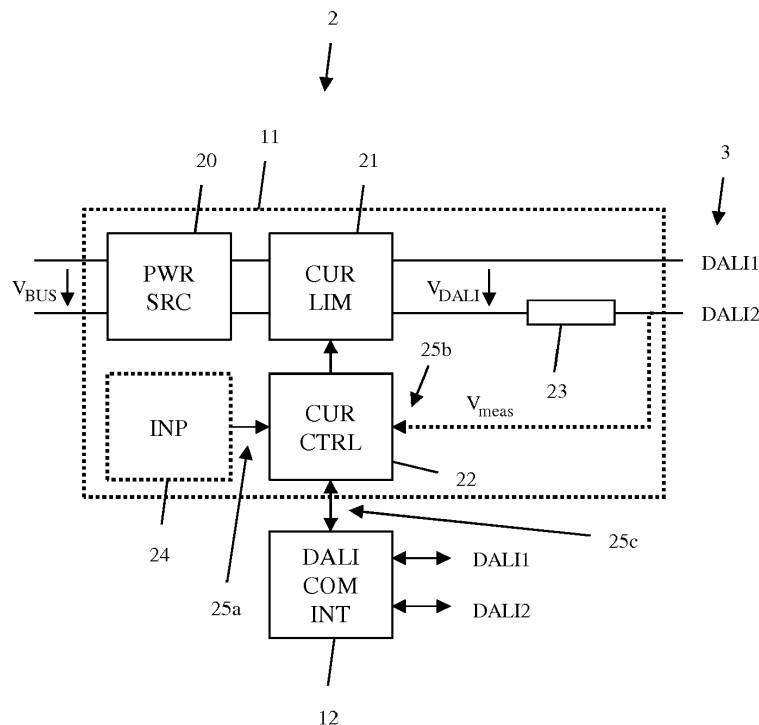


Fig. 2

Description

[0001] The invention relates to providing power to a DALI bus.

[0002] In the past, a separation of a DALI bus power supply and DALI device communication through the DALI bus was usually present. Abrupt power spikes on the DALI bus resulted in significant hardware demand on the DALI power supply but had no consequences with regard to the lighting by the individual DALI devices.

[0003] In a new implementation though, DALI devices with integrated power supply are suggested.

[0004] A DALI power supply delivers a limited output current (e.g. 60mA) that can be used to supply multiple devices on the DALI bus, where each device draws a maximum current of 2mA during idle times, in the following also referred to as idle current. A sum of all idle currents of all devices connected to the DALI bus is referred to as DALI bus idle current.

[0005] During communication, the DALI bus is short circuited by the communicating DALI device, which means that the maximum output current (e.g. 60mA), provided by the power supply flows.

[0006] If there are e.g. 30 further DALI devices connected to the bus, so the power supply is continuously delivering 60mA during idle times, short circuiting the DALI bus by the communicating DALI device is not a problem because the load difference between idle times and communication times is very low (60mA during idle times and also during communication times).

[0007] If there is on the other hand e.g. only one further DALI device connected to the bus, the DALI power supply delivers only 2mA during idle times. During communication times, when the bus is short circuited by the further DALI device, currents of up to 60mA flow - this means quite heavy dynamic load changes.

[0008] These heavy load changes do not only affect the DALI power supply of the DALI device but can also be visible as a voltage drop on the 400V bus voltage that is generated by a power factor correction (PFC) block. This 400V bus voltage is the input voltage for both - a DALI power supply as well as a LED current source (e.g. half bridge LLC or buck topology).

[0009] The voltage drop on the bus voltage can be visible in the light output as a light flicker if the PFC controller and/or the controller of the current source are not fast enough to compensate the drop. Adjusting these controller settings very quickly would be desired to avoid potential light flicker - but this introduces other potential problems and makes the system more complicated as different controller settings are required depending on the output current and/or working point.

[0010] A regular DALI device is shown in WO 2013/113888.

[0011] Accordingly, the object of the invention is to provide a DALI device and a method for operating a DALI or comparable device, which prevent undesired influence on the overall power supply, independent of a number of

devices connected to the DALI bus.

[0012] "DALI" according to the present invention preferably relates to all buses and devices in which the bus is designed to have a non-zero DC voltage level in the quiescent state. Preferably the bus thus can serve also as a power supply, wherein the maximum power/current is limited.

[0013] The object is solved by the features of claim 1 for the device and claim 12 for the method. The dependent claims contain further developments.

[0014] An inventive DALI device comprises a DALI power supply. The DALI device is adapted to be connected to a DALI bus, which is connected to a plurality of further DALI devices. The DALI power supply is adapted to provide a DALI bus idle current to the DALI bus during DALI bus idle times, and provide a communication current dependent upon a communication current input signal to the DALI bus, during DALI communication times. By making the level of the (DC) communication current adjustable, dynamic load effects are effectively prevented.

[0015] Preferably, the DALI power supply comprises a current controller, which is adapted to set the communication current dependent upon the communication current input signal, a power source, adapted to provide a supply current, and a current limiter, adapted to limit the supply current to the communication current set by the current controller. This allows for a very simple implementation.

[0016] Preferably, the DALI bus idle current is a sum of idle currents of all further DALI devices connected to the DALI bus.

[0017] Moreover, preferably the DALI power supply is adapted to set a communication current to 1 to 3 times the DALI bus idle current comes preferably to 1,1 to 2 times the DALI bus idle current, most preferably to 1,2 to 1,5 times the DALI bus idle current. The lower limitation assures a functioning communication, while the upper limitation limits the dynamic load shifts.

[0018] Preferably, the DALI power supply comprises a communication current signal input, adapted to receive a user input of the communication current input signal. This allows for a very simple setting of the communication current.

[0019] Preferably, the communication current signal input is a switch or a series of switches or a potentiometer. This further simplifies the construction.

[0020] Alternatively, the DALI power supply comprises a DALI bus sensor, adapted to determine a voltage indicative of the DALI bus idle current during idle times and indicative of the communication current during communication times. This idle current then is the communication current input signal. This allows for a very accurate determining of the communication current.

[0021] Preferably, the DALI power supply is adapted to, at the beginning of each communication time, supply a first communication current value to the DALI bus, monitor the DALI bus voltage, and successively increase the

communication current value until the DALI bus voltage is stable. This adaptive approach allows for an especially accurate setting of the communication current. Moreover, the iterative nature of this approach limits dynamic load shifts.

[0022] In a further alternative, the DALI device comprises a DALI communication interface, adapted to receive the communication current input signal through the DALI bus. This remote control allows for very flexible operation of the DALI device.

[0023] Advantageously, idle times are times in which all of the further DALI devices connected to the DALI bus do not communicate through the DALI bus but draw idle current. The communication times are times in which one of the further DALI devices connected to the DALI bus short circuits the DALI bus in order to send a communication through the DALI bus.

[0024] An inventive DALI system comprises a previously described DALI device, a DALI bus, and a plurality of further DALI devices. The previously described DALI device and the plurality of further devices are then connected to the DALI bus. This allows for and especially effective operations.

[0025] An inventive method for operating a DALI device, comprising a DALI power supply, the DALI device being connected to a DALI bus, connected to a plurality of further DALI devices, comprises:

- providing a DALI bus idle current to the DALI bus, during DALI bus idle times, by the DALI power supply, and
- providing a communication current the level of which is dependent upon a communication current input signal to the DALI bus, during DALI communication times, by the DALI power supply.

[0026] By making the level of the communication current adjustable, dynamic load effects are effectively prevented.

[0027] An exemplary embodiment of the invention is now further explained with respect to the drawings, in which

Fig. 1 shows a first exemplary embodiment of the inventive DALI system and a first embodiment of the inventive DALI device in a block diagram;

Fig. 2 shows a detailed construction of a second embodiment of the inventive DALI device;

Fig. 3 shows exemplary signals, in a regular DALI device;

Fig. 4 shows exemplary signals in a third embodiment of the inventive DALI device;

Fig. 5 shows further exemplary signals in a fourth embodiment of the inventive DALI device;

Fig. 6 shows further exemplary signals in a fifth embodiment of the inventive DALI device, and

Fig. 7 shows an embodiment of the inventive method in a flow diagram.

[0028] First, we demonstrate the construction and function of different embodiments of the inventive DALI device and the inventive DALI system along Fig. 1 - Fig. 6. Finally, we describe the function of an embodiment of the inventive method with regard to Fig. 7. Similar entities and reference numbers in different figures have been partially omitted.

[0029] The idea of this invention is that the heavy load changes that occur during DALI communication get reduced by a dynamic current limitation. In an exemplary implementation, the DALI power supply output current is limited by a current sink to a fixed value.

[0030] In case of e.g. only one DALI device being connected to the DALI bus, the DALI power supply does not need to deliver the full e.g. 60mA. In this case the limitation could be set to e.g. 5mA (at least >2mA). This would mean that the dynamic load change for the power supply is reduced (jump only from 2mA to 5mA instead of 2mA to 60mA), and therefore the drop in the bus voltage and a potential light flicker is reduced / eliminated.

[0031] The dynamic limit could be set either by measuring the DALI power supply output current in idle state (e.g. 10mA if 5 devices are connected) and then setting the current limitation to e.g. 150% of this value, or the limit could be set manually by the user via DALI or another interface (NFC).

[0032] Fig. 1 shows the context of this invention in a principle block diagram. A DALI system 1 comprises a DALI device 2 connected to a DALI bus 3. Moreover, the system 1 comprises further DALI devices 4, 5 and 6. The number of further DALI devices 4-6 is not limited, except for the general limitation of connected DALI devices in one DALI string.

[0033] The DALI device 2 comprises a DALI power supply 11. Optionally, it comprises a DALI communication interface 12 and additional function blocks connected to further operations, such as illuminating a string of LEDs. It should be noted that the DALI device 2 is only described in detail with regard to function blocks relevant to the present invention, but function blocks not relevant to the present invention are not shown or described in detail. This is not indicative, of these function blocks not being present.

[0034] The DALI device 2 is provided with a mains connection and is connected to the DALI bus 3. Furthermore, it may be connected to a string of LEDs by a connection LED+/LED-.

[0035] The DALI power supply 11 of the DALI device 2 provides the DALI bus voltage of the DALI bus 3. Moreover, it can communicate with other devices on the DALI bus 3 on the DALI bus communication interface 12. With regard to the detailed function, it is referred to the later

elaborations regarding Fig. 2.

[0036] In Fig. 2, a more detailed block diagram of the DALI device 2 is shown. The DALI device 2 comprises a DALI power supply 11, which again comprises a power source 20, connected to a current limiter 21, which is moreover connected to a current controller 22. The current controller 22 is moreover optionally connected to a communication current input 24, a DALI bus sensor 23 and the DALI communication interface 12. The current limiter 21 is moreover connected to the DALI bus 3, in case of the presence of the optional DALI bus sensor 23, through the DALI bus sensor 23.

[0037] The power source 20 is connected to a bus voltage V_{BUS} , which provides not only the input power for the DALI power supply 11, but also the power for illuminating the connected LED strings.

[0038] The current controller 22 is adapted to receive a communication current input signal 25a, 25b, 25c to determine a communication current therefrom. The value of this communication current is handed to the current limiter 21, which then limits a current provided by the power source 20 and provides it to the DALI bus 3 in form of a DALI voltage V_{DALI} .

[0039] The current controller 22 therein receives the communication current input signal either in form of a measured voltage V_{meas} from the DALI bus sensor 23, which in the most simple form of construction can be a shunt resistor. The measured voltage V_{meas} is then indicative of the communication current during communication through the DALI bus and indicative for the idle current on the DALI bus during idle times. The voltage V_{meas} therefore corresponds to the communication current input signal 25b in this case.

[0040] Depending on the topology that is used for the DALI power supply, the measurement/estimation of the provided current can also be done on the primary side (e.g. if a flyback converter or other isolated converter is used).

[0041] Another possibility would be to "find" the output current that is required by the external DALI devices by monitoring the DALI output voltage and slowly increasing the current limit. The DALI output voltage (V_{DALI} , after the current limiter) is measured with a voltage divider, then a current limit of e.g. 2mA is set in the beginning which is slowly increased. When more current is required by the external DALI devices, the DALI output voltage will increase when the current limit is increased. Once the whole current that is required is allowed to flow, the DALI output voltage will be stable - to have some margin the current limit then can further be increased slightly (e.g. 20-50% higher).

[0042] Therein, communication times are times in which one of the further DALI devices 4-6 short circuits the DALI bus 3 in order to perform a communication. Also, idle times are times in which none of the DALI devices 2, 4-6 connected to the DALI bus short circuits the DALI bus. During these times, each of the DALI devices 4-6 draws an idle current of e.g. 2 mA. By measuring the

idle current, it is possible to determine the necessary communication current, limiting the dynamic load shifts significantly.

[0043] In an alternative even simpler construction, the current controller 22 is connected to the communication current input 24. Through this input 24, the communication current is directly input as communication current input signal 25a. For example, the input can be a switch, e.g. a dip switch, by which a user can set the communication current. In a most simple construction, the switch merely switches between a high and a low communication current. Especially the high setting could be 20mA to 60mA, preferably 30mA to 60mA. Especially the low setting could be 3mA to 30mA, preferably 5mA to 10mA.

[0044] In a more complex construction manner, a series of switches, e.g. dip switches, can be used to set a specific communication current value. Also the use of a potentiometer for setting the communication current is possible. In any of those cases, the input 24 provides a communication current input signal 25a to the current controller 22.

[0045] In a further alternative construction, the current controller 22 receives the communication current input signal 25c from the DALI communication interface 12, which receives it as DALI signaling through the DALI bus 3. This allows for a remote control of the value of the communication current.

[0046] Fig. 3 shows relevant waveforms when the dynamic limitation is not active. In this case, the load changes on the current drawn from the DALI power supply 11 are very high, as can be seen as current 30. In case of short circuit (communication) ~62mA flow to the output as can be seen as curve 31. During idle times ~2mA flow. The dynamic current limitation is not active - so the current 32 is zero. The DALI bus voltage 33 is shown in the lower diagram.

[0047] Fig. 4 shows relevant waveforms for $V_{\text{limiter}} = 7.5\text{V}$, which corresponds to the communication current input signal. It can be seen that a current 42 of ~37mA flow and the output current 41 varies only between ~25mA and 2mA - this reduces the load change for current 40. The DALI bus voltage 43 is shown in the lower diagram.

[0048] Fig. 5 shows relevant waveforms for $V_{\text{limiter}} = 11.5\text{V}$. It can be seen that a current 52 of ~57mA flows and the output current 51 varies only between ~6mA and 2mA - this dramatically reduces the load change for current 50. The DALI bus voltage 53 is shown in the lower diagram.

[0049] Fig. 6 shows a DC sweep of V_{limiter} from 0V to 15V, with a short circuit at the output. V_{limiter} is shown on the x-axis, while the currents are shown on the y-axis. The current 60 corresponds to the currents 40, 50 of Fig. 4 and Fig. 5. The current 61 corresponds to the currents 41 and 51 of Fig. 4 and Fig. 5. The current 62 corresponds to the currents 42 and 52 of Fig. 4 and Fig. 5.

[0050] It can be seen how the dynamic current limitation works depending upon the level of V_{limiter} . Low val-

ues of $V_{limiter}$ lead to high allowed output currents, high values of $V_{limiter}$ lead to low allowed output currents.

[0051] It should be noted that $V_{limiter}$ corresponds to the previously mentioned communication current input signal.

[0052] In Fig. 7, finally an embodiment of the inventive method is shown in a flow diagram. In a first step 100, a DALI bus idle current is provided to the DALI bus, during DALI bus idle times. In a second step 101, a communication current is provided to the DALI bus, dependent upon a communication current input signal.

[0053] It should be noted that the inventive device and method very closely correspond to each other. Therefore, the elaborations regarding the device are also applicable to the method.

[0054] The invention is not limited to the examples, and especially not to a specific number of DALI devices connected to the DALI bus. Also, the invention is not limited to specific types of DALI devices. Although a DALI device providing LED strings with power is mentioned, any other type of DALI device can also be employed. The characteristics of the exemplary embodiments can be used in any advantageous combination.

[0055] The following method can be used to determine the required idle current level:

- at system startup set the current limiter to an initial low idle current value (e.g. 2mA)
- monitor the DALI bus voltage (V_{DALI} in Fig.2)
- increase the current limiter value -> if more idle current is required, V_{DALI} will increase
- keep increasing the current limiter value until V_{DALI} stays constant (afterwards further increase the current limiter value to have some reserve)
- > this is now the final current limiter value that will ensure two aspects:

- a) enough current can flow at idle times (to supply the DALI devices)
- b) current at communication times is low enough that the difference between currents in idle and communication times is low (no dramatic load changes for the PFC)

Claims

1. DALI device (2), comprising a DALI power supply (11), wherein the DALI device (2) is adapted to be connected to a DALI bus (3), connected to a plurality of further DALI devices, wherein the DALI power supply (11) is adapted to
 - provide a DALI bus idle current to the DALI bus (3), during DALI bus idle times, and
 - provide a communication current, the level of which is dependent upon a communication current input signal to the DALI bus (3), during DALI

communication times.

2. DALI device (2) according to claim 1, wherein the DALI power supply (11) comprises
 - a current controller, adapted to set the communication current dependent upon the communication current input signal,
 - a power source, adapted to provide a supply current, and
 - a current limiter, adapted to limit the supply current to the communication current set by the current controller.
3. DALI device (2) according to claim 1 or 2, wherein the DALI bus idle current is a sum of idle currents of all further DALI devices (4-6) connected to the DALI bus (3).
4. DALI device (2) according to any of claims 1 to 3, wherein the DALI power supply (11) is adapted to set the communication current to 1 to 3 times the DALI bus idle current, preferably to 1,1 to 2 times the DALI bus idle current, most preferably to 1,2 to 1,5 times the DALI bus idle current.
5. DALI device (2) according to any of claims 1 to 4, wherein the DALI power supply (11) comprises a communication current signal input (24), adapted to receive a user input of the communication current input signal (25a).
6. DALI device (2) according to claim 5, wherein the communication current signal input (24) is a switch or a series of switches or a potentiometer.
7. DALI device (2) according to any of claims 1 to 4, wherein the DALI power supply (11) comprises a DALI bus sensor (23), adapted to determine a voltage (V_{meas}) indicative of the DALI bus idle current during idle times and indicative of the communication current during communication times, and wherein the voltage (V_{meas}) is the communication current input signal (25b).
8. DALI device (2) according to any of claims 1 to 4, wherein the DALI device (2) comprises a DALI communication interface (12), adapted to receive the communication current input signal (25c) through the DALI bus (3).
9. DALI device (2) according to any of claims 1 to 8, wherein idle times are times in which all of the further DALI devices (4-6) connected to the DALI bus (3) do not communicate through the DALI bus (3) and draw an idle current, and wherein communication times are times in which one of the further DALI devices (4-6) connected to the

DALI bus (3) short circuits the DALI bus (3) in order to send a communication through the DALI bus (3).

10. DALI system (1) comprising a DALI device (2) according to any of the claims 1 to 10, a DALI bus (3), and a plurality of further DALI devices (4-6), wherein the DALI device (2) according to any of the claims 1 to 10 and the plurality of further DALI devices (4-6) are connected to the DALI bus (3).

11. Method for operating a DALI device (2), comprising a DALI power supply (11), the DALI device (2) being connected to a DALI bus (3), connected to a plurality of further DALI devices (4-6), wherein the method comprises:

- providing (100) a DALI bus idle current to the DALI bus (3), during DALI bus idle times, by the DALI power supply (11), and
- providing (101) a communication current dependent upon a communication current input signal to the DALI bus (3), during DALI communication times, by the DALI power supply (11).

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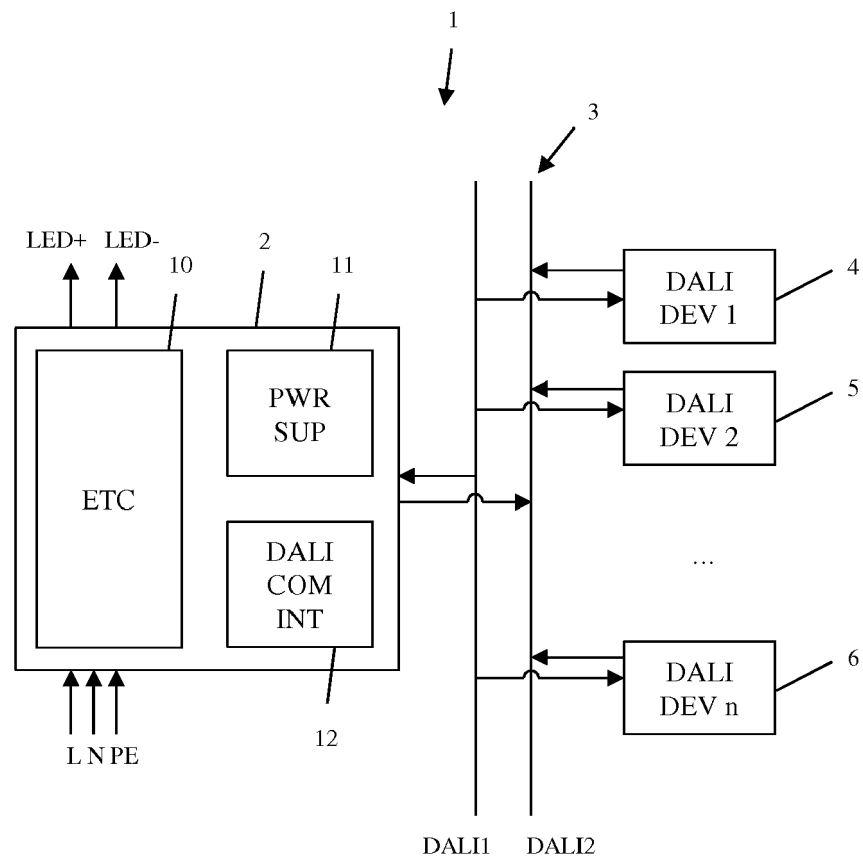


Fig. 1

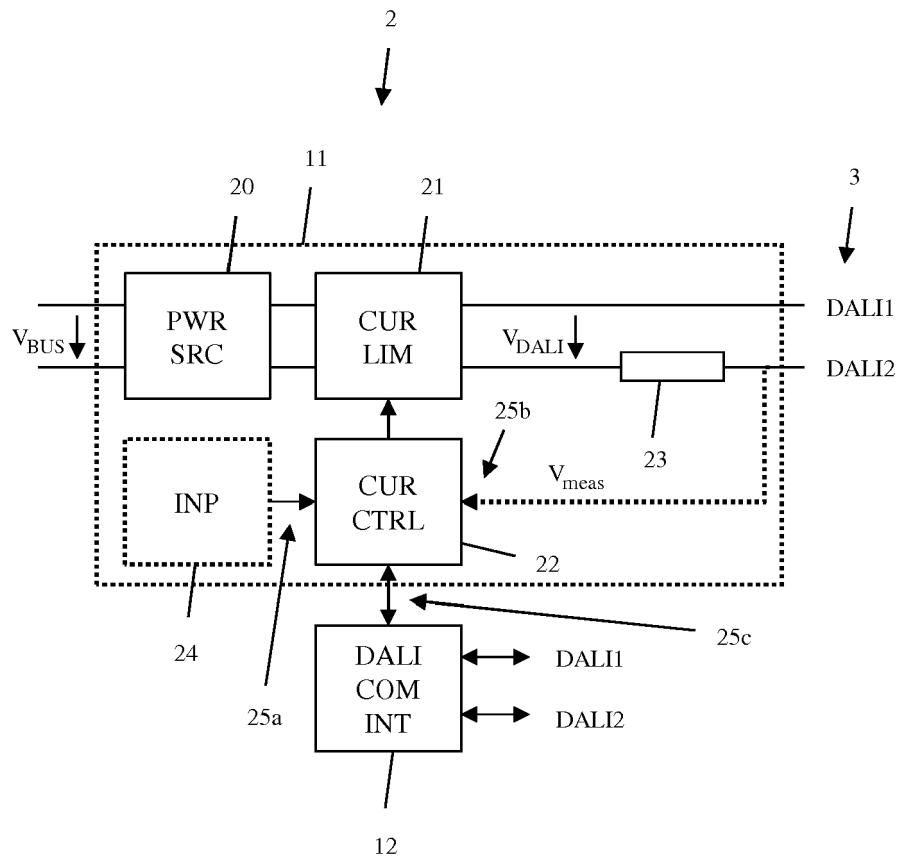


Fig. 2

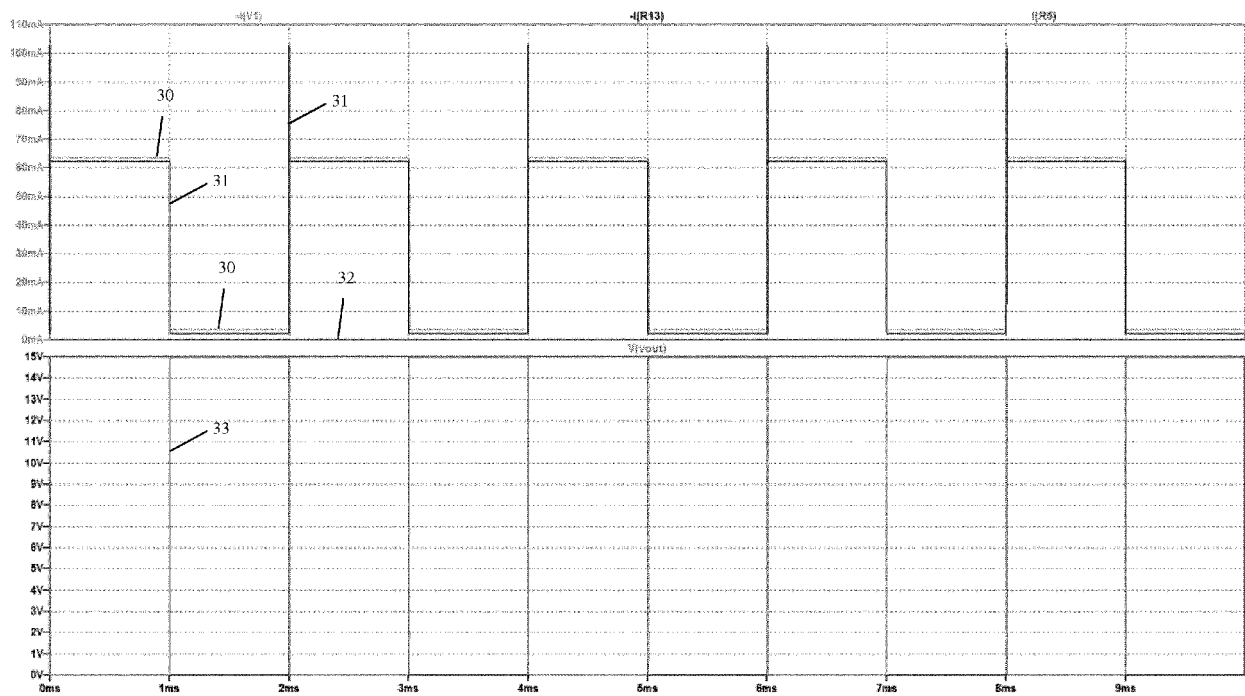


Fig. 3

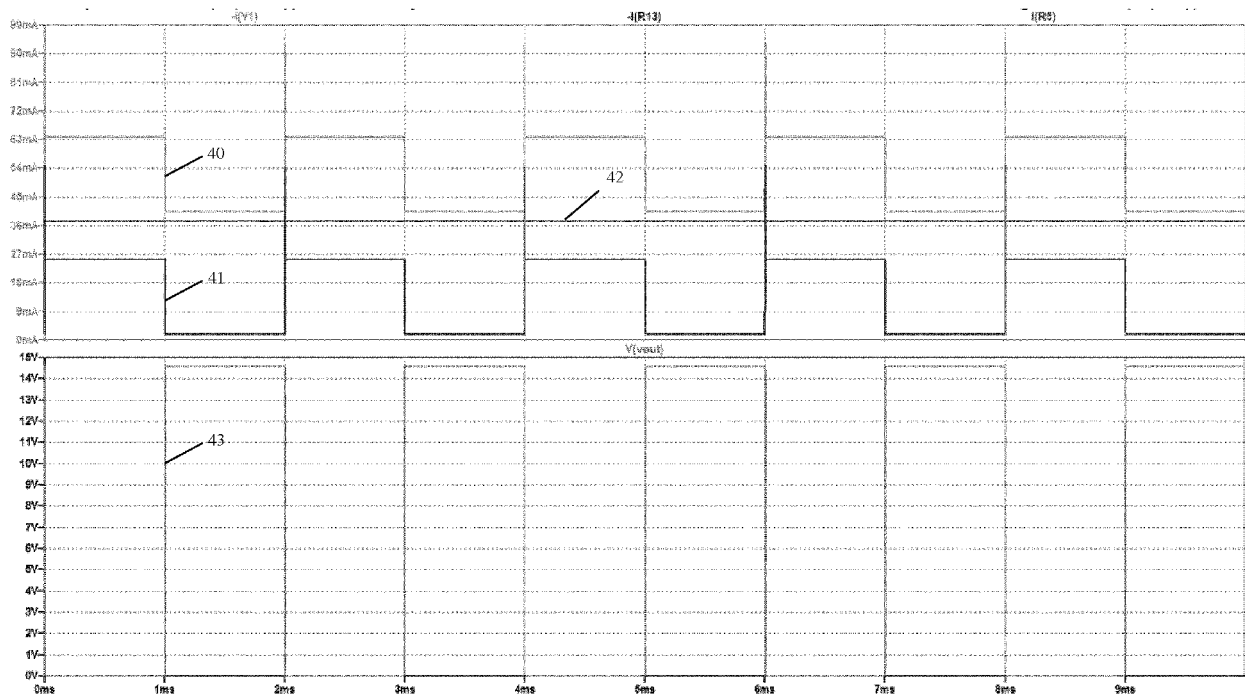


Fig. 4

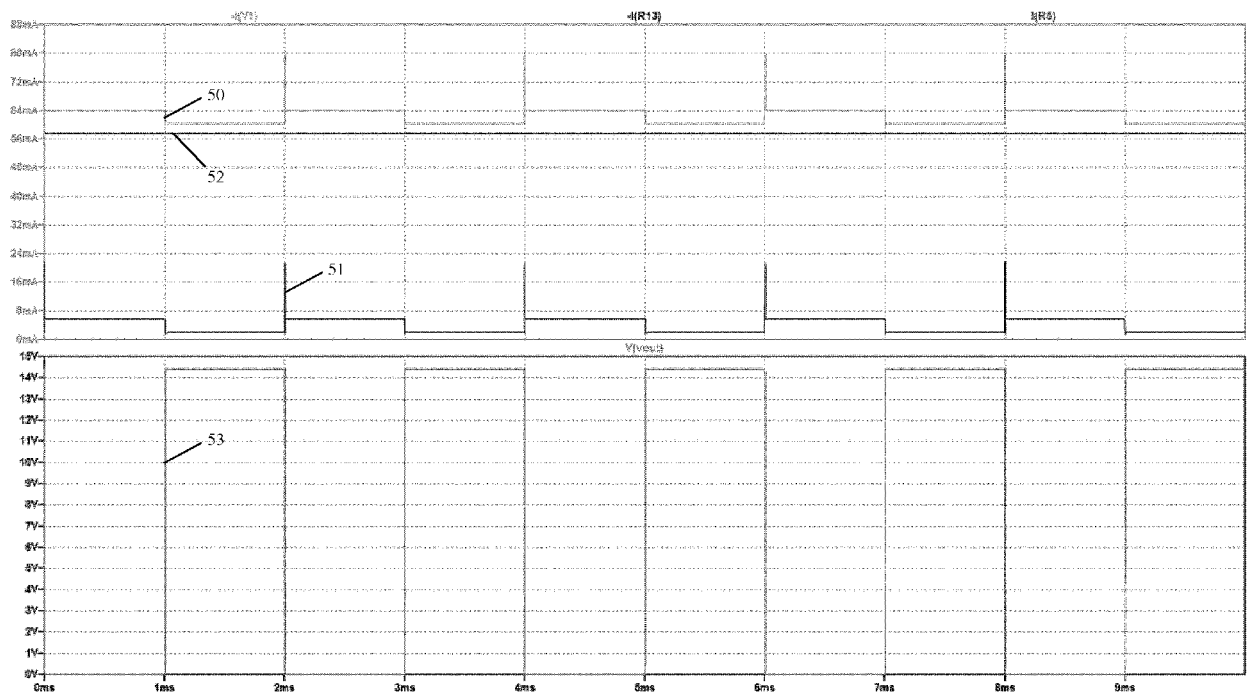


Fig. 5

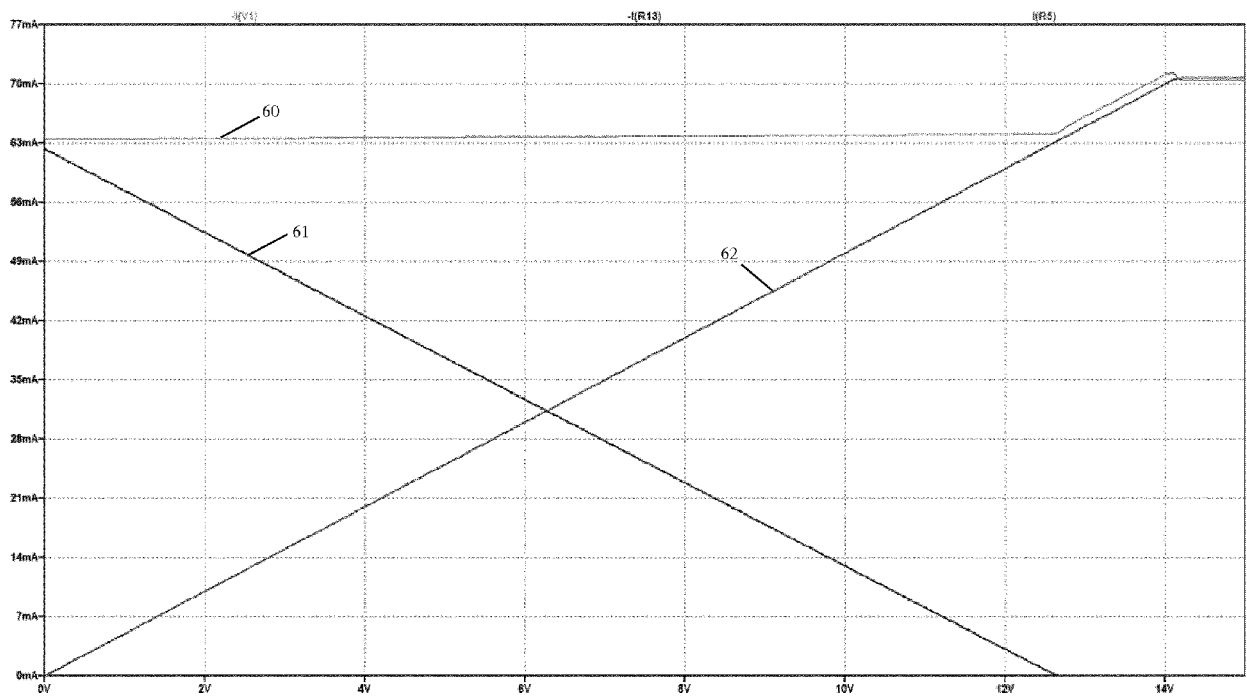


Fig. 6

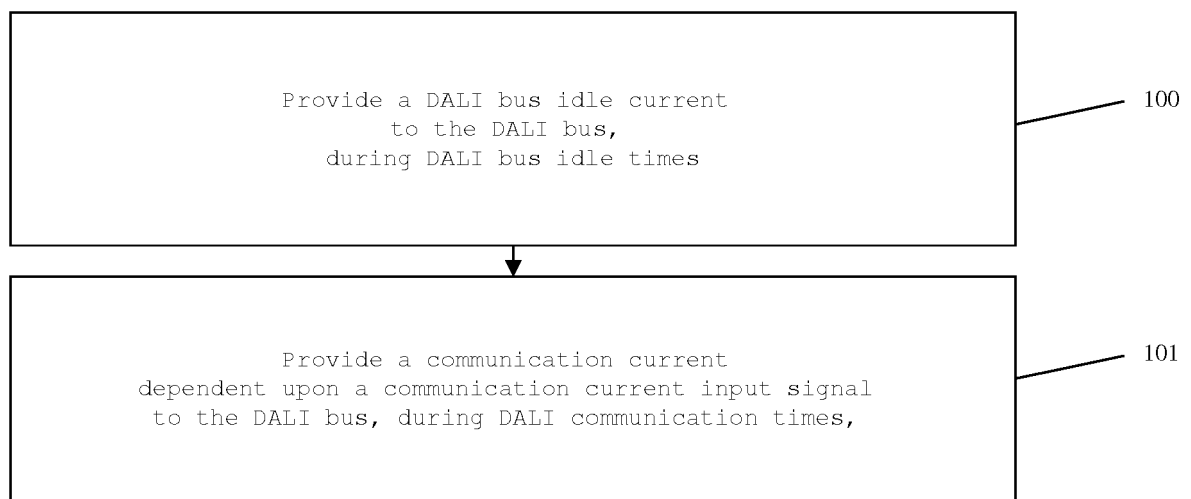


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 18 20 7718

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