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Amended claims in accordance with Rule 137 (2) EPC.

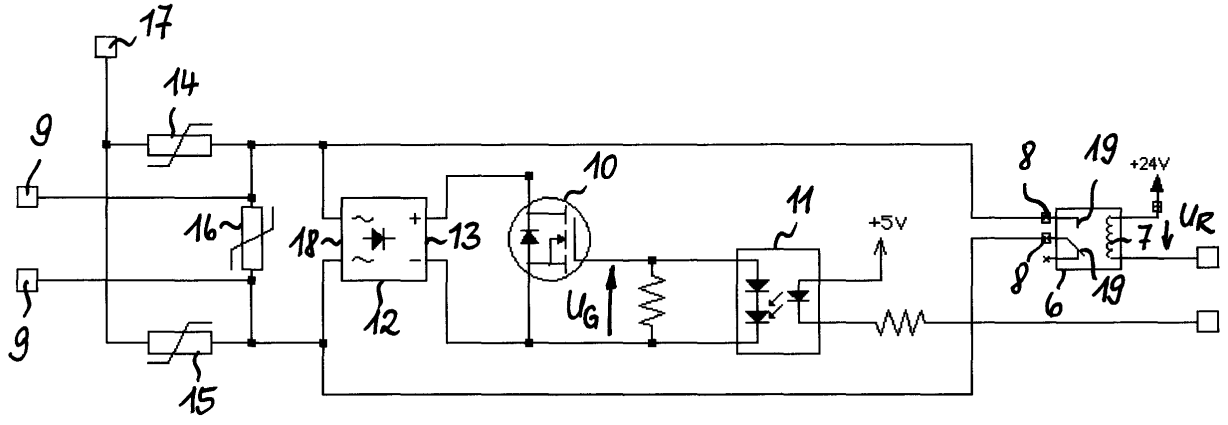
(54) **Signal generation unit and method to generate a data signal in a control unit of a power system device**

(57) A signal generation unit and a method for generating a data signal in a control unit of a power system device, especially of a tap changer drive unit, are provided. The signal generation unit comprises a signal relay (6) to alternately open and close at least one relay contact thereby performing a switching operation between two different output voltages and a protection circuit in parallel with the at least one relay contact for protecting the at least one relay contact against overvoltages. The at least one relay contact corresponds to two relay output terminals (8).

In order to allow the signal generation unit to be used for different DC output voltages and up to a maximum rated inductive load the protection circuit comprises a transistor switch (10) in parallel with the two relay output terminals (8) and

a switch control unit (11) for closing the transistor switch (10) before opening the at least one relay contact and opening the transistor switch (10) after the at least one relay contact is opened.

Fig. 5



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Description

[0001] The invention relates to a signal generation unit and a method to generate a data signal in a control unit of a power system device. In particular, the control unit is a drive unit for a tap-changer.

[0002] In today's high and medium voltage power systems and power networks different kinds of signals carrying data information are generated, transmitted and processed in order to perform the functions of measuring, controlling, regulating and protecting the various power system devices of the network, such as generators, transformers, busbars and high voltage switching devices. These devices are part of the so called high and medium voltage switchgear. In the "ABB Switchgear Manual" by Hennig Gremmel, 10th edition, ISBN 3464482367, pp. 711-771, the systems performing the different control functions are called secondary systems. They are distinguished from the primary systems by the fact that they manage information instead of power.

[0003] The data signals used in the control units of the secondary systems are generated either by contact-type electromechanical and electromagnetic devices or by contactless electronics. This invention relates to control units with contact-type devices and in particular to control units with signal or light-duty relays.

[0004] A signal relay is used to generate a data signal by performing a switching operation between two different output voltages, where the two output voltages represent the High and Low level of a binary signal. Usually, the signal relay simply switches only one output voltage on or off by closing and opening one of its contacts. This operational mode can also be described as switching between a rated voltage and zero volts. According to their switching behaviour, the relays may have a different number of output terminals, depending on the number of contacts. For example, they can be classified into relays with one normally closed or normally open contact and relays with two change-over contacts. Since these basic configurations can be multiplied, relays with more than two contacts and corresponding output terminals are on the market.

[0005] The output voltages of a signal relay used in a control unit of a power system device may be of AC or DC signal form and may vary significantly in their voltage level, i.e. from 24 to 250 V, depending on the actual implementation of the control unit within the power network and depending on regional or local specifications and standards.

[0006] Moreover, the electrical specification of the output port of the control unit where the data signal is output is user-dependent. The electrical circuit connected to the output port may be of capacitive or inductive behaviour. If an inductive load, which is often described by the time constance UR in this context, is connected to an output port of the control unit, a counter emf (electromagnetic force) with a high peak is generated when breaking the current by opening one of the contacts of the signal relay. As a result, a spark may be generated between the two contact elements of the contact which may cause material migration between the contact elements as well as evaporation due to high temperatures. The negative effect of the inductive load on the relay contacts is more damaging in a DC circuit than in an AC circuit.

[0007] In order to protect the relay contact elements in the case of DC, it is well known in the art to connect an RC-circuit, also called snubber, in parallel with the relay terminals. The capacitor suppresses the discharge at the moment the contact elments open since the current caused by the emf is shunted into it, while the series resistor limits the current to prevent spark formation. In the case of AC, the state of the art suggests to use a voltage dependent resistor, also called varistor, across the inductive load, which has a low resistance at high voltages and a high resistance at low voltages.

[0008] The variation of voltage levels and load characteristics with the application purpose of the control unit leads to a vast number of different types of control units for power system devices in the market. In the special field of tap changers for power transformers and their drive units, there exist up to several thousands of different configurations. A modern implementation of a drive unit for a tap changer is for example described in WO 01/92978 A1.

[0009] In order to reduce the number of different types of control units, it is an object of the invention to provide a signal generation unit and a method for a control unit of a power system device which can be used to generate data signals of different DC voltages and which allow the connection of the corresponding output port of the control unit to different inductive loads without the requirement of any adaptation or alteration. Since the variety of control units, in particular drive units, for tap changers is especially huge, it is a further object of the invention to provide a signal generation unit for the drive unit of a tap changer with the aforesaid features.

[0010] The invention is based on the recognition of the fact that if there could be provided a means to effectively protect the signal relay against the maximum possible inductive load at the maximum possible DC voltage level, then the signal generation unit would be suited for all other possible configurations as well.

[0011] Therefore, the object is achieved by the provision of a signal generation unit according to claim 1 and a method according to claim 9.

[0012] The signal generation unit comprises a signal relay as described above and a protection circuit in parallel with two of the output terminals of the relay, where at least one relay contact corresponds to the output terminals. According to the invention, the protection circuit comprises a transistor switch in parallel with the two output terminals and a switch control unit for closing the transistor switch before opening the at least one relay contact corresponding to the at least two relay terminals and for opening the transistor switch after the at least one relay contact is opened. The transistor switch can

be of any possible kind, i.e. a bipolar transistor, a MOSFET or an IGBT. If a relay comprises more than the at least one relay contact, protection circuits can be connected in parallel to each pair or only some of the pairs of relay output terminals corresponding to the relay contacts.

[0013] The method according to the invention comprises the steps of closing a transistor switch, where the transistor switch is connected in parallel with two output terminals corresponding to at least one relay contact of a signal relay, followed by the opening of the at least one relay contact, thereby performing a switching operation between two different output voltages, and thereafter opening the transistor switch

[0014] The closing of the transistor switch allows a continuous current flow so that any counter emf is prevented when the relay contact is opened afterwards. The low internal resistance of the transistor switch produces a low voltage across the pair of contact elements of the relay contact. Hence, when the relay contact is opened while the transistor switch is closed, no damaging voltage and no spark occurs across the contact elements.

[0015] After opening the relay contact the transistor is switched off, so that the emf increases the voltage on the output side of the transistor switch, which in the case of a bipolar transistor is the collector-emitter voltage. Accordingly, when choosing the transistor switch the maximum rating for the collector-emitter voltage or drain-source voltage, respectively, has to be taken into account, in relation to the maximum possible inductive load at the maximum possible DC voltage level. Another aspect of choosing the appropriate transistor is the energy loss in the transistor, which may lead to overheating in case the maximum power dissipation rating is exceeded. But since, according to the invention, the transistor switch is switched off again after the relay contacts have been opened, the transistor switch is not supposed to remain in the switched-on state longer than necessary. Thus, the power dissipation is held at a minimum level, so that it should not reach its maximum rating under normal circumstances.

[0016] The further object of the invention is achieved by a drive unit for a tap-changer that comprises means to automatically move the tap-changer to a desired position and which is provided with at least one of the signal generation units described above.

[0017] In a preferred embodiment of the invention, the switch control unit closes the transistor switch before closing the at least one relay contact and opens the transistor switch after the at least one relay contact is closed. Since it is not known beforehand what kind of load will be connected to the signal generation unit, the use of the transistor switch during the closing of the relay contact prevents mainly the occurrence of a damaging overcurrent caused by a capacitive load.

[0018] According to an advantageous embodiment of the invention, the protection circuit further comprises a rectifier unit in parallel with the at least two relay terminals. The transistor switch is then connected in parallel with the DC output of the rectifier unit so that the DC output of the rectifier unit is short-circuited when the transistor switch is closed by the switch control unit. With this embodiment, the possibilities of applying one and the same signal generation unit to different configurations are expanded to include AC output voltages as well. The rectifier unit will always provide a DC voltage to the transistor switch, so that the general functionality of the protection circuit is the same as described above.

[0019] In a further embodiment, the switch control unit leaves the transistor switch closed as long as a chatter in the signal relay occurs in order to fully ensure the protection of the at least one relay contact.

[0020] In yet another embodiment, the signal generation unit further comprises at least one varistor for protecting the signal generation unit against sudden and unpredicted voltage peaks. The at least one varistor is preferably connected in parallel with the AC input of the rectifier unit and/or between one of the terminals of the AC input of the rectifier unit and a protective ground.

[0021] The present invention will be more fully described by way of example with reference to the accompanying drawings in which:

Figure 1 shows a conventional drive unit for a tap changer,
Figure 2 is a circuit diagram of the parts of a signal generation unit related to the present invention,
Figure 3 is a time diagram of the control signals of the transistor switch and the signal relay, respectively,
Figure 4 is a circuit diagram of an embodiment of the present invention and
Figure 5 is a circuit diagram of a further extended embodiment of the invention.

[0022] The conventional drive unit 1 shown in figure 1 is intended for the use with a tap changer. It comprises as main components an electric motor 2 to drive an output drive shaft 4 via a gear unit 5, and a control unit 3 to monitor and control the operation of the motor 2 and thereby of the tap changer. The actual tap changer, which is not shown in figure 1, would be mechanically connected to the output drive shaft 4.

[0023] The control unit 3 receives control instructions from a superordinated control system and sensor signals from the motor 2. The control instructions and the sensor signals are then processed by the control unit 3 to generate output signals. One minor part of the output signals controls the voltage supply to the motor 2 so that the output drive shaft 4 is rotated to a desired angle and the tap changer is moved to the desired position, accordingly. These output signals are internal signals. The other main part of the output signals serves as measurement and monitoring information for external control units as well as for the superordinated control system. The are external output signals.

[0024] To generate the external output signals, the control unit 3 comprises signal generation units which contain electromechanical relays. The electrical specification of the output signals varies between AC (50/60 Hz) and DC of different voltage levels and the load on the output ports of the control unit 3 may be either capacitive or inductive. As a result, the drive unit 1 and especially the signal generation units of the control unit 3 have to be adapted to each application specifically, which results in an extensive and costly production process of drive units for today's tap changers.

[0025] To overcome this drawback, the present invention suggests to use a signal generation unit which comprises the electrical and electronic components according to figure 2. With this signal generation unit, one and the same control unit 3 can be utilised for different DC output voltages and up to the maximum rating of the inductive load.

[0026] The signal generation unit according to figure 2 comprises a signal relay 6 with a relay coil 7. When the relay coil 7 is energized by DC, in this example by a 24 V power supply, a relay contact corresponding to the relay output terminals 8 is closed. The relay contact comprises two contact elements 19 which are only shown schematically.

[0027] When the relay contact corresponding to the relay output terminals 8 is closed, the output voltage across the output terminals 9 of the signal generation unit becomes zero. If the relay contact is opened again, the output voltage across the output terminals 9 is determined by the external circuitry connected to terminals 9. This output voltage is a DC voltage and it varies from 24 to 250 V. The external circuitry connected to terminals 9 shows inductive load behaviour up to a maximum rating of UR=40 mS at 250 VDC and 100 mA.

[0028] In order to ensure the protection of the relay contact corresponding to the relay output terminals 8 at all DC output voltage levels and up to the maximum rated inductive loads, the signal generation unit contains a special protection circuit. In parallel with the relay output terminals 8 or the output terminals 9, respectively, there is connected a transistor switch 10. The transistor switch 10 is in this example an IGBT. The transistor switch 10 is controlled by a switch control unit 11, in this particular case an opto-isolated photovoltaic transistor driver. The switch control unit 11 produces a control signal U_G for the gate of the transistor switch 10 according to figure 3.

[0029] In figure 3, there is depicted the time characteristics of the control signal U_G for the gate of the transistor switch 10 as well as the time characteristics of a control signal U_R which controls the energizing of the relay coil 7. In both cases a high signal level indicates that the transistor switch 10 or the signal relay 6 should be switched on, respectively, where switching the signal relay 6 on means closing the relay contact corresponding to the relay output terminals 8. As can be seen from figure 3, the transistor switch 10 is controlled to be switched on for a time period $t_{pre,on}$ before the signal relay 6 is switched on, and the transistor switch 10 is controlled to be switched off for a time period $t_{past,on}$ after the signal relay 6 has been switched on. Similarly, the transistor switch 10 is controlled to be switched on for a time period $t_{pre,off}$ before the signal relay 6 is switched off, and the transistor switch 10 is controlled to be switched off for a time period $t_{past,off}$ after the signal relay 6 has been switched off. The time periods $t_{past,on}$ and $t_{past,off}$ which are applied after the switching operation of the signal relay 6 are each chosen to be long enough to allow a chatter in the signal relay 6 to subside under a predetermined level.

[0030] In order to apply one and the same signal generation unit to DC as well as to AC output voltages, a rectifier unit 12 is added to the components of the signal generation unit according figure 4. The rectifier unit 12, in this particular case a single phase rectifier bridge, is connected in parallel with the relay output terminals 8 or the output terminals 9, respectively. The transistor switch 10 is connected directly to the DC output 13 of the rectifier unit 12, so that the transistor switch 10 can fulfil the function of paralleling the relay output terminals 8 and thereby protecting the contact elements 19 regardless of AC or DC across the output terminals 9.

[0031] According to figure 5, three varistors 14, 15 and 16 are included in the signal generation unit to protect the different components 8, 10, 11 and 12 of the signal generation unit against voltage peaks. Two of the varistors, 14 and 15, are between one of the terminals of the AC input 18 of the rectifier unit 12 and a protective ground 17. The third varistor 16 is connected in parallel with the output terminals 9.

Claims

1. Signal generation unit for generating a data signal in a control unit (3) of a power system device comprising:

- a signal relay (6) to alternately open and close at least one relay contact thereby performing a switching operation between two different output voltages, where the at least one relay contact corresponds to two relay output terminals (8),
- a protection circuit in parallel with the two relay output terminals (8) for protecting the at least one relay contact against overvoltages,

characterized in that

- the protection circuit comprises
  - a transistor switch (10) in parallel with the two relay output terminals (8) and
  - a switch control unit (11) for closing the transistor switch (10) before opening the at least one relay contact and opening the

transistor switch (10) after the at least one relay contact is opened.

2. Signal generation unit according to claim 1, wherein the switch control unit (11) closes the transistor switch (10) before closing the at least one relay contact and opens the transistor switch (10) after the at least one relay contact is closed.

3. Signal generation unit according to one of the claims 1 or 2, wherein the protection circuit further comprises

- a rectifier unit (12) in parallel with the two relay output terminals (8) and
- where the transistor switch (10) is connected in parallel with the DC output (13) of the rectifier unit (12) so that the DC output (13) of the rectifier unit (12) is short-circuited when the transistor switch (10) is closed by the switch control unit (11).

4. Signal generation unit according to at least one of the preceding claims, where the switch control unit (11) leaves the transistor switch (10) closed as long as a chatter in the signal relay (6) occurs.

5. Signal generation unit according to at least one of the preceding claims, further comprising at least one varistor (14, 15, 16) for protecting the signal generation unit against voltage peaks.

6. Signal generation unit according to claim 5, where one of the varistors (16) is connected in parallel with the AC input (18) of the rectifier unit (12).

7. Signal generation unit according to one of the claims 5 or 6, where one of the varistors (14, 15) is connected between one of the terminals of the AC input (18) of the rectifier unit (12) and a protective ground (17).

8. Drive unit (1) for a tap-changer comprising

- means (2, 3, 4, 5) to automatically move the tap-changer to a desired position and
- at least one of the signal generation units according to at least one of the preceding claims.

9. Method for generating a data signal in a power system device, whereby at least one relay contact of a signal relay (6) is protected against overvoltages, **characterized by** the following steps in their given order:

- closing a transistor switch (10), where the transistor switch (10) is connected in parallel with two relay output terminals (8) corresponding to the at least one relay contact of the signal relay (6),
- opening the at least one relay contact, thereby performing a switching operation between two different output voltages,
- opening the transistor switch (10).

10. Method according to claim 9, further comprising the steps of:

- closing the transistor switch (10),
- closing the at least one relay contact,
- opening the transistor switch (10).

11. Method according to one of the claims 9 or 10, further comprising the steps of:

- rectifying the voltage between the two relay output terminals (8) and
- providing the rectified voltage to the transistor switch (10).

12. Method according to at least one of the preceding claims 9 to 11, further comprising the step of:

- waiting until a chatter in the signal relay (6) has subsided under a given level, where this step is performed after the opening or closing of the at least one relay contact.

Amended claims in accordance with Rule 137(2) EPC.

1. Signal generation unit for generating a data signal in a control unit (3) of a power system device comprising:

- a signal relay (6) to generate the data signal by alternately opening and closing at least one relay contact thereby performing a switching operation between two different output voltages, where the at least one relay contact corresponds to two relay output terminals (8), which are in parallel with the two output terminals (9),
- a protection circuit in parallel with the two relay output terminals (8) for protecting the at least one relay contact against overvoltages,

characterized in that

- the AC input (18) of a rectifier unit (12) is in parallel with the two relay output terminals (8) and with the two output terminals (9), where either a DC or an AC voltage is applied to the output terminals (9),
- the protection circuit comprises

  - a transistor switch (10) connected in par-

allel with the DC output (13) of the rectifier unit (12) so that the DC output (13) of the rectifier unit (12) is short-circuited when the transistor switch (10) is closed by the switch control unit (11).

■ a switch control unit (11) for closing the transistor switch (10) before opening the at least one relay contact and opening the transistor switch (10) after the at least one relay contact is opened.

2. Signal generation unit according to claim 1, wherein the switch control unit (11) closes the transistor switch (10) before closing the at least one relay contact and opens the transistor switch (10) after the at least one relay contact is closed.

3. Signal generation unit according to at least one of the preceding claims, where the switch control unit (11) leaves the transistor switch (10) closed as long as a chatter in the signal relay (6) occurs.

4. Signal generation unit according to at least one of the preceding claims, further comprising at least one varistor (14, 15, 16) for protecting the signal generation unit against voltage peaks.

5. Signal generation unit according to claim 5, where one of the varistors (16) is connected in parallel with the AC input (18) of the rectifier unit (12).

6. Signal generation unit according to one of the claims 5 or 6, where one of the varistors (14, 15) is connected between one of the terminals of the AC input (18) of the rectifier unit (12) and a protective ground (17).

7. Drive unit (1) for a tap-changer comprising

• means (2, 3, 4, 5) to automatically move the tap-changer to a desired position and
• at least one of the signal generation units according to at least one of the preceding claims.

8. Method for generating a data signal in a power system device by alternately opening and closing at least one relay contact of a signal relay (6), where the at least one relay contact corresponds to two relay output terminals (8), which are in parallel with the two output terminals (9), and where the at least one relay contact is protected against overvoltages **characterized in that**

• a DC voltage is applied to the two output terminals (9), which correspond to the at least one relay contact of the signal relay (6), and where in the case that an AC voltage is provided the AC voltage is rectified to generate DC voltage
• the at least one relay contact is protected by the following steps in their given order:

■ closing a transistor switch (10), where the transistor switch (10) is connected in parallel with the DC output of the rectifier (13), so that the DC output (13) of the rectifier unit (12) is short-circuited when the transistor switch (10) is closed by the switch control unit (11).
■ opening the at least one relay contact, thereby performing a switching operation between two different output voltages,
■ opening the transistor switch (10).

9. Method according to claim 8, further comprising the steps of:

• closing the transistor switch (10),
• closing the at least one relay contact,
• opening the transistor switch (10).

10. Method according to at least one of the preceding claims 8 or 9, further comprising the step of:

■ waiting until a chatter in the signal relay (6) has subsided under a given level, where this step is performed after the opening or closing of the at least one relay contact.

Fig. 1

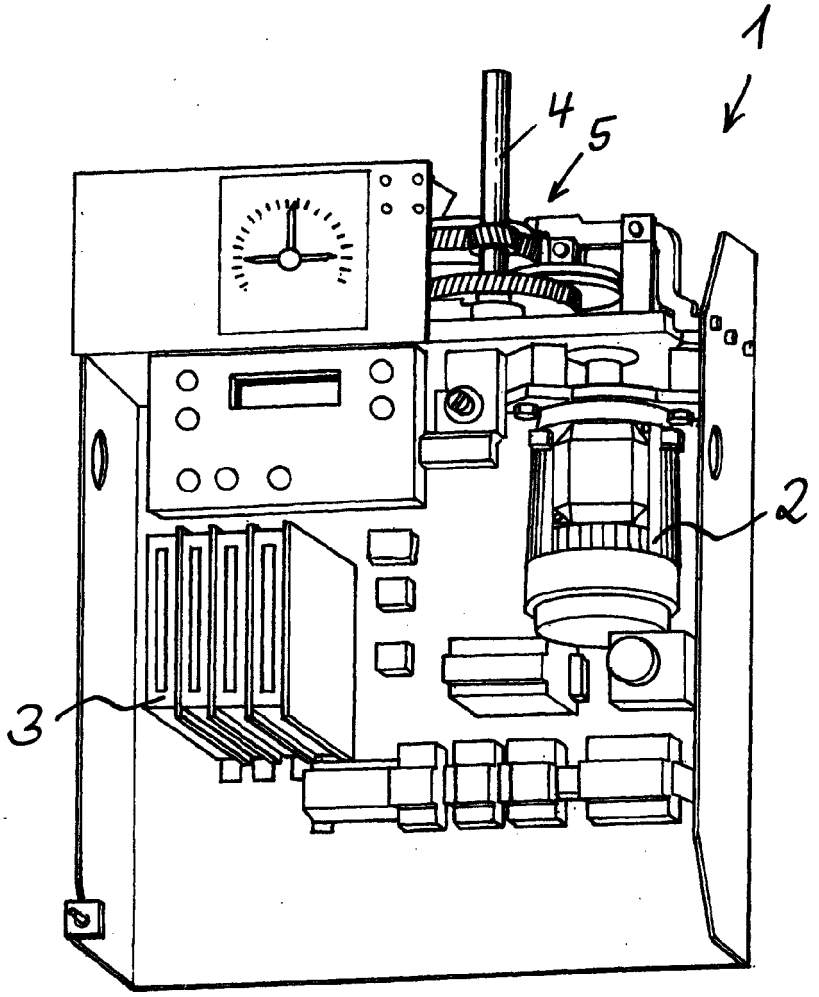
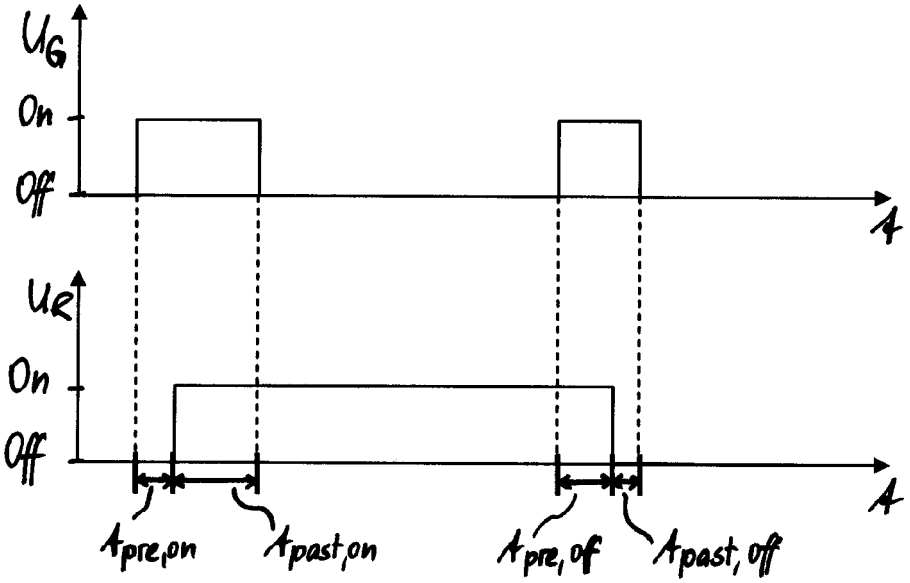


Fig. 3



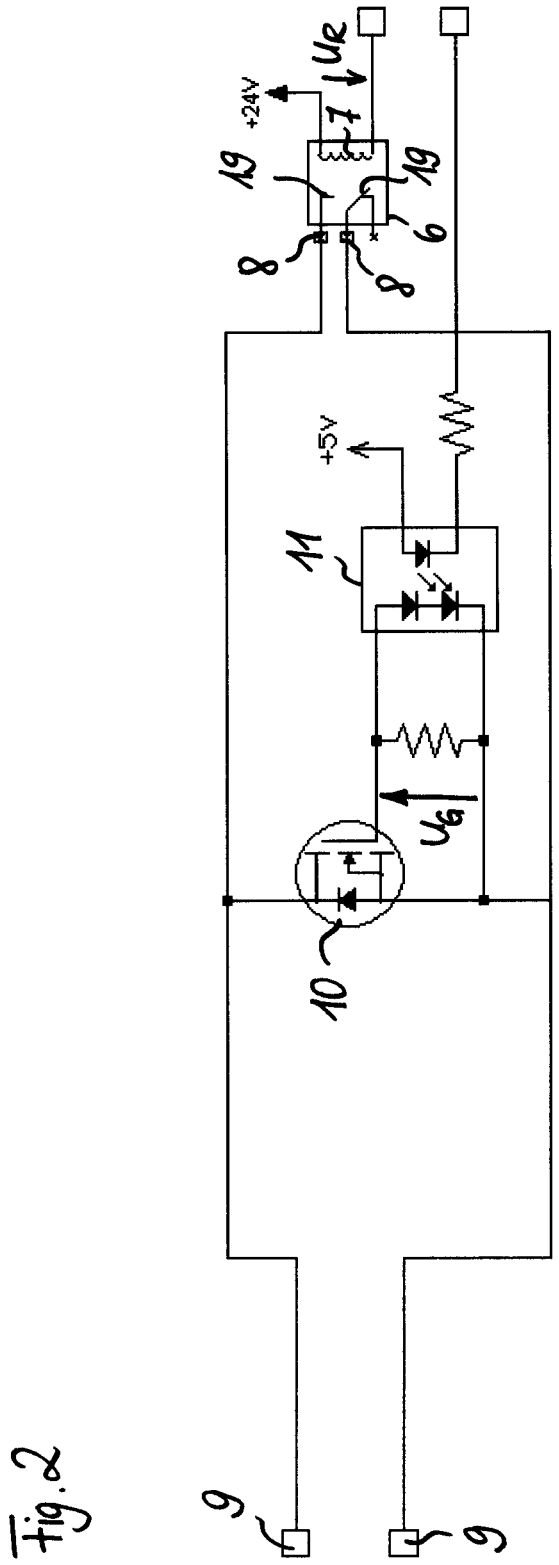


Fig. 2

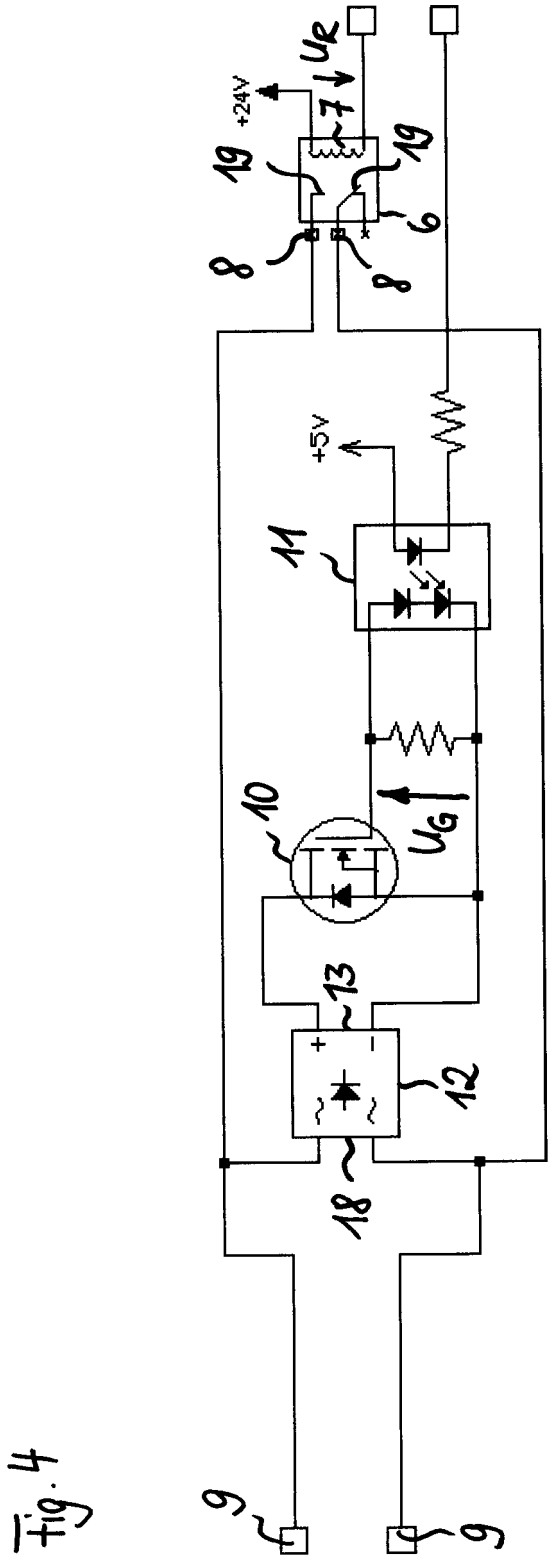


Fig. 4

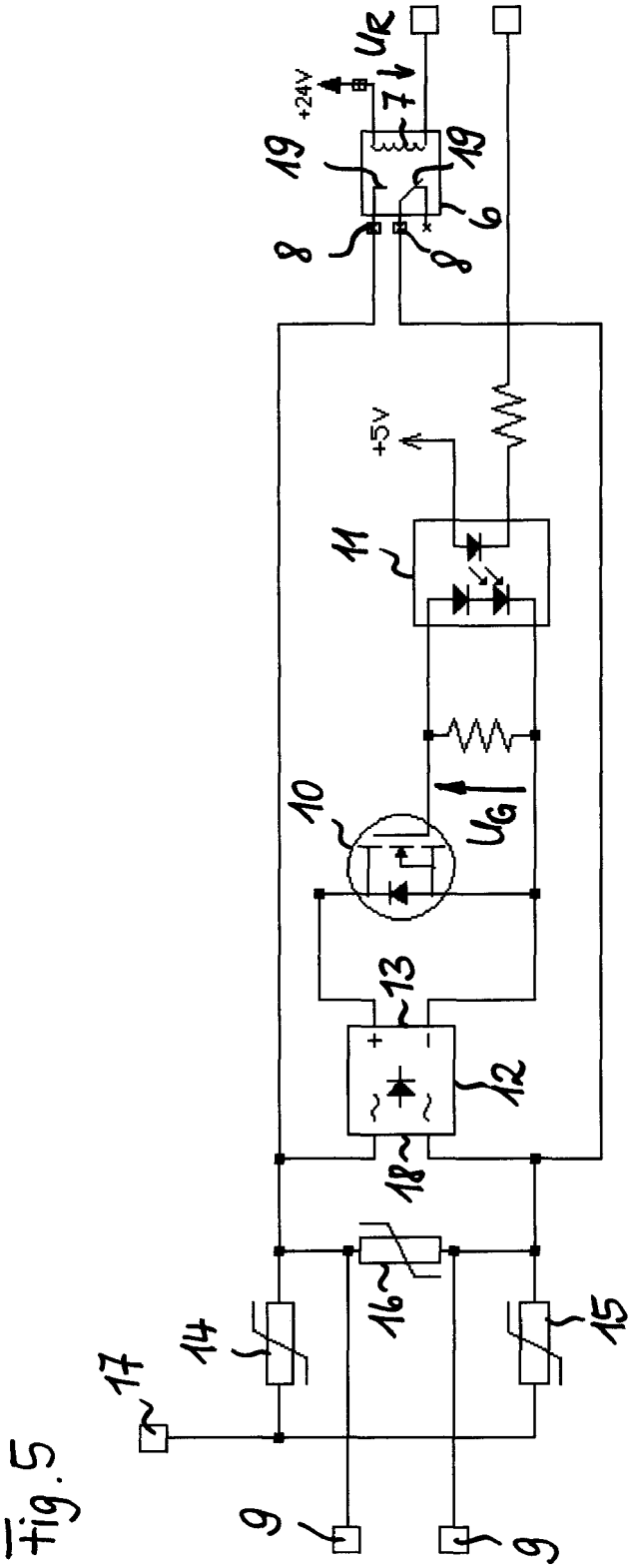


Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 06 11 8943

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A		1,2, 4-10,12	

X	US 3 639 808 A (RITZOW GERALD R) 1 February 1972 (1972-02-01) * column 1, line 24 - column 1, line 42 * * column 2, line 7 - column 2, line 43 * * column 3, line 17 - column 3, line 49 * * figure 2 *	1,2,9,10	
A		3-8,11, 12	TECHNICAL FIELDS SEARCHED (IPC) G05F H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 December 2006	Dörre, Thorsten

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 11 8943

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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