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(54)

Fotovoltaikus modul

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

PHOTOVOLTAIC MODULE

The invention relates to a photovoltaic module according to the preamble to Claim 1.

Photovoltaic modules comprise at least one solar cell and a connection box, where the connection box comprises the voltage outputs of the photovoltaic module. Usually the photovoltaic module comprises a large number of solar cells that are connected in series and/or in parallel to form what is known as a string, where the two ends of the string are brought to the connection box. In the known solar installations, several photovoltaic modules can then be connected to form one or more strings.

In the event of an apartment or house fire, the fire service must ensure that electricity and voltage are disconnected from their place of the deployment, so that, for example, no injuries from electric shock or from sparks result when extinguishing agents are used. Document US 6515215 B1 and document US 2001/023703 A describe photovoltaic modules.

DE 10 2005 018 173 A1 discloses a method for securely interrupting the operation of a photovoltaic installation with a safety device that is connected to the terminals of the solar installation and comprises a bypass to short-circuit the photovoltaic installation. This bypass can be manually or automatically triggered. Depending on the dimensions of the photovoltaic installation, high currents can flow to the consuming units or to the bypass, and these must be managed in the event of the safety device being triggered. The safety device must therefore have correspondingly large dimensions. The circuit is entirely constructed of electronic semiconductor components. The installation is therefore not galvanically isolated from the consuming units. The automatic triggering is initiated here by a control line via which the safety device is connected to a remotely arranged trigger device, with the effect that if the control line is defective, the installation is not isolated.

An emergency switch-off for solar electrical installations is known from DE 20 2007 002 077 U1, wherein switch-off commands are transmitted via a control line connected from a mains terminal to a switching box when a disconnection of the network is detected. Here again the problem is that no disconnection occurs if the control line is faulty.

A safety switching installation for a photovoltaic installation is known from DE 10 2009 022 508 A1, wherein the photovoltaic installation consists of at least one photovoltaic element, two terminals each for a feed line to a consuming unit, with a bypass that is arranged between the two terminals and prior to the at least one switching mechanism, and at least one switching mechanism for closing contact points, wherein at least one further switching mechanism for opening contact points is arranged in each of the two feed lines, wherein the at least one switching mechanism in the bypass and the further switching mechanisms located in each feed line of the photovoltaic installation are configured in such a way and operable jointly by a coupling that when the safety switching installation is actuated, the contact points of the at least one switching mechanism in each of the two feed lines are opened, after which, after a time

delay, the contact points of the at least one switching mechanism that is located in the bypass are closed. The actuation of the switching mechanism here occurs mechanically by a manual unit, or under remote control by a trip unit that is formed for example of an under-voltage trip connected electrically to the domestic network.

A generic photovoltaic module is known from DE 10 2008 003 272 A1, wherein a function module circuit board is arranged in a connection box of photovoltaic module, on which a large number of function-monitoring modules are arranged. Such a function monitoring module is a power module with which the current and voltage of the associated photovoltaic module is monitored, in order to obtain evidence relating to the function of the photovoltaic module. Monitoring the power here serves documentation and installation design purposes. The photovoltaic modules moreover are connected to a wired interface or to a wireless interface for communication with a server. It is furthermore provided that, operating from the central server, each individual photovoltaic module of a string can very easily be disconnected in that a switch-off module is present, controlled by the microprocessor that is arranged on a function module. In the event of fire it is therefore necessary for each individual photovoltaic module to be switched off by means of an appropriate switch-off signal sent from the server, since the switch-off command concerned is transmitted by wires or by radio transmission to each individual photovoltaic module.

The invention addresses the technical problem of creating a photovoltaic module which, with a simple construction, ensures safe switching off in the case of a module that is not fitted or connected, or in the event of a fault.

The technical problem is solved by the objects having the features of Claim 1. Further advantageous developments of the invention emerge from the subsidiary claims.

For this purpose the photovoltaic module comprises at least one solar cell and a connection box, wherein the connection box has the voltage outputs of the photovoltaic module, wherein an evaluation and control unit is arranged in or on the connection box, said evaluation and control unit detecting a voltage and/or a current of the photovoltaic module, wherein the photovoltaic module is assigned at least one switching element which is drivable by the evaluation and control unit, wherein the photovoltaic module can be switched off by means of the switching element, wherein the evaluation and control unit is designed in such a way that a fault state is detectable on the basis of the detected voltage and/or the detected current, and the switching element is directly drivable by the evaluation and control unit on the basis of the detected fault state in order to switch off or short-circuit at least one of the voltage outputs of the photovoltaic module or of the assembly. As a result, both the detection and the switching off of the voltage occur locally at the photovoltaic module itself, so that no communication with a central control unit or other central device is necessary for this purpose. Reliability is increased through this absence of the communication path. It should be noted here that the fault state also includes

states in which the photovoltaic module is not fitted or is not connected, such as, for example, during transport or assembly. The photovoltaic module switches itself off automatically in these situations too. Switching off the photovoltaic module can here be achieved through switching off or disconnecting the voltage outputs, or by short-circuiting the voltage outputs. Reliable contact protection is provided in either case. Due to the fact that the photovoltaic module safeguards itself autonomously, the photovoltaic module according to the invention can be installed flexibly with a variety of very different converters. Through evaluating the voltage and/or current it is here very easy to detect whether a connected converter is switched off on the DC or AC side, or whether a short circuit has occurred between the photovoltaic module(s) of the converter, or whether the photovoltaic module is installed at all. The evaluation and control unit can here be integrated into the connection box, or can be arranged with it as an assembly, so that it is also very easily possible to retrofit existing modules. In this case the voltage outputs of the photovoltaic module are brought to the assembly, and its voltage output or voltage outputs are switched off or short-circuited in the event of a fault. In both cases, however, the occurrence of the fault is detected locally at the photovoltaic module, and the voltage is switched off autonomously without a central control unit or central device. It should be noted here that the evaluation preferably includes the voltage and the current of the photovoltaic module. Preferably again, the assembly also comprises at least one switching element in addition to the evaluation and control unit.

In a further embodiment, the evaluation and control unit detects and evaluates the magnitude and/or form of the voltage and/or of the current. A working point of the photovoltaic module can thus for example be determined on the basis of the magnitude. If, for example, the working point is found to be in no-load or in short-circuit, it can be concluded that there is a fault. It can be concluded from the form, preferably the ripple, whether a converter is connected or not, since its switching results in a ripple in the current and voltage.

By means of the test device of Claim 1, it is possible to check, when switched off, whether the photovoltaic module is connected to a converter and/or whether any fault is still present or has been rectified, wherein the output voltage can be switched on when the connection of a converter or the rectification of a fault is detected. The photovoltaic module can thus not just switch itself off, but can also switch itself back on. It should be noted here that the test device is preferably also an element of the assembly. It should also be further noted that the test device can be entirely or partially integrated into the evaluation and control unit.

In a further embodiment, a test signal, changing in time, can be injected by means of the test device. This permits better assessment in order, for example, to establish whether a converter that was switched off but whose input capacitances however are already charged has again been switched on, a case which may not be detectable in all cases if, for example, a static test voltage is used.

In a further embodiment, a power supply to the evaluation and control unit and/or test device is provided by the photovoltaic module. Separate energy stores or voltage supply units can thus be dispensed with. There is again no safety penalty here since, if the photovoltaic module is not generating voltage, the voltage outputs also do not have to be switched off. A DC/DC converter, or a voltage limiter, may be used to reduce the voltage of the photovoltaic module to a suitable level for the supply voltage.

In a further embodiment, the switching element is implemented as a power relay, by means of which galvanic isolation is enabled.

In a further embodiment, all the poles of the the photovoltaic module or the assembly can be switched off, i.e. both voltage outputs are switched off or disconnected.

In a further embodiment, the switching element is open when idle, i.e. when no voltage supply is available, the voltage output is switched off. This further increases safety. It can be provided here that when the photovoltaic module again generates voltage, a check is first made by the test device to see that a fault is not present before the voltage output or outputs are enabled. This measure also increases safety further. Accordingly, when the photovoltaic module is switched off by a short circuit of the voltage outputs, the switching element is preferably closed when idle.

In a further embodiment, the evaluation and control unit is assigned a storage element for the supply voltage, in particular in order to ensure a safe run-on and to switch itself off properly if the voltage of the photovoltaic module fails.

In a further embodiment, the photovoltaic module is assigned a signalling and/or communication unit by means of which the photovoltaic module signals its status.

The invention is explained in more detail below with reference to preferred exemplary embodiments. In the figures:

Fig. 1

shows a schematic block diagram of a photovoltaic module with an external assembly,

Fig. 2

shows a schematic block diagram of a photovoltaic module with an integrated evaluation and control unit in a connection box of the photovoltaic module,

Fig. 3

schematically shows current and voltage curves when testing the fault-free connection to a converter, for switching the photovoltaic module on

Fig. 4

schematically shows current and voltage curves under no-load conditions,

Fig. 5

schematically shows current and voltage curves in the event of short-circuit conditions, and

Fig. 6

is a schematic illustration of the upstream connection of photovoltaic modules with a converter.

Fig. 1 illustrates a first embodiment of the invention. A photovoltaic module 1 is illustrated schematically, comprising three solar cells 2 on its front face V that are connected in series to form a string. The connections of the solar cells 2 are brought to a rear face R of the photovoltaic module 1, where bypass diodes 3 are arranged that facilitate the flow of current through the string even when a solar cell 2 fails. Voltage outputs 4, 5 of the photovoltaic module 1 are brought out of the rear face R. The bypass diodes 3 and the voltage outputs 4, 5 are arranged in a connection box 6 that is accessible from the rear face R. An assembly 7 is arranged locally at the photovoltaic module 1. The assembly 7 comprises two voltage inputs 8, 9 and two voltage outputs 10, 11. The assembly 7 furthermore comprises an evaluation and control unit 12, a measuring device 13, a test device 14, an internal voltage supply 15, a switching element 16 and a diode 17. One voltage output 4, 5 of the photovoltaic module 1 is here connected to one voltage input 8, 9 of the assembly 7. The at least one switching element 16 is located between the voltage input 8 and the voltage output 10, and is driven by the evaluation and control unit 12. The internal voltage supply 15 is connected to the voltage inputs 8, 9, and is thus fed directly by the photovoltaic module 1. The internal voltage supply 15 supplies the electronic components with voltage, and only the connection to the evaluation and control unit 12 is shown on Fig. 1. The measuring device 13 detects voltage and current at the voltage output 10, 11 of the assembly 7.

An alternative embodiment is illustrated in Fig. 2, in which the assembly 7 is integrated into the connection box 6 of the photovoltaic module 1. The voltage outputs 4, 5 are thus equivalent to the voltage outputs 10, 11 of the assembly 7. In other respects, we refer fully to the explanations given in reference to Fig. 1.

Before referring to Figs. 3 to 5 for explanation in more detail of the method of operation of the photovoltaic module 1 according to the invention with internal or external assembly 7, one part of a solar installation should be briefly explained in more detail with reference to Fig. 6.

The photovoltaic module 1 is here illustrated with an external assembly 7. The voltage outputs 10, 11 of the assembly 7 are connected to a DC isolator 20, which is connected to a converter 21. At the output of the converter 21 is the network, which can be constituted as a single-phase or multi-phase alternating current network or as a direct current network. One or more photovoltaic modules 1 or strings of photovoltaic modules 1 can be connected to, or also disconnected from, the converter 21 through the DC isolator 20. It should be noted here that due

to the ability according to the invention of individually switching photovoltaic modules 1 off, the DC isolator 20 can also technically be omitted.

Figs. 3 to 5 will now be explained in more detail in connection with Fig. 1. It is assumed here that the photovoltaic module 1 does not initially generate any voltage, for example because it is night-time. Accordingly, the assembly 7 is not supplied with voltage, and the switching element 16 is open ($S = 0$). The voltage at the voltage outputs 10, 11 is accordingly zero ($U_A = 0$). When the photovoltaic module 1 again generates voltage, the assembly 7 is supplied with voltage, while the switching element 16 remains open at first. At a time t_1 , the test device 14 applies a small test voltage U_p of, for example, 2 V to the voltage output 10. The converter referred to in Fig. 6 here has an input capacitance. Thus if the DC isolator 20 is closed and the converter 21 is connected, the test voltage will charge up the input capacitance of the converter 21. A large output current I_A , decaying exponentially, accordingly flows at first. The voltage U_A thus rises, and finally is equal to the test voltage. On the basis of the curves of voltage and current, measured by the measuring device 13, the evaluation and control unit 12 can recognize whether the converter 21 is connected or not connected. In the first case the switching element 16 is closed ($S = 1$) at time t_2 . Without a connected converter on the other hand, the switching element 16 remains open, and the voltage output is thus switched off. It can here be provided that the test device 14 generates a test voltage that changes over time, so that pre-charged capacitances of the converter 21 are also detected. When the switching element 16 is closed ($S = 1$) the test voltage U_p is switched off ($U_p = 0$).

Fig. 4 illustrates a current and voltage curve through which no-load conditions are detected. The photovoltaic module 1 here operates at a working point U_{AP} , I_{AP} . The values of the voltage and current are here monitored by the measuring device 13. At time t_1 the measuring device 13 then detects that the voltage U_A has risen to the no-load voltage U_L , and that the current I_A has dropped to I_L . This behaviour is interpreted by the evaluation and control unit 12 as no-load conditions, occurring, for example, because the network has been switched off at the converter 21. In this case, only a small no-load current I_L then flows to provide base power to the converter 21. Once the evaluation has been completed, the evaluation and control unit 12 opens the switching element 16 ($S = 0$) at a time t_2 . The voltage output 10 is thus switched off, and $U_A = I_A = 0$ applies. A test voltage U_p is then connected in order to establish whether the network has been reconnected or the cause of the fault has been rectified in some other way. It is to be noted here that the test voltage U_p does not have to be permanently present, but can also be switched on periodically.

Fig. 5 illustrates a current and voltage curve through which short-circuit conditions are detected. The photovoltaic module 1 here operates at a working point U_{AP} , I_{AP} . The values of the voltage and current are here monitored by the measuring device 13. At time t_1 the measuring device 13 then detects that the voltage has dropped to $U_A = 0$, and that at the same time the current has risen to I_k . This behaviour is interpreted by the evaluation and control unit 12 as a short-circuit

faulti. The evaluation and control unit 12 reacts by opening the switching element 16 ($S = 0$) at time t_2 , so that the voltage output 10 is switched off. $U_A = I_A = 0$ applies. The test voltage U_p is then reconnected. It should be noted that U_p is very small in comparison with U_{A0} , so that the resultant voltage and current are negligible, since $U_p, U_A = I_A = 0$ is not strictly speaking correct due to the test voltage.

FOTOVOLTAIKUS MODUL

Szabadalmi igénypontok

1. Fotovoltaikus modul (1), amely legalább egy szolár cellával (2) és egy csatlakozódobozzal (6) rendelkezik, ahol a csatlakozódoboz (6) tartalmazza a fotovoltaikus modul (1) feszültségkimeneteit (4, 5), ahol a csatlakozódobozon (6) vagy a csatlakozódobozban (6) építéscsoportként (7) egy kiértékelő és vezérlőegység (12) van elrendezve, amely a fotovoltaikus modul (1) feszültségét (U_A) és/vagy áramát (I_A) érzékeli, ahol a fotovoltaikus modulhoz (1) legalább egy kapcsolóelem (16) van hozzárendelve, amely a kiértékelő és vezérlőegységgel (12) vezérelhető, ahol a kapcsolóelem (16) révén a fotovoltaikus modul (1) lekapcsolható, ahol a kiértékelő és vezérlőegység (12) úgy van kiképezve, hogy az érzékelt feszültség (U_A) és/vagy az érzékelt áram (I_A) alapján egy hibás állapot detektálható, és a kapcsolóelem (16) az érzékelt hibás állapot alapján a kiértékelő és vezérlőegységgel (12) vezérelhető, hogy a fotovoltaikus modul (1) legalább egyik feszültségkimenetét (4, 5; 10, 11) vagy az építési csoportot (7) lekapcsoljuk vagy rövidre zárjuk,

azzal jellemezve, hogy

a kiértékelő és vezérlőegységhez (12) egy vizsgálóegység (14) van hozzárendelve, amellyel az egy lekapcsolt feszültségkimenetre (10) egy vizsgálójel juttatható és legalább egy mérési jel érzékelhető, ahol a mérési jel függvényében a kiértékelő és vezérlőegység (12) a kapcsolóelemet (16) vezérli.

2. Az 1. igénypont szerinti fotovoltaikus modul, *azzal jellemezve, hogy* a kiértékelő és vezérlőegység (12) a feszültség (U_A) és/vagy az áram (I_A) nagyságát és/vagy alakját érzékeli és értékeli ki.

3. A 2. igénypont szerinti fotovoltaikus modul, *azzal jellemezve, hogy* a vizsgálóegységgel (14) egy időben változó vizsgálójel vihető fel.

4. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve, hogy* a fotovoltaikus modul (1) révén történik a kiértékelő és vezérlőegység (12) és/vagy a vizsgálóegység (14) feszültséggel történő ellátása.

5. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve, hogy* a kapcsolóelem (16) teljesítmény jelfogóként van kiképezve.

6. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve, hogy* a

fotovoltaikus modul (1) összes kapesán lekapholható.

7. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve*, hogy a kapcsolóelem (16) nyugalmi állapotban nyitott.

8. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve*, hogy a kiértékelő és vezérlőegységhez (12) egy tápfeszültség tárolóelem van hozzárendelve.

9. Az előző igénypontok bármelyike szerinti fotovoltaikus modul, *azzal jellemezve*, hogy a fotovoltaikus modulhoz (1) egy jelző- és kommunikációs egység van hozzárendelve.

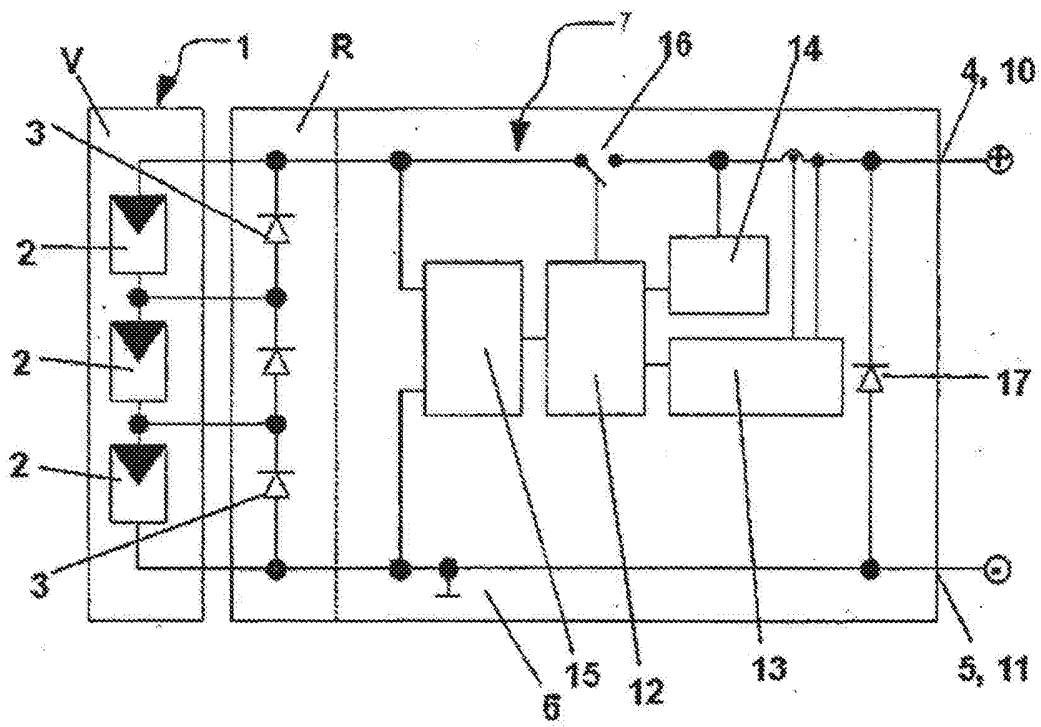


Fig. 2

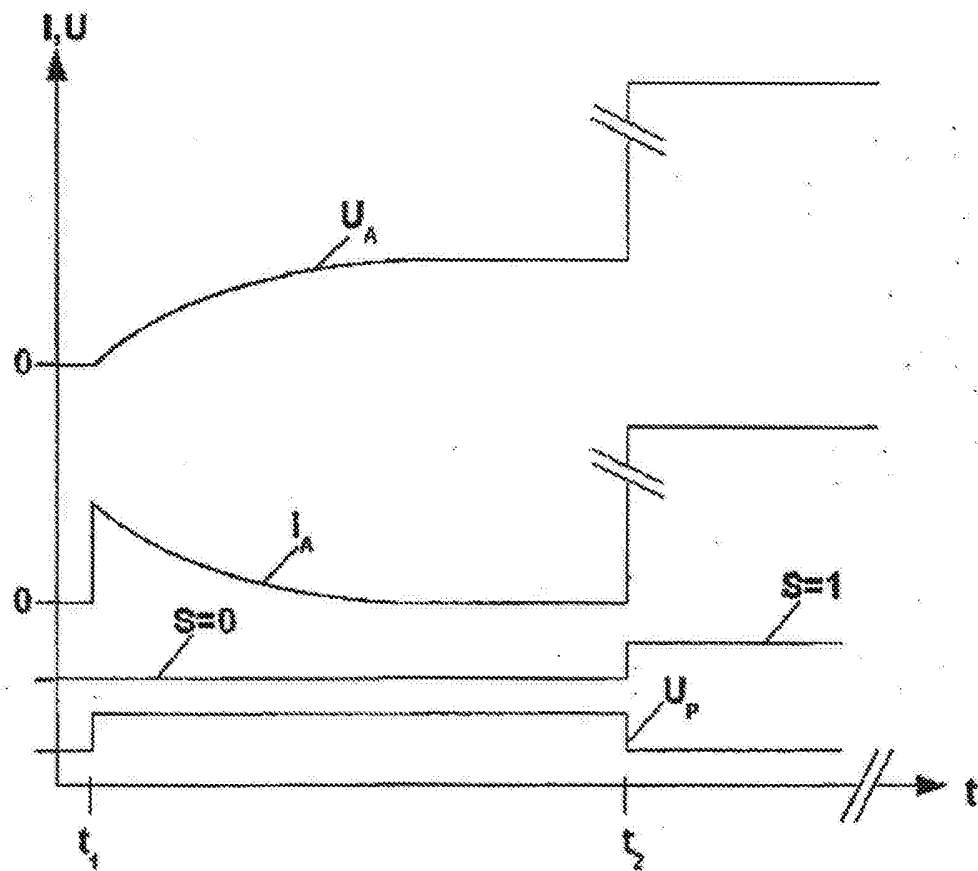


Fig. 3

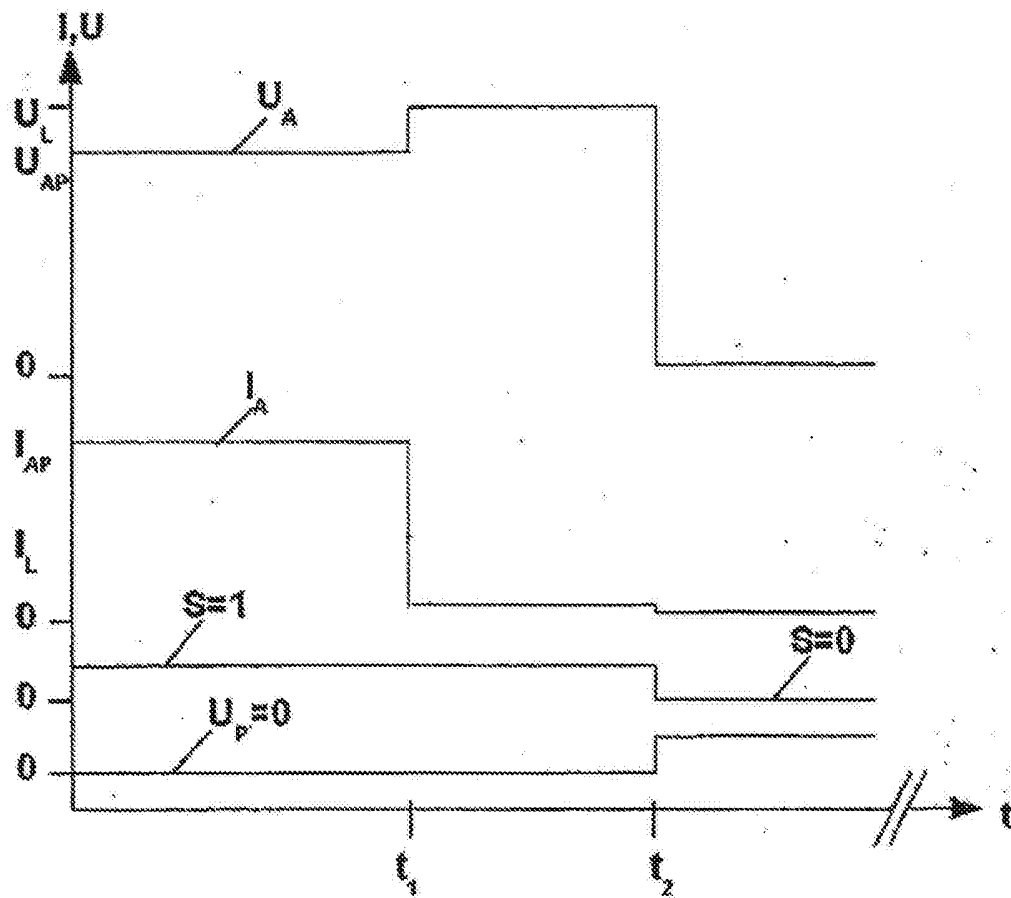


Fig. 4

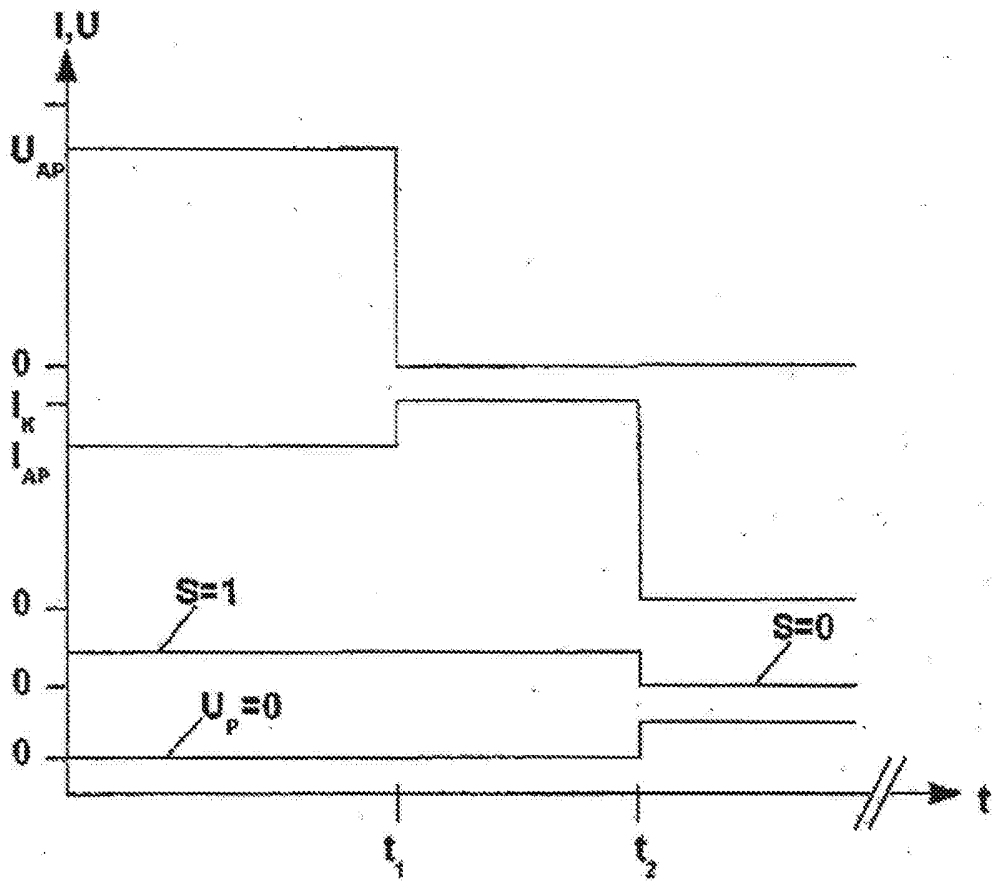


Fig. 5

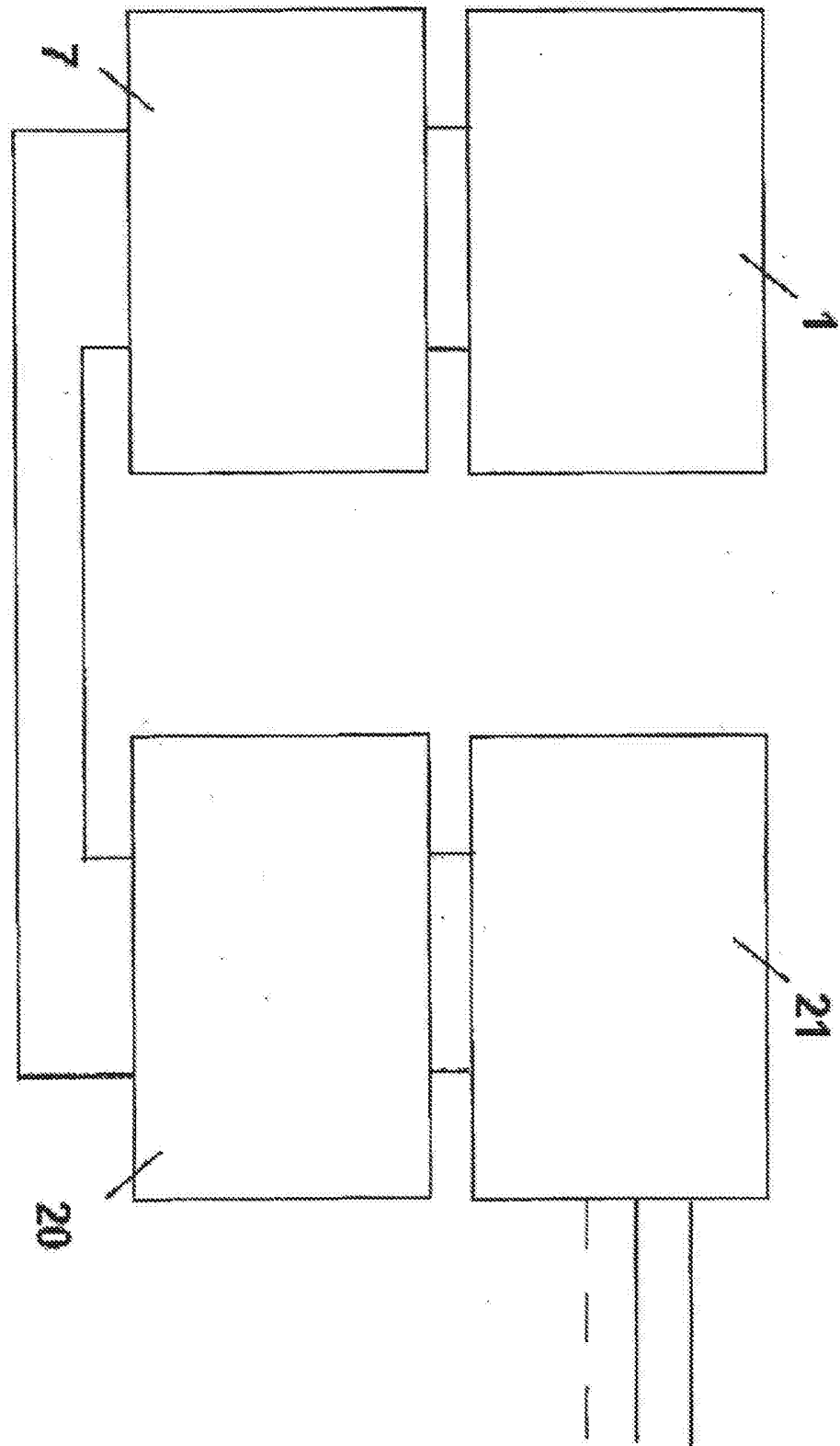


Fig. 6