(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 336 992 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.06.2011 Bulletin 2011/25

(51) Int Cl.:
G08B 13/14 *(2006.01)* ***H01L 31/042*** *(2006.01)*

(21) Application number: **10013842.9**

(22) Date of filing: **20.10.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **27.10.2009 IT AN20090081**

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(54) **Electronic control system for photovoltaic modules**

(57) The present invention relates to an electronic control system (PCS) for photovoltaic modules, comprising a control programmable device (CL), capable to generate an alarm signal, and a transmitter (RF) apt to transmit such alarm signal outside. The electronic control system (PCS) comprises a detector capable to detect an event such as a damaging or a theft in progress, a bistable memory element (FF), capable to change its logic level from low to high depending on the state of the detector; an energy source (EA), operatively connected to the memory element (FF) in such a way that the bistable memory element (FF) is electrically powered by the source (EA) after the variation of the state of said detector and a switch (S1), operatively connected to the source (EA) and to the supply of the programmable device (CL). The electricity supply of the programmable device (CL) through the switch (S1) is stopped when the logic level of the memory element (FF) is low and is allowed when the logic level of the memory element (FF) is high. The present invention relates also to a photovoltaic module (PVM) comprising such an electronic control system (PCS) and a plant for the production of electricity comprising such a photovoltaic module (PVM).

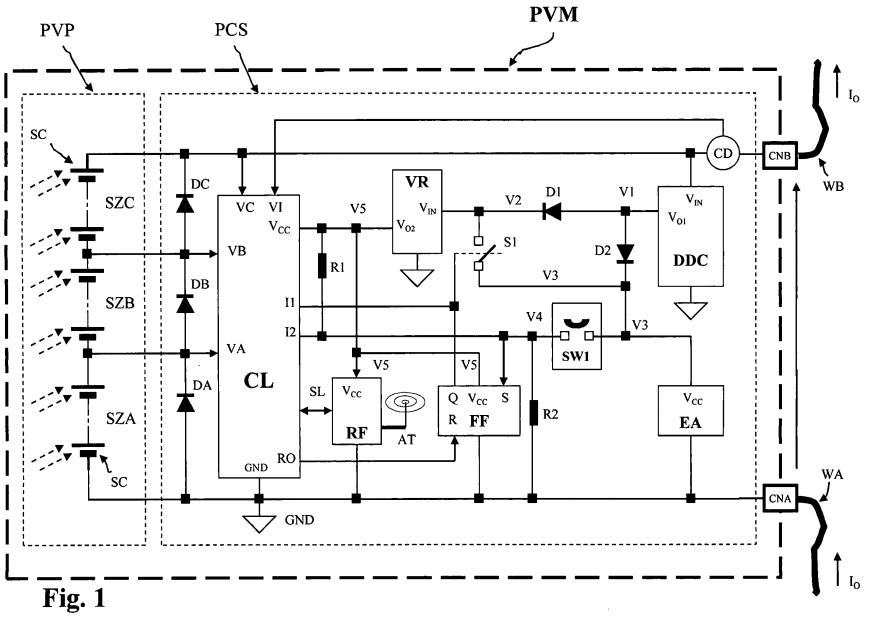

Fig. 1

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Description

[0001] The present invention relates to an electronic control system for photovoltaic modules according to the preamble of claim 1, and a photovoltaic module comprising such an electronic control system and a plant for the production of electricity comprising such a photovoltaic module. In particular, this invention joins in the field of the protection of photovoltaic modules or panels for producing electricity coming from solar radiation, from theft and damaging and refers, in a preferential but not limited way, to large-scale photovoltaic systems, which are often susceptible to events such as damaging or theft, especially when installed over large areas far from built-up areas.

[0002] Are known radical solutions that make the photovoltaic module permanently inoperable once it is removed from the initial context in which it is installed. This is achieved through a mechanism enabling the production of electricity, which is activated at the beginning of each day, when the module starts to work, and during periodic checks carried out during the operation of the module: this mechanism provides for the recognition of a specific "keyword" (ie an identification code uniquely associated with the module) by an appropriate supervision system, since the photovoltaic module is provided with a control system able to exchange information with the supervision system and of means for permanently inhibiting the generation of current when the check of that "keyword" fails. This approach has the advantage of discouraging theft of solar panels, but requires increased complexity in the module that tends to reduce its reliability over time, putting at risk the necessary guarantee of long-term efficiency on which the strong investments required by photovoltaic systems are based.

[0003] The present invention aims to create an anti-theft for photovoltaic modules different in approach, to overcome the drawbacks typical of the system with "keyword" described shortly above. The general idea underlying the present invention is in fact to act primarily at preventive level against the occurrence of an event such as theft or damaging in progress, proposing a system for an early detection of an attempted damaging or theft in progress, provided with communication means for signaliing the event promptly to a supervision system able to properly manage the alert. This is achieved by associating to the photovoltaic module a suitable control system comprising a control programmable device, susceptible to generate an alarm signal, and a transmitter operatively connected to the programmable device capable to transmit the alarm signal outside.

[0004] According to the invention, the electronic control system is provided with sensor means to early detect signals that can be associated with an attempted theft or damaging, means for processing the signals generated by said sensor means to detect the real presence of an attempted theft or damaging and means for notifying the event of theft or damaging in progress to said supervision system, even during periods when the photovoltaic module cannot generate electricity, for example during the night.

[0005] In more details, the electronic control system in accordance with the present invention comprises:

at least a detector capable to detect an event such as a damaging or a theft of the photovoltaic module to which said electronic control system is applied, said event causing a variation of the state of said detector from an inactive state to an operative state;

- a bistable memory element, capable to change its logic level from low to high depending on the state of the detector;
- an energy source, operatively connected to the memory element in such a way that said bistable memory element is electrically powered by the source after the variation of the state of the detector;
- a switch, operatively connected to the source and to the power supply of the control programmable device and controlled by the bistable memory element in such a way that the electricity supply of the control programmable device through the switch is stopped when the logic level of the bistable memory element is low and at the contrary is allowed when the logic level of the bistable memory element is high.

[0006] The detector may comprise an electric contact normally open, an event such as a damaging or a theft in progress causing a stable or temporary closure of the electric contact (eg for the realization of the present invention a detector comprising an electrical contact whose opening or closing states depend on the tilt of said detector with respect to the earth's vertical can be used) and/or a vibration transducer, apt to generate an impulsive electric signal when said detector vibrates at a frequency higher than a predetermined value. The transmitter, which allows the electronic control system of the photovoltaic module to communicate with a supervision system, depends on the characteristics of the same supervision system and can be a simple transmitter or a transceiver that can provide a two-way communication between the electronic control system of the photovoltaic module and the supervision system. According to the invention, the communication through the transmitter is based, in a preferential but not limited way, on radio frequency communication technologies, characterized by non-invasivity (no wiring) and low power consumption.

[0007] The present invention will appear clearer from the following description and attached drawings, provided by way of explanation and not limitation, in which:

- Figure 1 is a block diagram of a first embodiment according to the invention of the control system of a photovoltaic module that uses a first sensor or de-

tector for detecting theft's attempts in progress of the photovoltaic module itself;

- Figure 2 is a flowchart describing the process of detection by the control system of a photovoltaic module according to the invention, of a theft's attempt in progress of the photovoltaic module itself;
- Figure 3 is a block diagram of a second embodiment according to the invention of the control system of a photovoltaic module that uses a second sensor or detector for detecting theft's attempts in progress of the photovoltaic module itself;
- Figure 4 is a block diagram of a third embodiment according to the invention of the control system of a photovoltaic module that uses the combination of a first and a second sensor or detector for detecting theft's attempts in progress of the photovoltaic module itself.

[0008] Before proceeding to a detailed description of the invention, it is considered useful to provide some definitions regarding to photovoltaic systems, these definitions being shared by experts in the field of photovoltaic plants nowadays. The photovoltaic unit is typically identified with the term "photovoltaic module" or "photovoltaic panel" (in this description and in the annexed claims, the term "photovoltaic module" will be used, but it is good to clarify how that term is intended to have the same meaning of the term "photovoltaic panel"). Each photovoltaic module in turn consists of a set of primary "photovoltaic cells", aimed at converting the energy radiated by the sun into electricity. These photovoltaic cells allow to obtain, by appropriate electrical connections in series and in parallel, a total voltage Vo which is made available by means of two appropriate connectors CNA, CNB to the ends of the respective photovoltaic module, since a direct current Io,the value of which is determined by the technical characteristics of the photovoltaic module, in particular by its nominal power Po, is associated to this voltage Vo. A typical photovoltaic module, used in photovoltaic plants, dedicated to the production of electricity for domestic or industrial exploitations, has a power Po of the order of 200 W and an output voltage Vo of the order of 40 V, in which case the current Io made available by the module is obviously of the order of 5 A, according to the known formula Po = Vo * Io. However, there are commercial photovoltaic modules that have electrical characteristics different from the "typical module" of 200 W, mentioned purely for illustration and not for exhaustiveness, but this is irrelevant with respect to the present invention, since it does not depend on the nominal power of the photovoltaic PV module itself. In order to generate a direct voltage Vc adapted to be converted into an alternating network voltage by means of an appropriate inverter device, the photovoltaic modules are connected in series so that the sum of their output voltages Vo reaches the expected conversion value Vc. The set of photovoltaic modules, connected in series to obtain the required conversion voltage Vc, is typically indicated by the term "string", each string being characterized by a string current Is which is obviously equal to the value of the current Io associated to the photovoltaic module less efficient among all the modules belonging to the same string. For this reason it is appropriate that all the photovoltaic modules in a given string show homogeneous electrical characteristics in order to ensure the highest possible value of the current string Is. Moreover, in order to ensure that the conversion voltage Vc is associated with an adequate conversion current Ic, the latter is obtained by adding together the currents Is of an adequate number of strings that, for this purpose, are electrically connected in parallel each other and form a so-called "electric field panel". Similarly, a plurality of electric field panels connected in parallel each other ensure the attainment of the conversion power Pc = Vc * Ic requested by a predetermined inverter device responsible for converting the continuous voltage Vc into an alternating voltage Vca. A block diagram of a photovoltaic module PVM according to the invention is shown in Figure 1. The PVP block is representing the active or generating portion of the module that, through the joint action of a series of generating elements or photovoltaic cells SC, converts the energy radiated by the sun into electricity. The technology underlying the aforementioned PVP block is irrelevant to the present invention and may, for example, use amorphous or monocrystalline silicon, or even be based on emerging polymeric materials. The voltage Vo generated by the PVP block is applied to the two connecting terminals CNA and CNB, which are respectively connected to the cable WA from the previous module and to the cable WB towards the next module, said cables being crossed by the current Io common to the series of modules which form a string. The block PCS is the electronic control system of the photovoltaic module PVM according to the invention. The control system PCS in turn comprises the following fundamental functional elements:

- a control programmable device CL, typically based on the use of a commercial low-cost and low power consumption microcontroller, preferably equipped with measuring means apt to detect electrical quantities and computing means apt to monitor the proper functioning of the photovoltaic module. This programmable device CL is apt to perform, by means of its detection and processing capabilities, the function of alarm signal generating element in the anti-theft system according to the invention;
- a transmitter RF operatively connected (eg via the serial communication line SL) to the programmable device CL and capable of transmitting outside, particularly through the antenna AT, the alarm signal generated by the programmable device CL. The transmitter RF may be a bidirectional communication device, commonly identified with the term "transceiver", which allows the device to control CL to exchange information of any kind with the supervision system of the photovoltaic plant to which the photo-

voltaic module belongs;

- a theft alarm detector, capable of detecting an event such as damaging or theft in progress of the photovoltaic module in which the control system PCS is applied, said event generating a variation of the state of said detector SW1 from an inactive state to an operative state. In the embodiment of the invention represented in Figure 1, the detector includes an electrical contact SW1 normally open, an event such as damaging or theft in progress leading to a closure, stable or temporary, of the electrical contact SW1. Following such closure, the voltage V4 downstream from the electrical contact SW1 is equal to the voltage V3 upstream from the detector;
- a bistable memory element FF, which comprises in particular an electronic circuit commonly identified with the term "flip-flop", which can have two stable logic states: the high logic level or operative state, which is associated with an alarm situation and the low logic level or inactive state that, conversely, is associated with normal conditions. This memory element FF is susceptible to change its logic level from low to high when it is electrically powered. As shown in Figure 1, the memory element FF includes a first power input S connected to the electrical contact SW1, a second control input R connected to the controller CL and an output Q;
- an energy source EA, operationally connected to the memory element FF such that the memory element FF is electrically powered from the source EA after the variation of the state of the detector SW1. The source EA is advantageously capable of storing power when the photovoltaic module is active and of keeping it - and of making it available when needed - when the module cannot generate electricity, wherein said source EA could preferably comprise an energy accumulator capable of being powered by the same photovoltaic module PVP to which said control system PCS is associated;
- a switch S1, in particular an electronic switch, operatively connected to the source EA and to the supply of the programmable device CLand monitored by the memory element FF (particularly from the output Q of the memory element FF) so that the electricity supply of the programmable device CL through the switch S1 is stopped when the logic level of the memory element FF is low and is instead allowed when the logic level of said memory element FF is high. The electronic switch S1, being normally open, closes when the memory element FF takes the operative logic state corresponding to an alarm, allowing the control programmable device CL and the transceiver RF to be powered using the energy supplied directly by the source EA.

[0009] In addition to the basic functional elements listed above, the electrical and/or logical connections between these basic functional elements are represented in figure 1, as well as other components that may be part of the electronic control system PCS according to the present invention, wherein these components could include:

- a DC-DC converter of a direct voltage DDC capable to adapt the value of the voltage Vo generated by the photovoltaic module to the specific needs of the control system PCS;
- a voltage regulator VR, capable to supply the control programmable device CL with a stabilized voltage V5 appropriate with respect its electrical characteristics;
- the diodes DA, DB and DC - or by-pass diodes - that are intended to prevent the interruption of the flow of the current Io when, for whatever reason, there is a failure of the photovoltaic module or of a part thereof;
- the diodes D1 and D2 that decouples the output Vol of DDC with respect to the energy accumulator EA , preventing the discharge when the photovoltaic generator is inactive and consequently the voltage V1 tends to zero;
- the resistors R1 and R2 that respectively play the role of "pull-up" and "pull-down" with respect to the input S of the flip-flop FF, to avoid the situation of indeterminate logic signal at this input when the voltage V5 is not present, ie when the photovoltaic generator is inactive and is there is no theft or damaging attempts (contact SW1 open).

[0010] To enable the antitheft system according to the present invention to be effective in distinguishing a real event of damaging or theft from a different event (such as the eventuality of a gust of wind capable of shaking the photovoltaic module) which could be improperly interpreted as damaging or theft in progress (thus generating a false alarm signalling), advantageously the control system PCS comprises checking means for validating the detection of a theft or a damaging in progress. In particular, checking means comprise at least an operative connection between the programmable device CL and the detector or the memory element FF, the operative connection allowing the programmable device CL to execute a direct ascertainment of the state of the detector or the memory element FF and to validate or not (following a specific procedure) an initial detection of theft or damaging in progress: thus the generation and transmission, through the transmitter RF, of the alarm message are enabled by the programmable device CL only if the validation procedure has concluded positively. The validation of detection of theft or damaging in progress can advantageously use an iterative checking routine (performed by the programmable device CL) which consists of the following phases:

i) performing a verification of the state of the detector or of the memory element FF, using aforesaid check-

ing means;

ii) generating a confirmation only if aforesaid verification would succeed;

iii) repeating steps i) and ii) until a predetermined number of consecutive confirmations is reached, in which event the alarm signal is generated (the predetermined number of consecutive confirmations required for certification of the signal alarm can be determined so as to ensure a significant reliability of the checking routine, taking into account the characteristics of the energy source EA).

[0011] To describe in detail how the control system PCS represented in Figure 1 performs the function of anti-theft according to the invention, we refer to the flowchart of figure 2 (associated with the programmable control device CL) in which, at each power-on of the system (block 10) - that is, every time the photovoltaic module starts to generate electricity and also feeds the control system PCS - the control passes to block 20, which is a testing block that verifies the logic state of the output Q of the flip-flop FF. If the output Q of FF is at the low or inactive logic level, then the control remains in the testing block 20, otherwise the control passes to the next block 30, which is a testing block that verifies the state of opening or closing of the contact of the detector SW1. If the contact of SW1 is closed (alarm state), the control passes to block 70 which is a testing block that verifies the real presence of an alarm situation; otherwise the control passes to block 40, which is a testing block that verifies whether the time-out counter T has reached or not a predetermined time-out value Tmax. If T has not reached Tmax, then the counter T is incremented by one and the control returns to the block 20, otherwise (time-out reached) the alarm status of the flip-flop FF has been caused by a some fortuity or noise that cannot be associated with a theft attempt, as the contact of the theft detector SW1 has been found to be continuously open for the whole duration of the observation period Tmax. In this case, the control passes to the block 60, which resets the counter T, and then to the block 90, which brings back the flip-flop FF in the normal or inactive state, then the control returns to the block 20. The testing block 70, in charge of verifying the real presence of a situation of attempted theft of the photovoltaic module, performs a filtering operation based, for example, on the execution by the programmable control device CL, of an iterative checking routine, said routine being able to end with an alarm confirmation and the subsequent definitive generation of the alarm signal being able to occur after a predetermined number of consecutive confirmations. Where there are no conditions for the definitive generation of the alarm signal - that is, where the iterative routine does not confirm the real presence of an attempted theft in progress - the control returns to the previous block 30, otherwise (real presence of alarm), the control passes to the block 80, which forwards the alarm signal to the supervision system of the photovoltaic plant and then, after the normal or inactive state the flip-flop FF (block 90) has been restored, the control passes to the start block 20, which returns to repeat the process of verification of any alarm situations caused by theft or damaging attempts to the photovoltaic module.

[0012] With reference to the source of energy EA - including an energy accumulator chargeable from the same photovoltaic module PVP to which said control system PCS is applied - is necessary to clarify that, according to the invention, said accumulator can be a appropriate capacity capacitor or a rechargeable battery. It cannot be ruled out, according to the invention, that said accumulator can also be represented by a not rechargeable battery; this case, however, requires that the energy stored in the battery is capable of ensuring full functionality of the alarm system throughout all operational life of the photovoltaic module except a possible replacement with the passing of time. With reference to the bistable memory element FF, the transition from the inactive or normal state to the operative alarm state is caused by the presence, even if only temporary and of very short duration, of a high logic signal at the input S (input "SET" of the flip-flop FF), this high logic signal being applied by means of the closure - even if only temporary and of very short duration - of the alarm detector contact SW1, which directly connects the voltage of the source EA with the input S of the flip-flop FF. Similarly, FF returns to the inactive state when the programmable control device CL applies, through the output gate RO, a high logic signal at the input R (input "RESET") of the flip-flop FF. With reference to the programmable device control CL according to the invention, it consists of a microcontroller or programmable logic, with appropriate means for converting from analog to digital the analog signals relating to the voltages VA, VB and VC, respectively associated with three sections SZA, SZA + SZB and SZA + SZB + SZC in which typically a commercial photovoltaic module is subdivided. This allows to the programmable device CL to verify individually the functionality, in terms of value of voltage generated, of the photovoltaic cells associated with each section in which the photovoltaic module is subdivided. The number of sections, purely by way of example and not limitation assumed to be equal to three, can actually take, according to the invention, any other value deemed convenient, bearing in mind that the greater is the number of sections, the greater is the resolution of the control, but also the greater is the number of the by-pass diodes (one per section) required. The Applicant intends to specify how the feature of the programmable device CL to be able to make a diagnosis of the photovoltaic module to which it is associated (by means of a verification, through N analog input signals, of the functionality of each of the N parts which make up the module) has to be considered as a feature in itself inventive. With reference to the communication device RF according to the invention, it may include a radio frequency transceiver or RF transceiver and a microcontroller that manages the communication protocol, said RF transceiver and

said microcontroller being two separate devices dialoguing with each other, or two devices made with two silicon "dies" dialoguing with each other and assembled in the same container or package, or even two devices integrated in the same "die" of silicon. Said communication device RF communicates in a bidirectional way with the control programmable device CL through any wired communication line SL and exchanges information in a bidirectional way by means of radio signals, propagated and received through a suitable antenna AT, with a supervision system placed in rank to a higher level compared to the control system PCS object of this invention. The radiofrequency communication technology - characterized by a carrier frequency, modulation and demodulation techniques and a communication protocol - associated with the device RF may, according to the invention, be represented by any radiofrequency communication technology of standard or proprietary type characterised, in an advantageous but limitative way, by a low power consumption and possibly also a low cost. With reference to the device DDC and the voltage regulator VR, the first may be a DC-DC converter intended to provide, at the output VO1, a stabilized voltage V1, with a variable input voltage Vo generated by the photovoltaic generator at different intensities of solar radiation, and the second is used to generate the direct stabilized voltage V5 that feeds the programmable device CL, the transmitter (or transceiver) RF and the memory element (flip-flop) FF. The voltage V1, apart from feeding through the diode D1 the input VIN of voltage regulator VR keeps under full charge, through the diode D2, the energy accumulator EA. In the absence of sunlight, Vo tends to zero and therefore also V1 vanishes, so the diode D2, being inversely polarized, prevents the discharge of the accumulator EA. Where, as a result of an attempted theft or damaging, the normally open contact SW1 goes into the closed position, even for a brief moment, the voltage V3 across EA becomes coincident with the voltage V4 and leads, through the SET entrance S of the flip-flop FF, the passage of the flip-flop from the inactive state to the operative state. In this case the output Q of FF assumes a high logic level and causes the permanent closure of the switch S1 that, in turn, allows the device EA to feed steadily, through VR, the devices CL, RF and the same flip-flop FF. Upon the occurrence of such a situation, the programmable device CL sends the alarm signal by means of the radiofrequency RF transmitter according to the invention. With reference to the detector, part of the embodiment of the invention represented in Figure 1 and including a normally open electric contact SW1, it may include any sensor capable to detect abnormal tilts of the photovoltaic module compared to the tilting state (e.g. estimated such as angle from the earth's vertical) associated with a predefined condition of normality of the module itself. In this case, the state of the electric contact SW1 is therefore dependent on the tilt of the detector with respect to the earth's vertical. By way of a non-limitative example, said detector can be represented by an "on / off tilt" or lateral movement sensor, as a device belonging to the families SQ-SEN6XX or SQ-SEN7XX of SignalQuest.

[0013] Figure 3 shows a first variant of the present invention, in which the detector may include any sensor capable to detect abnormal vibrations of the photovoltaic module compared to the vibration level associated with a predefined condition of normality of the module itself In this first variant, the detector includes a vibration transducer SW2, capable to generate an electric pulsing signal when said detector vibrates at a frequency greater than a predetermined value. By way of a non-limitative example, the vibration transducer SW2 can be a piezoelectric vibration detector of the type "Minisens 100" of MSI (Measurement Specialties, Inc.), or similar sensor devices. A comparison between Figures 1 and 3 allows the circuital differences between the two embodiments of the present invention to be appreciated. For example, in Figure 1 the source EA is operationally connected to the memory element FF with the electric contact SW1 interposed, while in figure 3, the vibration transducer SW2 is not interposed between the source EA and the memory element FF, since the vibration transducer SW2, that is piezoelectric, can by itself generate an electric signal that constitutes, for the memory element FF, a power supply sufficient to change the logic state of this memory element FF . Figure 4 shows a second variant of the present invention, that includes the simultaneous presence of two detectors SW1 and SW2 with complementary characteristics - that in exemplificative but not limitative way can be represented respectively by a tilt sensor (with respect to the earth's vertical) and by a vibration sensor of type similar to that described above, or similar, wherein these detectors SW1 and SW2 are connected in "OR" logic between them, i.e. so that the closure of the contact of at least one of them causes the memory element FF's transition from the inactive state to the operative alarm state. The second variant, although more expensive than the embodiments described above is more effective than them to detect an event such as damaging or theft of the photovoltaic module PVM. In fact the two detectors SW1 and SW2 have a synergistic effect, since the detector SW1 is especially sensitive to changes in the tilt of the photovoltaic module PVM, such as those that occur in transport operations during a theft, and the detector SW2 is especially sensitive to the occurrence of significant vibrations on the photovoltaic module PVM caused for example by the action of tools such as drills.

[0014] In addition to the control system PCS and to the photovoltaic module PVM including the control system PCS and a plurality of photovoltaic cells, that have been previously described, also an electric energy production plant, comprising a plurality of photovoltaic modules PVM has to be considered as an object of the present invention. This plant comprises at least a control unit capable to receive and elaborate alarm signals transmitted by the transmitters RF of the control systems PCS of the photovoltaic modules PVM. The control unit can make ex-

plicit a warning of theft or damaging which included in particular a piece of information relative to the identity code and / or to the position of the photovoltaic modules PVM whose transmitters RF have caused an alarm signal. The warning of theft or damaging may consist in the activation of an alarm siren and / or in the displaying, on video terminals inside the plant and / or outside the plant (e.g. at a police station or at a vigilance institution), the precise location where the detected criminal event took place. Because the simultaneous occurrence of theft or damaging events against a number of photovoltaic modules PVM exceeding a predetermined number is considered impossible, the aforesaid control unit is able to associate the simultaneous reception of a considerable number of alarm signals to an event other than a theft or a damaging (eg a gust of wind or an earthquake) by executing a centralized validation procedure which adds to the procedure at the level of individual photovoltaic modules PVM, which was previously described. In this case, a warning of theft or damaging in progress is made explicit by the control unit if the number of alarm signals received is lower than a predetermined number.

[0015] The above description shows how the present invention achieves numerous advantages, if compared with the solutions belonging to the state of the art (in particular with the solution of photovoltaic module with "keyword"). A first important advantage of the invention is the capability to make an anti-theft alarm system that is not invasive with regard to the system of photovoltaic energy production and therefore does not affect the long term reliability of photovoltaic module itself. A second important advantage of the invention is the capability to detect and report promptly theft attempts even when the photovoltaic module is not in a condition in which electricity is generated by the module. A third advantage of the invention is that the alarm system according to the present invention requires no maintenance. The present invention has been described with reference to a particular example of realization (and two variants of this example), but it is entirely clear how many variants of realization, that all fall under the protection of claims later annexed, representing part of the present invention, should be associated with the present invention. More specifically, the Applicant intends to emphasize how the electronic components of the control system object of this invention can be any and that the type of these components, their design and the layout of the electric connections between them can be selected according to specific needs, while remaining within the inventive idea.

Claims

1. Electronic control system (PCS) for photovoltaic modules, comprising:

- a control programmable device (CL), capable to generate an alarm signal;
- a transmitter (RF) operatively connected to said control programmable device (CL) and apt to transmit said alarm signal outside;

characterised by further comprising:

- at least a detector capable to detect an event such as a damaging or a theft of the photovoltaic module to which said electronic control system (PCS) is applied, said event causing a variation of the state of said detector from an inactive state to an operative state;
- a bistable memory element (FF), capable to change its logic level from low to high depending on the state of said detector;
- an energy source (EA), operatively connected to said memory element (FF) in such a way that said bistable memory element (FF) is electrically powered by said source (EA) after said variation of the state of said detector;
- a switch (S1), operatively connected to said source (EA) and to the power supply of said control programmable device (CL) and controlled by said bistable memory element (FF) in such a way that the electricity supply of said control programmable device (CL) is stopped when the logic level of said bistable memory element (FF) is low and is allowed when the logic level of said bistable memory element (FF) is high.

2. Electronic control system (PCS) according to claim 1, wherein said detector comprises an electric contact (SW1) normally open, an event such as a damaging or a theft causing a stable or temporary closure of said electric contact (SW1), the state of said electric contact (SW1) depending in particular on the tilt of said detector with respect to the earth's vertical.

3. Electronic control system (PCS) according to any previous claim, wherein said detector comprises a vibration transducer (SW2), apt to generate an impulsive electric signal when said detector vibrates at a frequency higher than a predetermined value.

4. Electronic control system (PCS) according to any previous claim, wherein said source (EA) comprises an energy accumulator chargeable by the photovoltaic module (PVP) to which said control system is applied, said accumulator being in particular a capacitor or a rechargeable battery.

5. Electronic control system (PCS) according to claim 1 or 2 or 3, wherein said source (EA) comprises a not rechargeable battery.

6. Electronic control system (PCS) according to any previous claim, wherein said memory element (FF) comprises a flip-flop electronic circuit.

7. Electronic control system (PCS) according to any

previous claim, **characterized by** further comprising checking means for validating the detection of a theft or a damaging, said checking means preferably comprising at least an operative connection between said programmable device (CL) and said detector or said memory element (FF), said programmable device (CL) being in particular configured to execute an iterative checking routine, said routine being able to end with a confirmation and said alarm signal being able to be generated after a predetermined number of consecutive confirmations.

8. Electronic control system (PCS) according to any previous claim, wherein said transmitter (RF) is a radiofrequency transmitter or a radiofrequency transceiver.

9. Photovoltaic module (PVM) comprising an electronic control system (PCS) according to any previous claim and a plurality of photovoltaic cells.

10. Electric energy production plant comprising a plurality of photovoltaic modules (PVM) according to claim 9 and at least a control unit capable to receive and elaborate alarm signals transmitted by the transmitters (RF) of the electronic control systems (PCS) of said photovoltaic modules (PVM), said control unit being preferably capable to make explicit a warning of a theft or a damaging if the number of the alarm signals received is lower than a predetermined number, said warning comprising in particular an information about the identity code and/or the position of the photovoltaic modules (PVM) whose transmitters (RF) have caused an alarm signal.

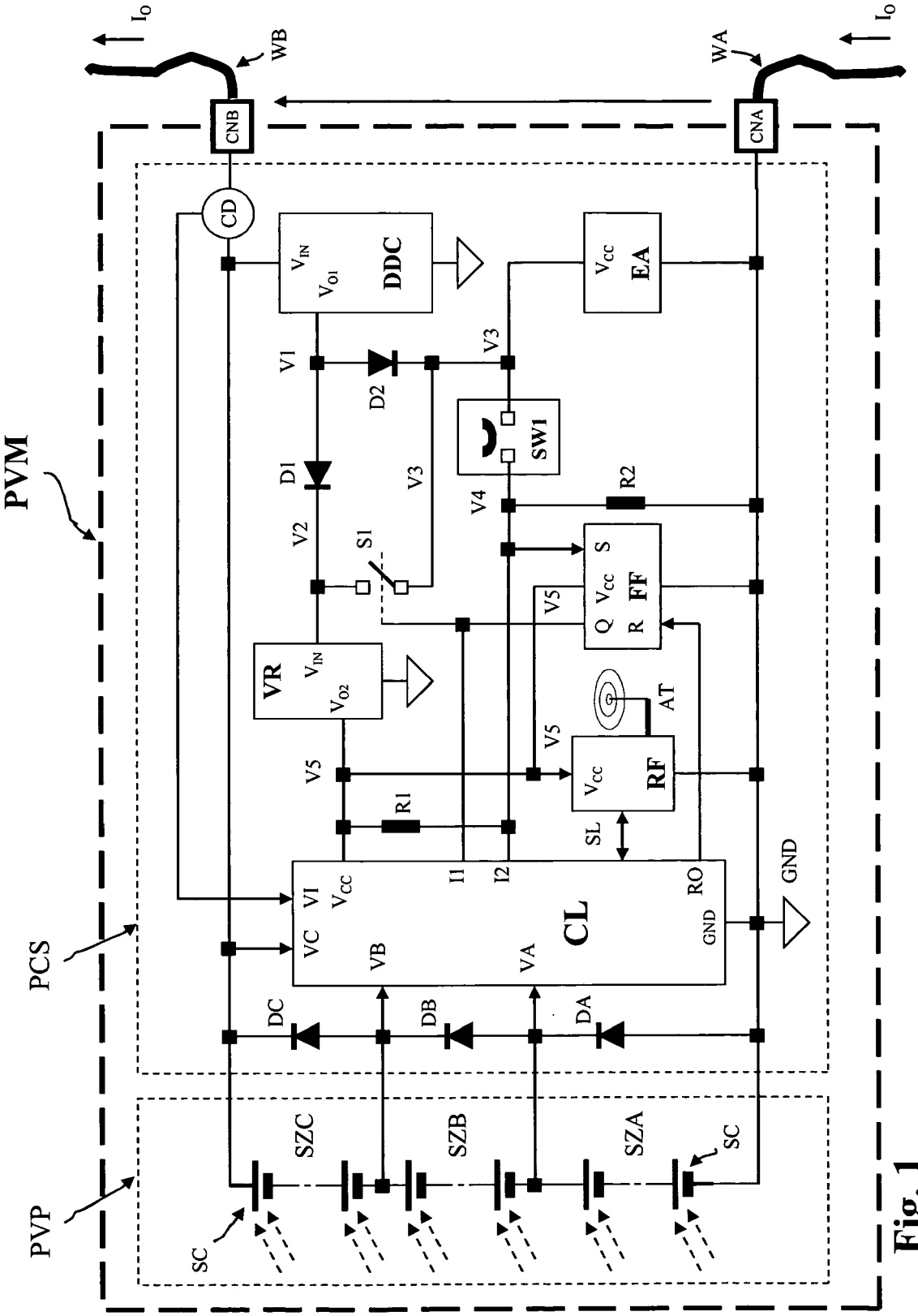
PVM
PCS
PVP
I_O
WB
WA
CNB
CNA
CD
DDC
V_{IN}
V_{O1}
V_{CC}
EA
V1
V2
V3
V4
V5
D1
D2
SW1
S1
R1
R2
VR
V_{O2}
S
Q
R
FF
AT
RF
SL
CL
VI
VC
VB
VA
I1
I2
RO
GND
DC
DB
DA
SZC
SZB
SZA
SC

Fig. 1

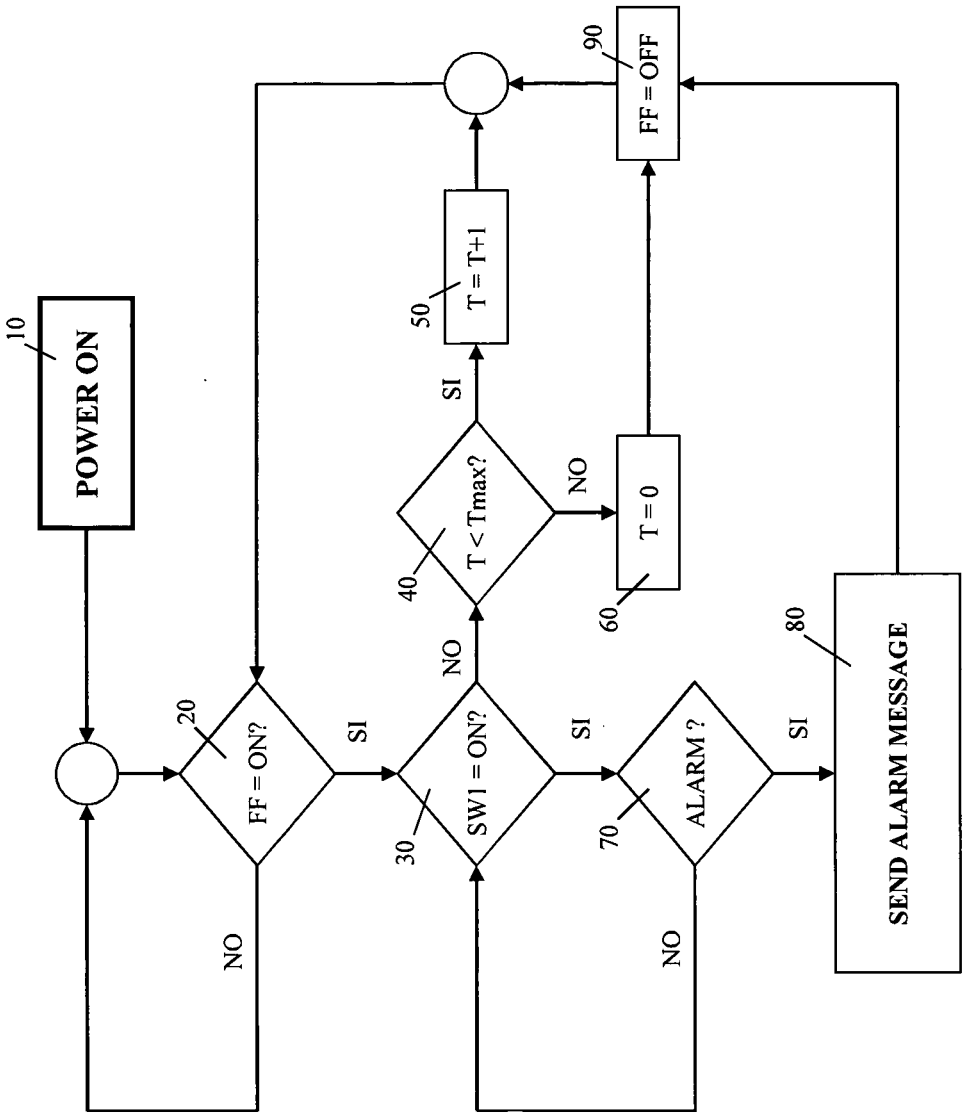
10
POWER ON
20
FF = ON?
SI
NO
30
SW1 = ON?
SI
NO
40
T < Tmax?
SI
NO
50
T = T+1
60
T = 0
70
ALARM ?
SI
NO
80
SEND ALARM MESSAGE
90
FF = OFF

Fig. 2

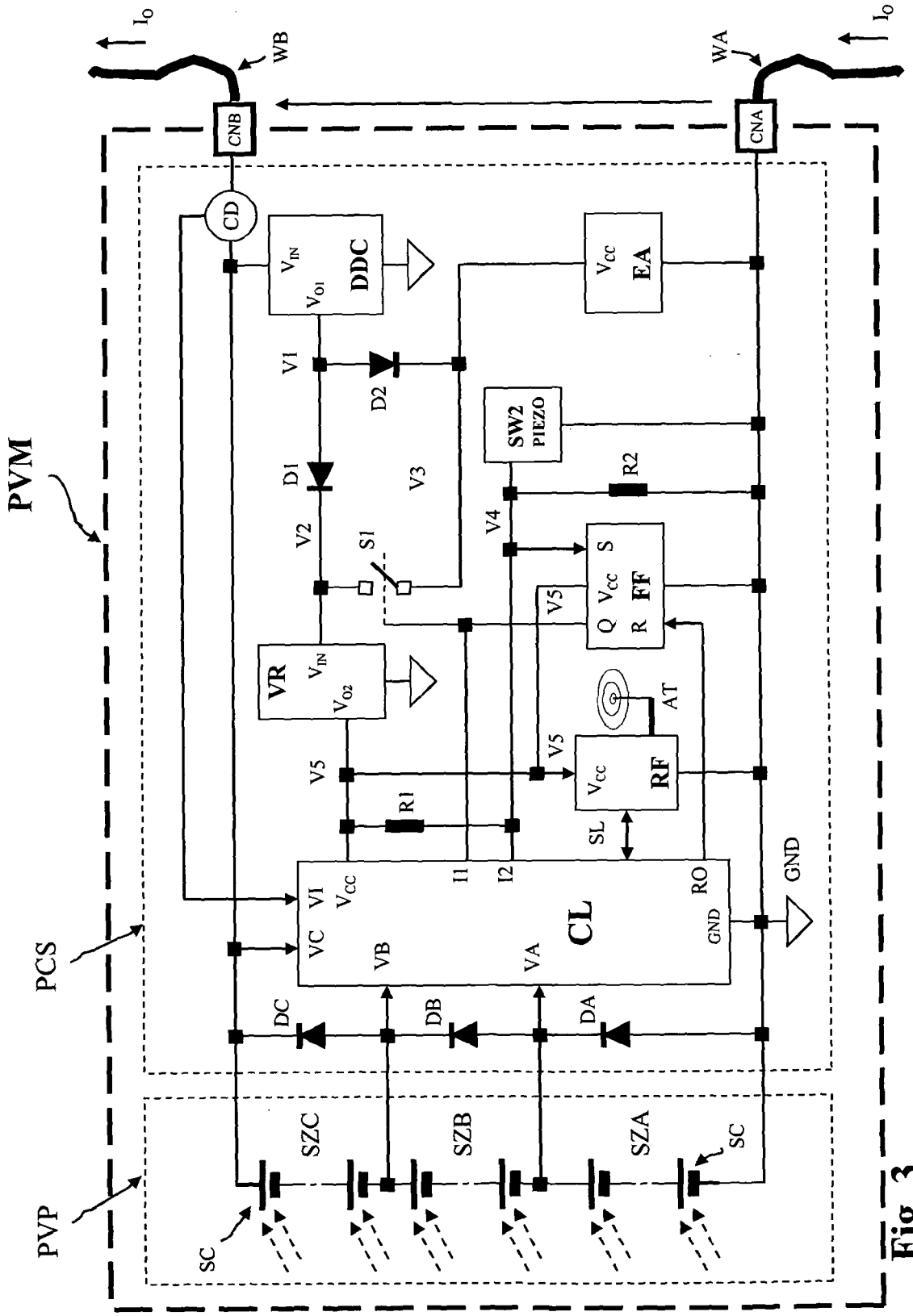
PVM
PCS
PVP
WB
WA
CNB
CNA
CD
DDC
EA
SW2
PIEZO
VR
FF
RF
CL
AT
SL
R1
R2
D1
D2
S1
V1
V2
V3
V4
V5
I1
I2
RO
GND
VC
VB
VA
DC
DB
DA
SZC
SZB
SZA
SC

Fig. 3

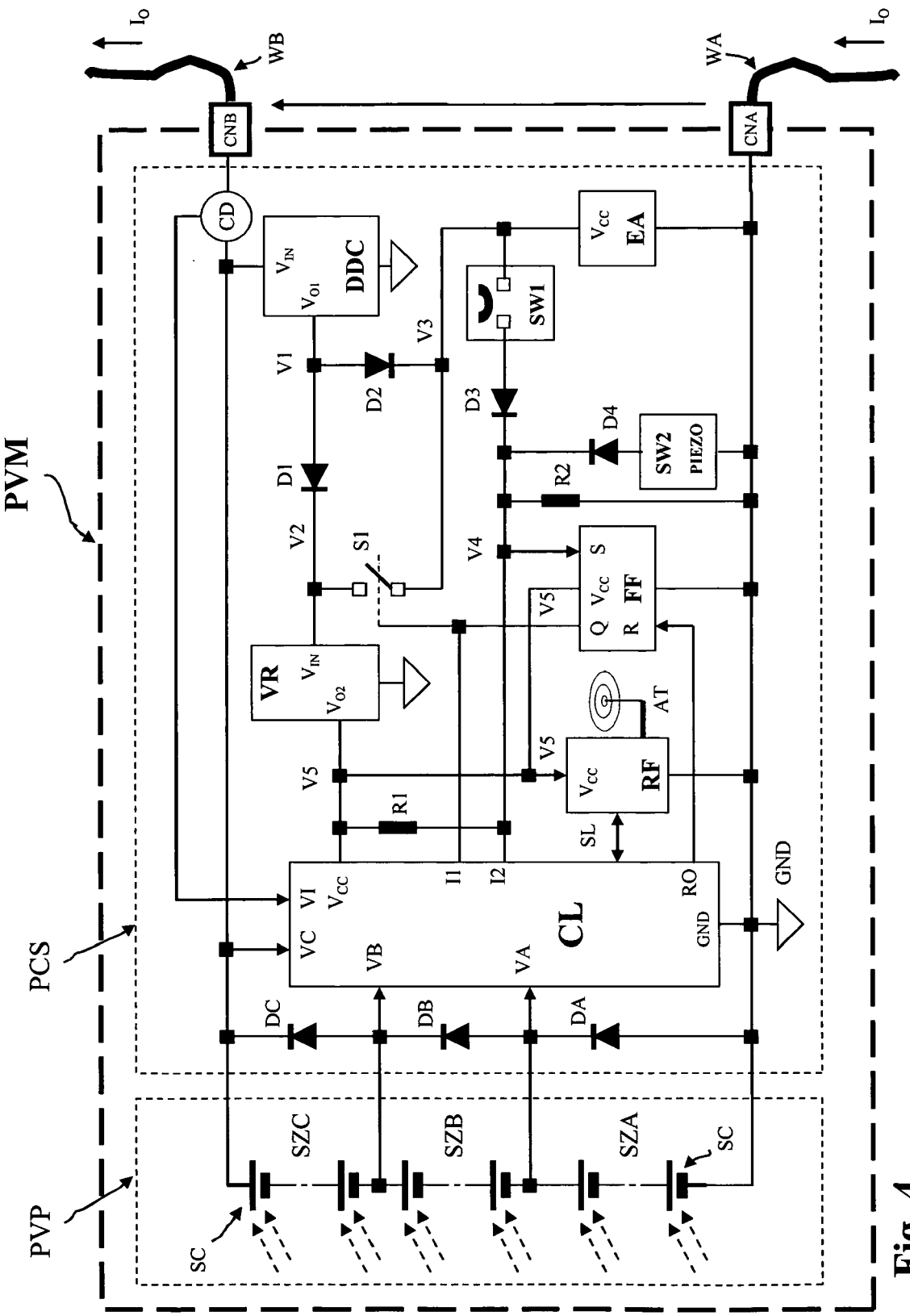
PVM
PCS
PVP
Io
WB
WA
CNB
CNA
CD
DDC
VIN
VO1
VCC
EA
SW1
V1
V2
V3
V4
V5
D1
D2
D3
D4
R1
R2
S1
SW2
PIEZO
VR
VO2
FF
S
R
Q
AT
RF
SL
CL
VI
VC
VB
VA
I1
I2
RO
GND
DC
DB
DA
SZC
SZB
SZA
SC

Fig. 4