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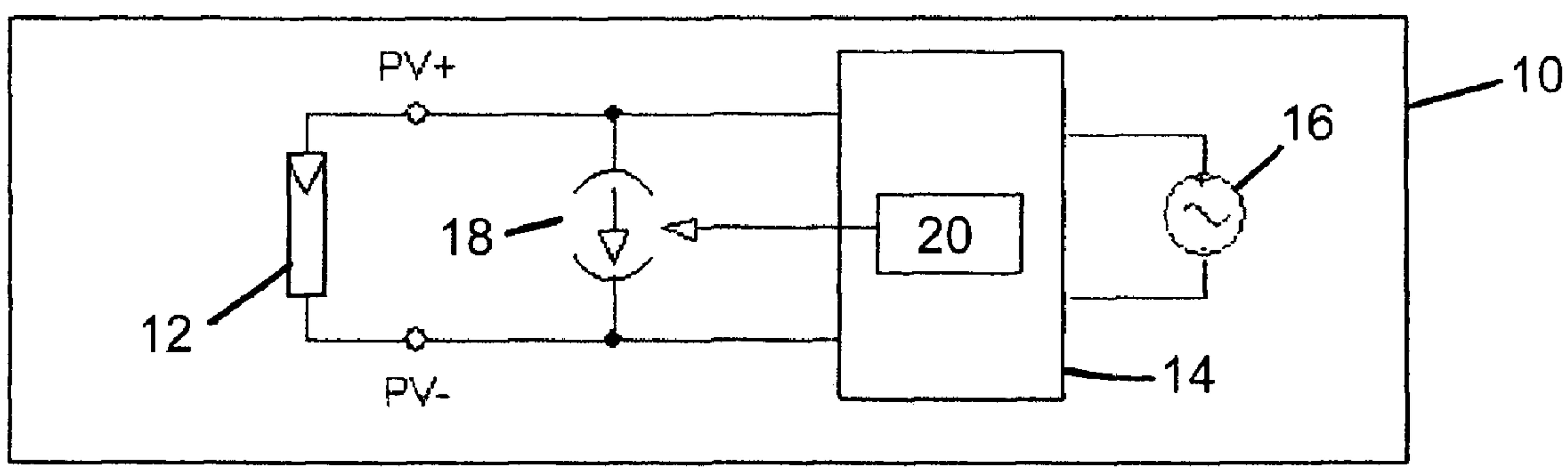


(57) **Abrégé/Abstract:**
A solar module (10) has a solar generator (12) for converting incident radiation into electrical power, and a solar inverter (14) for feeding the power generated by the solar generator (12) into a power supply system (16) or a load. The solar module (10) furthermore has: a variable bias load (18), which is connected in parallel with the solar generator (12), and a control device (20), which drives the variable bias load (18), detects a presently available power of the solar generator (12) and also a present no- load loss of the solar inverter (14), compares the detected power of the solar generator (12) and the detected no-load loss of the solar inverter (14) and enables the power of the solar generator (10) to be fed into the power supply system (16) or the load by the solar inverter (14) only when the detected power of the solar generator (12) exceeds the detected no-load loss of the solar inverter (14).

ABSTRACT

A solar module (10) has a solar generator (12) for converting incident radiation into electrical power, and a solar inverter (14) for feeding the power generated by the solar generator (12) into a power supply system (16) or a load. The solar module (10) furthermore has: a variable bias load (18), which is connected in parallel with the solar generator (12), and a control device (20), which drives the variable bias load (18), detects a presently available power of the solar generator (12) and also a present no-load loss of the solar inverter (14), compares the detected power of the solar generator (12) and the detected no-load loss of the solar inverter (14) and enables the power of the solar generator (10) to be fed into the power supply system (16) or the load by the solar inverter (14) only when the detected power of the solar generator (12) exceeds the detected no-load loss of the solar inverter (14).

Figure 1

SOLAR MODULE

The present invention relates to a solar module , and to a method for controlling the operation of a solar module.

A solar module usually has a solar generator comprising at least one solar cell for converting incident radiation into electrical power, at least one storage capacitor connected in parallel with the solar generator, and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load. In this case, the solar inverter should start to feed power to the power supply system as far as possible only if the power of the solar generator is high enough to compensate for the no-load losses of the solar inverter, since otherwise the power still lacking is drawn from the power supply system, which causes unnecessary losses.

One known approach for solving the above problem consists in turning on the solar inverter only when the solar generator voltage exceeds a predetermined threshold value. What is problematic in this case is that the no-load voltage of the solar generator says little about its possible power for feeding to the power supply system. It can happen, therefore, that even below the threshold value a sufficient power is available, which is not utilized. On the other hand, the case where the power of the solar generator is too low despite the voltage threshold value being exceeded (for example when the solar cells are partly shaded) can also occur. In order not to draw power from the power supply system unnecessarily in this case, the solar inverter has to be turned off again. Under unfavourable light conditions (for example full moon), this can result in the solar inverter being repeatedly switched on and off, which wears the relays and causes noise.

A second solution approach is known, which involves loading the solar generator with a resistance. In this case, however, for desirably good functioning, the constant value of the resistance has to be coordinated with the solar generator respectively used by the customer and other boundary conditions (for example power supply system voltage, illumination conditions), which is very complicated and significantly increases the production costs.

Some aspects of the present invention provide a solar module which may avoid the disadvantages present above in the prior art and in particular permits power to be fed to the power supply system by the solar inverter only when the power of the solar generator is sufficient.

In one aspect a solar module has a solar generator for converting incident radiation into electrical power and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load. The solar module is furthermore provided with a variable bias load, which is connected in parallel with the solar generator, and a control device. Said control device is designed to drive the variable bias load, to detect a presently available power of the solar generator and a present no-load loss of the solar inverter, to compare the detected power of the solar generator and the detected no-load loss of the solar inverter, and to enable the power of the solar generator to be fed into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter.

In a further aspect a corresponding method for controlling the operation of a solar module comprising a solar generator for converting incident radiation into electrical power and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load has the following steps: detection of a presently available power of the solar generator; detection of a present no-load loss of the solar inverter; comparison of the detected power of the solar generator and the detected no-load loss of the solar inverter; feeding of the power of the solar generator into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter.

The solar generator is loaded by means of the variable bias load, in which case the available power of the solar generator can be determined more precisely or exactly by suitable driving of the bias load. This may enable power to be fed to the power supply system by the solar inverter when the generator power compensates for the no-load losses of the solar inverter. Unnecessary relay switching is reduced or prevented, and a smoother or seamless transition to power-feeding operation without power losses may be possible.

In one configuration of the invention, the control device enables the power of the solar generator to be fed into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter for a predetermined minimum time duration. This enables a stabler function of the solar module for example in the case of a fluctuating generator power.

In a further configuration of the invention, the control device detects the power of the solar generator at an optimum operating point of the solar generator or of the entire solar module.

The control device may be for example a microcontroller integrated into the solar inverter.

The variable bias load may optionally be embodied in linear fashion (loading adjustable in analogue fashion) or in clocked fashion (loading adjustable by way of on/off ratio).

In a further configuration of the invention, at least one storage capacitor is connected in parallel with the solar generator, and the control device discharges said at least one storage capacitor via the bias load as required (for example opening the housing for service purposes or for production tests). In this case, the bias load may additionally be assigned an indicating device for indicating a discharge current through the bias load, in order to indicate a charge state of the storage capacitors in this way.

In yet another configuration of the invention, a plurality of series-connected storage capacitors are connected in parallel with the solar generator, and a variable bias load is assigned to each of the plurality of storage capacitors. Given a symmetrical embodiment, the variable bias loads can simultaneously serve here for balancing the storage capacitors.

A further aspect of the present invention proposes a solar module, comprising a solar generator for converting incident radiation into electrical power; at least one storage capacitor connected in parallel with the solar generator; and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load, the solar module furthermore having a variable bias load, which is connected in parallel with the solar generator; and a control device, which discharges the at least one storage capacitor via the bias load as required.

A further aspect of the present invention proposes a solar module, comprising a solar generator for converting incident radiation into electrical power; a plurality of series-connected storage capacitors connected in parallel with the solar generator; and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load, a variable bias load being assigned to each of the plurality of storage capacitors, it being possible to achieve a balancing of the storage capacitors by means of said bias load.

A further aspect of the present invention proposes a method for controlling the operation of a solar module comprising a solar generator for converting incident radiation into electrical power, at least one storage capacitor connected in parallel with the solar generator, and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load, wherein the at least one storage capacitors discharged as required via a bias load connected in parallel with the solar generator.

The above and also further features of the invention will become better understood from the following description of preferred, non-restrictive exemplary embodiments with reference to the accompanying drawings, in which:

Figure 1 shows a greatly simplified block diagram of a solar module in accordance with a first exemplary embodiment of the present invention;

Figure 2 shows a greatly simplified block diagram of a solar module in accordance with a second exemplary embodiment of the present invention; and

Figure 3 shows a more detailed block diagram of the solar module from Figure 1.

Referring to Figure 1, the construction and the functioning of a solar module in accordance with the first exemplary embodiment will now be explained in more detail.

The solar module 10 contains, in a well-known manner, a solar generator 12 comprising at least one solar cell for converting incident light into electrical power and a solar inverter 14 for feeding the power generated by the solar generator 12 into a power supply system 16 or a load. As illustrated in Figure 1, the solar module 10 is additionally provided with a variable bias load 18, which is connected in parallel with the solar generator 12 (and a storage capacitor that is likewise present, if appropriate). Said variable bias load 18 is driven by a microcontroller 20 integrated in the solar inverter 14.

The functioning of this solar module 10 is as follows.

Before the solar inverter 14 is connected to the power supply system 16, the solar generator 12 is loaded with the aid of the variable bias load 18. In this case, the loading is set by the microcontroller 20 such that the instantaneously available power of the solar generator 12 can be measured at an optimum operating point. At the same time the microcontroller 20 calculates the no-load losses of the solar inverter 14 that would result instantaneously upon power supply system connection 16. Said no-load losses are principally dependent on the power supply system voltage and the solar generator voltage, and their profile depends greatly on the topology of the solar inverter 14.

If the measured power of the solar generator 12 exceeds the calculated no-load losses of the solar inverter 14, then the microcontroller 20 connects the solar inverter 14 to the power supply system 16 or the load. Since the solar generator 12 is already at the optimum operating point a seamless transition to power feeding operation without power losses is possible.

In order to achieve a stable function of the solar module 10 even in the event of fluctuating generator power, further connection conditions can be used for the solar inverter 14. By way of example, the sufficient generator power must be available for a predetermined minimum time duration.

The operating point at which the power of the solar generator 12 is measured may be the MPP (maximum power point) of the solar generator 12. More preferably, however, measurement is effected at an operating point which represents the MPP for the entire solar module 10. This is possible without operation of the solar inverter 14, since the losses thereof and their dependence on power supply system voltage and generator voltage are known.

The operating point can optionally be chosen as fixed or in a manner dependent on various parameters (e.g. power supply system voltage). It can additionally be optimized by means of tracking and self-learning functions.

The variable bias load 18 of the solar generator 12 can optionally be embodied in linear fashion, that is to say with loading adjustable in analogue fashion, or in clocked fashion, that is to say with loading adjustable by way of the on/off ratio.

For the operation of the above bias load 18, no additional measuring devices are required in the solar module 10 since the voltages on the generator side 12 and the power supply system side 16 have to be measured anyway. If the U/I characteristic curve of the bias load 18 is known, the measurement of the solar generator current can additionally be dispensed with.

Referring to Figure 2, a second exemplary embodiment of a solar module will now be explained in more detail. In this case, identical or analogous components are identified by the same reference numerals, and only the differences with respect to the first exemplary embodiment of Figure 1 are described below.

A series circuit comprising a plurality (two in this case) of storage capacitors C1, C2 is connected in parallel with the solar generator 12 in a known manner. Each of said storage capacitors C1, C2 is assigned a variable bias load 18_1, 18_2 in the manner of a bridge circuit, as illustrated in Figure 2. All the bias loads 18_1, 18_2 are driven via the microcontroller 20 of the solar inverter 14.

The dimensioning of the storage capacitors C1, C2 is usually very large and they can be charged to above 800 V, for example. The bias loads 18_1, 18_2 can be used to eliminate these charges of the storage capacitors C1, C2 in a short time, which is advantageous for example during production and servicing. For this purpose, the storage capacitors C1, C2 are discharged via the bias loads 18_1, 18_2 by means of corresponding driving by the microcontroller 20.

This discharge function of the bias loads can also be utilized, of course, in an analogous manner for just one storage capacitor or more than two storage capacitors, with a corresponding number of bias loads.

On account of the high voltages, the storage capacitor is often embodied as a series circuit formed by a plurality of electrolytic capacitors C1, C2, as illustrated in Figure 2. In this case, given symmetrical embodiment, the variable bias loads 18_1, 18_2 can simultaneously serve for balancing the storage capacitors C1, C2.

Alongside the functions of discharging and balancing the storage capacitors C1, C2 as described here, the bias loads 18_1, 18_2 also serve, of course, in this second exemplary embodiment, analogously to the first exemplary embodiment of Figure 1 as described above, for enabling the solar inverter 14 to feed power to the power supply system 16 only when the solar generator 12 has a sufficient power, without this being described in detail again here.

Referring to Figure 3, a possible realisation of a bias load such as can be used in the solar modules of Figures 1 and 2 will now be explained in greater detail.

The construction of the solar module 10 essentially corresponds to that of Figure 1, apart from the fact that a storage capacitor C is additionally provided, said storage capacitor being connected in parallel with the solar generator 12 and the solar inverter 14.

In the variable bias load 18, which is driven by the microcontroller 20 integrated in the solar inverter 14, the two transistors T1 and T2 form a current sink which is influenced by means of the feedback resistor Rfb in such a way that the absorbed power is approximately constant in a wide range. In contrast to a discharge resistor that discharges less and less current as the capacitor voltage becomes smaller and smaller, here the current rises more and more, whereby the discharge time of the storage capacitor C is very much shorter. By virtue of the limited power, the circuit exhibits continuous load endurance independently of the solar generator voltage.

Via the transistor T3, the microcontroller 20 can switch the bias load 18 on and off. The loading of the solar generator 12 by the bias load 18 is controlled by way of the on/off ratio.

In order to determine the available solar generator power, the solar generator voltage is regulated in the manner of a two-point regulator by the bias load 18 being switched on and off. The voltage at the operating point is chosen in a manner dependent on the power supply system voltage. With the aid of the duty ratio produced during the regulation, the measured solar generator voltage and the known U/I characteristic curve of the bias load 18, the microcontroller 20 calculates the instantaneously available power of the solar generator 12 in order to compare it with the no-load losses of the solar inverter 14.

During the discharge function, the bias load 18 is automatically activated as soon as the solar inverter 14 is disconnected from the power supply system 16 or a dangerous state (e.g. opened housing, malfunction in the device) is identified. The indicating device 22 embodied as an LED in the discharge branch lights up on account of discharge current as long as the storage capacitor C is not yet totally discharged.

It goes without saying that the construction of the bias load 18 as illustrated in Figure 3 can also be applied, in an analogous manner, to a solar module 10 of the second exemplary embodiment with two or more storage capacitors C1, C2.

CLAIMS:

1. Solar module, comprising

a solar generator for converting incident radiation into electrical power;

a solar inverter for feeding the power generated by the solar generator into a power supply system or a loads;

a variable bias load, which is connected in parallel with the solar generator; and

a control device, which drives the variable bias load, detects a presently available power of the solar generator and also a present no-load loss of the solar inverter, compares the detected power of the solar generator and the detected no-load loss of the solar inverter and enables the power of the solar generator to be fed into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter.

2. Solar module according to Claim 1,

wherein the control device enables the power of the solar generator to be fed into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter for a predetermined minimum time duration.

3. Solar module according to Claim 1 or 2,

wherein the control device detects the power of the solar generator at an optimum operating point of the solar generator or of the entire solar module.

4. Solar module according to one of Claims 1 to 3,

wherein the control device is a microcontroller integrated into the solar inverter.

5. Solar module according to one of Claims 1 to 4,

wherein the variable bias load is embodied in linear or clocked fashion.

6. Solar module according to one of Claims 1 to 5,

wherein at least one storage capacitor is connected in parallel with the solar generator; and

wherein the control device discharges the at least one storage capacitor via the bias load as required.

7. Solar module according to Claim 6,

wherein the bias load is assigned an indicating device for indicating a discharge current through the bias load.

8. Solar module according to one of Claims 1 to 7,

wherein a plurality of series-connected storage capacitors are connected in parallel with the solar generator; and

wherein a variable bias load is assigned to each of the plurality of storage capacitors.

9. Method for controlling the operation of a solar module comprising a solar generator for converting incident radiation into electrical power and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load, wherein the method having the following steps:

detection of a presently available power of the solar generator;

detection of a present no-load loss of the solar inverter;

comparison of the detected power of the solar generator and the detected no-load loss of the solar inverter;

feeding of the power of the solar generator into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter.

10. Method according to Claim 9,

wherein the power of the solar generator is fed into the power supply system or the load by the solar inverter only when the detected power of the solar generator exceeds the detected no-load loss of the solar inverter for a predetermined minimum time duration.

11. Method according to Claim 9 or 10,

wherein the power of the solar generator is detected at an optimum operating point of the solar generator or of the entire solar module.

12. Method according to one of Claims 9 to 11,

wherein at least one storage capacitor is connected in parallel with the solar generator; and

wherein the method furthermore has, as required, the step of discharging the at least one storage capacitor via a bias load connected in parallel with the solar generator.

13. Method according to Claim 12,

wherein the method furthermore has the step of indicating a discharge current through the bias load.

14. Solar module, comprising

a solar generator for converting incident radiation into electrical power;

at least one storage capacitor connected in parallel with the solar generator;

a solar inverter for feeding the power generated by the solar generator into a power supply system or a load;

a variable bias load, which is connected in parallel with the solar generator; and

a control device, which discharges the at least one storage capacitor via the bias load as required.

15. Method for controlling the operation of a solar module comprising a solar generator for converting incident radiation into electrical power, at least one storage capacitor connected in parallel with the solar generator, and a solar inverter for feeding the power generated by the solar generator into a power supply system or a load,

wherein the at least one storage capacitor discharged as required via a bias load connected in parallel with the solar generator.

16. Solar module, comprising

a solar generator for converting incident radiation into electrical power;

a plurality of series-connected storage capacitors connected in parallel with the solar generator; and

a solar inverter for feeding the power generated by the solar generator into a power supply system or a load,

wherein a variable bias load is assigned to each of the plurality of storage capacitors.

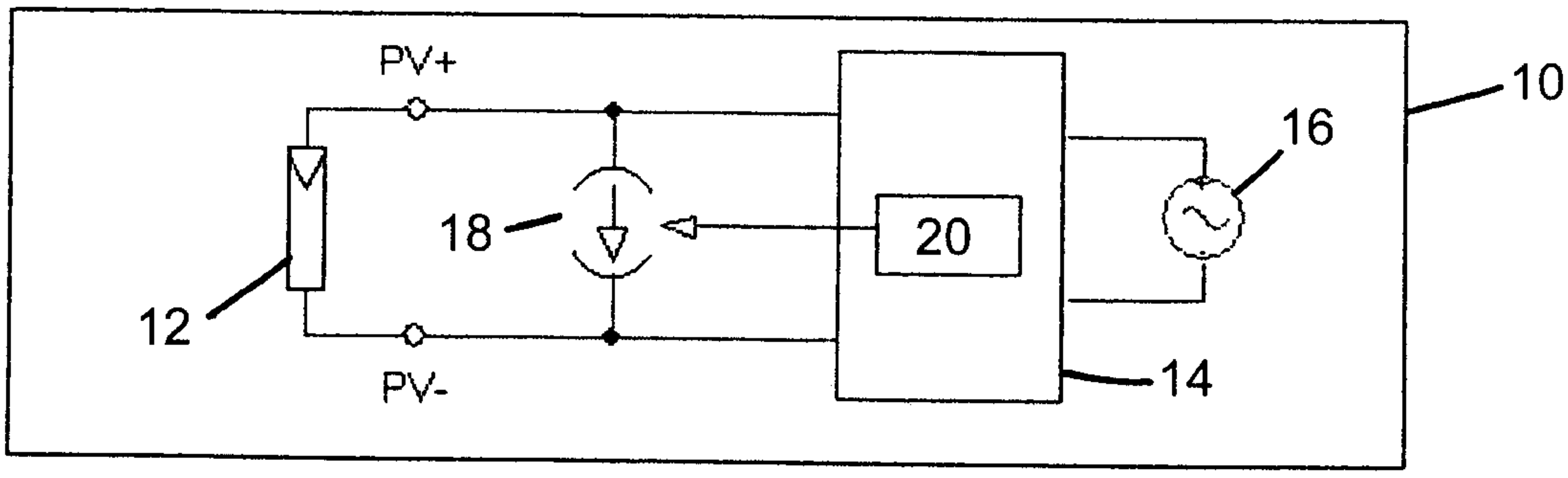


Fig. 1

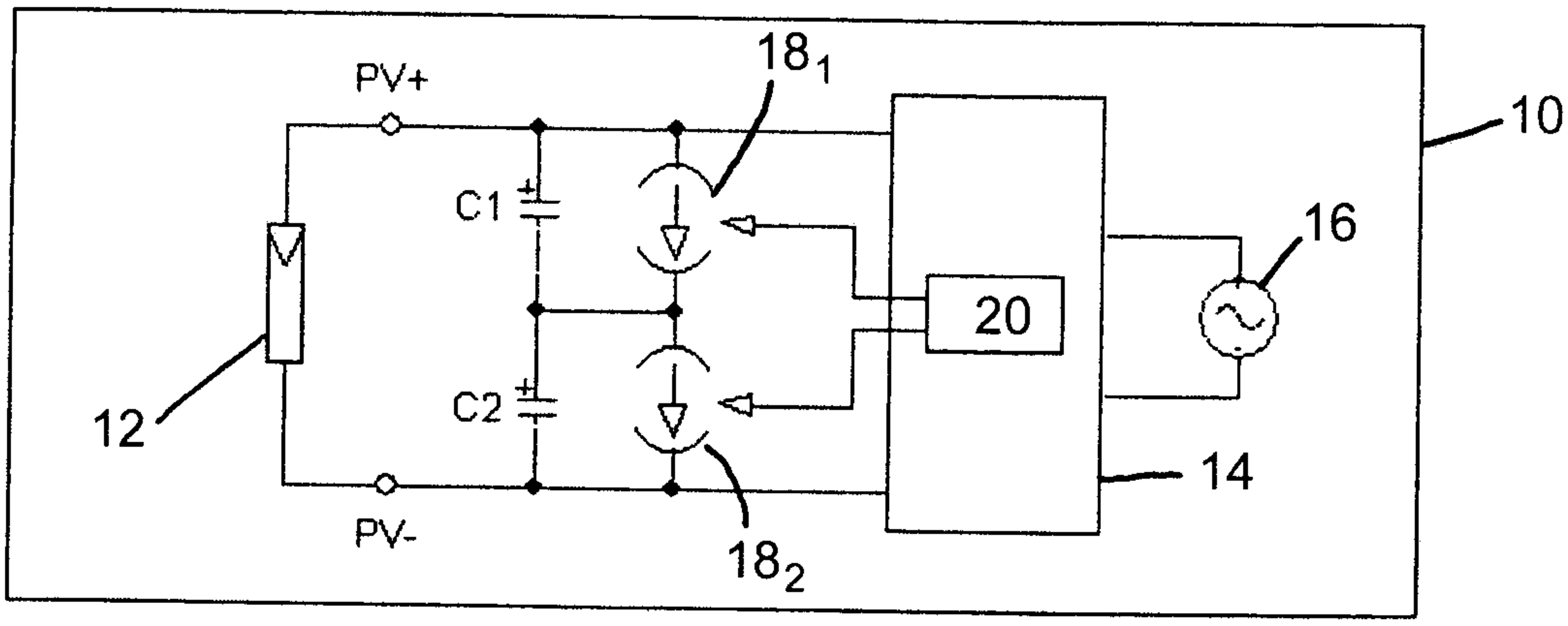


Fig. 2

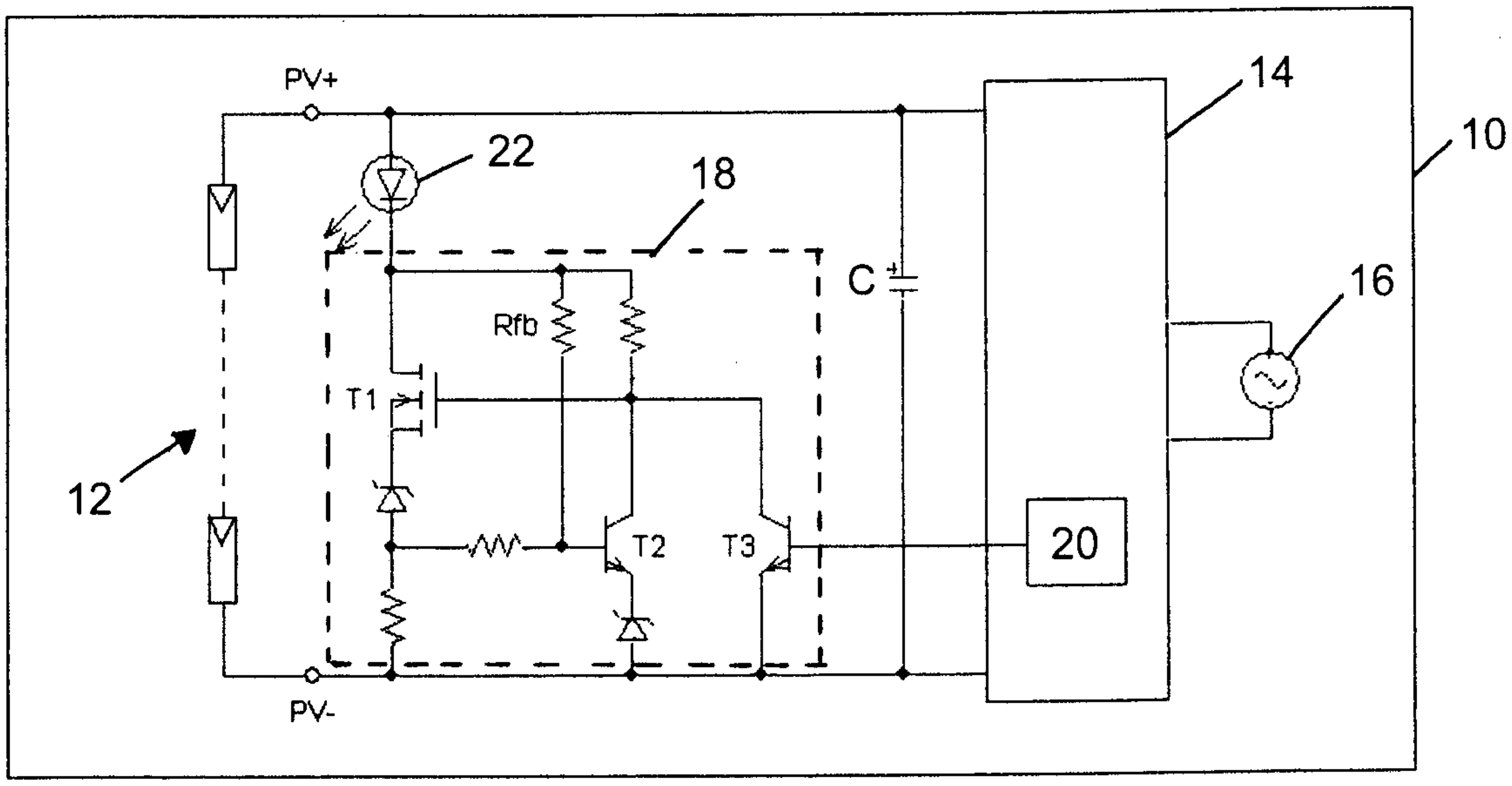
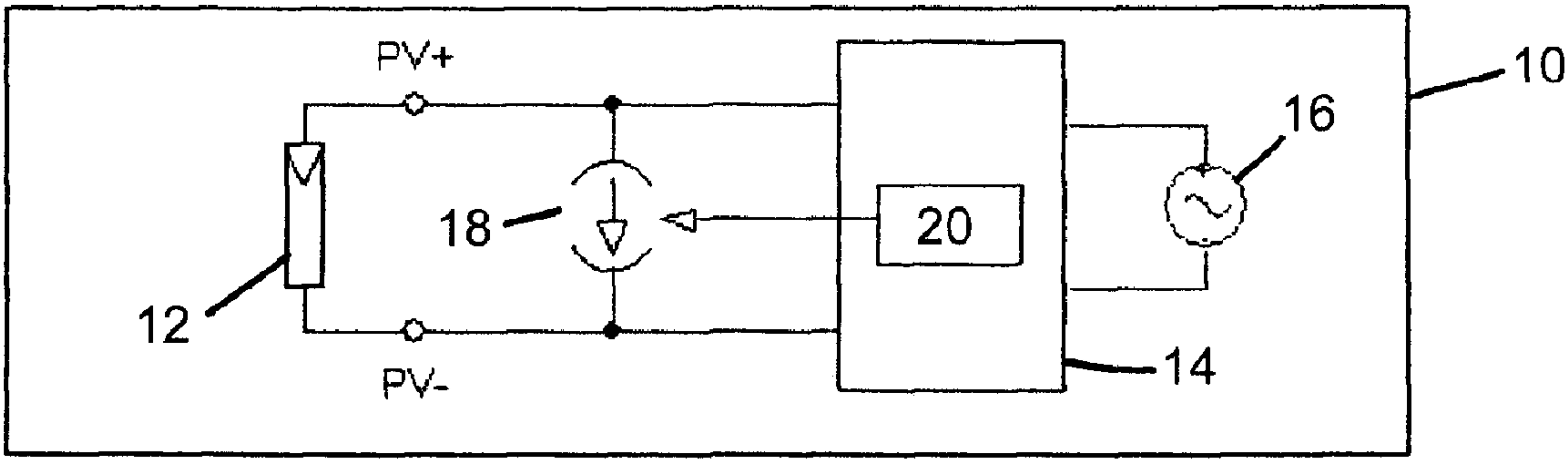


Fig. 3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