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54 Circuit arrangement for supplying power to an electrical load from an electrical energy source with fluctuating performance

Circuit arrangement for supplying power to an electrical load (20) from an electrical energy source with fluctuating performance, having a device for adapting the power consumption to the yield of the energy sources and having an apparatus for generating an auxiliary voltage. In order to guarantee reliable start-up operation, a switching apparatus (U1), which is able to be controlled by the voltage of the energy source, for selectively connecting a preliminary load (11) or the auxiliary voltage input (e2) of the power supply apparatus to the energy source is connected to the energy source. The circuit arrangement can be used in particular for supplying power to message transmission devices.

Figure for the abstract: Fig. 1

 SMA Solar Technology America, LLC, Ex. 1002

Patent claims

1. A circuit arrangement for supplying power to an electrical load (20, 20a) from an electrical energy source with fluctuating performance, a power supply apparatus (19, 19a), which is connected by way of a supply voltage input to the energy source and is routed by way of its output to a load (20, 20a), having a device, which contains an actuator and an open-loop and/or closed-loop control apparatus for controlling the actuator, for adapting the power consumption to the yield of the energy source, and an auxiliary voltage input (e2, e3) of the power supply apparatus (19, 19a) being connected to an apparatus for generating an auxiliary voltage supplied with power from the energy source, wherein a switching apparatus (U1, U2) for selectively connecting a preliminary load (11) or the auxiliary voltage input (e2, e3) of the power supply apparatus (19, 19a) to the energy source is connected to the energy source and wherein the switching apparatus (U1, U2) is able to be controlled by the voltage of the energy source in such a way that, in the case of voltages below a predefined minimum value of the voltage of the energy source that is required for reliable operation of the power supply apparatus (19, 19a), the preliminary load (11) is connected to the energy source and, in the case of voltages above the predefined minimum value, the apparatus for generating an auxiliary voltage is connected to the energy source and wherein the load formed by the preliminary load (11) and by the auxiliary-voltage-free power supply apparatus is dimensioned to be equal to or greater than the load on the energy source resulting from the apparatus for generating an auxiliary voltage and the power supply apparatus (19, 19a) supplied with auxiliary voltage.

2. The circuit arrangement as claimed in claim 1, wherein the switching apparatus (U1, U2) contains a reference voltage generator (3, 4), a voltage divider (5, 6)

connected to the energy source, and a comparator (9) connected to the reference voltage generator (3, 4) and to a tap of the voltage divider (5, 6) and wherein the control input of a first electronic switch (field-effect transistor 12) arranged in series with the preliminary load (11) is connected to the comparator (9).

3. The circuit arrangement as claimed in claim 1 or 2, wherein the voltage divider (5, 6) is provided with an apparatus (7, 8) for varying its division ratio, which apparatus is able to be controlled by the switching apparatus (U1, U2) in such a way that the voltage present across the tap of the voltage divider (5, 6) is reduced when the preliminary load (11) is connected up to the energy source.

4. The circuit arrangement as claimed in claim 3, wherein the apparatus (7, 8) for varying the division ratio is formed by a feedback branch arranged between the connection point of first electronic switch (field-effect transistor 12) and preliminary load (11) on one side and the input of the comparator (9) lying across the voltage divider (5, 6) on the other side, which feedback branch contains a diode (7) and a resistor (8) arranged in series therewith.

5. The circuit arrangement as claimed in one of claims 1 to 4, wherein the switching apparatus (U1) contains a second electronic switch (transistor 16), the switching path of which is arranged between the energy source and the auxiliary voltage input (e2) of the power supply apparatus (19) and the control electrode of which is connected to the comparator (9) via an inverter.

6. The circuit arrangement as claimed in claim 5, wherein the inverter is formed by a further comparator (13) which is connected by way of one input to a reference voltage source (Zener diode 4) and by way of the other input to

the connection point of the first electronic switch (field-effect transistor 12) and the preliminary load (11).

7. The circuit arrangement as claimed in claim 6, wherein the control electrode of the second electronic switch (transistor 16), the switching path of which is connected to an output connection of the energy source, is routed to the other output connection of the energy source via a reference voltage generator (Zener diode 15).

8. The circuit arrangement as claimed in one of claims 1 to 4, wherein an auxiliary converter (18) is connected upstream of the auxiliary voltage input (e3) of the power supply apparatus (19a) and is connected to the output of the comparator (9) by way of an enabling input (e5).

9. The circuit arrangement as claimed in one of claims 1 to 8, wherein the energy source is formed by a solar generator (1) and the power supply apparatus (19, 19a) is formed by a DC voltage converter.

Description

Circuit arrangement for supplying power to an electrical load from an electrical energy source with fluctuating performance

The invention relates to a circuit arrangement as specified in the preamble of patent claim 1. A solar generator can in particular serve as the energy source with fluctuating performance here.

A circuit arrangement of this kind is already known from the magazine Elektronik 19/09.21.1984, page 96.

In the known circuit arrangement, a switching regulator is connected to a solar generator and is used to

maintain the output voltage of the circuit arrangement at a predefined value. The known circuit arrangement intends for as much power as possible to be obtained from the solar generator in that the reference voltage that is effective in connection with a voltage regulation is correspondingly influenced by a photodiode when light irradiation changes.

Furthermore, a circuit arrangement for supplying power to an electrical load from a solar generator is already known from E-A1-02 06 253, which circuit arrangement has a device for adapting the power consumption to the yield of the energy source. The desired adaptation is achieved in that an actuator is controlled by a control circuit in such a way that the current drawn from the solar generator has a predefined relationship with the respective measured value of the short-circuit current.

A starter circuit is not provided in the mentioned circuit arrangements.

The performance of solar generators is dependent on the intensity of the sunlight, e.g. in the morning at sunrise the energy will not be sufficient for reliable start-up operation and, affected by mist or clouds, will assume values that are sufficient for utilization only after some time.

At the start, charging converters having electronic switches can pass through operating states which can be hazardous for the circuit because, e.g., the actuation of the circuit breakers is still insufficient and/or the control electronics have operating voltages that are too low.

Similar problems arise when generators that are driven by hydropower or wind energy are used as the energy source with fluctuating performance.

The object of the invention is therefore to develop a circuit arrangement as specified in the preamble of patent claim 1 in such a way that it guarantees reliable start-up operation.

According to the invention, the circuit arrangement for achieving this object is achieved in the manner specified in the characterizing part of patent claim 1. The measures according to the invention afford the advantage that reliable operation of the circuit arrangement is guaranteed for the entire power range of the energy source.

In the auxiliary-voltage-free state or in the case of auxiliary voltages below a predefined minimum value, the power supply apparatus is practically passive and is switched on when the auxiliary voltage is applied. If no auxiliary voltage is applied, the power supply apparatus consumes practically no current. This is in particular due to the fact that use is made of electronic switches which are transferred into the on-state by actuation means and are highly resistive when not actuated.

An expedient development of the invention, in which a comparator compares the voltage of the energy source with a reference voltage and optionally connects up the preliminary load, arises from patent claim 2.

The measures as claimed in patent claim 3 result in hysteresis for the switching apparatus, such that particularly stable operation is advantageously guaranteed.

Proceeding from the development as claimed in claim 3, a partial resistance of the voltage divider can be short-circuited in order to vary the division ratio.

Preferred measures for achieving the desired hysteresis arise from patent claim 4.

In the development of the invention in accordance with claim 5, the switching device, by means of which the auxiliary voltage input of the power supply apparatus or the preliminary load is selectively connected to the energy source, consists of two electronic switches. This circuit arrangement advantageously allows a continuous ground line between the energy source and the power supply apparatus.

The further configuration as claimed in claim 6 provides a further comparator. Given that integrated circuits having a plurality of comparators are common, practically no additional complexity is associated herewith.

The measures as claimed in claim 7 have the advantage that the second electronic switch is simultaneously a constituent part of a stabilization circuit for stabilizing the auxiliary voltage. In this case, a Zener diode in particular serves as the reference voltage generator.

The measures as claimed in claim 8 result in a circuit arrangement, in which an auxiliary converter, which is provided anyway in particular for the purpose of galvanic isolation, simultaneously undertakes the function of the second electronic switch. Depending on the magnitude and/or polarity of the voltages provided for the enabling or disabling, the enabling input can be connected to the comparator directly or via a corresponding control circuit.

The energy source with fluctuating performance is in particular formed by a solar generator, and the power

supply apparatus is in particular formed by a DC-DC voltage converter.

The invention is explained in more detail with reference to the exemplary embodiments illustrated in the figures.

Figs 1 and 2 depict circuit arrangements for supplying power to an electrical load from a solar generator.

Fig. 1 shows a circuit arrangement having a starter circuit and auxiliary power supply for a charging converter without electrical isolation and

Fig. 2 shows a circuit arrangement and auxiliary power supply for a charging converter with electrical isolation of auxiliary voltage and power supply voltage.

The circuit arrangement shown in Fig. 1 serves to supply power to the electrical load 20 from the solar generator 1, i.e. from an electrical energy source with fluctuating performance. The circuit arrangement contains a starter circuit and an apparatus for supplying an auxiliary voltage for the power supply apparatus 19. Electrical isolation of auxiliary voltage and power supply voltage is not provided here.

The power supply apparatus 19, in particular designed as a DC-DC voltage converter or charging converter, is connected by way of its supply voltage input e1 to the solar generator 1 and is routed by way of its output to the load 20. The auxiliary voltage input e2 of the power supply apparatus 19 is likewise connected to the solar generator 1, namely via the transistor 16.

The power supply apparatus 19 contains - not illustrated in Fig. 1 - an actuator and an open-loop

and/or closed-loop control apparatus for controlling the actuator. Details of the power supply apparatus 19 arise from Fig. 3.

The capacitor 2 is situated in parallel with the solar generator 1, the positive pole of which is grounded. The switching apparatus U1 is connected to the parallel connection comprising the solar generator 1 and the capacitor 2. The switching apparatus U1 serves to connect either the preliminary load 11 or the auxiliary voltage input e2 of the power supply apparatus 19 to the solar generator 1 depending on the particular voltage of the solar generator 1.

The switching apparatus U1 is controlled by the voltage of the solar generator 1 which is loaded by the preliminary load 11 or by the auxiliary voltage input e2 of the power supply apparatus 19. This control is performed in such a way that, in the case of voltages below a predefined minimum value that is required for reliable operation of the power supply apparatus 19, the preliminary load 11 is connected to the solar generator 1 and, in the case of voltages above the predefined minimum value, the auxiliary voltage input e2 of the power supply apparatus 19 is connected to the solar generator 1. The preliminary load 11 is dimensioned to be equal to or greater than the load on the solar generator formed by an idle power supply apparatus 19. If the auxiliary voltage is not applied to the power supply apparatus 19, the latter has at its supply voltage input e1 a substantially greater resistance compared to the preliminary load 11.

The comparator 9 contained in the switching apparatus U1 is connected by way of its positive input to a reference voltage generator and by way of its negative input to the tap of a voltage divider. The Zener diode 4 serves as the reference voltage generator and is

connected to the solar generator 1 via the resistor 3. The voltage divider consists of the resistors 5 and 6 and is likewise connected to the solar generator 1.

The control electrode of the field-effect transistor 12 is connected to the output of the comparator 9. The field-effect transistor 12 forms the first electronic switch of the switching apparatus U1. The series connection consisting of the preliminary load 11 and the source-drain path of the field-effect transistor 12 is connected to the solar generator 1. The control electrode of the field-effect transistor 12 is routed to the positive pole of the solar generator 1 via the resistor 10.

The voltage divider consisting of the resistors 5 and 6 is provided with an apparatus 7 for varying its division ratio, which apparatus is able to be controlled by the switching apparatus U1. This apparatus, which changes the division ratio according to a hysteresis, is formed by a feedback branch which is arranged between the connection point of the field-effect transistor 12 and the preliminary load 11 on one side and that at the negative input of the comparator 9 on the other side and which contains the diode 7 and the resistor 8 arranged in series therewith. The diode 7 is polarized in such a way that it is off when the field-effect transistor 12 is on, and is on when the field-effect transistor is off.

The switching apparatus U1 further contains the bipolar transistor 16 serving as the second electronic switch. The transistor 16 is connected by way of its collector to the negative pole of the solar generator 1 and is routed by way of its emitter to the auxiliary voltage input e2 of the power supply apparatus 19. The base of the transistor 16 is routed via the Zener diode 15 serving as the reference voltage generator to the

positive pole of the solar generator 1. The emitter-collector path of the transistor 16 forms the switching path of the second electronic switch of the switching apparatus U. The connection point of the base of the transistor 16 with the anode of the Zener diode 15 is connected to the further comparator 13. The comparator 13 is connected by way of its positive input to the Zener diode 4 serving as the reference voltage source and by way of its negative pole to the connection point of field-effect transistor 12 and preliminary load 11. The capacitor 17 is situated between the auxiliary voltage input e2 and ground.

The power supply apparatus 19 is preferably a charging converter serving as consumer for the solar generator 1. This charging converter requires energy for itself at the start, without delivering energy to the rechargeable battery that is to be supplied with power. Here, at the start, the solar generator is loaded with the dummy load 11 which consumes at least as much energy as the auxiliary energy needed by the charging converter in order to measure the voltage of the solar generator 1. The dummy load 11 is preferably greater than the load predefined by the auxiliary voltage input of the charging converter.

In spite of the preferably increased preliminary load, if the voltage rises above a threshold which guarantees reliable operation, the auxiliary supply is enabled for the charging converter and the preliminary load 11 is simultaneously interrupted. As a result, the voltage of the solar generator jumps to a higher value and the power supply apparatus or the charging converter begins to operate. Since the power supply apparatus has a device for adapting the power consumption to the yield of the energy source and therefore only ever consumes the current corresponding to a maximum power, the power supply apparatus continues to operate independently of

the load connected thereto. When the power of the solar generator 1 decreases, the starter circuit switches on the preliminary load 11 again at the lower operating limit and switches off the auxiliary supply. If the load formed by the preliminary load and - practically negligible - reverse currents of the power supply apparatus is greater than the load formed by the auxiliary voltage supply and the charging converter, the generator voltage breaks down further. In this way, particularly stable switching states arise.

The comparator 9 compares the voltage of the solar generator 1 with the reference voltage at the Zener diode 4 across the voltage divider 3, 4. If the generator voltage is too small, the field-effect transistor 12 serving as a circuit breaker has low resistance and the increased preliminary load formed by the resistor 11 is in effect. The bipolar transistor 16 is off here.

If the generator voltage rises above the predefined threshold voltage, which e.g. can be 20 V in the case of a 36 V solar generator, the transistor 12 is turned off and the transistor 16 is connected up and delivers auxiliary energy for the power supply apparatus 19 formed by a charging converter. Hysteresis is achieved by means of the resistor 8. The resistor 8 is dimensioned in such a way that the switching apparatus is switched back to the dummy load only in the case of a low threshold voltage of about 15 V.

The circuit arrangement shown in Fig. 2 largely corresponds to that according to Fig. 1. In contrast to the circuit arrangement according to Fig. 1, electrical isolation of auxiliary voltage and supply voltage is provided.

For this purpose, the auxiliary converter 18 is provided for the auxiliary voltage supply, which auxiliary converter is enabled when the preliminary load 11 is switched off and the three-pole output of which is routed to the likewise three-pole auxiliary voltage input e3 of the power supply apparatus 19a. The auxiliary converter 18 is connected by way of its power supply input e4 to the solar generator and is therefore supplied with power from the solar generator 1.

The auxiliary converter 18 is further connected by way of its enabling input e5 to the drain electrode of the field-effect transistor 12 and is connected to the comparator 9 via the field-effect transistor 12, i.e. indirectly. In contrast to Fig. 2, the auxiliary converter can be connected to the output of the comparator 9 via an inverter or, given a suitable enabling input, directly.

The auxiliary converter 18 is switched on or off by the field-effect transistor 12 depending on the voltage of the solar generator 1. The auxiliary converter 18 delivers auxiliary voltage only when correspondingly actuated and therefore simultaneously has the function of the second electronic switch of the circuit arrangement according to Fig. 1. The circuit arrangement shown in Fig. 2 thus does not have the components 12, 13, 14 and 15 of the circuit arrangement according to Fig. 1.

FIG 1

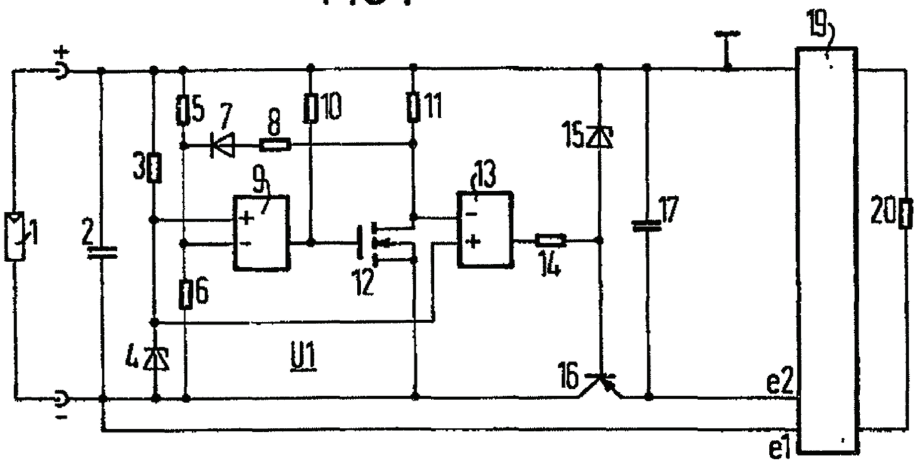
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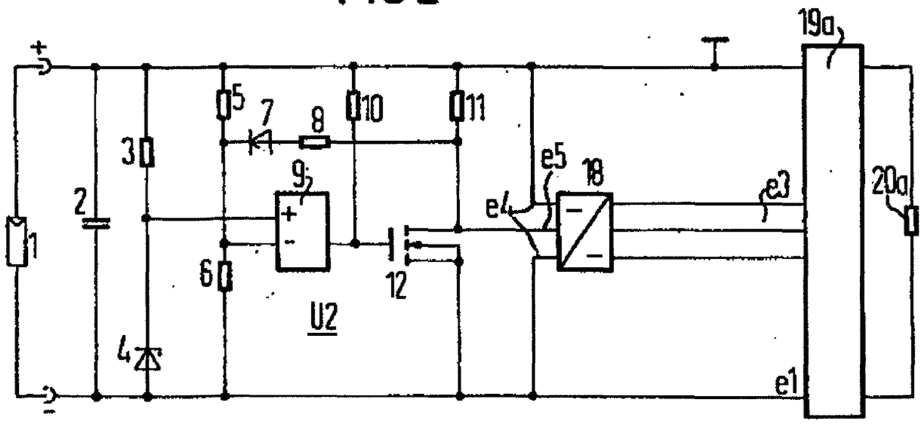
FIG 2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Signed this 10th day of October 2022

N. T. SIMPKIN
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For and on behalf of RWS Group Ltd