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(72) Inventors:
 • **Kaul, Holger**
68165 Mannheim (DE)
 • **Hozoi, Adrian**
68219 Mannheim (DE)
 • **Marinkovic, Stevan**
5430 Wettingen (CH)

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(74) Representative: **Marks, Frank**
ABB AG
GF-IP
Wallstadter Strasse 59
68526 Ladenburg (DE)

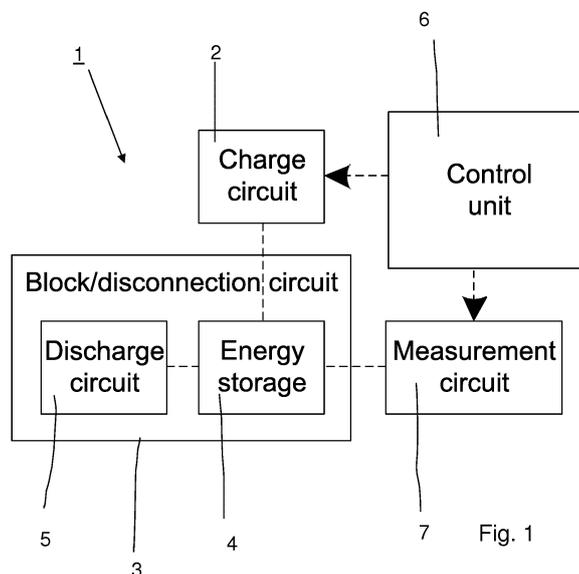
(71) Applicant: **ABB Schweiz AG**
5400 Baden (CH)

(54) **INSTALLATION DEVICE WITH A TIME MEASUREMENT CIRCUIT AND METHOD FOR MEASURING THE PAST TIME BETWEEN A FIRST AND A SECOND EVENT WITH A TIME MEASUREMENT CIRCUIT**

(57) The invention is about an installation device with a time measurement circuit, said time measurement circuit including

- an energy storage circuit including at least one capacitor,
- at least one diode D1 allowing to charge the energy storage circuit but not allowing it to discharge through any load which is not the intended discharge circuit,

- a discharge circuit connected to the energy storage circuit and including at least one resistor,
- a measuring circuit allowing to measure the voltage of the energy storage circuit and includes one analog to digital converter,
- a control circuit connected to the measurement circuit and being based on processing device such as a micro-controller, ASIC, FPGA or digital signal processor



Description

[0001] The invention is about an installation device with a time measurement circuit.

[0002] The invention is also about a method for measuring the past time between a first and a second event with a time measurement circuit.

[0003] A time measurement circuit uses an electrical energy storage e.g. capacitor, which will be charged and discharged in a defined way. Since, the charge and discharge of the energy storage is defined, the passed charge/discharge - time can be calculated using the measurement data of the energy storage.

[0004] The time measurement circuit features a charge control circuit, a discharge control circuit, a measurement circuit to measure the charge and discharge of the electrical storage and a calculation unit/circuit e.g. a micro-computer. The whole time measurement circuit setup features low power technologies and low power components e.g.: energy storage capacitors and diodes with low leakage current.

[0005] The time measurement feature is desired for example in low power or self-supplied installation devices which must be able to determine the past time in which the installation device had no or limited power.

[0006] The installation device may be employed for various purposes such as metering, control, monitoring, and protection of electrical equipment or electrical loads. Examples of such installation devices are electronic overload relays, circuit breakers, protective relays, motor starters, motor controllers, etc.

[0007] Timers and timing circuits in principle are known in the art. From short time delays of a few nanoseconds used in digital circuitry, to long periods of hours, used to control daily events, electronic circuits can provide this function reliably and repeatable. The time circuits can be simple analog circuits or integrated circuits, or they are available as a microcontroller peripheral.

[0008] The simplest timers are based on the charging and discharging of a capacitor through a resistor or current source. Its accuracy is however limited, with the error in the 1-10 percent range.

[0009] Most of the timing circuits offer a fixed or tunable timing behavior and need continuous power supply of the timing circuit. In the application area of measuring a past time between two events, there are no time measurement circuits, which are capable to run without power during the two events ("past time").

[0010] For example, if an installation device has no power during a certain time and still would need the information of the power down time. Then a first event, event one, is "power off" of the device, a second event, event two, is "power on" of the device. During these two events, no power is available for the timing circuit. After event two, the power down time has to be given by the timing circuit.

[0011] So it is the problem to be solved by this invention to provide an installation device with a time measurement

circuit, wherein the time measurement circuit is able to measure the past time between two events without powering the timing circuit during this time.

[0012] It is also the problem to be solved by this invention to find a method for measuring the past time between a first and a second event with a time measurement circuit, without powering the time measurement circuit during this time.

[0013] The problem is solved by an installation device with a time measurement circuit according to claim 1, and with a method according to claim 11.

[0014] According to the invention, the time measurement circuit includes

- an energy storage circuit including at least one capacitor,
- a discharge circuit connected to the energy storage circuit and including at least one resistor,
- at least one first diode allowing to charge the energy storage circuit but not allowing it to discharge through any load which is not the discharge circuit,
- a measuring circuit allowing to measure the voltage of the energy storage circuit and including one analog to digital converter,
- a control circuit connected to the measurement circuit and being based on an electronic processing device. Such an electronic processing device can be a microcontroller, an ASIC, an FPGA or a digital signal processor.

[0015] The time measurement circuit according to the invention allows to control the charge and the discharge of the energy storage, e.g. the capacitor, and to measure the data, e.g. voltage, of the energy storage and to calculate the past time based on the measurement data. The control

[0016] The method according to the invention comprises the steps of

- charging the energy storage device,
- measuring characteristic data of the energy storage before the first event and after the second event,
- determining the past time based on a comparison of the measured characteristic data of the energy storage before the first event and after the second event.

[0017] The invention will be described in greater detail by description of eight embodiments with reference to the accompanying drawings, wherein

Figure 1 shows in a block diagram the basic concept of the invention;

Figure 2 shows a basic schematic example of the measurement time circuit in a first embodiment,

Figure 3 shows a basic schematic example of the

- measurement time circuit in a second embodiment, including voltage mirror;
- Figure 4 shows a basic schematic example of the measurement time circuit in a third embodiment, including voltage mirror and signal amplification and filtering;
- Figure 5 shows a schematic example of the measurement time circuit in a fourth embodiment, which is equivalent to the embodiment shown in figure 4, but including a charge circuit,
- Figure 6 shows a schematic example of the measurement time circuit in a fifth embodiment, which is equivalent to the embodiment shown in figure 5, but including an extended charge circuit,
- Figure 7 shows a schematic example of the measurement time circuit in a sixth embodiment, which is equivalent to the embodiment shown in figure 5, but including control unit which charges the energy storage directly,
- Figure 8 shows a schematic example of the measurement time circuit in a seventh embodiment, which is equivalent to the embodiment shown in figure 5, but including an impedance match circuit;

[0018] Figure 1 below describes the basic concept of the invention. It shows schematically and in an exemplary manner the composition of the time measurement system according to the invention.

[0019] The time measurement circuit 1 comprises a charge circuit 2, a block/disconnection circuit 3 with an energy storage 4 and a discharge circuit 5, further the measurement circuit comprises a control unit 6 and a measurement circuit 7.

[0020] The components will now be described in more detail.

[0021] The charge circuit 2 powers the energy storage 4 over a defined time or a defined level. It is composed of at least one resistor 17, see figure 6, or a series connection of at least one resistor 17 and at least one transistor 18, see figure 6. It can be controlled by the control unit 6 or charges the energy storage 4 automatically when the device has power.

[0022] The Block/disconnection circuit 3 is responsible that the stored energy of the energy storage 4 is disconnected or blocked from the other. Therefore, the stored power will be only dissipated over the discharge unit 5.

[0023] The energy storage 4 can be any rechargeable electrical energy storage device, e.g. a capacitor.

[0024] The discharge circuit 5 is a circuit which discharges the energy storage 4 in a defined way. The dis-

charge circuit 5 is connected to the energy storage 4 circuit and including at least one resistor 10, see figure 2.

[0025] The energy stored in the energy storage 4 is measured by a measurement circuit 7, e.g. ADCs or comparator circuits.

[0026] The measurement signal can be attenuated or amplified, by a resistive divider or an operation amplifier amplifying circuit, and/or filtered, by a passive or active low pass filter, see figure 4.

[0027] The measurement data, e.g. voltage or/and current, is given to the control unit 6. The control unit 6 determines, based on look up tables, or calculates the past time between the two events, based on the measurement data of the measurement circuit. It can be a processing device such as a microcontroller, ASIC, FPGA or a digital signal processor.

[0028] The control unit 6 controls and configures the charge unit 2 and measurement unit 7. The charge and measurement unit 2, 7 could as well operate without the control unit 6.

[0029] The control unit 6 can optionally charge the energy storage 4 directly via a resistor 17, see figure 7.

[0030] Turning now to figure 2, there it is shown that the time measurement circuit 1 comprises the energy storage circuit 4 including at least one first capacitor 8. At least one first diode 9, diode D1, allows to charge the energy storage circuit 4 but not allowing it to discharge through any load which is not the intended discharge circuit 5. The discharge circuit 5 is connected to the energy storage circuit 4 and includes at least one first resistor 10. The measuring circuit 7 allows to measure the voltage of the energy storage circuit 4 and includes one analog to digital converter 11. The control circuit 6 is connected to the measurement circuit 7 and is based on processing device such as a microcontroller, ASIC, FPGA or digital signal processor.

[0031] Turning now to figure 3, this embodiment has as an additional feature a voltage mirror 12. The measuring circuit 7 comprises a circuit to mirror the voltage available on the storage circuit 4 with at least one second diode 13, diode D2, whose anode is connected to the anode of the first diode 9, a second resistor 14, resistor R2, connected in series with second diode 13, and a capacitor second capacitor 15, capacitor C2, for low pass filtering of the signal, connected in parallel to the second resistor 14.

[0032] The second diode 13, diode D2, compensates for the voltage drop over the first diode 9, allowing the ADC 11 to measure nearly the same voltage as on the energy storage 4, see also figure 4.

[0033] Turning now to figure 4, this embodiment has as an additional feature a third resistor 16, resistor R1, connected in series with the second resistor 14, resistor R2, such that it acts as a voltage divider.

[0034] Turning now to figure 5, this embodiment has as an additional feature a fourth resistor 17 placed in series with the second diode 13, diode D2, to limit the current charging the energy storage circuit 4.

[0035] The blocking diode 9 can in an advantageous embodiment be matched to the diode 13, such that they are of the same type and preferably on the same chip.

[0036] Turning now to figure 6, this embodiment has as an additional feature a transistor 18 connected to the resistor 17 or to the storage circuit 4 such that it controls the charging of the storage circuit 4.

[0037] Turning now to figure 7, the embodiment shown there has as an additional feature that the storage circuit 4 is charged by the control circuit 6.

[0038] Turning now to figure 8, the embodiment shown there has as an additional feature a fifth resistor 19, resistor R4, which is placed between the mirror circuit and the ADC 11.

[0039] In an advantageous embodiment, the ADC 11 can be part of the same integrated circuit as the control circuit 6.

[0040] In an advantageous embodiment the storage capacitor 8, capacitor C1, can be a tantalum or ceramic type capacitor.

[0041] The installation device with time measurement circuit allows to implement and execute a method for measuring the delayed time. Such a method would require certain steps in order to measure the delayed time:

Before event one, the control unit or a charge circuit charges the energy storage with a charge circuit. Charging may happen until the energy storage is full, or over a defined time, or until a defined level.

[0042] When event one is happening, be it with or without power loss of the installation device, the energy storage discharges itself over a discharge circuit in a defined way. The stored energy of the energy storage is decoupled from any load except for the discharge circuit. Therefore, the stored power will be only dissipated through this discharge circuit.

[0043] No external power is needed to power the time measurement circuit.

[0044] When then event two is happening and power is available of the installation device, then the energy storage is measured by a measurement circuit using an additional circuit to mirror the voltage available on the storage circuit with at least one second diode D2 whose anode is connected to the anode of the first diode D1. A resistor divider network (R1, R2 connected in series with D2) gains the measurement signal. The signal gaining can be realized also with an operation amplifier in combination with resistive network. A second capacitor C2 low pass filters the signal. It is connected in parallel to the second resistor R2. The low pass filter can be integrated in a gain circuit which can be composed of an operation amplifier in combination with resistive network.

[0045] The measurement circuit is composed of an AD-converter, or comparator circuits. The measurement data, e.g. voltage or/and current, is given to the control unit.

[0046] The control unit determines, based on look up tables, or calculates the past time between the two

events, based on the measurement data of the measurement circuit. It can be a processing device such as a microcontroller, ASIC, FPGA or digital signal processor.

[0047] The decouple technique and the voltage mirror circuit is established with diodes, see Fig. 4: The blocking technique with a diode would have the side effect of a temperature dependency which led to measurement error. By adding a second diode D2 into the measurement path a voltage mirror is created. The second diode D2 compensates for the voltage drop over the first diode D1, allowing to measure nearly the same voltage from the energy storage. The error caused by the blocking diode to the measurement circuit voltage is equal in this case to the mismatch between the forward voltages of the blocking diode, first D1, and of the feedback diode, second diode D2.

[0048] The accuracy of the measurement voltage is improved if the first and second diodes D2 and D1 feature identical construction and characteristics, such that they have identical voltage drop. Excellent matching of their electrical parameters is achieved when both diodes are built on the same chip such that they are manufactured using exactly the same processing. Having both diodes implemented on the same chip also ensures excellent thermal coupling and ensures that they are practically operating at identical temperatures. In practice, the forward voltages of the first and second diodes D1 and D2 can be matched to less than ± 0.07 V, for output currents from 0.01 mA to 1 mA and temperatures between -40°C and $+85^{\circ}\text{C}$. This is more than four times better the variation of the forward voltage of the blocking diode.

List of reference signs

1	Time measurement circuit
2	Charge circuit
3	Block/disconnection circuit
4	Energy storage
5	Discharge circuit
6	Control circuit
7	Measurement circuit
8	Capacitor in energy storage
9	First diode in block/disconnection circuit
10	First resistor, in discharge circuit
11	AD converter in measuring system
12	Voltage mirror circuit
13	Second diode, in voltage mirror
14	Second resistor, in voltage mirror
15	Second capacitor, in voltage mirror
16	Third resistor, as voltage divider
17	Fourth resistor

(continued)

18	Transistor
19	Fifth resistor

Claims

1. An installation device with a time measurement circuit (1), said time measurement circuit (1) including
- an energy storage circuit (4) including at least one capacitor (8),
 - a discharge circuit (5) connected to the energy storage circuit (4) and including at least one first resistor (10),
 - at least one first diode (9) allowing to charge the energy storage circuit (4),
 - a measuring circuit (7) allowing to measure the voltage of the energy storage circuit (4) and including one analog to digital converter (11),
 - a control circuit (6) connected to the measurement circuit (7) and being based on an electronic processing device.
2. An installation device according to claim 1, wherein the measuring circuit (7) comprises a circuit to mirror the voltage available on the storage circuit (4) with at least one second diode (13) whose anode is connected to the anode of the first diode (9), a second resistor (14) connected in series with the second diode (13), and a second capacitor (15) for low pass filtering of the signal connected in parallel to the second resistor (14).
3. An installation device according to claim 2, wherein a third resistor (16) is connected in series with the second resistor (14) such that it acts as a voltage divider.
4. An installation device according to claim 3, wherein a fourth resistor (17) is placed in series with the second diode (13) to limit the current charging the energy storage circuit (4).
5. An installation device according to claim 4, wherein the first diode (9) is matched to the second diode (13), such that they are of the same type and preferably on the same chip.
6. An installation device according to claim 5, wherein a transistor (18) is connected to the fourth resistor (17) or to the storage circuit (4) such that it controls the charging of the storage circuit (4).
7. An installation device according to claim 6, wherein the storage circuit (4) is charged by the control circuit
- (6).
8. An installation device according to claim 7, wherein a fifth resistor (19) is placed between the mirror circuit and the ADC (11).
9. An installation device according to claim 8, wherein the ADC (11) is part of the same integrated circuit as the control circuit (6).
10. An installation device according to claim 9, wherein the storage capacitor (8) is a tantalum or ceramic type capacitor.
11. Method for measuring the past time between a first and a second event with a time measurement circuit (1), said time measuring circuit (1) including an energy storage device (8) that can be charged by an energy storage circuit (4), without powering the time measurement circuit (1) during this past time, comprising the steps of
- charging the energy storage device (8),
 - measuring characteristic data of the energy storage before the first event and after the second event,
 - determining the past time based on a comparison of the measured characteristic data of the energy storage before the first event and after the second event.
12. Method according to claim 11, wherein the characteristic data is the voltage across an energy storage device (8).

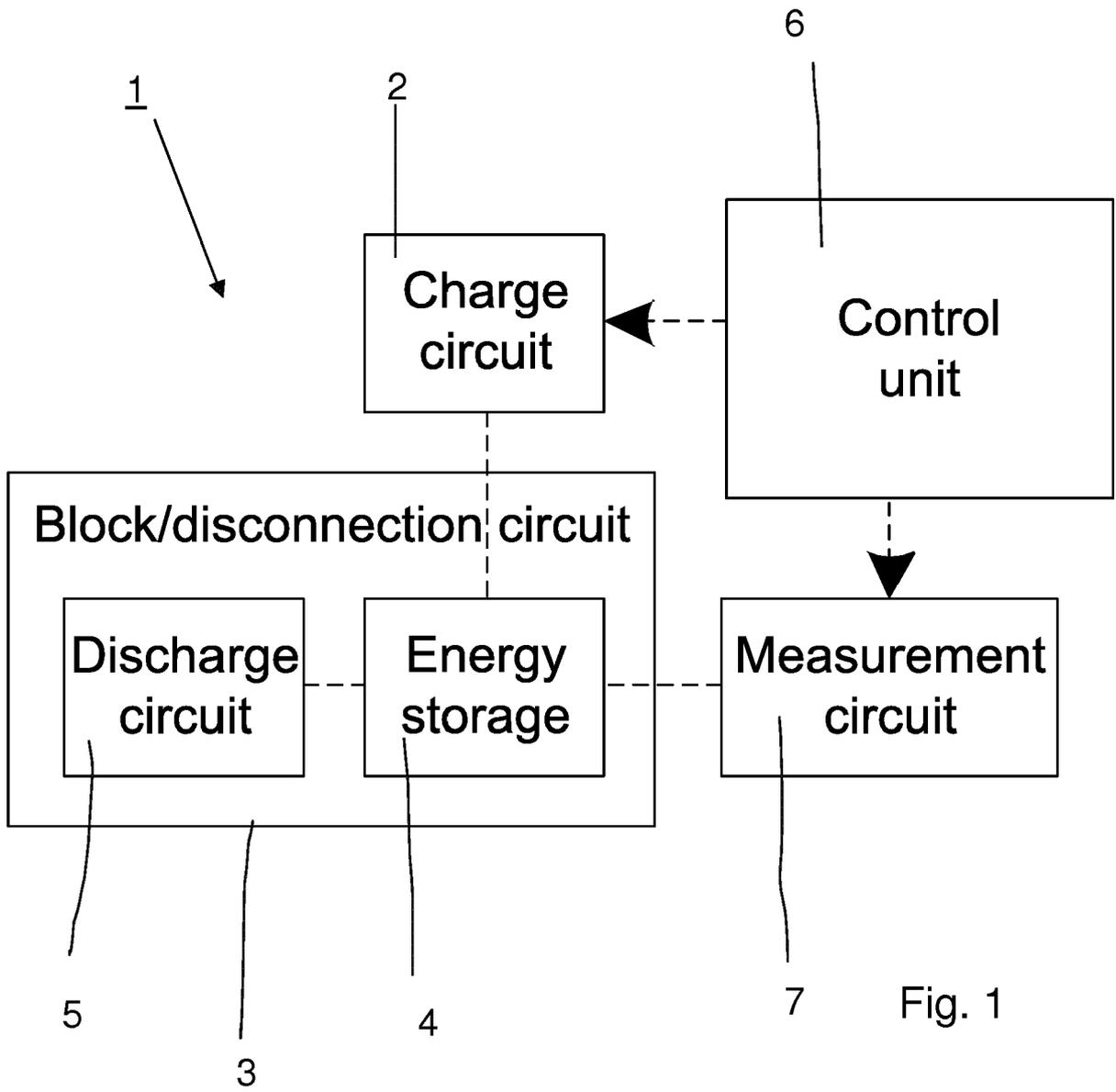


Fig. 1

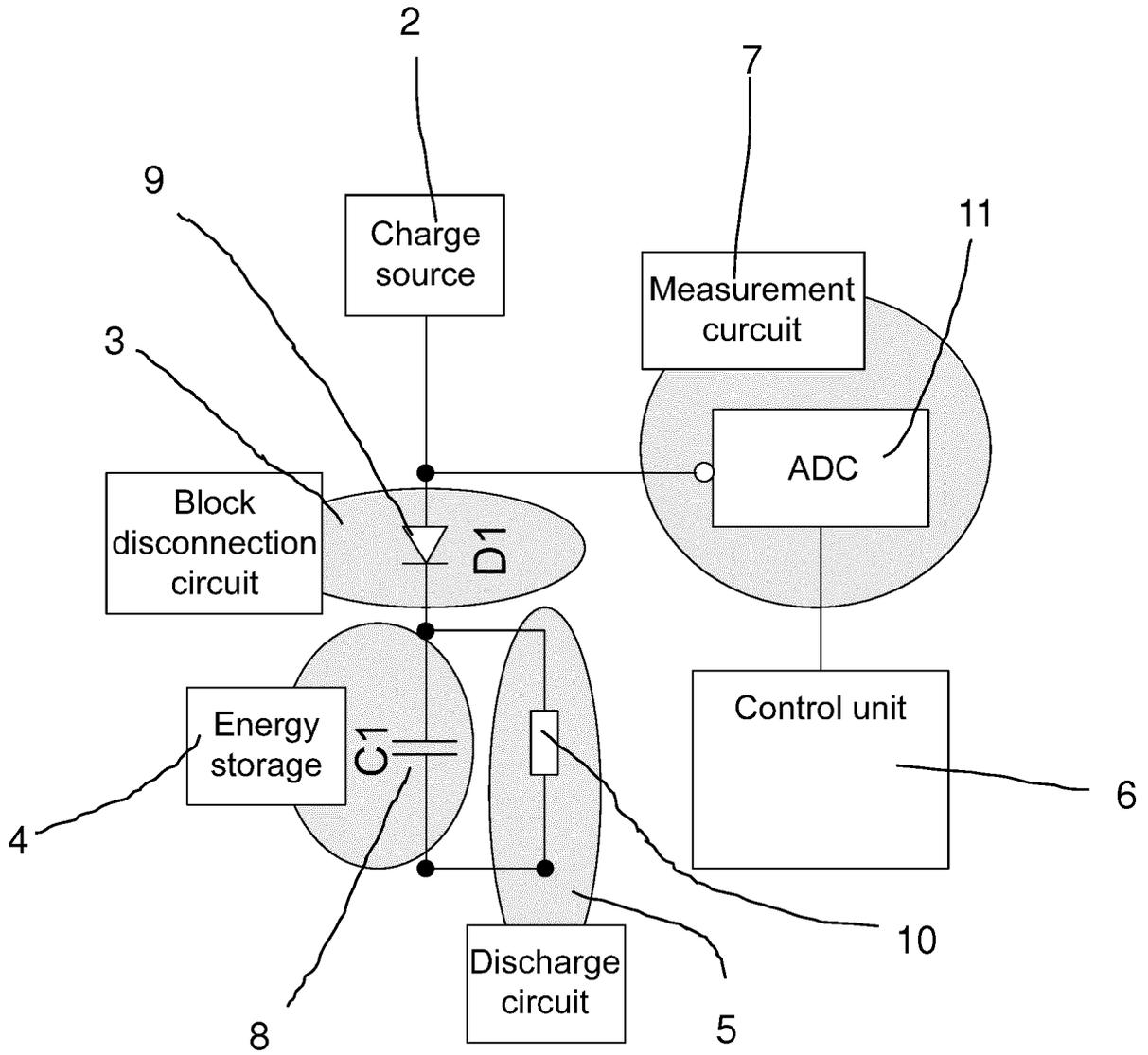


Fig. 2

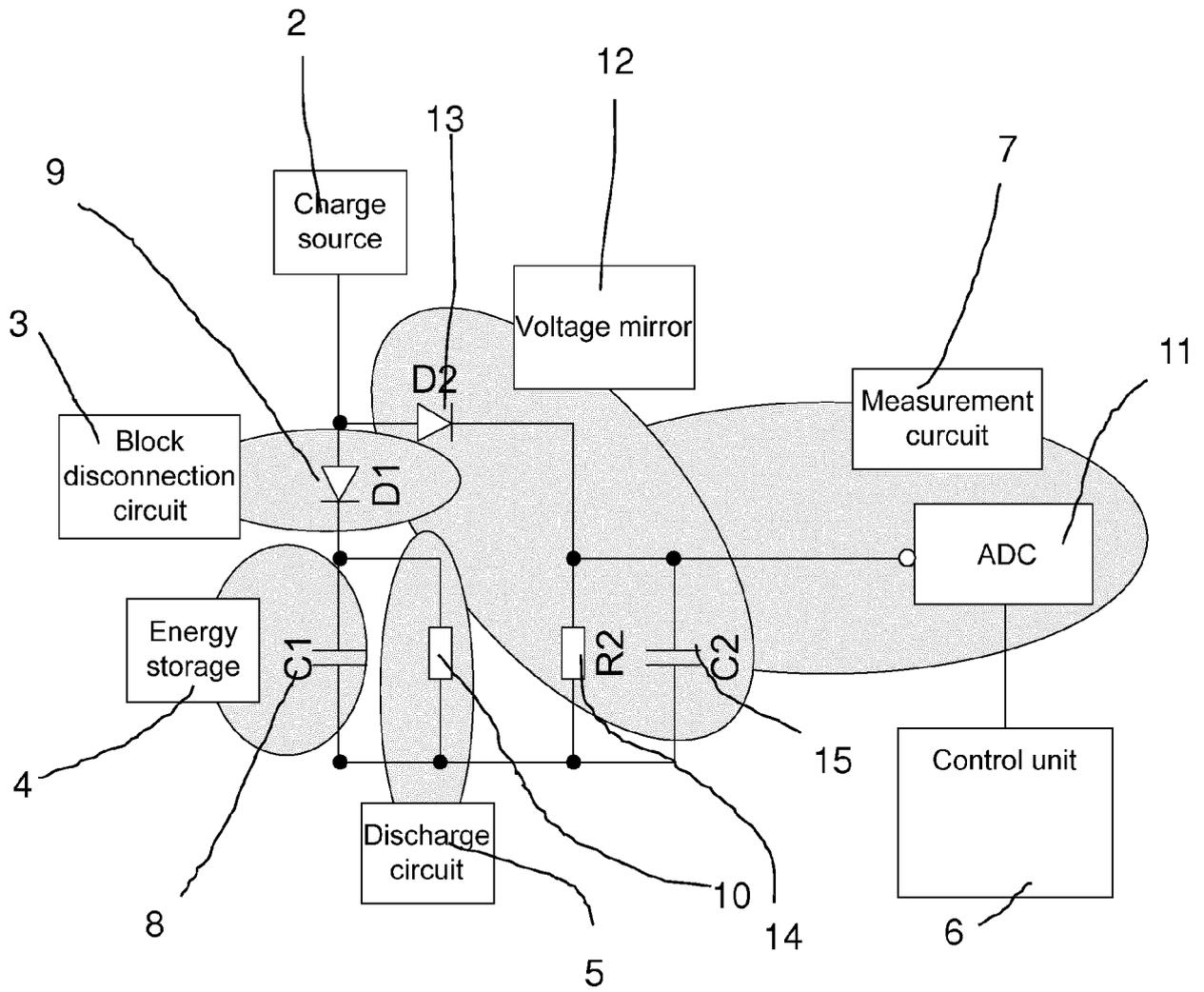


Fig. 3

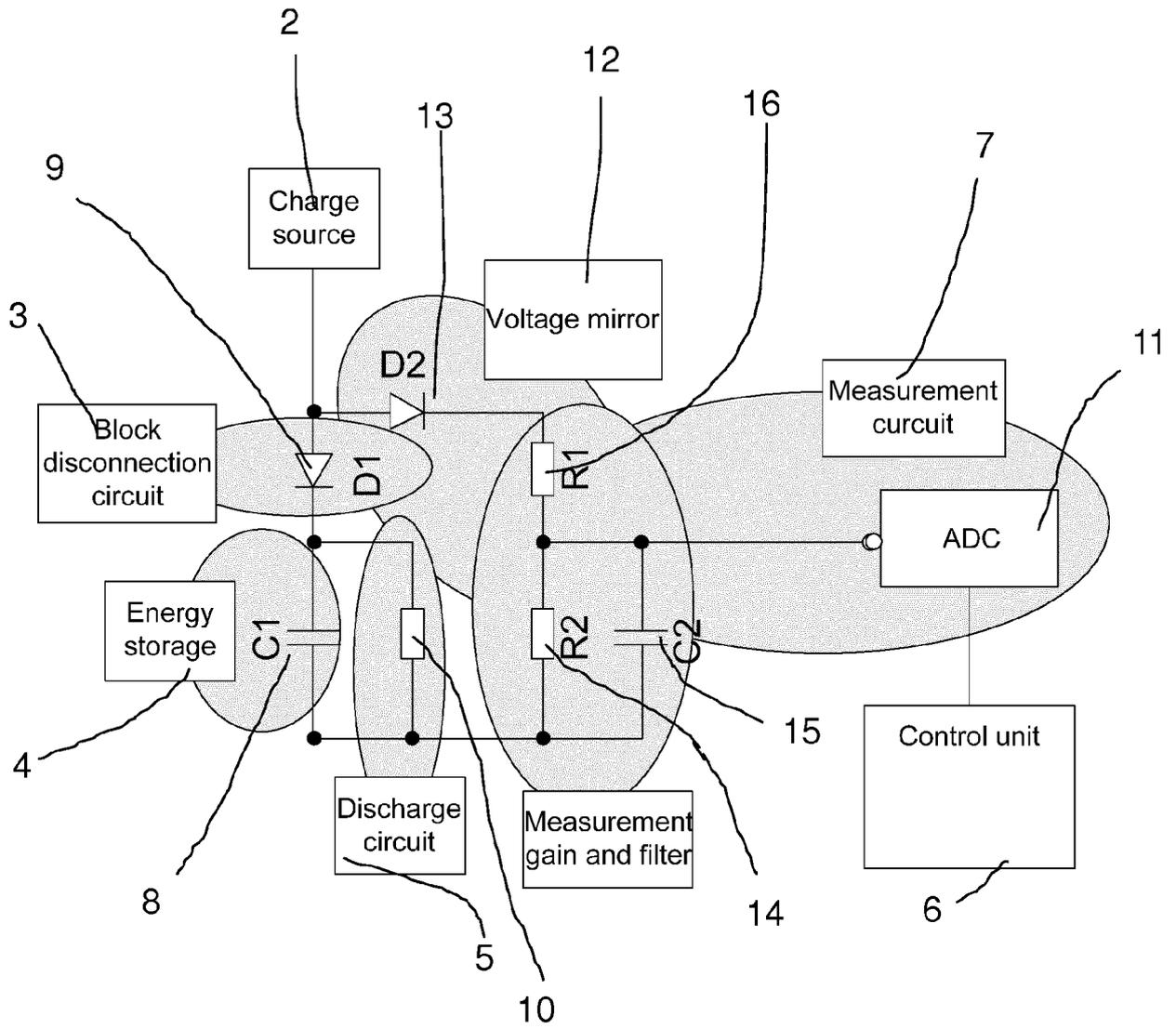


Fig. 4

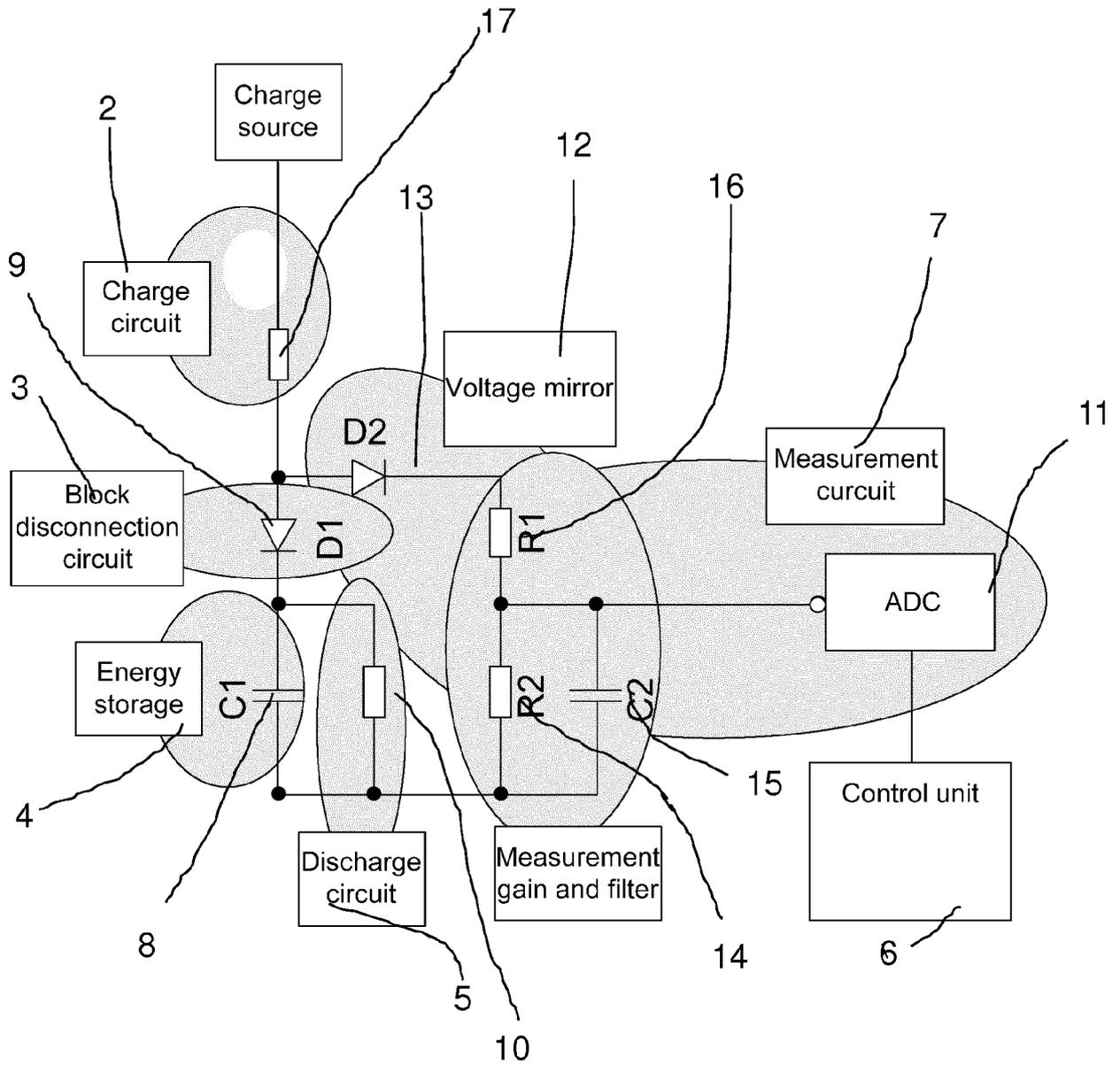


Fig. 5

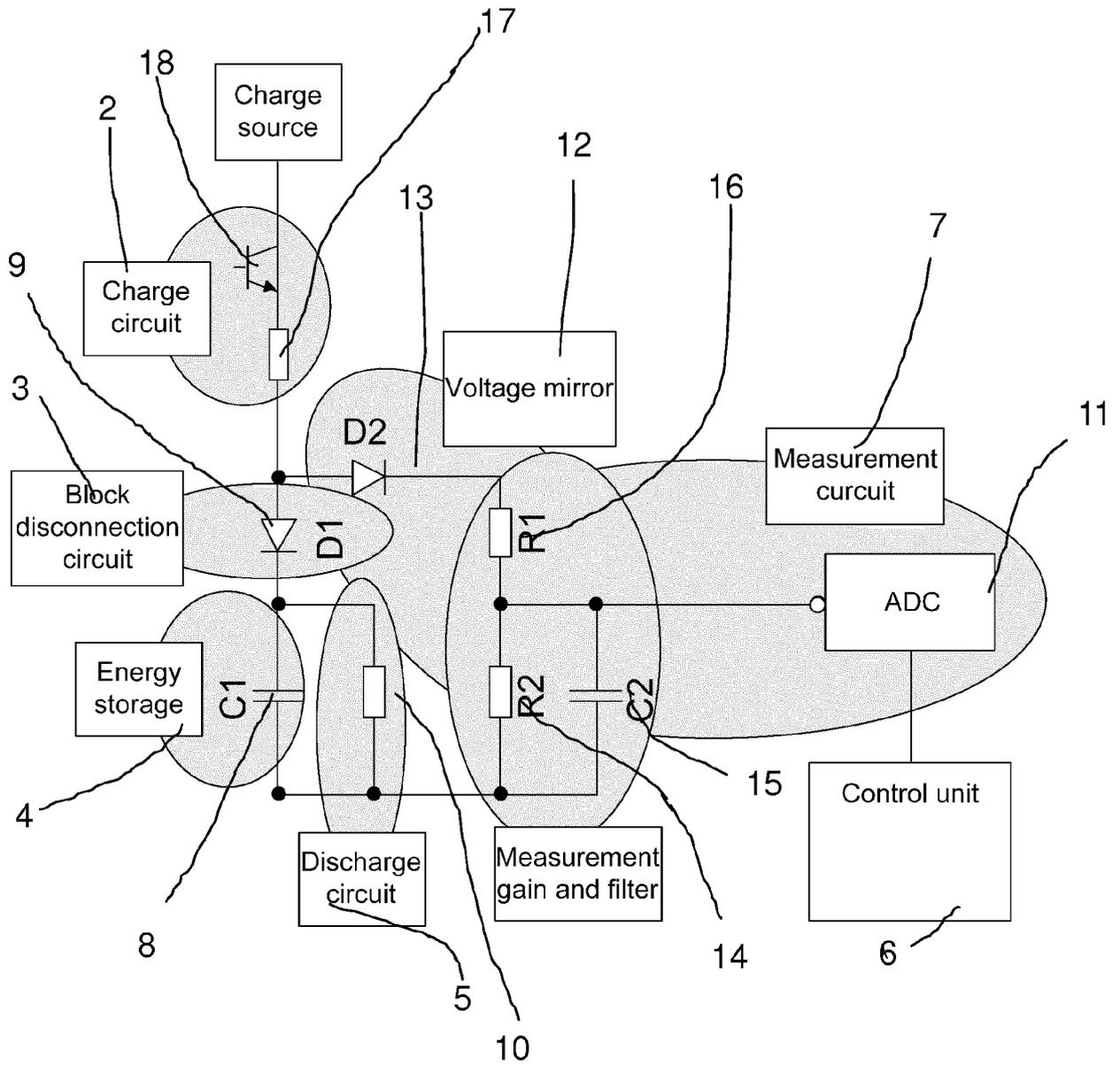


Fig. 6

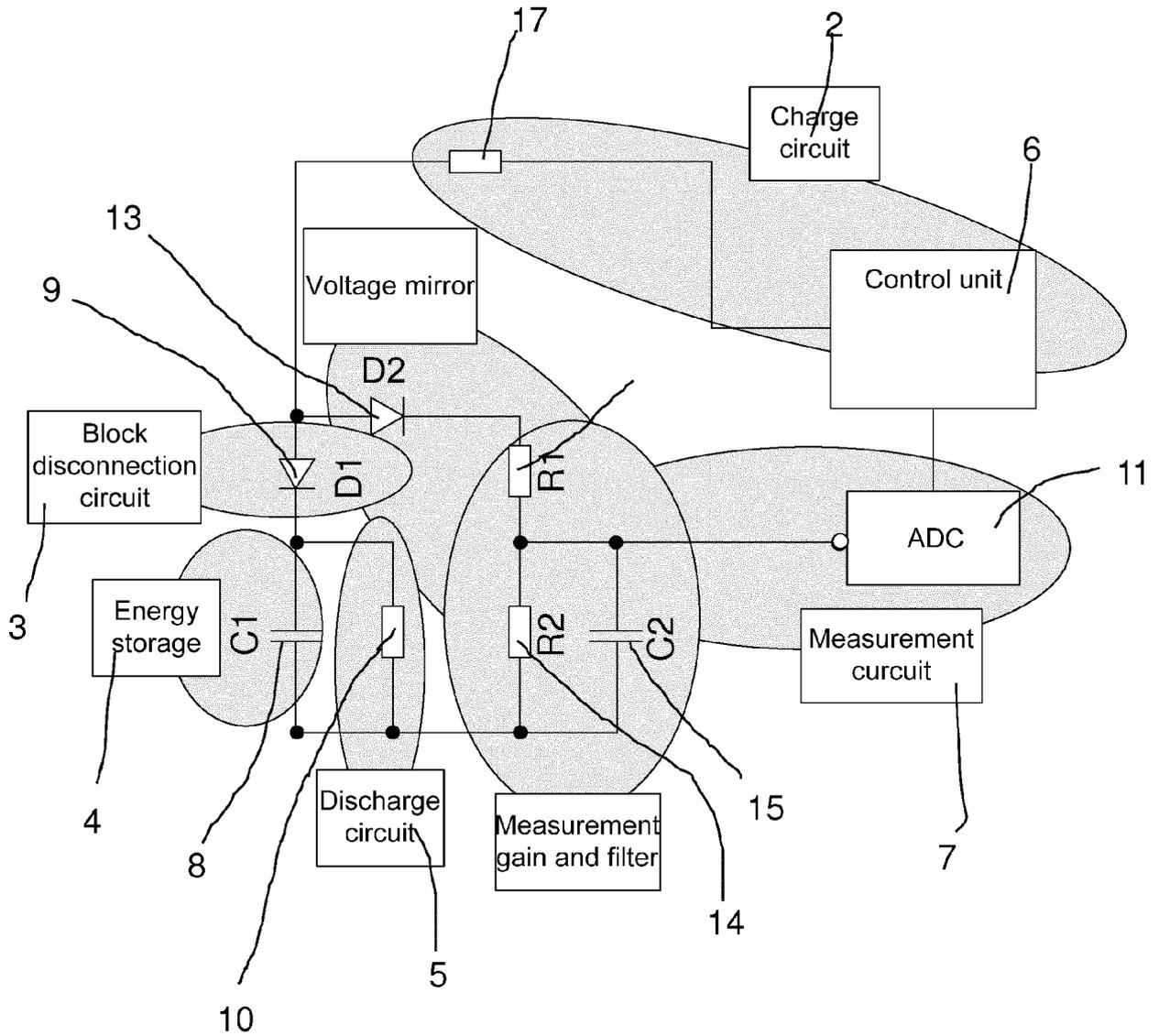


Fig. 7

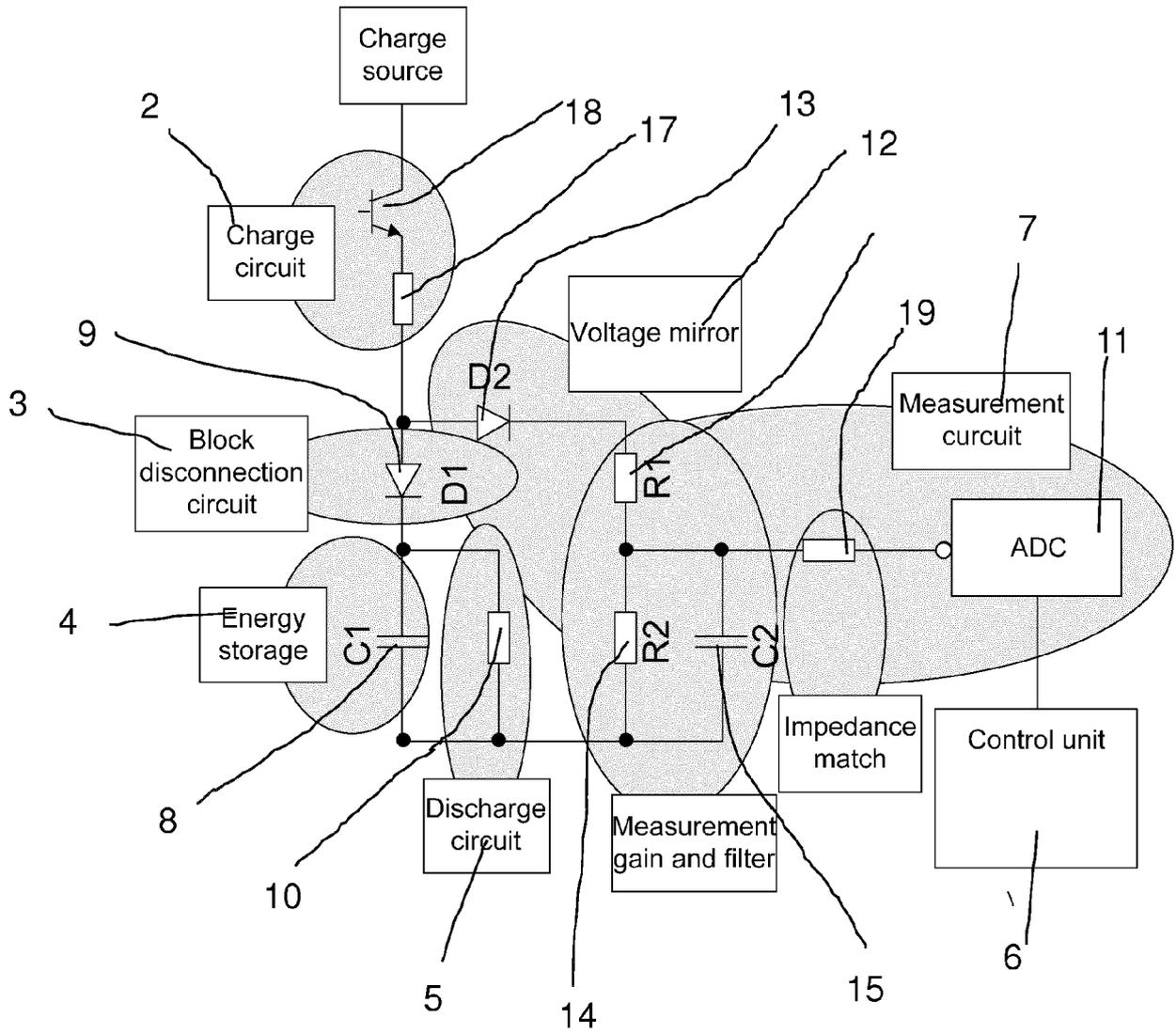


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 16 20 5900

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Place of search Munich		Date of completion of the search 19 May 2017	Examiner Lindquist, Jim
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ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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