Title: RECHARGEABLE POWER SUPPLY

Abstract: The invention relates to a rechargeable power supply suitable to be used in a battery-operated device comprising at least one supercapacitor and at least a first and a second DC-DC converter connected in series, wherein the supercapacitor is connectable to an entry of the first DC-DC converter and the device is connectable to an exit of the second DC-DC converter.
Rechargeable power supply

The invention relates to a rechargeable power supply suitable to be used in or in combination with a battery-operated device.

Nowadays, battery-operated devices exist in a wide variety. A universal example is the mobile telephone, which on the one hand is very convenient to use but on the other hand, can cause the user annoyance for a number of reasons.

It is especially annoying when the battery of the device is almost empty while one still wishes to make one or more calls. It is an even greater nuisance when during a conversation the battery ceases to fulfil its essential function of keeping the mobile telephone operational.

As already mentioned, the mobile telephone is only one example. There are also other battery-operated devices, which to a greater or lesser extent also exhibit the problem of the battery running down at an awkward moment.

The problem just mentioned, and the annoyance caused by the untimely depletion of the battery, is aggravated by the fact that recharging the battery requires some time.

Time, which the present-day man or woman feels they cannot spare so that they wait impatiently for the battery to recharge.

The object of the invention is to provide a rechargeable power supply that can be recharged fast and is operational for a relatively long time, and with which the annoyances referred to above can be limited.

From US 2003/0169022 a rechargeable power supply for a battery-operated notebook computer is known, which is provided with two serially connected supercapacitors and also with two serially connected DC-DC converters. The supercapacitors are connected to the connecting line of the two DC-DC converters in such a way, that either the supercapacitors are fed from the first DC-DC converter, or the notebook computer is via the second DC-DC converter fed by the supercapacitors. Thus the two DC-DC converters are not in operation simultaneously.
It has been shown, that a rechargeable power supply built around one or more supercapacitors can be recharged in approximately 5-120 seconds to a functional energy level so as to, for example in the case of the mobile telephone, provide an additional speaking time of approximately 30 minutes.

The rechargeable power supply according to invention has at least a first and a second DC-DC converter connected in series, and is characterized in that the supercapacitor is connectable to an entry of the first DC-DC converter and in that the device to be fed is connectable to an exit of the second DC-DC converter.

This measure avoids the problem that during use, the supercapacitor's voltage decreases with the approach of depletion. As a consequence, the voltage would at some point drop below the minimally required voltage demanded by the device to be fed. Since the effective charge of the supercapacitor is increased, the above-mentioned measure enables the supercapacitor to feed said device longer. To this end it is desirable for the first DC-DC converter to realise an increased output voltage, while the second DC-DC converter supplies an output voltage above the minimum voltage of the device to be fed. The first DC-DC converter is therefore a step-up-converter, while the second DC-DC converter is a step-down-converter.

In still another aspect of the invention, the rechargeable power supply is characterized, in that a battery is provided, which in relation to the supercapacitor discharges slowly, and may or may not be directly connected to the supercapacitor.

This solves the problem of the supercapacitor, when not in use, losing its effective charge in the course of a number of days due to leakage current. In this proposed embodiment, the supercapacitor can discharge its effective charge to the parallel-connected battery, so that even with a longer period of standstill, the effective charge remains available.
The supercapacitor referred to in the present invention comprises an electrolyte and electrodes, wherein the electrodes are selected from the group comprising activated carbon powders, carbon nanochannels, metal oxides, composite materials containing carbon (such as polypyrrole) and conductive polymers. Such supercapacitors are known from the literature, see for example, the article 'Development of new supercapacitor electrodes based on carbon nanotubes' by E. Frackowiak et al., published in Polish Journal of Chemistry, 78, p. 1345-1356 (2004).

The invention is also embodied in a supply unit for a rechargeable power supply as described above, provided with an electronic circuit into which the supercapacitor may be integrated, and which is connectable to an external power supply for recharging the supercapacitor. Such a supply unit is known from US 2004/0004462.

The supply unit according to the invention is characterized in that the electronic circuit comprises control electronics for controlling the electronic circuit subject to a charge level of the supercapacitor. By means of the electronic circuit, the supercapacitor is kept within the current and voltage limits as required in order to avoid damage to the supercapacitor.

A suitable embodiment of this supply unit for the rechargeable power supply according to the invention is further characterized in that the electronic circuit comprises a coil and an electronic switch serially connected therewith, and in that the supercapacitor can be connected at an electrical junction between the coil and the electronic switch.

Hereinbelow the invention will be further elucidated by way of some exemplary embodiments of a rechargeable power supply according to the invention, without limiting the appended claims.

The drawing shows in:
- Figure 1, an electrical circuit diagram of a direct-current voltage-fed supply unit for a rechargeable power supply according to the invention,
- Figure 2, an electrical circuit diagram of an alternating-voltage-fed supply unit for a rechargeable power supply according to the invention, and
- Figure 3, an electrical circuit diagram of a preferred embodiment of a rechargeable power supply according to the invention.

Identical reference numerals in the figures designate similar components.

Figure 1 shows a supply unit for a rechargeable power supply that can be connected to a direct-current supply for recharging a supercapacitor 1 connected to said supply unit.

Such a supercapacitor 1 is built into a housing comprising an electrolyte and electrodes. The electrodes are selected from the group comprising activated carbon powders, carbon nanochannels, metal oxides, composite materials containing carbon, and conductive polymers.

Figure 1 shows that the supercapacitor 1 is incorporated in an electronic circuit that is connectable to said external direct-current supply of 10-30 volt for charging the supercapacitor 1. The electronic circuit further comprises control electronics 2 for controlling the electronic circuit subject to a charge level of the supercapacitor 1 as determined by means of measuring bridges 3 and 4. Depending on the voltage levels measured at these measuring bridges 3 and 4, the control electronics 2 react through the controlled activation of an electronic switch 5, which is serially connected with a coil 6, which in turn is connected to the direct-current supply.

Via a low-loss diode, the said supercapacitor 1 is connected at the electrical connecting point 7, between the coil 6 and the electronic switch 5.

The control electronics 2 are designed to rapidly charge said supercapacitor 1 while avoiding any damage to said capacitor, obtaining the energy from the coil 6 connected to the power supply V-supply.

The circuit of Figure 1 works as follows.
The power supply is connected to a direct current in the range from 10-30 volt, able to supply sufficient power to charge the supercapacitor 1 within the desired time.

The power supply V-supply supports a capacitor 11, which ensures that possible power peaks during charging have little effect on the power supply V-supply.

Connected in parallel with the supercapacitor 1 is a zenerdiode 12, which serves as protection against overvoltage. Also connected in parallel is a capacitor 13 that absorbs transition effects resulting from coupling and uncoupling the supercapacitor 1. As a rule, this supercapacitor 1 is coupled with the circuit by means of a (long) cable.

The control electronics 2 deal with the charging process, which starts after establishing that the power supply V-supply measures more than 10 volt and the operating voltage of the supercapacitor 1 is below its maximum rating voltage. When these criteria are fulfilled, the control electronics 2 will cause the electronic switch 5, embodied as mosfet, to open with the result that coil 6 becomes energised. The current running through the coil 6 is measured using a measuring resistance 14. When this current, which is measured with the aid of resistance 14 reaches its maximum value, the control electronics 2 activate the switch 5 to shut again, so that the voltage over the coil 6 is the same as the voltage of the supercapacitor 1 minus the voltage over the Shottky-diode 8. As the current path is blocked due to the switch 5 being shut, the current now charges the supercapacitor 1 via the diode 8. In this process the current gradually decreases. When this current and the corresponding voltage over the coil 6 is sufficiently reduced, the charging cycle is completed and, if desired, may be repeated.

Figure 2 very schematically shows the electrical circuit diagram of an alternating current-fed supply unit according to the invention. The power supply Vcc is rectified via a diode 9 and charges a capacitor 10. This capacitor 10 supplies the power for charging the supercapacitor 1.

As in the case of the circuit shown in Figure 1, the circuit is for the purpose of charging the supercapacitor 1.
provided with an electronic switch 5 and a serially connected coil 6. In addition, control electronics 2 are provided for controlling the electronic switch 5 so as to alternately switch it on and off, depending on the charge cycle of the supercapacitor 1.

Consequently, the current running through coil 6 is also alternately switched on and off, enabling the power storing properties of the coil 6 to allow the supercapacitor 1 to be charged.

It will be obvious to the person skilled in the art that within the scope of the invention the circuits shown in Figs. 1 and 2 may be modified without departing from the inventive idea expressed in the appended claims.

The protective scope due the invention is therefore determined by the appended claims only, and they must not be understood to be limited to the specific exemplary embodiments, which are provided exclusively for the elucidation of said claims.

Figure 3 finally, shows a preferred configuration of the rechargeable power supply according to the invention.

The rechargeable power supply shown in Figure 3 is again comprised essentially of the supercapacitor 1, to which are connected preferably a first DC-DC converter 15 and a second DC-DC converter 16. The first DC-DC converter 15 and the second DC-DC converter 16 are connected in series.

The first DC-DC converter 15 is a step-up-converter and effects an upward conversion of the direct current from the supercapacitor 1, whereas the second DC-DC converter 16 is a step-down-converter effecting a downward conversion of the direct current in order to guarantee that the output voltage of said second DC-DC converter 16 provides at least the minimum voltage required by the device to be connected to the power supply.

Figure 3 further shows that between the first DC-DC converter 15 and the second DC-DC converter 16 a battery 17 may be placed, connected in parallel with the supercapacitor 1. This ensures that the relatively large amount of leakage current from the supercapacitor 1 will not adversely affect
the availability of energy at the output terminals of the second DC-DC converter 16, when the rechargeable power supply according to the invention has not been used for a longer period of time.
CLAIMS

1. A rechargeable power supply suitable to be used in a battery-operated device comprising at least one supercapacitor and at least a first and a second DC-DC converter connected in series, characterised in that the supercapacitor is connectable to an entry of the first DC-DC converter and in that the device is connectable to an exit of the second DC-DC converter.

2. A rechargeable power supply according to claim 1, characterised in that a battery is provided, which in relation to the supercapacitor discharges slowly, and may or may not be directly connected to the supercapacitor.

3. A rechargeable power supply according to claim 1 or 2, characterised in that the first DC-DC converter is a step-up-converter, while the second DC-DC converter is a step-down-converter.

4. A rechargeable power supply according to claim 1-3, characterised in that the supercapacitor comprises an electrolyte and electrodes, wherein the electrodes are selected from the group comprising activated carbon powders, carbon nanochannels, metal oxides, composite materials containing carbon and conductive polymers.

5. A supply unit for a rechargeable power supply according to one of the claims 1-3, provided with an electronic circuit into which the supercapacitor may be integrated, and which is connectable to an external power supply for recharging the supercapacitor, characterised in that the electronic circuit comprises control electronics for controlling the electronic circuit subject to a charge level of the supercapacitor.

6. A supply unit according to claim 5, characterised in that the electronic circuit comprises a coil and an electronic switch serially connected therewith, and in that the supercapacitor can be connected at an electrical junction between the coil and the electronic switch.
FIG. 1