

ELECTRICAL APPARATUSBACKGROUND OF THE INVENTIONFIELD OF THE INVENTION

5 The present invention relates to an item of electrical apparatus, and in particular to apparatus for converting the supply voltage of a DC power supply.

SUMMARY OF THE PRIOR ART

Recent years have seen the emergence and
10 development of a wide range of electronic accessories for motor vehicles, motor boats and other large pieces of equipment. Among such electrical accessories are lights, heating units, and more recently of course increasingly sophisticated telecommunications devices. Rather than
15 carry their own source of electrical power, many accessories are intended to draw energy from the battery power source of the larger pieces of equipment, and are therefore designed to be compatible with the 12 volt batteries which are now standard in motor cars. The
20 optimum input voltage of many electronic accessories is in fact 13.8 volts.

Unfortunately, the DC supply format used in other industrial, military, commercial, aviation, maritime and

other applications differs considerably. Large vehicles, for example, require electrical power to be carried over comparatively longer lengths of cable with, in addition, an increased number of devices using the DC supply.

Therefore, if the DC supply is doubled in voltage from the nominal 12 volts to a nominal 24 volts the current demand is halved although the overall power available would be unchanged.

For example, large commercial or heavy vehicles typically use the higher DC voltage format centred around a nominal 24 volts.

There is therefore a requirement for converters capable of receiving the output of these higher DC voltage formats and supplying current in an acceptable form to 12 volt format electric accessories, that is to say a converter capable for example, of providing a constant supply of 13.8 volts from a varying supply of between 23.3 volts and 27.6 volts.

It should be appreciated that such a converter may have to deliver a power supply of several watts, tens of watts or even hundreds of watts, and that in this context problems are encountered which have no

counterpart in microelectronic power conversion systems. For example, US-A-4827205 discloses an on-chip 10 volt voltage supply in which current is delivered through a 10k resistor, which limits the power delivery to be of the order of milli-watts. In such a context conversion efficiency is unimportant and heat generation causes no significant problems.

An early generation of DC power converters, often misnamed "Droppers", were based upon linear converters, which is to say devices which step-down and regulate a voltage supply principally using transistor technology. It was perceived, however, that such devices perform their tasks with unacceptably low power conversion efficiency. Furthermore, no design of linear converter was found which could provide an output voltage with sufficient stability, particularly when the current demand at the output increased to any significant degree.

Many devices used as accessories in vehicles, boats, the aviation industry or other equipment, require a reasonably smooth and stable DC supply voltage.

Recent developments in DC power converters have therefore concentrated on methods of DC power conversion in which a DC supply powers an oscillator circuit, often

housed under the dashboard of the lorry, for generating an oscillating voltage across the terminals of a step-down transformer. The output of the transformer is then rectified, smoothed and regulated to provide the desired supply, usually nominally 12 volts. Surprisingly, progressive refinements of this method have resulted in devices of up to 75% efficiency, and such systems are very widely employed.

The present inventor has found, however, that oscillation based power converters suffer from at least two serious disadvantages.

A first disadvantage of many switched-mode (oscillation) based converters is that their circuitry is all too likely to be damaged by the heat generated within them when the converter is abused, for example by direct electrical connection of its output terminals. In practice over the life of the converters operatives tend to replace any safety fuses (or fuses supplied with the converter) with incorrect fuses or, worse, by-pass them entirely.

This leads to significant fire hazards.

Secondly, they generate by their nature powerful electromagnetic radiation, often referred to as radio

frequency interference, which is often radiated in a manner that affects electrical, electronic and more often communications equipment within the local area of the converter.

5 This is a widespread occurrence and, although many devices are claimed to have adequate filtering within their design, this problem occurs continually.

 This problem is potentially more serious when the radiation affects users of devices and/or communications
10 equipment completely remote and both unattached and unconnected to the converter mounted on the vehicle or equipment in question.

 In many instances the user of the conversion device has no knowledge that it may be causing
15 interference externally to other services.

SUMMARY OF THE INVENTION

 The present invention, which is intended, inter alia for use in private, commercial and military vehicles, private, military and commercial maritime craft
20 or smaller boats, the aviation industry, industry generally and for other pieces of equipment, seeks to overcome the problems of electromagnetic radiation and/or of overload conditions whatever external protection may

exist with respect to relevant fuse ratings.

In its most general terms, the present invention proposes a converter having a first portion which controls DC voltage conversion and a second position, spaced from the first, in which heat may safely be developed.

Accordingly, in a first aspect the invention provides a converter for a DC power supply having an input resistance means in series with a DC regulating circuit of which an output is to be at a voltage lower than an input voltage into the converter, the resistance means being locatable distant from said regulating circuit.

In a second aspect, the invention provides a converter for a DC power supply comprising an input resistance means connected in series with a DC regulating circuit of which an output is to be at a voltage lower than the input voltage to the converter, the resistance means and regulating circuit being located in different respective housings.

In a third aspect, the invention provides a converter for a DC power supply comprising an input resistance means connected in series with a DC regulating

circuit of which an output is to be at a voltage lower than an input voltage into the converter, the resistance means and regulating circuit being adapted for mounting in different respective locations on a piece of
5 machinery.

A converter according to any aspect of the present invention is preferably capable of delivering electrical power of at least one watt, and more preferably electrical power up to several tens or
10 hundreds of watts.

The resistor of the input resistance means will usually have a value not greater than 10 ohms, preferably 0.1 to 5 ohms and most preferably 0.5 to 1.5 ohms.

It is intended that in use the converter is
15 connected to the battery power supply of a large piece of equipment, for example a lorry, and that the resistance means is mounted on the body of the equipment, e.g. the chassis of the lorry, so that heat may be dissipated to the body distant from the regulating circuit.

20 Although the regulating circuit may use oscillation it preferably employs linear converters, so that substantially no electrical noise is created on the output power supply. In this case both the disadvantages

of linear converters described above may be overcome, or at least substantially reduced, since the regulating circuit can be selected so that in use a major portion, for example at least 60% and preferably at least 70% of the heat generated by the voltage converter is produced in the resistance means, and be spaced distant from the regulating circuit. This arrangement significantly lessens the necessity for the circuit to perform power conversion at high efficiency, since there is less heat generation in the location of the regulating circuit itself, and hence the regulating circuit can be selected to optimise output stability and regulation regardless of the output current drawn. Overall power conversion efficiency is not of paramount importance in this application, since both the supply current capability and the battery capacity are very large in the application specified.

The regulating circuit is preferably further selected to limit the current which can be drawn from the converter, for example by limiting the output current to be below an upper critical limit, or simply by ceasing to supply output voltage when the converter detects an irregularity in the current drawn from the converter, a

technique known as fold back. This is preferably achieved independently of the presence or absence of interrupters such as fuses or circuit breakers, which can be tampered with.

5 The resistance means is preferably adapted for mounting on the body of a large piece of machinery in such a way that there is good heat conduction therebetween, whereby heat generated within the resistance means is rapidly conducted away. The
10 regulating circuit is preferably mounted on a heatsink formed with a high surface area to enhance its capacity to transmit heat generated by the regulating circuit to ambient air, e.g. by convection.

 The heatsink for use with the regulating circuit
15 preferably has high surface area and longitudinal symmetry. It may be mounted with its longitudinal axis vertical so that when it becomes warm a vertical flow of air is created along it, thereby improving the ability of the heatsink to transmit to the atmosphere the heat
20 generated by the regulating circuit.

 The regulating circuit is preferably selected to cease transmitting power when the temperature of the circuit rises above a predetermined value. This "thermal

cutout" is a useful safety feature, even in combination with the fold back feature described above, since the conditions which trigger fold back do not necessarily occur instantaneously upon occurrence of a fault.

5 Furthermore, it is possible to have overheating without electrical overload, for example if the regulating circuit is located in a region too warm for the heat sink to operate satisfactorily.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Further objects and advantages of the present invention will be explained in the following detailed description of preferred exemplary embodiments with reference to the accompanying figures in which:-

Fig. 1 shows the circuit diagram of a first
15 embodiment of a DC converter according to the invention;

Fig. 2 shows the circuit diagram of a second embodiment of the DC converter;

Fig. 3 shows a circuit diagram of a third embodiment of the DC converter;

20 Fig. 4 shows a circuit diagram of a fourth embodiment of the DC converter;

Fig. 5 shows a circuit diagram of a fifth embodiment of the DC converter;

Fig. 6 illustrates the relationship between the temperature of the heatsink of the third and fifth embodiments of the DC converter with the output current supplied;

5 Fig. 7 is an end view of a heat sink suitable for use in the present invention;

Fig. 8 is a cross-sectional view of a regulating circuit according to the present invention incorporated into the heat sink shown in Fig. 7;

10 Fig. 9 shows a perspective view of the heat sink of Fig. 7;

Fig. 10 shows a perspective view of a resistance unit for use in a converter according to the present invention; and

15 Fig. 11 illustrates the installation of a DC converter according to the invention.

DETAILED DESCRIPTION

Referring firstly to Fig. 1, the first embodiment of the DC converter of the present invention has input
20 terminals 1,2 for connection respectively to the terminals of an external battery of a piece of equipment, such as the 24V battery of a lorry. The regulating circuit is positioned within a regulating unit 3 which

has input terminals 8,10 for receiving electrical power and output terminals 5,6 for connection to the power inputs of electronic accessories. The converter steps down the DC voltage from the battery so that the voltage difference between its input terminals 1,2 is greater than e.g. twice the voltage difference between the output terminals 5,6. In series with the regulating unit 3 between the battery terminals 1,2 is resistance unit 4 comprising a resistor R1 and a fuse FS 1.

The resistance unit 4 is connected to the regulating unit 3 by a cable 9, the length of which is at least several centimetres and preferably up to several metres, so that the resistance unit 4 can be located distant from the regulating unit. The resistance unit 4 is adapted to be mounted on a massive part of the equipment such as the chassis of the lorry, so that the heat it generates is transmitted into the chassis. The regulating unit 3 is located elsewhere on the lorry, either at a different location on the chassis or, for example, under the lorry dashboard, and makes good thermal contact with a heatsink adapted to transmit the heat generated by the regulating unit 3 to the surrounding air.

Within the regulating unit 3, current is divided equally between the resistors R2, R3, R4, R5 and R6, all of equal resistance, of the same order as (but not necessarily the same as) the resistance of R1. The voltage between output terminals 5 and 6 is maintained at 12 volts using 5 regulators IC 1 to IC 5 which each have a 3 amp specification, and are controlled in operation by resistors R7 and R8 and capacitors C1, C2 and C3. In this way using standard components it is possible to maintain an output current of up to 15 amps, which is considerably higher than the current output of conventional converters.

The regulators IC1 and IC5 are preferably selected so that the regulating unit 3 ceases to supply power when the regulators reach a predetermined temperature. For example, the regulators may be integrated circuits KA350, which has that property.

In one selection of component values which gives correct 24 volt to 12 volt conversion, R1 takes the value of .5 ohms, while resistors R2 to R6 each have a resistance of .015 ohms; C1 is a 1,000 μ F/35 volt electrolytic capacitor; and C2 is a 100 μ F/16 volt electrolytic capacitor. IC 1 to IC 5 may be 8 volt/3 amp

regulators and in this case resistors R7 and R8 have values of 220 ohms and 150 ohms respectively.

Alternatively, IC 1 to IC 5 may be 5 volts/3 amp

regulators and in this case R7 and R8 have values of 500

5 and 860 ohms respectively. In alternative embodiments,

the regulators IC 1 to IC 5 are 12 volt regulators, and

the voltage of the output of the circuit can be made to

be 13.8 volts by selecting R7 and R8 to be 480 and 72

ohms respectively. C3 is a 2200 μ F/16 volt electrolytic

10 capacitor.

In this embodiment FS 1 and FS 2 are blade fuses

having respectively 25 amp and 15 amp capacities. FS 3,

FS 4 and FS 5 are a further three blade fuses, the total

value of which does not exceed 15 amps; usually each has

15 a capacity of 5 amps.

Fig. 2 illustrates a second embodiment of the invention being a modified version of the first

embodiment. This second embodiment is preferred to the first embodiment, since it is cheaper and simpler to

20 manufacture. It is designed to output 5 amps, and will

automatically cease supplying power in conditions of

electrical overload or overheating. The converter will

then automatically recommence normal functioning when the

fault condition has been removed or the temperature reduced to a permissible level.

In this embodiment the resistance unit 4 on the input side is separated from the regulator unit 3 by a multi-cable lead 9' including connector jack and plug assembly 9".

Values for the components in this circuit are:

IC 6, 1C 7 = Integrated circuit regulator type LM350
C 4 = Electrolytic capacitor 47 μ F/35V
10 C 5, C 6 = Electrolytic capacitor 100 μ F/16V
D 1 = Diode IN4001
R 1' = Wirewound resistor 1.5 ohms
R 9 = Wirewound resistor 120 ohms
R 10 = Wirewound resistor 1.2K ohms

15 A third embodiment shown in Fig. 3, employs a resistance unit 4 equivalent to that in the first embodiment, but uses a different regulating circuit in which current flows principally through resistor R2. The specification of the components in the circuit is as follows:
20

TR 1 = PNP Transistor (TO3) MJ15004.
TR 2 = PNP Transistor (TO220) BD744.

- IC 8 = Integrated Circuit Regulator type L7808CP.
- C 4 = Electrolytic Capacitor 2200 μ F/16 volts.
- R 1 = Wirewound Resistor, 0.5 ohm/100 watt.
- R 11 = Wirewound Resistor, 0.05 ohm/25 watt.
- 5 R 12 = Metal Film Resistor 220 ohm/1 watt.
- R 13 = Wirewound Resistor 3.3 ohm/2.5 watt.
- R 14 = Metal Film Resistor 150 ohm/1 watt.
- C 7 = Electrolytic Capacitor 1000 μ F/35 volts.
- C 8 = Electrolytic Capacitor 1 μ F/35 volts.
- 10 C 9 = Electrolytic Capacitor 1000 μ F/35 volts.
- C 10 = Electrolytic Capacitor 2000 μ F/16 volts.

As will be appreciated by a skilled person, the above choice of IC8 means that the circuit ceases to deliver a voltage when its temperature reaches a

15 predetermined value. Thus, there is a thermal cutout at this temperature.

Fig. 4 illustrates a fourth embodiment of the invention, being a modification of the third embodiment. The fourth embodiment is preferred to the third

20 embodiment since it is cheaper and easier to manufacture.

It is designed to output up to 15 amps.

As in the second embodiment, the regulator unit 3 is connected, via resistance unit 4, to the input and output via a lead 9' and jack and plug assembly 9".

5 Values of the components shown are:

- D 2 = Diode type IN4001
- IC 9 = Integrated circuit type LM 350
- TR 3 = Transmitter type MJE 15004
- TR 4 = Transistor type BD 744C
- 10 ZD 1 = Zener diode type IN5355B
- C 11 = Electrolytic capacitor 47 μ F/35V
- C 12, C 13 = Electrolytic capacitor 100 μ F/16V
- C 14 = Electrolytic capacitor 0.47 μ F/63V
- R 1 = Wirewound Resistor 0.5 ohms
- 15 R 15 = Wirewound Resistor 120 ohms
- R 16 = Wirewound Resistor 1.2K ohms
- R 17a-d = Each 27 ohms
- R 18 = Wirewound Resistor 0.05 ohms

 In the embodiment illustrated in Fig. 5, current
20 is again principally conducted to output terminals 5,6
 through resistor R19. The voltage is regulated using
 integrated circuit IC 9, which is a regulator of type
 L123CT. This converter has the feature that when the

circuit experiences a severe current fluctuation, which may arise for example if the output terminals of the circuit are connected together, IC 9 causes the output voltage to take a low level until it is reset, a
5 technique of current limitation known as "fold back".

Values of components in the circuit are as follows:

- TR 4 = NPN Transistor (TO3) 2N3771.
- 10 TR 5 = NPN Transistor (TO220) BD743C.
- IC 10 = Integrated Circuit Regulator type L123CT.
- C 15 = Electrolytic Capacitor 1000 μ F/35 volts.
- C 16 = Electrolytic Capacitor 10 μ F/16 volts.
- C 17 = Electrolytic Capacitor 2200 μ F/16 volts.
- 15 C 18 = Electrolytic Capacitor 4.7 μ F/35 volts.
- C 19 = Ceramic Capacitor 470 pF/100 volts.
- R 1 = Wirewound Resistor 0.5 ohm/100 watt.
- R 19 = Wirewound Resistor, 0.05 ohm/25 watt.
- R 20 = Metal Film Resistor 6.8 Kiloohm/0.25 watt.
- 20 R 21 = Metal Film Resistor 3.6 Kiloohm/0.25 watt.
- R 22 = Metal Film Resistor 7.5 Kiloohm/0.25 watt.

Other components have the same values as the corresponding components of the third embodiment of the

voltage converter.

Fig. 6 illustrates the relationship between the temperature of the heatsink and the current drawn from the output of the voltage converter of Fig. 3 or Fig. 5.

5 The two curves represent respectively the cases that the input to the voltage converter is 23.3 volts (the lowest voltage typically delivered by a lorry's battery) and 27.6 volts (which may be delivered while the battery is charging). Ideally, the converter is operated in a range
10 of currents between the two curves.

It has been found that the first, third and fifth embodiments of the invention given above fulfill the following specification.

Output Voltage :- 13.8 Volts DC.

15 Output Current :- 0 to 15 Amps.

Input Voltage :- 23.3 Volts to 27.6 Volts DC.

Maximum Input

Voltage Overvolt :- 35 Volts DC Short Term Fault
Condition Vehicle Supply

20

Current Overload

Protection :- Type 2 Current Limit at 15 amps.
(Also Type 1).
:- Type 3 Current Foldback at 15 amps.

25

Operating Temperature

Range :- Better than -40°C to +40°C *
*At +40°C Heatsink Temperature is

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86°C/15 amps.

The second and fourth embodiments deliver up to five and fifteen amps respectively, or a maximum wattage of 60 or 180 Watts respectively.

5 Fig 7 is an end view of a heatsink 14 suitable for use as the heatsink for the regulator unit. The heatsink 14 is suitably an aluminium extrusion. It has longitudinal symmetry, and is to be mounted with its longitudinal axis vertical for maximum dissipation of
10 heat by convention.

 Fig. 8 illustrates how the regulator circuit may be built into the heat sink 14 shown in Fig. 7 to provide a heat sink unit. Components 17 of the regulating circuit, connected by a printed circuit board 19, are
15 placed in contact with a central surface 15 of the heat sink 14, so that good thermal conduction is obtained between the components 17 and the surface 15. The circuit is then potted in a thermally conductive potting compound 21 which provides mechanical support for the
20 circuit board 19. The regulating circuit does not extend along the whole length of the heatsink 14, but leaves end portions of the surface 15 uncovered. Thus, when the potting compound is applied, along the whole length of

the heatsink 14, the regulating circuit is entirely surrounded by the potting compound except for the portions of the components 17 which contact the heatsink 14. Thus, the regulating circuit is completely protected from physical interference and also from contact with any moisture which comes into contact with the heatsink unit. The potting compound also makes a sealing contact with electrical leads projecting through it to the regulating circuit, thus ensuring that moisture does not leak to the regulating circuit in this way. Preferably, the heatsink unit is made completely waterproof, or at least splashproof, in this way.

An upper surface of the potting compound 21 is covered by a plate 22. Thus the heat sink 14, and the plate 22 constitute a housing 25 for the regulating circuit.

A second plate 23 closes the cavity at the other side of the heat sink. The two plates 22, 23 are secured together by a pin 24 with cap 25, 26. The cavity formed between the plate 23 and the central region 15 of the heat sink 14 is filled with a potting compound 27.

The potting compound 21, 27 used in this embodiment is preferably thermally conductive, for

example it may be a compound such as ER2/83 supplied by Electrolube.

Fig. 9 is a perspective view of the unit shown in Fig. 8. A bracket 30 is attached to the heat sink unit by screws 31, 33, and is adapted for connection using apertures 35, 37 to the body of a piece of machinery such as under the dashboard of or to the chassis of a lorry. Electrical inputs to the heat sink unit are via leads 38 and plug 39.

Fig. 10 illustrates in perspective view a resistor unit 45 containing the resistor (R1, R1') of an embodiment of a converter according to the invention. The resistor has pins 41, 43 by which it may be electrically connected to the rest of the converter. The resistor unit 45 includes its resistor surrounded by, and electrically insulated from, cylindrical portion 46 of a housing including plates 47, 49. The housing is an aluminium extrusion. The plates 47, 49 are provided with apertures 51, for attaching the housing, for example, to the chassis of a lorry, so that excellent thermal conduction between the resistor and the chassis is obtained. The cylindrical portion 46 is externally ribbed, to assist heat dissipation by convention, but

typically in use between 50 and 100 watts are thermally conducted to the chassis.

Fig. 11 illustrates the installation of a converter according to the invention into the cab 50 of a lorry. The heat sink unit 51 is placed, with its longitudinal axis vertical inside the bonnet bulkhead. The ballast resistor 53 is located in the chassis area. The converter further comprises a fuse holder 55 inside the cab bulkhead, a multi connector kit 57, also within the cab bulkhead, and a LED 59 kit mounted on the dashboard.

Many modifications to the above embodiments are possible within the scope of the invention, as will be clear to those skilled in the art. For example, although preferable it is not necessary that the regulating circuit is of the linear conversion form, and alternative embodiments employing an oscillation-based regulating circuit are acceptable. The converter may also be used in combination with vehicles other than lorries, such as marine vessels for example, or even with less transportable items of machinery containing a DC power source.



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CLAIMS:

1. A converter for a DC power supply having an input resistance means in series with a DC regulating circuit
5 of which an output is to be at a voltage lower than an input voltage into the converter, the resistance means (4) being locatable distant from the regulating circuit (3).
2. A converter according to claim 1, wherein the
10 resistance means and regulating circuit are in separate respective housings (4,3; 45,14).
3. A converter for a DC power supply comprising an input resistance means connected in series with a DC
15 regulating circuit of which an output is to be at a voltage lower than an input voltage into the converter, the resistance means (4) and regulating circuit (3) being adapted for mounting in different respective locations on a piece of equipment.
4. A converter according to any one of the preceding
20 claims in which the regulating circuit employs linear converters.
5. A converter according to any one of the preceding claim in which the regulating circuit is selected so that



in use a major proportion of the heat generated by the converter is generated by the resistance means.

6. A converter according to any one of the preceding claims in which the regulating circuit is selected to
5 limit the current which in use is drawn from the converter.

7. A converter according to any one of the preceding claims in which at least the resistance means is adapted for mounting on the body of a piece of equipment with
10 good heat conduction therebetween.

8. A converter according to any one of the preceding claims in which one or both of the resistance means and the regulating circuit is provided with means for transmitting heat generated therein to ambient air.

15 9. A converter according to any one of the preceding claims in which the regulating circuit contains no oscillator circuitry and which generates substantially no radio frequency electromagnetic radiation.

10. A converter according to any one of the preceding
20 claims in which the regulating circuit is selected to cease to supply an output voltage when at least a portion of the regulating circuit is at a temperature above a predetermined value.

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11. A converter according to any one of the preceding claims wherein the input resistance means has a resistance in the range of about 0.1 to about 10 ohms.

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