"APPLIANCE POWER SUPPLY"

TECHNICAL FIELD

This invention relates to DC power supplies and in particular, but not solely, power supplies for whiteware appliances.

BACKGROUND ART

Modern whiteware appliances commonly use switched mode power supplies to supply power to motors, solenoids and control electronics. Such power supplies consume power even when on standby (a condition which the user considers as being switched off). Further, switched mode power supplies require the use of relatively expensive components such as inductors and capacitors having a high working voltage. In such whiteware appliances it is common to control motor torque and speed using pulse width modulation (PWM) techniques to control current supplied to the motor windings. Such PWM circuits also require relatively expensive components.

It is an object of the present invention to provide a power supply which goes at least some way towards overcoming the abovementioned disadvantages.

DISCLOSURE OF INVENTION

Accordingly the invention consists in a controlled variable output DC power supply comprising:

a rectifier means, which receives AC from a mains supply,

a reservoir capacitor which in use provides the DC output of said power supply,

a semiconductor switching device in series with said reservoir capacitor which controls current flow from the output of said rectifier means to said reservoir capacitor,

a voltage dropping resistor connected in series with said rectifier means which when said supply is in the ON mode reduces the peak unidirectional voltage provided from the rectifier means to a level compatible with the maximum DC output voltage of said supply,

and means for variably controlling the conduction angle of said switching device to vary the DC voltage across said reservoir capacitor to a desired value.

In a further aspect the invention consists in a washing appliance having a motor and a water heating element, said motor being powered by a DC power supply having an ON mode and a standby mode comprising:

a rectifier means, which receives AC from a mains supply,

a reservoir capacitor which in use provides DC to said motor,

a semiconductor switching device in series with said reservoir capacitor which controls current flow from the output of said rectifier means to said reservoir capacitor,

said heating element connected in series with said rectifier means which when said supply is in the ON mode reduces the peak unidirectional voltage provided from the rectifier means to a level compatible with the maximum DC output voltage of said supply,

and means for variably controlling the conduction angle of said switching device to vary the DC voltage across said reservoir capacitor to a desired value.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred forms of the invention will be described with reference to the accompanying drawings in which:

Figure 1 is a circuit diagram of a dc power supply particularly suited to whiteware appliances such as dishwashers, and

Figure 2 is a waveform diagram of current through a semiconductor device in the power supply.

BEST MODES FOR CARRYING OUT THE INVENTION

The power supply of the present invention is particularly suited for use in whiteware appliances having built-in heater elements such as dishwashers and washing machines and such an embodiment will now be described.

A simplified circuit diagram of the power supply of the present invention is shown in Figure 1. This power supply is a transformerless design which uses a high power voltage dropping resistor R1 and phase control of mains halfwaves to provide a variable voltage direct current rail having a voltage V_{dc} which can be varied under microprocessor control in the range 30 volts to 85 volts. Typically the variable voltage

output would be used to control an appliance motor and voltage dropping resistor R1, which dissipates significant power, would form the water heating element.

The use of a power dissipating voltage dropping resistor, such as R1 in the present invention, would for many power supply applications be considered unacceptable, but for home appliances incorporating water heating the power dissipated from such a resistor can be put to good use as a water heating element. Thus in such applications this normally disadvantageous circuit feature can be converted to an advantage.

Referring to Figure 1 the AC mains supply voltage V_{ac}, which may be 230/240 volts or 110 volts, is fed to a full wave bridge rectifier BR via a voltage dropping resistor in R1 in series with the neutral conductor. Bearing in mind the maximum DC voltage to be supplied by the power supply is typically 85 volts the value of R1 must differ depending on the nominal mains voltage. For a 50 Hz 230 volt mains supply and an output of 85 volts with the maximum current of 1 amp the value of R1 is 129 ohms. For a 110 volt 60 Hz supply the value of R1 is 29 ohms.

A large value reservoir capacitor C3 is charged from bridge rectifier BR to provide the variable voltage DC power. The value of the output voltage is determined by phase switching of transistor Q_1 which is an insulated gate bipolar transistor (IGBT). The conduction angle of Q_1 is controlled by a microprocessor μP_1 for the purpose of determining appliance motor torque at various stages of a wash cycle. Conduction angle control of Q_1 is indicated by the waveform diagram in Figure 2 which shows collector current I. The value of conduction angle t_{on} is increased or decreased to in turn increase or decrease the output voltage V_{dc}.

It has been determined that a suitable value for reservoir capacitor C3 is 1000 μF. This will give a ripple voltage of between 3 and 4 volts and the capacitor will require a ripple current rating of at least 1 amp. The use of voltage dropping resistor R1 means that the DC voltage rating of capacitor C3 can be relatively modest, namely 100 volts.

To minimise radio frequency interference during switching of Q_1 it is necessary to control the turnoff time t_{off} to reduce the rate of change of current dI/dt. For triac

phase control it would be necessary to use inductances typically of the value from 2 to 5 mH. With the present power supply circuit the use of such inductances can be avoided by utilising the Miller effect. The gate resistance of IGBT Q_1 in conjunction with the Miller capacitance provides an approximately linear fall in voltage with respect to time. The gate charge of Q_1 is discharged at a rate determined by the gate voltage and the gate resistor R9.

The bias current for Q_1 must be obtained directly from the AC mains to ensure there will be sufficient voltage difference relative to the collector of Q_1 from which to derive supply during positive mains half cycles. The bias supply is a half wave supply provided by diode D1 and capacitor C4.

The bias supply for Q_1 must meet two onerous requirements. First it must ensure proper operation at both 110 and 230 volt mains supplies. Second it must ensure fast start-up on power on to ensure Q_1 does not operate in a potentially destructive linear mode. If Q_1 is either off or in a linear mode during a negative half cycle then there will be a voltage difference between the collector and gate producing a current to the bias supply via diode D2. Resistor R8 acts to isolate capacitor C4 which would otherwise prevent any instantaneous gate drive. Resistor R2 serves to protect diodes D1 and D2 during transient mains spikes which could cause reverse breakdown on either diode.

Microprocessor μP_1 which will usually be the same device that forms the appliance controller, controls the output voltage of the power supply by controlling Q_1 through transistor Q_2. The microprocessor requires time pulses so as to synchronise with the mains half cycles. A zero crossing detector circuit XD provides these timing signals.

The power supply of the present invention provides a number of advantages in applications where the power dissipated in voltage dropping resistor R1 can be put to good use. These include the absence of inductors, the avoidance of the need for a PWM circuit for motor control, low voltage rating for the reservoir capacitor, reduced radio frequency interference and reduced power consumption when the appliance is on standby. Further, the value of only one component needs to be changed as between a

power supply for 110 volt mains and a power supply for 230 volt mains. This is the value of the dropping resistor which, as already explained, is implemented by the appliance water heating element.

In Figure 1 dropping resistor R1 is shown located between the mains supply and the bridge rectifier, but it may be located on the DC side of the bridge rectifier.

In conjunction with the reduction of power when on standby the present circuit has the advantage over conventional switch mode controlled power supplies in that it is unnecessary to use a separate standby power supply.

In most appliances one or more fixed voltage DC power supplies will also be required and these can be derived from the present variable voltage DC supply by the use of pulse width modulator supplies to provide voltages at values such as 5 volts and 24 volts.

WHAT WE CLAIM IS:

1. A controlled variable output voltage DC power having a standby mode comprising:

a rectifier means, which receives AC from a mains supply,

a reservoir capacitor which in use provides the DC output of said power supply,

a semiconductor switching device in series with said reservoir capacitor which controls current flow from the output of said rectifier means to said reservoir capacitor,

a voltage dropping resistor connected in series with said rectifier means which when said supply is in the ON mode reduces the peak unidirectional voltage provided from the rectifier means to a level compatible with the maximum DC output voltage of said supply,

and means for variably controlling the conduction angle of said switching device to vary the DC voltage across said reservoir capacitor to a desired value.

2. A power supply according to claim 1 wherein said voltage dropping resistor is connected in series with the input of said rectifier means.

3. A power supply according to claim 1 wherein said voltage dropping resistor is connected in series with the output of said rectifier means.

4. A power supply according to any one of the preceding claims wherein said power supply supplies power to a motor in a home appliance which uses hot water and said voltage dropping resistor is a heating element for heating said water.

5. A power supply according to claim 4 wherein said means for variably controlling the conduction angle of said semiconductor switching device is a microprocessor.

6. A washing appliance having a motor and a water heating element, said motor being powered by a DC power supply having an ON mode and a standby mode comprising:

a rectifier means, which receives AC from a mains supply,

a reservoir capacitor which in use provides DC to said motor,

a semiconductor switching device in series with said reservoir capacitor which controls current flow from the output of said rectifier means to said reservoir capacitor,

said heating element connected in series with said rectifier means which when said supply is in the ON mode reduces the peak unidirectional voltage provided from the rectifier means to a level compatible with the maximum DC output voltage of said supply,

and means for variably controlling the conduction angle of said switching device to vary the DC voltage across said reservoir capacitor to a desired value.

7. A washing appliance according to claim 6 wherein said water heating element is connected in series with the input of said rectifier means.

8. A washing appliance according to claim 6 wherein said water heating element is connected in series with the output of said rectifier means.

9. A washing appliance according to any one of the preceding claims including a wash cycle controller and wherein said means for variably controlling the conduction angle of said semiconductor switching means is said controller.