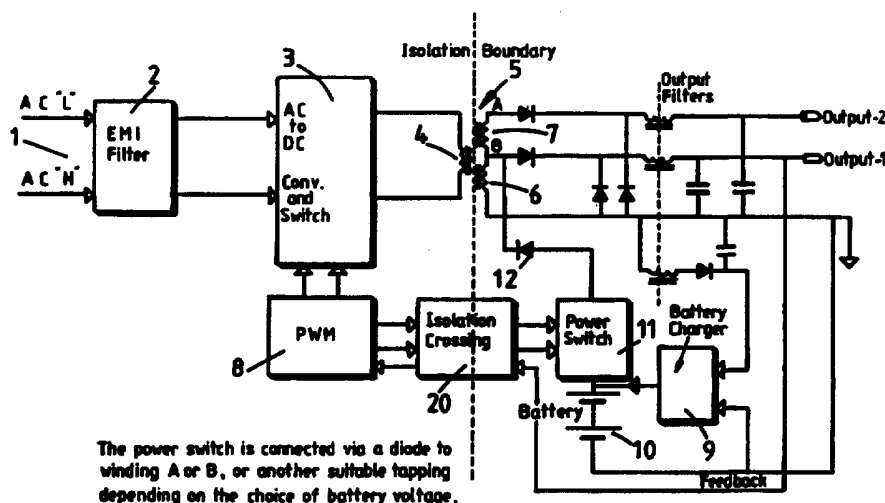




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(54) Title: UNINTERRUPTIBLE POWER SUPPLIES



Basic "Automatic" UPS
(Primary Side Control)

(57) Abstract

An uninterruptible power supply has an input (1) for receiving AC utility power and an AC to DC converter which acts in combination with a power switch (15) to provide a chopped DC signal to a primary winding (4) of a transformer (5). DC outputs of the supply are arranged to receive power from interconnected secondary windings (6, 7) of the transformer (5). A rechargeable battery (10), which receives charging power from one of the DC outputs, is connected to one of the secondary windings (6, 7) via a power switch (11) and an isolation diode (12) which is normally in a non-conducting state. When the AC utility power level drops below a threshold level the isolation diode conducts power from the battery to the connected secondary winding to maintain regulated voltages on the DC outputs. The power switches (11, 15) are both controlled by a pulse width modulator controller (8) so that the duty cycle of the switches (11, 15) is altered to maintain the regulated DC output voltage constant.

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UNINTERRUPTIBLE POWER SUPPLIES

The present invention relates to uninterruptible power supplies and in particular, though not necessarily, to uninterruptible power supplies for computers.

Uninterruptible power supplies are required for many applications where the loss of mains power has serious implications. For example, where computer systems are used to transfer large amounts of data over a network it is essential that a backup power supply is available in the event that mains power is lost in order to prevent the loss of valuable information.

Early uninterruptible power supplies were generally placed between a standard AC utility outlet and the AC input socket of an electrically powered device. Such power supplies typically included an AC to DC converter for converting received AC power into DC power to charge a battery and an DC to AC converter for reconvertng the DC power back into AC power for supply to the AC input socket of the electrical device. This resulted in considerable duplication of circuitry as an AC to DC converter was also included in the integral power supply of the electrical device.

GB 2,120,474A describes a standby power supply system intended to be integrated into an internal power supply of an electrical device and which is intended to reduce the above noted duplication of circuitry which arose with previous uninterruptible power supplies. The system includes an AC to DC converter and an inverter circuit which is used to couple chopped DC power through a transformer into a set of secondary windings arranged to provide regulated DC output voltages for internal use by the electrical device. A battery is coupled via a tertiary winding of the transformer to the secondary windings and is arranged to provide electrical power to the secondary windings when the input AC voltage fails. However, the additional winding required to couple the battery to the secondary windings results in increased manufacturing costs and an increase in the overall size

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of the system.

EPO,243,061 describes a power supply system similar to that of GB2,120,474A where the battery is coupled to the tertiary winding via a diode. The circuit is
5 arranged so that, under normal operating conditions the diode is reverse biased, isolating the battery from the tertiary winding. However, when the AC voltage drops, resulting in a corresponding drop in voltage across the tertiary winding, the diode becomes forward biased
10 providing power from the battery to the tertiary winding.

Document WO 91/07803 describes an uninterruptible power supply in which the battery is coupled directly to one of the secondary windings of the transformer to couple power directly to the corresponding output. Power
15 is also reflected through the transformer, from that secondary winding, to the other secondary windings to provide DC power to the other DC outputs. Whilst this power supply of WO 91/07803 results in a considerable simplification in the power supply circuitry, and to a
20 reduction in the size of the supply, there remains a need to provide a simpler and cheaper power supply system.

It is an object of the present invention to overcome or at least mitigate certain of the disadvantages of known uninterruptible power supplies.

25 According to the present invention there is provided an uninterruptible power supply comprising:

- an input for receiving AC utility power;
- an AC to DC converter coupled to the AC input and arranged to generate DC power at an output of the
30 converter;
- a transformer;
- an inverter coupled between the AC to DC converter and a primary winding of the transformer and arranged to supply a chopped DC voltage to the primary winding, so
35 that a corresponding chopped DC voltage, having an amplitude V_1 , is generated across a secondary winding of the transformer coupled to said output;

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an auxiliary power supply comprising energy storage means operable at a voltage V_b ; and

diode isolation means coupled between a supply terminal of the energy storage means and said secondary winding, wherein the diode isolation means is arranged to
5 be in a non-conductive state when V_i is greater than V_b to isolate the energy storage means from the secondary winding and in a conductive state when V_b is greater than V_i to supply current through the diode isolation means to
10 the secondary winding.

Using the arrangement of the present invention, there is no need for an extra transformer winding, or transformer, to couple the energy storage means to the regulated DC output(s) through the secondary winding(s).
15 There is also no need for complex comparison means for detecting a critical drop in AC utility input.

Preferably the auxiliary power supply comprises an inverter coupled between the energy storage means and said secondary winding of the transformer, the inverter
20 being in series with the diode isolation means and being arranged to supply a chopped DC voltage to said secondary winding when the diode isolation means is in a conducting state. Where the power supply comprises a pulse width modulation controller for providing a variable duty cycle
25 control signal to the first mentioned inverter in order to regulate the output voltage from the power supply, the auxiliary power supply inverter may also be controlled by the same control signal. The auxiliary power supply inverter may comprise a FET, preferably a MOSFET, or
30 another suitable semiconductor switch.

Typically, where the energy storage means is a battery, a battery capacitor is coupled in parallel with the battery, close to the power switch, for the purpose of providing current pulses to the secondary winding when
35 the diode is forward biased. Thus, the current drawn from the battery is substantially DC and noise radiation is kept to a minimum allowing the battery to be located

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remotely from the inverter or power switch. In one embodiment of the invention, the capacitor is coupled directly across the battery terminals, between the battery and the diode isolation means. However, in an
5 alternative embodiment, the diode isolation means is -coupled between the battery and the battery capacitor. This latter configuration results in the capacitor charging up to a voltage higher than the battery voltage, via the secondary winding, and a peak charging circuit,
10 when the diode isolation means is in a non-conducting state. This allows the battery to be charged by a battery charger connected to the battery capacitor. The necessity for coupling a battery charger independently to a DC output of the supply via an additional winding is
15 therefore eliminated. A further advantage is that the reduced power requirements made upon the diode allow the diode to be smaller and cheaper, and allow it to be positioned remotely from the main power supply components, e.g. together with a battery pack.

20 Preferably, a thermistor is coupled between the AC input and the primary winding of the transformer. More preferably, the thermistor is coupled between the rectifier of the AC to DC converter and the smoothing or hold-up capacitor. The thermistor is a resistor whose
25 resistance decreases with increasing temperature. When the AC utility power level is normal, the current flowing through the thermistor maintains it in a high temperature, low resistance state. However, following loss of AC power for a prolonged period, the thermistor
30 temperature falls and its resistance rises to a relatively high level. When the AC power is subsequently reapplied the high resistance of the thermistor limits the inrush current into the hold-up capacitor. This enables the changeover from the auxiliary power supply to
35 the main power supply to be conducted in an orderly manner.

For a better understanding of the present invention

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and in order to show how the same may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:

5 Figure 1 shows in schematic form an automatic uninterrupted power supply having a primary side pulse width modulation controller;

Figure 2 shows typical chopped DC waveforms present on a secondary winding of a transformer of the power supply of Figure 1;

10 Figure 3 shows in more detail the uninterrupted power supply of Figure 1;

Figure 4 shows an automatic uninterrupted power supply having a secondary side pulse width modulation controller;

15 Figures 5(a) to 5(f) show alternative circuits for implementing an auxiliary power supply power switch of the uninterruptible power supplies of Figures 1 and 4;

20 Figures 6(a) to 6(f) show six alternative configurations for the transformer secondary side circuits of the uninterruptible power supplies of Figures 1 and 4;

Figures 7 (a) to (c) illustrate a modification of the power supply of Figures 1 and 4;

25 Figure 8 shows a further alternative configuration for the transformer secondary side circuit of the power supplies of Figures 1 and 4; and

Figure 9 illustrates a modification of the power supply of Figure 1.

30 There is shown in Figure 1 an uninterruptible power supply (UPS) having an auxiliary power supply which "cuts-in" to replace a failed AC utility power supply.

35 The UPS has an input 1, comprising live and neutral input lines L,N, for receiving AC utility power from a mains socket. An electromagnetic interference (EMI) filter 2 is coupled to the AC input 1 to prevent switching noise being coupled back from the power supply into the mains supply. AC power transmitted through the

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EMI filter 2 is coupled to an AC to DC converter and switch unit 3 which provides at its output a chopped DC voltage, typically having an amplitude between 130 and 400 Volts, for example 384 Volts. This chopped DC voltage is fed into the primary winding 4 of a transformer 5 such that corresponding chopped voltages are induced on a pair of interconnected secondary windings 6,7 of the transformer 5. The induced voltages are rectified and smoothed to provide regulated DC output voltages, typically less than 50V, for example 3.3V and 5V at output_1 and output_2 of the power supply.

The unit 3 which generates the chopped DC voltage for application to the primary winding 4 of the transformer 5 includes a switch which is controlled by a pulse width modulation controller 8 which varies the duty cycle of the chopped signal in order to maintain the voltage at output_1 and output_2 at the correct levels. This is achieved by a feedback signal taken from output_1 and delivered to the controller 8 where it is compared against a reference value. The feedback signal is delivered to the controller 8 via an isolation circuit 20.

Power is inductively coupled from inductive filters, forming part of the smoothing circuit at the output side of the transformer 5, to a battery charger unit 9 which supplies power to maintain a battery 10 in its fully charged state. The positive terminal of the battery 10 is coupled through a power switch 11 and a commutation diode 12, which forms a diode isolation means, to the tap connecting the two secondary windings 6, 7. The power switch 11 functions in the same way as the switch of the unit 3 to provide a chopped DC output from the battery 10 and is controlled by the same pulse width modulation controller 8 that is used to control the unit 3. The switching signal from the controller 8 is delivered to the switch 11 via the isolation circuit 20.

During normal operation, when the AC input to the

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power supply is maintained at its regulated level, the primary winding 4 of the transformer 5 is supplied with a chopped DC voltage of amplitude 384V. For a turns ratio of 24:1 for the primary winding 4 with respect to the secondary winding 6, a corresponding chopped voltage V_s of amplitude 16V is induced on the secondary winding 6. With a 12V battery V_b , the commutation diode 12 is therefore reverse biased by a voltage of 4V. The pulse width modulation controller 8 is arranged to have a nominal duty cycle of 0.24 so that the output₁ of the power supply provides a 3.3V DC volt output.

As the pulse width modulation controller 8 drives the switch of unit 3 and the power switch 11 in synchrony, both switches are off at the same and, when they are both on, the commutation diode 12 prevents power from being drawn from the battery to supply output₁ and output₂.

When the AC utility supply fails, the voltage induced on the secondary winding 6 of the transformer will fall and in an effort to compensate for this the duty cycle of the controller will rise. When the voltage across the secondary winding 6 drops below 11.5V (allowing for the diode drop) the commutation diode 12 is forward biased and current is supplied from the battery 10 to the tap between the secondary windings 6, 7. This 11.5V threshold voltage is reached when the duty cycle has risen to approximately 0.33. The current delivered by the battery 10 flows directly to output₁ and indirectly via secondary winding 7 to output₂. Thus the feedback signal for the controller 8 is re-stabilised and control of the switch 11 is re-established to maintain output₁ and consequently output₂ at the correct level. Additionally, current flowing through the secondary windings 6 and 7 induces a voltage via the transformer core across the primary winding 4 so that any energy storage facility within unit 3 (see below) is at least partly re-charged despite the absence of energy from the

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utility supply 1.

Figure 2 shows the chopped 16V DC voltage present on the secondary winding 6 when the power supply is functioning normally. As the AC utility supply begins to fall, the pulse width modulation controller 8 increases the duty cycle of the chopped voltage supplied to the primary winding in order to maintain the DC output voltages at their correct levels. When the duty cycle reaches 0.33, corresponding to a DC voltage amplitude on the secondary winding 6 of 11.5V, the commutation diode 12 becomes forward biased and conducts power from the battery 10 to the supply outputs as described above. The system is designed so that the maximum duty ratio (0.33) during AC operation (at minimum AC voltage) is numerically less than the minimum duty ratio (say 0.35) when operating on a fully charged battery.

Figure 3 shows in more detail the power supply of Figure 1. Power transmitted through the EMI filter 2 is full wave rectified by a four diode arrangement and is supplied to a DC to DC forward converter 15 through a power factor corrected (PFC) pre-regulator. The PFC pre-regulator comprises a second pulse width modulation controller 13 operable to switch a FET 14 on and off to maintain a substantially constant voltage of approximately 384V on an energy storage capacitor 16.

The forward converter comprises a second FET 15 coupled in series with the primary winding 4 of the transformer 5, the gate of the FET being controlled by the first pulse width modulation controller 8. The capacitor 16 is connected across the series coupled primary winding 4 and FET switch 15 and acts as a "hold-up" capacitor to maintain the DC voltage supplied to the transformer for a short period following a drop in AC utility power.

As described above, the secondary windings 6,7 are coupled to respective DC regulated output terminals via respective pairs of rectifying diodes and filters. A

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signal from output_1 (3.3V) is fed back to the first pulse width modulation controller 8 via a voltage feedback and shaping circuit 17 and an opto-isolator 18 and the pulse width modulation controller 8 varies the duty cycle of the FET switching signal to maintain the DC output voltages at their regulated levels.

The power switch 11 which is coupled between the positive terminal of the battery 10 and the commutation diode 12 is formed by a circuit arrangement which in this embodiment comprises a FET 19, the gate of which is driven by the pulse width modulation controller 8 through an isolation transformer 20. A capacitor 22 is coupled in parallel across the terminals of the battery 10 and provides pulse current to the secondary winding 6 when the diode 12 is forward biased. The capacitor 22 is charged by DC current drawn from the battery. As the battery supplies substantially only DC current, it can be located remote from the power switch 11 without generating significant levels of electromagnetic interference.

A current feedback signal for the controller 8 to regulate the rate of change of the duty cycle is either supplied from FET 19 via a current transformer or from a sense resistor connected to the FET 15 on the primary side of the transformer, depending upon which energy source is supplying the transformer.

A thermistor 21 is connected between the full wave rectification circuit and an inductor of the PFC pre-regulator. The thermistor has a relatively low resistance when current is flowing through it and it is hot, and a relatively high resistance when that current ceases and its temperature falls. Following failure and subsequent reconnection of the AC supply, the thermistor remains relatively cool for a short period of time during which it has a relatively high resistance. This high resistance prevents a rapid inrush of current from the AC input 1 to the PFC pre-regulator and allows the "hold-up"

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capacitor to charge up in a smooth, orderly way until a point is reached where the amplitude of the chopped signal on the secondary winding 6 exceeds 11.5V, shutting off the auxiliary supply via diode 12 and supplying power to the regulated DC outputs from the AC input.

An additional signal is required to stop the controller 8 when the utility supply 1 is purposely switched off. This inhibits commencement of back-up operation via diode 12 and is accomplished by auxiliary contacts on the primary ON/OFF switch for the utility supply.

There is shown in Figure 4 a modification of the power supply of Figure 1. In the supply of Figure 4, the pulse width modulation controller 8 is arranged on the secondary side of the transformer 5 and is coupled directly to the power switch 11 of the auxiliary power supply and indirectly, through an isolation crossing 20, to the power switch of the unit 3.

There is shown in Figures 5(a) to 5(f) six alternative possible circuit arrangements for the auxiliary power switch 11 for use with the embodiments of Figures 1, 3 and 4. Of these, use of the power switch circuit arrangement shown in Figure 5(f) in the supply of Figure 1 (as an alternative to the power switch circuit arrangement shown in Figure 3) may considerably simplify the overall circuitry as there is no requirement for an additional isolation crossing, and control signals from the pulse width modulation controller 8 may be coupled directly to the power switch.

The embodiments described above are not limited to use with transformer secondary side circuits of the configuration shown in Figure 1. Whilst Figure 6(c) shows the configuration of Figure 1 (with a number of components omitted for simplicity), Figures 6(a), (b) (d), (e) and (f) show alternative configurations to which the above described automatic uninterruptible power supply principle can be applied. In particular, Figures

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6(b) and (d) show possible configurations with energy transfer capacitors Y-X and Z-W coupled to the secondary windings. Examples of such configurations are the Cuk and inverse Sepic converters. In Figures 6(e) and 6(f) the diode 12 of Figure 6(c) is supplemented with an additional diode in parallel but with its cathode connected to the output side of the rectifying diode in the line from the transformer tap to output_1. The result of this is that the power path from the FET 19 is split and the current which emerges from output_1 traverses only a single diode as a result of which there is a greatly reduced power loss, whilst the current which emerges from output_2 comes from the transformer via the same circuit as previously. This leads to a reduced requirement for heat dissipation from the heat sink at the output side of the transformer. With the additional diode of Figure 6(e) it becomes possible to supply each with parallel connected FET switches. This is shown in Figure 6(f). The additional FET which is connected to output_1, after the rectifying diode, is subjected to lower voltage stresses due to the clamping action of the normal free-wheeling diode so that it may be possible to use a lower on-resistance FET device which achieves better efficiency, and is generally cheaper, than the higher on-resistance higher voltage FET. The configurations of Figure 6(e) and 6(f) may require that output_1 and output_2 have separate regulation and filter circuits.

In the embodiments of the invention described above, the battery capacitor 22 is coupled directly across the terminals of the battery 10. For example, Figure 7(a) illustrates one such arrangement where the FET 19 is coupled between the secondary winding of the transformer and the diode 12. However, Figure 7(b) shows an alternative circuit configuration where the diode 12 is coupled between the battery 10 and the battery capacitor 22. In this configuration, the capacitor 22 is charged

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to a higher voltage than that at which the battery 10 is maintained when the AC supply is maintained and the diode 12 is reverse biased. In particular, the battery capacitor is charged to the peak voltage on the secondary winding via a peak charging circuit. When the AC supply fails and the diode 12 becomes forward biased, the battery 10 and capacitor 22 act as described above to provide power to the secondary winding 6 of the transformer 5.

A first advantage of the configuration of Figure 7(b) is that the diode 12 is required to handle a comparatively smooth DC current in its conducting state and not the high current pulses produced using the configuration of Figure 7(a). Thus, the diode can be made smaller and cheaper and, moreover, can be positioned remotely from the high power components of the power supply (e.g. together with a battery pack) because it forms part of the DC circuit. Whilst it may be necessary to provide a battery capacitor 22 having a higher voltage-rating, this is not a serious limitation.

A second advantage is illustrated in Figure 7(c) and involves coupling the battery charger 9 between the battery capacitor 22 and the battery 10. As the battery capacitor 22 is charged to a higher voltage than the battery 10, the battery charging current can be drawn from the capacitor 22. Thus, there is no need for additional wiring, and an additional winding coupled to the output, to provide charging current to the battery charger 9.

All of the arrangements shown in Figure 6 are based upon so-called 'forward' topologies and rely upon inductors in the output circuit and the transfer of power during the 'on' time of the pulse width modulator. However, there is a further class of converters which do not require discrete output inductors and in which energy is stored in the transformer (more correctly termed a 'coupled inductor' for this application) during the pulse

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width modulator 'on' time and is transferred to the output during the 'off' time. This class of converters includes the 'fly-back' or 'buck-boost' converter and the 'sepic' converter.

5 An important distinction when designing automatic
-switching-circuitry for the fly-back class of converter
is that the output polarity is reversed with respect to
the battery and the battery must be connected in a
negative configuration to obtain positive voltage
10 outputs. Figure 8 illustrates a possible secondary side
configuration based upon a flyback converter where the
switching diode 12 is coupled between the battery 10 and
the battery capacitor 22. Note that the source of the
power switch is connected to a fixed voltage point and
15 the switch can be driven without a level shift
transformer (c.f. the circuit of Figure 3).

It will be appreciated that various modifications
may be made to the above described embodiments without
departing from the scope of the present invention. For
20 example, certain components of the supply may be mounted
externally of the device to be powered by the supply. In
particular, where the battery is necessarily large in
order to provide prolonged back-up it may be mounted
externally. In a further modification, the battery may be
25 a standard non-rechargeable battery in which case the
battery charging circuitry described above is not
required. Figure 9 illustrates a particular modification
where the UPS of Figure 1 additionally drives a further
independent inverter and power supply unit via the high
30 voltage energy store on the primary side of the main
transformer. In this case only a single back-up battery
and power switch is required to maintain the various
outputs from the two power supply units because as
previously explained the main transformer charges the
35 primary side storage capacitor at least partially even
during battery back-up operation and the inverter of
switch unit 3 is intentionally kept running at all times

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and functions as a synchronous rectifier to thereby
control charge storage in the capacitor. Of course
further additional independent power supply units may be
connected in parallel with the primary energy storage
5 capacitor.

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CLAIMS

1. An uninterruptible power supply comprising:
an input for receiving AC utility power;
an AC to DC converter coupled to the AC input and
-arranged to generate DC power at an output of the
5 converter;
a transformer;
an inverter coupled between the AC to DC converter
and a primary winding of the transformer and arranged to
supply a chopped DC voltage to the primary winding, so
10 that a corresponding chopped DC voltage, having an
amplitude V_1 , is generated across a secondary winding of
the transformer coupled to said output;
an auxiliary power supply comprising energy storage
means operable at a voltage V_b ; and
15 diode isolation means coupled between a supply
terminal of the energy storage means and said secondary
winding, wherein the diode isolation means is arranged to
be in a non-conductive state when V_1 is greater than V_b to
isolate the energy storage means from the secondary
20 winding and in a conductive state when V_b is greater than
 V_1 to supply current through the diode isolation means to
the secondary winding.
2. A power supply according to claim 1, wherein the
diode isolation means is a single diode.
- 25 3. A power supply according to claim 1 or 2 and
comprising a second inverter coupled between the energy
storage means and said secondary winding of the
transformer, the inverter being in series with the diode
isolation means and being arranged to supply a chopped DC
30 voltage to said secondary winding when the diode
isolation means is in a conducting state.
4. A power supply according to claim 3 and comprising a
pulse width modulation controller arranged to provide a
variable duty cycle control signal to the first mentioned
35 inverter at least when the diode isolation means is in a

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non-conducting state and to the second inverter at least when the diode isolation means is in a conducting state, in order to regulate the output voltage from the power supply.

5 5. A power supply according to claim 3 or 4, wherein
-the energy storage means is a battery and the supply
further comprises a battery capacitor coupled across the
output terminals of the battery and between the battery
and the second inverter.

10 6. A power supply according to claim 5, the diode
isolation means being coupled between the battery supply
terminal and the battery capacitor wherein, when the
diode isolation means is in the conducting state,
substantially only DC current flows through the diode
15 isolation means.

7. A power supply according to claim 6 and comprising a
battery charger coupled in parallel with the diode
isolation means and between the battery capacitor and the
battery, wherein the battery charger supplies charging
20 current from the battery capacitor to the battery when
the diode isolation means is in a non-conducting state.

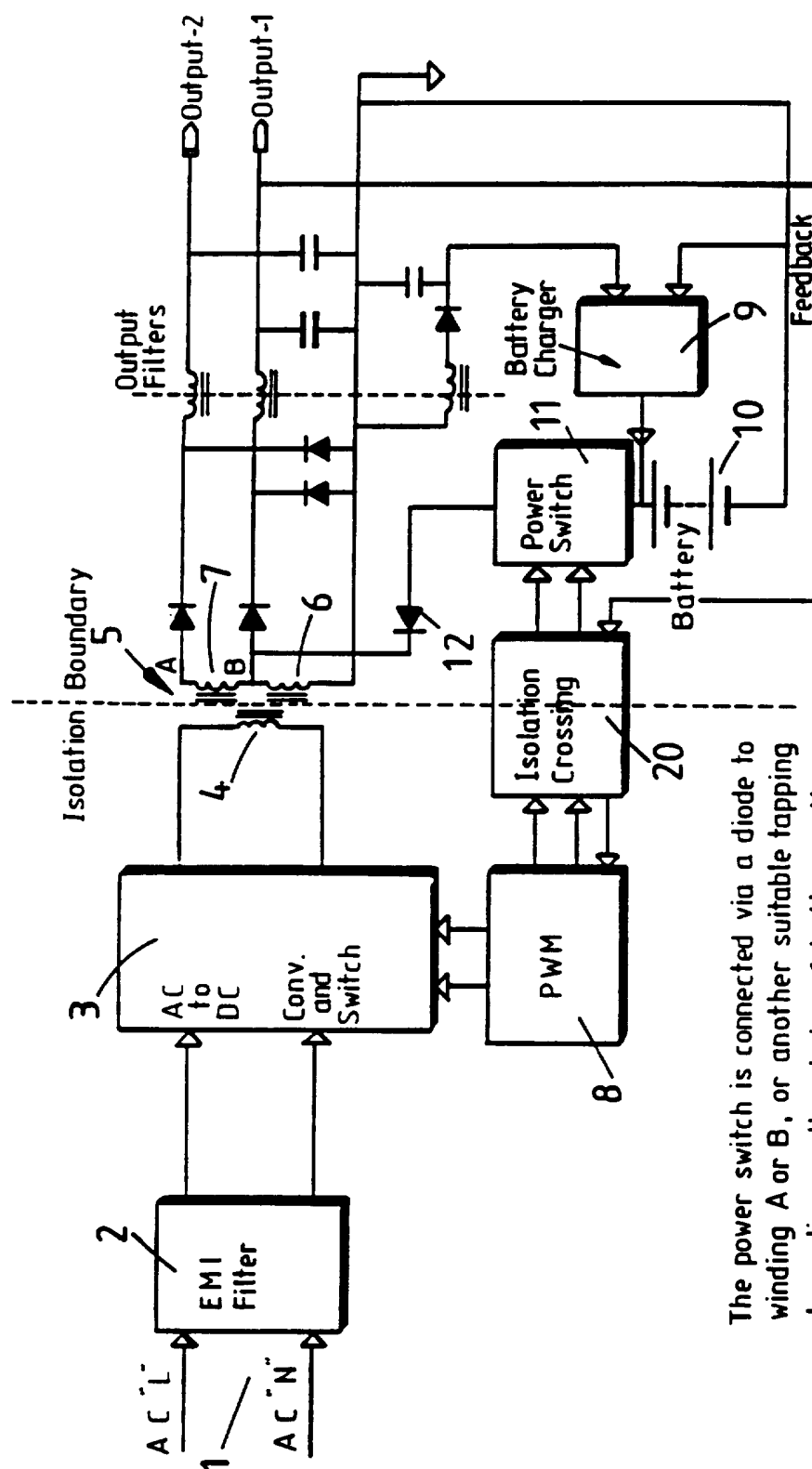
8. A power supply according to any one of claims 3 to
7, wherein the second inverter is selected from one of a
forward, fly-back or sepic configurations.

25 9. A power supply according to claim 8, wherein the
second inverter is a fly-back converter comprising a FET
switch having its source connected to a fixed voltage
point.

30 10. A power supply according to any one of the preceding
claims, and comprising a thermistor coupled between the
AC input and the primary winding of the transformer.

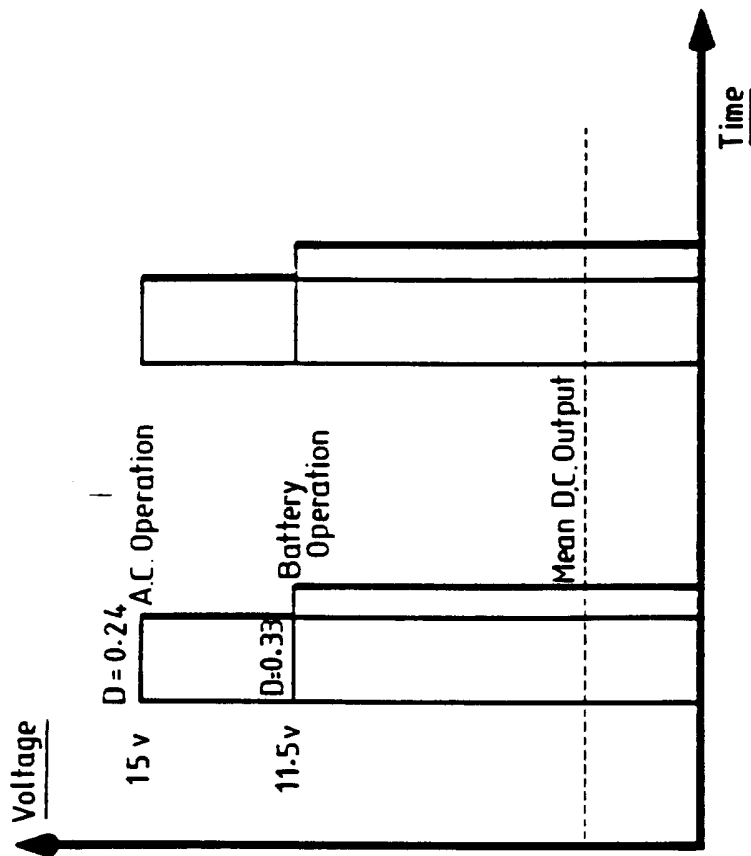
11. A power supply according to claim 10, wherein the
thermistor is coupled between the AC to DC converter and
the first inverter.

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Basic "Automatic" UPS
(Primary Side Control)

FIG. 1

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Voltage impressed on output filter during
normal A.C. operation and during Back-up

FIG. 2

3-10

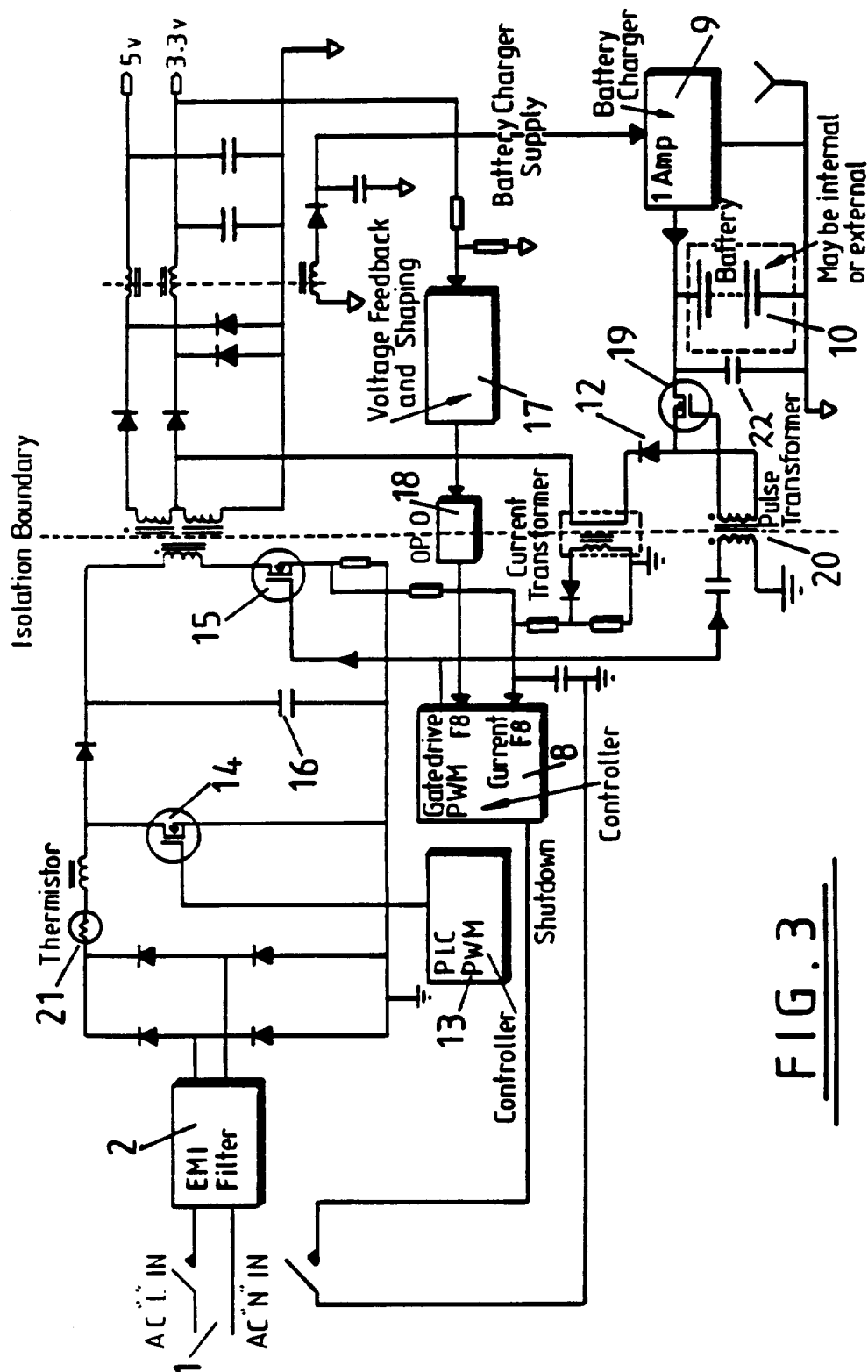
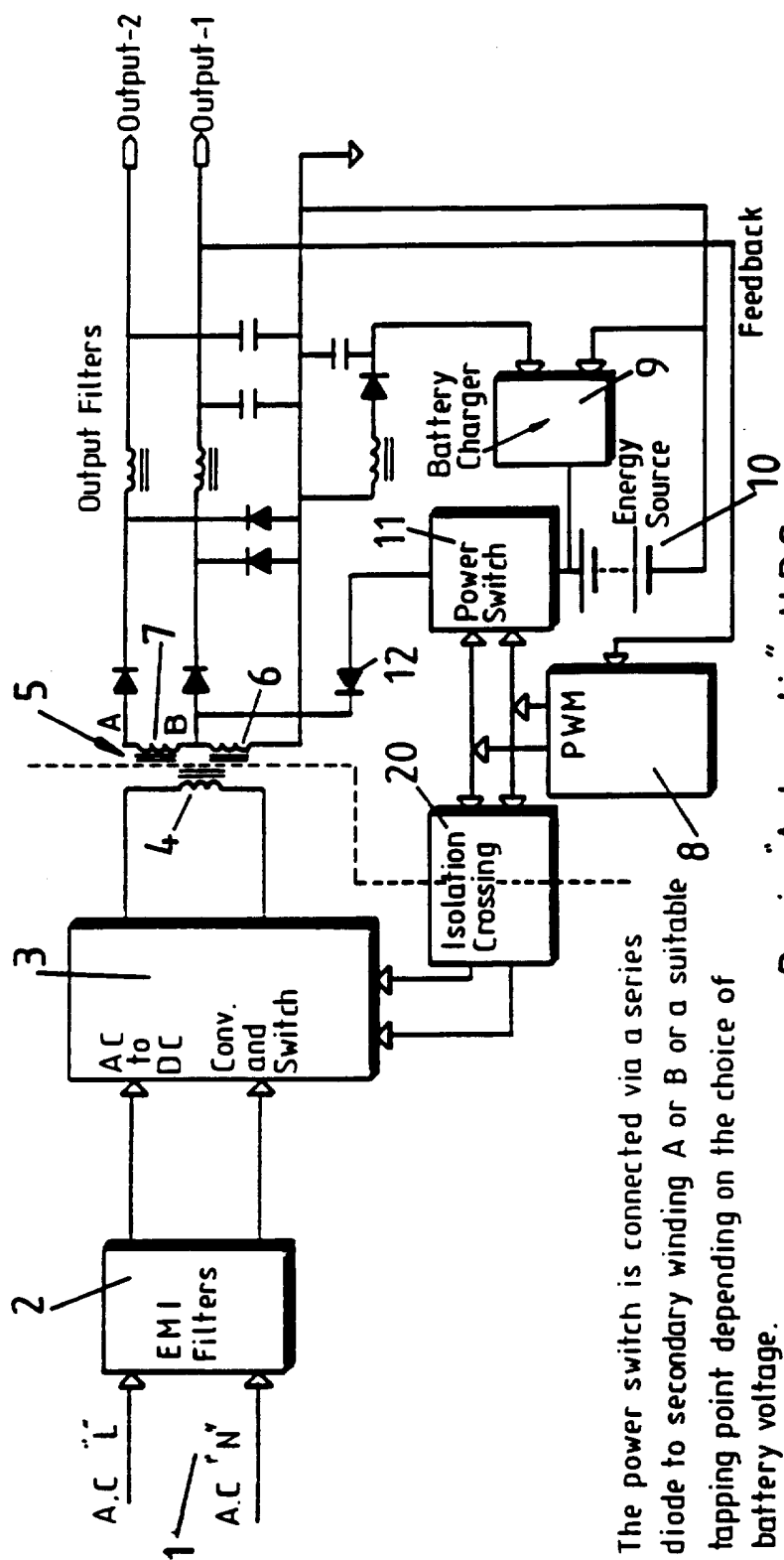


FIG. 3

Simplified Schematic of Practical Automatic UPS

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Basic "Automatic" UPS
(Secondary Side Control)

FIG. 4

Some Possible Arrangements for the Power Switch

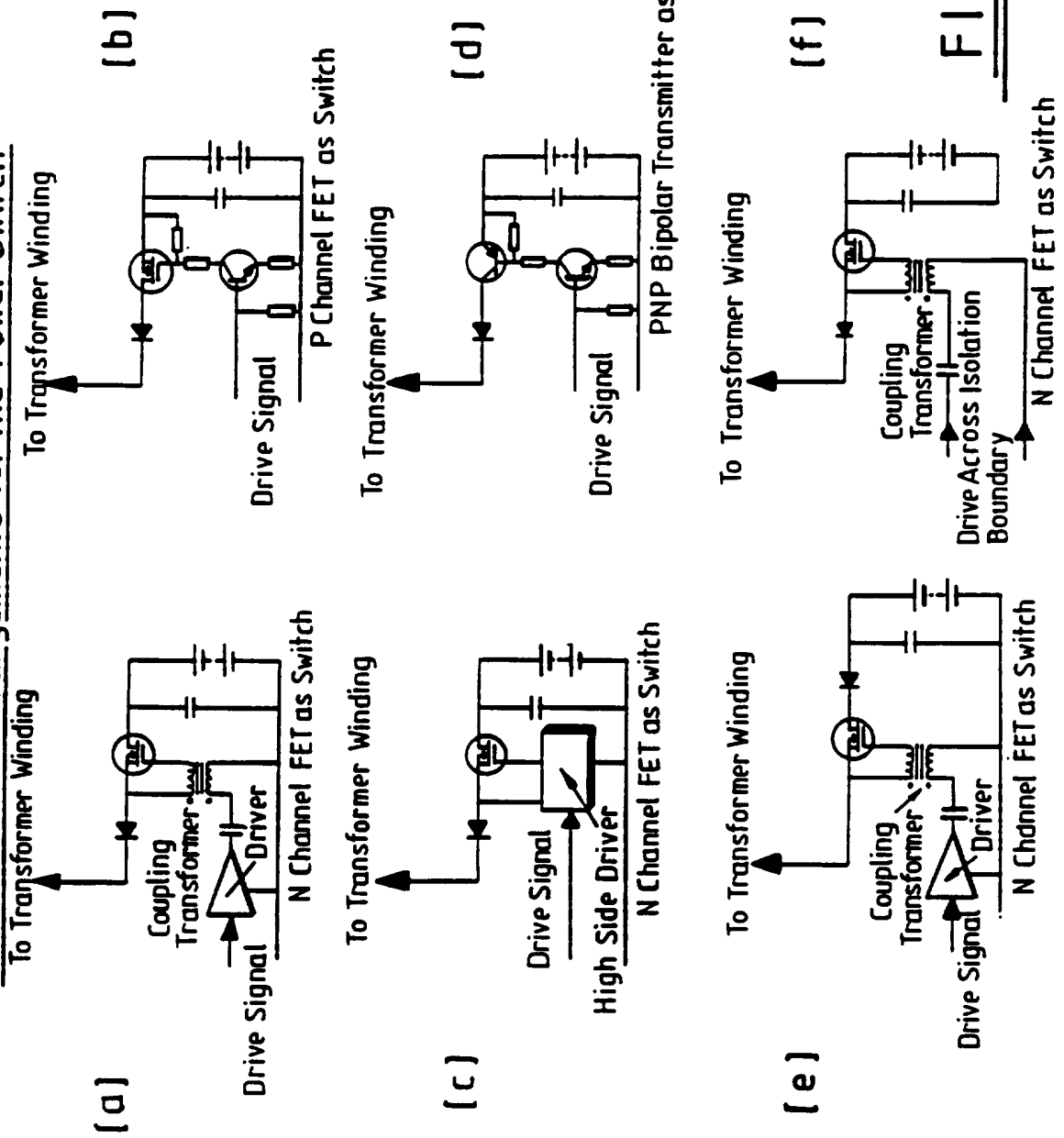
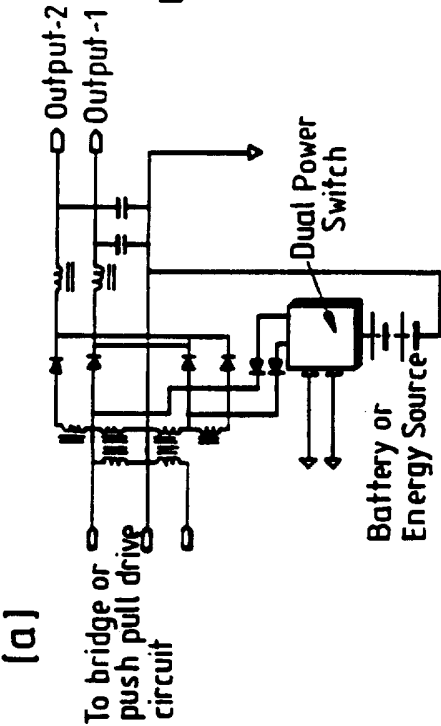
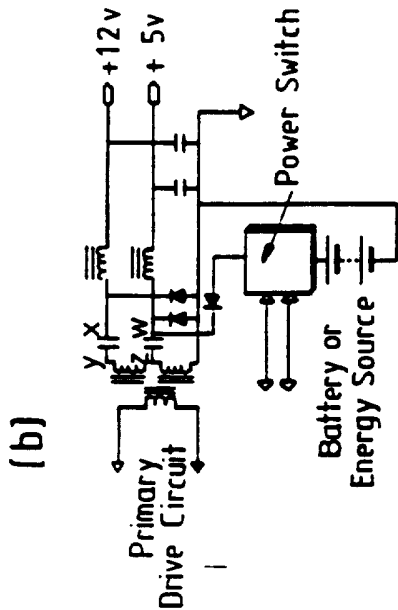


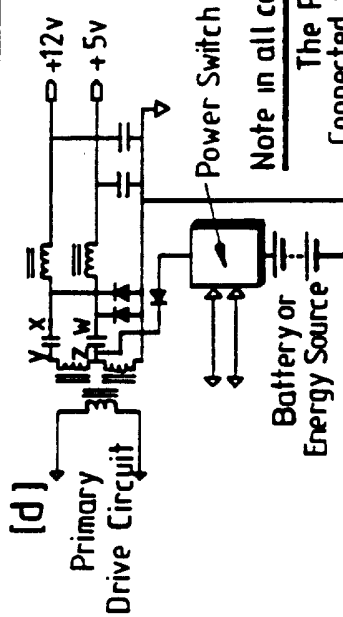
FIG. 5



Output Connections for Double Sided
Converters



Output Connections for Converters with
Energy Transfer Capacitors on Secondary



Note in all cases

The Power Switch is
Connected to an Output Winding
Appropriate to the Battery Voltage

Output Connections for Single
Side Converters

Alternative Output Connections for Converters
with Energy Transfer Capacitors on Secondary

FIG. 6

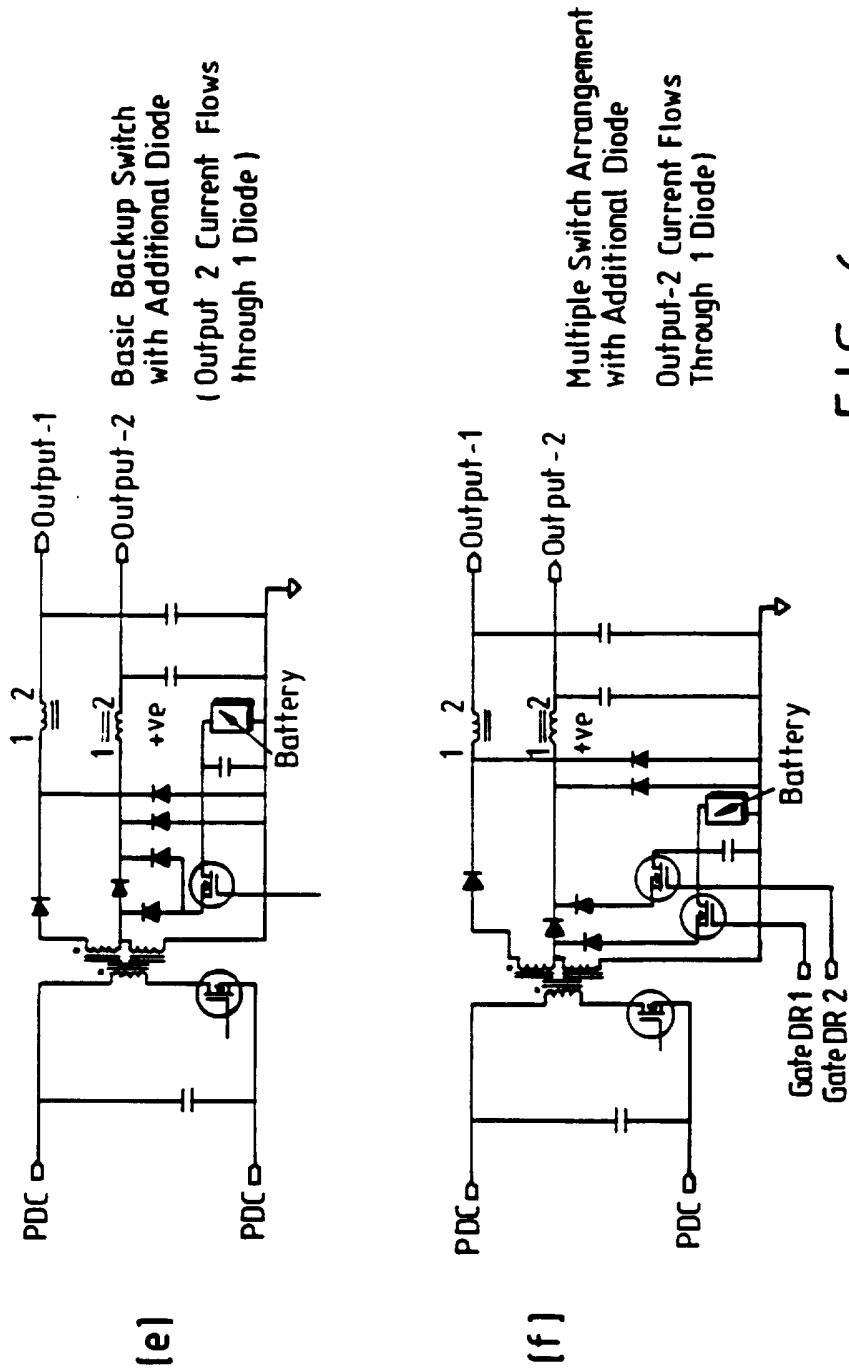
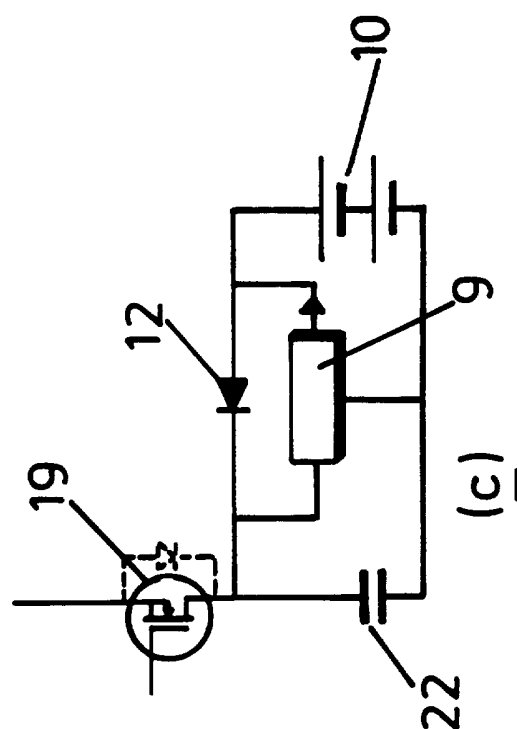
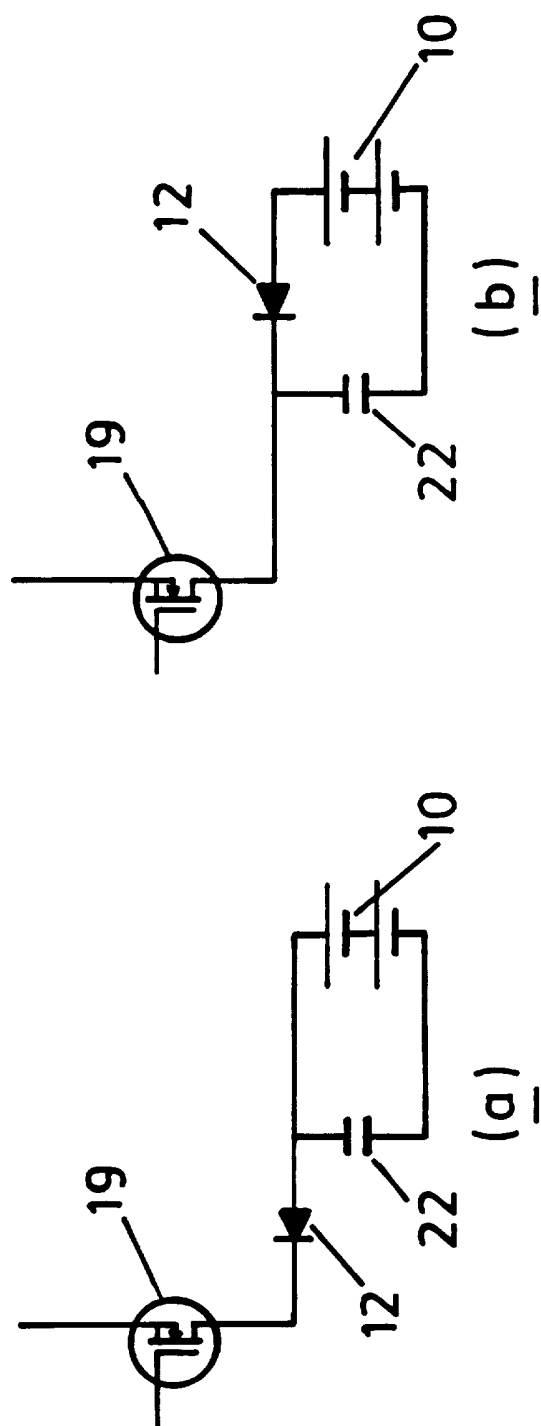
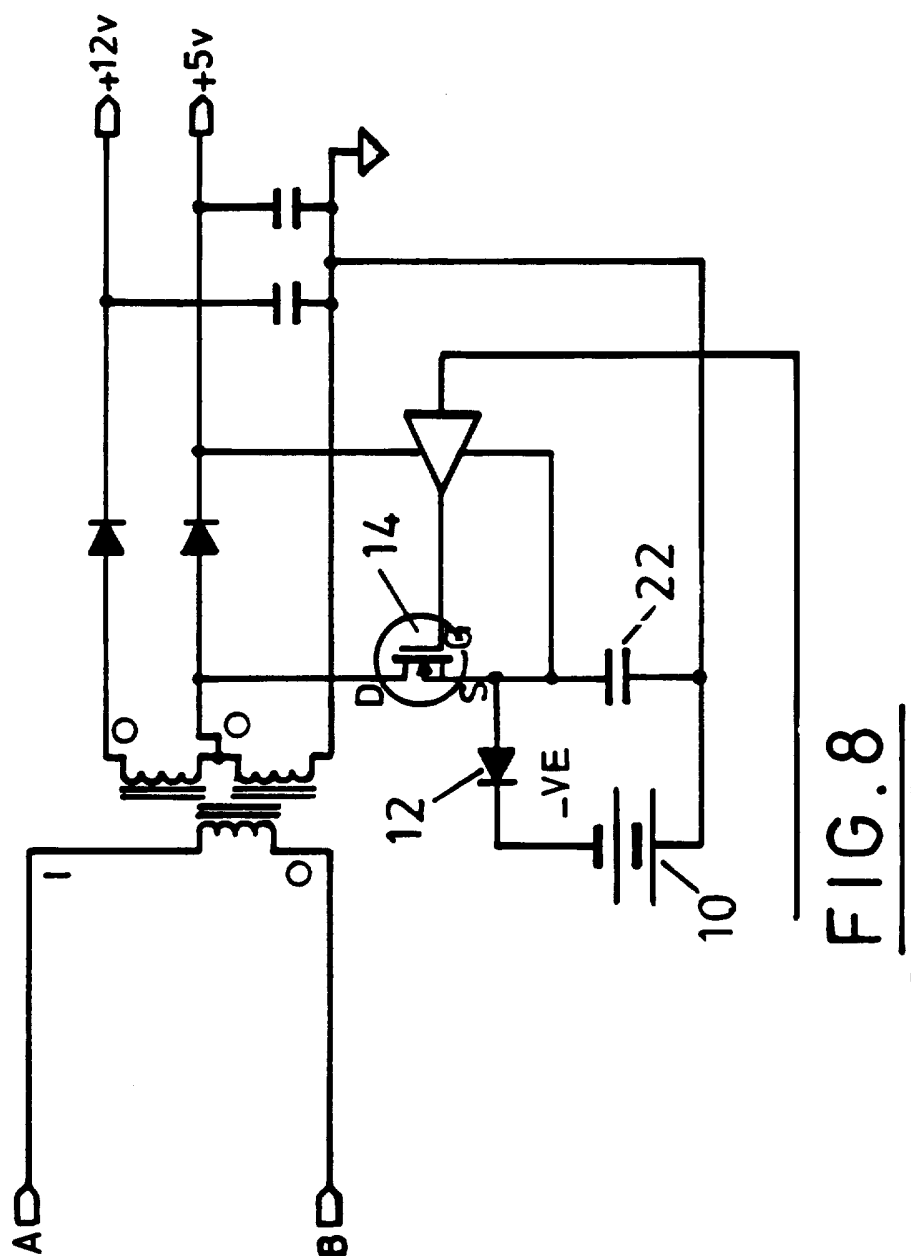


FIG. 6

8-10FIG. 7

9-10FIG. 8

10 - 10

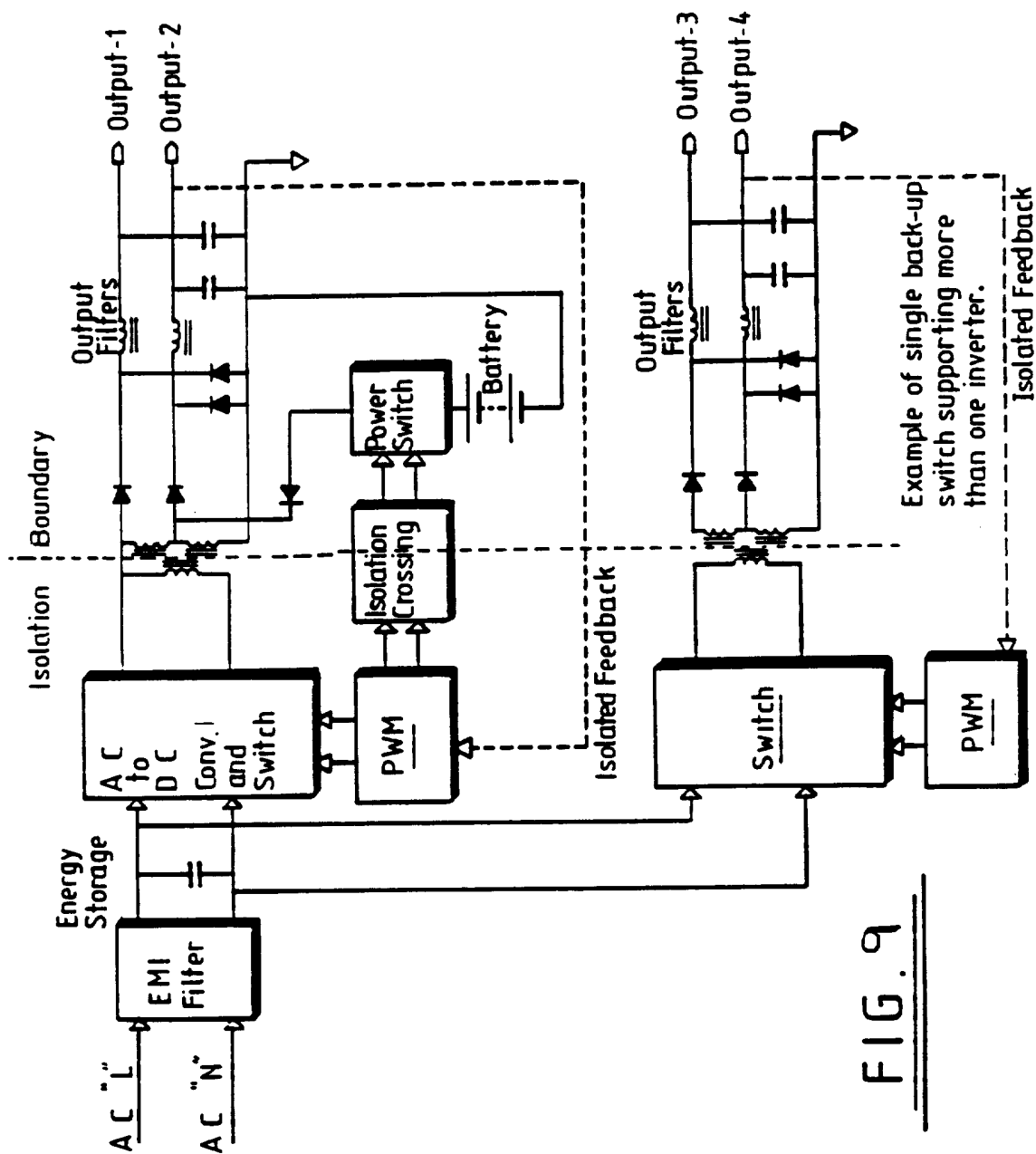


FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/00103

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H02J9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,91 07803 (NAT CSF CORP ;MAGNUM POWER SOLUTIONS LTD (GB)) 30 May 1991 cited in the application see page 3, line 35 - page 10, line 14; figure 1	1-4,8,9
Y	---	5,6
Y	US,A,4 238 690 (CLARKE PATRICK W) 9 December 1980 see abstract	5,6
A	---	1-5,8,9
	EP,A,0 243 061 (AMERICAN TELEPHONE & TELEGRAPH) 28 October 1987 cited in the application see abstract see column 2, line 31 - column 6, line 15; figures 1-3 ---	
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

21 March 1996

Date of mailing of the international search report

0 8. 05. 96

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Helot, H

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 96/00103

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 819 980 (MULLERSMAN F) 25 June 1974 see abstract	1
A	GB,A,2 120 474 (HARMER AND SIMMONS LIMITED) 30 November 1983 cited in the application	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 96/00103

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US-A-4238690	09-12-80	NONE	
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EP-A-0243061	28-10-87	US-A- 4745299 CA-A- 1314932 DE-A- 3786366 DE-T- 3786366 JP-A- 62296728	17-05-88 23-03-93 05-08-93 14-10-93 24-12-87
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US-A-3819980	25-06-74	NONE	
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GB-A-2120474	30-11-83	NONE	
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