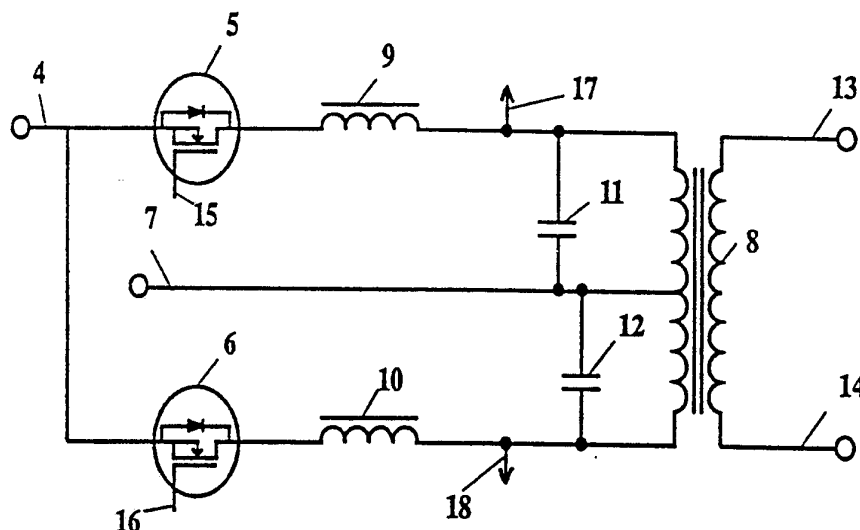




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(54) Title: SWITCHING CIRCUIT**(57) Abstract**

A means, arrangement and method applicable to bi-phase controlled switching circuit adapted to supply a load. Feedback signals (17, 18) related to current flowing into the load are processed and used to control the switching means (5, 6) of the switching circuit. The feedback signal is in phase with the voltage applied to the load across the switching circuit. These feedback signals are processed to form a signal which is then combined with a reference signal. The result of this is used to control a pulse width modulator which produces a pulse width modulated signal. The polarity of the reference signal is used to direct the pulse width modulated signal to the control inputs (15, 16) of the switching means. A preferred addition to this invention is the comparison of a reference voltage with a secondary signal which is dependent upon the voltage across the load. Thus the pulse width modulated signal can be adjusted to compensate for variations of load impedance.

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SWITCHING CIRCUIT

BACKGROUND OF THE INVENTION

The invention described herein relates to a feedback means, arrangement and method applicable to bi-phase controlled switching circuit.

- 5 It is known to have a bi-phase controlled switching circuit driving a load. Typically this load is a centre tapped transformer but this is not necessarily the case. For instance, the load may be one or more resistors and the load need not necessarily be centre tapped. However, using as an example a bi-phase controlled switching circuit driving a centre tapped transformer, of the basic
- 10 type as illustrated in FIG. 1, there are two controlled switching means which are both connected to a common rail. The other end is connected through a low pass filter to the primary ends of a centre tapped transformer.

- The control inputs which are the gate inputs of field effects transistors are periodically and alternatively turned on, causing current to flow through the
- 15 controlled switching means from the negative rail to the positive rail. The resultant output developed across the secondary of the transformer may be substantially a sinusoidal waveform where the voltage developed across the primary is a periodic half sinusoid.

- Typically, such a circuit is supplied with a free running gate signal.
- 20 Consequently, there is no feedback or adaptive control. In some cases feedback has been arranged to control the switching by feedback taken from the secondary side of the transformer. This approach may include one or more inherent problems regarding: phase shifts, phase variations, isolation of the feedback control signal and noise due to the load.

- 25 Whilst these problems can be overcome there are overheads regarding circuit complexity and cost. It is an intended object of the invention disclosed herein to provide a solution to the above problems or at least provide the public with a useful alternative.

SUMMARY OF THE INVENTION

According to one form of this invention there is provided a method of controlling a bi-phase controlled switching circuit having at least two switching means adapted to control the current flowing into a load, the method including

5 the steps of:

generating a reference signal of a desired shape and frequency;

sensing at least one voltage to provide a feedback signal dependent upon the current flowing into the load;

10 processing the reference signal and feedback signal to provide a control signal which is dependent upon the amplitude, phase difference and waveform shape of both the reference signal and feedback signal;

generating a pulse width modulated signal, the width of the generated pulses being dependent upon the amplitude and waveform shape of the control signal; and

15 directing the pulse width modulated signal to one of the switching means and then directing the pulse width modulated signal to another switching means, wherein the directing is dependent upon the frequency of the reference signal.

Alternatively, according to another form of this invention there is provided a

20 method of controlling a bi-phase controlled switching circuit having at least one first switching means adapted to allow electrical current to flow into a first end of a load and at least one second switching means adapted to allow electrical current to flow into a second end of the load, the method including the steps of:

25 generating a reference signal at a pre-determined shape and frequency;

sensing at least one voltage dependent upon the current flowing into the load to provide at least one feedback signal;

30 processing the reference and feedback signals to provide a control signal;

generating a pulse width modulated signal, the width of the generated pulses of the pulse modulated signal being dependent upon the control signal; and

selecting a control input of one of the switching means and applying the

pulse width modulated signal to the selected control input, wherein the selecting is dependent upon the reference signal.

Alternatively, according to another form of this invention there is provided a method of controlling a bi-phase controlled switching circuit having at least one first switching means adapted to allow electrical current to flow into a first end of a load and at least one second switching means adapted to allow electrical current to flow in a second end of the load, the method including the steps of:

- generating a reference signal at a pre-determined shape and frequency;
- sensing at least one voltage to provide a feedback signal, the voltage being dependent upon the current flowing in the load;
- combining the feedback signal and the reference signal to form a control signal;
- generating a pulse width modulated signal in which the width of the generated pulses are dependent upon the amplitude of the control signal;
- monitoring the reference signal to provide a polarity signal; and
- applying the pulse width modulated signal to the control inputs of the first or second switching means to selectively allow current to flow in the said first and second directions around the load, the applying being controlled by the polarity signal.

In preference, the method is further characterised by the voltage providing the feedback signal being substantially in phase with the voltage applied to the load.

- In preference, the method is further characterised by the load being a transformer and the sensing occurring at the primary side of the transformer.

In preference, the method is further characterised by the sensing occurring at the ends of the primary side of the transformer.

- In preference, the method is further characterised by the load being centre tapped.

In preference, the method is further characterised by the pulse width modulated signal being supplied to the control input of one of the switching

means when the reference signal reaches a first threshold value and pulse width modulated signal is supplied to the control input of the other switching means when the reference signal reaches a second threshold value.

- 5 In preference, the method is further characterised by the first and second threshold values being substantially identical.

In preference, the method is further characterised by the reference signal being rectified before being combined with the feedback signal, wherein the combining is the difference between a processed rectified reference signal and the feedback signal.

- 10 In preference, the method further includes the step of rectifying the reference signal before it is combined with the feedback signal to form the control signal.

- 15 Depending upon the particular embodiment of the invention the reference signal can be generated by an oscillator producing an analogue signal. In other embodiments this function may be dispensed with but in effect provided by a digital system.

- In preference, the input signal is of substantially sinusoidal shape. However, the input signal may be an input from an analogue source. In both cases the input signal may have a maximum frequency component of 60kHz.
- 20 Depending upon the reference signal the bi-phase controlled switching circuit may be used to provide a sinusoidal output or an output of some other shape. In one form the reference signal may be an audio input such as an output from a microphone or an output from a music cassette tape player.

- 25 It has been found that in some circumstances the impedance of the load varies to such an extent the impedance of the transformer becomes considerable. For some applications it is desirable to correct for such variations. This can be achieved by feeding back some of the signal appearing across the secondary of the transformer. This feedback signal can be used to vary the substantially constant pre-defined level which in turn controls the pulse width modulator.

- 30 Preferably the method further includes the steps of:
sensing voltage variations across the secondary of the transformer to

provide a secondary feedback signal, the variations being substantially dependent upon the load across the secondary of the transformer;

comparing the secondary feedback signal with a reference voltage and adjusting the signal amplitude level of the control signal so that when the

- 5 secondary feedback signal is less than a selected amplitude level the pulse width modulated signal is modified to effect a voltage increase on the primary side of the transformer, and when the secondary feedback signal is greater than the selected amplitude level the pulse width modulated signal is modified to effect a voltage decrease on the primary side of the transformer.

- 10 Preferably, the sensed secondary voltage is characterised by being substantially a low frequency signal, and the second reference voltage is also characterised by being substantially a low frequency signal.

In one preferred form the method is one wherein the secondary voltage is interpretable as the RMS (root means square) value of the voltage generated

- 15 across the secondary of the transformer.

By the method mentioned above, the feedback from the primary side can preferably correct substantially rapidly changing variations whilst, if used, the feedback from the secondary can be used to correct for variations due to substantial load variations.

- 20 In preference, the method is further characterised by the current flowing into the load being low pass filtered.

Alternatively, according to another form of this invention there is provided a method of controlling a bi-phase controlled switching circuit including two input controlled switching means and a centre tapped load with two ends,

- 25 wherein the method includes controlling the conduction state of the switching means by pulse width modulated signals, the pulse width modulated signals being generated such that the width of the generated pulses increase when a first control signal is of amplitude within a first selected range and decrease when the first control signal is of amplitude within a second selected range,
30 and the first control signal is generated by means using feedback sensed from the ends of the centre tapped load.

Alternatively, according to another form of this invention there is provided a method of controlling a bi-phase controlled switching circuit including two input controlled switching means and a centre tapped load with two ends, the circuit being of the type defined herein, the method including the steps of:

- 5 generating a reference signal characterised by signal amplitude variations about a selected signal amplitude level;
- sensing the voltage at each end of the load and combining the sensed voltages to form a combined feedback signal;
- combining the combined feedback signal and the reference signal to
- 10 form the difference therebetween and adding this difference signal to a further signal of selected signal amplitude level to form a control signal;
- generating a pulse width modulated signal where the width of the generated pulses are greater when the control signal is of amplitude within a first amplitude range partly bounded by a second selected signal amplitude
- 15 level and is smaller when the control signal is of amplitude within a second amplitude range partly bounded by a second selected signal amplitude level;
- sensing the polarity of the reference signal with respect to the selected signal amplitude level; and
- directing the pulse width modulated signal to either input controlled
- 20 switching means such that when the polarity of the reference signal is positive the pulse width modulated signal is supplied to the control input of one switching means and when the polarity is negative it is supplied to the control input of the other switching means.

- If the circuit is being operated to provide a sinusoidal output voltage, the
- 25 voltage waveform developed between each end of the primary of the transformer and the centre tap is sensed. These voltages are of half sinusoidal shape with a phase shift of 180° between them. These feedback voltages are summed and combined with a reference signal. The difference is added to a control signal supplied to a pulse width modulator which
 - 30 accordingly generates a pulse width modulated signal. When the polarity of the reference signal is positive the pulse width modulated signal is supplied to the control input of one switching means and when the polarity is negative it is supplied to the control input of the other switching means.

- Alternatively, according to another form of this invention there is provided a
- 35 control arrangement adapted for controlling a bi-phase controlled switching circuit including two input controlled switching means and a centre tapped

load with two ends, the control arrangement including:

generating means adapted to generate a reference signal, the reference signal being characterised by amplitude variations about a selected signal amplitude level;

5 sensor means adapted to sense the voltage at each end of the load and combine the sensed voltages to form a combined feedback signal;

means adapted to combine the combined feedback signal and the reference signal to form the difference therebetween and adding this difference signal to a further signal of selected signal amplitude level to form a
10 control signal;

modulator means adapted to generate a pulse width modulated signal where the width of the generated pulses are greater when the control signal is of amplitude within a first amplitude range partly bounded by a second selected signal amplitude level and is smaller when the control signal is of
15 amplitude within a second amplitude range partly bounded by a second selected signal amplitude level;

polarity sensor means adapted to sense the polarity of the reference signal with respect to the selected signal amplitude level; and

switching means adapted to direct the pulse width modulated signal to
20 either input controlled switching means such that when the polarity of the reference signal is positive the pulse width modulated signal is supplied to the control input of one switching means and when the polarity is negative it is supplied to the control input of the other switching means.

Alternatively, according to another form of this invention there is provided a
25 control means for controlling a bi-phase controlled switching circuit having at least one first switching means having a control input adapted to allow electrical current to flow in a first end of a load and at least one second switching means having a control input adapted to allow electrical current to flow in a second end of the load, the control means including:

30 a reference signal generator for providing a reference signal frequency and waveform shape;

a processing means adapted to provide a control signal, the control signal being derived from the processing means processing both one or more feedback voltages related to the current flowing in the load and the reference
35 signal;

a pulse width modulation means for providing a pulse width modulation signal, the characteristics of the pulse width modulation signal being

dependent upon the control signal;

a direction means adapted to direct the pulse width modulation signal to the control input of either the first switching means or the second switching means, the direction being related to the frequency of the reference signal.

- 5 In preference, there is a comparing means adapted to compare a reference voltage with a secondary feedback signal which is dependent upon the voltage across the load, the comparing means being adapted to provide a second control signal, wherein the pulse width modulation signal is dependent upon the control signal and second control signal.

10 BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described as exhibited by a preferred embodiment. It will be appreciated that this is not the only conceivable embodiment. To assist in the description of this preferred embodiment reference will be made to the accompanying drawings in which:

- 15 FIG. 1 illustrates a circuit of the type with which the invention is useful;

FIG. 2 illustrates a further circuit of the type with which the invention is useful;

FIG. 3 illustrates the feedback points of the preferred embodiment as applied to a circuit of the type illustrated in FIG. 1;

- 20 FIG. 4 is a functional block diagram of the preferred embodiment;

FIGS. 5(a) and 5(b) illustrate the circuit diagram of the preferred embodiment;

- 25 FIG. 6 illustrates the feedback points, and basic feedback processing circuitry, for providing additional feedback to the preferred embodiment as applied to a circuit of the type illustrated in FIG. 1;

FIG. 7 illustrates an alternative to the basic feedback processing circuitry; and

FIG. 8 is a functional block diagram of the additional feedback circuitry.

DETAILED DESCRIPTION OF THE DRAWINGS

The invention is applicable to the control of circuits of the general type such as those illustrated in FIG. 1 and FIG. 2. These circuits consists of two controlled
5 input switching means 1 and 2, in this case field effect transistors, each connected to a load in this case a transformer 3.

It will be appreciated that this invention is not limited loads such as transformers (centre tapped or otherwise). For example, resistive loads could be used for heating or lighting applications.

10 Circuits, such as the illustrated in FIG. 1 or FIG. 2, are known but the feedback arrangement to control these circuits disclosed herein is not. Typical feedback arrangements, if used, have feedback taken from the secondary side of the transformer 3. This leads to isolation and phase shift feedback problems which can be overcome by including additional circuitry, this leads to
15 additional cost and complexity.

The circuit illustrated in FIG. 3 includes a negative rail 4 connected to one terminal of each of the two controlled input switching means 5 and 6. The positive rail 7 connected to the centre tap of a centre tapped transformer 8. The controlled input switching means 5 and 6 are connected to the ends of the
20 centre tapped transformer 8 through low pass filters comprising inductors 9 and 10, and capacitors 11 and 12.

The circuit, in this example, is adapted to produce a substantially sinusoidal voltage waveform across the secondary terminals 13 and 14 of the transformer 8. The circuit operates by applying pulse width modulated signals
25 to the control inputs 15 and 16 of the two controlled input switching means 5 and 6. These pulse width modulated signals are characterised by a carrier frequency and a low frequency modulation signal of lower frequency than the carrier frequency. The pulse width modulated signals are applied to the control inputs 15 and 16 alternatively in accordance with the instant polarity of
30 the low frequency modulation signal.

This results in the bi-phase characteristics of the circuit. Note, although the majority of the above discussion referred to the centre tapped transformer configuration of FIG. 1, the invention is equally applicable to the arrangement of FIG. 2 or other loads such as a resistive load.

- 5 The circuit illustrated in FIG. 3 is of the general type illustrated in FIG. 1 (note other load configurations can be used such as illustrated in FIG. 2) but in this case primary feedback signals are taken from points 17 and 18. By taking feedback signals from these points phase shift and isolation problems can be substantially reduced or eliminated.
- 10 The feedback signals 17 and 18 are substantially at the potential of the negative rail 4. These signals are substantially characterised by the frequency of the low frequency modulation signal. This is due to the low pass filters effectively reducing the component of the carrier frequency.

- Referring to FIG. 4, the feedback signals are of the form pointed out by
- 15 numbers 19 and 20 which are applied to the inputs 17 and 18 respectively. They are combined to form the signal as illustrated by number 21. This is achieved with the feedback signals 19 and 20 being added, inverted and conditioned by the adder and inverter 22.

- The sinusoidal input at 26 is generated by a simple sine wave oscillator. This
- 20 is then rectified by the full wave rectifier 27 to provide the full wave rectified signal 23.

- The combined signal 21 is added to the full wave rectified signal 23 by the summer 24. The summer 24 includes a level shifting means adapted to set the steady state reference signal 33 level applied to a control input of the
- 25 pulse width modulator 25. Consequently, the pulse width modulator 25 produces a pulse width modulated signal in accordance with the reference signal from the summer 24. The pulse width modulated signal is applied to inputs of two dual input AND gates 30 and 31.

- The full wave rectified signal 23 is also applied to a zero voltage detector 28.
- 30 This provides a clock signal 32 each time the full wave rectified signal 23 is substantially zero which is used to clock a flip-flop 29. Note, in an alternative

form the zero voltage detector 28 can be replaced with a crossover detector to detect the sinusoidal input 26 crossing a threshold level.

The Q output of the flip-flop 29 is connected to the AND gate 30 and the Q-bar output is connected to the AND gate 31. This results in the pulse width
5 modulated signal being applied to first one control input ,15 or 16, of the switching means, 5 or 6, then to the other in accordance with the polarity of the reference signal. It will be appreciated that the outputs of the AND gates 30 and 31 may need buffering.

The diagram illustrated in FIG. 4 can be implemented by the circuit shown in
10 FIG. 5(a) and FIG. 5(b). Only the major parts of the circuit are pointed out as the details would be apparent to a person skilled in the art. Referring to FIG. 5(a) the operational amplifiers 42 are adapted to provide a substantially sinusoidal signal 26 to the operational amplifiers 27. These operational amplifiers 27 are configured with the connected diodes to provide a full wave
15 rectified signal 23 to the operational amplifier 28 configured as a zero detector.

The output of the operational amplifier configured as a zero detector 28 is connected to the clock of the flip-flop 29 which is configured in the toggle mode. The Q output of the flip-flop 29 is connected to a NAND gate which is
20 buffered by the inverters to provide an AND gate 30. Similarly the Q-bar output of the flip-flop 29 is connected to a NAND gate which is buffered by the inverters to provide an AND gate 31. The outputs of these AND gate configurations 30 and 31 are adapted to drive the inputs 15 and 16 of the switching means 5 and 6 illustrated in FIG. 3.

25 Referring to FIG. 5(b) the operational amplifiers 22 are adapted to process the feedback signals 17 and 18 supplied, for example, from the connections illustrated in FIG. 3. The full wave rectified signal 23, supplied from FIG. 5(a) is conditioned and added to the summer consisting of the operational amplifier 24 and its associated circuitry. The circuitry associated with FIG. 5(b) includes
30 a level shifting means adapted to set the steady state reference signal level 33 applied to a control input of the pulse width modulator 25 (illustrated on FIG. 5(a)). The pulse width modulator 25 is a standard chip NE5560 and it should be noted that other chips are available to provide this function. The output from the pulse width modulator 25 is connected to both the AND gate

configurations 30 and 31 to provide control to the inputs 15 and 16 of the switching means 5 and 6. Hence, using the circuitry substantially as described above, the switching means of FIG. 2, FIG. 3 or other similar circuits can be controlled to provide a power supply of a desired waveshape which in this embodiment is sinusoidal.

When using a load including a transformer variations in the impedance of the load can be such that the transformer's impedance becomes considerable in terms of the load as seen by the switching means. This results in the signal generated across the primary of the transformer not substantially reflecting the signal generated across the secondary of the transformer. Thus controlling the voltage generated across the primary of the transformer under some special and not necessarily common load conditions does not result in the desired voltage being generated across the secondary of the transformer.

The abovementioned effects of variations in the load impedance can be corrected by sensing the RMS (root mean square) value of the voltage generated across the secondary of the transformer. In effect, control of the switching is separated into two feedback arrangements. The first is illustrated above in FIGS. 1 to 5 and is adapted to substantially rapidly correct for variations in the voltage generated across the secondary of the transformer. Because of the arrangement, this can be done simply and effectively as described without the problems outlined earlier concerning known feedback arrangements. Further, this feedback quickly corrects for variations in waveform shape. The second is to correct for the variations in the voltage generated across the secondary of the transformer. This feedback control does not need to be as fast acting as the first and so the problems with known feedback arrangements are not substantially encountered.

The circuit illustrated in FIG. 6 includes secondary feedback sampling points 34 and 35 on the secondary side of the transformer 8. This feedback signal is filtered and adapted to detect the value of the voltage generated across the secondary terminals of the transformer 8. This can be achieved by a transformer 36 being connected to the feedback points 34 and 35. A rectifier 37 is connected to the output of the transformer 36. The output of the rectifier 37 is connected to a low pass filter 38 including the resistor and capacitor to provide a secondary feedback signal 39.

In an alternative arrangement, illustrated in FIG. 7, the resistor and capacitor arrangement are connected across the output of the transformer 8. Thus the secondary feedback signal 39 is a substantially sinusoidal wave oscillating about a steady state bias of approximately 6 volts.

- 5 Referring to FIG. 8 the secondary feedback signal 39 is conditioned and combined with a second reference signal 40 by the summer 41 (using a standard operational amplifier circuit). The output from the summer 41 is adapted to adjust the amplitude of the reference signal 33 for the pulse width modulator 25. This is achieved by the amplifier 42 being used such so its gain
10 is controlled by the output 43 of the summer 41. The other parts of FIG. 8 perform the same functions as the counter parts illustrated in FIGS. 4, 5(a) and 5(b).

- In the above descriptions the reference signal (the sinusoidal input at 26) is generated by a simple sine wave oscillator. However, this signal can be
15 generated by other means and although preferably this signal is sinusoidal it need not necessarily be of this shape.

- It will be appreciated that the invention can be exhibited in other embodiments which as person skilled in the art could conceive. With the advent of inexpensive microprocessors the feedback signal conditioning, reference
20 signal generation and generation of the pulse width modulated signals for the control inputs of the switching means can be done by a microprocessor. As a result the invention is not to be taken to be limited to the specific construction details disclosed herein.

CLAIMS

1. A method of controlling a bi-phase controlled switching circuit having at least two switching means adapted to control the current flowing into a load, the method including the steps of:
- generating a reference signal of a desired shape and frequency;
 - 5 sensing at least one voltage to provide a feedback signal dependent upon the current flowing into the load;
 - processing the reference signal and feedback signal to provide a control signal which is dependent upon the amplitude, phase difference and waveform shape of both the reference signal and feedback signal;
 - 10 generating a pulse width modulated signal, the width of the generated pulses being dependent upon the amplitude and waveform shape of the control signal; and
 - directing the pulse width modulated signal to one of the switching means and then directing the pulse width modulated signal to another
 - 15 switching means, wherein the directing is dependent upon the frequency of the reference signal.
2. A method of controlling a bi-phase controlled switching circuit having at least one first switching means adapted to allow electrical current to flow into a first end of a load and at least one second switching means adapted to allow
- 20 electrical current to flow into a second end of the load, the method including the steps of:
- generating a reference signal at a pre-determined shape and frequency;
 - sensing at least one voltage dependent upon the current flowing into
 - 25 the load to provide at least one feedback signal;
 - processing the reference and feedback signals to provide a control signal;
 - generating a pulse width modulated signal, the width of the generated pulses of the pulse modulated signal being dependent upon the control
 - 30 signal; and
 - selecting a control input of one of the switching means and applying the pulse width modulated signal to the selected control input, wherein the selecting is dependent upon the reference signal.
3. A method of controlling a bi-phase controlled switching circuit having at
- 35 least one first switching means adapted to allow electrical current to flow into a

first end of a load and at least one second switching means adapted to allow electrical current to flow in a second end of the load, the method including the steps of:

- generating a reference signal at a pre-determined shape and
5 frequency;
sensing at least one voltage to provide a feedback signal, the voltage being dependent upon the current flowing in the load;
combining the feedback signal and the reference signal to form a control signal;
10 generating a pulse width modulated signal in which the width of the generated pulses are dependent upon the amplitude of the control signal;
monitoring the reference signal to provide a polarity signal; and
applying the pulse width modulated signal to the control inputs of the first or second switching means to selectively allow current to flow in the said
15 first and second directions around the load, the applying being controlled by the polarity signal.

4. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further characterised by the voltage providing the feedback signal being substantially in phase with the voltage applied to the
20 load.

5. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further characterised by the load being a transformer and the sensing occurring at the primary of side of the transformer.

6. A method of controlling a bi-phase controlled switching circuit as in any
25 one previous claim further characterised by the sensing occurring at the ends of the primary side of the transformer.

7. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further characterised by the load being centre tapped.

8. A method of controlling a bi-phase controlled switching circuit as in any
30 one previous claim further characterised by the pulse width modulated signal being supplied to the control input of one of the switching means when the reference signal reaches a first threshold value and pulse width modulated

signal is supplied to the control input of the other switching means when the reference signal reaches a second threshold value.

9. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further characterised by the first and second threshold values being substantially identical.

10. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further characterised by the reference signal being rectified before being combined with the feedback signal, wherein the combining is the difference between a processed rectified reference signal and the feedback signal.

11. A method of controlling a bi-phase controlled switching circuit as in any one previous claim further including the steps of:
sensing voltage variations across the secondary of the transformer to provide a secondary feedback signal, the variations being substantially dependent upon the load across the secondary of the transformer;
comparing the secondary feedback signal with a reference voltage and adjusting the signal amplitude level of the control signal so that when the secondary feedback signal is less than a selected amplitude level the pulse width modulated signal is modified to effect a voltage increase on the primary side of the transformer, and when the secondary feedback signal is greater than the selected amplitude level the pulse width modulated signal is modified to effect a voltage decrease on the primary side of the transformer.

12. A method of controlling a bi-phase controlled switching circuit as in any one previous claim, wherein the sensed secondary voltage is characterised by being substantially a low frequency signal, and the second reference voltage is also characterised by being substantially a low frequency signal.

13. A method of controlling a bi-phase controlled switching circuit as in any one previous claim, wherein the current flowing into the load is low pass filtered.

14. A method of controlling a bi-phase controlled switching circuit including two input controlled switching means and a centre tapped load with two ends, wherein the method include controlling the conduction state of the switching

means by pulse width modulated signals, the pulse width modulated signals being generated such that the width of the generated pulses increase when a first control signal is of amplitude within a first selected range and decrease when the first control signal is of amplitude within a second selected range, and the first control signal is generated by means using feedback sensed from the ends of the centre tapped load.

15. A control arrangement adapted for controlling a bi-phase controlled switching circuit including two input controlled switching means and a centre tapped load with two ends, the control arrangement including:

10 generating means adapted to generate a reference signal, the reference signal being characterised by amplitude variations about a selected signal amplitude level;

sensor means adapted to sense the voltage at each end of the load and combine the sensed voltages to form a combined feedback signal;

15 means adapted to combine the combined feedback signal and the reference signal to form the difference therebetween and adding this difference signal to a further signal of selected signal amplitude level to form a control signal;

modulator means adapted to generate a pulse width modulated signal where the width of the generated pulses are greater when the control signal is of amplitude within a first amplitude range partly bounded by a second selected signal amplitude level and is smaller when the control signal is of amplitude within a second amplitude range partly bounded by a second selected signal amplitude level;

25 polarity sensor means adapted to sense the polarity of the reference signal with respect to the selected signal amplitude level; and

switching means adapted to direct the pulse width modulated signal to either input controlled switching means such that when the polarity of the reference signal is positive the pulse width modulated signal is supplied to the control input of one switching means and when the polarity is negative it is supplied to the control input of the other switching means.

16. A control means for controlling a bi-phase controlled switching circuit having at least one first switching means having a control input adapted to allow electrical current to flow in a first end of a load and at least one second switching means having a control input adapted to allow electrical current to flow in a second end of the load, the control means including:

a reference signal generator for providing a reference signal frequency and waveform shape;

a processing means adapted to provide a control signal, the control signal being derived from the processing means processing both one or more
5 feedback voltages related to the current flowing in the load and the reference signal;

a pulse width modulation means for providing a pulse width modulation signal, the characteristics of the pulse width modulation signal being dependent upon the control signal;

10 a direction means adapted to direct the pulse width modulation signal to the control input of either the first switching means or the second switching means, the direction being related to the frequency of the reference signal.

17. A control means for controlling a bi-phase controlled switching circuit as in claim 16 including a comparing means adapted to compare a reference
15 voltage with a secondary feedback signal which is dependent upon the voltage across the load, the comparing means being adapted to provide a second control signal, wherein the pulse width modulation signal is dependent upon the control signal and second control signal.

18. A method of controlling a bi-phase controlled switching circuit including
20 two input controlled switching means and a centre tapped load with two ends, the circuit being of the type defined herein, the method including the steps of:

generating a reference signal characterised by signal amplitude variations about a selected signal amplitude level;

25 sensing the voltage at each end of the load and combining the sensed voltages to form a combined feedback signal;

combining the combined feedback signal and the reference signal to form the difference therebetween and adding this difference signal to a further signal of selected signal amplitude level to form a control signal;

30 generating a pulse width modulated signal where the width of the generated pulses are greater when the control signal is of amplitude within a first amplitude range partly bounded by a second selected signal amplitude level and is smaller when the control signal is of amplitude within a second amplitude range partly bounded by a second selected signal amplitude level;

35 sensing the polarity of the reference signal with respect to the selected signal amplitude level; and

directing the pulse width modulated signal to either input controlled

switching means such that when the polarity of the reference signal is positive the pulse width modulated signal is supplied to the control input of one switching means and when the polarity is negative it is supplied to the control input of the other switching means.

- 5 19. A method of controlling a bi-phase switching circuit as in any one of the claims 1 to 14 further characterised by the voltage providing the feedback signal being substantially in phase with the voltage applied to the load.
20. A control means for controlling a bi-phase controlled switching circuit substantially as described in the specification with reference to and as
10 illustrated by the accompanying drawings.
21. A control arrangement adapted for controlling a bi-phase controlled switching circuit substantially as described in the specification with reference to and as illustrated by the accompanying drawings.
22. A method of controlling a bi-phase controlled switching circuit
15 substantially as described in the specification with reference to and as illustrated by the accompanying drawings.

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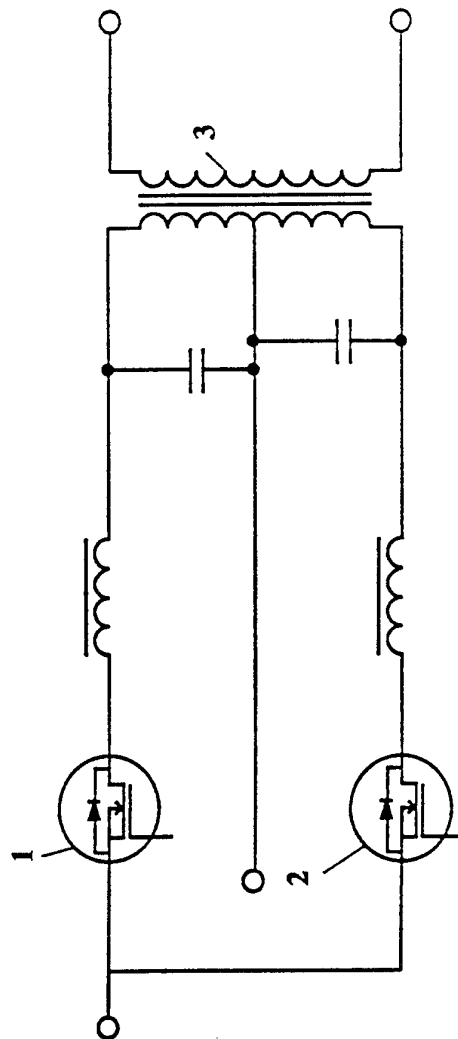


FIG. 1

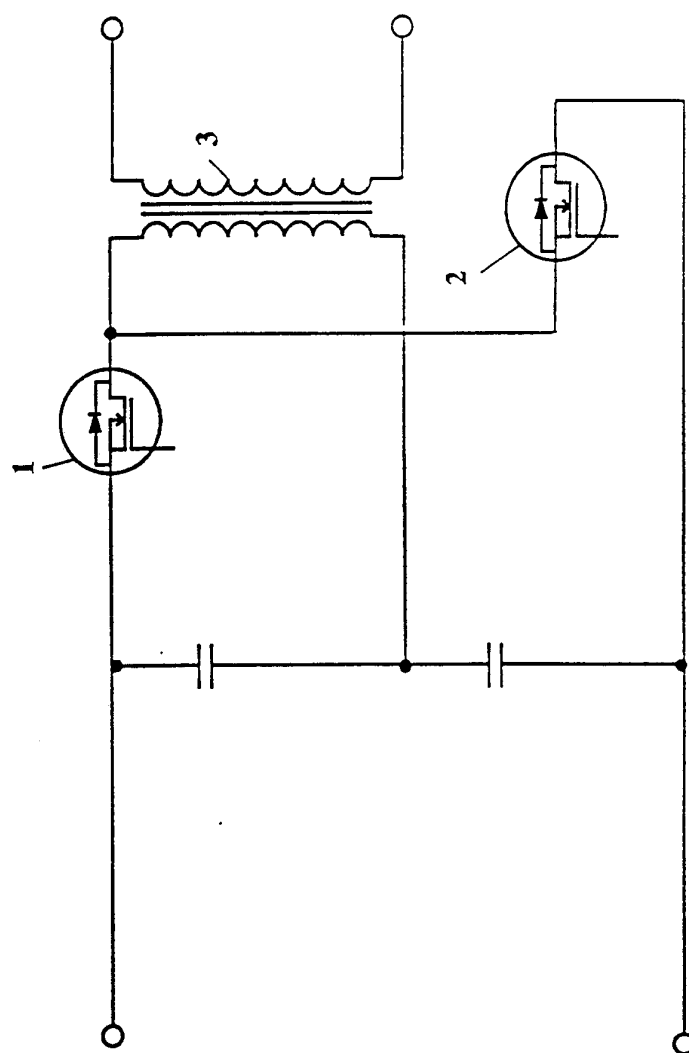


FIG. 2

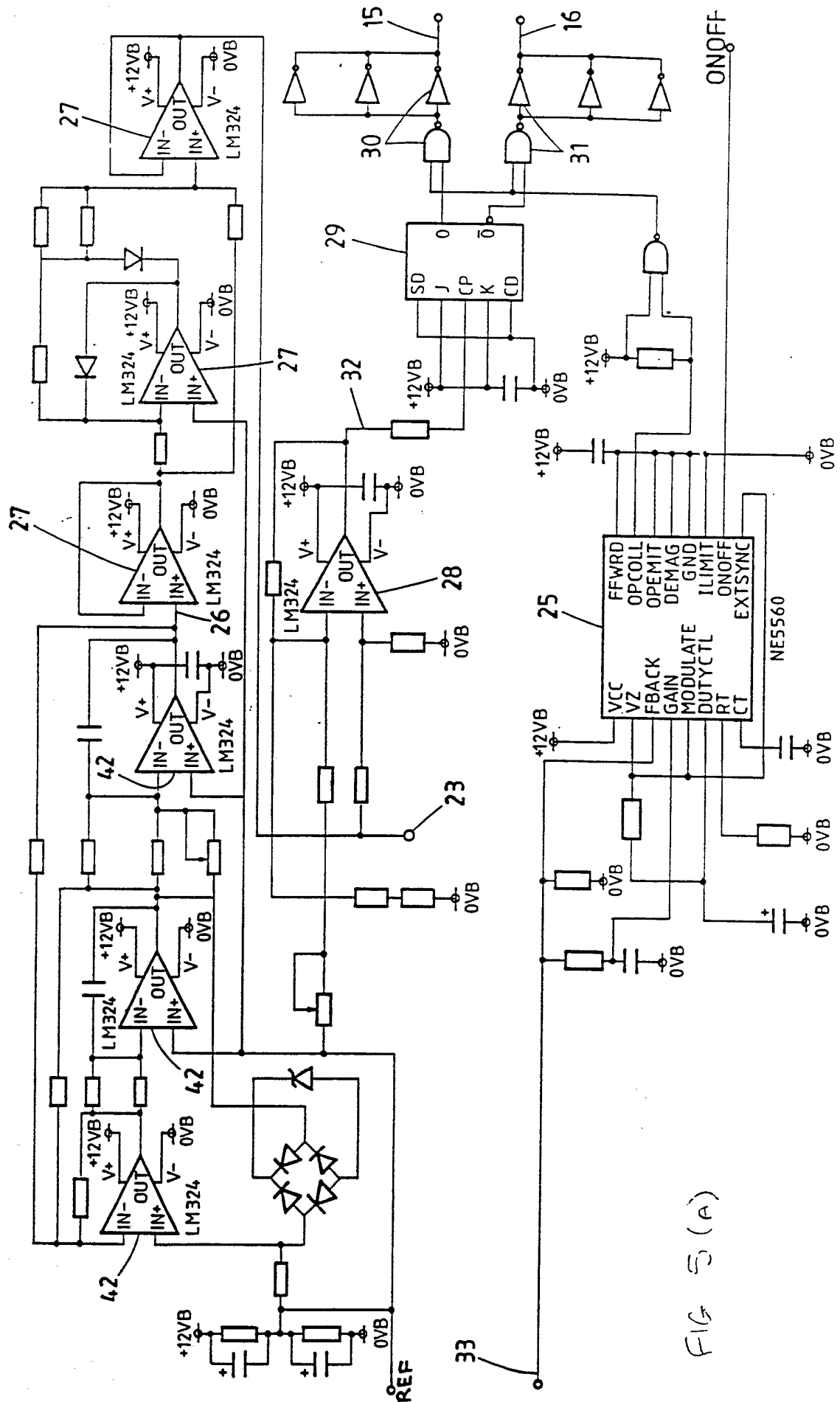
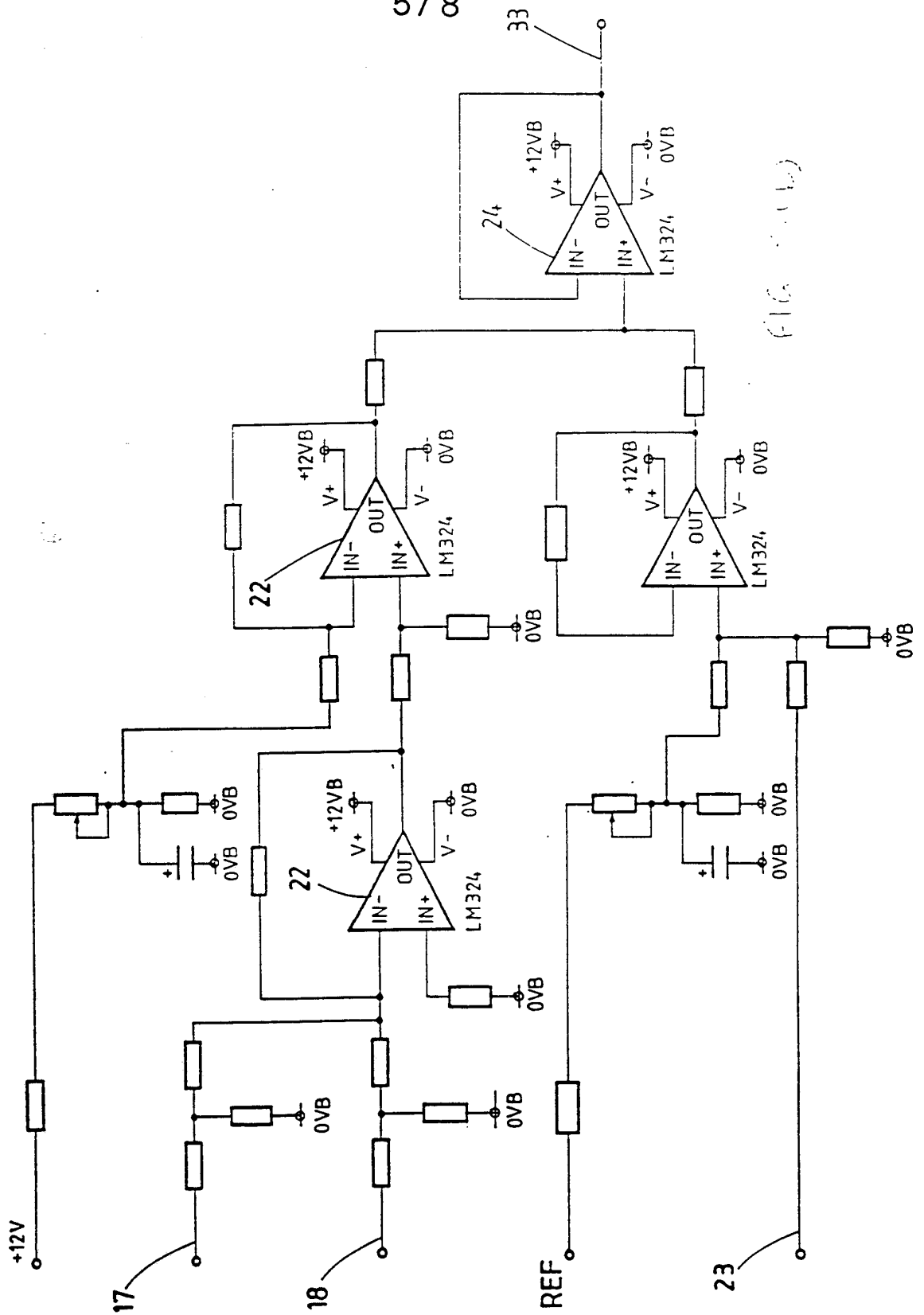


FIG 5 (A)

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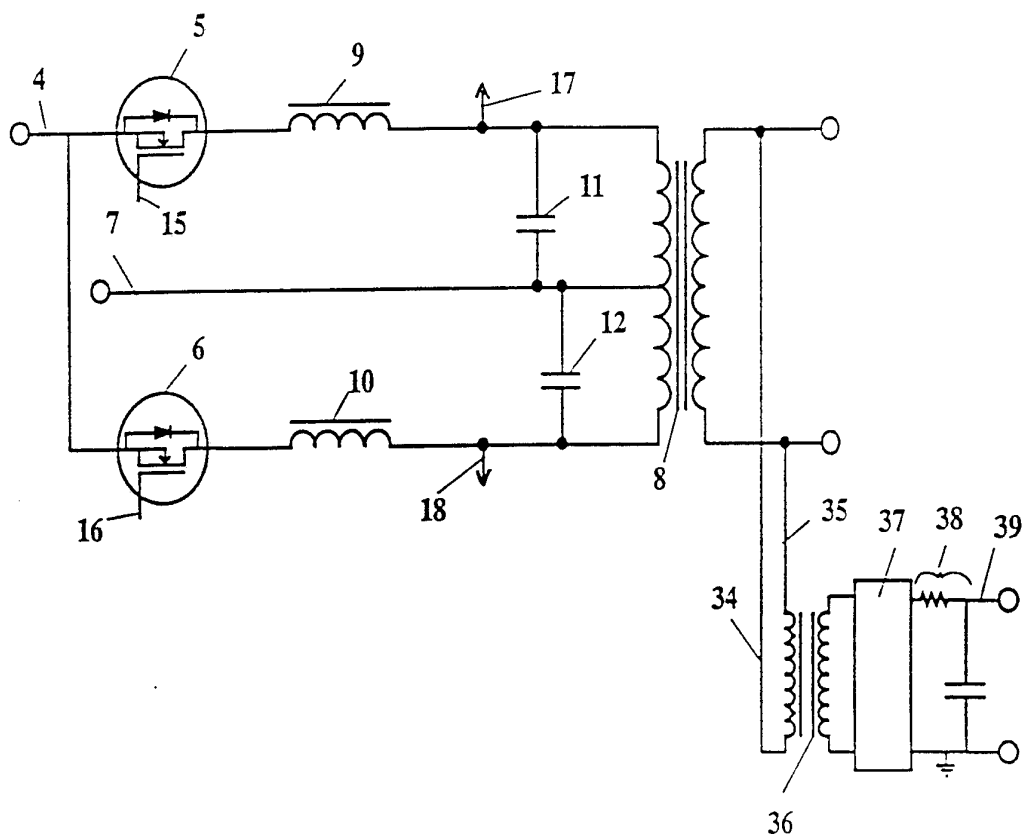


FIG 6

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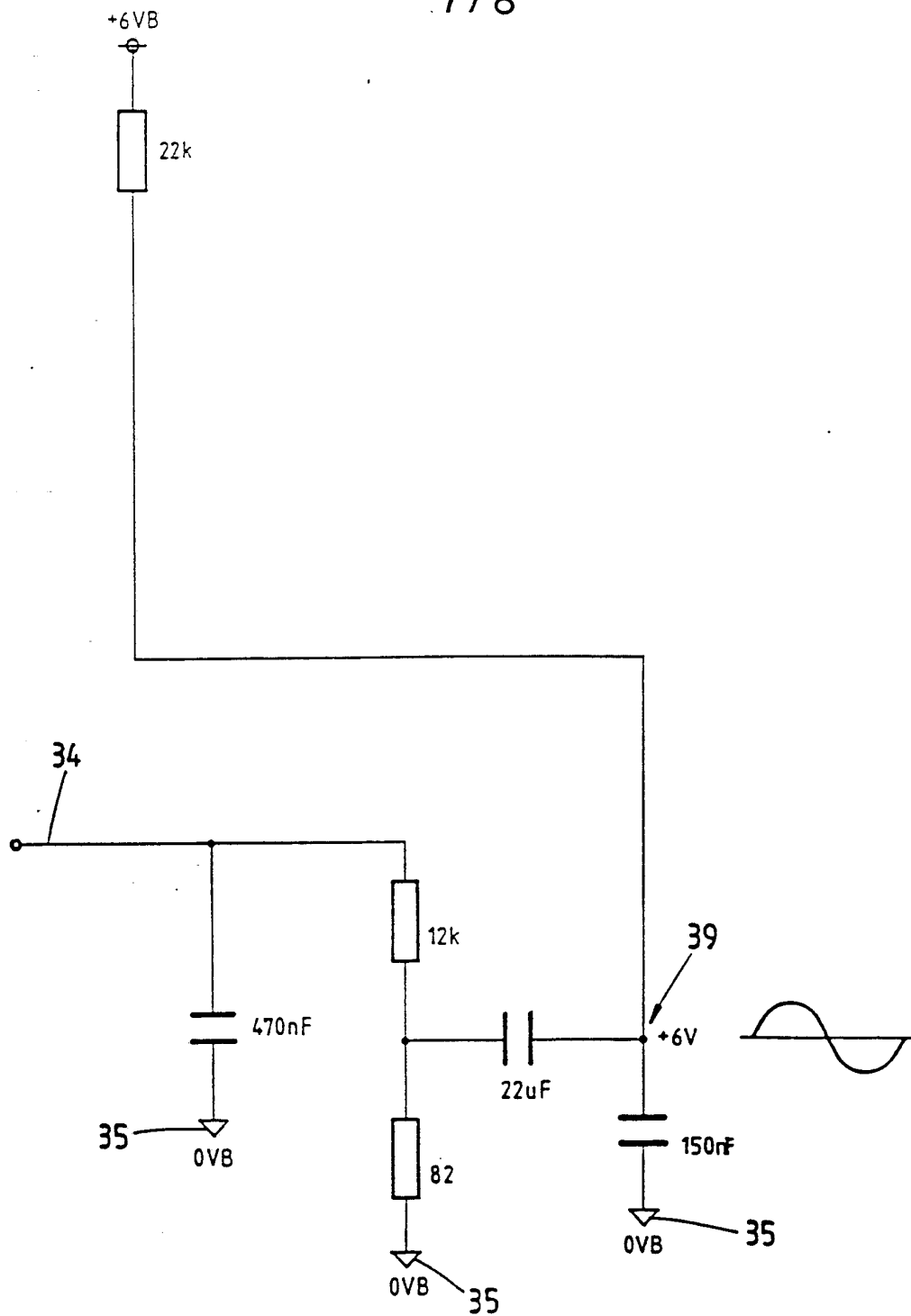


FIG 7

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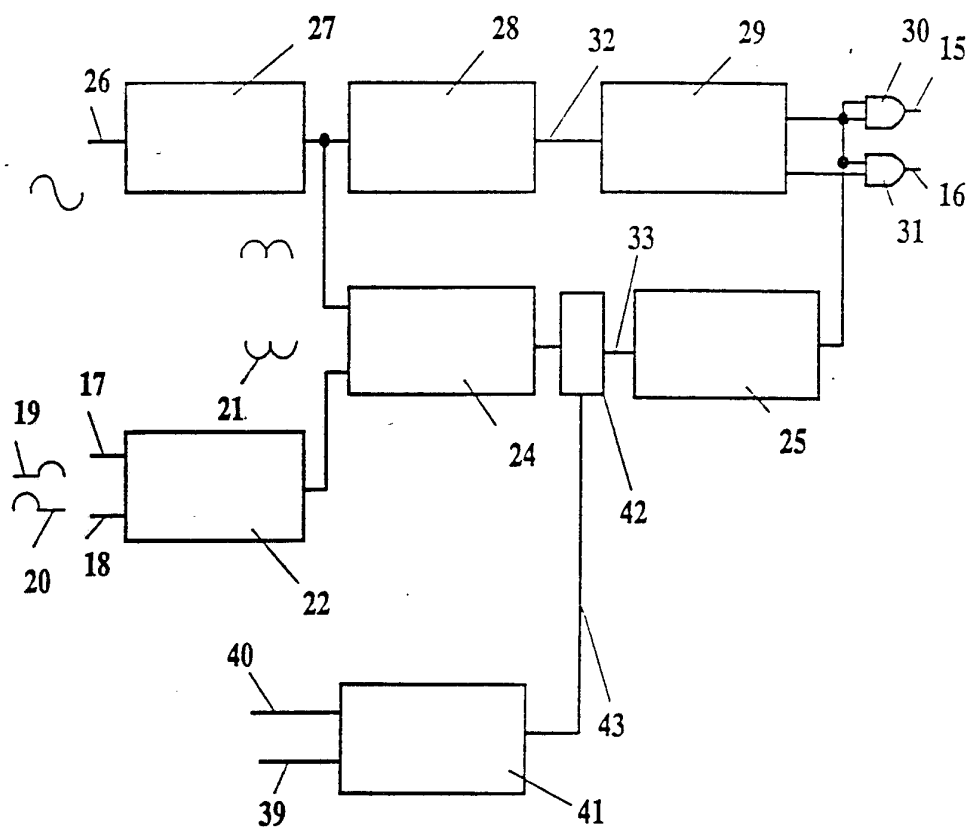


FIG 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU92/00630

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. ⁵ H02M 7/5395 H02P 13/12 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 G05F 1/45 1/455 H02M 7/5395 H02P 13/12 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU:IPC as above Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT, JAPIO, CAPRI				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.		
X	EP,A,358191 (KABUSHIKI KAISHA TOSHIBA) 14 MARCH 1990 (14.03.90) Column 3, line 30 to column 4 line 6, figure 3.	1-22		
A	AU,B,42525/78 (527678) (SONY CORPORATION) 21 JUNE 1979 (21.06.79)			
A	AU,B,42524/78 (527701) (SONY CORPORATION) 21 JUNE 1979 (21.06.79)			
A	EP,A,284021 (ZAIDAN HOJIN HANDOTAI KENKYU SINKOKAI) 28 SEPTEMBER 1988 (28.09.88)			
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.				
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> * Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width: 50%; vertical-align: top;"> "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 </td> </tr> </table>			* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 26 February 1993 (26.02.93)		Date of mailing of the international search report 19 MAR 1993 (19.03.93)		
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929		Authorized officer  R. CHIA Telephone No. (06) 2832185		

INTERNATIONAL SEARCH REPORT
Information on patent family member

International application No.
PCT/AU92/00630

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	358191	US	5045989	JP	2168897		
AU	42525/78	CA	1126811	DE	2854441	FR	2412113
		GB	2011194	JP	54084252	NL	7812274
		US	4236196				
AU	42524/78	CA	1130857	DE	2854410	FR	2412114
		GB	2010605	JP	54084225	US	4236198
EP	284021	CN	88101565	JP	63240376	US	5021936
		JP	63240377				
END OF ANNEX							