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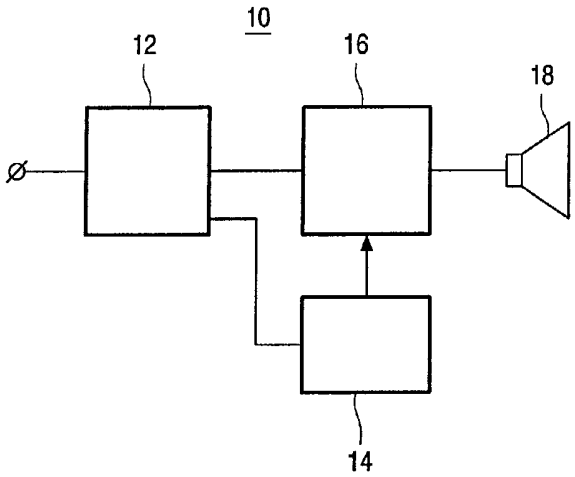
(54) Title: AUDIO SYSTEM WITH INACTIVE SMPS DURING TUNER SEARCH



(57) Abstract: An audio system (10) has a switch mode power supply (12), or SMPS, an output stage (16), connected to the switch mode supply (12) for receiving power therefrom. The audio system (10) has an audio input and an audio output. The audio signal generating device (14) or audio signal generating stage has a frequency controlled or free running converter stage or a frequency controlled tuner stage for the generation of an audio signal which is output from the audio signal generating device (14) to the input of the output stage, the audio signal generating device (14) being connected to the SMPS (12) for receiving power therefrom. The SMPS (12) is operated in alternating active and non-active intervals for pulsing and not pulsing, respectively, and the audio signal generating device (14) is operated in the non-active intervals exclusively while the SMPS (12) is not pulsed for avoiding interference between the SMPS (12) and the audio signal generating device (14).

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Audio system with inactive SMPS during tuner search

The present invention relates to an audio system comprising a switch mode power supply or SMPS, an output stage and an audio signal generating device.

Within the industry, a great number of audio devices or audio systems have been developed and are marketed. From the radio receiver and the phonograph, a great variety of products have through the last decades been marketed. Further, as far as audio source is concerned, a trend from shifting from analogue based systems to digital based systems have been pronounced within the last decade after the presentation of the CD in the early 80's. Examples of present audio products or audio systems are portable and stationary compact cassette recorders (CCC), digital compact cassette recorders (DCC) and tape stations, mini disc recorders (MD), compact disc apparatuses (CD), digital versatile disc apparatuses (DVD), radio receivers including VHF, UHF, FM, LW, MW and SW receivers based on frequency modulated, phase modulated or amplitude modulated reception technique and digital receivers and automobile appliances including automobile radios.

Portable or stationary apparatuses of the above kind together with numerous other kinds of apparatuses including home video tranceivers, TV sets, TV monitors, PC etc. may be powered by a mains power supply or from a battery package including a conventional 12 V battery of an automobile.

The present invention provides a novel technique of preventing interference in the audio signal generating stage or audio signal generating device originating from the SMPS. The concern of reducing power consumption of the audio system has promoted the development of high efficiency SMPS including oscillators oscillating at fairly high frequencies allowing the decoupling capacitors of the SMPS to be fairly small thereby reducing the size and weight of the SMPS and further the entire audio system.

The use of a fairly high switching frequency of the SMPS may, however, give rise to interference and modulation problems in the audio signal generating device, in particular in frequency control converter stages or frequency control tuner stages of the audio signal generating device or audio signal generating stage. Conventionally, interference problems originating from high frequency oscillators have been solved by shielding and decoupling which to a great extent may eliminate the interference problems.

The present invention, however, is based on a totally different approach of solving the interference problems originating from the oscillator of the SMPS and causing interference in the frequency control converter stage or frequency control tuner stage of the audio signal generating device or audio signal generating stage of the audio system allowing on the one hand a high efficiency SMPS to be utilised in conjunction with a high efficiency output stage and avoiding or eliminating interference in the frequency control audio stage of the audio signal generating device.

A particular advantage of the present invention relates to the provision of an audio system including a SMPS, an output stage and an audio signal generating stage or audio signal generating device, which audio system may be provided as a high compact and high efficiency system allowing stationary and also portable products to be based on the novel audio system technique according to the present invention.

The above object and the above advantage together with numerous other objects and advantages which will be evident from the below detailed description of the present invention is according to the teachings of the present invention obtained by means of an audio system comprising a switch mode power supply or SMPS, an output stage, connected to the SMPS for receiving power therefrom and having an audio input and an audio output, and an audio signal generating device or audio signal generating stage including a frequency controlled converter stage or a frequency controlled tuner stage for the generation of an audio signal output from the audio signal generating device to the input of the output stage, the audio signal generating device being connected to the SMPS for receiving power therefrom, the SMPS being operated in alternating active and non-active intervals for pulsing and not pulsing, respectively, the SMPS and the audio signal generating device being operated in the non-active intervals exclusively while the SMPS is not pulsed for avoiding interference between the SMPS and the audio signal generating device.

According to the basic teachings of the present invention, the SMPS is operated in an alternating mode, namely a pulsed and a non-pulsed mode allowing the audio signal generating device to be operated in the non-pulsed period of the alternating operational mode of the SMPS without any interference being generated from the oscillator of the SMPS as the SMPS is not pulsed.

In this context, the terms stage and device are to be considered genetic terms describing a separate part or apparatus or a part of an apparatus or a system conventionally considered a part of the overall apparatus or system performing a specific operation such as receiving an demodulating a wireless signal, converting a digital signal into an analogue

system etc. The terms, however, are to be construed as generic terms without in any sense limiting the relevant part of an apparatus or a system to a specific device or a specific stage. The terms are rather to be considered comprising any set of components conventionally considered by a person skilled in the art as a stage or a device in the true meaning of the terms.

As mentioned above, the audio system according to the present invention may be implemented in numerous embodiments and be based on a number of different signal processing and conversion techniques. Furthermore, the individual stages of the audio system according to the present invention may be dedicated for different applications as, among others, the output stage of the audio system may be implemented as a low level output stage or alternatively, a high level output stage meaning in this context, an output stage delivering a level of less than 1 W, such as 100 mW as a low level output stage or alternatively delivering an excess of 1 W, such as 10 W, 100 W or even more as a high level output stage.

Furthermore, the output stage may be based on well known techniques per se, such as the class A, the class B, the class AB, the class C, class T or alternatively and preferably the class D technique allowing an extremely high efficient and low weight audio system to be deduced. By the use of the class D output technology, the overall efficiency of the audio system may be increased, thereby reducing the heat emission requirements to be complied with and further reducing the overall size, weight and cost of the audio system.

As mentioned above, the audio signal generating device or audio signal generating stage of the audio system according to the present invention may constitute a converter or tuner stage or part, such as a D/A converter of a compact disc, a DVD, a DCC or mini disc reproducing apparatus or alternatively an A/D converter of a mini disc (MD) recorder or digital compact cassette (DCC) recorder. In recording applications, level shaping stages such as AGC (Automatic gaining control stages), compressors or limitors may further be based on the technique characteristic of the present invention as defined above.

A particular application of the present invention relates to tuner stages and the audio signal generating device, consequently, according to the presently preferred embodiments of the audio system according to the present invention constitutes a syntheziser tuner being an analogue VHF, UHF, FM, PM or AM tuner or a digital tuner, such as a mobile telephone receiver stage, e.g. a GSM or satellite receiver.

As mentioned above, the SMPS may for complying with the high efficiency requirements preferably be operated at a fairly high frequency, such as a frequency of the order of 5 kHz-5 MHz, such as 5-50 kHz, 50-500 kHz, 500-5 MHz, 5 MHz-50 MHz, e.g. 5-

10 kHz, 10-20 kHz, 20-50 kHz, 50-100 kHz, 100-200 kHz, 200-500 kHz, 500-1 MHz, 1-2 MHz, 2-5 MHz, 5-10, MHz, 10-50 MHz.

Dependent on the power requirements to be complied with by the SMPS, the active interval may be longer than, identical to or shorter than the inactive interval in the alternating operation of the SMPS. It is to be understood that the active interval in which the SMPS is operated or generating power to be delivered to the output stage and also to the audio signal generating device need to be long enough for allowing the voltage or the voltages output from the SMPS to be maintained by the charge capacitors of the SMPS at a level above a specific minimum level during the operation of the audio system. The active and non-active intervals together define a symmetric or asymmetric cycle defining a frequency smaller than the switch frequency or pulse frequency of the SMPS such as a frequency of at least one order lower than the frequency of a SMPS when operated in the active interval.

Although the switching of the SMPS between the pulsing mode and the non-pulsing mode may be controlled by a switching element or a clock of the switch mode supply, it is, however, preferred that the switch be performed by means of a voltage detector stage detecting the voltage supplied from the SMPS to the audio signal generating device and controlling the SMPS in the alternating active and non-active intervals by switching the SMPS into pulsing mode provided a specific minimum SMPS voltage level be detected at the audio signal generating device and by controlling the SMPS into non pulsing mode provided a specific maximum SMPS voltage level be detected at the audio generating device.

In the presently preferred embodiment of the audio system according to the present invention, the audio signal generating device is an AM tuner comprises the automatic search mode of the AM tuner or similar sweep or tuning operation.

The invention is now to be further described with reference to the drawings in which

Fig. 1 is a schematic view illustrating the general architectural set-up of the audio system according to the present invention.

Fig. 2 is a diagramatic view illustrating in a time diagram the operation of a SMPS and a tuner of the audio system according to the present invention, and

Fig. 3 is a schematic and diagramatic view of a prototype implementation of the SMPS of the audio system according to the present invention.

In Fig. 1, a diagram is shown illustrating the architectural set-up of an audio system according to the present invention. In this description, the audio system is being described with reference to an AM tuner exclusively, however, it is contemplated that the teachings of the present invention are also applicable in connection with different audio systems including FM or PM tuners, such as UHF, VHF or digital tuners or further alternatively frequency controlled clock operated apparatuses such as CD desks, MD, DCC or similar apparatuses including a clock controlled A/D or D/A converter.

In Fig. 1, the audio system is designated the reference numeral 10 and includes an SMPS 12 powering a tuner 14 and an output amp. 16 which is connected to a speaker 18. Conventionally, the SMPS function for an audio system including an amplifier and a tuner is realised by a transformer including bridge rectifier and buffer or an SMPS. The transformer/bridge rectifier solution is an AM tuner compatible solution, however causes uncontrolled, i.e. impedance and load dependent output voltages and is bulky and increases the weight of the system. The conventional SMPS's are, however, not compatible with AM tuner or similar clock or frequency controlled apparatus. During normal operation and tuner search mode, the SMPS switching may cause frequency disturbances or interference in the AM frequency spectrum. This interference may result in audio disturbance or noise in normal operation mode or alternatively false stop during the tuner search mode.

The amplifier may be of different type or class such as a conventional AB or preferably a D class amplifier. The class D amplifier is preferred due to its high efficiency, simplicity, power capability, low distortion, miniaturisation and cost. During normal tuner search mode, the D class amplifier is switched off (load switched off) resulting in zero amplifiers or tuner disturbances. Therefore, in conventional architecture set-ups, the AM tuner compatibility optimisation is focusing on the class D operation under normal operation only. According to the present invention, the SMPS is controlled into a active and non-active mode in order to eliminate the interference or disturbance problems caused by the clock frequency of the SMPS. In the active state, the SMPS is pulsed, whereas in the non-active state the SMPS is caused not to pulse allowing the AM tuner to be operated without any interference from the clock frequency of the SMPS. In the non-active state or in the non-active interval of the SMPS, the AM tuner is allowed to perform its search in search mode without interference or disturbance from the SMPS. The SMPS is, consequently, deduced as an AM tuner compatible solution allowing the SMPS and class D amplifier to be used in

combination with 300 or 350 kHz fixed frequency operation and 2.5 MHz (above AM frequency spectrum) operation. The AM tuner compatible SMPS allows for the construction of a low power consumption and high power efficiency class B output stage to be combined with the AM tuner.

In Fig. 2, a diagram is shown illustrating the operation of the SMPS and also the tuner of the audio system shown in Fig. 1.

In Fig. 2, two complete cycles of the active/non-active alternation of the SMPS is shown. The cycle of the alternating SM includes an ON and OFF state. In the ON state, the SMPS is operated as is illustrated in the top diagram of Fig. 2 as the SMPS is pulsed. In the OFF state, the SMPS is not pulsed. In the second diagram, the supply ripple of the SMPS controller is illustrated as the ripple is caused to increase during the ON state and slowly decreases during the OFF state, as the SMPS is OFF. Similarly, the tuner supply ripple illustrated in the third diagram of Fig. 3 varies in conformity with the variation of the SMPS supply ripple. The tuner supply ripple constitutes a reflected wave form of the controller supply ripple which is controlled as indicated in Fig. 2 between its maximum level OVP and minimum level UVLO. The operation of the tuner search is illustrated in the lowest or fourth diagram in Fig. 4 as the search mode is switched off during the SMPS ON interval and the search mode is switched on during the SMPS OFF interval. In doing so, any interference from an SMPS switching in the AM tuner search mode is eliminated. The switching of the SMPS between ON and OFF may be controlled by an external clock or alternatively be based on a detection of the SMPS ripple in order to prevent that the load of the output stage of the audio system shown in Fig. 1 causes the SMPS supply voltage to decrease below a certain critical limit as the SMPS controller at the same time switches off the search mode of the tuner and switches the SMPS from OFF to ON for allowing the SMPS controller ripple to increase. The controlling of the SMPS between its ON and OFF states is performed for maintaining the tuner supply voltage within a specific voltage range defined by a minimum voltage indicated in the diagram and a maximum level also indicated in the diagram. The controlling of the SMPS and at the same time the controlling of the tuner for allowing the tuner to be turned into its search mode may be performed by a commercially available circuit, namely a controller of the type Philips TEA1507. Reference is made to the Application Note AN00047 supplied by Philips Semi Conductors and describing a "75W SMPS TEA1507 Quasi-Resonant Flyback controller"

In Fig. 3, a diagram of a prototype implementation of the SMPS of the audio system according to the present invention is shown including a SMPS controller of the type

Philips TEA 1507. Generally, the microprocessor of the audio system controls the operation of the TEA 1507 SMPS controller by means of a current pulse generator 100 which is connected to the base of an NPN transistor 102 which switches ON and OFF a light emitting diode or LED 104. The LED 104 is connected in an opto coupler setup to a photo sensitive transistor 106, the collector emitter path of which is connected in a current path from a positive supply terminal 1 of the TEA 1507 SMPS controller designated the reference numeral 108 to a control input 3 of SMPS controller 108 as the LED 104 and the transistor 106 provide an output voltage control/feedback function for the SMPS controller 108 and the entire SMPS. The circuit constituted by the current pulse generator 100 and the NPN transmitter 102 provides a burst mode standby function which is sensed or detected by the SMPS controller 108 through the LED 104 and the transmitter 106. The SMPS controller further includes a driver output 6 which switches ON and OFF an FET transistor 110 for turning ON and OFF the SMPS part of the ON and OFF circuitry, which part includes a transformer 112 having a single primary winding and two secondary windings which are connected to respective charging capacitors 114 and 116 through rectifier diodes 118 and 120, respectively. The voltage across the stabilising capacitor 114 is further stabilised by means of a linear stabiliser circuit 122.

Although the present invention has above been described with reference to a presently preferred embodiment implemented in a combination of an AM tuner and an output stage, the invention may alternatively be implemented in numerous other audio system applications as already mentioned above and these applications are together with modifications and alterations obvious to a person skilled in the art to be considered part of the present invention as defined in the appending claims. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim, "a" or "an" does not exclude a plurality, and a single processor or other unit may fulfill the functions of several means recited in the claims.

CLAIMS:

1. An audio system comprising:

a) a switch mode power supply,

b) an output stage, connected to said switch mode power supply for receiving power therefrom and having an audio input and an audio output, and

c) an audio signal generating device for generating an audio signal output from said audio signal generating device to said input of said output stage, said audio signal generating device being coupled to said switch mode power supply for receiving power therefrom, said switch mode power supply being operated in alternating active and non-active intervals for pulsing and not pulsing, respectively, said audio signal generating device being operated in said non-active intervals exclusively while said switch mode power supply is not pulsed thereby avoiding interference between said switch mode power supply and said audio signal generating device.

2. An audio system according to claim 1, said output stage being a low-level output stage or a high-level output stage.

3. An audio system according to claims 1 or 2, said output stage being a class A, a class B, a class AB, a class C, a class T or a class D audio amplifier stage.

4. An audio system according to claim 1, wherein said audio signal generating device comprises an audio signal generating stage including a frequency controlled converter stage, said frequency controlled converter stage being an A/D or a D/A converter or a level shaping stage such as a AGC stage.

5. An audio system according to claim 1, wherein said audio signal generating device includes a frequency controlled tuner stage.

6. An audio system according to claim 1, wherein said active and non-active intervals together define a cycle, said cycle defining a frequency of at least one order lower

than the frequency of said switch mode of said switch mode power supply when operated in said active interval.

7. An audio system according to claim 1, further comprising a voltage detector stage detecting the voltage supplied from said switch mode power supply to said audio signal generating device and controlling said switch mode power supply in said alternating active and non-active intervals by switching said switch mode power supply into pulsing mode provided a specific minimum switch mode power supply voltage level be detected at said audio signal generating device and by controlling said switch mode power supply into non pulsing mode provided a specific maximum switch mode power supply voltage level be detected at said audio generating device.

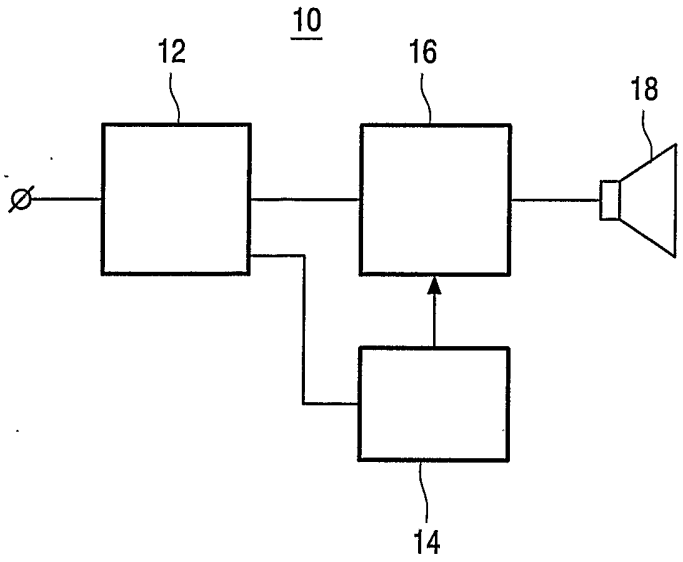
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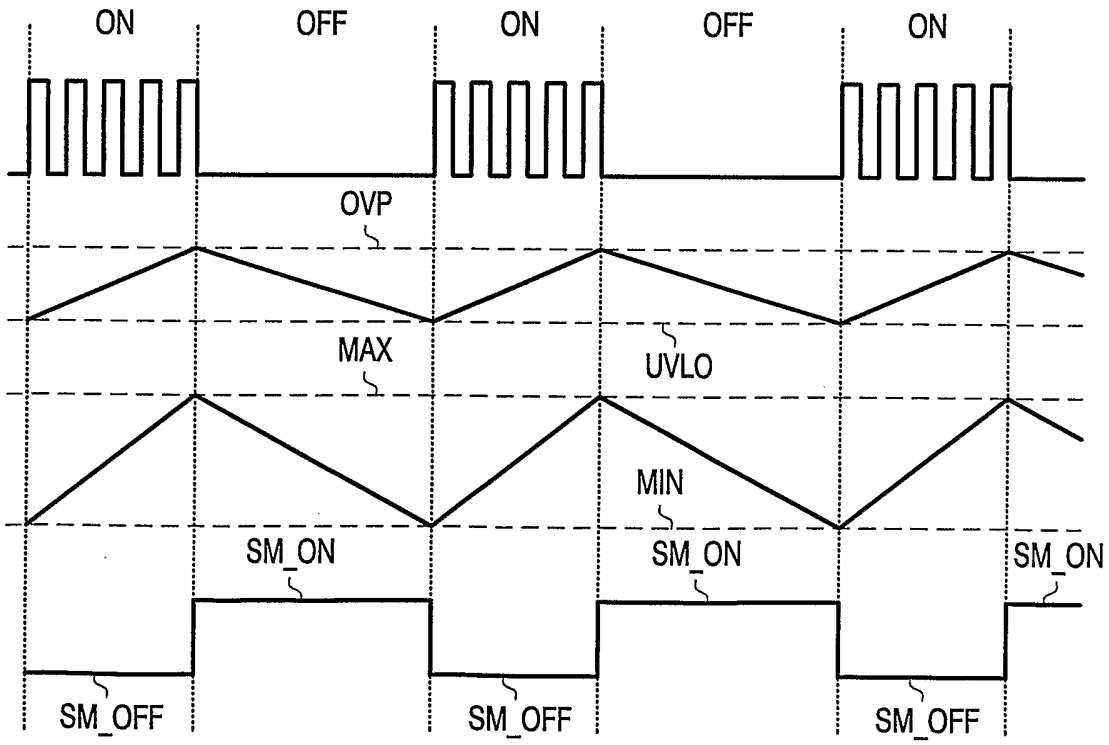
FIG. 1


ON
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MIN
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FIG. 2

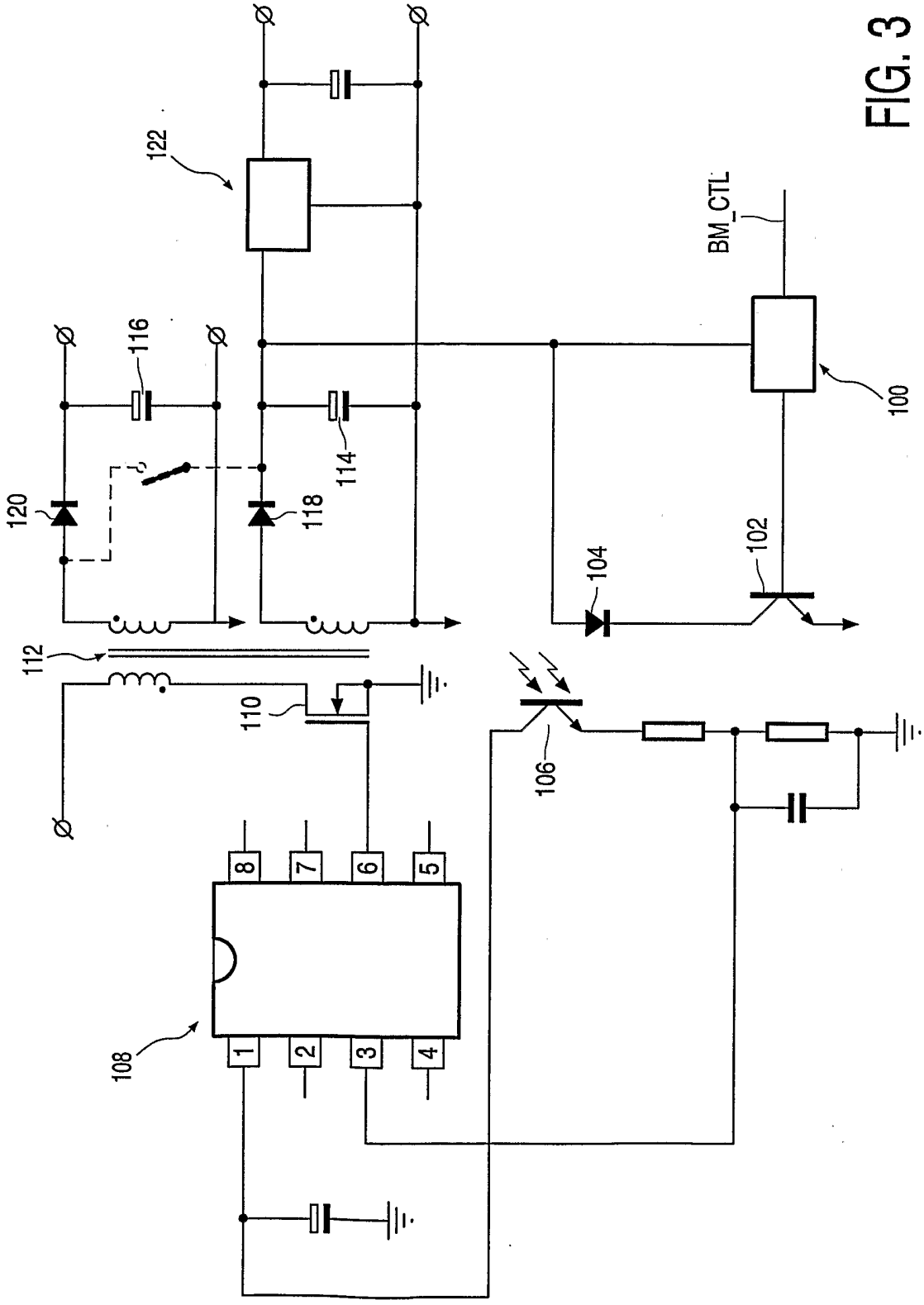

FIG. 3

INTERNATIONAL SEARCH REPORT

PCT/IB 03/04231

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02M3/335 H02M1/12

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 7 H02M

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	GB 2 308 950 A (MATSUSHITA COMMUNICATION IND U) 9 July 1997 (1997-07-09) the whole document	1-4,6
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X	EP 0 654 911 A (NOKIA MOBILE PHONES LTD) 24 May 1995 (1995-05-24) the whole document	1-3,6

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[X] Further documents are listed in the continuation of box C.

[X] 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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"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	Date of mailing of the international search report
19 January 2004	27/01/2004

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 01 37414 A (KONINKL PHILIPS ELECTRONICS NV) 25 May 2001 (2001-05-25) cited in the application the whole document	5

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