



(12)

EUROPEAN PATENT APPLICATION

(43)

Date of publication:
28.05.2014 Bulletin 2014/22

(51)

Int Cl.:
H04R 1/10 (2006.01) G10K 11/175 (2006.01)

(21)

Application number: 12193699.1

(22)

Date of filing: 21.11.2012

(84) Designated Contracting States: AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR Designated Extension States: BA ME	(72) Inventors: • Jones, Oliver 8042 Graz (AT) • Gether, Horst 8345 Straden (AT)
(71) Applicant: ams AG 8141 Unterpremstätten (AT)	(74) Representative: Epping - Hermann - Fischer Patentanwalts-gesellschaft mbH Schloßschmidstraße 5 80639 München (DE)

(54)

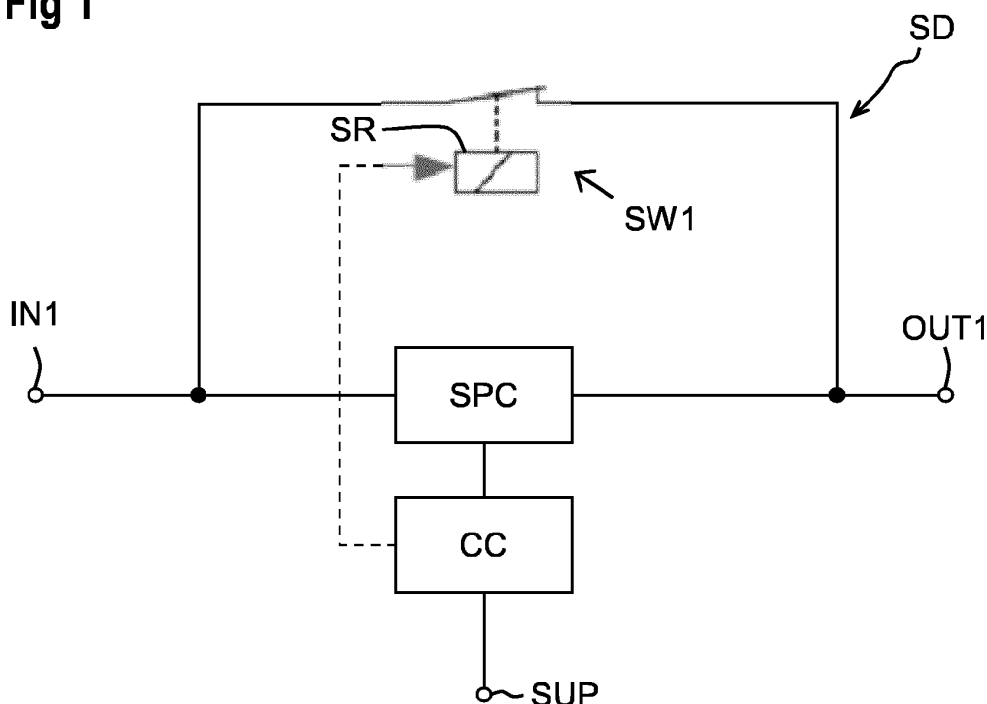
Signal processing device and active headphone with such a signal processing device

(57)

A signal processing device (SD) comprises a signal processing circuit (SPC) having a signal input (IN1, IN2) for receiving an input signal, and a signal output (OUT1, OUT2) for providing a processed output signal. A supply signal is supplied to the signal processing circuit (SPC) at a supply terminal (SUP). A bypass switch (SW1, SW2) connects the signal input (IN1, IN2) to the signal

output (OUT1, OUT2). The bypass switch (SW1, SW2) is in a conductive state in case no control signal is applied to its control terminal. A control circuit (CC) is configured to detect, whether the supply signal is suitable for operation of the signal processing circuit (SPC), and to control the bypass switch (SW1, SW2) to a non-conducting state based on a detected suitable supply signal.

Fig 1



Description

[0001] The invention relates to a signal processing device, which generates a processed output signal based on an input signal, and to an active headphone with such a signal processing device.

[0002] When using active accessories for consumer applications, end users expect a certain quality of service even if the accessory is unpowered. In particular, such active accessories may include signal processing portions, which actively process an input signal in order to provide an output signal thereof. However, if the signal processing portion is unpowered, no output signal can be generated in conventional accessories, thus the active accessory delivers no function.

[0003] An object to be solved is to provide an improved concept for active circuits being operated unpowered.

[0004] This object is achieved with the subject-matter of the independent claims. Embodiments and developments of the improved concept are subject-matter of the dependent claims.

[0005] The improved concept is based on the idea that a signal processing circuit, which actively processes an input signal in order to generate an output signal during normal operation conditions, is made electrically transparent if there is not enough power to actively operate the signal processing circuit. In particular, a bypass switch is provided, which connects a signal input to a signal output of the signal processing circuit, wherein the bypass switch is normally on and has to be switched off actively. For example, if a suitable supply for the signal processing circuit is detected, the bypass switch can be controlled to a non-conducting state, hence activating the function of the signal processing circuit. In the unpowered state, the output signal is identical to the input signal such that a minimum functionality of such an arrangement is achieved.

[0006] For example, an embodiment of a signal processing device comprises a signal processing circuit having a signal input for receiving an input signal and a signal output for providing a processed output signal on the basis of the input signal. The signal processing device further comprises a supply terminal for supplying a supply signal to the signal processing circuit, and a bypass switch connecting the signal input to the signal output. The bypass switch is in a conductive state in case no control signal is applied to a control terminal of the bypass switch. The signal processing device additionally comprises a control circuit that is configured to detect whether the supply signal at the supply terminal is suitable for operation of the signal processing circuit, and to control the bypass switch to a non-conducting state based on a detected suitable supply signal.

[0007] Hence, if the signal processing device is unpowered or a supply signal is determined to be not sufficient for operating the signal processing device or the signal processing circuit, respectively, the bypass switch is in a conducting state and electrically connects the signal

input to the signal output without any further intervention needed. For example, if the signal processing circuit comprises functionality for amplifying and/or filtering the input signal, the output signal is identical to the input signal in the state of no or insufficient power, allowing usage of the output signal respectively the input signal. In other words, the conducting bypass switch makes the signal processing circuit transparent as if it was not there. In contrast, in a conventional signal processing device, no output signal is present in case of unpowered operation, such that the conventional signal processing device has no remaining function.

[0008] According to the improved concept, if the control circuit detects a suitable supply for the signal processing circuit, it actively disables the bypass switch and thus allows the signal processing circuit to process the input signal as desired.

[0009] In various embodiments of the signal processing device the bypass switch comprises a switching relay. For example, the switching relay may be arranged externally to an integrated circuit comprising a signal processing circuit and a control circuit.

[0010] In other embodiments of the signal processing device, the signal processing circuit, the supply terminal, the bypass switch and the control circuit are integrated in a joint integrated circuit. This is particularly advantageous if the bypass switch comprises a depletion-mode transistor, in particular a depletion-mode field-effect-transistor. However, the depletion-mode transistor can also be provided externally to the integrated circuit.

[0011] If integrated in a joint integrated circuit, the signal processing device may be produced in a standard CMOS process with little effort.

[0012] In various embodiments of the signal processing device, the control circuit is configured to compare the supply signal to a threshold signal in order to detect whether the supply signal is suitable. The threshold signal may also be a threshold level, which may be defined by characteristics of circuit parts. Hence, if the supply signal, for example a supply voltage, exceeds a given threshold level, the control circuit can deactivate the bypass switch such that the signal processing circuit can perform its desired signal processing of the input signal.

[0013] For example, in various embodiments of the signal processing device, the control circuit comprises a power-on reset circuit. Such power-on reset circuits or POR circuits are well-known to the skilled person and are usually used to activate an electronic circuit if power, in particular enough power, is provided to the electronic circuit. However, according to the improved concept, the detection signal of the POR circuit can also be used as a basis for deactivating the bypass switch.

[0014] In various embodiments, the signal processing circuit may also be actively deactivated or switched off, even if a suitable power supply is preset. For example, a user can switch off the signal processing circuit or the signal processing device, respectively. According to an embodiment of the improved concept, the signal process-

ing circuit can be made transparent in this case too.

[0015] For example, in an embodiment of the signal processing device, the signal processing circuit is configured to be switched between an activated state and a deactivated state. Furthermore, the control circuit is configured to control the bypass switch to a conductive state in case the signal processing circuit is switched to the deactivated state. Hence, by deactivating the function of the signal processing circuit, the signal processing circuit itself is made transparent between signal input and signal output.

[0016] Merely as a non-limiting example, the function of the signal processing circuit may be an amplification of the input signal, such that the output signal is either an amplified version of the input signal or, in the deactivated state of the signal processing circuit, the input signal itself. Thus, in this example, a user may select to have either the original signal or an amplified signal.

[0017] The embodiments of the signal processing device described above are described with a single signal input and a single signal output for the sake of simplicity. However, the signal processing circuit may have more signal inputs and more signal outputs associated with each other. For example, in audio processing, two or more signal inputs and signal outputs may be present for providing a stereo signal or other multichannel audio signals. In this case, respective bypass switches may be provided for each signal channel, i.e. between each signal input and their corresponding signal output.

[0018] Hence, according to further embodiments of the signal processing device, the signal processing circuit comprises a plurality of signal inputs and a plurality of signal outputs, wherein each of the signal outputs is, by means of a respective bypass switch, connected to one of the signal inputs associated therewith. The bypass switches are controlled commonly. In other words, all bypass switches are activated together or deactivated together, respectively.

[0019] The various embodiments of the signal processing device can be produced and operated with little effort. In particular, the possibility of integrating various embodiments of the described signal processing device allows for a higher quality and smaller solutions. Also the costs can be reduced due to the lower component count. Furthermore, the mechanical size of the signal processing device is reduced, allowing for easier integration with other parts.

[0020] A signal processing device according to the improved concept may be used in various applications where an input signal is processed actively to produce an output signal. For example, the function of the signal processing circuit may contain some sort of amplification or filtering or a combination thereof. The improved concept may particularly be advantageous in applications where the unprocessed input signal is still useful compared to the processed signal, although with a reduced quality of service.

[0021] For example, a signal processing device ac-

cording to the improved concept may be used in an active headphone. Such an active headphone may comprise at least one loudspeaker and a signal processing device according to one of the embodiments described above.

5 An audio input of the headphone is connected to the signal input for receiving an audio signal. The at least one loudspeaker is connected to the signal output. A battery connector is connected to the supply terminal. The signal processing circuit is configured to generate a loudspeaker signal at the signal output based on the audio signal.

10 **[0022]** A battery, in particular a rechargeable battery, can be connected to the battery connector for supplying the signal processing device. For example, if no battery is connected to the battery connector or the battery power of the battery is low, the control circuit does not detect a suitable supply for the signal processing circuit. Hence, the bypass switch is left in or brought to the conducting state in order to make the signal processing circuit transparent. Consequently, in the unpowered or low-powered case, the input signal or audio signal is directly provided to the loudspeaker without processing. If a suitable supply is detected by the control circuit, the bypass switch is deactivated or brought to a non-conducting state and the signal processing circuit can operate as desired. In any case, some sort of loudspeaker signal is provided to the loudspeaker such that a minimum functionality of the headphone is achieved.

20 **[0023]** As described above, the signal processing circuit can have more than one signal input and corresponding signal output, for example for processing a stereo audio signal. Accordingly, for each of the audio channels, a respective bypass switch is provided. It is self-explanatory that the headphone has at least two loudspeakers in this configuration.

25 **[0024]** In one embodiment of the active headphone a signal processing device is implemented having the signal processing circuit being switchable between an activated state and a deactivated state as described above. Accordingly, the control circuit is configured to control a bypass switch to a conducting state in case the signal processing circuit is switched to the deactivated state. The headphone further comprises an activation switch for switching the signal processing circuit between the activated state and the deactivated state. Hence, if a user actively deactivates the signal processing device, respectively the signal processing circuit, signal input and signal output are automatically connected in order to provide the unprocessed input signal to the loudspeaker. Hence, even if the signal processing circuit is not actively operated, a basic function of the headphone, namely providing an audio signal to the loudspeakers, remains.

30 **[0025]** In various embodiments of the active headphone, the headphone further comprises a microphone for providing a microphone signal. The signal processing circuit is configured to provide the loudspeaker signal based on audio signal and the microphone signal in order to perform active noise cancellation, ANC.

35 **[0026]** Active noise cancellation headphones use a mi-

crophone signal in order to provide ambient noise to a signal processing circuit, which generates, e.g. by means of filtering and amplification, a compensation signal being basically opposite to the ambient noise. The compensation signal is combined with the original audio signal and provided to the loudspeaker. At the user's ear, the ambient noise and the compensation signal at least partially cancel out each other. Such active noise cancellation systems are well-known in the art.

[0027] If the signal processing circuit with such an ANC functionality is deactivated due to an unsuitable supply or deactivation by a user, the headphone can still be used to play the audio signal, however without active noise cancellation. In case a suitable supply returns, for example by changing or recharging the battery, or by activating the signal processing circuit with the ANC functionality, the bypass switches are automatically deactivated and the processed audio signal is provided to the loudspeaker.

[0028] The text below explains the invention in detail using exemplary embodiments with reference to the drawings. Components and circuit elements that are functionally identical or have the identical effect bear identical reference signs. In so far as circuit parts or components correspond to one or another function, description of them will not be repeated in each of the following figures.

[0029] In the drawings:

- Figure 1 shows an exemplary embodiment of a signal processing device,
- Figure 2 shows a further exemplary embodiment of a signal processing device,
- Figure 3 shows a further exemplary embodiment of a signal processing device, and
- Figure 4 shows an exemplary embodiment of an active headphone.

[0030] Figure 1 shows an exemplary embodiment of a signal processing device SD that comprises a signal processing circuit SPC. The signal processing circuit SPC has a signal input IN1 and a signal output OUT1. The signal input IN1 and the signal output OUT1 are further connected by a bypass switch SW1, which in this embodiment comprises a switching relay SR. The signal processing device SS further comprises a supply terminal SUP for supplying a supply signal to the signal processing circuit SPC. A control circuit CC is connected to the supply terminal SUP and has a control output for controlling the bypass switch SW1.

[0031] The signal processing device is configured to receive an input signal at the signal input IN1, which is to be processed by the signal processing circuit SPC for providing a processed output signal on the basis of the input signal at the signal output OUT1. However, this

processing can only be performed if a suitable supply signal is provided at the supply input SUP, for example at least a predetermined supply voltage. The bypass switch SW1 is normally on, i.e. in a conducting state, in case no control signal is applied to a control terminal of the bypass switch SW1. Hence, if not controlled otherwise, the bypass switch SW1 electrically connects the signal input IN1 to the signal output OUT2, thus making the signal processing circuit SPC transparent.

[0032] The control circuit CC is configured to detect whether the supply signal at the supply terminal is suitable for operation of the signal processing circuit SPC. If a suitable supply signal is detected, the bypass switch SW1 is controlled to a non-conducting state by the control circuit CC. Furthermore, the signal processing circuit SPC can be brought to a normal mode of operation, thus processing the input signal.

[0033] If the supply signal comes to a state which is not suitable for supplying the signal processing circuit, the signal processing circuit SPC stops operation and the bypass switch SW1 is controlled to the conducting state again. In particular, if the supply fails, the bypass switch SW1 automatically returns to the conducting state, as no control signal is present at its control terminal. Hence, even if the signal processing circuit SPC is not fully operable, the signal processing device itself remains usable with a limited functionality. For example, the signal processing circuit may amplify and/or filter the input signal to generate the output signal, such that in the bypass state of the bypass switch SW1, the output signal becomes the unfiltered and/or unamplified input signal. This happens without any active intervention from a user. As an additional positive effect, the signal processing device consumes no power in the case of the bypass switch being activated due to loss of power.

[0034] Figure 2 shows a further exemplary embodiment of a signal processing device SD, which is mainly based on the embodiment of Figure 1. However, in the embodiment of Figure 2, the signal processing circuit SPC, the control circuit CC and the bypass switch SW1 are integrated on a joint integrated circuit IC. Additionally, the bypass switch SW1 comprises a depletion-mode field-effect-transistor, which is embodied as a p-channel field-effect-transistor in this case. The integration within an integrated circuit allows the usage of standard CMOS-based technology, for example. Additionally, the integrated circuit implies lower costs, better quality and smaller solutions.

[0035] In the above-described embodiments of Figure 1 and Figure 2, the control circuit CC may be configured to compare the supply signal at the supply terminal SUP to a threshold signal or a threshold level in order to detect whether the supply signal is suitable for operation of the signal processing circuit SPC. For example, the control circuit CC comprises an implementation of a well-known power-on reset circuit. Such a power-on reset, POR, circuit conventionally serves the function of indicating to an electronic circuit that sufficient supply is present for op-

erating the electronic circuit. In the embodiments of Figure 1 and Figure 2, such a POR circuit may additionally serve the function of generating the control signal for the bypass switch SW1 for deactivating the bypass switch SW1. If a POR circuit is already provided within a signal processing device, no or little additional effort is needed for the detection function of the control circuit CC.

[0036] Figure 3 shows a further embodiment of a signal processing device SD, which is based on the previous embodiments of Figure 1 and Figure 2. In particular, in the embodiment of Figure 3 various components are integrated in a joint integrated circuit IC.

[0037] The signal processing circuit SPC of Figure 3, which is indicated by two adjustable amplifiers for simplicity reasons, comprises a first signal input IN1, a second signal input IN2, a first signal output OUT1 and a second signal output OUT2. For example, the signal processing circuit SPC comprises two audio channels, which are processed by the signal processing circuit SPC, respective processed signals being provided to a first and a second loudspeaker LS1, LS2 connected to the signal outputs OUT1, OUT2. A first bypass switch SW1 is connected between the first signal input IN1 and the first signal output OUT1. A second bypass switch SW2 is connected between the second signal input IN2 and the second signal output OUT2. Each of the bypass switches SW1, SW2 comprises a depletion-mode field-effect-transistor P1, P2 as described for the embodiment of Figure 2. In particular, the depletion-mode field-effect-transistors are normally on and can be actively controlled to a non-conducting state.

[0038] The control circuit CC comprises a power management block PM connected to the supply terminal SUP. In this embodiment, a battery BAT is connected to the supply terminal SUP for supplying the signal processing device SD. However, any other kind of supply source could be alternatively used. The control circuit CC further comprises a bypass control logic block BCL, which at its output is connected to the control terminals or gate terminals of the transistors P1, P2. The bypass control logic block BCL may contain driver circuits for generating respective control signals for the transistors P1, P2. For example, gate voltages for the transistors P1, P2 are generated by means of a charge pump based on the supply signal.

[0039] Furthermore, the control circuit CC comprises a power logic block PL connected to an activation input ACT. An activation signal can be provided to the activation terminal ACT by means of an activation switch SWA that can be switched between a high and a low voltage potential. The power logic block PL interacts with the bypass control logic block BCL to indicate an activation or deactivation state of the signal processing device SD, respectively the signal processing circuit SPC. Additionally, the power logic block PL interacts with the power management block PM in both directions for indicating the above-described information to the power management block PM and for receiving information about the

state of a power supply from the power management block PM. Such information about the state of the power supply is further indicated from the power management block PM to the bypass control logic BCL. The power management block PM may comprise a POR circuit as described above.

[0040] Accordingly, if the battery BAT is not present or is empty or not sufficiently charged, the power management block PM cannot detect a suitable supply for operating the signal processing circuit SPC. Hence, in this state, the bypass switches SW1, SW2, respectively the transistors P1, P2, are in their normally on state, thus conducting and connecting the respective signal inputs IN1, IN2 electrically to the signal outputs OUT1, OUT2. If a suitable power supply is detected by the power management block PM, and this information is indicated to the bypass control logic BCL, the bypass control logic BCL controls the transistors P1, P2 to a non-conducting state, thus deactivating the bypass between signal inputs and signal outputs.

[0041] However, if a user decides to deactivate the function of the signal processing device SD manually by actuating the activation switch SWA, the function of the signal processing circuit SPC is turned off or deactivated. Additionally, the deactivated state of the signal processing circuit SPC is indicated to the bypass control logic BCL, which then reactivates the bypass between signal inputs and signal outputs by controlling the transistors P1, P2 to the conducting state. Hence, in any case some kind of output signal is present at the signal outputs OUT1, OUT2, namely either a processed input signal or an unprocessed input signal. As a consequence, even in the non-functional state of the signal processing circuit SPC itself, the signal processing device SD retains a basic functionality for the user.

[0042] It should be noted that the functionality of the signal processing circuit SPC may contain further functions in addition to the mere amplification. For example, filtering or processing of additional signals like sensor signals or microphone signals or the like may be included in the generation of the processed output signal. Furthermore, more than the two depicted processing channels can be provided, such that the signal processing circuit SPC can comprise a greater number of signal inputs and a greater number of signal outputs associated with the respective signal inputs.

[0043] Figure 4 shows a possible implementation form of the signal processing device SD according to one of the embodiments described above. In particular, Figure 4 shows an active headphone HP comprising the signal processing device SD as an integrated circuit IC. The headphone HP comprises a loudspeaker LS1, a microphone MIC, a battery BAT and an activation switch SWA. For a better overview, only a single channel version of the headphone is shown in Figure 4. However, provision of a second loudspeaker and additional parts becomes apparent, at least in combination with the embodiment of Figure 3.

[0044] The microphone MIC is configured to provide a microphone signal in particular to record ambient noise around the headphone and to provide the microphone signal to the signal processing circuit SPC. The signal processing circuit SPC is configured to generate its output signal, namely a loudspeaker signal for the loudspeaker LS1 based on an audio signal provided at its signal input and the microphone signal in order to perform active noise cancellation, ANC. Hence, if the battery is sufficiently charged, the signal processing circuit within the integrated circuit IC can provide the loudspeaker signal with active noise cancellation, which improves the hearing quality of the headphone. In particular, the microphone signal is processed by amplifying and filtering in order to generate a compensation signal. The compensation signal is combined with the audio signal in order to provide the loudspeaker signal. At the user's ear, the compensation signal and the ambient noise cancel out each other at least partially. Such ANC systems are well-known in the art.

[0045] Hence, during ANC operation, the user can have an improved hearing impression. However, if the user deactivates the signal processing circuit and therefore the ANC functionality, by actuating the activation switch SWA, or if the supply of the battery is insufficient, the signal processing circuit within the integrated circuit IC will be bypassed by respective bypass switches as described above. Hence, even in this mode of operation, the user can use the headphones for playing the audio signal via the loudspeaker LS1.

Reference List

[0046]

SD	signal processing device
SPC	signal processing circuit
CC	control circuit
SW1, SW2	bypass switch
IN1, IN2	signal input
OUT1, OUT2	signal output
SUP	supply terminal
SR	switching relay
P1, P2	transistor
IC	integrated circuit
BAT	battery
ACT	activation terminal
SWA	activation switch
LS1, LS2	loudspeaker
HP	headphone
MIC	microphone

Claims

1. Signal processing device (SD), comprising
 - a signal processing circuit (SPC) having a sig-

nal input (IN1, IN2) for receiving an input signal, and a signal output (OUT1, OUT2) for providing a processed output signal on the basis of the input signal;

- a supply terminal (SUP) for supplying a supply signal to the signal processing circuit (SPC);
- a bypass switch (SW1, SW2) connecting the signal input (IN1, IN2) to the signal output (OUT1, OUT2), the bypass switch (SW1, SW2) being in a conductive state in case no control signal is applied to a control terminal of the bypass switch (SW1, SW2); and
- a control circuit (CC) that is configured to detect, whether the supply signal at the supply terminal (SUP) is suitable for operation of the signal processing circuit (SPC), and to control the bypass switch (SW1, SW2) to a non-conducting state based on a detected suitable supply signal.

2. Signal processing device (SD) according to claim 1, wherein the bypass switch (SW1, SW2) comprises a switching relay (SR).
3. Signal processing device (SD) according to claim 1, wherein the signal processing circuit (SPC), the supply terminal (SUP), the bypass switch (SW1, SW2) and the control circuit (CC) are integrated in a joint integrated circuit (IC).
4. Signal processing device (SD) according to claim 1 or 3, wherein the bypass switch (SW1, SW2) comprises a depletion-mode transistor (P1, P2), in particular field-effect-transistor.
5. Signal processing device (SD) according to one of claims 1 to 4, wherein the control circuit (CC) is configured to compare the supply signal to a threshold signal in order to detect whether the supply signal is suitable.
6. Signal processing device (SD) according to one of claims 1 to 5, wherein the control circuit (CC) comprises a power-on reset circuit.
7. Signal processing device (SD) according to one of claims 1 to 6, wherein the signal processing circuit (SPC) is configured to be switched between an activated state and a deactivated state, and wherein the control circuit (CC) is configured to control the bypass switch (SW1, SW2) to a conducting state in case the signal processing circuit (SPC) is switched to the deactivated state.
8. Signal processing device (SD) according to one of claims 1 to 7, wherein the signal processing circuit (SPC) comprises a plurality of signal inputs (IN1, IN2) and a plurality of signal outputs (OUT1, OUT2),

wherein each of the signal outputs (OUT1, OUT2) is, by means of a respective bypass switch (SW1, SW2), connected to one of the signal inputs (IN1, IN2) associated therewith, the bypass switches (SW1, SW2) being controlled commonly.

5

9. Active headphone (HP) comprising at least one loudspeaker (LS1, LS2) and a signal processing device (SD) according to one of claims 1 to 8, wherein

10

- an audio input of the headphone is connected to the signal input (IN1, IN2) for receiving an audio signal;

- the at least one loudspeaker (LS1, LS2) is connected to the signal output (OUT1, OUT2);

15

- a battery connector is connected to the supply terminal (SUP); and

- the signal processing circuit (SPC) is configured to generate a loudspeaker signal at the signal output based on the audio signal.

20

10. Active headphone (HP) according to claim 9 comprising a signal processing device (SD) according to claim 7 or 8, and further comprising an activation switch (SWA) for switching the signal processing circuit (SPC) between the activated state and the deactivated state.

25

11. Active headphone (HP) according to claim 9 or 10, further comprising a microphone (MIC) for providing a microphone signal, wherein the signal processing circuit (SPC) is configured to provide the loudspeaker signal based on the audio signal and the microphone signal in order to perform active noise cancellation.

30

35

40

45

50

55

Fig 1

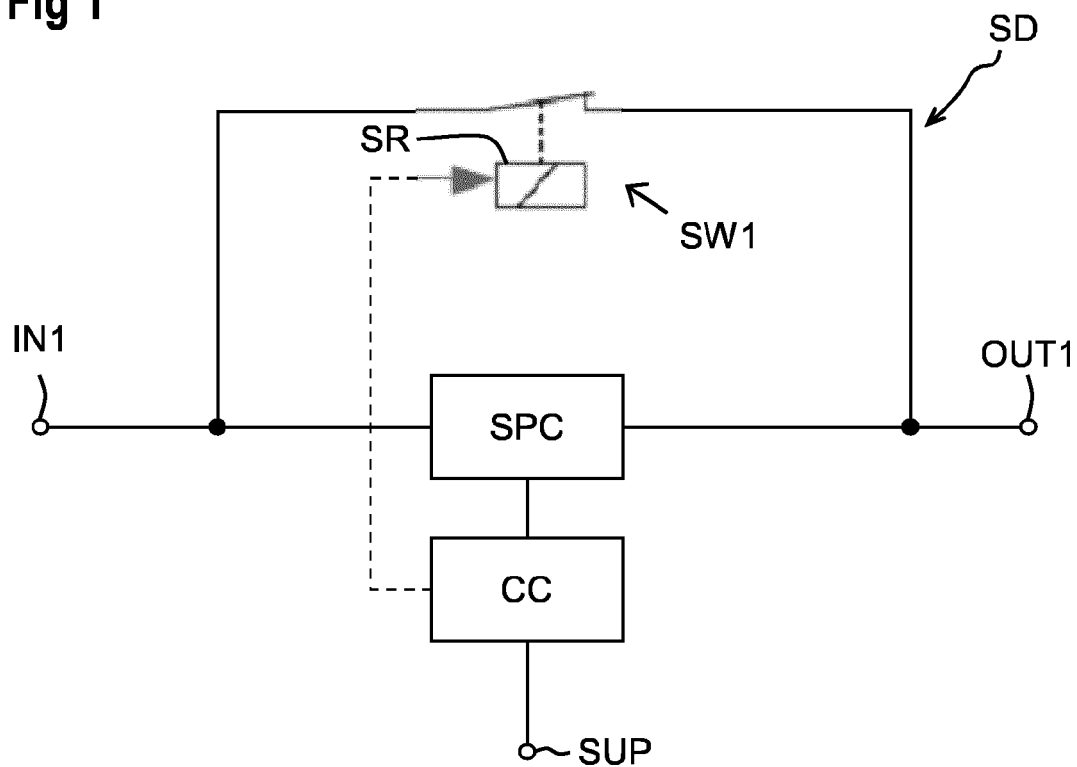


Fig 2

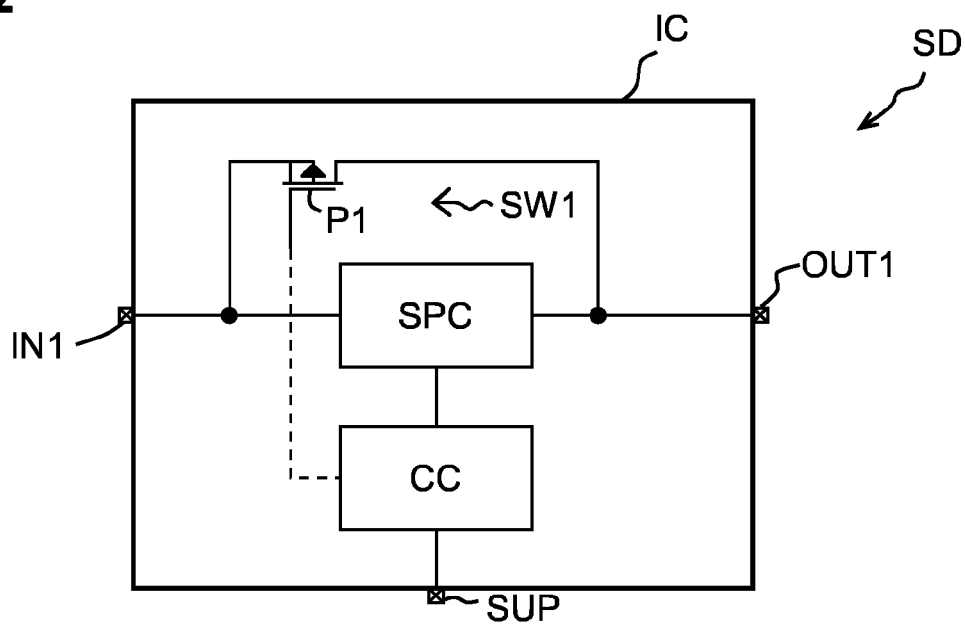


Fig 3

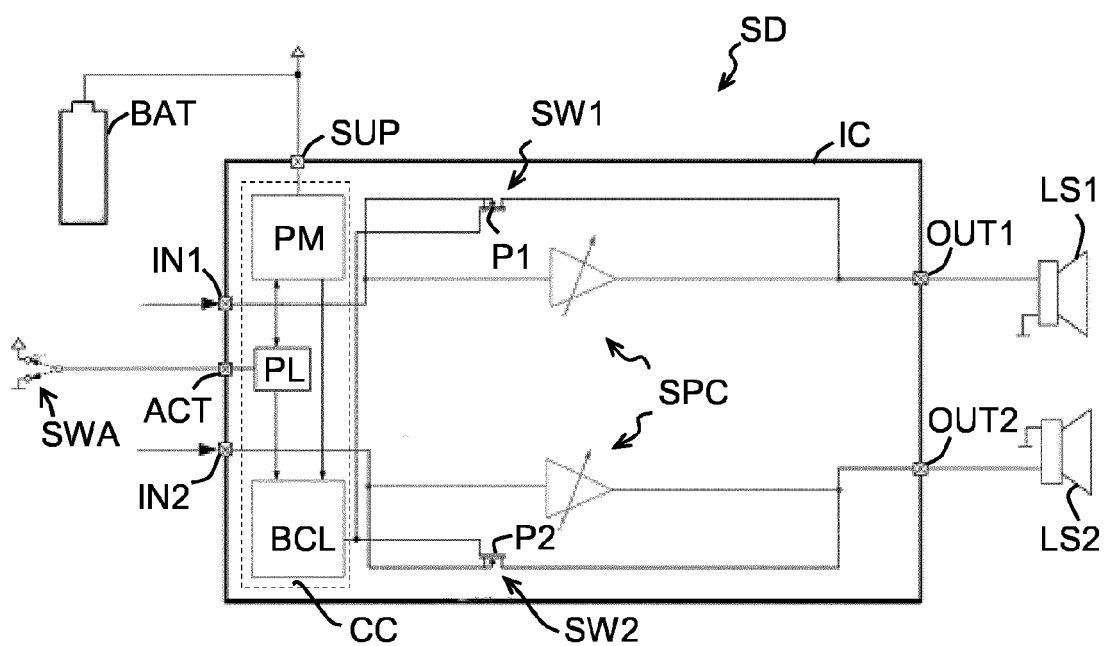
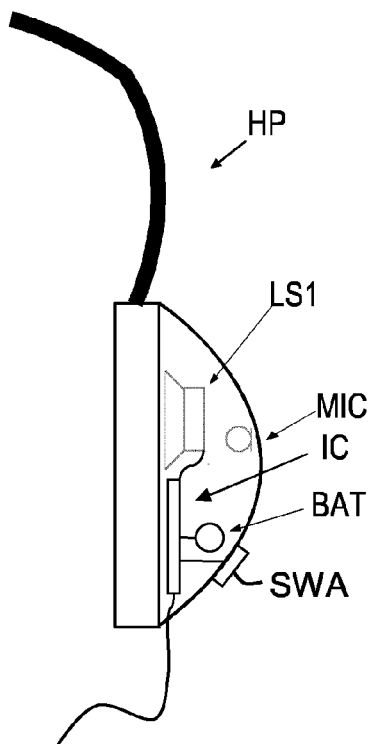


Fig 4





EUROPEAN SEARCH REPORT

Application Number
EP 12 19 3699

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 792 075 A2 (HEWLETT PACKARD CO [US]) 27 August 1997 (1997-08-27) * abstract; figures 7,9,10 * * column 12, lines 8-22 * * column 21, lines 16-21 * -----	1-4,6,8	INV. H04R1/10 G10K11/175
X	US 4 412 245 A (KWOK SAI W [US]) 25 October 1983 (1983-10-25) * abstract; figure 1 * * column 1, lines 5-33 * * column 3, lines 24-42 * -----	1,2,5	
X	EP 2 131 354 A2 (AUDIO TECHNICA KK [JP]) 9 December 2009 (2009-12-09) * paragraphs [0017], [0043] - [0047]; figure 11 * -----	1,7-11	
X	JP 2001 007942 A (NIPPON ELECTRIC ENG) 12 January 2001 (2001-01-12) * abstract; figure 2 * -----	1,2,8	
X	JP 4 213986 A (HOCHIKI CO) 5 August 1992 (1992-08-05) * abstract; figure 1 * -----	1,2	TECHNICAL FIELDS SEARCHED (IPC)
X	JP 2000 207654 A (NOHMI BOSAI LTD) 28 July 2000 (2000-07-28) * abstract; figure 1 * -----	1,2,8	H04R G10K
X	JP 6 014036 A (HITACHI CABLE) 21 January 1994 (1994-01-21) * abstract; figure 2 * -----	1,2	
X	JP 1 008748 A (MITSUBISHI CABLE IND LTD) 12 January 1989 (1989-01-12) * abstract; figure 2 * -----	1,2,8	
		-/--	
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		18 March 2013	Bücker, Martin
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
EP 12 19 3699

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 61 148985 A (PIONEER ELECTRONIC CORP) 7 July 1986 (1986-07-07) * abstract; figure 2 *	1,2	
A	----- Texas Instruments Incorporated: "TLV320AIC3101 LOW-POWER STEREO AUDIO CODEC FOR PORTABLE AUDIO/TELEPHONY", December 2008 (2008-12), XP055056392, Retrieved from the Internet: URL:www.ti.com/lit/ds/symlink/tlv320aic3101.pdf [retrieved on 2013-03-13] * pages 3,20 - pages 22,40,41 *	1,3,4, 6-10	
A	----- "Harman Kardon CL Headphones, Are One Of Five New Headphones From Harman Kardon", thestreet.com Press Releases, 12 June 2012 (2012-06-12), XP055056401, Retrieved from the Internet: URL:http://www.thestreet.com/story/1157747/1/harman-kardon-cl-headphones-are-one-of-five-new-headphones-from-harman-kardon-ph oto-business-wire.html [retrieved on 2013-03-13] * the whole document *	9-11	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
Place of search		Date of completion of the search	Examiner
The Hague		18 March 2013	Bücker, Martin
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1
EPO FORM 1503 03.82 (P04C01)



Application Number

EP 12 19 3699

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:
- ☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



LACK OF UNITY OF INVENTION
SHEET B

Application Number

EP 12 19 3699

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-4, 8

A signal processing device according to EP 0 792 075 A2 comprising the additional features of integrating the signal processing circuit, the supply terminal, the bypass switch.

1.1. claim: 5

A signal processing device according to EP 0 792 075 A2 comprising the additional feature of a comparison of the supply signal to a threshold signal.

1.2. claim: 6

A signal processing device according to EP 0 792 075 A2 comprising the additional feature of a power-on reset circuit.

1.3. claim: 7

A signal processing apparatus according to EP 0 792 075 A2 comprising the additional feature of switching between activated state and deactivated state of the signal processing circuit, wherein the control circuit is configured to control the bypass switch to a conducting state in case the signal processing circuit is switched to the deactivated state.

1.4. claims: 9-11

A signal processing device according to EP 0 792 075 A2 comprising the additional features of an active headphone comprising at least one loudspeaker, wherein an audio input of the headphone is connected to the signal input for receiving an audio signal, the at least one loudspeaker is connected to the signal output, a battery connector is connected to the supply terminal, and the signal processing circuit is configured to generate a loudspeaker signal at the signal output based on the audio signal.

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 19 3699

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-03-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0792075 A2	27-08-1997	EP 0792075 A2	27-08-1997
		JP H09247235 A	19-09-1997
		US 5905724 A	18-05-1999
US 4412245 A	25-10-1983	CA 1173949 A1	04-09-1984
		US 4412245 A	25-10-1983
EP 2131354 A2	09-12-2009	CN 101583059 A	18-11-2009
		EP 2131354 A2	09-12-2009
		JP 2009135874 A	18-06-2009
		US 2009285408 A1	19-11-2009
JP 2001007942 A	12-01-2001	NONE	
JP 4213986 A	05-08-1992		
JP 2000207654 A	28-07-2000	NONE	
JP 6014036 A	21-01-1994		
JP 1008748 A	12-01-1989		
JP 61148985 A	07-07-1986		