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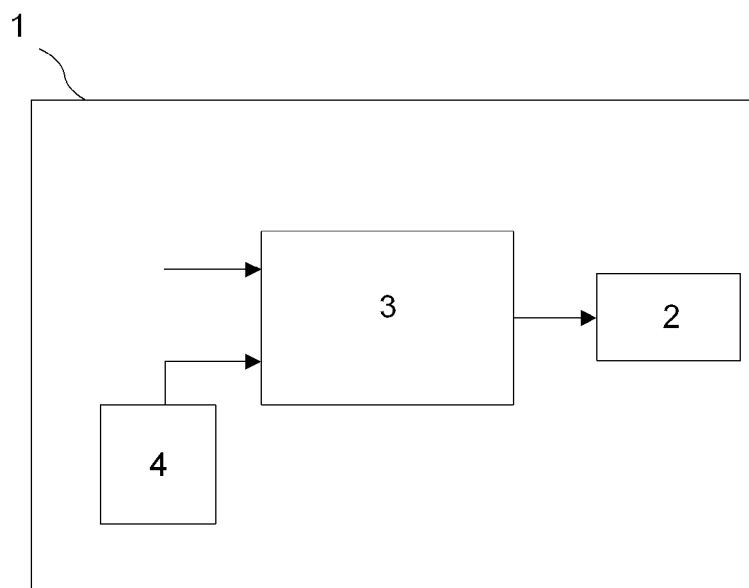
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(54) Title: AN ELECTRONIC DEVICE

Figure 1



(57) Abstract: The present invention relates to an electronic device (1) comprising at least one audio processing unit (2) which processes the audio signals and either converts them into audible sound waves or transmits them to another audio output unit, a noise reduction circuit (3) which prevents the pop-noises on the audio signals from being transmitted while these signals are transmitted to the audio processing unit (2), and a microprocessor (4) which controls the operation of the noise reduction circuit (3).

Description**AN ELECTRONIC DEVICE****[0001] Technical Field**

[0002] The present invention relates to an electronic device which is prevented from making undesired pop-noises while turning an audio system on and off.

[0003] The Prior Art

[0004] In electronic devices having audio output, undesired audio signals can be sent to a speaker connected to the device or to other audio output circuits while the device is turned on and off. By providing or cutting the energy, the undesired signals, occurring due to the unanticipated behaviors of the circuits during the charging and discharging of the capacitors located in the circuits wherein audio signals are processed and transmitted, reach the audience as pop-noises. In the state of the art, various embodiments for preventing pop-noises are present.

[0005] In the state of the art Japanese Patent Document No JP4086109, a system developed for suppressing pop-noises in electronic devices is described. The said system delays the voltage applied during the start-up of the device and reflects it to the output.

[0006] Brief Description of the Present Invention

[0007] The aim of the present invention is the realization of an electronic device which is prevented from making pop-noise while being turned on and off.

[0008] The electronic device realized in order to attain the aim of the present invention, explicated in the first claim and the respective claims thereof, comprises a noise reduction circuit which is designed for preventing pop-noises. The reduction circuit cuts off the connection between the input and the output of the device for a certain period of time during the start-up of the device and thus, prevents the audio signal containing noise from being transmitted to the output. A coupling capacitor, which is located at the output of the reduction circuit, is provided to be charged in a controlled manner during the transmission of the audio signal to the output, and the same capacitor is provided to be discharged in a controlled manner while the device is turned off. Thus, the noises on the audio signal are reduced

and pop-noises are prevented from reaching the audience.

[0009] Detailed Description of the Present Invention

[0010] The electronic device realized in order to attain the aim of the present invention is illustrated in the attached figures.

[0011] Figure 1 - is the schematic view of an electronic device of the present invention.

[0012] Figure 2 - is the schematic view of a noise reduction circuit.

[0013] Figure 3 - is the schematic view of another noise reduction circuit.

[0014] The elements illustrated in the figures are numbered as follows:

1. Electronic device
2. Audio processing unit
3. Noise reduction circuit
4. Microprocessor
5. 15, 25, 35, 45 Capacitor
6. 16, 26, 36, 46 Transistor
7. 17, 27, 37, 47, 57, 67, 77, 87, 97, 107, 117, 127 Resistor
8. 18, 28, 38, 48 Diode

[0015] The electronic device (1) of the present invention comprises at least one audio processing unit (2) which processes the audio signals and either converts them into audible sound waves or transmits them to another audio output unit, a noise reduction circuit (3) which prevents the pop-noises on the audio signals from being transmitted while these signals are transmitted to the audio processing unit (2), and a microprocessor (4) which controls the operation of the noise reduction circuit (3) (Figure 1).

[0016] The noise reduction circuit (3) is the circuit, through which the audio signals in the electronic device (1) pass before being transmitted to the audio processing unit (2) and wherein the noise components on the audio signals are removed. The audio signals enter through the input point (IN) of the noise reduction circuit (3) and exit from its output point (OUT). The noise reduction circuit (3) buffers the voltage (Vs), which provides its operation, from A-node and the control signals, which are received from the microprocessor (4) and regulate the operation of the noise reduction circuit (3), from the control input (SD).

- [0017] The noise reduction circuit (3) comprises a transistor (16) which is disposed between its output (OUT) and input (IN) and which separates the output (OUT) from the input (IN) for a certain period of time during the start-up of the electronic device (1); and a coupling capacitor (15) which is charged in a controlled manner **as a result of** the output (OUT) being reconnected to the input (IN) by the voltage that occurs at the base of the transistor (16) being transmitted to the emitter at the end of the said period of time and thus, which prevents audio signals containing noise from occurring at the output (OUT). While the electronic device (1) is turned off, by a controlled discharge of the same capacitor (15), the noise reduction circuit (3) prevents audio signals containing noise from occurring at the output (OUT).
- [0018] The noise reduction circuit (3) comprises more than one capacitor (5, 15, 25, 35, 45), more than one transistor (6, 16, 26, 36, 46), more than one resistor (7, 17, 27, 37, 47, 57, 67, 77, 87, 97, 107, 117, 127) and more than one diode (8, 18, 28, 38, 48). The transistors are preferably BJTs and in the preferred embodiment of the present invention, four transistors (6, 16, 26, 36) are NPN-type transistors and one transistor (46) is a PNP-type transistor (Figure 2).
- [0019] A coupling capacitor (5) is connected to the input (IN) of the noise reduction circuit (3) and the other end of this capacitor (5) is connected to H-node, to which the base of the first transistor (6) is connected. A resistor (7) is connected between A-node, wherein the voltage (Vs) feeding the noise reduction circuit (3) is provided, and H-node. The collector of the first transistor (6) is connected to A-node, too. The emitter of the transistor (6) is connected to B-node, to which also the collector of the second transistor (16) is connected. Another resistor (57) is situated between H-node and ground (GND). The other end of the capacitor (25), which is connected to A-node, forms K-node. A resistor (87) and a diode (48), the anode of which is connected to ground (GND), that are connected to each other in series, and another resistor (107) parallel to these two components are located between K and ground (GND). One end of a resistor (97), the other end of which is connected to K-node, is connected to L-node, to

which the base of the third transistor (26) is connected. The collector of this transistor (26) is connected to M-node and its emitter is connected to ground (GND). A diode (38), the anode of which is connected to ground (GND), is located between L and GND. A resistor (17) is connected between A and M-nodes. A capacitor (45) is situated between M and GND. The collector of the fourth transistor (36) is, furthermore, connected to M-node. The emitter of the transistor (36) is connected through a resistor (117) to ground (GND). Two diodes (18, 28), the anodes of which face the base output and the cathodes of which face the ground (GND)-side, are connected in series between the transistor (36) base and ground (GND). A resistor (127) is situated between the fourth transistor (36) and the control signal input (SD). M-node, that is, the collector of the fourth transistor (36), is connected to the base of the fifth transistor (46), which is the only PNP-type transistor in the circuit. The collector of the PNP transistor (46) is connected to ground (GND) and its emitter to G-node. A capacitor (35) is connected between G and GND, and a resistor (37) is connected between G and B-nodes. Furthermore, the anode of a diode (8) is connected to G-node. The cathode of this diode (8) is connected to C-node, to which the base of the second transistor (16) is connected. The emitter of the transistor (16) is connected to D-node and a resistor (47) is situated between C and D-nodes. One end of another resistor (27) is connected to E-node, the other end of which is connected to D-node, and another resistor (67) is situated between E and ground (GND). The output point (OUT) of the noise reduction circuit (3) is at F-node. The output coupling capacitor (15) is situated between E and F. A resistor (77) is connected between F and GND.

- [0020] The first transistor (6) located at the input (IN) of the noise reduction circuit (3) and two resistors (7, 57) connected to the base of this transistor (6) provide the circuit input signal to be buffered without being affected by the other components and provide the bias voltage that is required for the operation of the second transistor (16) used as a switch.
- [0021] When the noise reduction circuit (3) is energized after starting up the electronic device (1), the capacitor (25), which is connected to the voltage

feeding the circuit (3), is charged up to a certain level and thus, provides the third transistor (26) to start transmitting. When the third transmitter (26) starts transmitting, the voltage at M-node decreases and the fifth transistor (46) starts transmitting, too. Thus, the base of the second transistor (16) is connected to ground (GND) and this transistor (16) is prevented from starting to transmit. By the second transistor (16) not starting to transmit, an open-circuit is formed between B and D-nodes and thus, the inputs and outputs of the noise reduction circuit (3) are separated from each other during the said period of time. Hence, the pop-noises occurring during the start-up of the electronic device (1) are prevented from being transmitted to the output (OUT).

[0022] When the capacitor (25) is charged up to a certain level, the voltage at K and L-nodes becomes insufficient to keep the transistor (26) transmitting and hence, the transmitter (26) stops transmitting. By the third transistor (26) being turned off, the capacitor (45) connected to the collector of the transistor (26) starts being charged through the resistor (17) which connects the capacitor (45) to the supply voltage (V_s). By the voltage on the capacitor (45) being transmitted to D-node through the transistors (46, 16) operating as an emitter follower in the meantime, the coupling capacitor (15) at the output (OUT) of the noise reduction circuit (3) is slowly charged. Thus, no signal at an audible frequency occurs at the output point (OUT) during the start-up of the electronic device (1). After the voltage at M-node reaches a certain value, the PNP transistor (46) switches to the off mode and the AC signal at B-node is transmitted to D-node by means of the transistor (16), resistor (37) and diode (8) components, all of which operate as a DC level shifter. As long as the electronic device (1) is on, the noise reduction circuit (3) continues to operate in this mode. During the start-up of the electronic device (1) and in its normal operating mode, the control signal going from the microprocessor (4) to the noise reduction circuit (3) is at low level and keeps the fourth transistor (36) deactivated.

[0023] While the electronic device (1) is turned off, the microprocessor (4) raises the control signal it sends to the noise reduction circuit (3) to high level.

Depending on the increase of the voltage at SD-point, the base voltage of the fourth transistor (36) increases and the transistor (36) starts transmitting. The transistor (36) that starts transmitting forms a current source together with the resistors (117, 127), which are connected to the emitter and the base of the transistor (36), and thus, provides the capacitor (45), connected to the collector of the transistor (36), to be slowly discharged and also provides the voltage on the capacitor (45) to slowly decrease. By the voltage at M-node decreasing to a certain value, the PNP transistor (46) starts transmitting and operating as an emitter follower together with the second transistor (16). As a result of this, the voltage at D-node slowly decreases together with the voltage at M-node and the coupling capacitor (15) is slowly discharged without forming a signal at an audible frequency at the output point (OUT). Depending on the decrease of the voltage at M-node, also the voltage at C-node decreases in the course of time and after a while, the second transistor (16) stops transmitting. The small amount of electric charge remaining on the coupling capacitor (15) is completely discharged through two resistors (67, 77) connected to ground (GND) and thus, an audible signal is prevented from being produced at the output (OUT). After all these steps are completed, supply to the noise reduction circuit (3) is cut off by the microprocessor (4).

[0024] In an alternative embodiment of the present invention, in the situation that the input signal contains the required bias voltage component, the input signal is connected directly to B-node without using the coupling capacitor (5), the first transistor (6) and the connected resistors (7, 57), all of which are at the input (IN) of the noise reduction circuit (3) (Figure 3). In this embodiment of the present invention, no change is made in the abovementioned connection structures and operations of the other elements of the noise reduction circuit (3).

Claims

1. An electronic device (1) **comprising** at least one audio processing unit (2) which processes the audio signals and either converts them into audible sound waves or transmits them to another audio output unit, a noise reduction circuit (3) which prevents the pop-noises on the audio signals from being transmitted while these signals are transmitted to the audio processing unit (2), and a microprocessor (4), and **characterized by** the noise reduction circuit (3) having
 - a transistor (16) which is disposed between its output (OUT) and input (IN) and which separates the output (OUT) from the input (IN) for a certain period of time during the start-up of the electronic device (1), and
 - a coupling capacitor (15) which prevents audio signals containing noise from occurring at the output (OUT) by being charged in a controlled manner as a result of the output (OUT) being reconnected to the input (IN) by the transmission of the voltage that occurs at the base of the transistor (16) to the emitter at the end of the said period of time during the start-up of the electronic device (1), and by being discharged in a controlled manner while the electronic device (1) is turned off,
 - and **characterized by** the microprocessor (4) which controls the operation of the noise reduction circuit (3) by the high or low signal it sends to the SD input.
2. An electronic device (1) as in Claim 1, **characterized by** the noise reduction circuit (3) wherein the collector of the transistor (6) is connected to A-node and its emitter to B-node, and which comprises a coupling capacitor (5) connected to the input (IN) thereof and a transistor (6), the base of which is connected to the other end (H) of the capacitor (5),
a resistor (7) between the node (A) wherein the supply voltage (Vs) is provided and H-node, and another resistor (57) connected between H-node and ground (GND).
3. An electronic device (1) as in Claim 2 or Claim 1, **characterized by** a noise reduction circuit (3) that comprises a capacitor (25) connected to A-node, a resistor (87) and a diode (48), the anode of which is connected to ground (GND), that are connected to each other in series, and another resistor (107) parallel to these two components, all of which are located between the other end (K) of the capacitor (25) and ground (GND),

- a resistor (97) connected between K-node and L-node,
a diode (38) which is located between L and GND, and the anode of which is connected to ground (GND),
a transistor (36), the collector of which is connected to M-node and the emitter of which is connected to ground (GND) through a resistor (117), and between the base of which and the ground (GND) two diodes (18, 28) are connected in series, wherein their anodes face the base-side and their cathodes face the ground (GND)-side, and between the base of which and the control signal input (SD) a resistor (127) is situated,
a capacitor (35) between G and GND,
a resistor (47) between C and D-nodes,
another resistor (27) between D and E-nodes.
- 4. An electronic device (1) as in Claim 2 or Claim 3, **characterized by** the noise reduction circuit (3), the input (IN) of which is connected to B-node.
- 5. An electronic device (1) as in Claim 3, **characterized by** the noise reduction circuit (3) that comprises
 - a capacitor (25) that is connected to the voltage feeding the circuit (3) and that is, by the start-up of the device (1), charged up to a certain level and thus, starts the transmission of the transistor (26), the base of which is connected to L-node, the collector of which is connected to M-node and the emitter of which is connected to ground (GND),
 - a transistor (46) which starts transmitting when the third transistor (26) starts transmitting and when the voltage at M-node decreases, and the base of which is connected to M-node, the collector of which is connected to ground (GND) and the emitter of which is connected to G-node,
 - a transistor (16) which, by its base (C) being connected to ground (GND) when the transistor (46) starts transmitting, is prevented from starting to transmit and which forms an open-circuit between B and D-nodes when the transistor (46) does not start transmitting and thus, which, by separating the inputs (IN) and the outputs (OUT) from each other, prevents the pop-noises from being transmitted to the output (OUT), and the base of which is connected to C-node, the collector of which is connected to B-node and the emitter of which is connected to D-node.

6. An electronic device (1) as in Claim 5, **characterized by** the noise reduction circuit (3) that comprises
 - a capacitor (25) which, during the start-up of the electronic device (1), is charged up to a certain level and thus, prevents the third transistor (26) from transmitting,
 - a capacitor (45) between the collector (M) of the transistor (26) and GND which, by the third transistor (26) being turned off, starts being charged through a resistor (17) connected between A and M-nodes,
 - a coupling capacitor (15) which is between F-node, being the output point (OUT), and E-node, and which is slowly charged by the voltage on the capacitor (45) being transmitted to D-node through the transistors (46, 16) operating as an emitter follower in the meantime and thus, which prevents a signal at an audible frequency from occurring at the output point (OUT).
7. An electronic device (1) as in Claim 6, **characterized by** the noise reduction circuit (3) that comprises
 - a PNP transistor (46) which switches to the off mode after the voltage at M-node reaches a certain value,
 - a resistor (37) between G and B-nodes and a diode (8), the anode of which is connected to G-node and the cathode of which is connected to C-node, both of which transmit the AC signal at B-node to D-node by operating as a DC level shifter together with the transistor (16),and that continues to operate in this mode as long as the electronic device (1) is on.
8. An electronic device (1) as in Claim 7, **characterized by** the microprocessor (4) which provides the fourth transistor (36) to be deactivated by sending a control signal at low level to the noise reduction circuit (3) during the start-up of the electronic device (1) and in its normal operating mode (when it is on), and which raises the control signal to high level while the electronic device (1) is turned off, and which drops the control signal again to low level after the electronic device (1) is turned off.
9. An electronic device (1) as in Claim 8, **characterized by** the noise reduction circuit (3) that comprises
 - a fourth transistor (36), the base voltage of which increases depending on the

increase of the voltage at the SD point as a result of the control signal reaching the high level and thus, which starts transmitting,

- a capacitor (45) which is connected to the collector of the transistor (36) and which is slowly discharged after the transistor (36) that starts transmitting forms a current source together with the resistors (117, 127) that are connected to the emitter and the base of the transistor (36),
- a PNP transistor (46) which, by the voltage at M-node decreasing to a certain value, starts transmitting and operating as an emitter follower together with the second transistor (16),
- a coupling capacitor (15), which, during the operation of the transistors (16, 46) as an emitter follower, is slowly discharged depending on the voltage at D-node slowly decreasing together with the voltage at M-node and thus, which prevents a signal at an audible frequency from occurring at the output point (OUT).

10. An electronic device (1) as in Claim 9, **characterized by** the noise reduction circuit (3) that comprises

- a second transistor (16) which, while the electronic device (1) is turned off, stops transmitting as a result of the voltage at C-node decreasing in the course of time depending on the decrease of the voltage at M-node,
- two resistors (67, 77) connected between E-GND and F-GND each, which discharges the small amount of electric charge remaining on the coupling capacitor (15) and thus, which prevents an audible signal from being produced at the output (OUT).

Figure 1

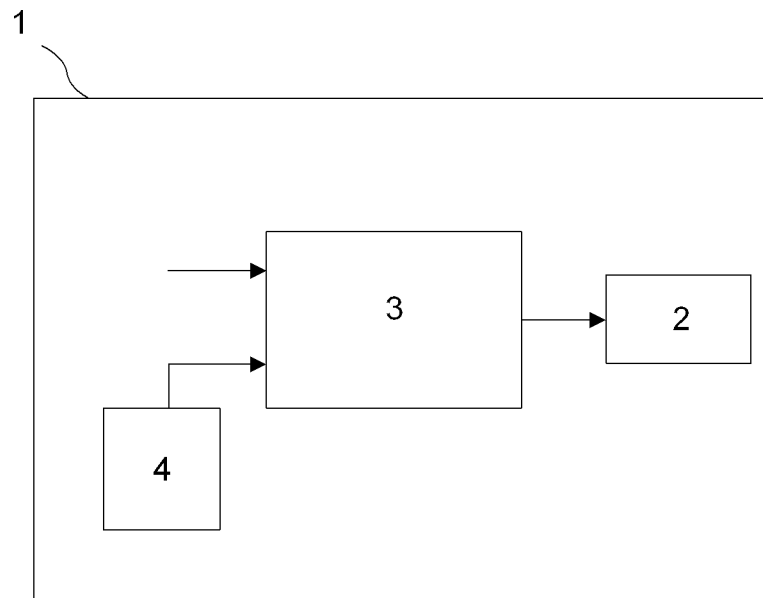


Figure 2

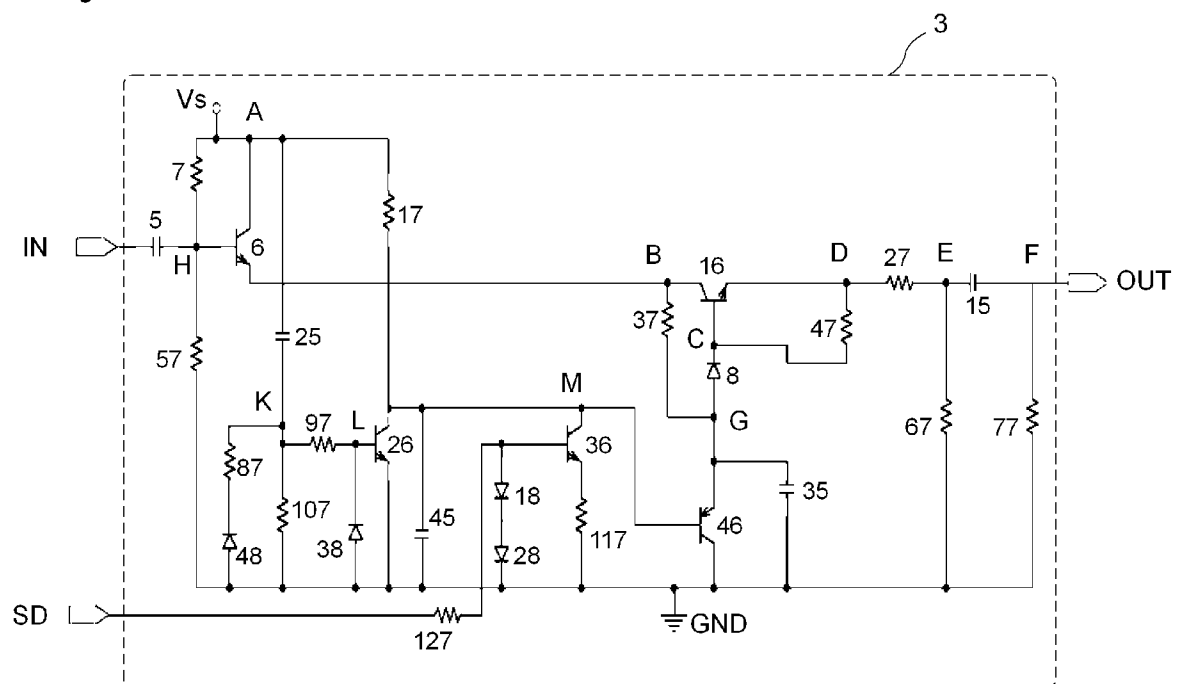
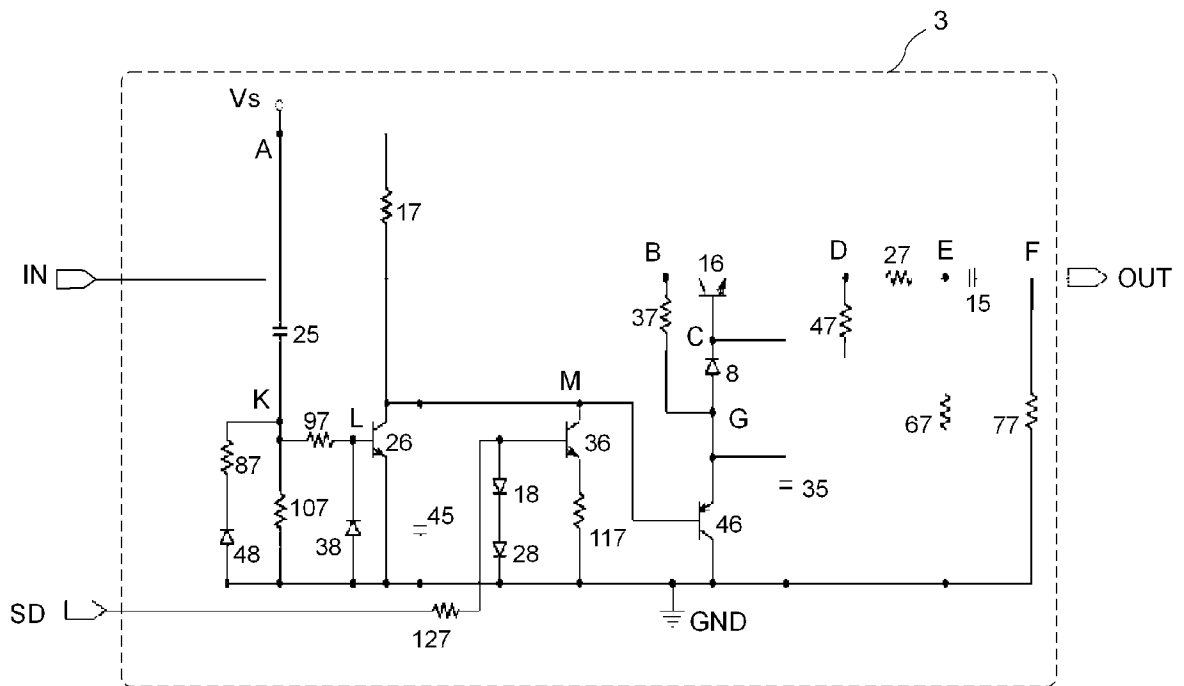


Figure 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/065087

A. CLASSIFICATION OF SUBJECT MATTER
INV. H03F1/30 H03F3/183 H03G3/34

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)
H03F H03G

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 371 841 A (ECKERT WOLFGANG [DE] ET AL) 1 February 1983 (1983-02-01) column 1, lines 6-9 column 1, line 36 - column 2, line 37 column 2, line 50 - column 5, line 41; figures 1,2	1-10
X	WO 03/075456 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]; TOKAWA OSATOSHI [JP]; FUJIMORI KA) 12 September 2003 (2003-09-12) abstract; figure 6	1-10
X	US 6 157 726 A (CARROLL BRIAN [US] ET AL) 5 December 2000 (2000-12-05) column 1, lines 6-9; figure 2 column 2, line 19 - column 4, line 7	1-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/065087

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