

Description

The invention relates to a switching device for suppressing a signal, comprising:

—a first differential amplifier which is powered by a disconnectable first current source and which has a first input for the signal to be suppressed, a second input, a first output, and a second output,

—a first conversion circuit, coupled to the first output and the second output of said differential amplifier, for converting the differential output current of the differential amplifier into a single-ended output current which is applied to an output, and

—an output amplifier having an input which is coupled to the output of the conversion circuit, which output amplifier comprises two complementary emitter-follower output transistors whose emitters are coupled to an output of the switching device, and a bias circuit comprising two semiconductor junctions which are arranged in series between the bases of the output transistors and which are driven into conduction by means of a disconnectable second current source.

When the power supply is switched on and switched off this gives rise to irregular voltage transients on the output of a circuit, which transients are caused by varying direct-voltage and direct-current settings. Such voltage transients occur *inter alia* at the output of a compact-disc player, which output is constituted by the output of an active low-pass filter. If the player is connected to an amplifier which drives a loudspeaker system, these voltage transients are reproduced as popping sounds which may even damage the loudspeakers. In order to preclude the occurrence of these voltage transients on the output of a circuit, use is made of switching devices (muting circuits), which suppress the signal to the output of the circuit when the power supply is switched on and off. In addition, such switching devices may also be driven by actuation of a switch while the power supply is switched on, so that the signal to the output is also suppressed then.

Such a switching device is disclosed in United States Patent Specification US-A-4,315,221. The device described therein is constituted by a differential amplifier which is arranged as a voltage follower and whose output drives an output stage comprising two complementary output transistors arranged as emitter followers. These output transistors are operated in class AB by means of a bias circuit comprising two diodes and two current sources included in a switchable current mirror. The signal to the output of the output stage is suppressed by switching off the current mirror and hence the quiescent current of the output stage. However, a drawback of this circuit is that in the switched-off condition the input signal is present on the input of the output stage, so that the signal may still appear on the output of the output stage as a result of crosstalk. Another drawback is that in the switched-on condition the output signal may be distorted as a

result of the non-linear resistance of the output transistors.

United States Patent Specification US-A-4,366,442 discloses a switching device of the type defined in the opening paragraph, which also comprises a differential amplifier whose output drives a class AB output stage by means of two diodes and a current source. However, the output stage in this switching device comprises two parallel branches each comprising two complementary output transistors. The output of the first branch is fed back to an input of the differential amplifier and the output of the second branch constitutes the output of the switching device. The signal to this output is suppressed by switching off the current sources of the differential amplifier and the output stage. This arrangement also has the drawback that the output signal may be distorted in the switched-on condition. The output transistors of the first branch produce hardly any distortion owing to the feedback, but unless they are loaded in the same way as the output transistors of the first branch the output transistors of the second branch will give rise to distortion. However, in general these transistors are not loaded in the same way.

Therefore, it is the object of the invention to provide a switching device which in the switched-on condition produces less distortion of the output signal and in the switched off condition suppresses the signal to the output to a large extent, in such a way that crosstalk of the signal to the output is substantially impossible.

In accordance with the invention a switching device of the type specified in the opening paragraph is characterized in that the circuit further comprises:

—a second differential amplifier which is powered by a disconnectable third current source and which has a first input which is earthed for signals, a second input, a first output, and a second output, and

—a second conversion circuit, coupled to the first output and the second output of the second differential amplifier, for converting the differential output current of the second differential amplifier into a single ended output current which is applied to an output connected to the second input of the second differential amplifier and to the input of the output amplifier, and in that

—the output of the output amplifier is connected to the second input of the first differential amplifier, and

—for suppressing the signal to the output of the switching device, the first current source and the second current source are switched off and the third current source is switched on.

The invention is based on the recognition of the following facts. In the switched-on condition the output of the output stage is fully fed back to the second input of the first differential amplifier, so that the switching device operates as a voltage follower. This negative feedback leads to a substantial reduction of the distortion produced by the non-linear resistance of the output transistors,

so that the input signal appears substantially undistorted on the output. In the switched-off condition the first differential amplifier and the output amplifier are currentless, whilst a second differential amplifier is switched on. The first input of the latter is connected to earth and its output is fully fed back to the second input, so that this differential amplifier operates as a voltage follower. Then there is no signal on the input of the output amplifier in the switched-off condition, so that the input signal is suppressed almost completely and the occurrence of cross-talk is precluded.

An advantageous embodiment of the invention is characterized in that the first current source and the third current source are replaced by a current source which is common to the first differential amplifier and the second differential amplifier and which is switchable from the first differential amplifier to the second differential amplifier and *vice versa*, and the first conversion circuit and the second conversion circuit are replaced by a conversion circuit which is common to the first differential amplifier and the second differential amplifier. A further embodiment may be characterized in that the output of the conversion circuit is connected to the input of a driver amplifier having an output coupled to the input of the output amplifier.

Embodiments of the invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 represents the basic diagram of a switching device in accordance with the invention,

Fig. 2 shows the diagram of Fig. 1 in simplified form,

Fig. 3 shows a switching device in accordance with a first embodiment of the invention,

Fig. 4 shows a switching device in accordance with a second embodiment of the invention, and

Fig. 5 shows a switching device in accordance with a third embodiment of the invention.

Fig. 1 is the basic diagram of a switching device in accordance with the invention. The switching device comprises a first input amplifier 1 having a non-inverting input 2, to which an input signal v_i may be applied, and an inverting input 3. The input amplifier 1 comprises a differential amplifier, not shown for the sake of clarity, whose bias current is furnished by a current source 4 which can be disconnected by means of a switch 5. The output 6 of the amplifier 1 is connected to the input 7 of an output amplifier 8. The output 9 of this amplifier 8 constitutes the output of the switching device and is connected to the inverting input 3 of the input amplifier 1. The output amplifier 8 receives a bias current which is supplied by at least one current source 10, which can be disconnected by means of a switch 11. Further, the switching device comprises a second input amplifier 12 having a non-inverting input 13 which is earthed for signals, and an inverting input 14. The output 15 of this amplifier 12 is connected to the inverting input 14 and to the

input 7 of the output amplifier 8. The second input amplifier 12 also comprises a differential amplifier, not shown, whose bias current is furnished by a current source 16 which can be switched on by means of a switch 17. The switches 5, 11 and 17 are energised by control means, not shown, in such a way that the switches 5 and 11 are closed simultaneously and at the same time the switch 17 is opened, and *vice versa*.

The switching device operates as follows. In the switched-on condition of the switching device the switches 5 and 11 are closed and the switch 17 is consequently open. The first input amplifier 1 and the output amplifier 8 are powered by the current sources 4 and 10. Owing to full negative feedback from the output 9 of the output amplifier 8 to the inverting input 3 of the first input amplifier 1 the switching device operates as a voltage follower. The distortion, which is mainly caused by the output amplifier 8 is reduced substantially by this negative feedback, so that the substantially undistorted input voltage v_i appears on the output 9. In the switched-off condition of the switching device the switches 5 and 11 are open and the switch 17 is closed, so that now only the second input amplifier 12 is operative. Owing to the full negative feedback from the output 15 to the inverting input 14, this input amplifier 12 operates as a voltage follower. The voltage on the output 15 and hence on the input 7 of the output amplifier is therefore 0 V. As in the switched-off condition no signal appears on the input 7 of the output amplifier 8, the signal cannot appear on the output 9 as a result of crosstalk.

The first differential amplifier 1 and the second differential amplifier 12 have equal loads, which may be followed by identical driver amplifiers. The basic arrangement shown in Fig. 1 may be simplified by combining the two loads into one common load and the driver amplifiers into one common driver amplifier. Fig. 2 shows this simplified arrangement, in which the common load and, as the case may be, the common driver amplifier bear the reference numeral 20. Further, the current sources 4 and 16 may be combined to form one current source 21 which can be switched from differential amplifier 1 to differential amplifier 12 and *vice versa* by means of one switch 22. Otherwise the circuit operates in the same way as that shown in Fig. 1.

A switching device in accordance with a first embodiment based on the diagram of Fig. 2 will be described in more detail with reference to Fig. 3. Identical parts bear the same reference numerals as in Fig. 2. The first differential amplifier 1 comprises two transistors T_1 and T_2 , the base 2 of the transistor T_1 constituting the non-inverting input to which an input signal v_i is applied, and the base 3 of transistor T_2 constituting the inverting input. The collector of transistor T_1 is connected to an input of a current mirror 20, which comprises a diode-connected transistor T_3 and a transistor T_4 , and which has its output connected to the collector of transistor T_2 and to the output 6 of the differential amplifier. The

current mirror 20 constitutes a conversion circuit by means of which the differential collector currents of the transistors T_1 and T_2 are converted into a single-ended output current. The second differential amplifier 12 comprises two transistors T_3 and T_4 , the base 13 of the transistor T_3 being connected to earth and constituting the non-inverting input. The collector of transistor T_3 and the collector of transistor T_4 are connected to the collector of transistor T_1 and the collector of transistor T_2 , respectively, so that the current mirror 20 constitutes a conversion circuit which is common to the two differential amplifiers 1 and 12. The base 14 of transistor T_4 constitutes the inverting input of the differential amplifier 12 and is connected to the output 6 of this amplifier. The emitter currents of the differential amplifiers 1 and 12 are furnished by a current source 21 which comprises a transistor T_7 whose base is at a reference voltage V_{ref} and whose emitter is connected to the negative power-supply line 30 by means of a resistor R_1 . The current from the current source 21 can be switched from one differential amplifier to the other by means of a switch 22 comprising two transistors T_5 and T_6 arranged as a differential pair, the control signals for this change-over being applied to the base 33 of the transistor T_5 and the base 34 of the transistor T_6 , respectively.

The common output 6 of the two differential amplifiers 1 and 12 is connected to the input 7 of an output amplifier 8 comprising two complementary output transistors T_{10} and T_{11} arranged as an emitter followers, the common emitter terminal constituting the output 9 of the switching device. The base of the transistor T_{11} is connected to the emitter of a transistor T_{13} , whose base is connected to the input 7 of the output amplifier 8 and whose collector is connected to the positive power-supply terminal 31. The emitter of the transistor T_{13} can be connected to a current source 10a by means of a switch 11a, which current source comprises a transistor T_{18} whose base is at a reference voltage and whose emitter is connected to the negative power-supply terminal 30 via a resistor R_2 . The switch 11a comprises two transistors T_{14} and T_{15} arranged as a differential pair, the collector of the transistor T_{14} being connected to the emitter of the transistor T_{13} and the collector of the transistor T_{15} being connected to the positive power-supply terminal 31. The control signals applied to the bases of the transistors T_{14} and T_{15} are the same as those applied to the bases 33 and 34 of the transistors T_5 and T_6 . The base of transistor T_{10} is connected to the emitter of a transistor T_{12} , whose base is connected to the input 7 and whose collector is connected to the negative power-supply terminal 30. The emitter of the transistor T_{12} is connected to the output of a current mirror comprising a diode-connected transistor T_{20} and transistor T_{21} , whose base-emitter junction is arranged in parallel with that of the transistor T_{20} . The input of the current mirror may be connected to a current source 10b by means of a switch 11b, which

current source comprises a transistor T_{19} whose base is at a reference voltage and whose emitter is connected to the negative power-supply terminal 30 via a resistor R_3 . The switch 11b comprises two transistors T_{17} and T_{18} arranged as a differential pair, the collector of the transistor T_{17} being connected to the input of the current mirror T_{20} , T_{21} and the collector of the transistor T_{18} being connected to the positive power-supply terminal 31. The base of the transistor T_{17} is connected to the base 33 of the transistor T_5 and the base of the transistor T_{18} is connected to the base 34 of the transistor T_6 .

In the switched-on condition of the switching device the bases 33 and 34 receive such control signals that the voltage on the base 33 of the transistor T_5 is high relative to the voltage on the base 34 of the transistor T_6 . As a result of this, the transistor T_5 is turned on and the transistor T_6 is turned off. Thus, the current source 21 is connected to the differential amplifier 1 and the differential amplifier 12 is disconnected. Similarly, the transistor T_{14} conducts and the transistor T_{15} is cut off, so that the current source 10a is connected to the emitter of the transistor T_{13} . In the same way, the current source 10b is connected to the emitter of the transistor T_{12} via the conductive transistor T_{17} and the current mirror T_{20} , T_{21} . The conducting transistors T_{12} and T_{13} ensure that a voltage equal to two base-emitter voltages appears between the bases of the transistors T_{10} and T_{11} . As a result of this voltage a small quiescent current will flow in the output transistors T_{10} and T_{11} , so that the output amplifier 8 is operated in class AB.

Since there is full negative feedback from the output of the output amplifier 8 to the inverting input 3 of the differential amplifier 1, the combination of the differential amplifier and the output amplifier 8 will behave as a voltage follower in the switched-on condition. Therefore, the voltage on the output 9 is substantially equal to the voltage on the input 2 and the harmonic distortion of the output signal as a result of the non-linearity of the resistances of the output transistors T_{10} and T_{11} is reduced substantially by the negative feedback.

In the switched-off condition the voltage on the base 34 of the transistor T_6 is high relative to the voltage on the base of the transistor T_5 , so that the transistor T_6 is turned on and the transistor T_5 is cut off. As a result of this, the current source 21 is connected to the commoned emitters of the transistors T_3 and T_4 via the transistor T_6 , so that now the differential amplifier 12 is switched on and the differential amplifier 1 is turned off. The voltages on the bases of the transistors T_{18} and T_{15} are now also high relative to the voltages on the bases of the transistors T_{17} and T_{14} , so that the transistors T_{18} and T_{15} conduct and the transistors T_{14} and T_{17} are cut off. In this case the current sources 10a and 10b are connected to the positive power-supply terminal 31, so that the output amplifier 8 is currentless. The output 9 of the output amplifier 8 then has a high impedance. As the output 6 is connected to the inverting input 14,

the differential amplifier 12 will behave as a voltage follower. The voltage on the output 6 and hence on the input 7 of the output amplifier 8 is then 0 V. Therefore, no signal will appear on the input 7 of the output amplifier 8 in the switched-off condition, so that a very good suppression of the input signal is obtained.

It is to be noted that in the present embodiment the transistors of the differential amplifiers 1 and 2, the switch 22 and the current source 21 may alternatively be PNP transistors, in which case the transistors of the current mirror 20 should be NPN transistors. The input of the current mirror should then be connected to the collector of the transistor T_2 and the output of the current mirror should be connected to the collector of the transistor T_1 . Further other current mirror may be used instead of the current mirror shown. Moreover, the collectors of the transistors T_{12} and T_{13} may be connected to the base of the relevant transistor instead of to the negative power-supply terminal and the positive power-supply terminal, so that the transistors T_{12} and T_{13} are then connected as diodes.

A switching device in accordance with a second embodiment will now be described in more detail with reference to Fig. 4, in which identical parts bear the same reference numerals as in Fig. 3. Now the interconnected collectors of the transistors T_1 and T_3 and the interconnected collectors of the transistors T_2 and T_4 are not connected to the input and to the output of a current mirror, respectively, but are connected to the positive power-supply terminal 31 by means of a resistor R_4 and an identical resistor R_5 , respectively. The voltages across the resistors R_4 and R_5 are applied to the base of a transistor T_{23} , which is operated as an emitter follower by means of a current source 35, and to the base of a transistor T_{24} , which is operated as an emitter follower by means of a current source 36, respectively.

The current sources 35 and 36 comprise transistors T_{25} and T_{26} whose bases are at a reference voltage and whose emitters are connected to the negative power-supply terminal 30 by a resistor R_8 and a resistor R_9 , respectively. The emitter of the transistor T_{23} is connected to the base of a transistor T_{27} , whose emitter is connected to the positive power-supply terminal 31 by a resistor R_6 . Similarly, the emitter of the transistor T_{24} is connected to the base of a transistor T_{28} having a resistor R_7 arranged in the emitter line. The collector of the transistor T_{27} is connected to the collector of the transistor T_{28} by a current mirror comprising a diode-connected transistor T_{29} and a transistor T_{30} whose base-emitter junction is arranged in parallel with that of the transistor T_{29} . The transistors T_{23} to T_{30} with the resistors R_4 to R_7 constitute a conversion circuit for converting the collector currents of the transistors T_1 and T_2 into a single-ended output current. The collector current of the transistor T_1 is converted into a voltage by means of resistor R_4 , which voltage is applied to the voltage-to-current converter, T_{27} , R_6 via the emitter follower T_{23} and the current source

35. The collector current of the transistor T_{27} is consequently inverted relative to the collector current of the transistor T_1 . Similarly, the collector current of the transistor T_{28} is inverted relative to the collector current of the transistor T_2 . As a result of this, the output current of the current mirror T_{29} , T_{30} is inverted relative to the output current of the current mirror 20 in the embodiment shown in Fig. 3, which is necessary in view of the inverting driver amplifier used in the circuit shown in Fig. 4. The collector of the transistor T_{28} is connected to the input 41 of this driver amplifier 40, which comprises two transistors T_{41} and T_{42} in Darlington arrangement, the collector of the transistor T_{41} being connected to the positive power-supply terminal 31 and the collector of the transistor T_{42} being connected to a current source 37. The collector of the transistor T_{42} constitutes the common output 6 of the first input amplifier and the second input amplifier. For the purpose of frequency compensation a capacitor C_1 is arranged between the output 6 and the input 41 of the driver amplifier 40. The output 6 is connected to the inverting input 14 of the second differential amplifier 12 and to the input 7 of the output amplifier 8, which is of the same construction as that shown in Fig. 3. The driver amplifier 40 provides an additional amplification of the signal from the differential amplifiers. The circuit operates in the same way as that in Fig. 3. In the switched-on condition the differential amplifier 1 together with the driver amplifier 40 and the output amplifier 8 are driven and the negative feedback between the output 9 and the inverting input 3 ensures that the voltage on the output 9 is substantially identical to the voltage on input 2. In the switched-off condition the second differential amplifier 12 together with the driver amplifier 40 is driven. The negative feedback from the output 6 to the inverting input 14 ensures that the voltage on the output 6 is again 0 V, so that again no signal will appear on the input 7 of the output amplifier 8 in the switched-off condition. In this embodiment the first differential amplifier 1 and the second differential amplifier 12 may comprise PNP transistors in which case the collectors of the transistors T_1 and T_2 should be connected to the input and the output, respectively, of a current mirror, the input of the driver amplifier being driven directly by the output.

A switching device in accordance with a third embodiment will be described with reference to Fig. 5, in which identical parts bear the same reference numerals as in Fig. 4. Up to the common driver amplifier the circuit is identical to that shown in Fig. 4. The output amplifier 8 differs from that shown in Fig. 4 in that the transistor T_{12} is an NPN-transistor instead of a PNP-transistor and the transistor T_{13} is a PNP-transistor instead of an NPN-transistor. The transistors T_{12} and T_{13} are now arranged between the bases of the output transistors T_{10} and T_{11} and are connected as diodes, the emitters of these transistors being interconnected and being connected to the input 14 of the second differential amplifier 12 and to

the collectors of the transistors T_{15} and T_{51} . The collector of the transistor T_{13} constitutes the input 7 of the output amplifier 8 and is again connected to the collector of the transistor T_{14} which together with transistor T_{18} constitutes the switch 11a. In the present embodiment the common emitter terminal of the transistors T_{14} and T_{15} is not connected to a current source but to the output 6 of the driver amplifier 40, which is otherwise identical to the driver amplifier 40 in Fig. 4, except for the capacitor C_1 which is now arranged between the input 41 of the driver amplifier 40 and the junction point of the emitters of the transistors T_{12} and T_{13} . In the same way as in Fig. 4 the collector of the transistor T_{12} is connected to the collector of the transistor T_{17} via a current mirror comprising transistors T_{20} and T_{21} , which transistor T_{17} together with the transistor T_{18} constitutes a differential pair whose common emitter terminal is connected to a current source 10b, which comprises the transistor T_{19} and the resistor R_3 . Now the collector of the transistor T_{18} is not connected to the positive power-supply terminal 31 but to the collector of the transistor T_{15} via a current mirror comprising the transistors T_{50} and T_{51} .

In the switched-on condition the voltage on the bases of the transistor T_{14} and the transistor T_{17} is high relative to the voltage on the bases of the transistor T_{15} and the transistor T_{18} , so that the transistors T_{14} and T_{17} conduct and the transistors T_{15} and T_{18} are cut off. The current from the current source 10b now flows through the diodes T_{12} , T_{13} via the transistor T_{17} and the current mirror T_{20} , T_{21} . The current now flowing in these diodes T_{12} , T_{13} is of the order of magnitude of 1 mA. If the input 41 of the driver amplifier 40 is driven as far as possible towards the level of the negative power-supply terminal, the transistor T_{42} will be substantially cut off and the collector current of the transistor T_{21} will flow almost entirely to the base of the transistor T_{10} . The last-mentioned transistor is a NPN transistor whose current gain factor $\beta \approx 100$, so that the maximum output current in the present case is of the order of magnitude of 100 mA. If the input 41 of the driver amplifier is driven as far as possible towards the level of the positive power-supply terminal 31, the transistor T_{42} will be fully conductive. The maximum collector current of the transistor T_{42} is equal to the product of the current gain factors of the NPN transistors T_{41} and T_{42} and the maximum output current of the input amplifiers 1 and 2. The current gain factors are $\beta \approx 100$ and the maximum output current is dictated by the output current of the current source 21, which may be of the order of magnitude of 10 μ A. Consequently, the maximum collector current of the transistor T_{42} is of the order of magnitude of 100 mA. Of this current 1 mA is furnished by the transistor T_{21} . The remainder (99 mA) is obtained via the base of the transistor T_{11} . For large currents the current gain factor of this PNP-transistor T_{11} is $\beta \approx 0.5$, so that the maximum output current ($\approx \beta + 1$) is of the order of mag-

nitude of 100 mA. The maximum output currents of the NPN transistor T_{10} and the PNP transistor T_{11} are better in conformity with each other in this circuit, which has a favourable effect on the distortion introduced by the output transistors. In the switched-off condition the voltages on the bases of the transistor T_{18} and the transistor T_{15} are high relative to the voltages on the bases of the transistors T_{17} and T_{14} , so that the transistors T_{18} and T_{15} conduct and the transistors T_{17} and T_{14} are cut off. The current from the current source 10b now flows to the output 6 of the driver amplifier 40 via the current mirror T_{50} , T_{51} and the transistor T_{15} , which driver amplifier takes up this entire current. As the transistors T_{21} and T_{14} do not conduct, the output amplifier 8 is turned off and no signal will appear on its input 7.

The invention is not limited to the present embodiments. For example, other types of switches may be used for the switches 22, 11a and 11b shown in the Figures. Moreover, the differential amplifiers 1 and 12 may be of different types. The same applies to the driver amplifiers 40. In the embodiments shown the switching device is connected to a symmetrical power supply. In order to ensure that the first input of the first differential amplifier, to which the input signal is applied, and the first input of the second differential amplifier, which is connected to earth for input signals, are at a direct voltage of zero volts, these inputs may be connected to, for example, a tapping of a voltage divider comprising two identical resistors and arranged between the positive power-supply terminal and the negative power-supply terminal. However, the switching device may also be operated with an asymmetrical power supply. The first inputs of the two differential amplifiers and the output of the switching device may then be connected by a resistor, in known manner, to a tapping on a series arrangement of a resistor and a capacitor arranged between the positive power-supply terminal and the negative power-supply terminal. The delay in coupling the output to the remainder of the circuit when the power supply is switched on should then be adapted to the time required for charging this capacitor.

Claims

1. A switching device for suppressing a signal, comprising:

—a first differential amplifier which is powered by a disconnectable first current source and which has a first input for the signal to be suppressed, a second input, a first output, and a second output,

—a first conversion circuit, coupled to the first output and the second output of said differential amplifier, for converting the differential output current of the differential amplifier into a single-ended output current which is applied to an output, and

—an output amplifier having an input which is coupled to the output of the conversion circuit,

the collectors of the transistors T_{18} and T_{51} . The collector of the transistor T_{18} constitutes the input 7 of the output amplifier 8 and is again connected to the collector of the transistor T_{14} which together with transistor T_{15} constitutes the switch 11a. In the present embodiment the common emitter terminal of the transistors T_{14} and T_{15} is not connected to a current source but to the output 6 of the driver amplifier 40, which is otherwise identical to the driver amplifier 40 in Fig. 4, except for the capacitor C_1 which is now arranged between the input 41 of the driver amplifier 40 and the junction point of the emitters of the transistors T_{12} and T_{13} . In the same way as in Fig. 4 the collector of the transistor T_{12} is connected to the collector of the transistor T_{17} via a current mirror comprising transistors T_{20} and T_{21} , which transistor T_{17} together with the transistor T_{18} constitutes a differential pair whose common emitter terminal is connected to a current source 10b, which comprises the transistor T_{19} and the resistor R_3 . Now the collector of the transistor T_{18} is not connected to the positive power-supply terminal 31 but to the collector of the transistor T_{15} via a current mirror comprising the transistors T_{50} and T_{51} .

In the switched-on condition the voltage on the bases of the transistor T_{14} and the transistor T_{17} is high relative to the voltage on the bases of the transistor T_{15} and the transistor T_{18} , so that the transistors T_{14} and T_{17} conduct and the transistors T_{15} and T_{18} are cut off. The current from the current source 10b now flows through the diodes T_{12} , T_{13} via the transistor T_{17} and the current mirror T_{20} , T_{21} . The current now flowing in these diodes T_{12} , T_{13} is of the order of magnitude of 1 mA. If the input 41 of the driver amplifier 40 is driven as far as possible towards the level of the negative power-supply terminal, the transistor T_{42} will be substantially cut off and the collector current of the transistor T_{21} will flow almost entirely to the base of the transistor T_{10} . The last-mentioned transistor is a NPN transistor whose current gain factor $\beta \approx 100$, so that the maximum output current in the present case is of the order of magnitude of 100 mA. If the input 41 of the driver amplifier is driven as far as possible towards the level of the positive power-supply terminal 31, the transistor T_{42} will be fully conductive. The maximum collector current of the transistor T_{42} is equal to the product of the current gain factors of the NPN transistors T_{41} and T_{42} and the maximum output current of the input amplifiers 1 and 2. The current gain factors are $\beta \approx 100$ and the maximum output current is dictated by the output current of the current source 21, which may be of the order of magnitude of 10 μ A. Consequently, the maximum collector current of the transistor T_{42} is of the order of magnitude of 100 mA. Of this current 1 mA is furnished by the transistor T_{21} . The remainder (99 mA) is obtained via the base of the transistor T_{11} . For large currents the current gain factor of this PNP-transistor T_{11} is $\beta \approx 0.5$, so that the maximum output current ($\approx \beta + 1$) is of the order of mag-

nitude of 100 mA. The maximum output currents of the NPN transistor T_{10} and the PNP transistor T_{11} are better in conformity with each other in this circuit, which has a favourable effect on the distortion introduced by the output transistors. In the switched-off condition the voltages on the bases of the transistor T_{18} and the transistor T_{15} are high relative to the voltages on the bases of the transistors T_{17} and T_{14} , so that the transistors T_{18} and T_{15} conduct and the transistors T_{17} and T_{14} are cut off. The current from the current source 10b now flows to the output 6 of the driver amplifier 40 via the current mirror T_{50} , T_{51} and the transistor T_{15} , which driver amplifier takes up this entire current. As the transistors T_{21} and T_{14} do not conduct, the output amplifier 8 is turned off and no signal will appear on its input 7.

The invention is not limited to the present embodiments. For example, other types of switches may be used for the switches 22, 11a and 11b shown in the Figures. Moreover, the differential amplifiers 1 and 12 may be of different types. The same applies to the driver amplifiers 40. In the embodiments shown the switching device is connected to a symmetrical power supply. In order to ensure that the first input of the first differential amplifier, to which the input signal is applied, and the first input of the second differential amplifier, which is connected to earth for input signals, are at a direct voltage of zero volts, these inputs may be connected to, for example, a tapping of a voltage divider comprising two identical resistors and arranged between the positive power-supply terminal and the negative power-supply terminal. However, the switching device may also be operated with an asymmetrical power supply. The first inputs of the two differential amplifiers and the output of the switching device may then be connected by a resistor, in known manner, to a tapping on a series arrangement of a resistor and a capacitor arranged between the positive power-supply terminal and the negative power-supply terminal. The delay in coupling the output to the remainder of the circuit when the power supply is switched on should then be adapted to the time required for charging this capacitor.

Claims

1. A switching device for suppressing a signal, comprising:

—a first differential amplifier which is powered by a disconnectable first current source and which has a first input for the signal to be suppressed, a second input, a first output, and a second output,

—a first conversion circuit, coupled to the first output and the second output of said differential amplifier, for converting the differential output current of the differential amplifier into a single-ended output current which is applied to an output, and

—an output amplifier having an input which is coupled to the output of the conversion circuit,



which output amplifier comprises two complementary emitter-follower output transistors whose emitters are coupled to an output of the switching device, and a bias circuit comprising two semiconductor junctions which are arranged in series between the bases of the output transistors, and which are driven into conduction by means of a disconnectable second current source.

characterized in that the circuit further comprises:

—a second differential amplifier which is powered by a disconnectable third current source and which has a first input which is earthed for signals, a second input, a first output, and second output, and

—a second conversion circuit, coupled to the first output and the second output of the second differential amplifier, for converting the differential output current of the second differential amplifier into a single-ended output current which is applied to an output connected to the second input of the second differential amplifier and to the input of the output amplifier, and in that

—the output of the output amplifier is connected to the second input of the first differential amplifier, and

—for suppressing the signal to the output of the switching device, the first current source and the second current source are switched off and the third current source is switched on.

2. A switching device as claimed in Claim 1, modified in that the first current source and the third current source are replaced by a current source which is common to the first differential amplifier and the second differential amplifier and which is switchable from the first differential amplifier to the second differential amplifier and *vice versa*, and the first conversion circuit and the second conversion circuit are replaced by a conversion circuit which is common to the first differential amplifier and the second differential amplifier.

3. A switching device as claimed in Claim 2 characterized in that the conversion circuit comprises a current mirror having an input which is coupled to the first output of the first differential amplifier and the second differential amplifier and an output which is coupled to the second output of the first differential amplifier and the second differential amplifier.

4. A switching device as claimed in Claim 3, characterized in that a current inverting circuit is arranged between the first output of the first differential amplifier and the second differential amplifier and the input of the current mirror and between the second output of the first differential amplifier and the second differential amplifier and the output of the current mirror.

5. A switching device as claimed in Claim 2, 3 or 4, characterized in that the output of the conversion circuit is connected to the input of a driver amplifier having an output coupled to the input of the output amplifier.

6. A switching device as claimed in Claim 5,

characterized in that the disconnectable second current comprises two current sources which are each connected to one end of the series arrangement of the two semiconductor junctions, and the output of the driver amplifier is loaded by a fourth current source.

7. A switching device as claimed in Claim 5, characterized in that the output of the driver amplifier is connected to the input of the output amplifier by means of a first switch and to a fourth current source by means of a second switch, the first switch being opened and the second switch being closed to suppress the signal.

8. A modification of a switching device as claimed in Claim 7, characterized in that the second current source and the fourth current source are combined to form a common current source, which is switched from the output amplifier to the output of the driver amplifier to suppress the signal.

Patentansprüche

1. Schaltungsanordnung zum Unterdrücken eines Signals, mit

—einem ersten Differenzverstärker, der durch eine abschaltbare erste Stromquelle mit Strom versorgt wird und einen ersten Eingang für das zu unterdrückende Signal, einen zweiten Eingang, einen ersten Ausgang und einen zweiten Ausgang enthält,

—einer ersten Umsetzungsschaltung, die mit dem ersten Ausgang und mit dem zweiten Ausgang des Differenzverstärkers gekoppelt ist, um den Differenzausgangsstrom des Differenzverstärkers in einen unsymmetrischen Ausgangsstrom umzusetzen, die an einen Ausgang gelegt wird, und

—einem Ausgangsverstärker mit einem Eingang, der mit dem Ausgang der Umsetzungsschaltung gekoppelt ist, wobei der Ausgangsverstärker zwei komplementäre Emitterfolger-Ausgangstransistoren, deren Emitter mit einem Ausgang der Schaltungsanordnung gekoppelt sind, und eine Vorspannungsschaltung mit zwei Halbleiterübergängen enthält, die in Reihe zwischen den Basen der Ausgangstransistoren angeordnet sind und mittels einer abschaltbaren zweiten Stromquelle in den leitenden Zustand gebracht werden,

dadurch gekennzeichnet, daß die Schaltung außerdem enthält,

—einen zweiten Differenzverstärker, der von einer abschaltbaren dritten Stromquelle mit Strom versorgt wird und einen ersten für Signale geerdeten Eingang, einen zweiten Eingang, einen ersten Ausgang und einen zweiten Ausgang enthält, und

—eine zweite Umsetzungsschaltung, die mit dem ersten Ausgang und mit dem zweiten Ausgang des zweiten Differenzverstärkers gekoppelt ist, um den Differenzausgangsstrom des zweiten Differenzverstärkers in einen unsymmetrischen Ausgangsstrom umzusetzen, der an einen Ausgang gelangt, der mit dem zweiten Eingang des



zweiten Differenzverstärkers und mit dem Eingang des Ausgangsverstärkers verbunden ist, und daß

—der Ausgang des Ausgangsverstärkers an den zweiten Eingang des ersten Differenzverstärkers angeschlossen ist, und daß

—zum Unterdrücken des Signals am Ausgang der Schaltungsanordnung die erste Stromquelle und die zweite Stromquelle abgeschaltet werden und die dritte Stromquelle eingeschaltet wird.

2. Schaltungsanordnung nach Anspruch 1, mit der Abwandlung, daß die erste Stromquelle und die dritte Stromquelle durch eine Stromquelle ersetzt werden, der dem ersten Differenzverstärker und dem zweiten Differenzverstärker gemeinsam und vom ersten Differenzverstärker zum zweiten Differenzverstärker und umgekehrt schaltbar ist, und daß die erste Umsetzungsschaltung und die zweite Umsetzungsschaltung durch eine Umsetzungsschaltung ersetzt werden, die dem ersten Differenzverstärker und dem zweiten Differenzverstärker gemeinsam ist.

3. Schaltungsanordnung nach Anspruch 2, dadurch gekennzeichnet, daß die Umsetzungsschaltung einen Stromspiegel mit einem Eingang, der mit dem ersten Ausgang des ersten Differenzverstärkers und des zweiten Differenzverstärkers gekoppelt ist, und einen Ausgang enthält, der mit dem zweiten Ausgang des ersten Differenzverstärkers und des zweiten Differenzverstärkers gekoppelt ist.

4. Schaltungsanordnung nach Anspruch 3, dadurch gekennzeichnet, daß eine Stromumkehrschaltung zwischen dem ersten Ausgang des ersten Differenzverstärkers und des zweiten Differenzverstärkers und dem Eingang des Stromspiegels sowie zwischen dem zweiten Ausgang des ersten Differenzverstärkers und des zweiten Differenzverstärkers und dem Ausgang des Stromspiegels angeordnet ist.

5. Schaltungsanordnung nach Anspruch 2, 3 oder 4, dadurch gekennzeichnet, daß der Ausgang der Umsetzungsschaltung an den Eingang eines Treiberverstärkers mit einem Ausgang angeschlossen ist, der mit dem Eingang des Ausgangsverstärkers gekoppelt ist.

6. Schaltungsanordnung nach Anspruch 5, dadurch gekennzeichnet, daß die abschaltbare zweite Stromquelle zwei Stromquellen enthält, die beide mit dem Ende der Reihenschaltung der beiden Halbleiterübergänge verbunden sind, und der Ausgang des Treiberverstärkers durch eine vierte Stromquelle belastet wird.

7. Schaltungsanordnung nach Anspruch 5, dadurch gekennzeichnet, daß der Ausgang des Treiberverstärkers mit dem Eingang des Ausgangsverstärkers mittels eines ersten Schalters und mit einer vierten Stromquelle mittels eines zweiten Schalters verbunden ist, wobei der erste Schalter zum Unterdrücken des Signals geöffnet und der zweite Schalter geschlossen werden.

8. Abwandlung einer Schaltungsanordnung nach Anspruch 7, dadurch gekennzeichnet, daß die zweite Stromquelle und die vierte Stromquelle zur Bildung einer gemeinsamen Strom-

quelle kombiniert werden, die zum Unterdrücken des Signals von Ausgangsverstärker zum Ausgang des Treiberverstärkers geschaltet wird.

5 Revendications

1. Dispositif de commutation pour supprimer un signal, dispositif comportant:

10 —un premier amplificateur différentiel qui est alimenté par une première source de courant pouvant être déconnectée et qui présente une première entrée pour le signal à supprimer, une deuxième entrée, une première sortie et une deuxième sortie,

15 —un premier circuit de conversion couplé à la première sortie et à la deuxième sortie dudit amplificateur différentiel pour convertir le courant de sortie différentiel en un courant de sortie à sens unique qui est appliqué à une sortie et

20 —un amplificateur de sortie présentant une entrée qui est couplée à la sortie du circuit de conversion, amplificateur de sortie qui comporte deux transistors de sortie émetteur-suiveur complémentaires, dont les émetteurs sont couplés à une sortie du dispositif de commutation et un circuit de polarisation comportant deux jonctions semiconductrices qui sont montées en série entre les bases des transistors de sortie et qui sont rendues conductrices à l'aide d'une deuxième

30 source de courant pouvant être déconnectée, caractérisé en ce que
—un deuxième amplificateur différentiel qui est alimenté par une troisième source de courant pouvant être déconnectée et qui présente une

35 première entrée qui est mise à la masse pour des signaux, une deuxième entrée, une première sortie et une deuxième sortie et,
—un deuxième circuit de conversion couplé à la première sortie et à la deuxième sortie du

40 deuxième amplificateur différentiel pour la conversion du courant de sortie différentiel du deuxième amplificateur différentiel en un courant de sortie à sens unique qui est appliqué à une

45 sortie connectée à la deuxième entrée du deuxième amplificateur différentiel et à l'entrée de l'amplificateur de sortie et en ce que
—la sortie de l'amplificateur de sortie est connectée à la deuxième entrée du premier amplifica-

teur différentiel et

50 —pour la suppression du signal à la sortie du dispositif de commutation, la première source de courant et la deuxième source de courant sont déclenchées et la troisième source de courant est enclenchée.

55 2. Dispositif de commutation selon la revendication 1, modifié du fait que la première source de courant et la troisième source de courant sont remplacées par une source de courant qui est commune au premier amplificateur différentiel et au deuxième amplificateur différentiel et qui peut être commutée du premier amplificateur différentiel au deuxième amplificateur différentiel et inversement et le premier circuit de conversion et le deuxième circuit de conversion sont remplacés

60 par un circuit de conversion qui est commun au

65



premier amplificateur différentiel et au deuxième amplificateur différentiel.

3. Dispositif de commutation selon la revendication 2, caractérisé en ce que le circuit de conversion comporte un miroir de courant muni d'une entrée qui est couplée à la première sortie du premier amplificateur différentiel et du deuxième amplificateur différentiel et une sortie qui est couplée à la deuxième entrée du premier amplificateur différentiel et du deuxième amplificateur différentiel.

4. Dispositif de commutation selon la revendication 3, caractérisé en ce qu'un circuit inverseur de courant est disposé entre la première sortie du premier amplificateur différentiel et du deuxième amplificateur différentiel et l'entrée du miroir de courant et entre la deuxième entrée du premier amplificateur différentiel et du deuxième amplificateur différentiel et la sortie du miroir de courant.

5. Dispositif de commutation selon la revendication 2, 3 ou 4, caractérisé en ce que la sortie du circuit de conversion est connectée à l'entrée d'un amplificateur de commande munie d'une entrée couplée à l'entrée de l'amplificateur de sortie.

6. Dispositif de commutation selon la revendication 5, caractérisé en ce que la deuxième source de courant pouvant être connectée comporte deux sources de courant qui sont connectées chacune à une extrémité du montage en série des deux jonctions semiconductrices et la sortie de l'amplificateur de commande est chargée par une quatrième source de courant.

7. Dispositif de commutation selon la revendication 5, caractérisé en ce que la sortie de l'amplificateur de commande est connectée à l'entrée de l'amplificateur de sortie à l'aide d'un premier commutateur et à une quatrième source de courant à l'aide d'un deuxième commutateur, le premier commutateur étant ouvert et le deuxième commutateur étant fermé pour supprimer le signal.

8. Une variante d'un dispositif de commutation selon la revendication 7, caractérisée en ce que la deuxième source de courant et la quatrième source de courant selon combinées de façon à former une source de courant commune qui est commutée de l'amplificateur de sortie à la sortie de l'amplificateur de commande pour supprimer le signal.

