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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Differential microphone circuit

(57) An apparatus for a portable electronic device for receiving a jack of a headset, the jack including a set of lines, the set of lines including at least one audio line, a ground signal and a microphone signal line, the apparatus comprising a set of switches for receiving the ground

signal line and the microphone signal line and a sensing circuit for reducing induced noise from the headset, wherein the sensing circuit is located between the set of switches and the microphone signal line and ground signal line.

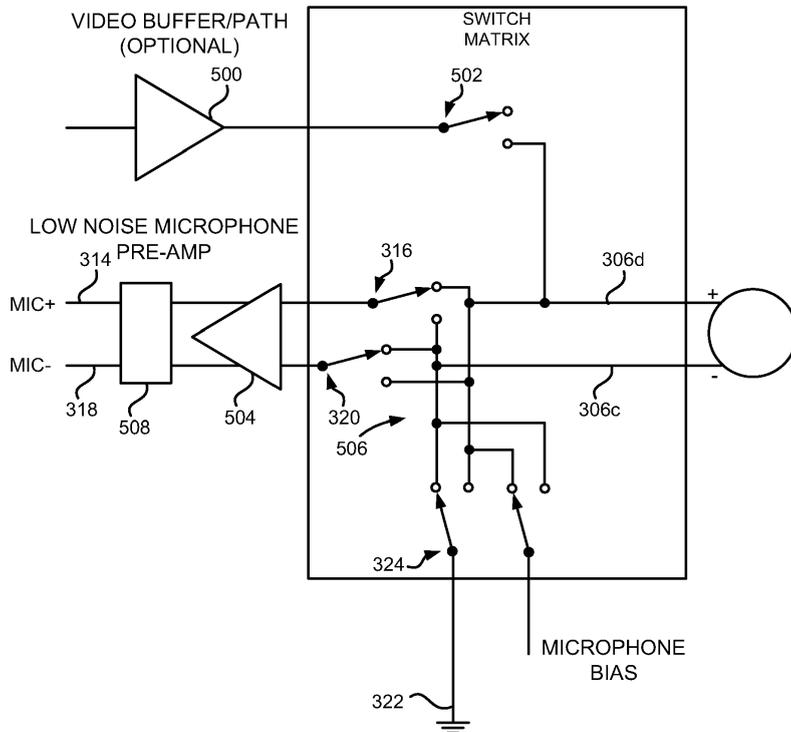


Figure 16

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Description

[0001] The present disclosure is generally directed at microphone circuits and more specifically at a differential microphone circuits.

[0002] Electret microphones have been used for almost half a century since their introduction in 1962. The microphone itself has a very high output impedance due to the capacitance of the electret material. In order to overcome this problem, a junction gate field-effect transistor (JFET) or a complementary metal-oxide semiconductor (CMOS) buffer transistor is integrated within the microphone capsule to change the output impedance. The traditional way to capture the electrical output from these microphones has been to measure the voltage across the microphone, amplify the voltage and then digitize it inside a codec.

GENERAL

[0003] The current disclosure is generally directed at embodiments of a differential microphone circuit configuration. In some of the embodiments, the differential microphone circuit configuration may provide the advantage of a high power supply rejection ratio (PSRR) or high attenuation of bias noise. In current microphone technology, little attention has been paid to the internal workings of the junction gate field effect transistor (JFET) within the microphone capsule. The JFET may operate as a current source with high output impedance

[0004] In the current disclosure, the electrical output from the microphone may be measured across the bias resistor supplying current to the JFET. Since the JFET in the normal bias point works as a current source, any voltage variations and noise from the supply voltage will also happen over the JFET. However, the bias resistor will see an almost completely constant current with the result of a very high PSRR and noise immunity, typically 17-28 dB being achieved. This is an improvement over conventional single ended microphone circuit, and can be accomplished with the same number of or fewer external components. Other advantages include, but are not limited to, improved performance, lower costs and less board space required. The differential microphone circuit may be implemented in various ways but in each configuration similar benefits are achieved. Another advantage of some of the embodiments disclosed within include that the supporting circuitry to the microphone may be less costly and more noisy and still meet microphone specifications. Furthermore any external interference such as from battery noise may be reduced.

[0005] In the current disclosure, apparatus for reducing the level of disturbance on microphone lines when a headset is connected to a portable electronic device is disclosed. By having a portable electronic device which may be able to interact with different headsets, i.e. with different ground signal and microphone signal lines, a sensing circuit, such as a Kelvin sensing circuit is inte-

grated within the portable electronic device interface to reduce offset caused by connection with ground.

BRIEF DESCRIPTION OF THE DETAILED DRAWINGS

[0006] Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

[0007] Figure 1 is a schematic diagram of a microphone circuit;

[0008] Figure 2 is a schematic diagram of a microphone circuit in accordance with one embodiment of the disclosure;

[0009] Figure 3 is a schematic diagram of another embodiment of a microphone circuit;

[0010] Figure 4 is a schematic diagram of another embodiment of a microphone circuit;

[0011] Figure 5 is a schematic diagram of another embodiment of a microphone circuit;

[0012] Figure 6 is a schematic diagram of another embodiment of a microphone circuit;

[0013] Figure 7 is a schematic diagram of another embodiment of a microphone circuit;

[0014] Figure 8 is a schematic diagram of another embodiment of a microphone circuit;

[0015] Figure 9 is a schematic diagram of another embodiment of a microphone circuit;

[0016] Figure 10 is a schematic diagram of another embodiment of a microphone circuit;

[0017] Figure 11 is a schematic diagram of another embodiment of a microphone circuit;

[0018] Figure 12 is a schematic diagram of another embodiment of a microphone circuit;

[0019] Figure 13 is a schematic diagram of another embodiment of a microphone circuit;

[0020] Figure 14 is a schematic diagram of a headset connected with a portable electronic device in a first mode;

[0021] Figure 15 is a schematic diagram of another headset connected with a portable electronic device in a second mode; and

[0022] Figure 16 is a schematic diagram of another embodiment of an apparatus for connecting a portable electronic device with a headset.

DETAILED DISCLOSURE

[0023] The present disclosure is generally directed at embodiments of a differential microphone circuit configuration with a high power supply rejection ratio (PSRR) and high attenuation of bias noise. Different implementations of the circuitry are contemplated such as the microphone circuit being supplied by a negative or a positive bias or the positioning of the bias resistor to have a higher or lower potential than the junction gate field transistor (JFET) within the microphone.

[0024] In microphone technology, it is desirable to

achieve high power supply rejection ratio (PSRR) and low noise, and this is typically accomplished with filtering components and a special low power supply. Also, various circuit configurations have been proposed in the art to increase the PSRR and noise immunity, typically with a penalty of higher current consumption, higher cost or with the requirement of non-grounded connections. Still, noise and PSRR are regular concerns for the audio electronics designer.

[0025] Turning to Figure 1, a schematic diagram of circuitry within a traditional electret microphone circuit is shown. The circuit 10 includes a bias resistor 12, electret microphone portion 14 (including a two-terminal electret capsule 16 and a JFET 18) and a pair of microphone lines 20 seen as +MIC OUT line 20a and -MIC OUT line 20b. Each of the microphone lines 20 includes a capacitor 22 which can be used to block out DC signals.

[0026] In traditional operation of the microphone of Figure 1, voltage is supplied to the JFET 18 via the bias resistor 12 and then an output signal taken between the microphone lines 20, or the negative and positive terminals across the microphone. The differential voltage between the two microphone lines 20 may provide a voltage proportional to the acoustic pressure received at the microphone inlet or input.

[0027] Turning to Figure 2, a schematic diagram of circuitry for a differential microphone circuit in accordance with the disclosure is shown. In this embodiment, the microphone circuit provides the advantage of a higher PSRR and a high attenuation of bias noise.

[0028] The microphone circuit 30 comprises a bias resistor 32 which is connected to a voltage source 34 (providing a positive bias) and to an electret microphone circuit 36. The electret microphone circuit 36 is also connected to ground and includes a two-terminal electret capsule 38 and a JFET 40. A pair of microphone lines 42, seen as a +MIC OUT line 42a and a -MIC OUT line 42b are connected across the bias resistor 32. Each microphone line 42 may include a capacitor 44. Selection of higher resistance values for the bias resistors may result in an increase of acoustic sensitivity, however, the selection of the resistance value for the bias resistor is such that the JFET should not go out of saturation during operation of the microphone circuit.

[0029] In another embodiment, a very high bias voltage and a bias resistor with a large resistance value may be used. In this example, a large output signal would be sensed over the microphone lines which may also provide an improved immunity to electromagnetic interference (EMI). In this embodiment, there may be no need for a pre-amplifier circuit.

[0030] Operation of the microphone circuit 30 is similar to operation of the traditional microphone circuit of Figure 1, however the sensing is performed at a different location within the circuit 30. In this embodiment and the ones disclosed below, the sensing of the output signal is performed across the bias resistor 32.

[0031] Advantages of measuring the differential volt-

age or output signal, across the bias resistor include the benefit that the bias resistor 32 experiences an almost constant current which results in the microphone circuit 30 having a very high PSRR and improved noise immunity over other circuits. Another advantage is that the resistance value of the bias resistor 32 may be increased with respect to bias resistors in traditional electret microphone circuits. Another advantage is that by increasing the PSRR or reducing the noise or both within the microphone circuit, fewer components are required to implement the microphone of the current disclosure and therefore the size and cost of the microphone circuit 30 can be reduced with improved performance. Furthermore, implementation of the biasing or sensing circuitry over the bias resistor allows the supporting circuitry of the microphone to be cheaper and noisier while still meeting microphone specifications. Also, any interference from battery noise or any external interference will be lowered.

[0032] Turning to Figure 3, yet another embodiment of a microphone circuit is shown. The microphone circuit 50 includes a bias resistor 52 which is connected to a voltage source 54 (providing a negative bias) and to electret microphone circuit 56. The electret microphone circuit 56 is also connected to ground and includes a two-terminal electret capsule 58 and a JFET 60. A pair of microphone lines 62, seen as a +MIC OUT line 62a and a -MIC OUT line 62b are connected across the bias resistor 52. Each microphone line 62 may include a capacitor 64. The output signal is then sensed over the microphone lines 62.

[0033] Turning to Figure 4, yet another embodiment of a microphone circuit in accordance with the disclosure is shown. The microphone circuit 70 includes a bias resistor 72 which is connected to ground and to electret microphone circuit 76. The electret microphone 76 is also connected to a voltage source 74 (providing a negative bias) and includes a two-terminal electret capsule 78 and a JFET 80. A pair of microphone lines 82, seen as a +MIC OUT line 82a and a -MIC OUT line 82b are connected across the bias resistor 72. In the current embodiment, the +MIC OUT line 82a includes a capacitor 84.

[0034] Turning to Figure 5, yet another embodiment of a microphone circuit is shown. The microphone circuit 90 includes a bias resistor 92 which is connected to ground and to electret microphone circuit 96. The electret microphone 96 is also connected to a voltage source 94 (providing a positive bias) and includes a two-terminal electret capsule 98 and a JFET 100. A pair of microphone lines 102, seen as a +MIC OUT line 102a and a -MIC OUT line 102b are connected across the bias resistor 92. In the current embodiment, both of the microphone lines 102 may include a capacitor 104.

[0035] Turning to Figure 6, yet another embodiment of a microphone circuit is shown. The microphone circuit 110 includes a bias resistor 112 which is connected to ground and to electret microphone circuit 116. The electret microphone 116 is also connected to a voltage source 114 (providing a negative bias) and includes a two-ter-

minal electret capsule 118 and a JFET 120. A pair of microphone lines 122, seen as a +MIC OUT line 122a and a -MIC OUT line 122b are connected across the bias resistor 112. In the current embodiment, both of the microphone lines 122 may include a capacitor 124.

[0036] Turning to Figure 7, yet another embodiment of a microphone circuit is shown. The microphone circuit 130 includes a bias resistor 132 which is connected to ground and to electret microphone circuit 136. The electret microphone 136 is also connected to a voltage source 134 (providing a positive bias) and includes a two-terminal electret capsule 138 and a JFET 140. A pair of microphone lines 142, seen as a +MIC OUT line 142a and a -MIC OUT line 142b are connected across the bias resistor 132. In the current embodiment, a capacitor 144 is located on the +MIC OUT line 142a.

[0037] Turning to Figure 8, yet another embodiment of a microphone circuit is shown. The microphone circuit 150 includes a bias resistor 152 which is connected to a voltage source 154 (providing a positive bias) and to electret microphone circuit 156. The electret microphone 156 is also connected to ground and includes a two-terminal electret capsule 158 and a JFET 160. A pair of microphone lines 162, seen as a +MIC OUT line 162a and a -MIC OUT line 162b are connected across the bias resistor 152. In the current embodiment, each microphone line 162 includes a capacitor 164 and the -MIC OUT line 162b also includes a resistor, or resistive element 166 although the capacitors 164 and resistive elements 166 are not mandatory components.

[0038] Turning to Figure 9, yet another embodiment of a microphone circuit is shown. The microphone circuit 170 includes a bias resistor 172 which is connected to a voltage source 174 (providing a negative bias) and to electret microphone circuit 176. The electret microphone 176 is also connected to ground and includes a two-terminal electret capsule 178 and a JFET 180. A pair of microphone lines 182, seen as a +MIC OUT line 182a and a -MIC OUT line 182b are connected across the bias resistor 172. In the current embodiment, each microphone line 182 includes a capacitor 184 and the -MIC OUT line 182b also includes a resistor, or resistive element 186.

[0039] Turning to Figure 10, yet another embodiment of a microphone circuit is shown. The microphone circuit 190 includes a bias resistor 192 which is connected to ground and to electret microphone circuit 196. The electret microphone 196 is also connected to a voltage source 194 (providing a negative bias) and includes a two-terminal electret capsule 198 and a JFET 200. A pair of microphone lines 202, seen as a +MIC OUT line 202a and a -MIC OUT line 202b are connected across the bias resistor 192. In the current embodiment, each microphone line 202 includes a capacitor 204 and the -MIC OUT line 202b also includes a resistor, or resistive element 206.

[0040] Turning to Figure 11, yet another embodiment of a microphone circuit is shown. The microphone circuit

210 includes a bias resistor 212 which is connected to ground and to electret microphone circuit 216. The electret microphone 216 is also connected to a voltage source 214 (providing a positive bias) and includes a two-terminal electret capsule 218 and a JFET 220. A pair of microphone lines 222, seen as a +MIC OUT line 222a and a -MIC OUT line 222b are connected across the bias resistor 212. In the current embodiment, both of the microphone lines 222 may include a capacitor 224 while the -MIC OUT line 222b also includes a resistive element, seen as resistor 226.

[0041] Turning to Figure 12, yet another embodiment of a microphone circuit is shown. The microphone circuit 230 includes a bias resistor 232 which is connected to ground and to electret microphone circuit 236. The electret microphone 236 is also connected to a voltage source 234 (providing a negative bias) and includes a two-terminal electret capsule 238 and a JFET 240. A pair of microphone lines 242, seen as a +MIC OUT line 242a and a -MIC OUT line 242b are connected across the bias resistor 232. In the current embodiment, both of the microphone lines 242 may include a capacitor 244 and the -MIC OUT line 242b includes a resistive element 246.

[0042] Turning to Figure 13, yet another embodiment of a microphone circuit is shown. The microphone circuit 250 includes a bias resistor 252 which is connected to ground and to electret microphone circuit 256. The electret microphone 256 is also connected to a voltage source 254 (providing a positive bias) and includes a two-terminal electret capsule 258 and a JFET 260. A pair of microphone lines 262, seen as a +MIC OUT line 262a and a -MIC OUT line 262b are connected across the bias resistor 252. In the current embodiment, a capacitor 264 is located on the +MIC OUT 262a along with a resistive element 266.

[0043] Another benefit of the embodiments of Figures 2 to 13 is that when the JFET within the preamplifier is biased in a particular setup, the JFET functions as a current source with a high output impedance. This allows for a bias resistor with a higher resistive value to be implemented within the microphone circuit, thereby increasing the acoustic sensitivity of the microphone. In the preferred embodiment, the resistive value for the bias resistor is selected so that after the voltage drop over the bias resistor there is enough voltage supplied to the JFET so that it does not go out of saturation.

[0044] Furthermore, by having a high value resistive value for the bias resistor along with a high bias voltage, a high output signal would be experienced over the microphone lines and therefore, reduce the needed gain for any following stages

[0045] In a further embodiment of the disclosure, in order to provide further noise reduction within the circuit when this circuit is combined with ground switching, such as via ground noise, a extra set of switches can be implemented within the microphone circuit as will be discussed below.

[0046] As schematically shown in Figure 14, further

circuitry for use with a headset is shown. The headset 300 includes a pair of speakers 302, seen as a right headset speaker 302a and a left headset speaker 302b, and a microphone 304. Alternatively, the headset may include only one headphone. The headset 300 further includes a jack (represented by wires 306) which may be inserted into a portable electronic device, such as via a port, in order to connect the headset with the device. As schematically shown, the jack includes four separate wires which are a left speaker audio line 306a, a right speaker audio line 306b, a ground signal line 306c and a microphone signal line 306d. In this embodiment, the left speaker 302b is connected to the left speaker audio line 306a and to the ground line 306c. The right speaker 302a is connected to the right speaker audio line 306b and the ground signal line 306c while the microphone is connected to the microphone signal line 306d and the ground line 306c.

[0047] Within the device, the left speaker audio line 306a is connected to a left headphone output signal (HPL) signal line 310 while the right speaker audio line 306b is connected to a right headphone output signal (HPR) signal line 312. In one embodiment the lines are communicatively connected via the ports.

[0048] A MIC+ line 314, such as the +MIC OUT lines of Figures 2 to 13, is connected via a switch 316 to the microphone signal line 306d. Similarly, a MIC- line 318, such as the -MIC OUT line of Figures 2 to 13, is connected via a switch 320 to the ground signal line 306c. As some headsets have different ground connections, the switches 316 and 320 enable the portable electronic device to support headsets that have ground and microphone signal reversed, as in Figure 15. A ground signal 322 is also connected via a switch 324 to the ground signal line 306c in Figure 14. A MIC Bias voltage signal 326 is connected to the microphone signal line 306d via a switch 327 after passing a resistor 328.

[0049] In the current embodiment, such as for use with a first headset, the switches 316 and 327 are set such that the MIC+ line 314 and the MIC Bias lines are connected to the microphone signal line 306c. The switches 320 and 324 are set such that the MIC-line 318 and the ground reference voltage 322 are connected to the ground signal line 306c.

[0050] In the embodiment of Figure 15, such as for use with a second headset with the ground signal line and microphone signal line reversed (from the viewpoint of the device), the switches 316 and 327 are set such that the MIC+ line 314 and MIC Bias are connected to the ground signal line 306c and switches 320 and 324 connect the MIC- line and the ground reference voltage 322 to the microphone line 306d. The advantage of using separate switches for the microphone signals and for the ground current switch is that the voltage that will be generated over the ground switch will not be sensed by the microphone input terminals, since these switches are placed after the ground switch. This will be described in more detail with respect to Figure 16.

[0051] Each of the pair of speakers 302 is connected to respective audio lines 304a and 304b which provide the audio signals to the user via the speakers 302. The audio signals are generated by the portable electronic device and transmitted to the headset via the jack which is connected to the device, typically via a port.

[0052] Turning to Figure 16, a more detailed schematic of the connections between a portable electronic device and a headset is shown. In the embodiment shown in Figure 16, the headset is connected to a chip within the device. The chip may be a switch matrix having ports for receiving the individual lines within the jack of the headset.

[0053] A video buffer or path (represented by amplifier 500) may also be connected to the microphone line 306d of the headset via a switch 502. The video buffer or path is not a necessary part but may be included in various embodiments. The MIC+ line 314 and the MIC- line 316 are connected to a low noise microphone pre-amplifier 504.

[0054] In the embodiment of Figure 16, the MIC+ line 314 and the MIC- line 316 are connected to the microphone signal line 306d and the ground signal line 306c via a sensing circuit, such as a Kelvin sensing circuit 506. By including a sensing circuit between the switches and ground 322 and the headset, the microphone input (signals along lines MIC+ and MIC-), the effect of any changes to the ground potential 322 will be reduced. A delta-sigma connector 508 may also be located within the device for digitizing analog signals.

[0055] Kelvin sensing may be used on the microphone lines (MIC+ and MIC-) to reduce the affect on the microphone input by changes in or the ground signal 322, or ground potential itself. The switch 324 for the ground line will still be modulated by signals from the headset, but the microphone shall use the signal before this switch 324 to reduce the effect of the modulation. Thus, the microphone pre-amplifier 504 shall sense the differential signal at the jack, before the ground switch 324. Furthermore the switched microphone ground signal may be used in another configuration for reducing or eliminating any ground potential offset observed by the headset or the device (ground loop elimination)

[0056] In one embodiment, for economic and space reasons, this is most economically achieved via low-resistance switches for the ground switching, while somewhat larger resistance switches may be used for the separate set of switches used to carry the microphone signals. As an example, a resistance of 0.5 Ω may be used for switching the ground line, while a resistance of 10 Ω may be used to switch the microphone lines. In this manner, a larger resistance may be used for the differential microphone input since the input impedance is high and the output from the microphone itself is also relatively high as compared to the headphone impedances.

[0057] In the preceding description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the embodiments of

the disclosure. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the disclosure. In other instances, well-known electrical structures and circuits are shown in block diagram form in order not to obscure the disclosure. For example, specific details are not provided as to whether the embodiments of the disclosure described herein are implemented as a software routine, hardware circuit, firmware, or a combination thereof.

[0058] The above-described embodiments of the disclosure are intended to be examples only. Alterations, modifications and variations can be effected to the particular embodiments by those of skill in the art without departing from the scope of the disclosure, which is defined solely by the claims appended hereto.

Claims

1. An apparatus for a portable electronic device for receiving a jack of a headset, the jack including a set of lines, the set of lines including at least one audio line, a ground signal and a microphone signal line, the apparatus comprising:
 - a set of switches for receiving the ground signal line and the microphone signal line; and
 - a sensing circuit for reducing induced noise from the headset;
 - wherein the sensing circuit is located between the set of switches and the microphone signal line and ground signal line.
2. The apparatus of Claim 1 wherein the sensing circuit comprises a Kelvin sensing circuit.
3. The apparatus of Claim 1 or Claim 2 wherein the set of switches are arranged to be connected to a pair of microphone lines within the portable electronic device.
4. The apparatus of Claim 3 wherein the pair of microphone lines comprises a MIC+ line and a MIC- line.
5. The apparatus of Claim 4 wherein a pre-amplifier is connected to the set of switches via the MIC+ line and the MIC- line.
6. The apparatus of any preceding Claim further comprising a video path connected to the microphone signal line.
7. The apparatus of Claim 6 wherein the video path is connected to the microphone signal line via a switch.
8. The apparatus of any preceding Claim wherein the set of switches includes a ground switch to connect a ground reference voltage to one of the ground sig-

nal line and the microphone signal line.

9. The apparatus of any preceding Claim wherein the set of switches and the sensing circuit are integrated with a chip.
10. The apparatus of Claim 9 wherein the chip comprises a switch matrix.
11. A portable electronic device comprising apparatus as claimed in any preceding claim.

Amended claims in accordance with Rule 137(2) EPC.

1. An apparatus for a portable electronic device for receiving a jack (306) of a headset (300), the jack including a set of lines, the set of lines including at least one audio line, a ground signal line (306c) and a microphone signal line (306d), the apparatus comprising:

- a set of switches (316, 320) for receiving the ground signal line (306c) and the microphone signal line (306d) to switch between the signal lines (306c, 306d) in accordance with the setup of the headset (300); and
- a sensing circuit (506) for reducing induced noise from the headset (300);
- wherein the sensing circuit (506) is connected between the set of switches (316, 320) and the microphone signal line (306d) and ground signal line (306c).

2. The apparatus of Claim 1 wherein the sensing circuit (506) comprises a Kelvin sensing circuit.
3. The apparatus of Claim 1 or Claim 2 wherein the set of switches (316, 320) are arranged to be connected to a pair of microphone lines within the portable electronic device.
4. The apparatus of Claim 3 wherein the pair of microphone lines comprises a MIC+ line (314) and a MIC- line (318).
5. The apparatus of Claim 4 wherein a pre-amplifier (504) is connected to the set of switches (316, 320) via the MIC+ line (314) and the MIC- line (318).
6. The apparatus of any preceding Claim further comprising a video path (500) connected to the microphone signal line (306d).
7. The apparatus of Claim 6 wherein the video path (500) is connected to the microphone signal line (306d) via a switch (502).

8. The apparatus of any preceding Claim wherein the set of switches includes a ground switch (324) to connect a ground reference voltage to one of the ground signal line (306c) and the microphone signal line (306d). 5

9. The apparatus of any preceding Claim wherein the set of switches and the sensing circuit (506) are integrated with a chip. 10

10. The apparatus of Claim 9 wherein the chip comprises a switch matrix.

11. A portable electronic device comprising an apparatus as claimed in any preceding claim. 15

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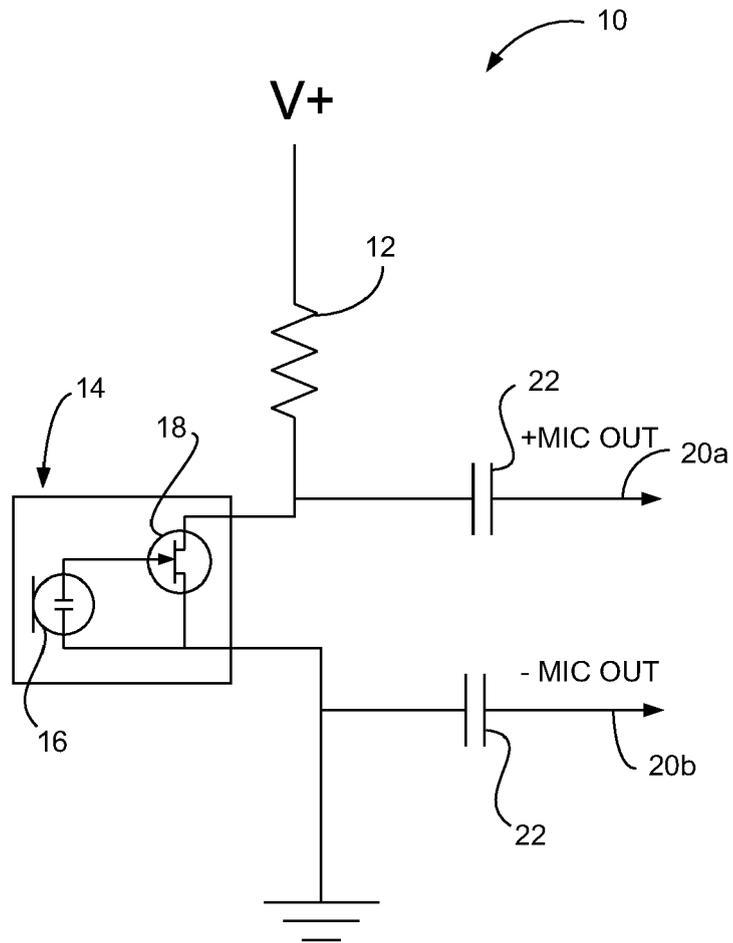


Figure 1

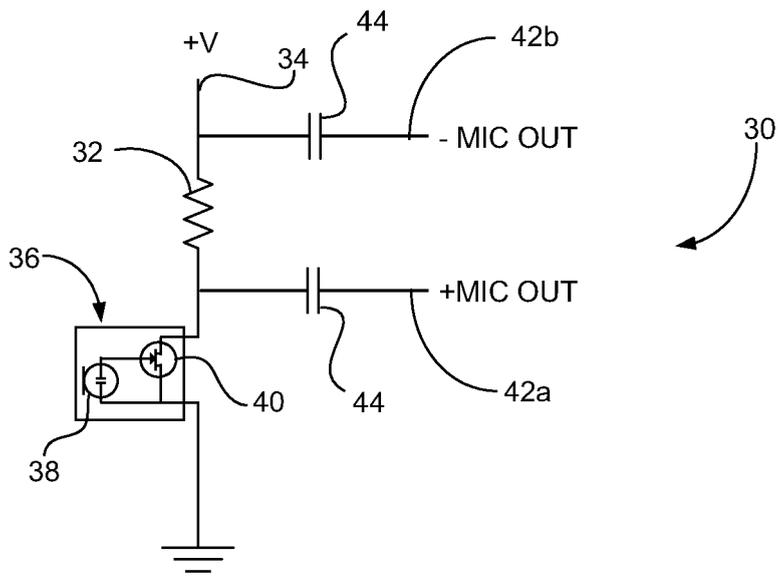


Figure 2

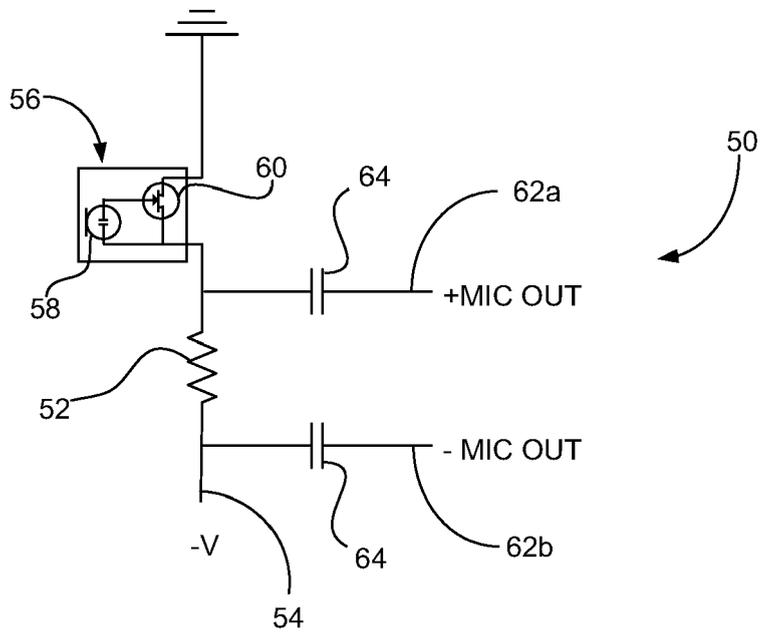


Figure 3

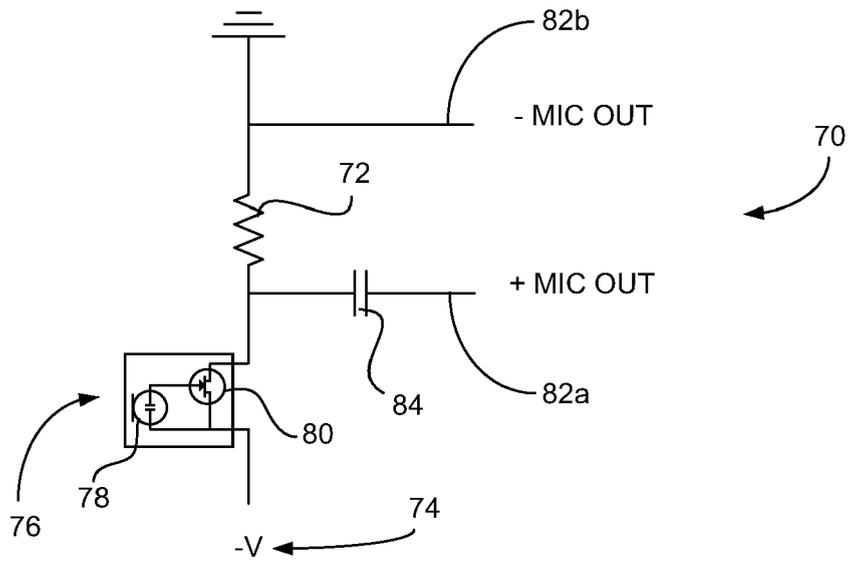


Figure 4

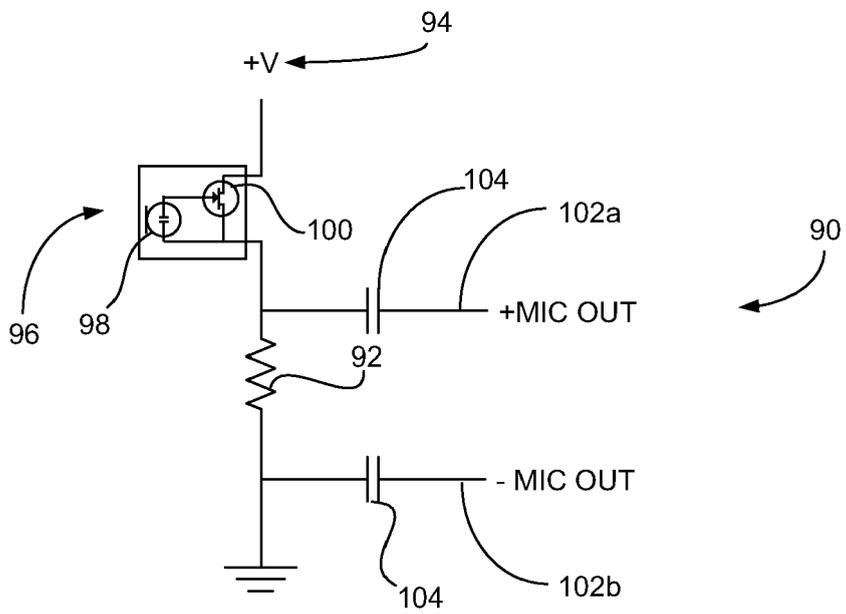


Figure 5

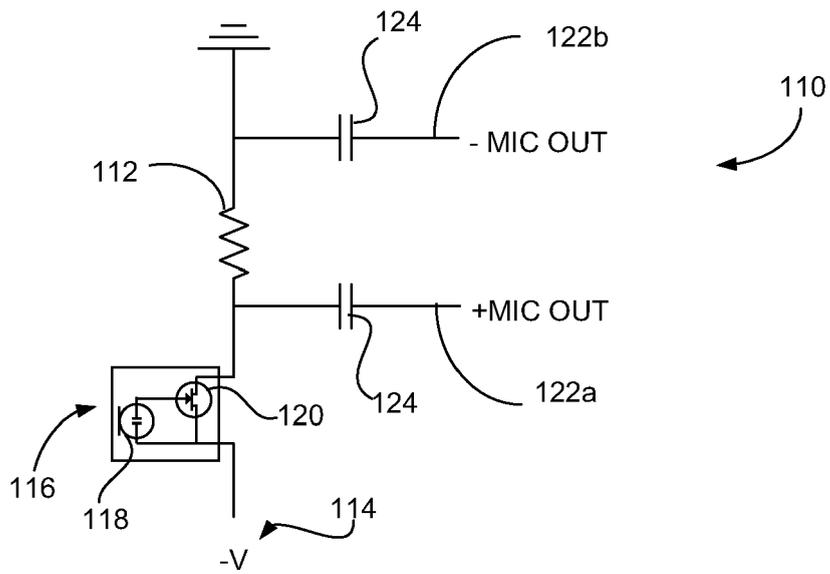


Figure 6

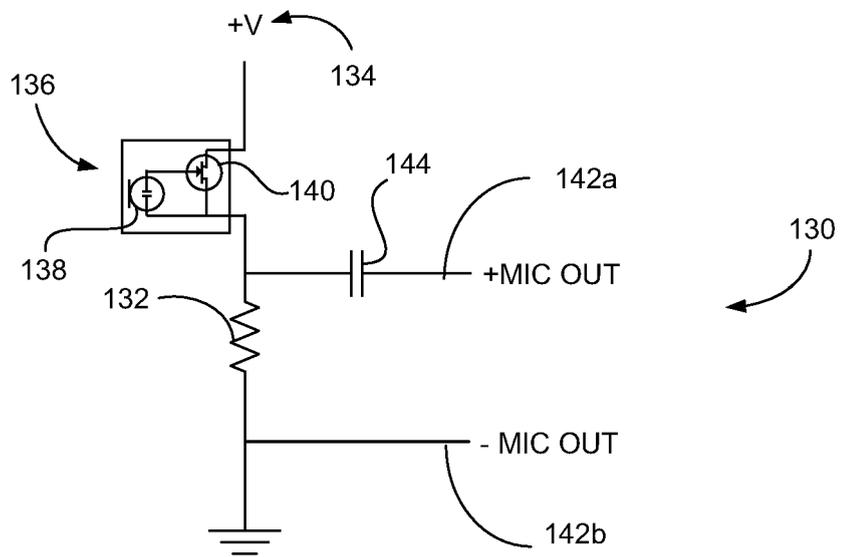


Figure 7

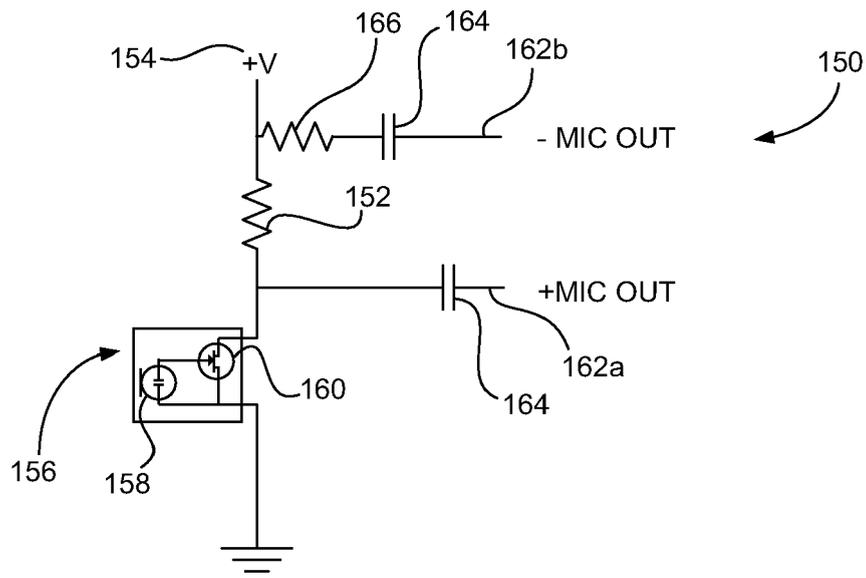


Figure 8

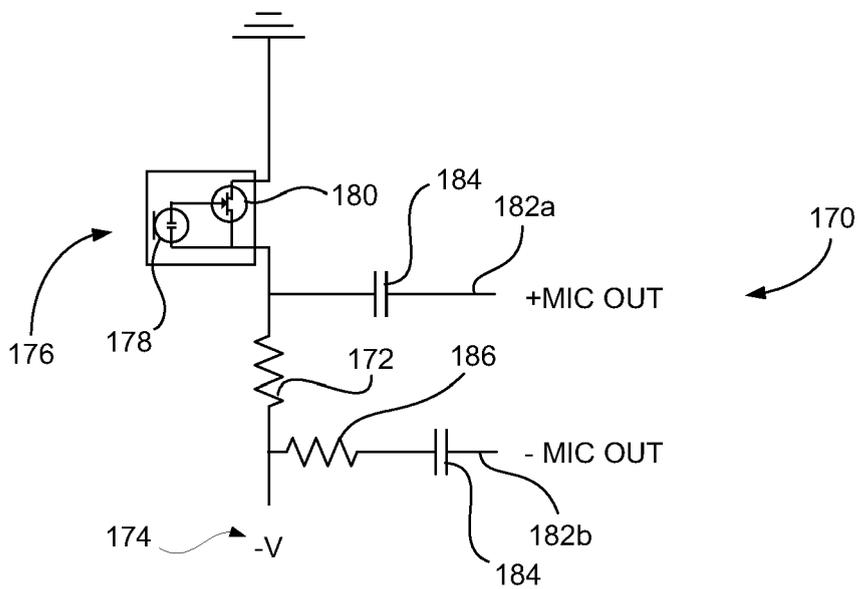


Figure 9

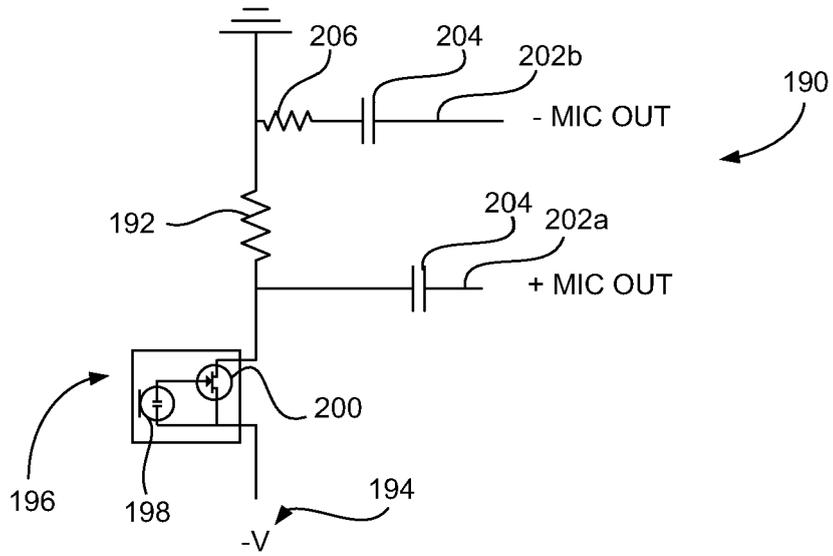


Figure 10

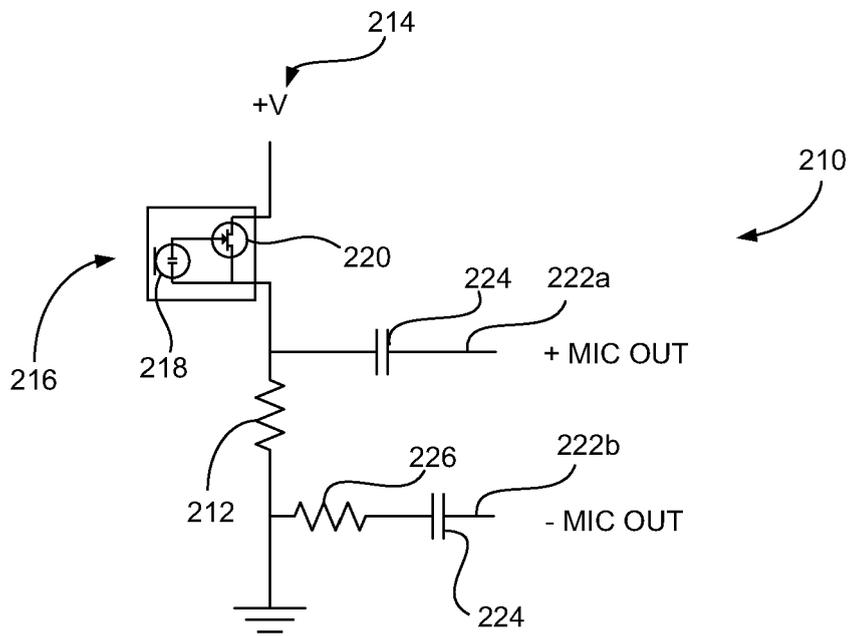


Figure 11

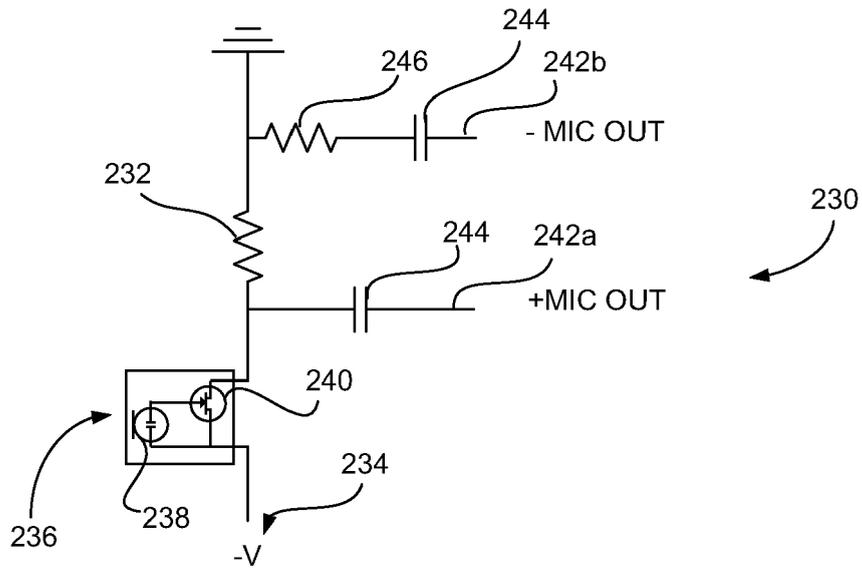


Figure 12

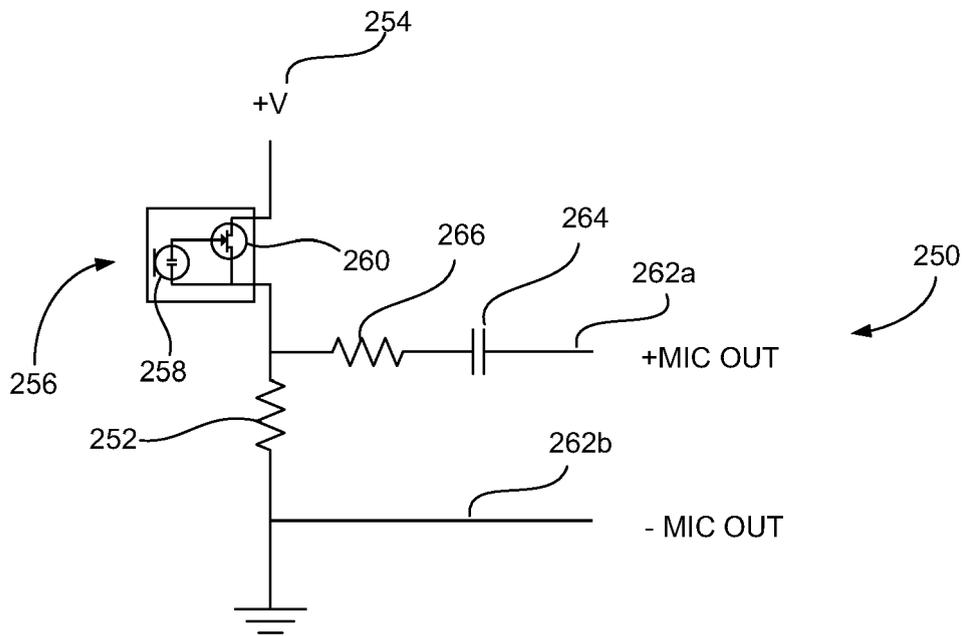


Figure 13

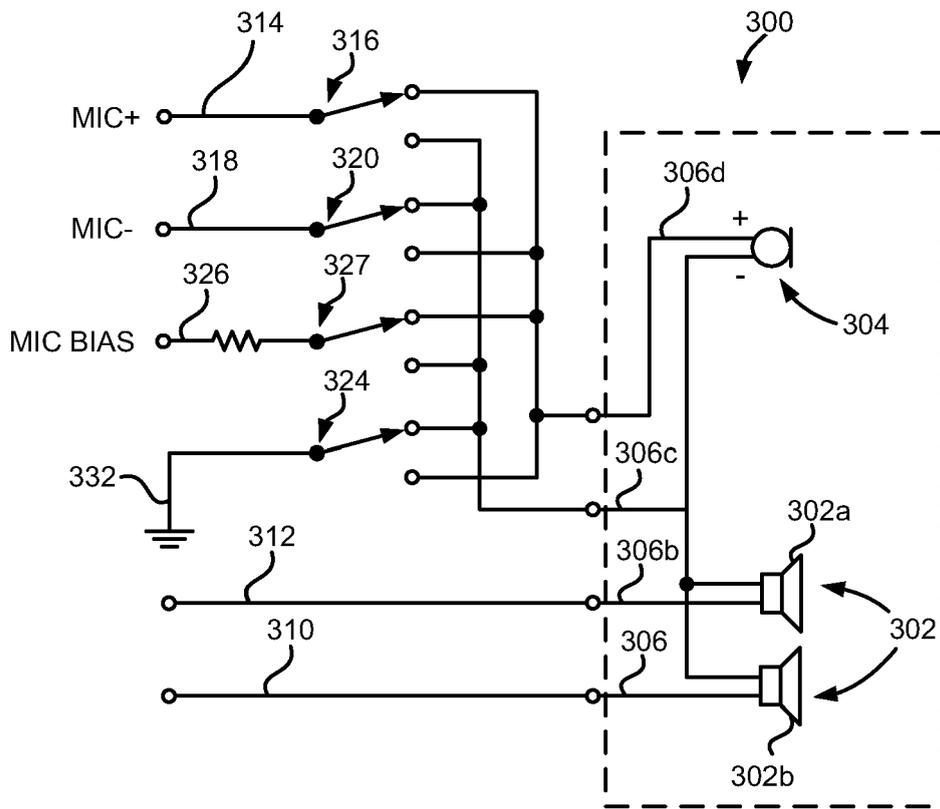


Figure 14

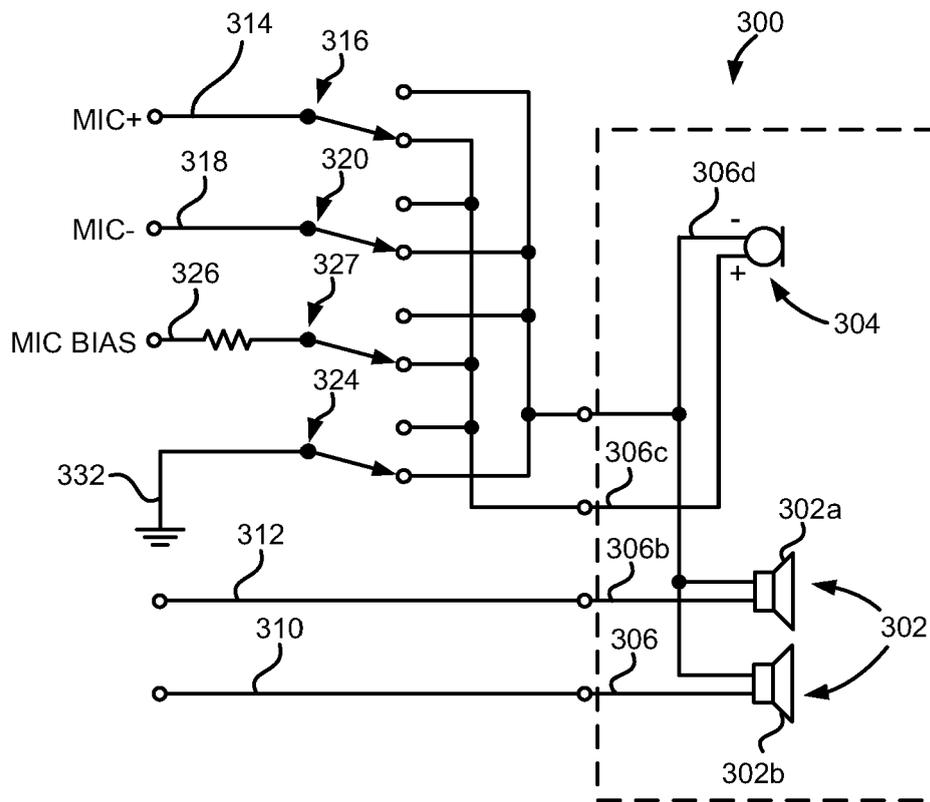


Figure 15

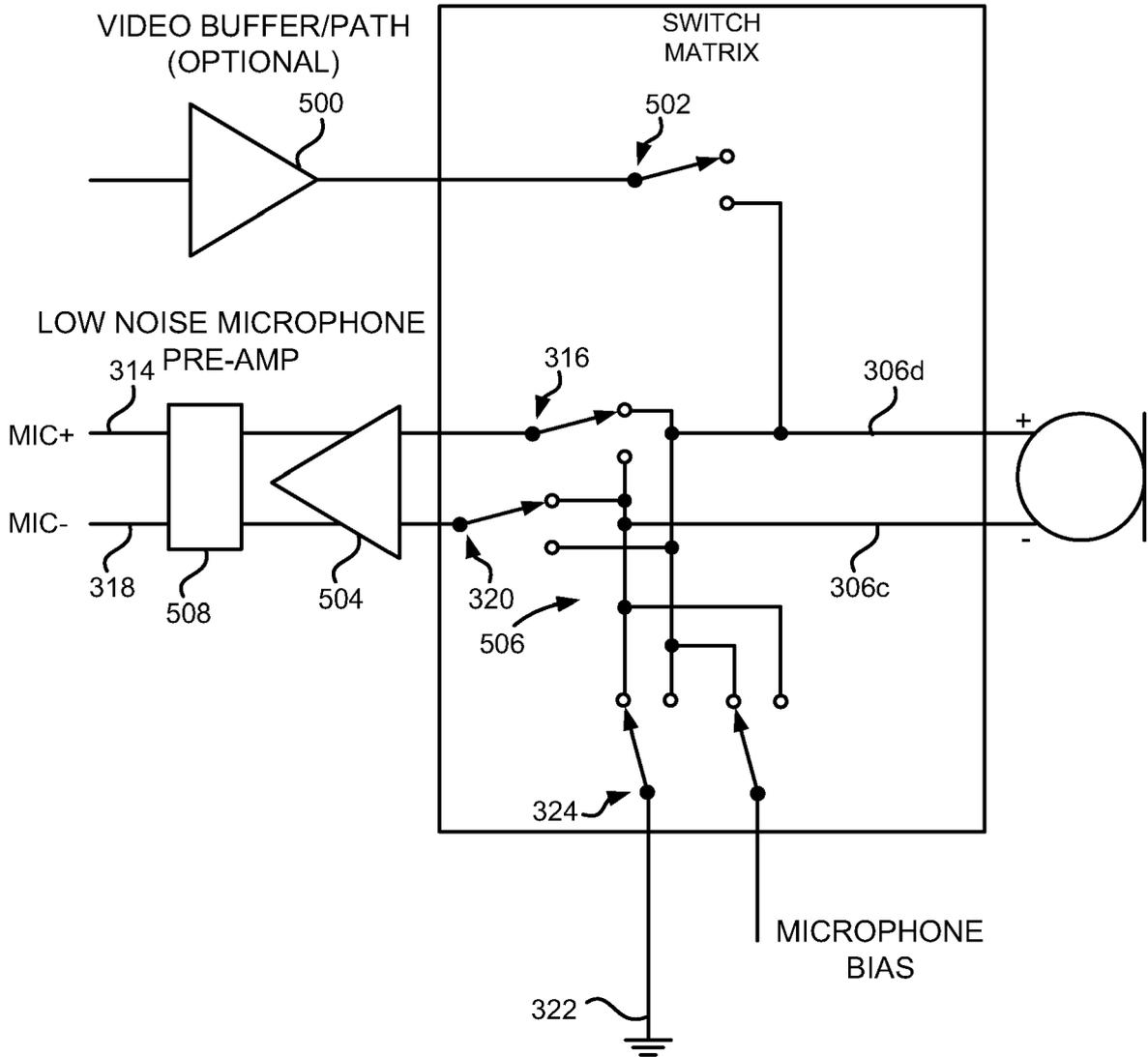


Figure 16



EUROPEAN SEARCH REPORT

Application Number
EP 10 19 3885

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	W0 99/57937 A1 (TUORINIEMI VEIJO MATIAS [US]) 11 November 1999 (1999-11-11)	1,3,4,11	INV. H04R3/00
Y	* abstract *	2,5-10	
Y	* figure 2 *	2,5-10	
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