

**SYSTEMS AND METHODS FOR RESTORING
MICROELECTROMECHANICAL SYSTEM TRANSDUCER OPERATION
FOLLOWING PLOSIVE EVENT**

RELATED APPLICATIONS

5 The present disclosure claims priority to United States Non-Provisional Patent Application Serial No. 15/131,886, filed April 18, 2016, which claims priority to United States Provisional Patent Application Serial No. 62/269,328, filed December 18, 2015, each of which is incorporated by reference herein in its entirety.

10 **FIELD OF DISCLOSURE**

 The present disclosure relates in general to audio systems, and more particularly, to restoring a microelectromechanical system (MEMS) based transducer operation following a plosive event and configuring a filter having at least two frequency response configurations to achieve an effective frequency response configuration intermediate to
15 the at least two frequency response configurations.

BACKGROUND

 Microphones are ubiquitous on many devices used by individuals, including computers, tablets, smart phones, and many other consumer devices. Generally speaking,
20 a microphone is an electroacoustic transducer that produces an electrical signal in response to deflection of a portion (e.g., a membrane or other structure) of a microphone caused by sound incident upon the microphone. For example, a microphone may be implemented as a MEMS transducer. A MEMS transducer may include a diaphragm or membrane having an electrical capacitance, such that a change in acoustic pressure
25 applied to the MEMS transducer causes a deflection or other movement of the membrane, and thus causes a change in the electrical capacitance. Such change may be sensed by a sensing circuit and processed.

 Sensing of a MEMS transducer may rely on a constant charge present on the electrical capacitance of the MEMS transducer. Thus, a large bias voltage, typically
30 higher than a breakdown voltage of the MEMS transducer, may be used to bias the MEMS transducer. Therefore, it is often necessary to protect a MEMS transducer to

prevent too large of a voltage appearing on the electrical capacitance of the MEMS transducer. Such protection is often achieved with a voltage clamp, which may be implemented with diodes. However, when such a voltage clamp activates during a very large input (e.g., very high acoustic pressure), charge may be added or removed from the electrical capacitance of the MEMS transducer. When the large input is removed, the charge on the electrical capacitance must recover from the point at which the voltage clamps to its original charge. This voltage recovery can cause a large voltage offset of the microphone, which may cause audio artifacts (e.g., clipping, distortion) that last several seconds until the charge on the electrical capacitance returns to its original level.

Such a large input event may be referred to as a “plosive event.” A plosive event may be defined as any event in which the MEMS transducer is exposed to an input (e.g., very high acoustic pressure) greater than a peak input, such that undesirable charge is added or removed from the electrical capacitance of the MEMS transducer. A plosive event may include a “pull-in event,” in which capacitive plates of the electrical capacitance of the MEMS transducer electrically short together (e.g., due to very high acoustic pressure). Such plosive events may cause high-impedance nodes of sensing circuitry coupled to the MEMS transducer to lose charge, leading to reduced sensitivity of the MEMS transducer, and in some cases, loss of functionality due to signal clipping or other audio artifacts.

Traditional analog MEMS transducers typically rely on diodes to prevent overload and to provide a low-impedance path to replenish charge in a MEMS transducer responsive to a plosive event. However, such approach may be disadvantageous as it may require design tradeoffs. If too few diodes are used, the diode conduction path may turn on at expected large audio inputs, causing distortion of audio signals. On the other hand, if too many diodes are used, then they may not return high-impedance nodes of a sensing circuit to a value close enough to its direct current level to settle back to normal operation in a reasonable amount of time.

SUMMARY

In accordance with the teachings of the present disclosure, certain disadvantages and problems associated with restoring operation to a MEMS transducer following a plosive event may be reduced or eliminated.

5 In accordance with embodiments of the present disclosure, a system may include control circuitry for detecting a plosive event associated with a microphone transducer and in response to the plosive event, causing restoration of acoustic sense operation of the microphone transducer and a processing circuit associated with the microphone transducer.

10 In accordance with these and other embodiments of the present disclosure, a method may include detecting a plosive event associated with a microphone transducer and, in response to the plosive event, causing restoration of acoustic sense operation of the microphone transducer and a processing circuit associated with the microphone transducer.

15 In accordance with these and other embodiments of the present disclosure, a method of configuring a filter having at least two frequency response configurations to achieve an effective frequency response configuration intermediate to the at least two frequency response configurations may include rapidly switching between the at least two frequency response configurations such that a weighted average frequency response of
20 the filter corresponds to the effective frequency response configuration.

In accordance with these and other embodiments of the present disclosure, a system for configuring a filter having at least two frequency response configurations to achieve an effective frequency response configuration intermediate to the at least two frequency response configurations may include control circuitry for rapidly switching
25 between the at least two frequency response configurations such that a weighted average frequency response of the filter corresponds to the effective frequency response configuration.

Technical advantages of the present disclosure may be readily apparent to one having ordinary skill in the art from the figures, description and claims included herein.
30 The objects and advantages of the embodiments will be realized and achieved at least by the elements, features, and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are explanatory examples and are not restrictive of the claims set forth in this disclosure.

5 BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

10 FIGURE 1 illustrates a block diagram of selected components of an example audio system, in accordance with embodiments of the present disclosure;

FIGURE 2 illustrates a block diagram of selected components of an example control circuit, in accordance with embodiments of the present disclosure; and

15 FIGURE 3 illustrates a block diagram of selected components of an example dithering system for modifying pole frequency of a filter from an original frequency and transitioning the pole frequency of the filter back to the original frequency, in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

20 A plosive response system may detect plosive events and take appropriate corrective actions to minimize impact of plosive events on performance of a microphone transducer. A large number of diodes (not shown in the associated figures for purposes of clarity of exposition) may be used to protect a microphone transducer, and additional recovery of the microphone transducer may be accomplished via the systems and methods
25 described below.

FIGURE 1 illustrates a block diagram of selected components of an example audio system 100, in accordance with embodiments of the present disclosure. As shown in FIGURE 1, audio system 100 may include an analog signal path portion comprising a charge pump power supply 102, a charge-pump filter 118, a microphone transducer 104,
30 two or more processing paths 105a and 105b (which may be referred to herein individually as a processing path 105 and collectively as processing paths 105), a data

combiner 113, a driver 112, a digital audio processor 114, a control circuit 116, and one or more reset switches 124, 126, 128, and 130.

Charge pump power supply 102 may comprise any suitable system, device, or apparatus configured to supply microphone transducer 104 with a direct current (DC) bias voltage V_{BIAS} , such that microphone transducer 104 may generate an electrical audio signal. Charge pump filter 118 may comprise any suitable system, device, or apparatus configured to low-pass filter DC bias voltage V_{BIAS} in order to remove noise and other high-frequency components present in DC bias voltage V_{BIAS} . For example, as shown in FIGURE 1, charge pump filter 118 may comprise an resistor-capacitor (RC) filter comprising a resistive element 120 (e.g., a resistor, a diode having a significant resistance) and a capacitive element 122. DC bias voltage V_{BIAS} as filtered by charge pump filter 118 may be supplied to a terminal of microphone transducer 104 in order to bias microphone transducer 104.

Microphone transducer 104 may comprise any suitable system, device, or apparatus configured to convert sound incident at microphone transducer 104 to an electrical signal, wherein such sound is converted to an electrical analog input signal v_{IN} using a diaphragm or membrane having an electrical capacitance (modeled as variable capacitor 106 in FIGURE 1) that varies based on sonic vibrations received at the diaphragm or membrane. Microphone transducer 104 may include an electrostatic microphone, a condenser microphone, an electret microphone, a microelectromechanical systems (MEMS) microphone, or any other suitable capacitive microphone.

As shown in FIGURE 1, processing paths 105 may receive analog input signal v_{IN} (as filtered by DC blocking capacitor 132 or as divided by a capacitor divider implemented by capacitors 134 and 136) and process analog input signal v_{IN} such that each processing path 105 generates a corresponding intermediate digital output signal based on analog input signal v_{IN} . Each processing path 105 may include a respective analog front end (AFE) 107 (e.g., AFE 107a, AFE 107b), a respective analog-to-digital converter (ADC) 110 (e.g., ADC 110a, ADC 110b), and a respective filter 111 (e.g., filter 111a, filter 111b).

An AFE 107 may receive analog input signal v_{IN} via one or more input lines which may allow for receipt of a single-ended signal, differential signal, or any other

suitable analog signal format and may comprise any suitable system, device, or apparatus configured to condition analog input signal v_{IN} for processing by ADC 110. As shown in FIGURE 1, an AFE 107 may comprise a pre-amplifier 108 (e.g., pre-amplifier 108a, pre-amplifier 108b) having an input to receive analog input signal v_{IN} output from microphone transducer 104 and may comprise any suitable system, device, or apparatus configured to condition analog input signal v_{IN} for processing by ADC 110.

An ADC 110 may comprise any suitable system, device, or apparatus configured to convert an analog signal received at its input to a digital signal representative of analog input signal v_{IN} . ADC 110 may itself include one or more components (e.g., delta-sigma modulator, decimator, etc.) for carrying out the functionality of ADC 110.

Each filter 111 (e.g., filter 111a, filter 111b) may filter a digital signal generated by its associated ADC 110, to remove undesired frequency components present in the digital signal. In some embodiments, each filter 111 may comprise a high-pass filter to filter out any direct-current offsets present in the digital signal.

Although not shown in FIGURE 1, one or both of processing paths 105 may include one or more elements for latency matching, phase matching, or otherwise balancing a difference in propagation time of signals through processing paths 105.

In some embodiments, a magnitude of a gain of amplifier 108a may be substantially larger than (e.g., significantly more than manufacturing tolerances, one or more orders of magnitude) a magnitude of a gain of amplifier 108b. In addition, in these and other embodiments, a magnitude of a gain of ADC 110b (or other digital element in processing path 105b) may be substantially larger than (e.g., significantly more than manufacturing tolerances, one or more orders of magnitude) a magnitude of a gain of ADC 110a (or other digital element in processing path 105a). Consequently, in such embodiments, a first path gain equal to the product of the magnitude of the gain of amplifier 108a and the magnitude of the gain of ADC 110a (or other digital gain element within processing path 105a) may be substantially equal (e.g., within manufacturing tolerances) to a second path gain equal to the product of the magnitude of the gain of amplifier 108b and the magnitude of the gain of ADC 110b (or other digital gain element within processing path 105b). Accordingly, each processing path 105 may be adapted to process a particular amplitude of analog input signal v_{IN} . For example, AFE 107a may be

suited to process lower signal amplitudes, as its larger gain may permit effective processing of smaller signals, but characteristics of AFE 107a may not be amenable to higher amplitudes. On the other hand, AFE 107b may be suited to process higher signal amplitudes, as its lower gain will reduce the likelihood of signal clipping, and may provide for greater dynamic range for analog input signal v_{IN} as compared to traditional single-path approaches.

A data combiner 113 may receive a respective digital signal from each of processing paths 105 and may select one of the digital signals as digital output signal DIGITAL_OUT based on a control signal generated by and communicated from control circuit 116. Thus, depending on an amplitude of analog input signal v_{IN} , control circuit 116 may select one of the processing paths 105 as an active path for generating digital output signal DIGITAL_OUT. In some embodiments, data combiner 113 may also be configured to generate a weighted average of its inputs, such that when changing between selection of its inputs, it blends or cross-fades between processing paths 105, to reduce or eliminate audio artifacts that may occur due to switching between processing paths 105.

Driver 112 may receive digital signal output by ADC 110 and may comprise any suitable system, device, or apparatus configured to condition such digital signal (e.g., encoding into Audio Engineering Society/European Broadcasting Union (AES/EBU), Sony/Philips Digital Interface Format (S/PDIF), or other suitable audio interface standards), in the process generating a digitized microphone signal for transmission over a bus to digital audio processor 114. For example, in some embodiments driver 112 may comprise a single-bit output modulator to generate pulse-density modulated data.

Digital audio processor 114 may comprise any suitable system, device, or apparatus configured to process the digitized microphone signal for use in a digital audio system. For example, digital audio processor 114 may comprise a microprocessor, microcontroller, digital signal processor (DSP), application specific integrated circuit (ASIC), or any other device configured to interpret and/or execute program instructions and/or process data, such as the digitized microphone signal output by driver 112.

Control circuit 116 may comprise any suitable system, device, or apparatus for detecting a plosive event associated with microphone transducer 104 and in response to the plosive event, causing restoration of acoustic sense operation of the microphone

transducer 104 and the processing circuit (e.g., components of system 100 other than microphone transducer 104) associated with microphone transducer 104. For example, as described in greater detail below, control circuit 116 may, based on monitoring one or more characteristics of system 100, determine whether one or more indications of a plosive event has occurred, determine from the one or more indications whether a plosive event has occurred, and in response to determining that a plosive event has occurred, enable one or more of reset switches 124, 126, 128, and 130 to reset electrical characteristics of electrical nodes coupled to such switches, and/or control a pole of one or both filters 111 in order to cause restoration of acoustic sense operation of microphone transducer 104 and the processing circuit associated with microphone transducer 104.

FIGURE 2 illustrates a block diagram of selected components of an example control circuit 116, in accordance with embodiments of the present disclosure. As shown in FIGURE 2, control circuit 116 may include a state machine 225 configured to receive one or more indications of a plosive event, determine from the one or more indications whether a plosive event has occurred, and in response to determining a plosive event has occurred, enable one or more of reset switches 124, 126, 128, and 130 to reset electrical characteristics of electrical nodes coupled to such switches, and/or control a pole of one or both filters 111 in order to cause restoration of acoustic sense operation of microphone transducer 104 and the processing circuit associated with microphone transducer 104. For example, one indication of a plosive event may be detection of saturation of an AFE 107, as indicated by one or more of the “OVERLOAD” signals communicated from amplifiers 108 to control circuit 116. In some embodiments, state machine 225 may determine that a plosive event has occurred if such saturation has lasted longer than a threshold period of time (e.g., 100 milliseconds). As another example, another indication of a plosive event may be detection of clipping in the digital domain of the processing circuit, such as may be indicated by analyzing the magnitude of output signals “ADC_OUT” of one or more ADCs 110. In some embodiments, state machine 225 may determine that a plosive event has occurred if such clipping has lasted longer than a threshold period of time (e.g., 100 milliseconds).

As a further example, another indication of a plosive event may be detection of presence of a DC component of a signal in a signal path of the processing circuit.

Specific examples of detecting DC components of a signal in a signal path of the processing circuit may include threshold-based time detection implemented by DC detector 202 and leaky-integrator based DC detection implemented by DC detector 204.

In threshold-based time detection of DC components, DC detector 202 may detect
5 presence of a DC offset responsive to a magnitude of a signal (e.g., signal ADC_OUT output by an ADC 110) continuously exceeding a threshold magnitude (e.g., 0.1 relative to a full scale magnitude) for a threshold duration of time (e.g., 25 milliseconds). In operation, the signal (e.g., signal ADC_OUT output by an ADC 110) may be low-pass filtered by low-pass filter 206 to remove any delta-sigma or other noise of ADC 110.
10 Such filtered output may roughly correspond to the output of the amplifier 108 that generates an input signal to ADC 110. Threshold comparator 208 may determine if a magnitude (e.g., absolute value) of such filtered signal exceeds the threshold magnitude. Threshold comparator 208 may enable a counter 210 that outputs to state machine 225 an indication that a DC offset is present in the signal if the filtered signal exceeds the
15 threshold magnitude for the threshold duration of time.

In leaky-integrator based DC detection of DC components, DC detector 204 may detect presence of a DC offset in a signal responsive to a determination that a filtered version of the signal filtered to remove audible frequencies from the signal has a magnitude that exceeds a threshold magnitude (e.g., 0.65 relative to a full-scale
20 magnitude). In operation, the signal (e.g., signal ADC_OUT output by an ADC 110) may be received by leaky integrator 212 which has a pole set at a frequency (e.g., 7.3 Hz) to reject substantially all of the audible frequencies from the signal. Threshold comparator 214 may determine if a magnitude (e.g., absolute value) of such filtered signal exceeds the threshold magnitude, and if so, may output to state machine 225 an indication that a
25 DC offset is present in the signal.

In some embodiments, DC component detection may be enabled only in response to another indication of a plosive event, as indicated by the signal DC_ENABLE communicated by state machine 225 to DC detector 202 and DC detector 204. For example, state machine 225 may enable DC component detection responsive to saturation
30 of an AFE 107, as indicated by one or more of the "OVERLOAD" signals communicated from amplifiers 108 to control circuit 116. As a specific example, in some embodiments,

DC component detection may be enabled in response to detection of saturation for any period of time.

If, from the one or more indications of a plosive event, control circuit 116 determines a plosive event has occurred, control circuit 116 may cause restoration of acoustic sense operation of microphone transducer 104 and the processing circuit associated with microphone transducer 104 by taking one or more actions. For example, in some embodiments, control circuit 116 may cause restoration of acoustic sense operation of microphone transducer 104 and/or its associated processing circuit by modifying a pole of charge-pump filter 118. As a specific example, in some of such embodiments, control circuit 116 may modify a pole of charge-pump filter 118 by activating (e.g., closing, turning on) reset switch 124, to effectively short the terminals of resistive element 120 of charge-pump filter 118 together. For large plosive events, capacitive element 122 of charge-pump filter 118 may have significant charge added or removed. Shorting of the terminals of resistive element 120 of charge-pump filter 118 together in response to a plosive event may speed up recovery of both capacitive element 122 and capacitor 106 of microphone transducer 104.

In these and other embodiments, control circuit 116 may cause restoration of acoustic sense operation of microphone transducer 104 and/or its associated processing circuit by forcing one or more electrical nodes of the processing circuit used for sensing to their common-mode voltages. As specific examples, in some of such embodiments, control circuit 116 may: (a) force the output node of microphone transducer 104 to its common-mode voltage by activating (e.g., closing, turning on) reset switch 126 to short the output node of microphone transducer 104 to alternating current (AC) ground; (b) force the input node of AFE 107a to its common-mode voltage by activating (e.g., closing, turning on) reset switch 128 to short the input node of AFE 107a to AC ground; and/or (c) force the input node of AFE 107b to its common-mode voltage by activating (e.g., closing, turning on) reset switch 130 to short the input node of AFE 107b to AC ground.

In these and other embodiments, control circuit 116 may cause restoration of acoustic sense operation of microphone transducer 104 and/or its associated processing circuit by modifying a pole frequency of one or more of filters 111 from an original pole

frequency to increase a response of the one or more filters 111 to voltage ringing in one or more of AFEs 107, and then transitioning the pole frequency back to the original pole frequency in a plurality of steps in order to render the transition substantially inaudible. Such modification of pole frequency of the one or more filters 111 may be desirable due to activation of reset switches 124, 126, 128, and 130. Once reset switches 124, 126, 128, and 130 and inputs to AFEs 107 are shorted to ground, processing paths 105 have no analog input signal to process and thus, reset switches 124, 126, 128, and 130 must be deactivated (e.g., opened, turned off) after a fixed period of time that is long enough to allow nodes coupled to reset switches 124, 126, 128, and 130 to settle. This manner of switch operation may cause charge on microphone transducer 104 to be “incorrect” in the sense that microphone transducer 104 may not be producing an analog input signal v_{IN} of zero when switches 124, 126, 128, and 130 are deactivated. In many cases, such difference may be small in comparison to the maximum allowed magnitude for analog input signal v_{IN} , and thus, may settle out over time. Nonetheless, some voltage ringing may be present during such time, and modification of the poles of filters 111 may remove any such offset caused by ringing.

Any suitable system, device, or apparatus may be used to modify the pole frequency of one or more of filters 111 from its original pole frequency and then transitioning its pole frequency back to the original pole frequency in a plurality of steps. FIGURE 3 illustrates a block diagram of selected components of an example dithering system 300 for modifying pole frequency of a filter from an original frequency and transitioning the pole frequency of the filter back to the original frequency. In some embodiments, dithering system 300 may be integral to state machine 225. As shown in FIGURE 3, dithering system 300 may include a digital counter 302 configured to count between 0 and N, a delta-sigma modulator 304, and a multiplexer 312.

The values output by counter 302 may represent steps of intermediate frequencies between an original frequency f_0 and another frequency f_1 . In the case of a high-pass filter, frequency f_1 may be greater than original frequency f_0 . For example, in some embodiments, original frequency f_0 may be 2 Hz and frequency f_1 may be 14 Hz, which may be suitable for removing DC components by a high-pass filter (e.g., filter 111) as both frequencies are below the audible range of frequencies. In operation, in response to

a plosive event, state machine 225 may assert the ENABLE signal to counter 302, which may reset counter 302 to zero. Counter 302 may increment in accordance with a clock signal CLK1. Because counter 302 counts from 0 to N, the output of counter 302 may represent N+1 frequencies between original frequency f_0 and frequency f_1 .

5 Delta-sigma modulator 304 may receive the output of counter 302 and generate a one-bit overflow signal having a duty cycle proportional to the output of counter 302. As shown in FIGURE 3, delta-sigma modulator 304 may include a summer 306 for combining the output of counter 302 with a feedback signal which is a time-based integral of the output of counter 302 as delayed by delay element 308 clocked with a clock signal
10 CLK2. An overflow detector 310 may detect each time the integrated counter signal output by summer 306 overflows, and output an overflow signal indicating such overflow. Clock signal CLK2 may be at a substantially higher frequency than CLK1, such that for each value of counter 302, delta-sigma modulator 304 may overflow multiple times, such that the output of overflow detector 310 is a pulse-width modulation-
15 like signal having a duty cycle proportional to the output of counter 302. Although FIGURE 3 depicts a first-order delta-sigma modulator 304, in some embodiments, dithering system 300 may employ a second-order or higher delta-sigma modulator.

The output of the overflow detector 310 may serve as a control signal to multiplexer 312, which passes one of original frequency f_0 and frequency f_1 based on the
20 control signal. Accordingly, for each value of counter 302, the output of multiplexer 312 rapidly switches between two frequency response configurations (e.g., original frequency f_0 and frequency f_1) thus providing a time-varying pole frequency having a weighted average frequency based on the duty cycle of the switching signal output by delta-sigma modulator 304 (and thus, based on the value output by counter 302) which serves as an
25 effective frequency response configuration for such value of counter 302 which is intermediate to the two frequency response configurations.

Accordingly, dithering system 300 enables a high-pass filter (e.g., filter 111) to transition in a plurality of steps (e.g., 0 to N) between a first effective frequency response approximately equal to one of the two frequency response configurations (e.g., frequency
30 f_1) and a second effective frequency response approximately equal to another of the at least two frequency response configurations (e.g., frequency f_0) by sequentially applying

at least one effective frequency response configuration intermediate to the two frequency response configurations. Such transitioning in steps between the first effective frequency response and the second effective frequency response, rather than directly between the first effective frequency response and the second effective frequency response, may minimize audio artifacts.

Although the foregoing discussion contemplates application of dithering system 300 to enable recovery from plosive events of microphone transducer 104, dithering system 300 and systems substantially similar to dithering system 300 are not limited in application to plosive event recovery and may also be used in applications other than recovery from plosive events of a microphone transducer. In addition, although the foregoing discussion contemplates application of dithering system 300 to modify a pole of a high-pass filter, dithering system 300 and systems substantially similar to dithering system 300 are not limited in application to modifying poles of high-pass filters and may also be used to modify poles of other filters, including without limitation low-pass filters, band-pass filters, and notch filters.

This disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Similarly, where appropriate, the appended claims encompass all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Moreover, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, or component, whether or not it or that particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative.

All examples and conditional language recited herein are intended for pedagogical objects to aid the reader in understanding the disclosure and the concepts contributed by the inventor to furthering the art, and are construed as being without limitation to such specifically recited examples and conditions. Although embodiments of the present disclosure have been described in detail, it should be understood that various changes,

substitutions, and alterations could be made hereto without departing from the spirit and scope of the disclosure.

WHAT IS CLAIMED IS:

1. A system comprising:
control circuitry for detecting a plosive event associated with a microphone transducer and in response to the plosive event, causing restoration of acoustic sense
5 operation of the microphone transducer and a processing circuit associated with the microphone transducer.
2. The system of Claim 1, further comprising the microphone transducer coupled to the control circuitry.
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3. The system of Claim 1, wherein the control circuitry detects a plosive event by detecting saturation of an analog front-end circuit of the processing circuit.
4. The system of Claim 1, wherein the control circuitry detects a plosive
15 event by detecting signal clipping in a digital domain of the processing circuit.
5. The system of Claim 1, wherein the control circuitry detects a plosive event by detecting presence of a direct current component of a signal in a signal path of the processing circuit.
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6. The system of Claim 5, wherein the control circuitry detects presence of a direct current component offset responsive to a magnitude of the signal continuously exceeding a threshold magnitude for a threshold duration of time in order to detect presence of a direct current component of a signal in a signal path of the processing
25 circuit.
7. The system of Claim 5, wherein the control circuitry detects presence of a direct current component by low-pass filtering the signal to generate a filtered signal and comparing a magnitude of the filtered signal to a threshold magnitude.
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8. The system of Claim 1, wherein the control circuitry causes restoration of acoustic sense operation of the microphone transducer and the processing circuit by modifying a pole of a charge-pump filter at an output of a charge pump for generating a bias voltage for the microphone transducer.

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9. The system of Claim 1, wherein the control circuitry causes restoration of acoustic sense operation of the microphone transducer and the processing circuit by forcing one or more electrical nodes of the processing circuit used for sensing to their common-mode voltages.

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10. The system of Claim 1, wherein the control circuitry causes restoration of acoustic sense operation of the microphone transducer and the processing circuit by:

modifying a pole frequency of a high-pass filter of the processing circuit from an original pole frequency to increase a response of the high-pass filter to ringing of an analog front-end circuit of the processing circuit; and

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transitioning the pole frequency back to the original pole frequency in a plurality of steps in order to render the transition substantially inaudible.

11. The system of Claim 1, wherein the microphone transducer comprises a microelectricalmechanical system (MEMS) transducer.

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12. A method comprising:

detecting a plosive event associated with a microphone transducer; and

in response to the plosive event, causing restoration of acoustic sense operation of the microphone transducer and a processing circuit associated with the microphone transducer.

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13. The method of Claim 12, wherein detecting the plosive event comprises detecting saturation of an analog front-end circuit of the processing circuit.

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14. The method of Claim 12, wherein detecting the plosive event comprises detecting signal clipping in a digital domain of the processing circuit.

15. The method of Claim 12, wherein detecting the plosive event comprises
5 detecting presence of a direct current component of a signal in a signal path of the processing circuit.

16. The method of Claim 15, wherein detecting presence of the direct current component comprises detecting presence of a direct current component offset responsive
10 to a magnitude of the signal continuously exceeding a threshold magnitude for a threshold duration of time.

17. The method of Claim 15, wherein detecting presence of the direct current component comprises low-pass filtering the signal to generate a filtered signal and
15 comparing a magnitude of the filtered signal to a threshold magnitude.

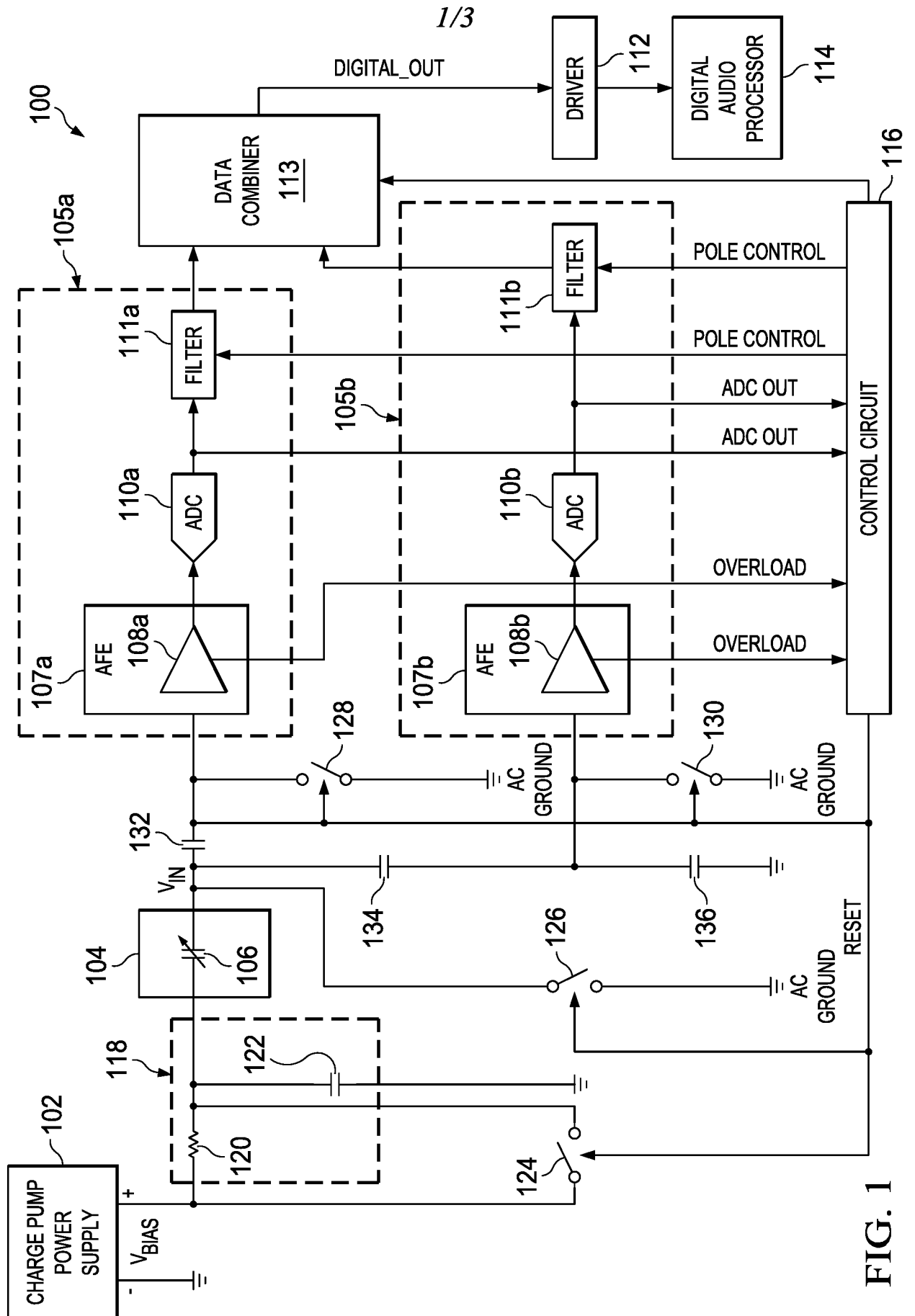
18. The method of Claim 12, wherein causing restoration of acoustic sense operation of the microphone transducer and the processing circuit comprises modifying a pole of a charge-pump filter at an output of a charge pump for generating a bias voltage
20 for the microphone transducer.

19. The method of Claim 12, wherein causing restoration of acoustic sense operation of the microphone transducer and the processing circuit comprises forcing one or more electrical nodes of the processing circuit used for sensing to their common-mode
25 voltages.

20. The method of Claim 12, wherein causing restoration of acoustic sense operation of the microphone transducer and the processing circuit comprises:
modifying a pole frequency of a high-pass filter of the processing circuit from an
30 original pole frequency to increase a response of the high-pass filter to ringing of an analog front-end circuit of the processing circuit; and

transitioning the pole frequency back to the original pole frequency in a plurality of steps in order to render the transition substantially inaudible.

21. The method of Claim 12, wherein the microphone transducer comprises a
5 microelectricalmechanical system (MEMS) transducer.



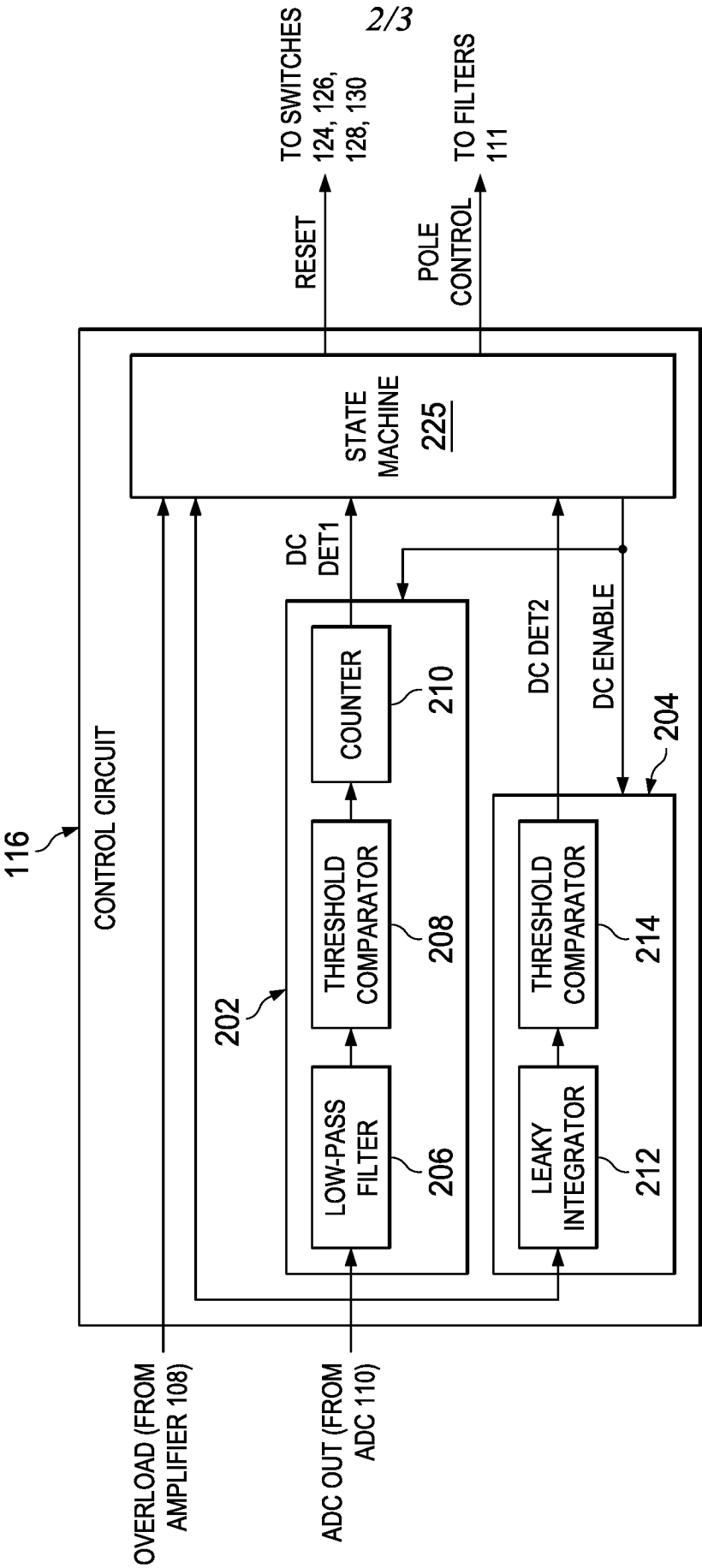


FIG. 2

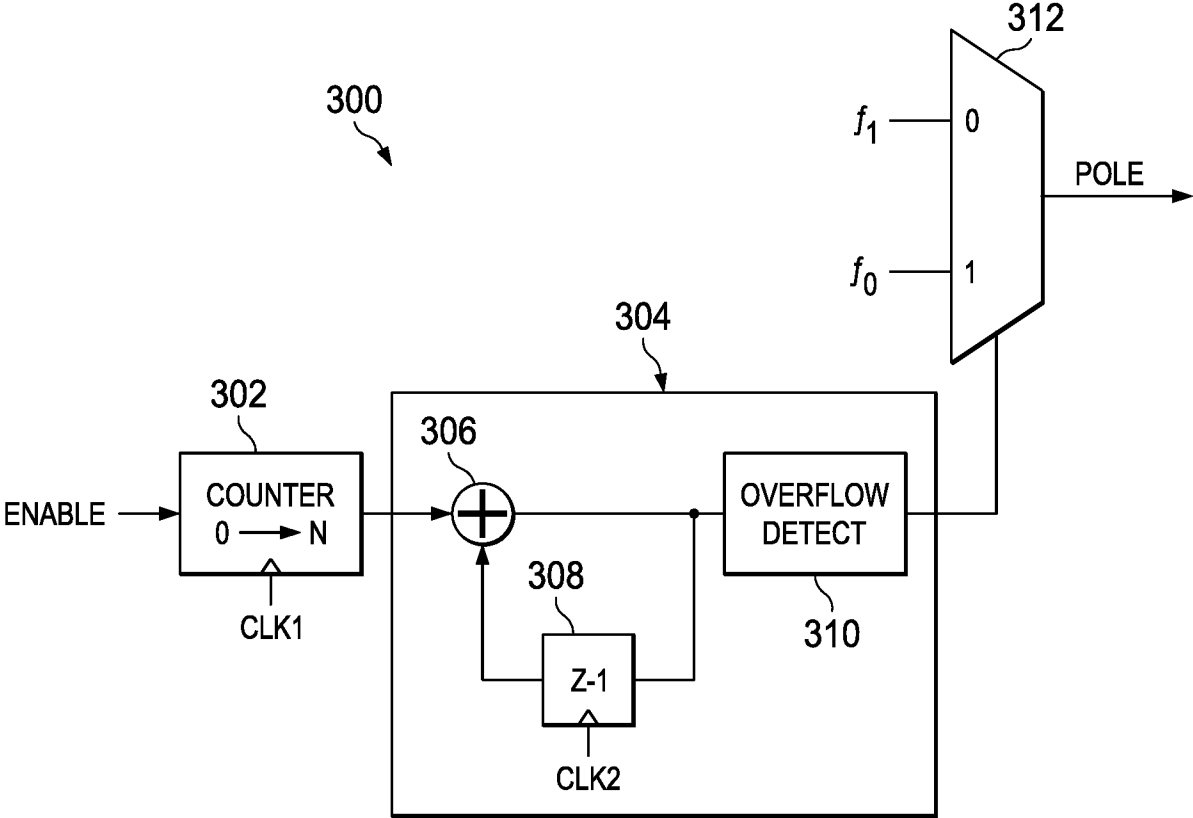


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/066910

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04R3/00 H04R19/00
ADD.

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)

H04R

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/064397 A1 (DUENSER WOLFGANG [CH]) 14 March 2013 (2013-03-14) paragraphs [0006] - [0008], [0039] - [0050]; figures 1-4 -----	1-3,5,6, 9,11-13, 15,16, 19,21
X	US 2009/279719 A1 (LESSO JOHN PAUL [GB]) 12 November 2009 (2009-11-12) paragraphs [0002], [0044], [0052] - [0061]; figures 1-3 5a ----- -/--	1,2,4,5, 8,11,12, 14,15,18



Further documents are listed in the continuation of Box C.



See patent family annex.

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