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(54) **Title:** PLATFORM NOISE IDENTIFICATION USING PLATFORM INTEGRATED MICROPHONE

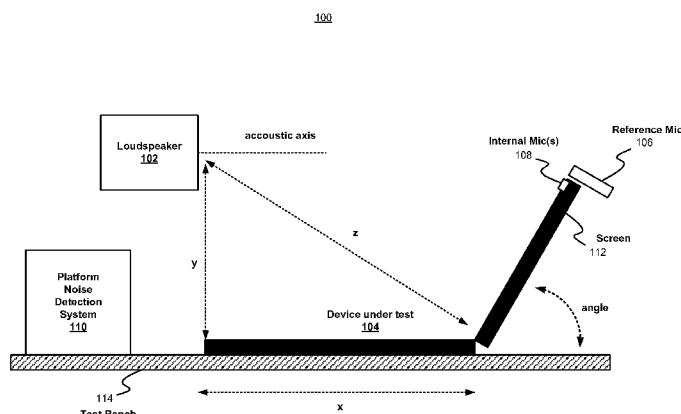


FIG. 1

(57) **Abstract:** Generally, this disclosure provides systems, devices, methods and computer readable media for platform noise detection and identification using a platform integrated (built-in) microphone. A system may include a test condition manager to configure the platform into a specified test condition; a reference microphone to record an audio response to an audio signal received from a loudspeaker; and an internal microphone, integrated in the platform, to record an audio response to the audio signal received from the loudspeaker. The system may also include a power spectral density (PSD) calculation circuit to calculate a first PSD based on the reference microphone audio response and a second PSD based on the internal microphone audio response. The system may further include a noise source identification circuit to compare spectral components of the first PSD to the second PSD to identify the platform noise associated with the specified test condition.



PLATFORM NOISE IDENTIFICATION USING PLATFORM INTEGRATED MICROPHONE

5

FIELD

10 The present disclosure relates to platform noise identification, and more particularly, to platform noise detection and identification using a platform integrated (built-in) microphone.

BACKGROUND

15 Modern hardware platforms, for example, computing or communication systems, etc., typically provide one or more integrated (built-in) microphones, for example to record a user's voice or for other purposes. The performance of these built-in microphones, however, is often degraded due to presence of internal (to the platform) and external noise sources. Detection and identification of these noise
20 sources, as well as determination of whether they are internal or external, is generally the first step toward correction or elimination of the problem. Existing detection and identification methods typically require relatively expensive test equipment, laboratory facilities and skilled acoustic engineers. Additionally, the procedures often relied on subjective judgments and could be difficult to reproduce, thus increasing
25 product cost and time to market.

BRIEF DESCRIPTION OF THE DRAWINGS

 Features and advantages of embodiments of the claimed subject matter will become apparent as the following Detailed Description proceeds, and upon reference
30 to the Drawings, wherein like numerals depict like parts, and in which:

 Figure 1 illustrates a top level system diagram of an example embodiment consistent with the present disclosure;

Figure 2 illustrates a block diagram of one example embodiment consistent with the present disclosure;

Figure 3 illustrates a flowchart of operations of one example embodiment consistent with the present disclosure;

5 Figure 4 illustrates a noise floor power spectral density plot consistent with another example embodiment of the present disclosure;

Figure 5 illustrates microphone power spectral density plots consistent with another example embodiment of the present disclosure;

10 Figure 6 illustrates a flowchart of operations of another example embodiment consistent with the present disclosure; and

Figure 7 illustrates a system diagram of a platform of another example embodiment consistent with the present disclosure.

Although the following Detailed Description will proceed with reference being made to illustrative embodiments, many alternatives, modifications, and variations
15 thereof will be apparent to those skilled in the art.

DETAILED DESCRIPTION

Generally, this disclosure provides systems, devices, methods and computer readable media for platform noise detection and identification using one or more
20 platform integrated (e.g., internal or built-in) microphones. In some embodiments, a series of recordings are made through both the internal microphones and an external reference microphone located in relatively close proximity to the internal microphones. The recordings may be obtained under a variety of test conditions, each of which may result in a different noise environment. For example, the platform or
25 device under test may be operating on line (mains) power or battery power, with the screen turned on or off, with Wi-Fi turned on or off, etc., any of which may serve as a potential noise source. Power spectral densities (PSDs) may be calculated for each of the recordings and the spectral components analyzed and compared to distinguish between internal and external noise sources and to estimate the location of those noise
30 sources, as will be explained in greater detail below.

Figure 1 illustrates a top level system diagram 100 of one example embodiment consistent with the present disclosure. A platform or device under test

104 is shown in the form of a laptop positioned on a test bench 114. Of course, in various embodiments, the platform may be any type of computing or communication device or other electronic equipment configured with any type of audio recording capability. The platform 104 may include one or more internal microphones 108,
5 which in this example are shown to be located near the top of the screen or display element 112, which may also serve as a lid that can be opened and closed. A reference microphone 106 is shown located in relatively close proximity to the internal microphones. An external loudspeaker 102 and a platform noise detection system 110 are also shown, the operations of which will be described in greater detail
10 below. The entire test setup depicted in diagram 100 may be located in an environment that provides “quiet” room conditions, such as, for example, those specified by noise rating curves NR15 of International Standards Organization (ISO) Rec. R1996 (1972), or other suitable conditions. The distances x, y and z between the platform 104 and the loudspeaker 102 as well as the angle of the screen may be
15 adjusted to any desired values. For example, they may conform to specifications for laptop testing as employed in Skype/Lync speakerphone group testing setups, in which case the values may be approximately $z = 50\text{cm}$, $y = 30\text{ cm}$, $x = 40\text{ cm}$ and screen angle = 70 degrees.

20 Figure 2 illustrates a block diagram 200 of one example embodiment consistent with the present disclosure. The platform noise detection system 110 is shown to include a calibration circuit 204 to manage calibration in conjunction with calibration source 202 and loudspeaker 102, as will be described below. The platform noise detection system 110 may also include noise floor calculation circuit 206, test
25 condition manager 210, PSD calculation circuit 212, PSD normalization circuit 214, Noise source identification circuit 216 and optional linearization filter 208, the operations of which will also be described below.

As an initial matter, the reference microphone 106 may be calibrated to scale all subsequent measurements to common sound pressure levels (SPLs) so that
30 comparisons of audio signals from different microphones may be based on a common reference that can be related back to SPLs. Calibration source 202 may be configured to generate an audio tone calibration signal at a specified SPL and frequency with a suitable level of accuracy, such as for example, a class 2 calibrator, as defined in the International Electrotechnical Commission (IEC) 60942 standard. In some

embodiments, the audio tone may be any type of audio signal of a known SPL, including white noise, pink noise or any other wide band or narrow band signal. The reference microphone 106 may be chosen with the capability to capture audio within the audible frequency band of 20 Hz to 20 kHz, with a suitable level of fidelity. For example, in some embodiments, a measurement microphone such as the Earthworks M30™ model, or similar, may be used as the reference microphone 106. The audio response of the reference microphone 106 to the calibration signal (e.g., signal voltage or amplitude) may be measured and stored for subsequent use. After calibration of the reference microphone 106 it may be positioned proximate to the one or more internal microphones 108a, 108b, for example as close as possible given physical constraints of the test set up and/or the geometry of the platform, so that the response of the internal microphones more closely matches that of the reference microphone.

Calibration circuit 204 may be configured to calibrate the internal microphones 108 to the reference microphone 106 based on a tone or other narrow band or wideband audio signal generated by the external loudspeaker 102. In some embodiments, a tone at 1 kHz or some other suitable frequency may be used. In some embodiments, a 1 kHz signal may be generated by the platform 104 and used to drive the loudspeaker 102 to generate the tone. The gains of each internal microphone 108a, 108b may then be set to a value that produces a response to the 1 kHz tone, from that microphone, which matches the response of the reference microphone 106 to the tone. Thus, the internal microphones 108 will produce the same response as the reference microphone 106, to a given SPL. Calibration circuit 204 may be configured to cause the tone to be generated and further to monitor the internal microphone responses and adjust the gains. In some embodiments, calibration circuit 204 may also be configured to operate the calibration source 202 used for initial calibration of the reference microphone 106 as previously described.

Noise floor calculation circuit 206 may be configured to estimate the noise floor associated with the testing environment. While the platform or device under test 104 is powered off, to eliminate the platform as a source of noise, the noise floor calculation circuit 206 may cause the reference microphone 106 to record the ambient noise of the testing environment for a suitable period of time, such as, for example 30 seconds. A PSD may be calculated on the recorded noise, for example by PSD calculation circuit 212, to generate a noise floor as a function of frequency, $N(f)$, an example of which is shown in Figure 4. As can be seen, a number of spectral

components 402, 404, 406, which appear as spikes in the PSD, are associated with ambient noise sources in the testing environment. These noise sources may include power line hum and other electrical and electrical or acoustic noise sources that are not associated with the platform 104 or internal microphones 108, and which will be
5 present under all subsequent platform test conditions. Knowledge of the noise floor PSD allows for compensation or removal during subsequent testing as will be described below.

The platform 104 may then be powered on and testing may be performed under a variety of conditions under the control of test condition manager 210. Test
10 conditions may include, for example: battery operation, line power operation, screen on or off, screen at various levels of brightness, Wi-Fi (Wireless Fidelity) on or off, keyboard back-light on or off, HDMI (High Definition Multimedia Interface) cable connected or unconnected, device position/orientation (e.g., landscape/portrait), lid closed or open, etc., in any desired combination. Any of these platform conditions, or
15 combination of conditions, may be expected to generate different noise profiles. For each desired test condition, recordings may be obtained from the reference and internal microphones, with all loudspeakers silenced.

A PSD may be calculated on the recorded signals from reference and internal microphones, for example by PSD calculation circuit 212. In some embodiments, the
20 PSD may be calculated using a Welch estimator or any other suitable known PSD estimation method. The term “power spectral density,” as used herein will be understood to encompass any equivalent frequency domain or time domain analysis technique including, for example, an amplitude or magnitude spectrum or an autocorrelation.

PSD normalization circuit may be configured to normalize the microphone
25 PSDs relative to the noise floor. For example, the noise floor $N(f)$ may be subtracted from each microphone PSD to remove noise sources that are common to all test conditions and therefore not of interest. Figure 5 illustrates example normalized PSDs for the reference microphone, $R(f)$ 502 and 508, a left internal microphone, $IL(f)$ 504
30 and 510, and a right internal microphone, $IR(f)$ 506 and 512.

The left side of Figure 5 illustrates PSDs 502, 504, 506, for microphone signals $R(f)$, $IL(f)$ and $IR(f)$ recorded under a test condition of full screen brightness. In contrast, the right side of Figure 5 illustrates PSDs 508, 510, 512, for microphone signals $R(f)$, $IL(f)$ and $IR(f)$ recorded under a test condition where the screen is turned

off. Noise source identification circuit 216 may be configured to analyze the normalized PSDs from each microphone and compare them under different test conditions to detect and identify the sources of noise generated by the platform 104.

For example, referring again to the PSDs illustrated in Figure 5, spectral components in $R(f)$ generally indicate external noise sources for a particular test condition. Comparing $R(f)$ at full screen brightness 502 to $R(f)$ with the screen off 508 shows that spectral components 520 (the larger spikes) may be associated with an audible buzz from the backlight powering system as a function of screen brightness level. Similarly, if the test conditions were battery powered operation versus line powered operation, spectral components differences in $R(f)$ could indicate different types of noise emanating from the different power charging systems.

A comparison of reference microphone to internal microphone PSDs may indicate internal microphone noise, that is noise not audible in the test room but rather noise that is present in the internal microphone signal. For example, spectral components 530 in $IL(f)$ 510 and $IR(f)$ 512, which are not present in $R(f)$ 508 may indicate unshielded microphone electrical lines. Finally, a comparison between internal microphones $IR(f)$ and $IL(f)$ can indicate both internal and external noise sources.

An optional linearization filter 208 may be applied to the internal microphones to improve the analysis of the spectral components. Linearization filter 208 may be configured to unify (e.g., more closely match) the frequency response characteristics of the reference and internal microphones. The filter may be applied in real-time to the output signal from the internal microphones to alter the frequency response (e.g., amplitude and phase as a function of frequency) to produce a corrected microphone signal. This may reduce ambiguities resulting from power differences between the analyzed spectral components from the reference and internal microphones arising from differences in the microphone characteristics.

In some embodiments, the platform noise detection system 110 may be considered to additionally encompass one or more of the other components including the microphones 106, 108, loudspeaker 102 and/or calibration source 202.

Figure 3 illustrates a flowchart of operations 300 of one example embodiment consistent with the present disclosure. The operations provide a method for platform noise detection and identification using a platform integrated (built-in) microphone

and an external reference microphone. At operation 302, the test procedure begins by calibrating the reference microphone to a known calibration source to scale all subsequent measurements to common SPLs. At operation 304, the internal microphones of the platform (or device under test) are also calibrated relative to the reference microphone based on an audio signal of known characteristics generated by an external speaker.

At operation 306, a noise floor PSD for the test environment is calculated based on recording through the reference microphone while the platform is powered off.

At operation 308, a loop is initiated during which, at each iteration of the loop, a new test condition is applied. Various test conditions, as described previously, may be imposed. At operation 310, the reference microphone response during the test condition is recorded. At operation 312, the internal microphone responses during the test condition are recorded. At operation 314, PSDs are calculated for the audio data of each microphone (reference and internal microphones) and are then normalized, at operation 316, relative to the noise floor. At operation 318, the spectral components of the PSDs associated with each microphone are analyzed and compared to each other to detect and identify sources of noise as previously described. At operation 320, if there are additional test conditions to be considered, the loop repeats back to operation 308.

Figure 4 illustrates a noise floor power spectral density plot 400 consistent with another example embodiment of the present disclosure. The noise floor PSD, $N(f)$, provides a measurement of noise power as a function frequency. Spectral components 402, 404, and 406, for example, may be associated with various sources of noise in the test environment that are not related to the operation of the platform as described above in connection with Figure 2.

Figure 5 illustrates microphone power spectral density plots 500 consistent with another example embodiment of the present disclosure. On the left side, example PSDs are shown for the reference microphone 502, the left internal microphone 504 and the right internal microphone 506 under conditions of full screen brightness. On the right side, example PSDs are shown for the reference microphone 508, the left internal microphone 510 and the right internal microphone 512 when the

screen is turned off. Comparing $R(f)$ at full screen brightness 502 to $R(f)$ with the screen off 508 shows that spectral components 520 may be associated with an audible buzz from the backlight powering system as a function of screen brightness level. Spectral components 530 in $IL(f)$ 510 and $IR(f)$ 512, which are not present in $R(f)$ 508
5 may indicate unshielded microphone electrical lines, as explained previously.

Figure 6 illustrates a flowchart of operations 600 of another example embodiment consistent with the present disclosure. The operations provide a method for platform noise detection. At operation 610, the platform is configured into a
10 specified test condition. At operation 620, an audio signal is generated from a loudspeaker. At operation 630, an audio response to the audio signal is recorded from a reference microphone. At operation 640, an audio response to the audio signal is recorded from one or more internal microphones integrated in the platform. At operation 650, a first power spectral density (PSD) is calculated based on the
15 reference microphone audio response. At operation 660, a second PSD is calculated based on the internal microphone audio response. At operation 670, spectral components of the first PSD are compared to the second PSD to identify the platform noise associated with the specified test condition.

Figure 7 illustrates a system diagram 700 of one example embodiment consistent with the present disclosure. The system 700 may be the platform or device under test 104, configured as a communication and/or computing device such as, for example, a smart phone, smart tablet, personal digital assistant (PDA), mobile Internet device (MID), convertible tablet, notebook or laptop computer, workstation or
20 desktop computer.

The system 700 is shown to include one or more processors 720 and memory 730. In some embodiments, the processors 720 may be implemented as any number of processor cores. The processor (or processor cores) may be any type of processor, such as, for example, a micro-processor, an embedded processor, a digital signal
30 processor (DSP), a graphics processor (GPU), a network processor, a field programmable gate array or other device configured to execute code. The processors may be multithreaded cores in that they may include more than one hardware thread context (or “logical processor”) per core. The memory 730 may be coupled to the processors. The memory 730 may be any of a wide variety of memories (including

various layers of memory hierarchy and/or memory caches) as are known or otherwise available to those of skill in the art. It will be appreciated that the processors and memory may be configured to store, host and/or execute one or more operating systems, user applications or other software. The applications may include, but not be limited to, for example, any type of computation, communication, data management, data storage and/or user interface task. In some embodiments, these applications may employ or interact with any other components of the platform 104.

System 700 is also shown to include network interface circuit 740 which may include wireless communication capabilities, such as, for example, cellular communications, Wireless Fidelity (Wi-Fi), Bluetooth®, and/or Near Field Communication (NFC). The wireless communications may conform to or otherwise be compatible with any existing or yet to be developed communication standards including past, current and future version of Bluetooth®, Wi-Fi and mobile phone communication standards.

System 700 is also shown to include an input/output (IO) system or controller 750 which may be configured to enable or manage data communication between processor 720 and other elements of system 700 or other elements (not shown) external to system 700. The system may generally present various interfaces to a user via a display element or screen 112 such as, for example, a touch screen, liquid crystal display (LCD) or any other suitable display type. System 700 is also shown to include one or more internal microphones 108. System 700 is also shown to include a storage system 770, for example a hard disk drive (HDD) or solid state drive (SSD), coupled to the processor 306.

It will be appreciated that in some embodiments, the various components of the system 700 may be combined in a system-on-a-chip (SoC) architecture. In some embodiments, the components may be hardware components, firmware components, software components or any suitable combination of hardware, firmware or software.

“Circuit” or “circuitry,” as used in any embodiment herein, may comprise, for example, singly or in any combination, hardwired circuitry, programmable circuitry such as computer processors comprising one or more individual instruction processing cores, state machine circuitry, and/or firmware that stores instructions executed by programmable circuitry. The circuitry may include a processor and/or controller configured to execute one or more instructions to perform one or more operations

described herein. The instructions may be embodied as, for example, an application, software, firmware, etc. configured to cause the circuitry to perform any of the aforementioned operations. Software may be embodied as a software package, code, instructions, instruction sets and/or data recorded on a computer-readable storage
5 device. Software may be embodied or implemented to include any number of processes, and processes, in turn, may be embodied or implemented to include any number of threads, etc., in a hierarchical fashion. Firmware may be embodied as code, instructions or instruction sets and/or data that are hard-coded (e.g., nonvolatile) in memory devices. The circuitry may, collectively or individually, be embodied as
10 circuitry that forms part of a larger system, for example, an integrated circuit (IC), an application-specific integrated circuit (ASIC), a system on-chip (SoC), desktop computers, laptop computers, tablet computers, servers, smart phones, etc. Other embodiments may be implemented as software executed by a programmable control device. As described herein, various embodiments may be implemented using
15 hardware elements, software elements, or any combination thereof. Examples of hardware elements may include processors, microprocessors, circuits, circuit elements (e.g., transistors, resistors, capacitors, inductors, and so forth), integrated circuits, application specific integrated circuits (ASIC), programmable logic devices (PLD), digital signal processors (DSP), field programmable gate array (FPGA), logic gates,
20 registers, semiconductor device, chips, microchips, chip sets, and so forth.

Any of the operations described herein may be implemented in one or more storage devices having stored thereon, individually or in combination, instructions that when executed by one or more processors perform one or more operations. Also, it is intended that the operations described herein may be performed individually or in
25 any sub-combination. Thus, not all of the operations (for example, of any of the flow charts) need to be performed, and the present disclosure expressly intends that all sub-combinations of such operations are enabled as would be understood by one of ordinary skill in the art. Also, it is intended that operations described herein may be distributed across a plurality of physical devices, such as processing structures at more
30 than one different physical location. The storage devices may include any type of tangible device, for example, any type of disk including hard disks, floppy disks, optical disks, compact disk read-only memories (CD-ROMs), compact disk rewritables (CD-RWs), and magneto-optical disks, semiconductor devices such as read-only memories (ROMs), random access memories (RAMs) such as dynamic and

static RAMs, erasable programmable read-only memories (EPROMs), electrically erasable programmable read-only memories (EEPROMs), flash memories, Solid State Disks (SSDs), magnetic or optical cards, or any type of media suitable for storing electronic instructions.

5 Thus, the present disclosure provides systems, devices, methods and computer readable media for platform noise detection and identification using a platform integrated (built-in) microphone. The following examples pertain to further embodiments.

 According to Example 1 there is provided a system for platform noise
10 detection. The system may include: a test condition manager to configure the platform into a specified test condition; a reference microphone to record an audio response to an audio signal received from a loudspeaker; an internal microphone, integrated in the platform, to record an audio response to the audio signal received from the loudspeaker; a power spectral density (PSD) calculation circuit to calculate a
15 first PSD based on the reference microphone audio response and a second PSD based on the internal microphone audio response; and a noise source identification circuit to compare spectral components of the first PSD to the second PSD to identify the platform noise associated with the specified test condition.

 Example 2 may include the subject matter of Example 1, and the reference
20 microphone is located proximate to the internal microphone.

 Example 3 may include the subject matter of Examples 1 and 2, and the specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid
25 open and lid closed.

 Example 4 may include the subject matter of Examples 1-3, further including a calibration circuit to calibrate the reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level.

30 Example 5 may include the subject matter of Examples 1-4, further including a calibration circuit to calibrate the internal microphone relative to the reference microphone based on a second audio calibration signal generated by the loudspeaker.

 Example 6 may include the subject matter of Examples 1-5, further including a noise floor calibration circuit to calculate a third PSD based on background noise

recorded from the reference microphone while the platform is powered off, the third PSD to represent a noise floor.

Example 7 may include the subject matter of Examples 1-6, further including a PSD normalization circuit to normalize the first PSD and the second PSD relative to
5 the noise floor.

Example 8 may include the subject matter of Examples 1-7, further including a linearization filter to filter the internal microphones to modify frequency characteristics of the internal microphones based on frequency characteristics of the reference microphone.

10 According to Example 9 there is provided a method for platform noise detection. The method may include: configuring the platform into a specified test condition; generating an audio signal from a loudspeaker; recording an audio response to the audio signal from a reference microphone; recording an audio response to the audio signal from one or more internal microphones integrated in the platform;
15 calculating a first power spectral density (PSD) based on the reference microphone audio response; calculating a second PSD based on the internal microphone audio response; and comparing spectral components of the first PSD to the second PSD to identify the platform noise associated with the specified test condition.

Example 10 may include the subject matter of Example 9, further including
20 locating the reference microphone proximate to the one or more internal microphones.

Example 11 may include the subject matter of Examples 9 and 10, and the specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid
25 open and lid closed.

Example 12 may include the subject matter of Examples 9-11, further including calibrating the reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level and frequency.

30 Example 13 may include the subject matter of Examples 9-12, further including calibrating the internal microphones relative to the reference microphone based on a second audio calibration signal generated by a loudspeaker.

Example 14 may include the subject matter of Examples 9-13, further including: powering off the platform; recording, from the reference microphone, a

background noise of the environment in which the method is being performed; and calculating a third PSD based on the background noise, the third PSD to represent a noise floor.

Example 15 may include the subject matter of Examples 9-14, further
5 including normalizing the first PSD and the second PSD relative to the noise floor.

Example 16 may include the subject matter of Examples 9-15, further including applying a linearization filter to the internal microphones to modify frequency characteristics of the internal microphones based on frequency characteristics of the reference microphone.

10 According to Example 17 there is provided at least one computer-readable storage medium having instructions stored thereon which when executed by a processor result in the following operations for platform noise detection. The operations may include: configuring the platform into a specified test condition; generating an audio signal from a loudspeaker; recording an audio response to the
15 audio signal from a reference microphone; recording an audio response to the audio signal from one or more internal microphones integrated in the platform; calculating a first power spectral density (PSD) based on the reference microphone audio response; calculating a second PSD based on the internal microphone audio response; and comparing spectral components of the first PSD to the second PSD to identify the
20 platform noise associated with the specified test condition.

Example 18 may include the subject matter of Example 17, further including locating the reference microphone proximate to the one or more internal microphones.

Example 19 may include the subject matter of Examples 17 and 18, and the specified test condition is selected from the group consisting of battery power
25 operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid open and lid closed.

Example 20 may include the subject matter of Examples 17-19, further including calibrating the reference microphone to an audio calibration source
30 configured to produce a first audio calibration signal at a specified sound pressure level and frequency.

Example 21 may include the subject matter of Examples 17-20, further including calibrating the internal microphones relative to the reference microphone based on a second audio calibration signal generated by a loudspeaker.

Example 22 may include the subject matter of Examples 17-21, further including: powering off the platform; recording, from the reference microphone, a background noise of the environment in which the operations are being performed; and calculating a third PSD based on the background noise, the third PSD to represent
5 a noise floor.

Example 23 may include the subject matter of Examples 17-22, further including normalizing the first PSD and the second PSD relative to the noise floor.

Example 24 may include the subject matter of Examples 17-23, further including applying a linearization filter to the internal microphones to modify
10 frequency characteristics of the internal microphones based on frequency characteristics of the reference microphone.

According to Example 25 there is provided a system for platform noise detection. The system may include: means for configuring the platform into a specified test condition; means for generating an audio signal from a loudspeaker;
15 means for recording an audio response to the audio signal from a reference microphone; means for recording an audio response to the audio signal from one or more internal microphones integrated in the platform; means for calculating a first power spectral density (PSD) based on the reference microphone audio response; means for calculating a second PSD based on the internal microphone audio response;
20 and means for comparing spectral components of the first PSD to the second PSD to identify the platform noise associated with the specified test condition.

Example 26 may include the subject matter of Example 25, further including means for locating the reference microphone proximate to the one or more internal microphones.

25 Example 27 may include the subject matter of Examples 25 and 26, and the specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid open and lid closed.

30 Example 28 may include the subject matter of Examples 25-27, further including means for calibrating the reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level and frequency.

Example 29 may include the subject matter of Examples 25-28, further including means for calibrating the internal microphones relative to the reference microphone based on a second audio calibration signal generated by a loudspeaker.

5 Example 30 may include the subject matter of Examples 25-29, further including: means for powering off the platform; means for recording, from the reference microphone, a background noise of the environment in which the system is being performed; and means for calculating a third PSD based on the background noise, the third PSD to represent a noise floor.

10 Example 31 may include the subject matter of Examples 25-30, further including means for normalizing the first PSD and the second PSD relative to the noise floor.

Example 32 may include the subject matter of Examples 25-31, further including means for applying a linearization filter to the internal microphones to modify frequency characteristics of the internal microphones based on frequency
15 characteristics of the reference microphone.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described (or portions thereof), and it is recognized that various modifications are
20 possible within the scope of the claims. Accordingly, the claims are intended to cover all such equivalents. Various features, aspects, and embodiments have been described herein. The features, aspects, and embodiments are susceptible to combination with one another as well as to variation and modification, as will be understood by those having skill in the art. The present disclosure should, therefore, be considered to
25 encompass such combinations, variations, and modifications.

CLAIMS

What is claimed is:

1. A system for platform noise detection, said system comprising:
 - a test condition manager to configure said platform into a specified test condition;
 - a reference microphone to record an audio response to an audio signal received from a loudspeaker;
 - an internal microphone, integrated in said platform, to record an audio response to said audio signal received from said loudspeaker;
 - a power spectral density (PSD) calculation circuit to calculate a first PSD based on said reference microphone audio response and a second PSD based on said internal microphone audio response; and
 - a noise source identification circuit to compare spectral components of said first PSD to said second PSD to identify said platform noise associated with said specified test condition.
2. The system of claim 1, wherein said reference microphone is located proximate to said internal microphone.
3. The system of claim 1, wherein said specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid open and lid closed.
4. The system of any of claims 1-3, further comprising a calibration circuit to calibrate said reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level.
5. The system of any of claims 1-3, further comprising a calibration circuit to calibrate said internal microphone relative to said reference microphone based on a second audio calibration signal generated by said loudspeaker.

6. The system of claim 1, further comprising a noise floor calibration circuit to calculate a third PSD based on background noise recorded from said reference microphone while said platform is powered off, said third PSD to represent a noise floor.
7. The system of claim 6, further comprising a PSD normalization circuit to normalize said first PSD and said second PSD relative to said noise floor.
8. The system of any of claims 1-3, further comprising a linearization filter to filter said internal microphones to modify frequency characteristics of said internal microphones based on frequency characteristics of said reference microphone.
9. A method for platform noise detection, said method comprising:
 - configuring said platform into a specified test condition;
 - generating an audio signal from a loudspeaker;
 - recording an audio response to said audio signal from a reference microphone;
 - recording an audio response to said audio signal from one or more internal microphones integrated in said platform;
 - calculating a first power spectral density (PSD) based on said reference microphone audio response;
 - calculating a second PSD based on said internal microphone audio response;
 - and
 - comparing spectral components of said first PSD to said second PSD to identify said platform noise associated with said specified test condition.
10. The method of claim 9, further comprising locating said reference microphone proximate to said one or more internal microphones.
11. The method of claim 9, wherein said specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid open and lid closed.

12. The method of any of claims 9-11, further comprising calibrating said reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level and frequency.
13. The method of any of claims 9-11, further comprising calibrating said internal microphones relative to said reference microphone based on a second audio calibration signal generated by a loudspeaker.
14. The method of claim 9, further comprising:
powering off said platform;
recording, from said reference microphone, a background noise of the environment in which said method is being performed; and
calculating a third PSD based on said background noise, said third PSD to represent a noise floor.
15. The method of claim 14, further comprising normalizing said first PSD and said second PSD relative to said noise floor.
16. The method of any of claims 9-11, further comprising applying a linearization filter to said internal microphones to modify frequency characteristics of said internal microphones based on frequency characteristics of said reference microphone.
17. At least one computer-readable storage medium having instructions stored thereon which when executed by a processor result in the following operations for platform noise detection, said operations comprising:
configuring said platform into a specified test condition;
generating an audio signal from a loudspeaker;
recording an audio response to said audio signal from a reference microphone;
recording an audio response to said audio signal from one or more internal microphones integrated in said platform;
calculating a first power spectral density (PSD) based on said reference microphone audio response;
calculating a second PSD based on said internal microphone audio response;
and

comparing spectral components of said first PSD to said second PSD to identify said platform noise associated with said specified test condition.

18. The computer-readable storage medium of claim 17, further comprising locating said reference microphone proximate to said one or more internal microphones.

19. The computer-readable storage medium of claim 17, wherein said specified test condition is selected from the group consisting of battery power operation, line power operation, screen on, screen off, Wi-Fi on, Wi-Fi off, keyboard backlight on, keyboard backlight off, landscape orientation, portrait orientation, lid open and lid closed.

20. The computer-readable storage medium of any of claims 17-19, further comprising calibrating said reference microphone to an audio calibration source configured to produce a first audio calibration signal at a specified sound pressure level and frequency.

21. The computer-readable storage medium of any of claims 17-19, further comprising calibrating said internal microphones relative to said reference microphone based on a second audio calibration signal generated by a loudspeaker.

22. The computer-readable storage medium of claim 17, further comprising:
powering off said platform;
recording, from said reference microphone, a background noise of the environment in which said operations are being performed; and
calculating a third PSD based on said background noise, said third PSD to represent a noise floor.

23. The computer-readable storage medium of claim 22, further comprising normalizing said first PSD and said second PSD relative to said noise floor.

24. The computer-readable storage medium of any of claims 17-19, further comprising applying a linearization filter to said internal microphones to modify

frequency characteristics of said internal microphones based on frequency characteristics of said reference microphone.

100

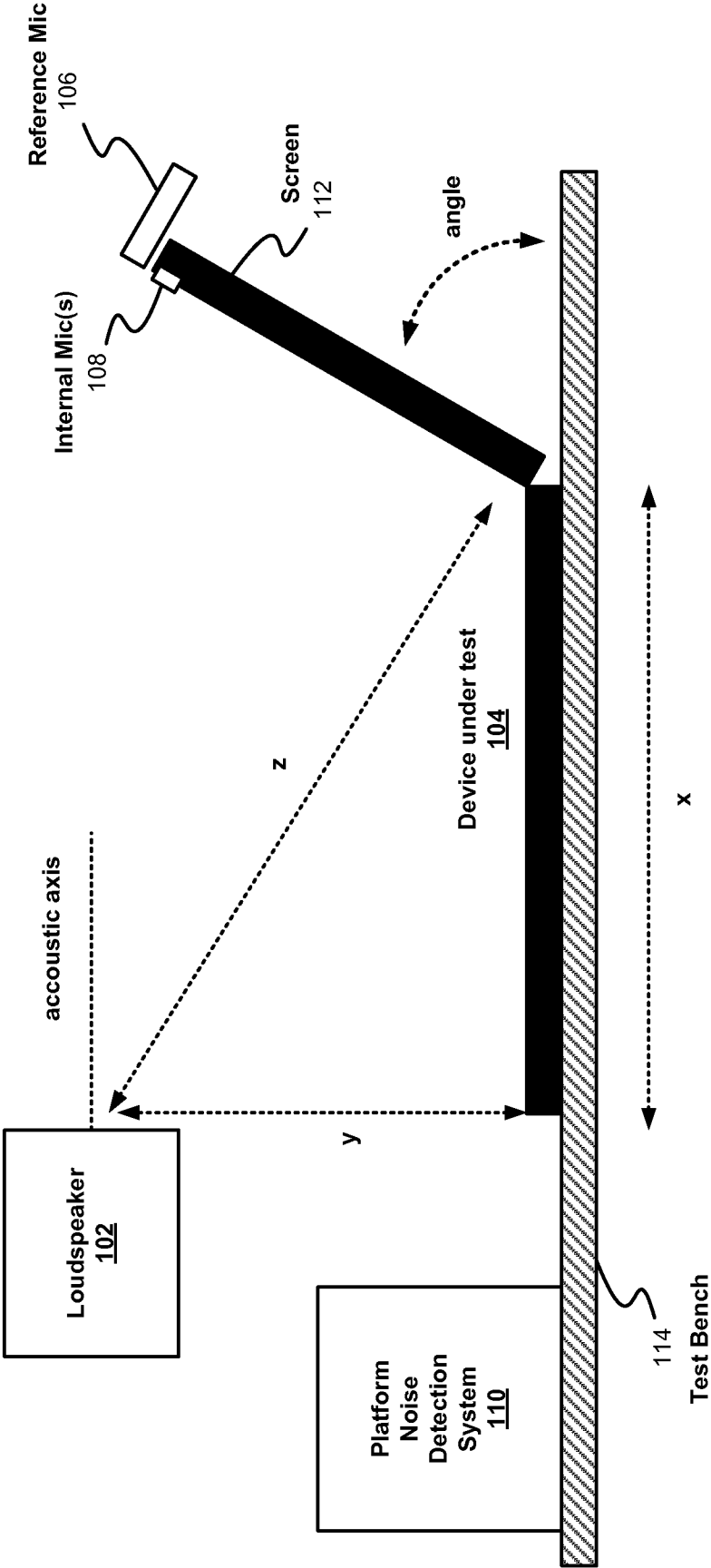


FIG. 1

200

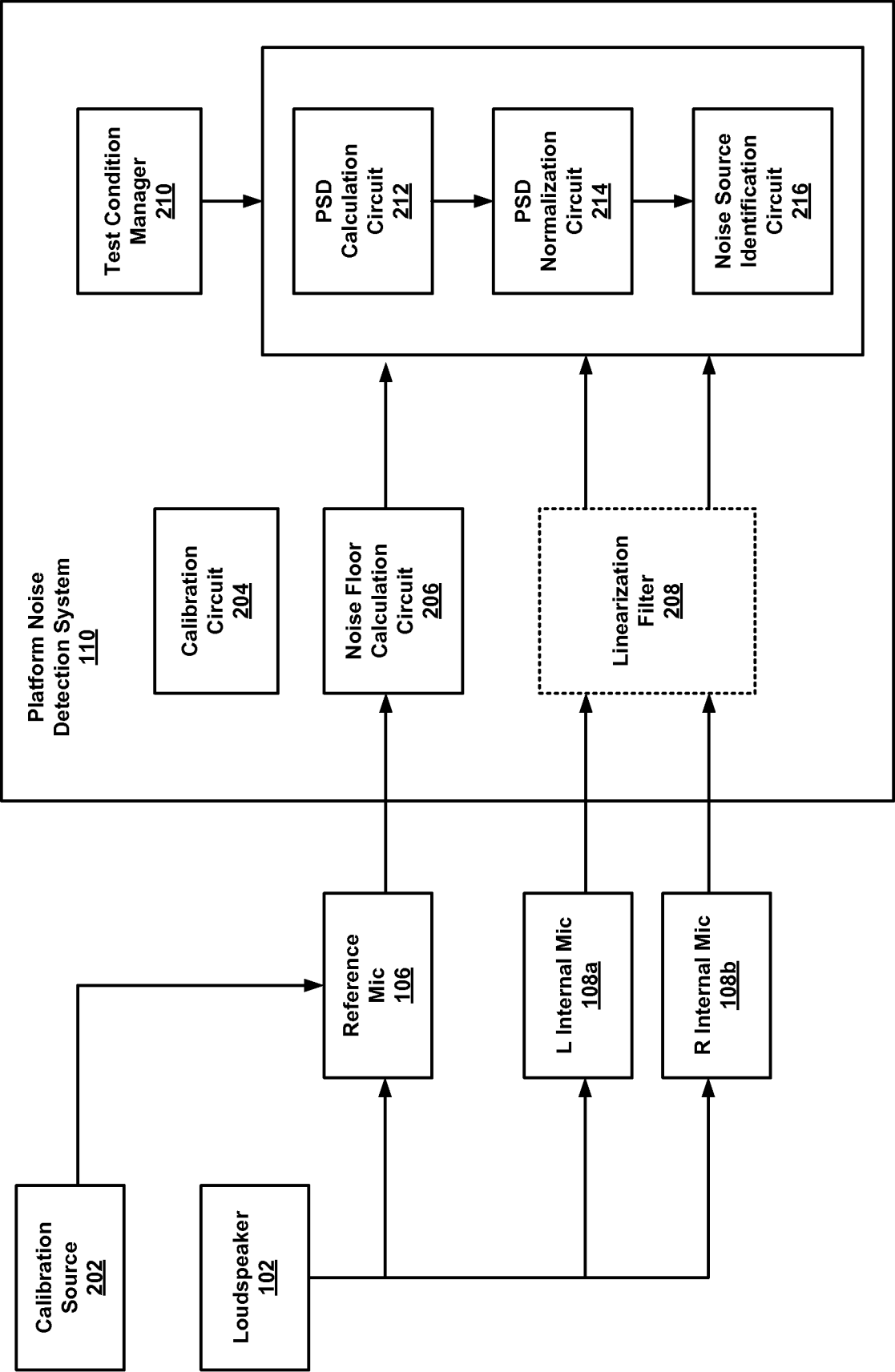


FIG. 2

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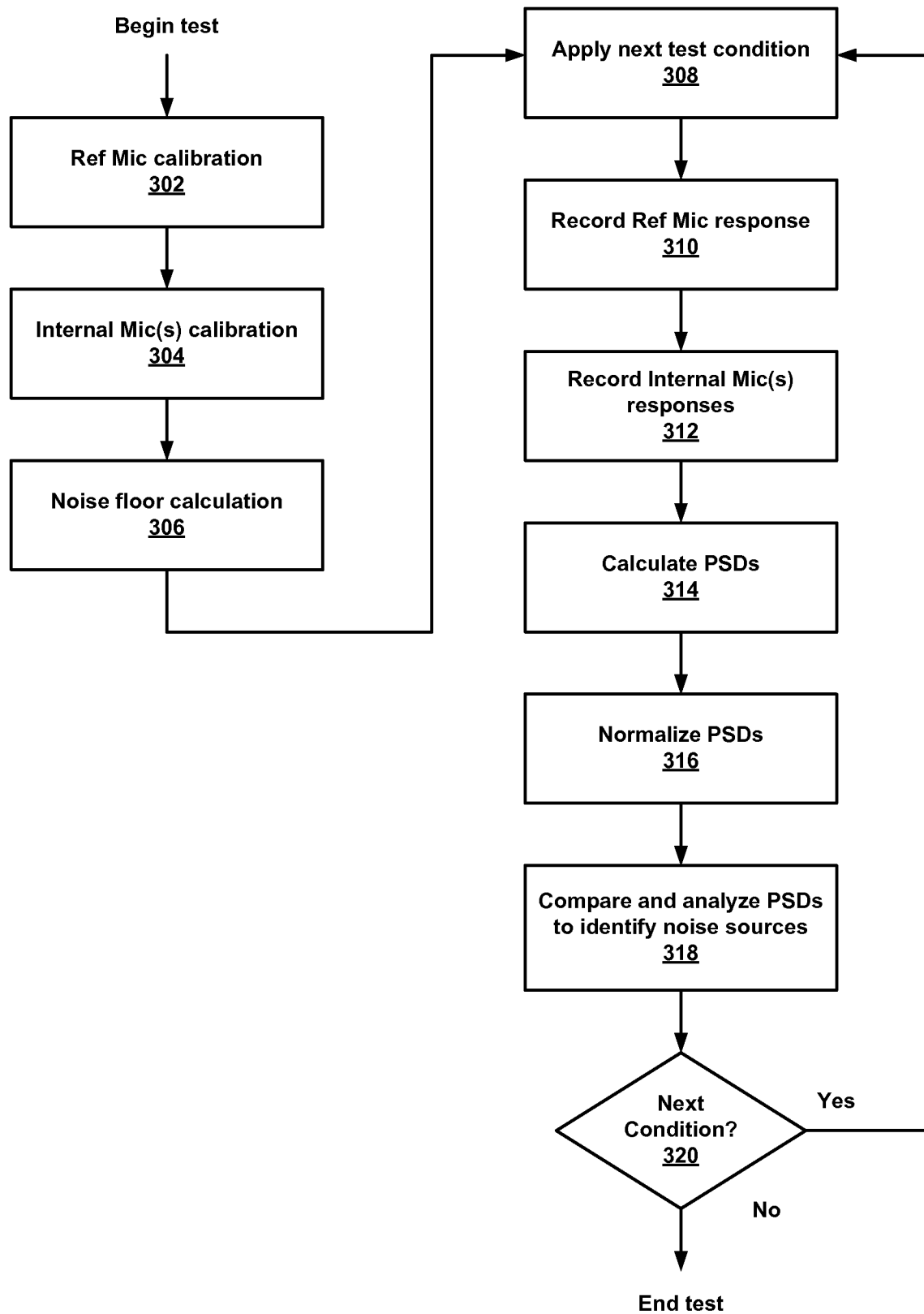
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FIG. 3

400

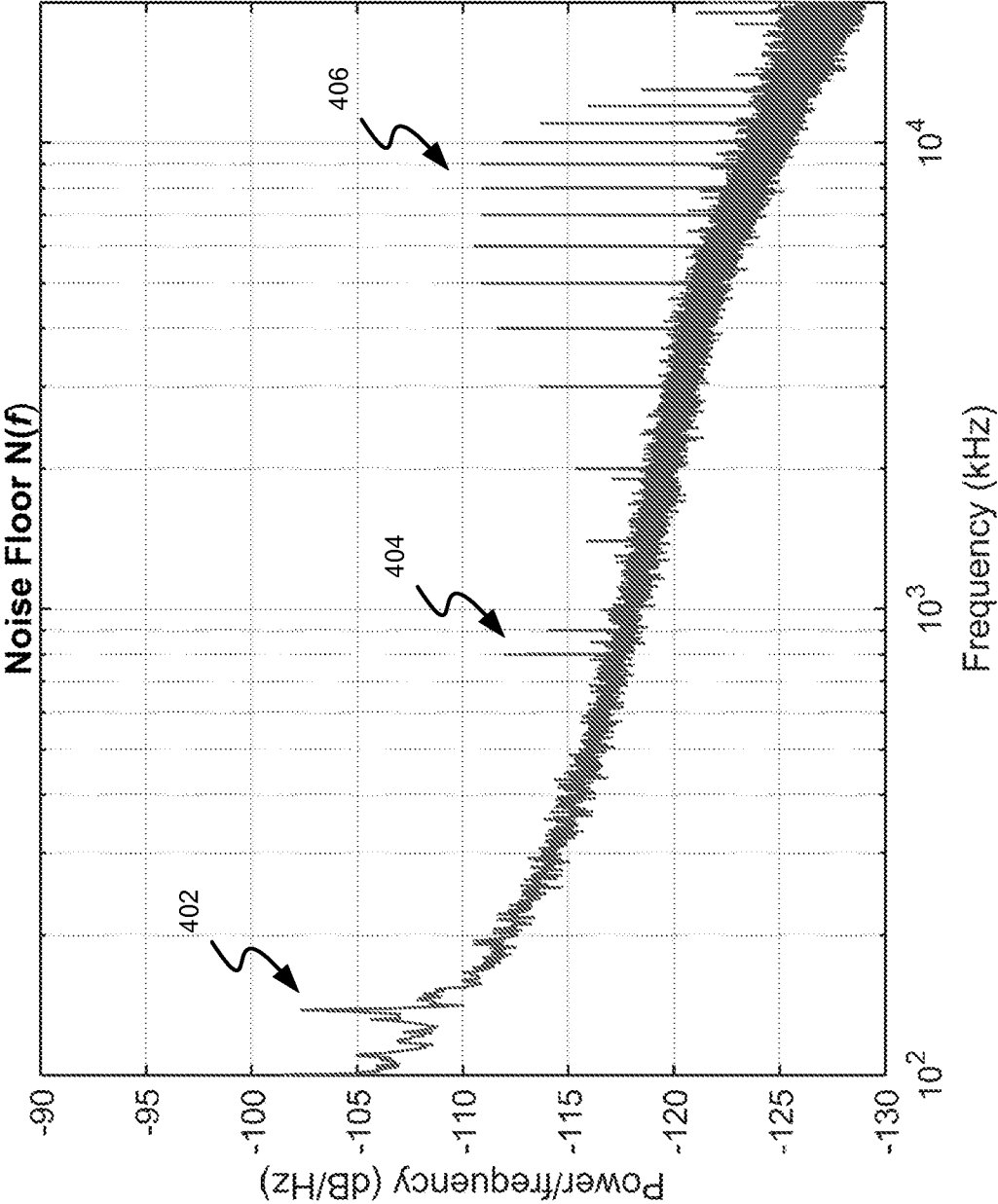


FIG. 4

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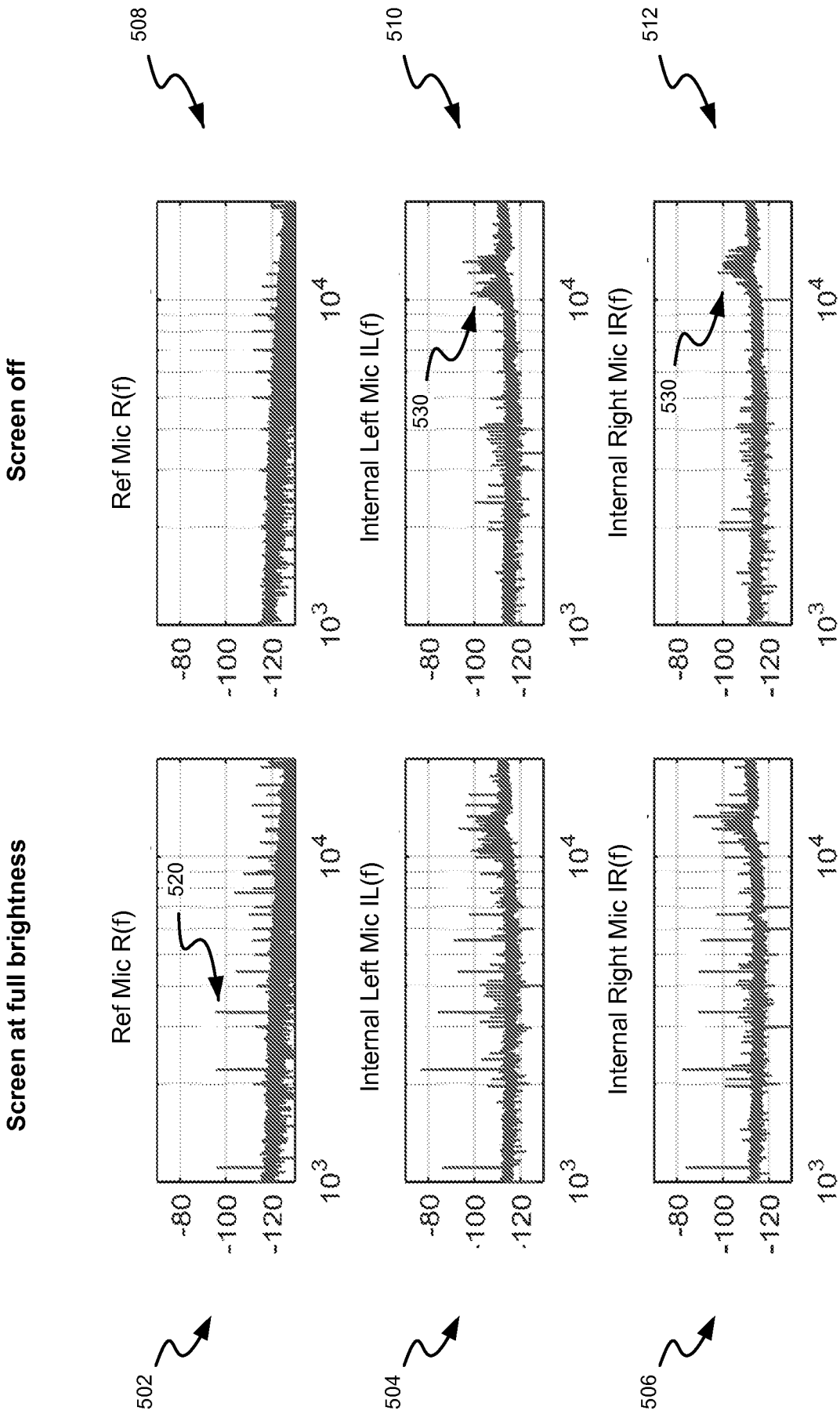


FIG. 5

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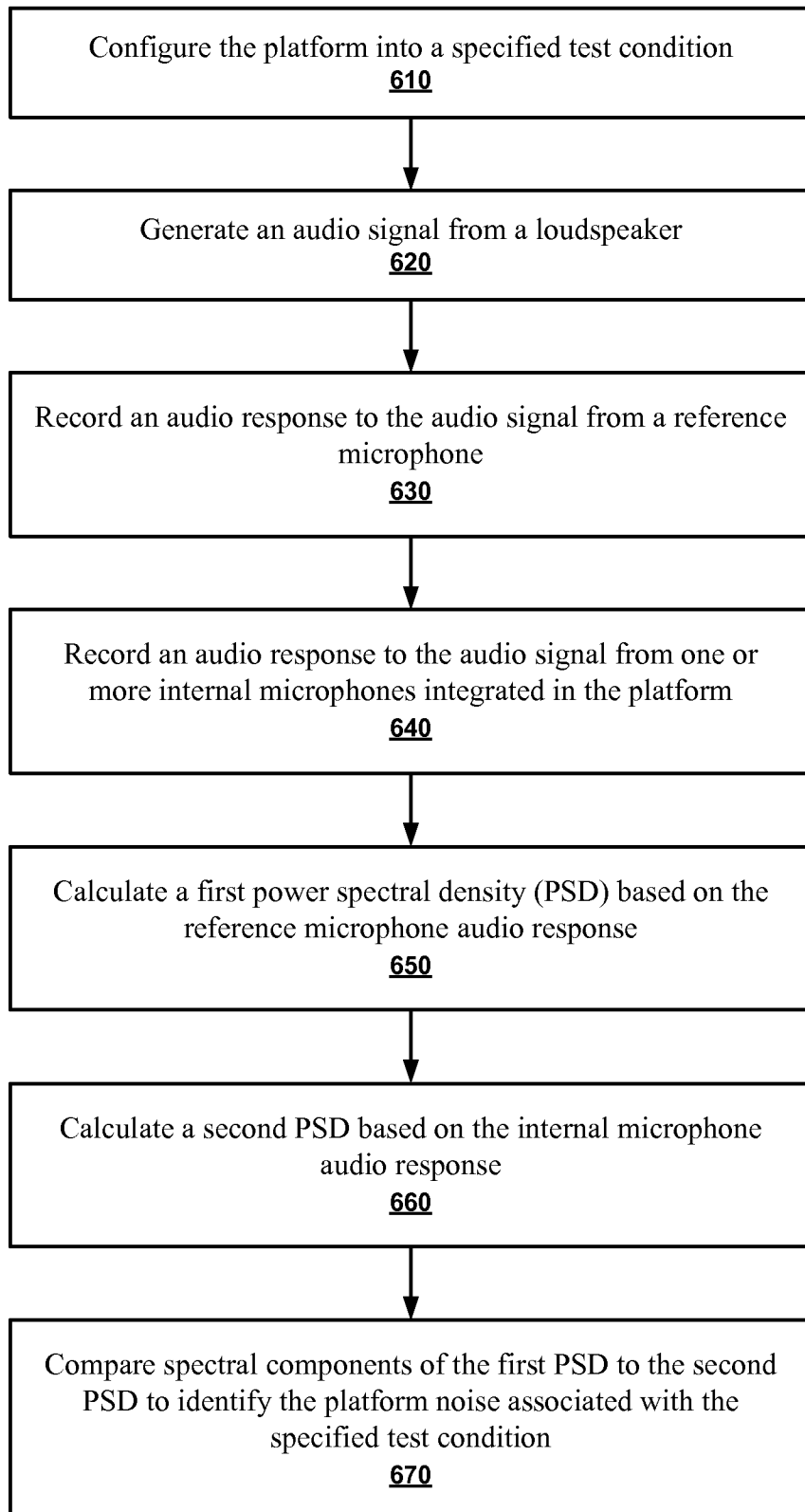
600

FIG. 6

700

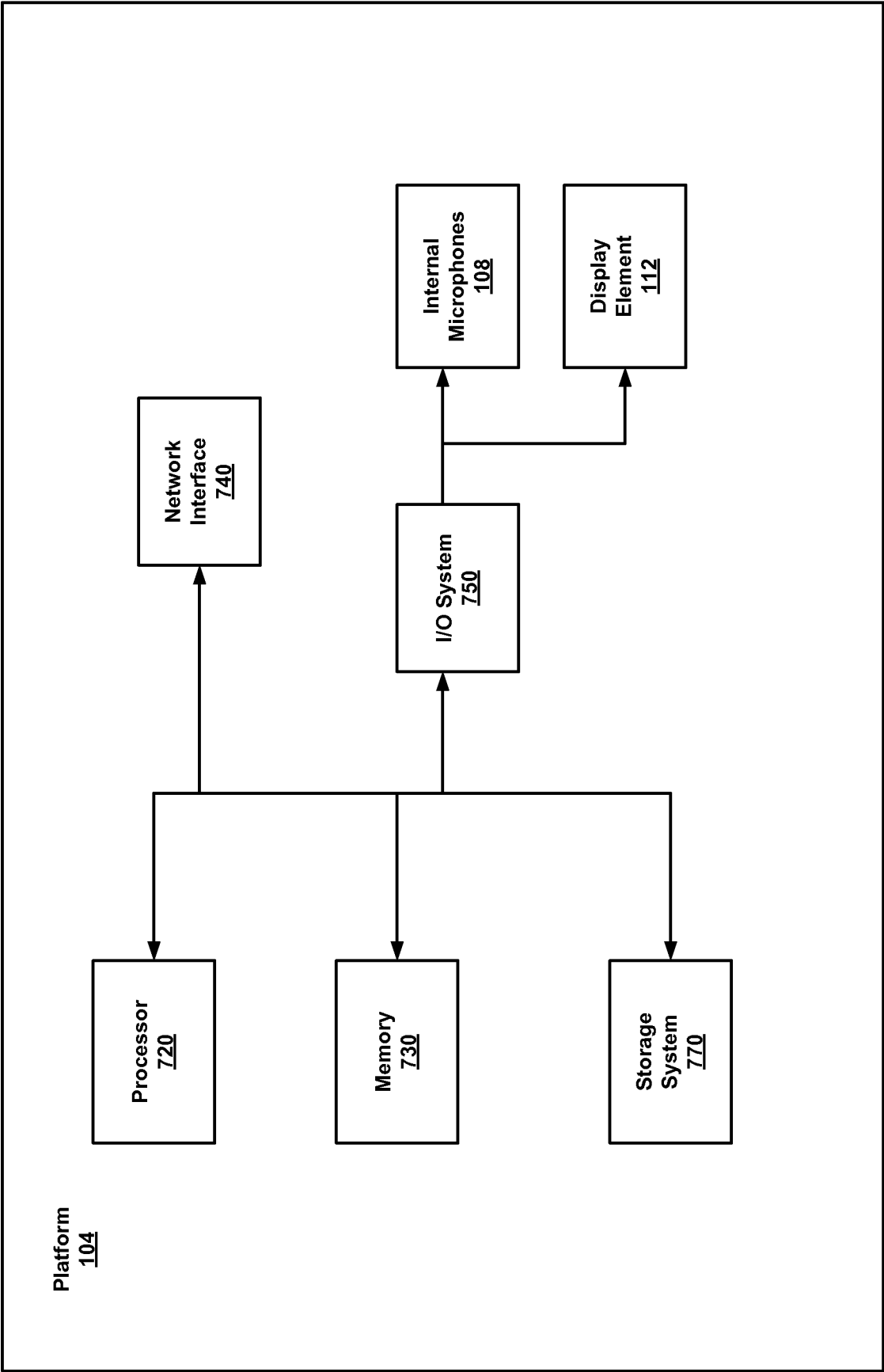


FIG. 7

A. CLASSIFICATION OF SUBJECT MATTER**G01H 11/06(2006.01)i**

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)

G01H 11/06; H04N 7/173; H04R 29/00; H04R 3/00; H03G 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: platform, noise, microphone, loudspeaker, detection, identification

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014-0363001 A1 (FORTEMEDIA, INC.) 11 December 2014 See claim 4 and figures 1-2.	1-24
A	US 2013-0058492 A1 (FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN F ORSCHUNG E.V.) 07 March 2013 See claim 1 and figure 1.	1-24
A	US 2015-0208185 A1 (NITTOBO ACOUSTIC ENGINEERING CO., LTD.) 23 July 2015 See claim 1 and figures 1-2.	1-24
A	US 2008-0267427 A1 (JAMES D. JOHNSTON) 30 October 2008 See claim 1 and figures 1-3.	1-24
A	US 2009-0089851 A1 (YONGFANG GUO et al.) 02 April 2009 See claim 1 and figures 1-5.	1-24



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 June 2016 (23.06.2016)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/051930

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