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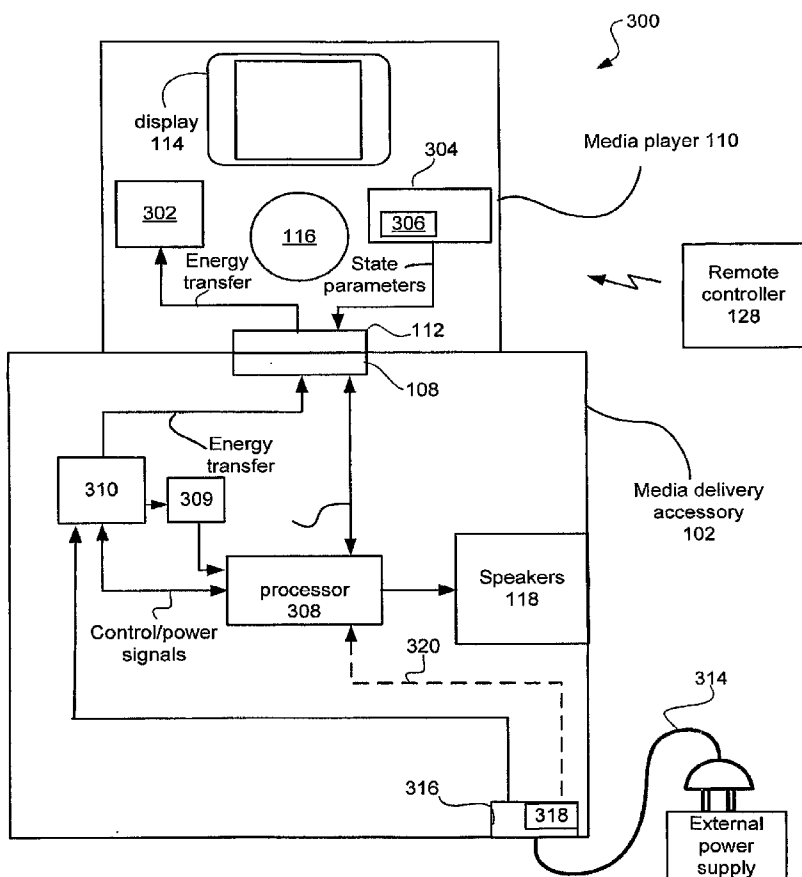
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(54) Title: DYNAMIC POWER MANAGEMENT IN A PORTABLE MEDIA DELIVERY SYSTEM



(57) Abstract: A consumer electronic product (e.g., a portable media player ported to a media delivery accessory) is powered by a limited capacity DC power source (such as a battery or mini-fuel cell). The consumer electronic product limits the maximum allowable sound pressure level (SPL) that can be produced by the speakers. In one embodiment, the maximum allowable SPL is based upon an amount of stored energy available in the limited capacity DC power source.

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DYNAMIC POWER MANAGEMENT IN A PORTABLE MEDIA DELIVERY SYSTEM

FIELD OF INVENTION

5 [0001] This invention relates generally to personal, portable electronic devices such as media players, radios and the like.

DESCRIPTION OF RELATED ART

10 [0002] Recent developments in consumer electronics have included the introduction of portable media players (such as MP3 players, minidisk players), cell phones, personal digital assistants (PDAs) and the like. For example, in the case of an MP3 player (or, for that matter, any other digital media playback device), a number of digitized audio files are stored in a storage medium included in or coupled to the MP3 player in a fashion deemed most suitable to the user. Until recently, the listening
15 enjoyment of these stored music files was typically limited to the use of earphones or other individual listening devices preventing the user from providing a listening experience to a group of devotees. In order to provide such a listening experience, a number of portable accessories having comparatively large speakers have been developed. Such portable accessories are often known as speaker systems or speaker
20 docks. In any case, the portable accessories provide for broadcasting of music to more than a single user. Unfortunately, however, the power requirements to drive the comparatively large speakers such as the portable accessory far outweigh the power requirement of the portable media player.

25 [0003] Therefore, there is a need for improved approaches to provide and manage power consumption and preserving overall power consumption of a consumer electronic product by limiting power used to drive speakers is desirable.

SUMMARY OF THE INVENTION

30 [0004] A method for managing power in a media delivery system arranged to output audio by way of one or more speakers is described. A consumer electronic product includes a portable media player arranged to playback a selected one of a plurality of media files stored therein connected to a media delivery accessory unit having at least one speaker. When the consumer electronic product is operating in a

DC mode, a maximum allowable sound pressure level (SPL) of an output audio signal that can be produced by the at least one speaker is set to a DC maximum allowable SPL.

[0005] In another embodiment, a consumer electronic product operable in a DC mode and an AC mode is described that includes a portable media player arranged to
5 playback a selected one of a plurality of media files stored therein and a media delivery accessory unit electrically coupled to the portable media player having at least one speaker. When the consumer electronic product is operating in the DC mode, a maximum allowable sound pressure level (SPL) of an output audio signal
10 that can be produced by the at least one speaker is set to a DC maximum allowable SPL.

[0006] In yet another embodiment, a method of shutting down a consumer electronic product so as to avoid generation of audio artifacts is performed by determining if a shutdown is imminent and muting an audio amplifier. A user
15 feedback indicating that a loss of power is imminent is provided and if all remaining electronic components are not powered down then all remaining electronic components in the consumer electronic product are shutdown. The user feedback is continued until all residual power is exhausted.

[0007] Another embodiment provides computer program product executable by a
20 processor for shutting down a consumer electronic product so as to avoid generation of audio artifacts. The computer program product includes computer code for determining if a shutdown is imminent, computer code for muting an audio amplifier; computer code for providing a user feedback indicating that a loss of power is imminent, computer code for powering down all remaining electronic components in
25 the consumer electronic product if all remaining electronic components are not powered down, computer code for discontinuing the user feedback if all residual power is exhausted, and computer readable medium for storing the computer code.

[0008] Computer program product executable by a processor for shutting down a
30 consumer electronic product so as to avoid generation of audio artifacts is also described that includes computer code for determining if a shutdown is imminent, computer code for muting an audio amplifier, computer code for providing a user feedback indicating that a loss of power is imminent, computer code for powering down all remaining electronic components in the consumer electronic product if all

remaining electronic components are not powered down, computer code for discontinuing the user feedback if all residual power is exhausted, and computer readable medium for storing the computer code.

[0009] Other aspects and advantages of the invention will become apparent from
5 the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention will be better understood by reference to the following
10 description taken in conjunction with the accompanying drawings.

[0011] FIG. 1 shows a media system in accordance with an embodiment of the invention.

[0012] FIG. 2 shows a portable media player according to one embodiment of the invention.

15 [0013] FIG. 3 shows a consumer electronic product in accordance with an embodiment of the invention.

[0014] FIGs. 4A - 4B illustrates a monitored capacitor voltage and charge status, respectively, in accordance with an embodiment of the invention.

[0015] FIGs. 5 - 7 illustrates a speaker output for consumer electronic product in
20 DC operating mode in accordance with an embodiment of the invention.

[0016] FIG. 8 shows a flowchart detailing a process in accordance with an embodiment of the invention.

[0017] FIG. 9 shows a flowchart detailing a process in accordance with an embodiment of the invention.

25 [0018] FIG. 10 shows a flowchart detailing a process in accordance with an embodiment of the invention.

[0019] FIG. 11 shows a flowchart detailing a process for shutting down the consumer electronic product in accordance with an embodiment of the invention.

[0020] FIG. 12 shows a representative schematic diagram of a charge status
30 monitor in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF SELECTED EMBODIMENTS

[0021] Reference will now be made in detail to a particular embodiment of the invention an example of which is illustrated in the accompanying drawings. While the invention will be described in conjunction with the particular embodiment, it will
5 be understood that it is not intended to limit the invention to the described embodiment. To the contrary, it is intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

[0022] A consumer electronic product in the form of a portable media delivery
10 system is described. In particular, when the consumer electronic product (e.g., a portable media player connected to a media delivery accessory having a plurality of speakers) is powered by a limited capacity DC power source (such as a battery or mini-fuel cell), the consumer electronic product limits the maximum allowable sound pressure level (SPL) that can be produced by the speakers. In one embodiment, the
15 limitation of the maximum allowable SPL is based upon an amount of stored charge available in the limited capacity DC power source or in some cases an intermediate storage capacitor.

[0023] In the described embodiment, the media delivery accessory includes a processor, an audio output device, and limited capacity DC power source coupled to
20 an external power unit by way of a power cable. The portable media player is arranged to store any number and type of suitably formatted digital multimedia data files that are ultimately selected by a user for playback. It should also be noted, that in a particularly useful embodiment, the media delivery accessory includes a user interface that provides user input signals to the accessory. In this way, the accessory
25 performs a limited control function for the media delivery system by, for example, increasing or decreasing the sound volume produced at a speaker unit coupled thereto.

[0024] The invention will now be described in terms of a consumer electronic product that includes a portable media player capable of storing a number of multimedia digital data files connected to a media delivery accessory arranged to
30 broadcast audio by way of a plurality of speakers. In the case of the media player being a pocket sized portable player (such as the IPOD™ player manufactured by the Apple Computer Inc. of Cupertino, CA), the multimedia data files can include MP3 files as well as any other appropriately formatted data files.

[0025] FIG. 1 is a diagram of a media system 100 according to one embodiment of the invention. The media system 100 includes a media delivery accessory 102. The media delivery accessory 102 serves to output media, such as outputting audio sounds. For example, the audio sound can pertain to music.

5 [0026] The media delivery accessory 102 includes a housing 104 that supports or contains various components of the media delivery accessory 102. The housing 104 includes an opening or receptacle 106 and a connector 108 disposed therein. Beyond the media delivery accessory 102, the media system 100 also includes a portable media player 110. The portable media player 110 is, more generally, a portable
10 computing device, such as the mobile computing device 200 illustrated in FIG. 2. Although the portable media player 110 is fully operational apart from the media delivery accessory 102, the portable media player 110 can be connected to the media delivery accessory 104. In particular, the portable media player 110 includes a connector 112. The portable media player 110 can be placed in the opening or
15 receptacle 106 such that the connector 108 physically and electrically connects with the connector 112 of the portable media player 110, thereby connecting the portable media player 110 to the media delivery accessory 104. It should also be noted that in some cases the connection can be made wirelessly using a WiFi type wireless interface, for example.

20 [0027] The media delivery accessory 102 includes a plurality of speakers 118. In one embodiment, the speakers 118 include a pair of midrange speakers and a subwoofer speaker. The housing 104 also includes volume control devices 120 and 122. In one embodiment, the volume control devices 120 and 122 are buttons. Still further, the housing 104 can include an indicator light 124 that provide visual
25 feedback to the user regarding the operation or condition of the media delivery accessory 102. The housing 104 can also include a receiver window 126 that can be used by a receiver internal to the housing 104 when picking-up wireless transmissions from a remote controller 128 having a plurality of user input controls 130. It should be noted that the remote controller 128 can transmit any of a number of signals such
30 as infrared, radio frequency (RF), audio signals, and the like. Through use of the user input controls 130 on the remote controller 128, the user is able to indirectly interact with the portable media player 110 or directly interact with the media delivery accessory 102. For example, the user of the remote controller 128 can interact with

the user input controls 130 to select a media item to be played on the portable media player 110 with its audio output being provided by the speakers 118 of the media delivery accessory 102. The remote controller 128 can also be used to alter the volume of the audio output from the media delivery accessory 102.

5 [0028] FIG. 2 shows a portable media player 200 according to one embodiment of the invention. The media player 200 is, for example, suitable for use as the battery powered portable media player 110 shown in FIG. 1. The media player 200 includes a processor 202 that pertains to a microprocessor or controller for controlling the overall operation of the media player 200. The media player 200 stores media data
10 pertaining to media assets in a file system 204 and a cache 206. The file system 204 is, typically, a storage disk or a plurality of disks. The file system 204 typically provides high capacity storage capability for the media player 200. However, since the access time to the file system 204 is relatively slow, the media player 200 can also include a cache 206. The cache 206 is, for example, Random-Access Memory
15 (RAM) provided by semiconductor memory. The relative access time to the cache 206 is substantially shorter than for the file system 204. However, the cache 206 does not have the large storage capacity of the file system 204. Further, the file system 204, when active, consumes more power than does the cache 206. The power consumption is particularly important when the media player 200 is a portable media
20 player that is powered by a battery (not shown). The media player 200 also includes a RAM 220 and a Read-Only Memory (ROM) 222. The ROM 222 can store programs, utilities or processes to be executed in a non-volatile manner. The RAM 220 provides volatile data storage, such as for the cache 206.

[0029] The media player 200 also includes a user input device 208 that allows a
25 user of the media player 200 to interact with the media player 200. For example, the user input device 208 can take a variety of forms, such as a button, keypad, dial, etc. Still further, the media player 200 includes a display 210 (screen display) that can be controlled by the processor 202 to display information to the user. A data bus 224 can facilitate data transfer between at least the file system 204, the cache 206, and the
30 processor 202. The media player 200 also includes a bus interface 216 that couples to a data link 218. The data link 218 allows the media player 200 to couple to a host computer over a wired connection.

[0030] In one embodiment, the media player 200 serves to store a plurality of media assets (e.g., songs) in the file system 204. When a user desires to have the media player 200 play a particular media item, a list of available media assets is displayed on the display 210. Then, using the user input device 208, a user can select one of the available media assets. The processor 202, upon receiving a selection of a particular media item, supplies the media data (e.g., audio file) for the particular media item to a coder/decoder (CODEC) 212. The CODEC 212 then produces analog output signals for a speaker 214. The speaker 214 can be a speaker internal to the media player 200 or external to the media player 200. For example, headphones or earphones that connect to the media player 200 would be considered an external speaker.

[0031] The media player 200 also includes a wireless network interface 226 arranged to wirelessly transmit any selected data from the media player 200 to any appropriately configured receiver unit (e.g., the wireless network interface 114) over a wireless network. In the embodiment shown in FIG. 1, the wireless network interface 226 that takes the form of, for example, a "WiFi" interface according to the IEEE 802.11b or 802.11g standards. Other wireless network standards could also be used, either in alternative to the identified standards or in addition to the identified standards. Such other network standards could include the IEEE 802.11a standard or the Bluetooth standard.

[0032] In one embodiment, the media player 200 is a portable computing device dedicated to processing media such as audio. For example, the media player 200 can be a media player (e.g., MP3 player), a game player, a remote controller, a portable communication device, and the like. These devices are generally battery-operated and highly portable so as to allow a user to listen to music, play games or video, record video or take pictures, communicate with others, and/or control other devices. In one implementation, the media player 200 is a handheld device that is sized for placement into a pocket or hand of the user. By being handheld, the media player 200 is relatively small and easily handled and utilized by its user. By being pocket sized, the user does not have to directly carry the device and therefore the device can be taken almost anywhere the user travels (e.g., the user is not limited by carrying a large, bulky and often heavy device, as in a portable computer). Furthermore, the device may be operated by the user's hands, no reference surface such as a desktop is needed.

[0033] FIG. 3 shows a consumer electronic product 300 in accordance with an embodiment of the invention. In the described embodiment, the consumer electronic product 300 is formed when the portable media player 110 is placed in the opening of receptacle 106 such that the connector 108 physically and electrically connects with the connector 112 of the portable media player 110 thereby creating a data/power pathway between the portable media player 110 and the media delivery accessory 102. The media player 102 includes a media player internal power supply 302 arranged to store energy used to power to media player 110 before (i.e., booting up) and during playback of selected digital media files. The media player 110 also includes a memory unit 304 suitably arranged to store, in addition to media files, media player operational parameters 306 indicative of an operating state of the media player 110. For example, the media player operational parameters 306 can include an indication of whether or not a backlight used to illuminate the display 114 is operational, and if so, the duration of time and intensity of the backlight. The media player operational parameters 306 can also include a current stored energy state indicating an amount of available useful energy that is stored in the internal power supply 302.

[0034] The media delivery accessory 102 also includes a processor unit 308 coupled to an internal power supply monitor 309 arranged to monitor a charge status of a media delivery accessory internal power supply 310 that is used to provide power to the speakers 118. In the described embodiment, the internal power supply monitor 309 includes a capacitor 312 that is coupled to the media delivery accessory internal power supply 310 in such a way that a capacitor voltage V_c across the capacitor 312 correlates to the charge status of the internal power supply 310. It should be noted that the internal power supplies 310 and 302 are contemplated to be any of a number and type of DC internal power supplies suitable for portable applications such as a battery (alkaline, nickel metal hydride, etc.) or a small fuel cell.

[0035] A detachable power cable 314 provides power to the internal power supply 310 from an external power supply when connected to a power port 316. In a particularly useful embodiment, the power port 316 includes a power cable sensor 318 that reacts to a power cable connect/disconnect event by sending a power cable status signal 320 to the processor unit 308 that signals in the case of a disconnect event that the consumer electronic product 300 is in a self powered mode (i.e., power is supplied only by the internal power supplies 310 and 302).

[0036] During operation of the consumer electronic product 300 when the internal power supply 310 is providing power to the speakers 118, the monitor 309 tracks the capacitor voltage V_c in real time as illustrated in FIG. 4A. In the described embodiment, the voltage fluctuations are used to modify the SPL of the speakers 118 when the charge status of the internal power supply 310 is in an active region as indicated in FIG. 4B. It should be noted that when the charge status falls below a threshold value Q_{th} , the charge status is in what is referred to as a shutdown regime. Furthermore, since an amount of charge Q_c stored in the internal power supply 310 correlates to the energy E (joules) stored in a capacitor having a capacitance C (farads) is related to the capacitor voltage V_c by equation $E = CV_c^2/2$. Therefore, ΔE (and therefore ΔQ_c) is directly proportional to ΔV_c . In the self-powered mode, the internal power supply 310 provides all the necessary electrical energy to drive the speakers 118. The speakers 118, in turn, mechanically convert this electrical energy to acoustic energy that can be measured as a sound pressure level (SPL) perceived by the human ear as a volume level. Therefore, in order to reduce the amount of charge drained from the internal power supply 310 and therefore extend the operation of the consumer electronic product 300, the maximum allowable SPL of the speakers 118 is reduced. In this way, the charge stored in the energy storage device 310 is preserved, prolonging the operation of the consumer device 300 without noticeably affecting a user's enjoyment of same.

[0037] In order to quantify this reduction in SPL, the monitor 309 tracks the capacitor voltage V_C (typically in a range of 200 - 300 volts) in real time (as in FIG. 4A) and whenever the tracked capacitor voltage V_c has a down-going voltage transition 400 that crosses a threshold voltage V_{TH} (about 180 - 200 volts) and re-crosses the threshold during a subsequent up-going voltage transition, the monitor 309 notifies the processor 308 that a volume clipping event has occurred (noted as A, B, and C). This notification is communicated by the monitor 309 to the processor 308 by way of a volume clipping signal V_{CL} . The processor 308 responds to the volume clipping signal V_{CL} by decreasing the maximum available sound pressure level of the speakers 118 by a SPL reduction factor ΔSPL (see FIG. 5). In this way, the remaining available stored charge in the internal power supply 310 is preserved resulting in a longer playtime for the consumer electronic product 300 than would otherwise be available. In those situations, however, then the tracked capacitor voltage V_c has an

down-going voltage transition 400 that crosses a threshold voltage V_{TH} and does not subsequently re-cross the threshold during a subsequent up-going voltage transition, the monitor 309 notifies the processor 308 that a gentle shutdown event has occurred (noted as D). The processor 308 then gently shuts down the system in order to avoid
5 audio artifacts.

[0038] It should be noted, in those situations where a user set output SPL (using a volume control input) is less than the maximum allowable SPL (see FIG. 6), there is no reduction in output SPL (or perceived volume). However, in those cases where the maximum allowable SPL is reduced due to a clipping event and that clipping event
10 induced reduction in SPL causes the output SPL to exceed the new maximum allowable SPL, then the user set output SPL is reduced to a level no greater than the most recent maximum allowable SPL. In this case, there remains the possibility that a user would notice a reduced perceived volume of any audio from the speakers 118. However, it is reasonable that the volume reduction would be slight and barely
15 noticed.

[0039] As the charge stored in the internal power supply 310 decreases with usage over time, every subsequent volume clipping event causes the processor 308 to reduce the maximum allowable SPL by the SPL reduction factor ΔSPL . However, at some point ($t=t_5$ in FIG. 5) down going voltage fluctuations cross a second, lower threshold
20 indicating that the internal power supply 310 no longer has sufficient stored charge to operate the media delivery accessory 102 in satisfactory manner (i.e., the speakers 118 can no longer be adequately driven to produce an acceptable SPL, resulting in unacceptably low perceived volume). At this point, the processor 308 executes what is referred to as a graceful shutdown by sending a muting signal to the output audio
25 processor concurrently with shutting down power to the remaining components in the consumer electronic product 300. Such components include any digital signal processing circuitry, audio amplifiers, and any other related subsystems.

[0040] It should be noted that at any time the power cable 314 is connected to the external power supply while the media delivery accessory 102 is operating in the self
30 powered mode, the processor 308 immediately signals the media delivery accessory 102 to enter an external power mode. In the external power mode (also referred to as the AC mode), the maximum allowable SPL reverts to the AC mode maximum allowable SPL affording the user the ability to increase the perceived audio volume

accordingly. However, it is well to note that this increase in allowable SPL is only a potentiality and does nothing to increase the already set output SPL of the consumer electronic product 300 (i.e., the perceived volume is unchanged unless user action is taken). Conversely, when the power cable is disconnected and the media delivery accessory 102 goes from the AC mode into the self powered, or DC mode, the maximum allowable SPL is reduced to the DC mode maximum allowable SPL. In this situation, the processor 308 determines an amount of charge stored in the internal power supply 310 and based upon that determination sets the maximum SPL level accordingly. For example, if the transition from the AC to DC mode occurs when the internal power supply 310 is fully charged, then the maximum SPL level is set to SPL_{DC0} , whereas if the energy stored in the internal power supply 310 is less than fully charged, then the maximum SPL_{DC} level is set to a lesser value, such as SPL_{283} , SPL_{284} , and so on.

[0041] In some embodiments, the energy provided by the external power supply by way of the cable 314 is used to not only operate the consumer electronic product 300, but to recharge (if necessary) the internal power supplies 302 and 310. In this case, a transition from DC mode to AC mode and back to DC mode again can result in the processor 308 setting the maximum allowable SPL_{DC} at a higher level than would otherwise be the case with no recharging.

[0042] FIG. 7 illustrates a causal relationship between the period of time of useful operation of the consumer electronic product 300 and the actual output SPL of the speakers 118. It is not surprising when the actual output SPL is reduced (and the charge drain from the internal power supply 310 is concomitantly reduced), the length of time t_7 that the consumer electronic product 300 can operate in a satisfactory manner is extended. (This can also be seen in FIG. 6 where the actual SPL is less than the DC maximum allowable SPL from t_0 to approximately t_4 .)

[0043] FIG. 8 shows a flowchart detailing a process 800 in accordance with an embodiment of the invention. The process 800 begins at 802 by determining if the media player is connected to the media delivery accessory. When connected, a determination is made at 804 if the power cable is connected to an external power supply. It should be noted that this determination can be accomplished in any number of ways. For example, the determination can be performed by physically detecting the cable or electrically sensing an AC input voltage. In the case where the power cable is

connected to the external power supply, then at 806, then maximum allowable sound pressure level (SPL) for the speakers is set to AC maximum allowable SPL. It should be noted that a processor is continually monitoring for a power cable connect and disconnect event that would in turn change the operating mode from externally
5 powered mode (AC mode) to self powered mode (DC mode) respectively. Returning to 804, if the power cable is not connected to the external power supply (DC mode), a maximum allowable sound pressure level (SPL) for the speakers is set to DC maximum allowable SPL based upon the monitoring of the energy output of the stored energy unit.

10 **[0044]** FIG. 9 shows a flowchart detailing a process 900 in accordance with another embodiment of the invention. The process 900 begins at 902 by determining if the media player is connected to the media delivery accessory. When connected, a determination is made at 904 if the power cable is connected to an external power supply. In the case where the power cable is connected to the external power supply,
15 then at 906, then maximum allowable sound pressure level (SPL) for the speakers is set to AC maximum allowable SPL. On the other hand, if the power cable is not connected to the external power supply (DC mode), then at 908 a maximum allowable sound pressure level (SPL) for the speakers is set to DC maximum allowable SPL based upon the monitoring of the charge status of the stored energy unit. At 910, a
20 charge status of an internal power supply is monitored and if at 912 the charge status is less than a threshold value, then the consumer electronic product is shutdown at 914. On the other hand, if the charge status at 912 is found to be greater than the threshold value then control is passed back to 910.

[0045] FIG. 10 shows a process 1000 for monitoring the charge status of the
25 internal power supply in accordance with an embodiment of the invention. More particularly, the process 1000 represents a particular implementation of the monitoring operation described above with reference to step 910 in the process 900 shown in FIG. 9. Accordingly, the process 1000 begins at 1002 by coupling a capacitor to the internal power supply. At 1004, a voltage V_c is generated by the
30 capacitor that is directly related to the charge status of the internal power supply. At 1006, the capacitor voltage is tracked in real time and at 1010 a determination is made whether the tracked voltage is downward going. If the tracked voltage is downward going, a determination is made whether or not the downward going voltage has

crossed a clipping event threshold at 1012. If, at 1014, the downward going voltage has crossed the clipping event threshold but a subsequent upward going voltage (if any) does not re-cross the clipping event threshold within a predetermined amount of time, then at 1016 the monitor generates a shutdown signal that instructs the processor to carefully control the shutdown of the system in order to avoid undesired audio artifacts. Otherwise, the monitor generates a clipping event signal at 1016. It should be noted that the clipping event signal can also be proportional to an amount of time that the upward going voltage is below the threshold indicating a weakened state of the internal power supply.

10 **[0046]** FIG. 11 shows a flowchart detailing a process 1100 for gently shutting down the consumer product in accordance with an embodiment of the invention. At 1102 a determination is made whether or not there is an imminent loss of power expected. In the described embodiment, the shutdown signal is used to notify the processor to begin gently shutting down the consumer electronic product. Once it has been determined that loss of power is imminent, then at 1104 the audio amplifier is muted in order to prevent any audio artifacts (such as a popping sound typically heard when sound systems are shut off abruptly). At 1106, a user feedback is provided indicating that a loss of power is imminent and at 1108, if all remaining electronic components are not powered down, then at 1110, all remaining electronic components are powered down. If, or when, all remaining components are powered down, then at 1112, a determination is made whether or not all residual power used to drive the gentle shutdown operation has been exhausted. In the described embodiment, the residual power is derived from the residual charge stored in the capacitor used to monitor the charge status of the internal power supply. Typically, there is sufficient stored residual charge to last approximately 5 seconds after the loss of power from the internal power supply. When all residual power has been exhausted, then at 1114, all user feedback is stopped. It should be noted, that when the consumer electronic product is powered up subsequent to the gentle shutdown, the consumer electronic product undergoes a hardware reset operation.

30 **[0047]** Fig. 12 shows a schematic diagram of a representative monitoring circuit 1200 in accordance with an embodiment of the invention. The monitoring circuit 1200 includes a capacitor 1202 capable maintaining the capacitor voltage V_c on the order of 300 to 400 volts (equivalent to an energy E related to the capacitor voltage V_c

as $E = CV^2$ discussed above) that is used to monitor the charge status of the internal power supply. A battery 1204 (in this case, 9V) provides an input voltage V_{batt} to a boost, or step up, converter 1206 that boosts the input voltage V_{batt} to a range of approximately 300 - 400 volts that is applied to a first node of the capacitor 1202, the second of which is connected to ground. The capacitor voltage V_c developed across the capacitor 1202 is used to monitor the charge status of the internal power supply. A buck (or DC to DC step down) converter 1208 also coupled to the first node of the capacitor 1202 provides an output voltage V_{out} that is used by a speaker amplifier (not shown) to drive the speakers. In this way, the energy used to drive the speakers (which is ultimately provided by energy stored in the internal power supply) is reflected in the dynamic characteristics of the capacitor voltage V_c as illustrated above with reference to Fig. 4A. In this way, by monitoring the capacitor voltage V_c , the charge status (and therefore the capability of the internal power supply to provide the requisite energy to drive the speakers) can be inferred without directly monitoring the internal power supply itself.

[0048] Although the media items of emphasis in several of the above embodiments where audio items (e.g., audio files or songs), the media items are not limited to audio items. For example, the media item can alternatively, pertain to recorded discussions and the like.

[0049] The invention is preferably implemented by software, but can also be implemented in hardware or a combination of hardware and software. The invention can also be embodied as computer readable code on a computer readable medium. The computer readable medium is any data storage device that can store data which can thereafter be read by a computer system. Examples of the computer readable medium include read-only memory, random-access memory, CD-ROMs, DVDs, magnetic tape, optical data storage devices, and carrier waves. The computer readable medium can also be distributed over network-coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

[0050] The many features and advantages of the present invention are apparent from the written description and, thus, it is intended by the appended claims to cover all such features and advantages of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, the invention should not be limited to the exact construction and operation as illustrated and

described. Hence, all suitable modifications and equivalents may be resorted to as falling within the scope of the invention.

[0051] While this invention has been described in terms of a preferred embodiment, there are alterations, permutations, and equivalents that fall within the scope of this invention. It should also be noted that there are many alternative ways
5 of implementing both the process and apparatus of the present invention. It is therefore intended that the invention be interpreted as including all such alterations, permutations, and equivalents as fall within the true spirit and scope of the present invention.

10

What is claimed is:

1. A method for managing power in a media delivery system operable in either a DC or an AC mode arranged to output audio by way of one or more speakers, comprising:
 - 5 setting a maximum allowable sound pressure level (SPL) of an output audio signal that can be produced by the one or more speakers when the media delivery system is operating in the DC mode.
 2. A method as recited in claim 1, further comprising:
 - 10 monitoring a charge status of an internal power supply that provides power to the one or more speakers.
 3. A method as recited in claim 2, comprising:
 - when the charge status is less than a threshold value, then, shutting down the media delivery system, otherwise,
 - changing the maximum allowable SPL based upon the charge status of the
 - 15 internal power supply.
 - 4 A method as recited in any of claim 3, wherein the changing the maximum allowable SPL comprises:
 - reducing the maximum allowable SPL by a preset factor.
 5. A method as recited in any of claims 2 - 3, wherein the monitoring
 - 20 comprises;
 - sensing, in real time, a voltage across a capacitor electrically coupled to the internal power supply, wherein the sensed voltage is directly related to the charge status of the internal power supply.
 6. A method as recited in claim 5, further comprising:
 - 25 if the voltage is a downward going voltage,
 - determining if the downward going voltage crosses a threshold voltage level.
 7. A method as recited in claim 6, further comprising;
 - when the downward going voltage crosses the threshold voltage level, then determining if a subsequent upward going voltage re-crosses the threshold
 - 30 voltage within a predetermined length of time; and
 - generating a shutdown signal used to shut down the media delivery system if the subsequent upward going voltage does not re-cross the threshold voltage level in the predetermined length of time.

8. A method as recited claim 7, further comprising:
providing a clipping event signal if the subsequent upward going voltage does
re-cross the threshold voltage level within the predetermined length of time, and
using the clipping event signal to reduce the maximum allowable SPL.

5 9. A method as recited claim 7, further comprising:
providing a proportional clipping event signal that is proportional to an
amount of time that the upward going voltage remains below the threshold voltage
that is less than the predetermined length of time; and
using the proportional clipping event signal to proportionally reduce the
10 maximum allowable SPL.

10. A method as recited in claims 1 or 2, wherein the maximum allowable
(SPL) in the DC mode is a DC maximum allowable SPL

11. A method as recited in claim 10, comprising;
setting the media delivery system to the AC mode by connecting to an external
15 power supply that provides the power for the media delivery system; and
setting the maximum allowable SPL to an AC limited maximum SPL that is
greater than the DC maximum allowable SPL in all cases.

12. A method as recited in claim 11, comprising:
setting the system to the DC mode when the media delivery system is
20 disconnected from the external power supply; and
setting the DC maximum allowable SPL based upon a current charge status of
the internal power supply.

13. A method as recited in claim 1, wherein when the speaker's requested
actual output SPL would be greater than the allowable maximum SPL, then
25 reducing the actual output SPL to a value that is no greater than the allowable
maximum SPL.

14. A consumer electronic product operable in a DC mode and an AC
mode, comprising:
a portable media player arranged to playback a selected one of a plurality of
30 media files stored therein; and
a media delivery accessory unit electrically coupled to the portable media
player having at least one speaker, wherein when the consumer electronic product is
operating in the DC mode, a maximum allowable sound pressure level (SPL) of an

output audio signal that can be produced by the at least one speaker is set to a DC maximum allowable SPL.

15. A consumer electronic product as recited in claim 14, further comprising:

5 a charge monitor coupled to an internal power supply that provides power to the one or more speakers arranged to monitor a charge status of internal power supply.

16. A consumer electronic product as recited in claim 15 wherein when the charge status is less than a threshold value, then the media delivery system is
10 shutdown, otherwise, the maximum allowable SPL is changed based upon the charge status of the internal power supply.

17 A consumer electronic product as recited in claim 16 wherein when the maximum allowable SPL is changed, the maximum allowable SPL is changed by reducing the maximum allowable SPL by a preset factor.

15 18. A consumer electronic product as recited in claims 15 - 16, wherein the charge monitor comprises:

a capacitor electrically coupled to the internal power supply capable of developing a capacitor voltage; and

20 a capacitor voltage sensor arranged to sense, in real time, the capacitor voltage, wherein the sensed voltage is directly related to the charge status of the internal power supply.

19. A consumer electronic product as recited in claim 18, wherein if the sensed voltage is a downward going voltage that crosses a threshold voltage level and if a subsequent up going voltage does not re-cross the threshold voltage level in a pre-
25 determined length of time, then the consumer electronic product generates a shutdown signal used to shut down the media delivery system.

20. A consumer electronic product as recited claim 19, wherein the monitor further comprises:

30 a clipping event signal generator for providing a clipping event signal if the subsequent upward going voltage does re-cross the threshold voltage level within the predetermined length of time that is used to reduce the maximum allowable SPL.

21. A consumer electronic product as recited claim 20, wherein the clipping event signal generator provides a proportional clipping event signal that is

proportional to an amount of time when the upward going voltage remains below the threshold voltage for a period of time that is less than the predetermined length of time that is used to proportionally reduce the maximum allowable SPL 1.

22. A consumer electronic product as recited in claim 15, wherein the maximum allowable (SPL) in the DC mode is a DC maximum allowable SPL

23. A consumer electronic product as recited in claim 22 wherein in the AC mode, the maximum allowable SPL is set to an AC limited maximum SPL that is greater than the DC maximum allowable SPL in all cases.

24. A consumer electronic product as recited in claim 23 wherein when the media delivery system is in the DC mode, then the maximum allowable SPL is set to the DC maximum allowable SPL based upon a current charge status of the internal power supply.

25. A consumer electronic product as recited in claim 24, wherein when the speaker's requested actual output SPL would be greater than the allowable maximum SPL, then the actual output SPL is reduced to a value that is no greater than the allowable maximum SPL.

26. A method of shutting down a consumer electronic product so as to avoid generation of audio artifacts, comprising:
determining if a shutdown is imminent,
muting an audio amplifier;
providing a user feedback indicating that a loss of power is imminent;
if all remaining electronic components are not powered down, then powering down all remaining electronic components in the consumer electronic product;
if all residual power is exhausted, then
discontinuing the user feedback.

27. A method as recited in claim 26, wherein the determining if a shutdown is imminent comprises:

receiving a shutdown signal indicating the imminent loss of power.

28. A method as recited in claim 27, further comprising:
receiving residual power from a stored charge in a capacitor coupled to an internal power supply used to monitor a charge status of the internal power supply prior to shutdown.

29. A method as recited in claim 28, wherein when the stored charge is depleted, then the residual power is exhausted.

30. Computer program product executable by a processor for shutting
5 down a consumer electronic product so as to avoid generation of audio artifacts, comprising:

computer code for determining if a shutdown is imminent,

computer code for muting an audio amplifier;

10 computer code for providing a user feedback indicating that a loss of power is imminent;

computer code for powering down all remaining electronic components in the consumer electronic product if all remaining electronic components are not powered down;

15 computer code for discontinuing the user feedback if all residual power is exhausted; and

computer readable medium for storing the computer code.

31. Computer program product as recited in claim 30, wherein the computer code for determining if a shutdown is imminent comprises:

20 computer code for receiving a shutdown signal indicating the imminent loss of power.

32. Computer program product as recited in claim 31, further comprising;

computer code for receiving residual power from a stored charge in a capacitor coupled to an internal power supply used to monitor a charge status of the internal power supply prior to shutdown.

25 33. Computer program product as recited in claim 32, wherein when the stored charge is depleted, then the residual power is exhausted.

34. Computer program product executable by a processor for managing power in a media delivery system operable in either a DC or an AC mode arranged to output audio by way of one or more speakers, comprising:

30 computer code for setting a maximum allowable sound pressure level (SPL) of an output audio signal that can be produced by the one or more speakers when the media delivery system is operating in the DC mode; and

computer readable medium for storing the computer code.

35. Computer program product as recited in claim 34, further comprising:
computer code for monitoring a charge status of an internal power supply that
provides power to the one or more speakers.

36. Computer program product as recited in claim 35, comprising:
5 computer code for shutting down the media delivery system, when the charge
status is less than a threshold value; and
computer code for changing the maximum allowable SPL based upon the
charge status of the internal power supply, otherwise.

37. Computer program product as recited in claim 36, wherein the
10 computer code for changing the maximum allowable SPL comprises:
computer code for reducing the maximum allowable SPL by a preset factor.

38. Computer program product as recited in claims 35 - 37, wherein the
computer code for monitoring comprises;
computer code for sensing, in real time, a voltage across a capacitor
15 electrically coupled to the internal power supply, wherein the sensed voltage is
directly related to the charge status of the internal power supply.

39. Computer program product as recited in claim 38, further comprising:
computer code for determining if the downward going voltage crosses a
threshold voltage level if the voltage is a downward going voltage.

40. Computer program product as recited in claim 39, further comprising;
20 computer code for determining if a subsequent upward going voltage re-
crosses the threshold voltage within a predetermined length of time when the
downward going voltage crosses the threshold voltage level; and
computer code for generating a shutdown signal used to shut down the media
25 delivery system if the subsequent upward going voltage does not re-cross the
threshold voltage level in the predetermined length of time.

41. Computer program product as recited claim 40, further comprising:
computer code for providing a clipping event signal if the subsequent upward
going voltage does re-cross the threshold voltage level within the predetermined
30 length of time, and
computer code for using the clipping event signal to reduce the maximum
allowable SPL.

42. Computer program product as recited claim 41, further comprising:

computer code for providing a proportional clipping event signal that is proportional to an amount of time that the upward going voltage remains below the threshold voltage that is less than the predetermined length of time; and

5 computer code for using the proportional clipping event signal to proportionally reduce the maximum allowable SPL l.

43. Computer program product as recited in claim 34, wherein the maximum allowable (SPL) in the DC mode is a DC maximum allowable SPL

44. Computer program product as recited in claim 43, comprising:
10 computer code for setting the media delivery system to the AC mode by connecting to an external power supply that provides the power for the media delivery system; and

computer code for setting the maximum allowable SPL to an AC limited maximum SPL that is greater than the DC maximum allowable SPL in all cases.

45. Computer program product as recited in claim 44, comprising:
15 computer code for setting the system to the DC mode when the media delivery system is disconnected from the external power supply; and

computer code for setting the DC maximum allowable SPL based upon a current charge status of the internal power supply.

46. Computer program product as recited in claim 34, comprising:
20 computer code for reducing the actual output SPL to a value that is no greater than the allowable maximum SPL when the speaker's requested actual output SPL would be greater than the allowable maximum SPL.

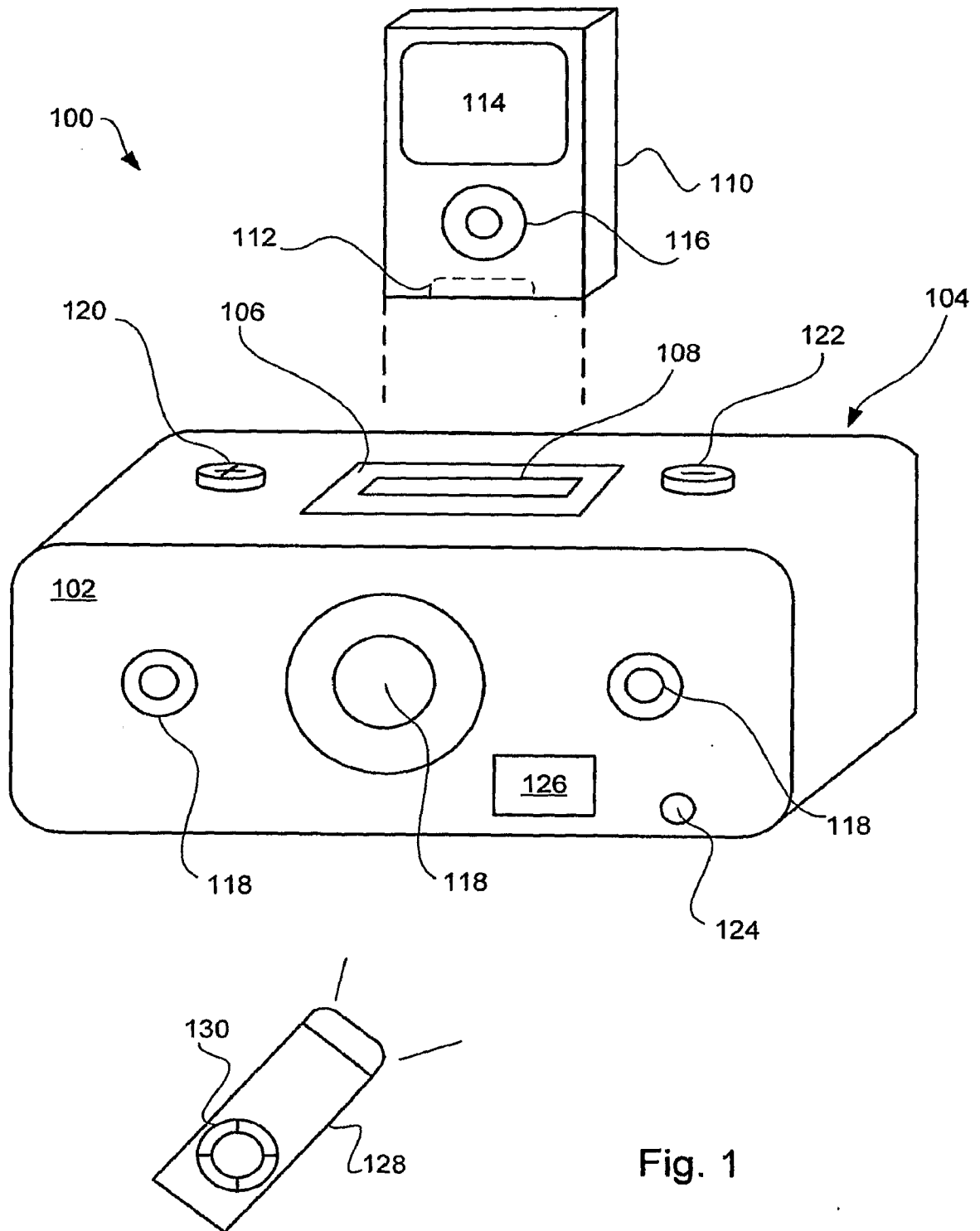


Fig. 1

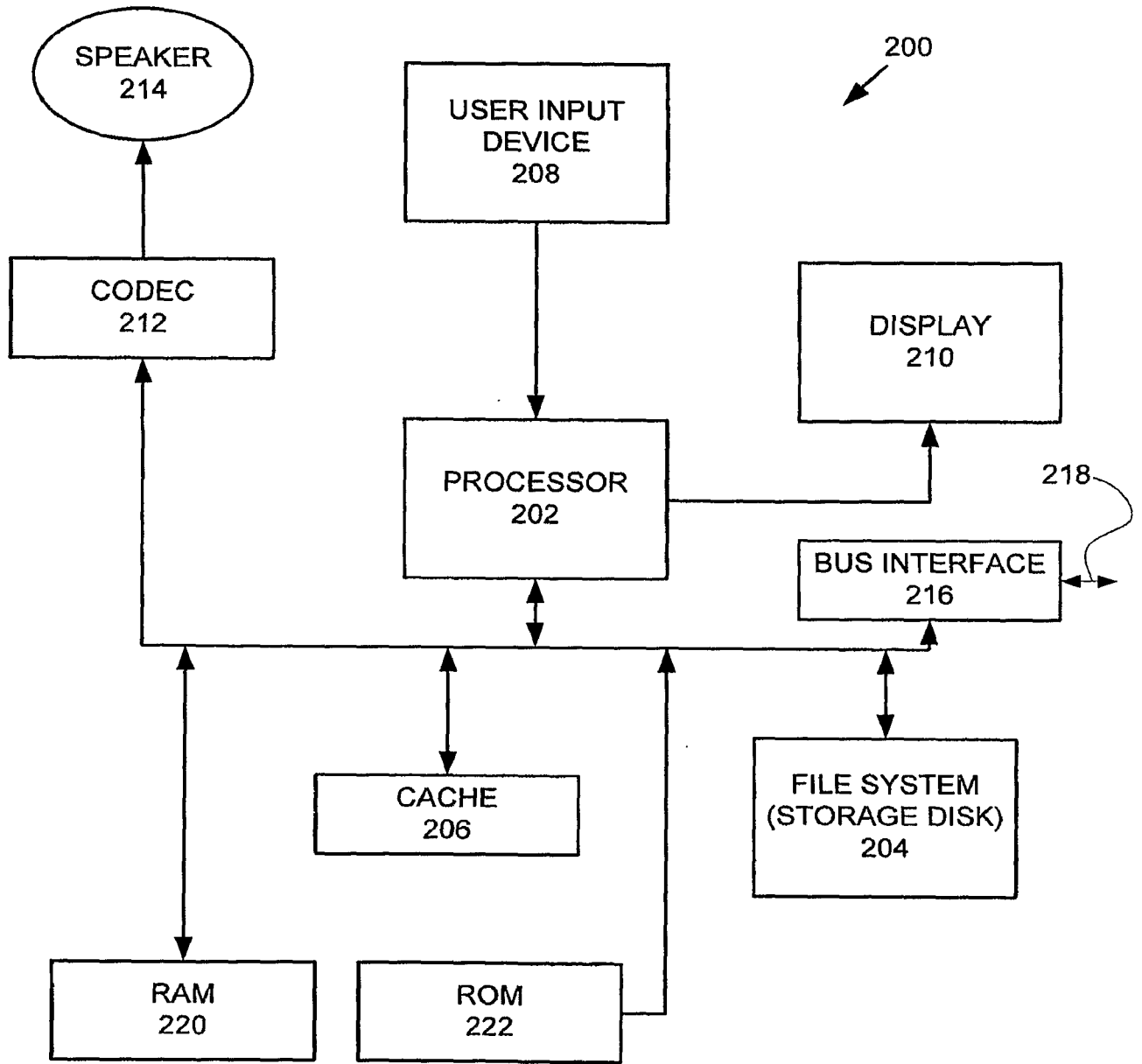


Fig. 2

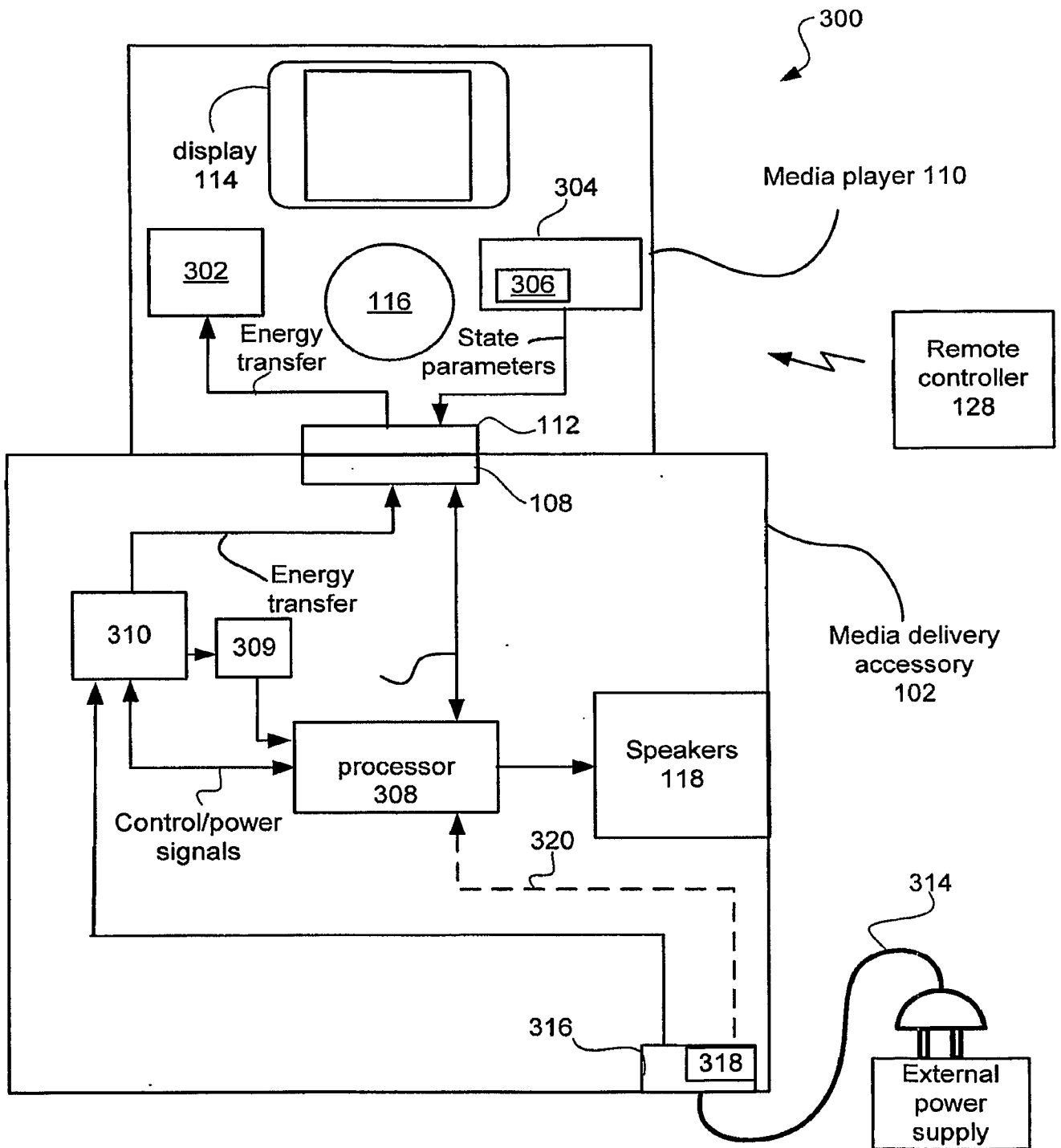


FIG. 3

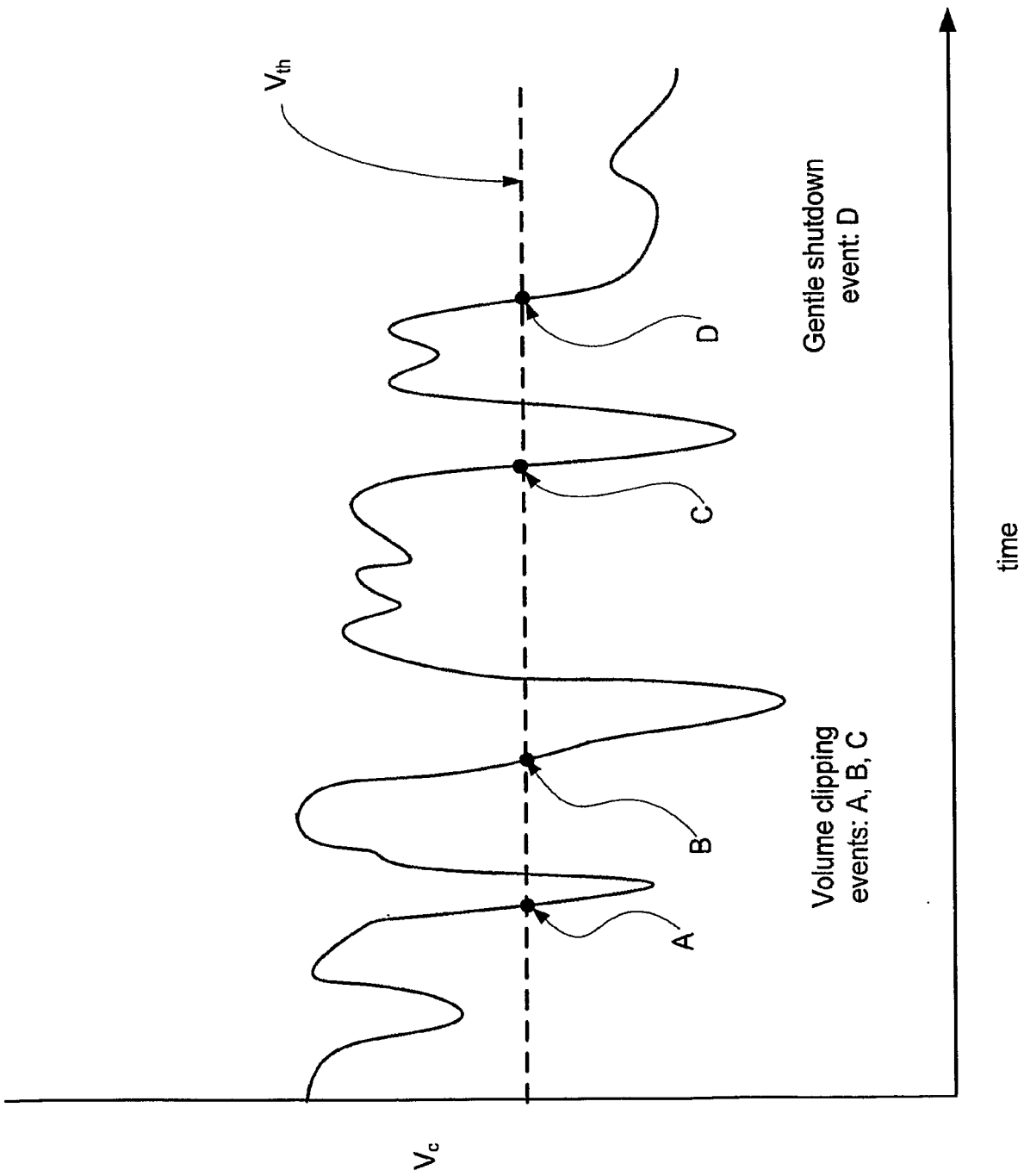


Fig. 4A

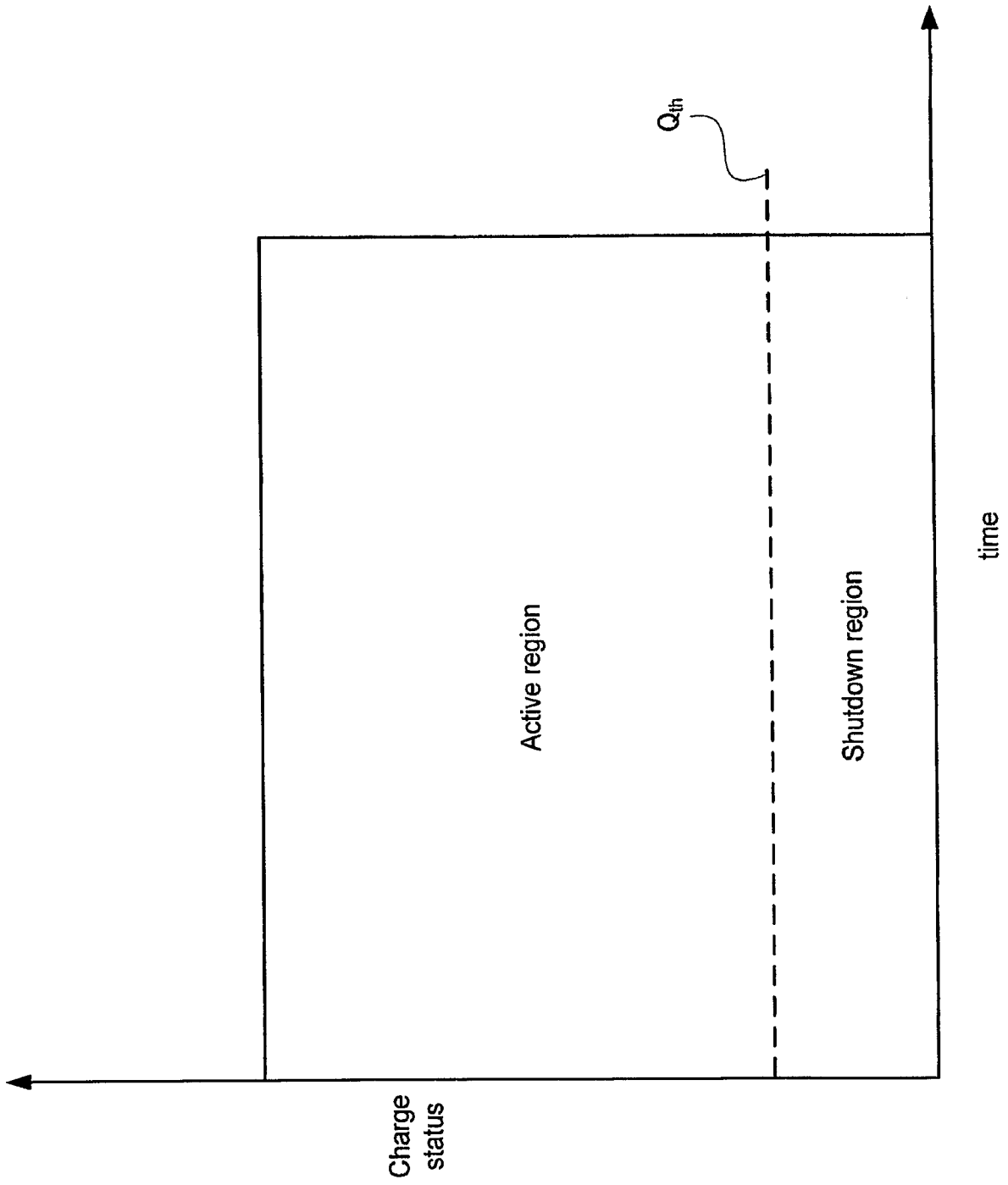


Fig. 4B

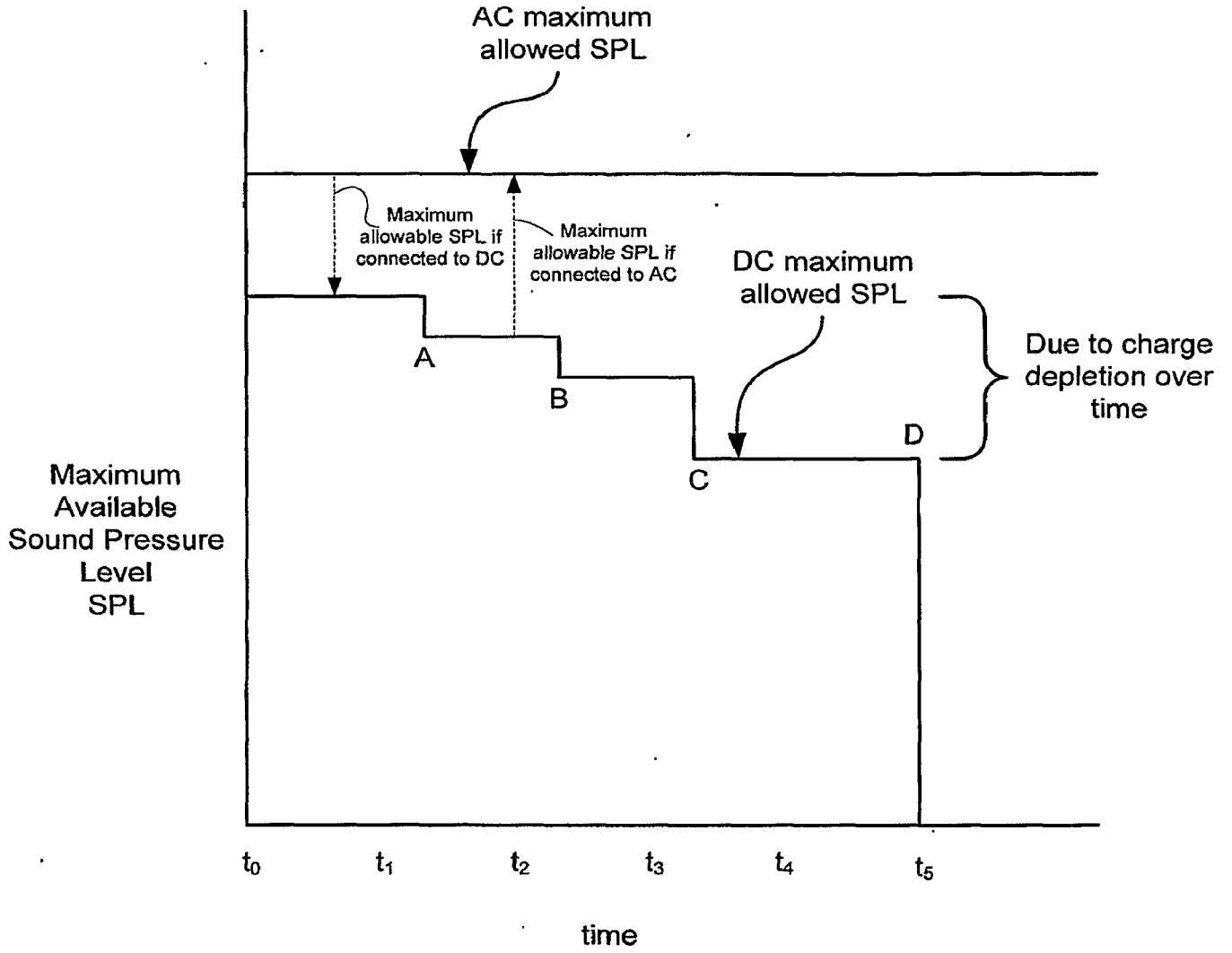


Fig. 5

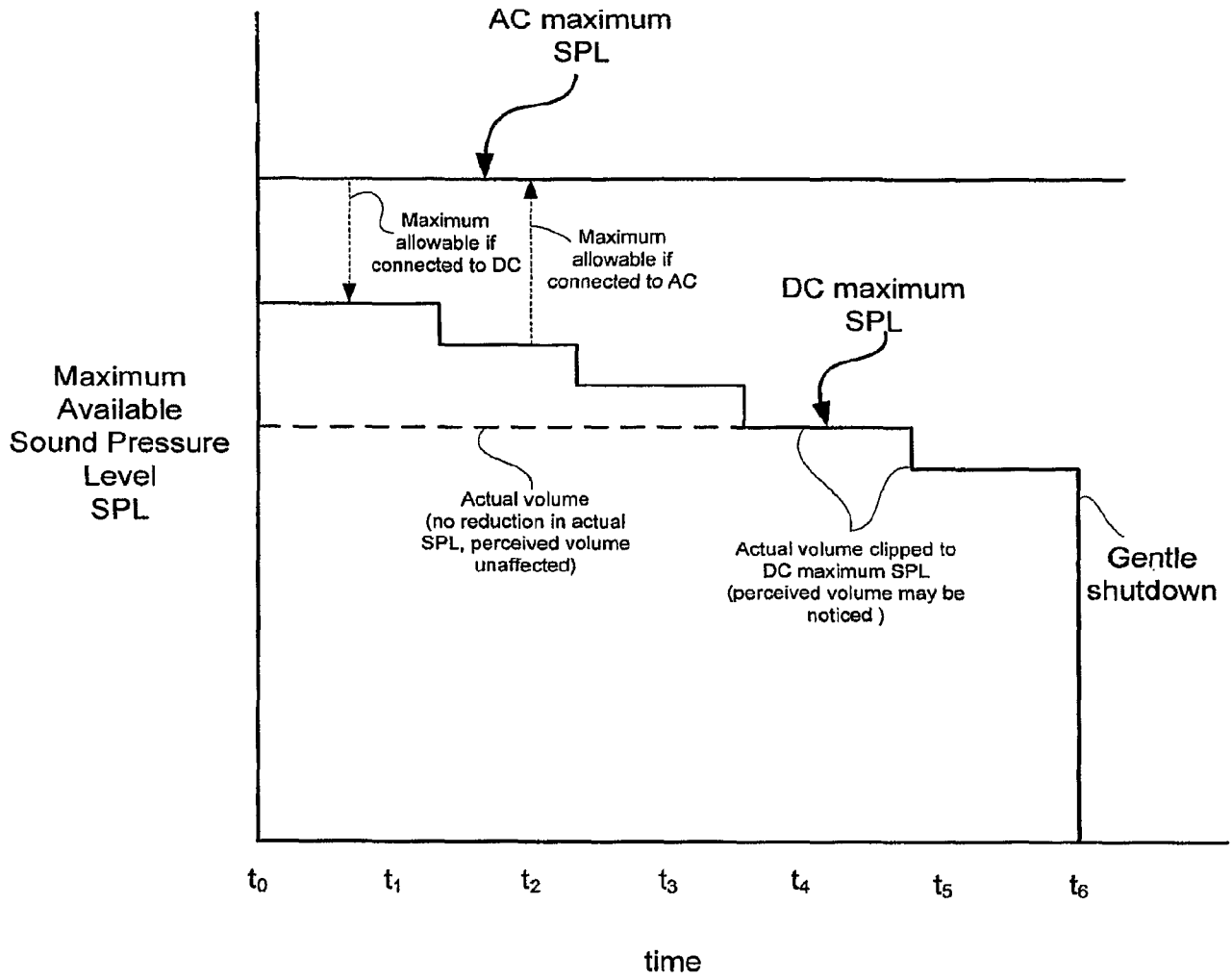


Fig. 6

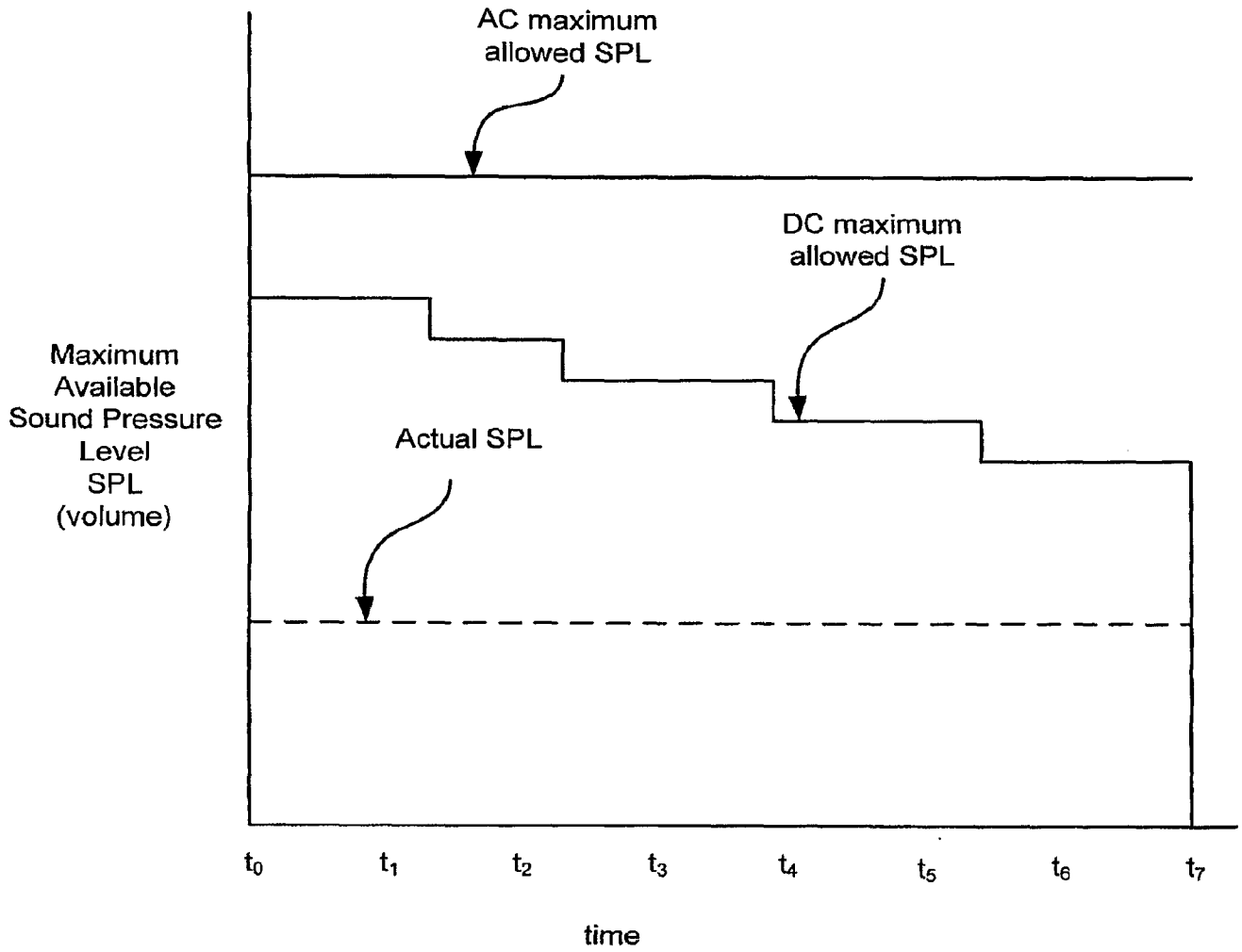


Fig. 7

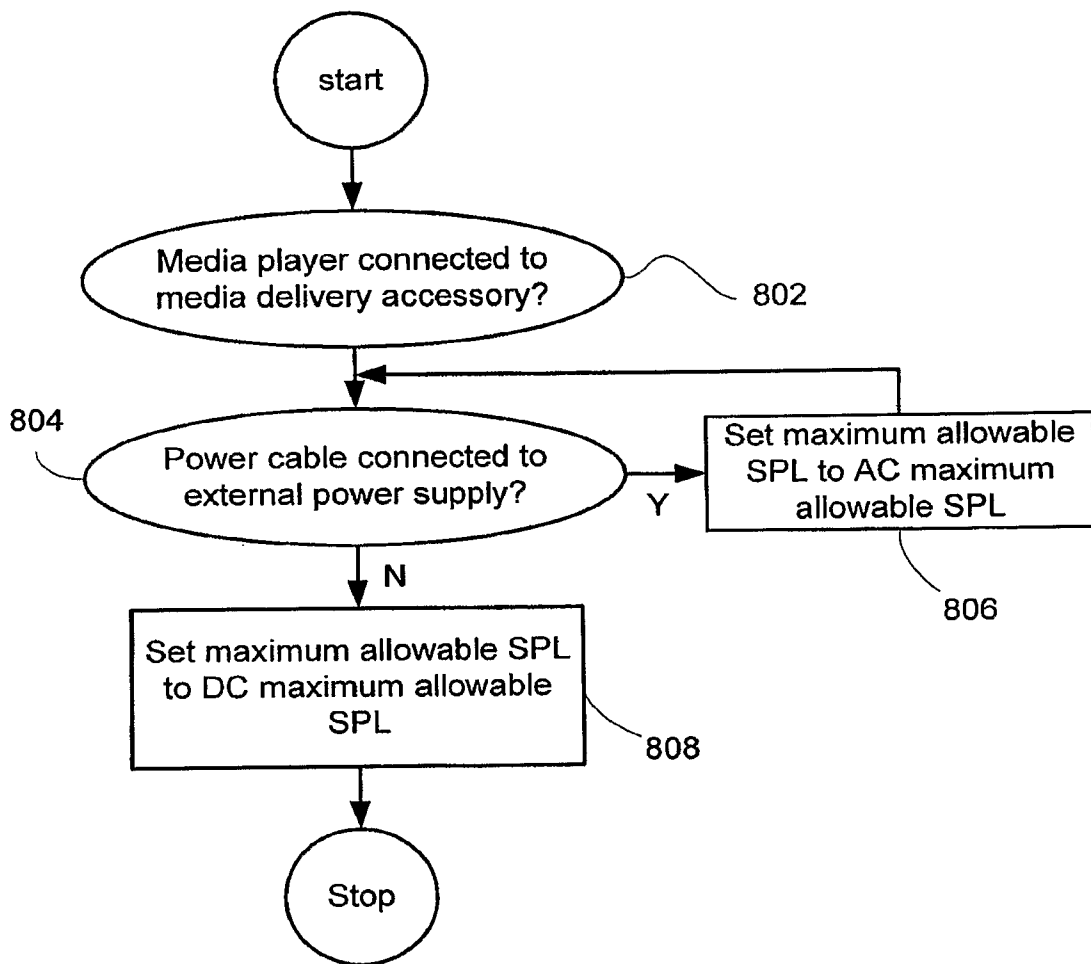


Fig. 8

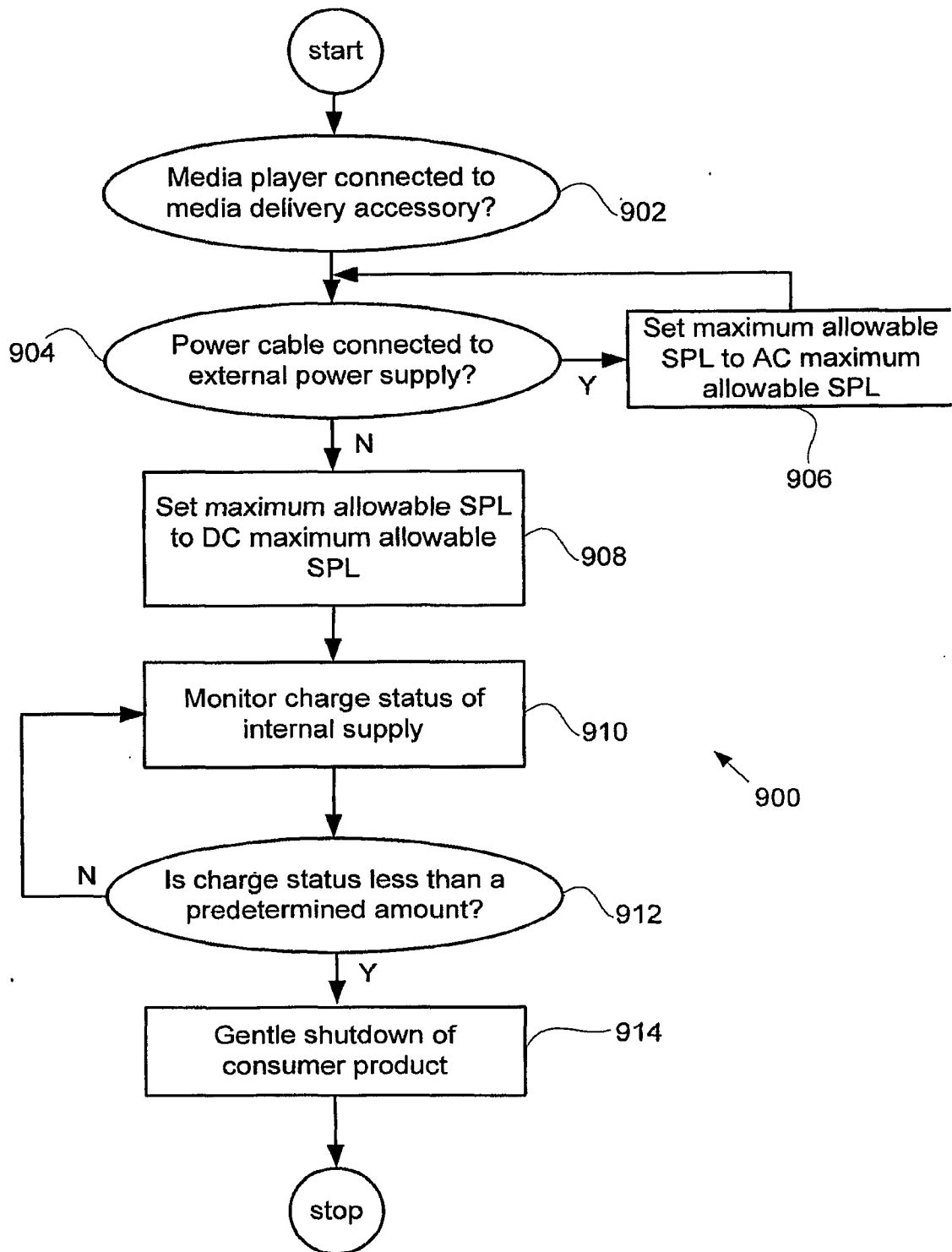


FIG. 9

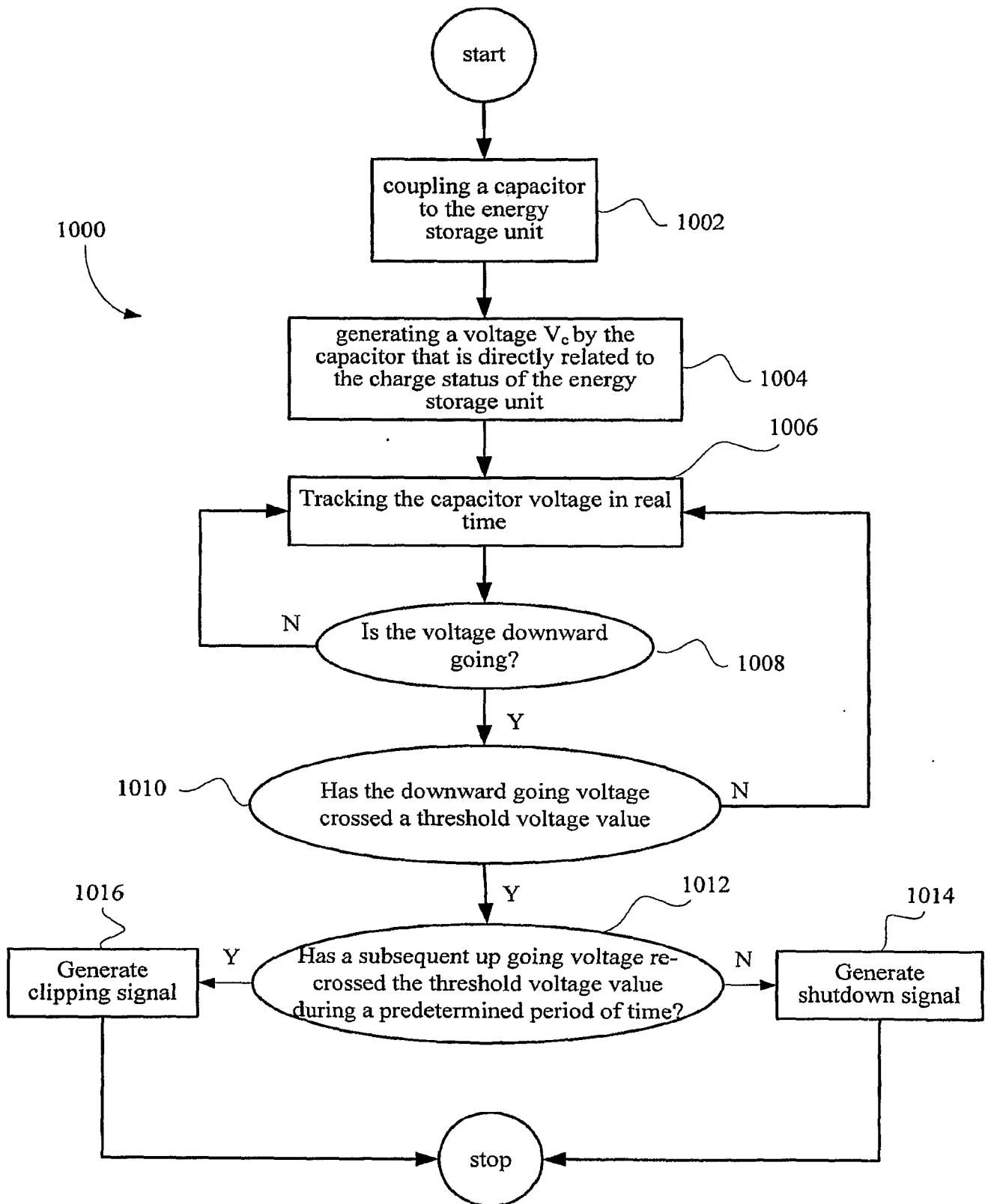


FIG. 10

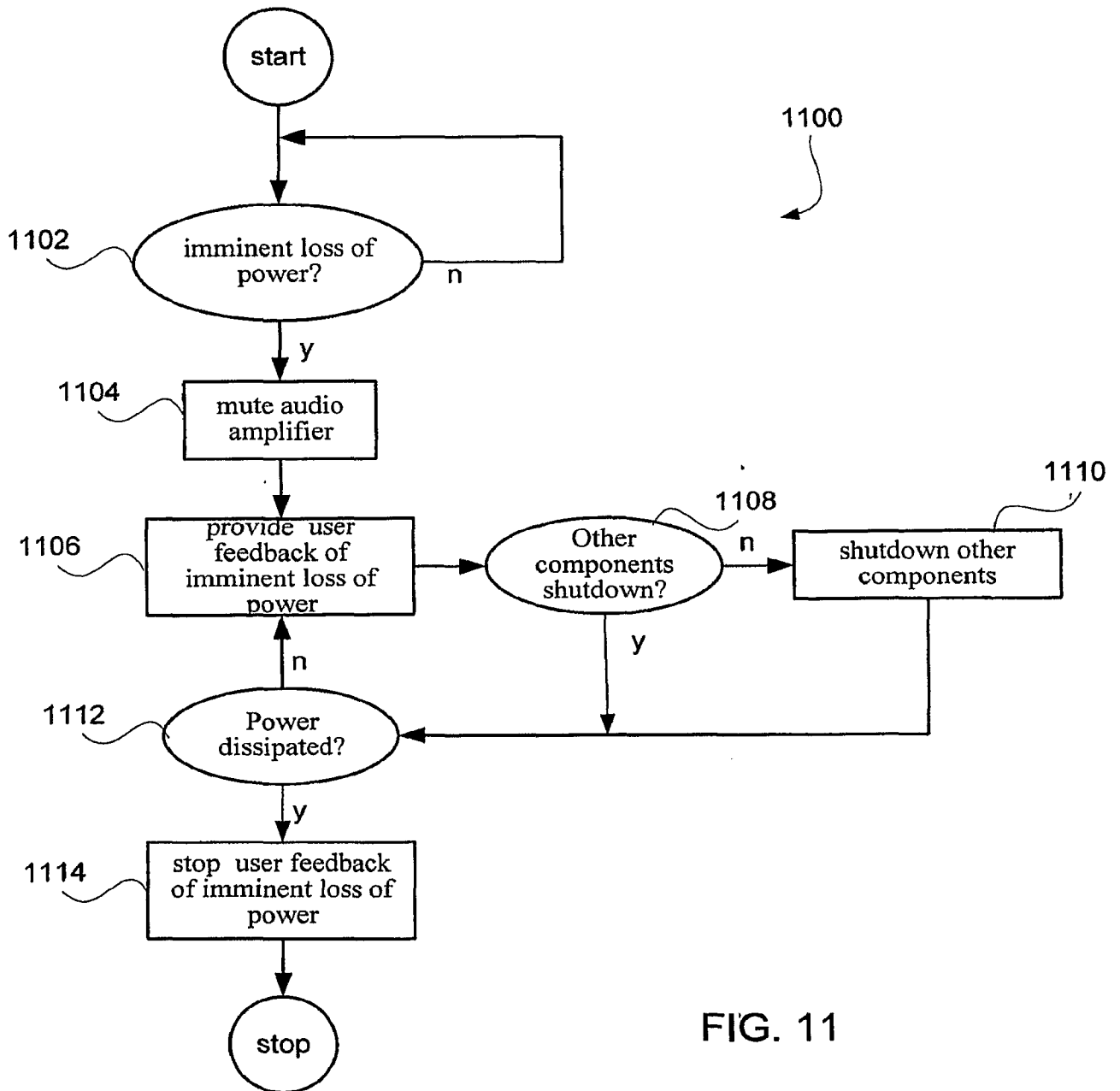


FIG. 11

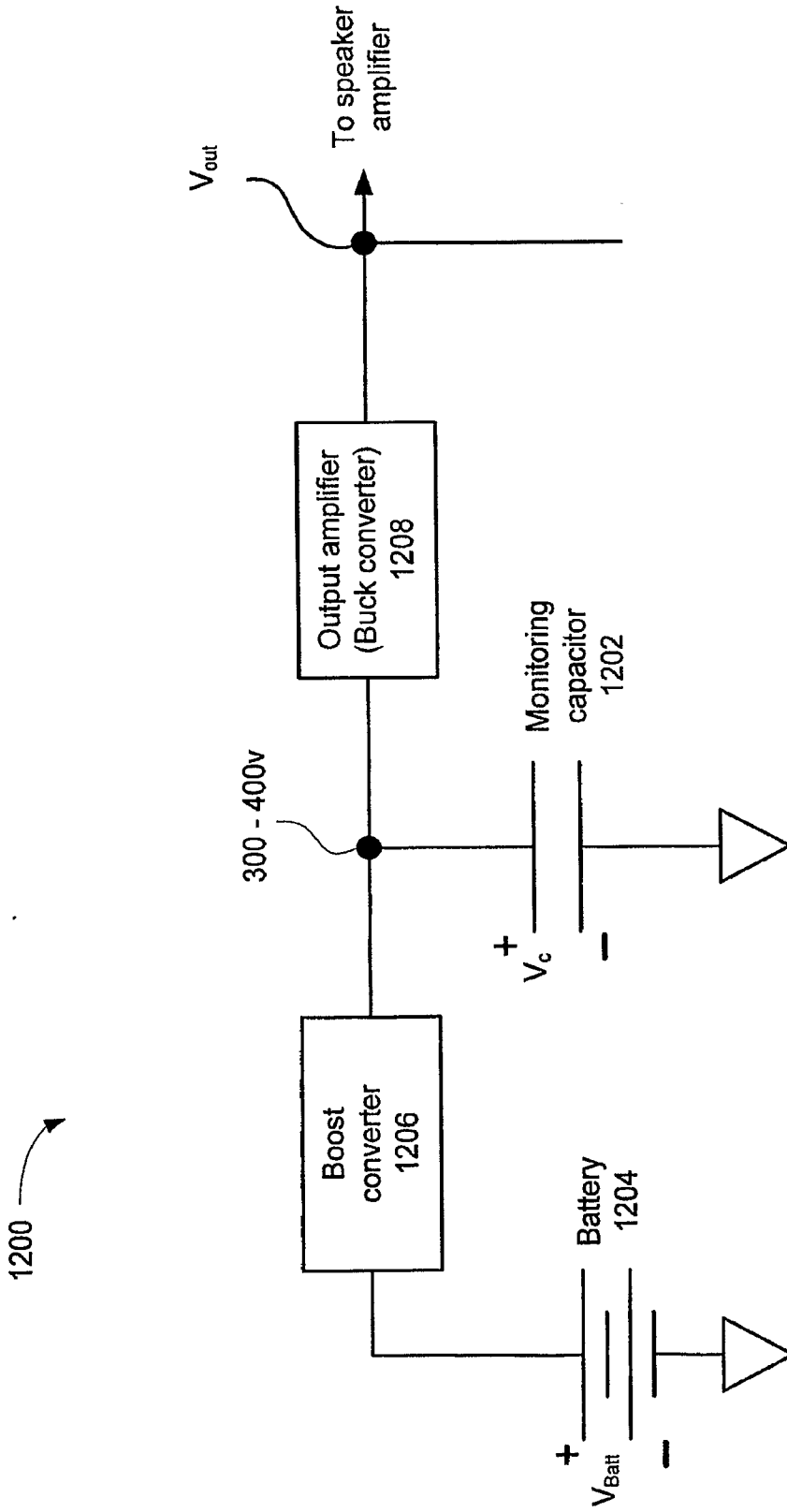


FIG. 12