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(54) **Using a loudspeaker as a vibration sensor**

(57) The invention relates to a communication system having a first operational mode and a second operational mode, at least one of which is used for communication purposes. The system comprises: i) an incoming signal terminal (IN) for receiving an incoming signal (Rx) that is representative for incoming communication or sound that needs to be reproduced by the system; ii) a first terminal (T1) for receiving an acoustic signal (ACS); iii) a second terminal (T2) for receiving a noise reference signal (NR) in the second operational mode; iv) a noise-cancellation unit (AEC/NS) coupled to the first terminal (T1) and the second terminal (T2) for reducing a noise level of the acoustic signal (ACS) to obtain an enhanced acoustic signal for outgoing communication (Tx), and v) a plurality of loudspeakers (LSP1, LSP2, LSP3, LSP4), wherein at least part of the plurality of loudspeakers is

coupled to the incoming signal terminal (IN) for producing sound that is representative for the incoming signal (Rx). The communication system is further configured for i) producing the sound with a first respective one (LSP4) of the plurality of loudspeakers in the first operational mode, the communication system being further configured for ii) sensing back-ground noise with the first respective one (LSP4) of the plurality of loudspeakers in the second operational mode to obtain the noise reference signal (NR) that is coupled to the second terminal (T2). The advantage of the proposed invention is to have the benefits of a vibration sensor for acoustic echo cancellation and/or noise suppression, without having to actually integrate such a vibration sensor into the system, but to use hardware (a loudspeaker) that is already available in many cases.

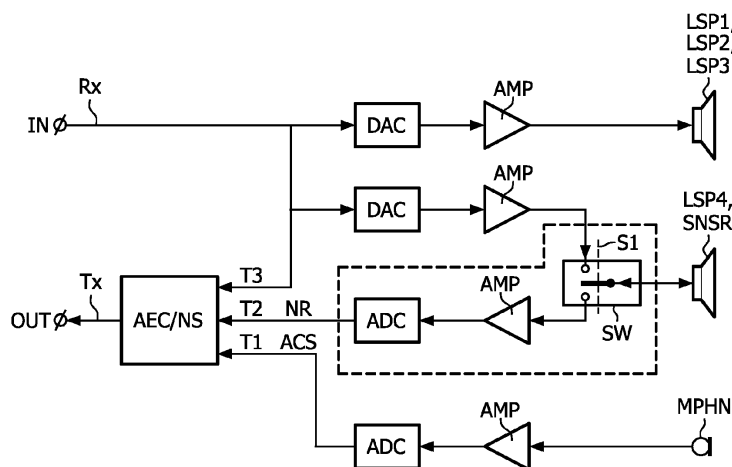


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The invention relates to a communication system having a first operational mode and a second operational mode, at least one of which is used for communication purposes, and to an electronic device comprising such communication system, such as a mobile phone and a hands-free kit.

BACKGROUND OF THE INVENTION

[0002] A microphone that is part of a hands-free voice communications system generally registers a lot of undesired noise. This noise consists of acoustic echo (linear and nonlinear), ambient noise, and possibly signals that originate from mechanical vibrations. Examples of these mechanical vibrations occur in car hands-free voice communications systems, where the vibrations of the car (engine and road noise) cause interferences on the microphone. In mobile phones, it is often the case that in hands-free (speakerphone) mode, the acoustic echo on the microphone is nonlinear due to loudspeaker nonlinearities and mechanical vibrations of the housing. In mobile phones in handset (normal) mode, the microphone signal can be disturbed by interferences originating from handling the mobile phone (contact and/or cable noise).

[0003] Current solutions use arrays of sensors (microphones and vibration sensors) to generate a noise reference that is correlated to the undesired disturbance in the microphone. This noise reference can be estimated from the array of sensors in a fixed or adaptive manner, and can be used for suppressing the undesired noise in the microphone. Several methods exist that generate a noise reference from an additional vibration sensor.

[0004] EP 1,879,180 B1 discloses a method for processing an audio signal, comprising detecting an acoustic signal by at least one microphone to obtain a microphone signal; detecting structure-borne noise by means of at least one acoustic emission sensor to obtain a noise reference signal; and noise compensating the digitized microphone signal on the basis of the at least one noise reference signal to obtain a noise compensated signal. It further discloses a hands-free set comprising at least one microphone configured to generate a microphone signal; at least one acoustic emission sensor configured to generate a noise reference signal; a noise compensation filtering means configured to filter the digitized microphone signal on the basis of the noise reference signal to obtain a noise compensated signal.

[0005] US 5,917,921 discloses a noise-reducing microphone apparatus having an adaptive noise canceller which has a primary input and a reference input and in which the reference input is subtracted from the primary input through an adaptive filter. The adaptive filter is adaptively controlled by an output signal resulted from the subtraction. The apparatus includes a pair of microphone units disposed in proximate locations; and subtracting means for performing subtraction of outputs from the pair of microphone units. An output from one of the microphone units is supplied as the primary input of the adaptive noise canceller. A differential output from the subtracting means is supplied as the reference input of the adaptive noise canceller.

[0006] In US 2005/063553 A1 vibration-dependent noise reduction is achieved by the use of a microphone to pick up an audio signal and a vibration sensor. The microphone apparatus has one or more microphones, one or more sensors, noise extraction means for extracting the noise bandwidth section from the output signal of the sensor, an adaptive filter coordinated with the microphone for receiving the output signal of the noise extraction means as the reference input signal, and an adder for subtracting the output signal of the adaptive filter from the output signal of the microphone. The vibration detection directions of the microphone and the sensor match. The output polarities of the vibration signal match too.

[0007] A problem of the known systems is that they are relatively complex because of the additional sensors for sensing the background noise.

SUMMARY OF THE INVENTION

[0008] It is a first object of the invention to provide a communication system which is less complex than the known systems.

[0009] The invention is defined by the independent claims. The dependent claims define advantageous embodiments.

[0010] In a first aspect, in accordance with the first object, the invention relates to a communication system having a first operational mode and a second operational mode, at least one of which is used for communication purposes, at least one of which is used for communication purposes. The system comprises:

- an incoming signal terminal for receiving an incoming signal that is representative for incoming communication or sound that needs to be reproduced by the system;
- a first terminal for receiving an acoustic signal;

- a second terminal for receiving a noise reference signal in the second operational mode;
- a noise-cancellation unit coupled to the first terminal and the second terminal for reducing a noise level of the acoustic signal to obtain an enhanced acoustic signal for outgoing communication, and
- a plurality of loudspeakers, wherein at least part of the plurality of loudspeakers is coupled to the incoming signal terminal for producing sound that is representative for the incoming signal;

wherein the communication system is further configured for i) producing the sound with a first respective one of the plurality of loudspeakers in the first operational mode, the communication system being further configured for ii) sensing back-ground noise with the first respective one of the plurality of loudspeakers in the second operational mode to obtain the noise reference signal that is coupled to the second terminal.

[0011] The effect of the features of the invention is as follows. The communication system is configured such that it has two operational modes, for instance, the system constitutes a mobile phone with a hands-free mode (first operational mode) and a normal mode (second operational mode) and another example is a car hands-free kit with a sound-reproduction mode (the first operational mode, wherein all speakers are used for sound reproduction) and communication-mode (second operational mode, wherein one speaker is used as noise sensor). In case of a car hands-free kit the invention can be explained as follows (for the mobile application a similar reasoning can be given). In the normal mode the incoming signal is converted into sound through the plurality of loudspeakers. Noise cancellation is of particular importance in case of hands-free communication where environmental sound is more easily picked up deteriorating the signal-to-noise ratio. In this example the hands-free communication mode is the second operational mode. The first terminal is configured for receiving an acoustic signal which may be obtained using a microphone for example. This acoustic signal is to be transmitted as outgoing communication. The communication system is further provided with a noise-cancellation unit which is at least coupled to the first terminal and to a second terminal, wherein the second terminal is configured for receiving a noise reference signal. The noise-cancellation unit is configured for generating an enhanced acoustic signal for the outgoing communication using the noise reference signal. The invention relies on the inventive thought to (re)use the first selective one of the plurality of loudspeakers to sense back-ground noise to obtain the noise reference signal. This is in huge contrast with the prior art solutions where additional noise sensors are provided to generate such reference signal. The integration of additional noise sensors is cumbersome and rendered superfluous by the invention, i.e. the communication system of the invention is less complex.

[0012] Throughout the description the wording "noise cancellation unit" must be interpreted as any unit which is designed for improving the signal to noise ratio of a signal (reduce the unwanted component, i.e. noise), and particularly an acoustic signal.

[0013] An embodiment of the communication system in accordance with the invention further comprises a switching circuit being coupled to the incoming signal terminal, the first selective one of the plurality of loudspeakers, and to the second terminal, wherein the switching circuit is configured for coupling the first respective one of the plurality of loudspeakers to the incoming signal terminal in the first operational mode, and for coupling the first respective one of the plurality of loudspeakers to the second terminal in the second operational mode. The switching circuit may, optionally, also be configured for disconnecting the microphone in the first operational mode. The switching circuit advantageously provides a means to let the communication system switch between said operational modes. The first respective one of the plurality of speakers is configured for producing the sound corresponding with the incoming signal in the first operational mode. Further, the first respective one of the plurality of speakers is configured for sensing back-ground noise to obtain the noise reference signal in the second operational mode.

[0014] In an embodiment of the communication system in accordance with the invention the incoming signal terminal is further coupled to at least a second one of the plurality of loudspeakers for producing the sound at least in the first operational mode. The advantage of this embodiment is that it features a further embodiment, wherein the switching circuit is further configured for coupling the second respective one of the plurality of loudspeakers to the incoming signal terminal in the second operational mode, and for coupling the second respective one of the plurality of loudspeakers to the second terminal in the first operational mode. This embodiment enables toggling between the first and the second loudspeaker to be used as sensor, whereas the other is used as loudspeaker.

[0015] An embodiment of the communication system in accordance with the invention further comprises a control unit for controlling the switching circuit in accordance with said operational modes.

[0016] An embodiment of the communication system in accordance with the invention further comprises a microphone coupled to the first terminal for generating the acoustic signal in at least one operational mode.

[0017] In an embodiment of the communication system in accordance with the invention the noise-cancellation unit is provided with a third terminal for receiving the incoming signal, wherein the noise-cancellation unit is configured for further reducing the noise level of the acoustic signal using the incoming signal. Using the incoming signal as an input for the noise-cancellation unit enables to reduce the noise level even further, because the sound of the loudspeakers corresponding with the incoming signal may be sensed by the microphone that senses sound to be transmitted as outgoing communication.

[0018] In an embodiment of the communication system in accordance with the invention the first operational mode is a hand-held mode, and the second operational mode is a hands-free mode. The invention is particularly useful in systems having a normal-mode, here being referred to as a hand-set mode, and a hands-free mode, where the microphone is typically far away from the speaker and thus easily picking undesired environmental sound.

[0019] In a second aspect, in accordance with the second object, the invention relates to an electronic device comprising the communications system of the invention. Examples of such electronic devices are a mobile phone and a hands-free kit for a car. Both devices typically have hands-free modes which may benefit from the invention.

[0020] These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In the drawings:

Fig. 1 shows a communication system in accordance with a first embodiment of the invention, and Fig. 2 shows a communication system in accordance with a second embodiment of the invention.

List of reference numerals:

[0022]

Rx	incoming signal
Tx	outgoing communication
IN	incoming signal terminal
OUT	outgoing communication terminal
DAC	digital-to-analog converter
ADC	analog-to-digital converter
AMP	amplifier
LSP1...LSP4	a plurality of loudspeakers
SNSR	specific one of the plurality of loudspeakers being configured as noise sensor
AEC/NS	noise-cancellation unit
T1	first (input) terminal of noise-cancellation unit
T2	second (input) terminal of noise-cancellation unit
T3	third (input) terminal of noise-cancellation unit
NR	noise-reference
MPHN	microphone
SW	switching circuit of first embodiment
SW'	switching circuit of second embodiment
S1	control signal of switching circuit

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0023] In order to facilitate the discussion of the detailed embodiments a few expressions are defined hereinafter.

[0024] Throughout the description the term "communication system" should be interpreted broadly so as to include

any system that used for enabling communication between at least two individuals. The outgoing communication (e.g. speech) from a first individual is incoming communication for a second individual, and the incoming communication from the first individual is outgoing communication (e.g. speech) for the second individual. Typically, but not essentially, for a specific one of the individuals the speech of the other individual needs to be converted into sound through sound generation means, such as loudspeakers. Further, the speech of the specific one of the individuals needs to be converted into a signal to be transmitted by means of a sound sensor, such as a microphone.

[0025] Throughout the description the term "signal" should be interpreted broadly so as to include both signals in the analog domain as well as signals in the digital domain, unless explicitly mentioned otherwise in the description.

[0026] Throughout the description the term "loudspeaker" should be interpreted broadly so as to include any device which converts a signal into sound waves that can be heard by the human ear.

[0027] Throughout the description the term "microphone" should be interpreted broadly so as to include any device which converts sound waves into signals that can be heard processed and subsequently transmitted.

[0028] Throughout the description the term "noise" should be interpreted broadly so as to include any undesired interference that is present in a signal, which also includes echos.

[0029] In a car hands-free communications system, there are often multiple (built-in) loudspeakers connected to the system, not all of which are necessary for voice communication. Since all loudspeakers are built-in, they are mechanically coupled to the chassis of the vehicle, and are therefore, subject to the same mechanical vibrations as the chassis (originating from engine and/or road noise). In many types of mobile phones that have hands-free (speakerphone) capabilities, there are two loudspeakers, one for the hands-free (speakerphone) mode, and the other one for hand-set (normal) mode. Both loudspeakers are mechanically coupled to the same casing as the microphone(s), and therefore, are subject to the same mechanical vibrations. The advantage of the proposed invention is to have the benefits of a vibration sensor for acoustic echo cancellation and/or noise suppression, without having to actually integrate such a vibration sensor into the system, but to use hardware (a loudspeaker) that is already available in many cases.

[0030] Fig. 1 shows a communication system in accordance with a first embodiment of the invention. The system constitutes part of a car communication system, such as a hands-free car-kit. Car audio systems typically consist of multiple speakers (for example one in each door) and in this example four. This embodiment of the invention takes advantage of such multiple-speaker system which is present in most cars. The car communication system is configured for two operational modes, namely a first (normal) operational mode, wherein all loudspeakers are used for producing sound from a signal, such as a radio signal or a navigation voice signal, and a second operational mode for voice communication. In the second operational mode (e.g. someone is calling the driver) a voice of the car driver or passenger must be sensed and transmitted to another user, whereas a voice of the other user is received and being output through the loudspeakers. Typically, in a car communication system such sensing is done hands-free as the driver needs both hands on his or her steering wheel. While doing so the microphone of the communication system is typically relatively remote from the mouth of the driver (or passenger) and will capture a lot of environmental sound, a considerable part of which originates from mechanical vibrations (engine or road noise). Noise-cancellation is advisory in order to enable proper conversation without too much noise.

[0031] The system of Fig. 1 comprises an incoming signal terminal IN for receiving incoming signal Rx. In this example the incoming signal is received in a digital format (but this is not essential to the invention) and subsequently converted into an analog signal by a digital-to-analog converter DAC. The analog signal is further amplified by an amplifier AMP and converted into sound by a plurality of loudspeakers LSP1, LSP2, LSP3. Even though only one line with one digital-to-analog converter DAC, one amplifier AMP and one loudspeaker has been drawn this can be a plurality of lines, with a plurality of corresponding converters and corresponding amplifiers. Alternatively, the amplifiers may optionally be merged into one circuit. The same is true for the converters. This is a design choice. Fig. 1 merely serves to illustrate that there is at least one of the plurality of loudspeakers which has a second function in the invention in addition to the loudspeaker function. In order to provide the second function the line to this at least one loudspeaker is provided with a switching circuit SW. In the first operational mode the fourth loudspeaker LSP4 is coupled to the incoming signal terminal IN through a further digital-to-analog converter DAC, a further amplifier AMP, and the switching circuit SW as illustrated in Fig. 1. In the second operational mode (voice communication during a phone call) the fourth loudspeaker LSP4 is coupled to a reference input terminal T2 of a noise-cancellation unit AEC/NS (via a further amplifier AMP and an analog-to-digital converter ADC. In this mode the fourth loudspeaker acts as a noise-sensor SNSR for sensing environmental sound (noise).

[0032] A loudspeaker can be used for registration purposes, as it generates a voltage that is related to the velocity of the loudspeaker diaphragm. This is easily illustrated by the 'voltage equation' of a loudspeaker:

$$v(t) = R_e i(t) + L_e di(t)dt + \Phi(x(t)) v_e(t) \quad (1)$$

where $v(t)$ is the voltage across the loudspeaker voice coil, R_e and L_e are the blocked electrical resistance and inductance of the voice coil, $i(t)$ is the current flowing through the voice coil, $v_e(t)$ is the first derivative (velocity) of the diaphragm position, $x(t)$, and $\Phi(x(t))$ is the force factor function. In a traditional operation of a loudspeaker, either a voltage or a current is applied to the voice coil, resulting in a displacement of the loudspeaker diaphragm, $x(t)$. In the invention, a displacement of the diaphragm, resulting from mechanical vibrations that generate noise on the microphone, results in a voltage signal, $v(t)$, across the loudspeaker voice coil that is related to the mechanical vibrations.

[0033] The noise sensor LSP4, SNSR converts the environment sound (noise) into a signal. The further amplifier AMP amplifies the signal and the analog-to-digital ADC converter converts the signal into a digital noise-reference signal NR.

[0034] Noise-reduction is carried out by the noise-cancellation unit AEC/NS and typically carried out for the outgoing communication, i.e. the voice of the driver that is to be transmitted to the recipient. Obviously, a similar system can be used at the recipient's side. In the field the noise-reduction is typically carried out in the digital domain, but this is not essential to the invention. Next to the reference input terminal T2 the noise-cancellation unit AEC/NS further comprises a first terminal T1 for receiving an acoustic signal ACS, which is generated by a microphone MPHN (wherein the microphone signal is amplified by an amplifier AMP and converted into the digital domain with a further analog-to-digital converter ADC). The noise-cancellation unit is configured for reducing the noise level of the acoustic signal ACS in order to obtain an enhanced acoustic signal for the outgoing communication. Optionally the noise-cancellation unit AEC/NS is provided with a third terminal T3 which receives the incoming signal for serving as a further noise-reference signal. As the incoming signal is typically converted into sound this sound may be received by the microphone (MPHN) and result in an additional undesired signal component, i.e. noise. Using the incoming signal as further noise reference input enables to further reduce the noise.

[0035] The principle of operation of the noise-cancellation unit AEC/NS is known as such and will not be further elaborated upon in this description. Lots of literature exists on this subject and a few references are given here purely for giving a background on this topic:

- 1) Haykin, S. (2001), "Adaptive Filter Theory", (4th Edition), Prentice Hall.
- 2) S.F. Boll (1979). "Suppression of acoustic noise in speech using spectral subtraction." IEEE Trans. on ASSP, ASSP-27(2):113 - 120.
- 3) Loizou P.C. (2007), "Speech Enhancement: Theory and Practice", CRC Press.

[0036] The switching circuit SW is controlled by a control signal S1 which is generated by a control circuit (not shown). The communication system of Fig. 1 operates as follows.

[0037] In the first operational mode (the switching circuit SW is in the upper position), each loudspeaker is connected to a corresponding amplifier AMP, which receives its input from a corresponding digital-to-analog converter DAC. The fourth loudspeaker LSP4 is disconnected from the noise reference input of the noise-cancellation unit AEC/NS. The first operational mode may be used for sound reproduction purposes, and disconnecting the microphone in this mode may therefore be beneficial. In an embodiment the microphone MPHN is disconnected from the amplifier (or the amplifier may be switched off) by the switching circuit SW. Alternatively, such disconnection may be implemented via a further switching circuit. Such switching circuit has been left out to render the figure clearer. During voice communication, the switching circuit SW is set to the lower position, due to which the fourth loudspeaker/sensor LSP4/SNSR functions as a sensor, i.e. not for sound reproduction, but for sound capture. The signal of the sensor SNSR is sent to an amplifier AMP and analog-to-digital converter ADC, and this signal functions as additional input to the processing in the noise-cancellation unit AEC/NS. The signal can be used as a noise reference signal, or it can be used to derive a noise reference signal. The additional elements of the proposed embodiment of the invention are represented in the dashed rectangle.

[0038] Fig. 2 shows a communication system in accordance with a second embodiment of the invention. The system constitutes a part of a mobile phone. The proposed system can be built if there are multiple (not necessarily identical) loudspeakers available in such mobile phone, such as is the case in mobile phones with speakerphone capabilities with separate loudspeakers for the normal (handset) and speakerphone mode. This embodiment will be discussed in as far as it differs from Fig. 1. The system comprises typically two loudspeakers LSP1, LSP4. The embodiment of Fig. 2 provides for a toggling feature between both loudspeakers. In the first operational mode the first loudspeaker LSP4 is used for sound reproduction, whereas the second loudspeaker LSP1 is used as a noise-sensor. In the second operational mode, the roles of both loudspeakers are exchanged. In order to achieve this, the switching circuit SW' is slightly different from the switching circuit SW illustrated in Fig. 1

[0039] The system of Fig. 2 operates as follows. In the first operational mode the switching circuit SW' is set to position 1 (upper position). The first loudspeaker LSP4 is coupled to the incoming signal line and the second loudspeaker LSP1 is coupled to the noise-cancellation unit AEC/NS and acts as a noise sensor. In the second operational mode the switching circuit SW' is set to position 2 (lower position). The second loudspeaker LSP1 is coupled to the incoming signal line and the first loudspeaker LSP4 is coupled to the noise-cancellation unit AEC/NS and acts as a noise sensor. It must

be noted that the switching circuit functionality may also be incorporated into the amplifiers for example, i.e. the corresponding amplifier AMP is switched off. The additional elements of the proposed invention are encircled by a dashed line.

[0040] To build the proposed system, at least the following components are required:

- one or several microphones to register the Tx (transmit) part of the communication;
- one or several loudspeakers to reproduce the Rx (receive) part of the Communication;
- one or several loudspeakers to be used as vibration sensor(s) to register the mechanical vibrations (car or engine noise, contact noise, nonlinear echo), and
- a means to perform acoustic echo cancellation (AEC), noise suppression (NS) or both in order to remove undesired interferences from the microphone signal(s).

[0041] It must be noted that the method for acoustic echo-cancellation and noise suppression as such is not part of the invention. It may be performed on a DSP and it may be based on temporal and/or spectral, fixed or adaptive processing. The microphone signal on which the processing is performed can be a combination obtained from several microphones (by means of, e.g., beamforming).

[0042] Various variations of the communication system in accordance with the invention are possible and do not depart from the scope of the invention as claimed.

[0043] The invention provides a communication system having a first operational mode and a second operational mode. The system comprises: i) an incoming signal terminal IN for receiving an incoming signal Rx that is representative for incoming communication or sound that needs to be reproduced by the system; ii) a first terminal T1 for receiving an acoustic signal ACS; iii) a second terminal T2 for receiving a noise reference signal NR in the second operational mode; iv) a noise-cancellation unit AEC/NS coupled to the first terminal T1 and the second terminal T2 for reducing a noise level of the acoustic signal ACS to obtain an enhanced acoustic signal for outgoing communication Tx, and v) a plurality of loudspeakers LSP1, LSP2, LSP3, LSP4, wherein at least part of the plurality of loudspeakers is coupled to the incoming signal terminal IN for producing sound that is representative for the incoming signal Rx. The communication system is further configured for i) producing the sound with a first respective one LSP4 of the plurality of loudspeakers in the first operational mode, the communication system being further configured for ii) sensing back-ground noise with the first respective one LSP4 of the plurality of loudspeakers in the second operational mode to obtain the noise reference signal NR that is coupled to the second terminal T2. The advantage of the proposed invention is to have the benefits of a vibration sensor for acoustic echo cancellation and/or noise suppression, without having to actually integrate such a vibration sensor into the system, but to use hardware (a loudspeaker) that is already available in many cases.

[0044] The invention may be applied in various application areas. For example, the invention may be applied in a number of applications of voice communications:

- to reduce engine or road noise in a car communications system;
- to reduce contact noise in a mobile phone in handset mode;
- to reduce nonlinear acoustic echo in a mobile phone in hands-free (speakerphone) mode, and
- to reduce noise originating from mechanical vibrations in a mobile phone (both in hand-set and speakerphone mode).

[0045] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Throughout the Figures, similar or corresponding features are indicated by same reference numerals or labels.

Claims

1. A communication system having a first operational mode and a second operational mode, at least one of which is used for communication purposes, the system comprising:

- an incoming signal terminal (IN) for receiving an incoming signal (Rx) that is representative for incoming communication or sound that needs to be reproduced by the system;

- a first terminal (T1) for receiving an acoustic signal (ACS);
- a second terminal (T2) for receiving a noise reference signal (NR) in the second operational mode;
- a noise-cancellation unit (AEC/NS) coupled to the first terminal (T1) and the second terminal (T2) for reducing a noise level of the acoustic signal (ACS) to obtain an enhanced acoustic signal for outgoing communication (Tx), and
- a plurality of loudspeakers (LSP1, LSP2, LSP3, LSP4), wherein at least part of the plurality of loudspeakers is coupled to the incoming signal terminal (IN) for producing sound that is representative for the incoming signal (Rx);

wherein the communication system is further configured for i) producing the sound with a first respective one (LSP4) of the plurality of loudspeakers in the first operational mode, the communication system being further configured for ii) sensing back-ground noise with the first respective one (LSP4) of the plurality of loudspeakers in the second operational mode to obtain the noise reference signal (NR) that is coupled to the second terminal (T2).

2. The communication system as claimed in claim 1, further comprising a switching circuit (SW) being coupled to the incoming signal terminal (IN), the first selective one (LSP4) of the plurality of loudspeakers, and to the second terminal (T2), wherein the switching circuit (SW) is configured for coupling the first respective one (LSP4) of the plurality of loudspeakers to the incoming signal terminal (IN) in the first operational mode, and for coupling the first respective one (LSP4) of the plurality of loudspeakers to the second terminal (T2) in the second operational mode.
3. The communication system as claimed in claim 1, wherein the incoming signal terminal (IN) is further coupled to at least a second one (LSP1, LSP2, LSP3) of the plurality of loudspeakers (LSP1, LSP2, LSP3, LSP4) for producing the sound at least in the first operational mode.
4. The communication system as claimed in claim 2, wherein the switching circuit (SW') is further configured for coupling the second respective one (LSP1) of the plurality of loudspeakers to the incoming signal terminal (IN) in the second operational mode, and for coupling the second respective one (LSP1) of the plurality of loudspeakers to the second terminal (T2) in the first operational mode.
5. The communication system as claimed in any one of claims 2 to 4, further comprising a control unit for controlling the switching circuit in accordance with said operational modes.
6. The communication system as claimed in any one of the preceding claims, further comprising a microphone (MPHN) coupled to the first terminal (T1) for generating the acoustic signal (ACS) in at least one operational mode.
7. The communication system as claimed in any one of the preceding claims, wherein the noise-cancellation unit (AEC/NS) is provided with a third terminal (T3) for receiving the incoming signal (Rx), wherein the noise-cancellation unit (AEC/NS) is configured for further reducing the noise level of the acoustic signal (ACS) using the incoming signal (Rx).
8. The communication system as claimed in any one of the preceding claims, wherein the first operational mode is a hand-held mode, and the second operational mode is a hands-free mode.
9. An electronic device comprising the communications system as claimed in any one of the preceding claims.
10. A mobile phone comprising the communication system as claimed in any one of claims 1 to 8, and comprising a housing for supporting the system.
11. A hands-free kit comprising the communication system as claimed in any one of claims 1 to 8, and comprising a housing and a support for mounting the housing to a surface, such as a car dashboard.

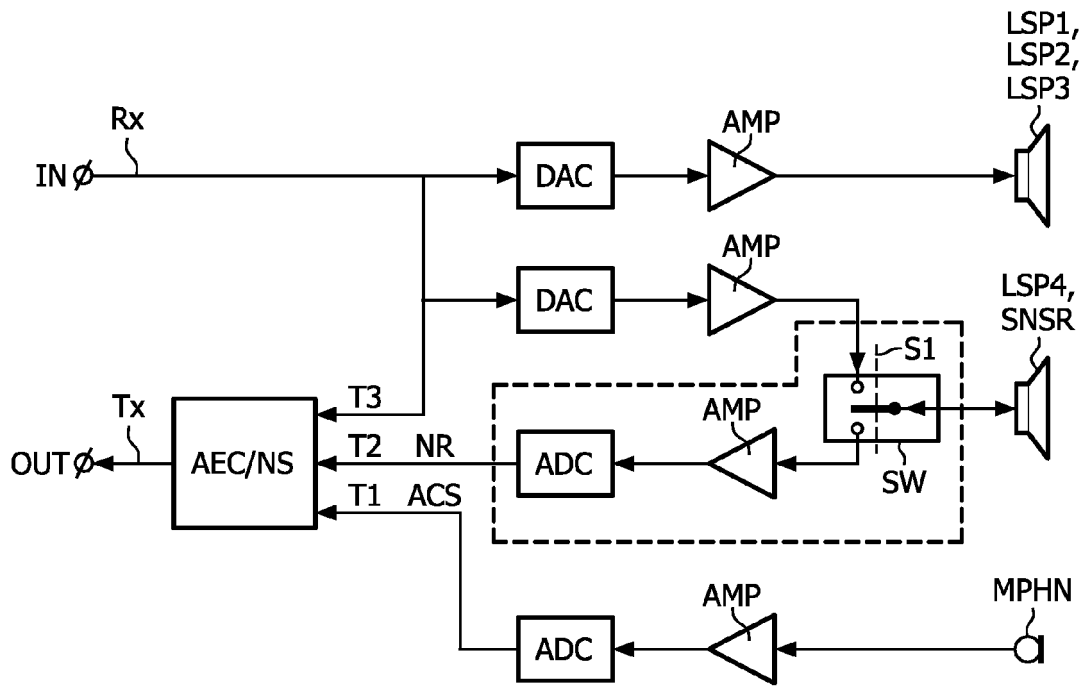


FIG. 1

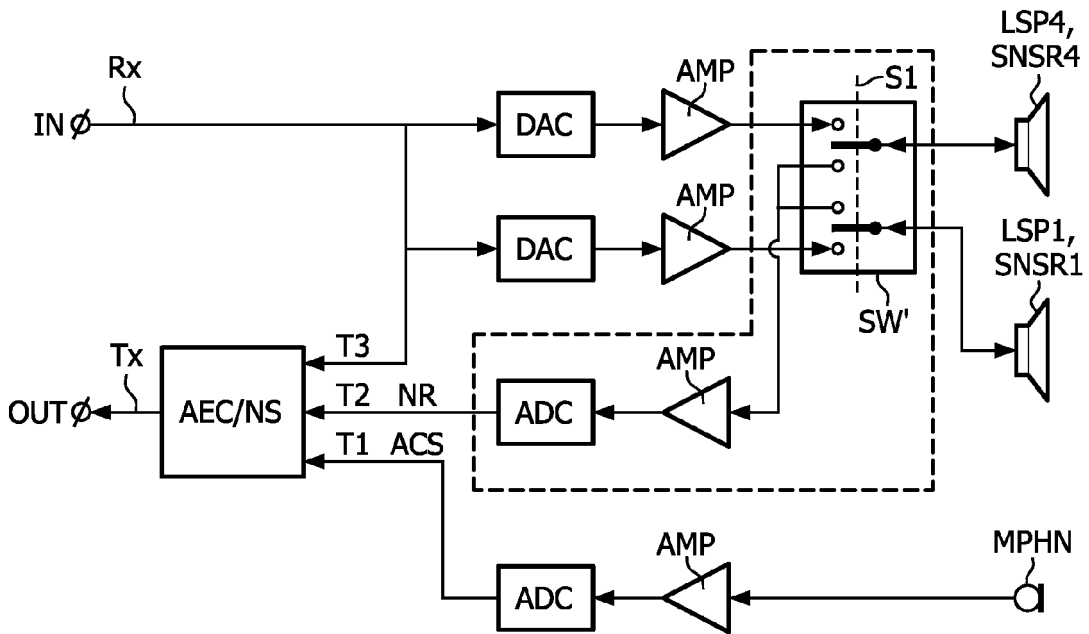


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 10 16 1313

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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