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(54) **AUDIO DEVICE WITH SIGNAL PARAMETER-BASED PROCESSING, RELATED METHODS AND SYSTEMS**

(57) An audio device configured to act as a receiver device, the audio device comprising an interface, an audio speaker, and a microphone, the audio device comprising a processor and a memory, the processor comprising a first decoder and a receiver configuration controller, wherein the audio device is configured to: obtain an input signal from a transmitter device, where the input signal comprises audio; obtain, based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio; determine, based on the first signal parameter, a receiver configuration; and control, based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder.

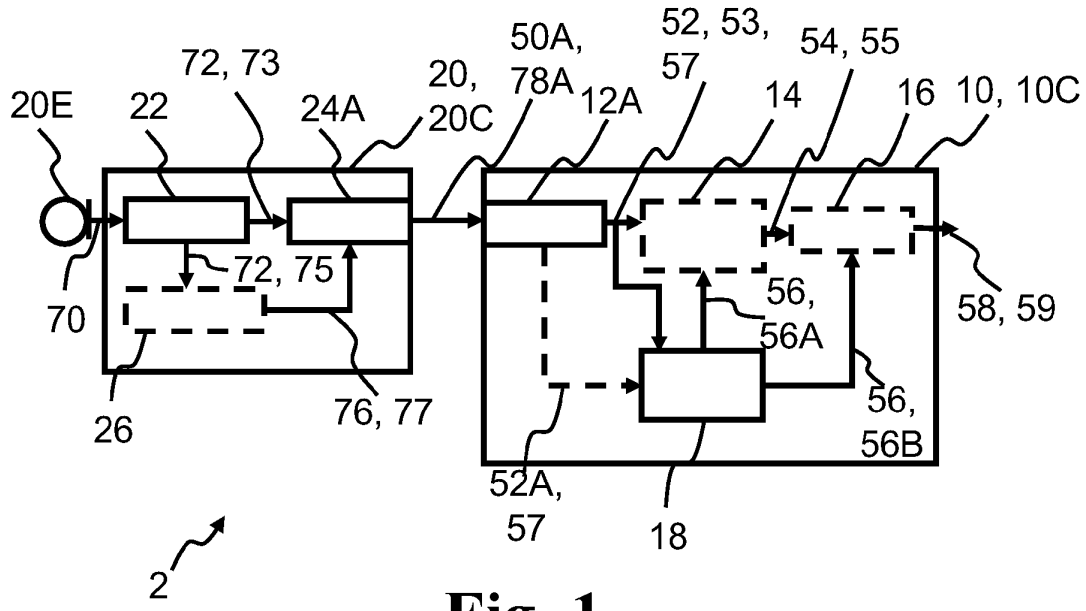

Fig. 1

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Description

[0001] The present disclosure pertains to the field of audio devices and methods of operating audio devices, and in particular to audio devices with signal parameter-based processing and related methods.

BACKGROUND

[0002] Noise suppression (NS) methods have already shown promising speech enhancement performance at both transmitter (TX) audio devices and receiver (RX) audio devices. A known noise suppression method when performing deep noise reduction (DNS) is to find a mapping function (mask) from a noisy input signal to clean targets. The mapping function or mask is defined in Time-Frequency (T-F) and is applied on the noisy input signal to obtain an enhanced input signal, such as an enhanced speech signal.

[0003] Despite the success of noise reduction methods (in particular the mask-based DNS method), they are however limited in their achievable performance. In particular, there is a trade-off between the introduced speech distortion versus the achievable noise attenuation of an input signal. These signal processing blocks can be different from TX audio devices to RX audio devices. This may result in different configurations running at the same time at a TX audio device and at a RX audio device.

[0004] For example, challenges may arise due to remaining residual amount of noise in heavily corrupted T-F regions of an input signal (e.g., regions having low signal-to-noise ratio). This may result in the retrieval of speech when applying a mapping function or mask on a noisy signal becoming difficult or nearly impossible. This may for example be the case when the modulation-depth of noise in a signal is large (wind noise, noise bursts, and transient noise types) due to their unpredictable nature.

SUMMARY

[0005] Accordingly, there is a need for audio devices with signal parameter-based processing and methods of operating an audio device, which may mitigate, alleviate, or address the shortcomings existing and may provide improved signal processing.

[0006] An audio device is disclosed. The audio device may be configured to act as a receiver device. The audio device comprises an interface, an audio speaker, and a microphone. The audio device comprises a processor and a memory. The processor comprises a first decoder and a receiver configuration controller. The audio device is configured to obtain an input signal from a transmitter device. The input signal comprises audio. The audio device is configured to obtain, e.g., based on the input signal, one or more signal parameters. The one or more signal parameters comprise a first signal parameter, e.g., indicative of signal information of the audio. The audio device is configured to determine, e.g., based on the first signal parameter, a receiver configuration. The audio device is configured to control, e.g., based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder.

[0007] Further, an audio device configured to act as a transmitter device is disclosed. The audio device comprises an interface, an audio speaker, a microphone, a processor, and a memory. The processor comprises a signal processor, a feature extractor, and a first encoder. The audio device is configured to obtain, e.g., via the microphone, a microphone input signal. The audio device is configured to determine, e.g., based on the microphone input signal and using the signal processor, a signal processor output signal. The audio device is configured to obtain, e.g., based on the signal processor output signal and using the feature extractor, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor output signal. The audio device is configured to encode, e.g., using the first encoder, the signal processor output signal for provision of a transmitter output signal. The audio device is configured to output, e.g., via the interface to a receiver device, the transmitter output signal and the first transmitter signal parameter.

[0008] Further, a system is disclosed. The system comprises an audio device configured to act as a receiver device as disclosed herein, such as a receiver audio device, and an audio device configured to act as a transmitter device as disclosed herein, such as a transmitter audio device.

[0009] A method of operating an audio device configured to act as a receiver device is disclosed. The method comprises obtaining an input signal from a transmitter device, where the input signal comprises audio. The method comprises obtaining, e.g., based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio. The method comprises determining, e.g., based on the first signal parameter, a receiver configuration. The method comprises controlling, e.g., based on the receiver configuration, a processing of a decoder output signal from the first decoder.

[0010] The disclosed system, audio devices, and related methods provide improved signal processing of input signals comprising audio. In other words, the present disclosure may provide improved signal parameter-based processing of input signals comprising audio. It may be appreciated that the present disclosure provides informed signal processing of input signals comprising audio. For example, the present disclosure may provide informed enhancement of speech signals, e.g., by using bandwidth extension and noise suppression. In other words, the present disclosure may provide improved deep noise reduction performance, both in terms of residual noise and overall perceived quality. It may be ap-

preciated that the present disclosure may provide improved speech enhancement of input signals comprising audio.

[0011] It may be appreciated that the present disclosure may provide improved signal processing, such as improved tuning of a signal processing pipeline. The signal processing may be improved based on the first signal parameter indicative of signal information of the audio and/or based on the receiver configuration. In turn, the present disclosure may provide improved output signal(s), such as improved audio output quality at the receiver-end, such as for a receiver-end user. In other words, the present disclosure may provide an improved audio quality of speech at the receiver-end, e.g., during a call or a meeting.

[0012] An advantage of the present disclosure is that an improved communication experience, such as speech communication, is achieved between a transmitter side, such as a transmitter audio device, and a receiver side, such as a receiver audio device. For example, the present disclosure may provide an improved communication experience for telephone and/or conference calls, e.g., using a headset, a speakerphone, and/or a video bar.

[0013] Currently used signal processing methods do not provide a satisfying output quality at the receiving end. The present disclosure may optimize the overall achievable speech enhancement performance in terms of the available bandwidth and/or provided signal information about the transmitted, TX, signal and its received version (e.g., input signal) at the receiving end, RX. The present disclosure increases the performance of the signal processing of input signals at the receiving end (such as receiving audio device) based on the signal information in the input signal, without degrading the quality of the output.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The above and other features and advantages of the present disclosure will become readily apparent to those skilled in the art by the following detailed description of examples thereof with reference to the attached drawings, in which:

Fig. 1 schematically illustrates an example system according to the present disclosure,

Fig. 2 schematically illustrates an example system according to the present disclosure,

Fig. 3 schematically illustrates an example system according to the present disclosure,

Fig. 4 schematically illustrates an example system according to the present disclosure,

Fig. 5 schematically illustrates an example system according to the present disclosure,

Figs. 6A-6B is a flow chart of an example method according to the present disclosure, and

Fig. 7 is a flow chart of an example method according to the present disclosure.

DETAILED DESCRIPTION

[0015] Various examples and details are described hereinafter, with reference to the figures when relevant. It should be noted that the figures may or may not be drawn to scale and that elements of similar structures or functions are represented by like reference numerals throughout the figures. It should also be noted that the figures are only intended to facilitate the description of the examples. They are not intended as an exhaustive description of the disclosure or as a limitation on the scope of the disclosure. In addition, an illustrated example needs not have all the aspects or advantages shown. An aspect or an advantage described in conjunction with a particular example is not necessarily limited to that example and can be practiced in any other examples even if not so illustrated, or if not so explicitly described.

[0016] The figures are schematic and simplified for clarity, and they merely show details which aid understanding the disclosure, while other details have been left out. Throughout, the same reference numerals are used for identical or corresponding parts.

[0017] A system is disclosed. The system may be seen as an audio device system, such as an audio communication system. The system may be seen as a communication system for performing calls, such as audio and/or video calls. The system, such as communication system, may be seen as a system with signal parameter-based processing.

[0018] The system comprises an audio device configured to act as a receiver device as disclosed herein, such as a receiver audio device, and an audio device configured to act as a transmitter device as disclosed herein, such as a transmitter audio device. The system may comprise one or more audio devices, such as a plurality of receiver audio devices and a plurality of transmitter audio devices.

[0019] An audio device is disclosed. The audio device is configured to act as receiver device. In other words, the audio device is configured to receive input signals from an audio device configured to act as a transmitter device. The audio device as disclosed herein may comprise an interface, an audio speaker, one or more microphones, e.g., including a first microphone, one or more processors, and a memory.

[0020] In one or more example audio devices, the audio device may comprise one or more interfaces, one or more processors, and one or more memories. Further, the audio device may comprise one or more microphones, such as a first microphone, optionally a second microphone, optionally a third microphone and optionally a fourth microphone. The audio device may comprise

one or more audio speakers, such as audio receivers, e.g., loudspeaker(s).

[0021] The processor comprises a first decoder and a receiver configuration controller.

[0022] A decoder as disclosed herein, such as the first decoder and/or a second decoder, may be implemented as hardware and/or software on the audio device. A decoder as disclosed herein may be seen as a module configured to convert and/or decode an input signal from a transmitter device to a decoder output signal. In other words, a decoder may be configured to decompress an input signal from a transmitter device. For example, a decoder may be configured to convert and/or decode an input signal from a transmitter device to an audio signal.

[0023] The receiver configuration controller as disclosed herein may also be denoted a parameter setup module. The receiver configuration controller may be configured to determine and/or set a receiver configuration at the audio device. In other words, the receiver configuration controller may be configured to determine a set of receiver configuration parameters that the audio device is configured to operate according to. For example, the receiver configuration controller may be configured to determine a receiver configuration comprising a set of receiver configuration parameters that a signal processor, such as a first signal processor and/or a second signal processor, of the audio device is configured to operate according to.

[0024] The audio device may be seen as an audio device configured to obtain input signals, such as audio signals, output audio signals, and process input signals, such as audio signals. The audio device may be seen as or comprise a headset, a speakerphone, and/or a videobar. The audio device may for example be seen as a conference audio device, e.g., configured to be used by a party (such as one or more users at a near-end) to communicate with one or more other parties (such as one or more users at a far-end). The audio device configured to act as a receiver device may also be configured to act as a transmitter device when transmitting back an output signal to the far-end. The receiver audio device and the transmitter audio device may therefore switch between being receiver audio device and transmitter audio device. The audio device may be seen as a smart audio device. The audio device may be used for a conference and/or a meeting between two or more parties being remote from each other. The audio device may be used by one or more users in a vicinity of where the audio device is located, also referred to as a near-end. The audio device may be configured to output, such as using the audio speaker and based on the input signal, an audio device output at the receiver end. The audio device output may be seen as an audio output signal that is an output of the audio speaker at a near-end where the audio device and the user(s) of the audio device are located.

[0025] The audio device may be a single audio device. The audio device may be seen as a plurality of interconnected audio devices, such as a system, e.g., an audio device system. The system may comprise one or more users. It is noted that the term speaker may be seen as the user of the audio device.

[0026] In one or more example audio devices, the interface comprises a wireless transceiver, also denoted as a radio transceiver, and an antenna for wireless transmission and reception of an input signal, such as an audio signal, such as for wireless transmission of an output signal and/or wireless reception of a wireless input signal. The audio device may be configured for wireless communication with one or more electronic devices, such as another audio device, a smartphone, a tablet, a computer and/or a smart watch. The audio device optionally comprises an antenna for converting one or more wireless input audio signals to antenna output signal(s). The audio device system and/or the audio device, may be configured for wireless communications via a wireless communication system, such as short-range wireless communications systems, such as Wi-Fi, Bluetooth, Zigbee, IEEE 802.11, IEEE 802.15, infrared and/or the like.

[0027] The audio device system and/or the audio device, may be configured for wireless communications via a wireless communication system, such as a 3GPP system, such as a 3GPP system supporting one or more of: New Radio, NR, Narrow-band IoT, NB-IoT, and Long Term Evolution - enhanced Machine Type Communication, LTE-M, millimeter-wave communications, such as millimeter-wave communications in licensed bands, such as device-to-device millimeter-wave communications in licensed bands.

[0028] In one or more example audio device systems and/or audio devices, the interface of the audio device comprises one or more of: a Bluetooth interface, Bluetooth low energy interface, and a magnetic induction interface. For example, the interface of the audio device may comprise a Bluetooth antenna and/or a magnetic interference antenna.

[0029] In one or more example audio devices, the interface may comprise a connector for wired communication, via a connector, such as by using an electrical cable. The connector may connect one or more microphones to the audio device. The connector may connect the audio device to an electronic device, e.g., for wired connection. The connector may be seen as an electrical connector, such as a physical connector for connecting the audio device via an electrical wire to another device.

[0030] The one or more interfaces can be or comprise wireless interfaces, such as transmitters and/or receivers, and/or wired interfaces, such as connectors for physical coupling. For example, the audio device may have an input interface configured to receive data, such as a microphone input signal. In one or more example audio devices, the audio device can be used for all form factors in all types of environments, such as for headsets and/or video conference equipment. For example, the audio device may not have a specific microphone placement requirement. In one or more example audio devices, the audio device may comprise an external microphone.

[0031] An audio device configured to act as a receiver device, the audio device comprising an interface, an audio speaker, and a microphone, the audio device comprising a processor and a memory, the processor comprising a first decoder and a receiver configuration controller, wherein the audio device is configured to: obtain an input signal from a transmitter device, where the input signal comprises audio; obtain, based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio; determine, based on the first signal parameter, a receiver configuration; and control, based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder.

[0032] The audio device is configured to obtain, such as using the processor and/or via the interface, an input signal from a transmitter device. In one or more example audio devices, the audio device is configured to obtain the input signal from a far-end, such as a far-end party or user(s). In other words, the transmitter device may be seen as an audio device at a far-end. The input signal comprises audio. In one or more embodiments or examples, the input signal has undergone signal processing, such as encoding, compression, and/or enhancement, at the transmitter device. The input signal may be indicative of an audio signal generated by user(s) at the far-end. In other words, the input signal may be indicative of speech, such as speech from the far-end transmitter device. The input signal may be based on and/or be seen as an output signal of the transmitter device, such as of a signal processor of the transmitter device.

[0033] The audio device is configured to obtain, such as based on the input signal, one or more signal parameters. The one or more signal parameters comprise a first signal parameter indicative of signal information of the audio. The signal information may be seen as and/or denoted as side information, such as side information regarding the signal processing of the input signal at the transmitter device. In other words, the signal parameter, such as the first signal parameter, may be indicative of information regarding the signal processing of the input signal at the transmitter device, such as indicative of information regarding the signal processing of the audio at the transmitter device. The signal parameter, such as the first signal parameter, may comprise one or more features regarding the signal processing of the input signal at the transmitter device. The signal parameter, such as the first signal parameter, may be indicative of signal information regarding an encoding, a compression, and/or an enhancement of the input signal at the transmitter device.

[0034] To obtain the one or more signal parameters may comprise to determine, retrieve, and/or receive the one or more signal parameters, such as the first signal parameter. To obtain the one or more signal parameters may comprise to determine the one or more signal parameters at the audio device based on the input signal. In one or more example audio devices, to obtain the one or more signal parameters may comprise to retrieve, and/or receive the one or more signal parameters from the transmitter device, e.g., based on the input signal.

[0035] In one or more example audio devices, the first signal parameter is a signal-to-noise ratio, a confidence probability map, a quality representation, or a mean opinion score. In one or more example audio devices, the first signal parameter is a signal-to-noise ratio of the input signal, a confidence probability map of the input signal, a quality representation of the input signal, or a mean opinion score of the input signal. In other words, the first signal parameter is indicative of signal information regarding one or more of: a signal-to-noise ratio of the input signal, a confidence probability map of the input signal, a quality representation of the input signal, and a mean opinion score of the input signal. A conference probability map (Time-Frequency, T-F, map) may indicate the confidence of a denoised signal, for example the reliability of a gain time-frequency, T-F, map. The mean opinion score may be seen as a predicted mean opinion score, such as a predicted mean opinion score quality prediction. For example, the mean opinion score may be determined based on an intrusive method, e.g., by comparing the input signal with a reference signal, such as reference audio signal. Alternatively or additionally, the mean opinion score may be determined based on a non-intrusive method, e.g., by performing a blind prediction, such as using a pre-trained neural network dedicated to MOS scores and/or alternative scores estimation.

[0036] In one or more example audio devices, the first signal parameter comprises entity, such as an entity of the transmitter device, information of the input signal. In one or more example audio devices, the first signal parameter comprises a direct-to-reverberation ratio (DRR), a coherence-to-diffuse ratio (CDR), a spatial noise coherence, a room impulse response, a noise/speech/jammer level/direction, a transcript of the audio of the input signal. The direct-to-reverberation ratio (DRR), coherence-to-diffuse ratio (CDR), spatial noise coherence, room impulse response, and noise/speech/jammer level/direction may be associated with the room and/or location where the transmitter is located.

[0037] The receiver configuration controller may be configured to use the first signal parameter, e.g., being a signal-to-noise ratio, a confidence probability map, a quality representation, and/or a mean opinion score, to determine, such as target, regions of the input signal that may be processed more or less by the first signal processor and/or the second signal processor.

[0038] For example, the receiver configuration controller may be configured to use the first signal parameter, e.g., being a signal-to-noise ratio, a confidence probability map, a quality representation, and/or a mean opinion score, to determine, such as target, regions of the input signal having low signal-to-noise ratio and/or low mean opinion score that may be processed more by the first signal processor than regions of the input signal having

lower signal-to-noise ratio and/or higher mean opinion score. It may be appreciated that by removing and/or reducing the processing of regions with higher signal-to-noise ratio and/or higher mean opinion score by the first signal processor, the audio device may reduce the introduction of noise and artifacts in the input signal when being processed at the receiver device. It may be appreciated that by guiding the processing carried out by the first signal processor, the audio device may reduce the introduction of noise and artifacts in the processing of the input signal at the receiver device. In other words, by guiding the processing carried out by the first signal processor, the audio device may reduce the introduction of noise and artifacts in the receiver output signal.

[0039] For example, the receiver configuration controller may be configured to use the first signal parameter, e.g., being a signal-to-noise ratio, a confidence probability map, a quality representation, and/or a mean opinion score, to determine, such as target, regions of the T-F spectrum of the input signal that may be processed more by the second signal processor than other regions of the input signal. It may be appreciated that by removing and/or reducing the processing of regions of the T-F spectrum of the input signal, the audio device may provide a more accurate T-F mask output of the second signal processor output signal, e.g., more accurate according to one more metrics and/or to human perception, when being processed at the receiver device.

[0040] The above example may be applied when the first signal processor comprises a bandwidth extender, such as a bandwidth extender configured to operate according to a generative model based on Generative Adversarial Networks (GANs), which may also perform reduction of noise of the first signal processor input signal. For example, for regions of the input signal already having high signal-to-noise ratio and/or high mean opinion score, the first signal processor may not need to perform noise reduction since it may compromise the input signal. The first signal processor may compromise the input signal by needlessly introducing artefacts and other processing defects into the processing of the input signal. The first signal processor may compromise the input signal by removing regions of the input signal having high signal-to-noise ratio and/or high mean opinion score and try to regenerate these regions.

[0041] The above example may be applied when the second signal processor comprises a denoiser and/or an echo controller, such as a deep noise reduction, DNS, denoiser configured to operate according to a neural network, NN, where the first signal parameter may be used to remove and/or reduce the masking of regions of the T-F spectrum of the input signal and let the entire input signal (e.g., speech signal including noise) through in the regions where the signal-to-noise ratio and/or higher mean opinion score is high. For example, for regions of the input signal already having high signal-to-noise ratio and/or high mean opinion score, the second signal processor may not need to perform noise reduction since it may compromise the input signal by removing too much of the input signal, or by introducing processing artefacts.

[0042] The one or more signal parameter, such as the first signal parameter, as disclosed herein may be binary or weighted. For example, the signal-to-noise ratio, the confidence probability map, the quality representation, and/or the mean opinion score may be normalized in a [0,1] interval. The audio device, such as the receiver configuration controller, may then be configured to determine a receiver configuration based on the normalized signal parameter(s). In other words, the audio device, such as receiver configuration controller, may be configured to control the processing of the decoder output signal, e.g., by the first signal processor and/or the second signal processor, based on the normalized signal parameter(s). For example, the audio device may be configured to control the second signal processor to suppress the masking in regions of the T-F spectrum of the input signal based on the normalized interval of the signal parameter(s).

[0043] In one or more example audio devices, the input signal comprises one or more audio signals and the first signal parameter. In other words, the first signal parameter may be determined at the transmitter device and comprised in the input signal when transmitted to the audio device at receiver end. It may be appreciated that the first decoder may be configured to decode, extract, and/or obtain the one or more audio signals and/or the first signal parameter from the input signal.

[0044] In one or more example audio devices, the processor comprises a signal feature extractor. In one or more example audio devices, to obtain the one or more signal parameters comprises to extract the one or more signal parameters from the input signal by using the signal feature extractor. It may be appreciated that the audio device may be configured to extract the first signal parameter from the input signal by using signal feature extractor. For example, the audio device may be configured to extract one or more of a signal-to-noise ratio, a confidence probability map, a quality representation, and a mean opinion score from the input signal by using signal feature extractor. In one or more example audio devices, to obtain the one or more signal parameters comprises to extract the one or more signal parameters from the decoder output signal by using the signal feature extractor. In other words, the feature extractor is configured to receive the decoder output signal as a feature extractor input signal for providing a feature extractor output signal. The feature extractor output signal may then be transmitted to the receiver configuration controller. In other words, the audio device may be configured to determine the receiver configuration based on the feature extractor output signal by using the receiver configuration controller. The feature extractor may be configured to extract features by using ML-based methods and/or signal processing-based methods. For example, a feature may be extractor by the feature extractor by performing one or more operations on spectrograms, such as combining spectrograms.

[0045] In one or more example audio devices, to obtain the input signal comprises to obtain a first input signal via a first channel using a first decoder and to obtain a second input signal via a second channel using a second decoder. In one or more example audio devices, the second input signal comprises the first signal parameter. In other words, the first input signal may comprise one or more audio signals and/or one or more signal parameters and the second input signal may comprise the first signal parameter. It may be appreciated that the audio device may obtain the first signal parameter via a dedicated channel (the second channel) different from the first channel via which the audio signals are obtained. In one or more example audio devices, the first decoder may be configured to bandwidth extend the first input signal from a narrow band signal to broader band signal. In one or more example audio devices, the second decoder is configured to decode the second input signal for providing a second decoder output signal. The second decoder may be configured to decode one or more signal parameters based on the second input signal for providing the first signal parameter. The first signal parameter may be comprised in the second decoder output signal. An advantage of obtaining a second input signal comprising the first signal parameter via a second channel is that the second decoder may work on a longer time scale dependent on the signal parameter(s) (e.g., depending on the extracted features), and at a lower bit rate, e.g., 20kbps. On the other hand, the first decoder may be working in real-time or near real-time. By having a second decoder dedicated to obtain the signal parameter(s), such as the first signal parameter, it may be possible to save power and/or computational power.

[0046] The audio device is configured to determine, based on the first signal parameter, a receiver configuration. In one or more example audio devices, the audio device is configured to determine the receiver configuration using the receiver configuration controller and based on the first signal parameter. The receiver configuration may comprise a set of receiver configuration parameters that the audio device is configured to operate according to. It may be appreciated that the receiver configuration may comprise at least a first receiver configuration parameter. For example, to determine the receiver configuration may comprise to determine a first range of the input signal to be processed by the first signal processor and a second range of the input signal to be processed by the second signal processor. In other words, to determine the receiver configuration may comprise to determine a first range of T-F regions to be processed by the first signal processor and a second range of T-F regions to be processed by the second signal processor.

[0047] In one or more example audio devices, the audio device is configured to obtain, based on the first input signal, one or more signal parameters indicative of input signal information, the one or more signal parameters comprising a second signal parameter. In other words, the audio device is configured to obtain different signal parameters via the first channel than via the second channel. For example, the second signal parameter may be indicative of information regarding the audio signal(s) obtained with the first input signal.

[0048] In one or more example audio devices, the audio device is configured to determine the receiver configuration based on the second signal parameter. In one or more example audio devices, the audio device is configured to determine the receiver configuration based on the first signal parameter and the second signal parameter. In one or more example audio devices, the audio device may be configured to determine the first receiver configuration parameter based on the first signal parameter and/or the second signal parameter.

[0049] The audio device is configured to control, based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder. In other words, the audio device is configured to control a processing by the processor of a decoder output signal from the first decoder based on the receiver configuration and using the receiver configuration controller. The decoder output signal may be based on the input signal. In other words, the decoder output signal may be seen as a decoded input signal. The first decoder may be configured to process, such as decode, the input signal for provision of the decoder output signal. The input signal may also be seen as a decoder input signal. To control a processing of a decoder output signal from the first decoder may comprise to apply the receiver configuration to the controlling of the processing of the decoder output signal using the receiver configuration controller. To control a processing of a decoder output signal from the first decoder may comprise to transmit control signals from the receiver configuration controller to the processor based on the receiver configuration. In one or more example audio devices, to control a processing of a decoder output signal from the first decoder may comprise to transmit control signals from the receiver configuration controller to a first signal processor and/or a second signal processor based on the receiver configuration. By controlling the processing of the decoder output signal based on the receiver configuration it may be possible to perform informed control the processing of the decoder output signal based on the receiver configuration. In other words, by controlling the processing of the decoder output signal based on the receiver configuration it may be possible to perform informed control the processing of the decoder output signal based on the first signal parameter.

[0050] In one or more example audio devices, the audio device is configured to determine a receiver output based on the controlling of the processing of the decoder output signal.

[0051] In one or more example audio devices, to determine the receiver configuration comprises to determine one or more receiver configuration parameters including a first receiver configuration parameter. To determine the receiver configuration may comprise to de-

termine one or more receiver configuration parameters including a set of receiver configuration parameters. The set of receiver configuration parameters may comprise a first receiver configuration parameter, a second receiver configuration parameter, a third receiver configuration parameter, and/or a fourth receiver configuration parameter. In one or more example audio devices, the audio device is configured to control the processing of the decoder output signal based on the first receiver configuration parameter. In other words, the audio device is configured to control a processing by the processor of a decoder output signal from the first decoder based on the first receiver configuration parameter and using the receiver configuration controller. To control a processing of a decoder output signal from the first decoder may comprise to apply the first receiver configuration parameter to the controlling of the processing of the decoder output signal using the receiver configuration controller. To control a processing of a decoder output signal from the first decoder may comprise to transmit control signals from the receiver configuration controller to the processor based on the first receiver configuration parameter. In one or more example audio devices, to control a processing of a decoder output signal from the first decoder may comprise to transmit control signals from the receiver configuration controller to a first signal processor and/or a second signal processor based on the first receiver configuration parameter.

[0052] In one or more example audio devices, the one or more receiver configuration parameters comprise one or more of: a codec parameter, a user parameter, and a mode parameter. In other words, the first receiver configuration parameter may be: a codec parameter, a user parameter, or a mode parameter.

[0053] A codec parameter may be seen as a bit-rate that the transmitter device functions at. For example, the transmitter device may function at a bit rate being a narrow-band mode, a wide-band mode, or a super-wideband/full-band mode. It may be appreciated that the transmitter device may function at any other bit-rate that the codec supports. A codec parameter may comprise a latency and/or a sampling frequency. The latency may for example be used for certain applications, e.g., gaming/3D audio demand for ultra-low latency and sampling frequency and bit-width may for example be used for high-resolution music quality. A codec parameter may be indicative of and/or comprise a Bluetooth codec. It may be appreciated that different codec configuration settings may be selected to support different sampling frequencies and bit-rates, hence different quality for the transmitted signal from the transmitter device, e.g., the input signal.

[0054] A user parameter may be indicative of information associated with the target receiver at the receiver device end. In other words, a user parameter may be indicative of information associated with a user at the receiver audio device. For example, a user parameter may be indicative of and/or comprise a hearing profile of a user at the receiver device end and/or his/her preference regarding the played-back audio, e.g., in terms of distortions, noise attenuation, and/or echo annoyance which is subjective to the target user. Alternatively and/or additionally, a user parameter may be indicative of information associated with the transmitter device, such as transmitter end. For example, a user parameter may be indicative of intended audio quality and/or modification/adjustment that the transmitter device wants to submit towards the receiver device, e.g., so that the receiver end hears the picked-up signal (input signal) in that particular fashion. For example, a user parameter may be indicative of settings such as extra bass, denoising, preferred bandwidth selected by the user at the transmitter device, and/or a target language that the transmitter device and/or the receiver device have access to and/or play at the received end.

[0055] A mode parameter may be indicative of information associated with augmented hearing settings and/or near-end (receiver device end) listening enhancement settings. Augmented hearing settings and/or near-end (receiver device end) listening enhancement settings may for example balance the input signal at the receiver device differently, such as balance the played-back audio at the receiver differently. A mode parameter may be indicative of information associated with spatialization and/or externalization of the sound at the receiver device. Spatialization and/or externalization may allow an immersive sound experience, which can be set as the mode to be applied at the receiver device. These may for example be used to improve the hear-through mode of an audio device.

[0056] In one or more example audio devices, the processor comprises a first signal processor configured to operate according to a generative model for generative-based signal processing. In one or more example audio devices, the first signal processor comprises a bandwidth extender. The first signal processor, such as the bandwidth extender, may be configured to regenerate part of or a whole audio signal from the transmitter device based on the input signal and the first signal parameter. For example, the first signal processor, such as the bandwidth extender, may be configured to regenerate an audio signal with extended bandwidth and/or reduced level of noise. The first signal processor may be configured to operate according to a generative model based on Generative Adversarial Networks (GANs), e.g., using a Wavenet generator and/or two deep convolutional discriminators operating at different time domains, respectively time domain and T-F domain. It may be appreciated that the first signal processor may be configured to extend a bandwidth of the first signal processor input signal and to reduce the noise of the first signal processor input signal based on the receiver configuration.

[0057] In one or more example audio devices, the first signal processor is configured to operate according to a non-generative model for non-generative based signal processing. Thereby, both the first signal processor and

the second signal processor may be configured to operate according to non-generative models with different characteristics that may take into account the weaknesses of each other. For example, the first signal processor and the second signal processor may be used for the same purpose, e.g., noise reduction, however, the first signal processor may be trained with a "light" loss function not trained to punish noise harshly, e.g., to keep audio cues and avoid introducing excessive processing artifacts. Such a light loss function may be used to process regions with a higher SNR. The second signal processor may be trained with a "harsh" loss function trained to punish noise harshly. Such a harsh loss function may be used to process regions with a lower SNR.

[0058] In one or more example audio devices, the first signal processor is configured to process a first signal processor input signal for provision of a first signal processor output signal. For example, when the first signal processor comprises a bandwidth extender, the bandwidth extender is configured to process a first bandwidth extender input signal for provision of a first bandwidth extender output signal. The audio device may be configured to output an audio device output based on the first signal processor output signal. In one or more example audio devices, the first signal processor output signal may be seen as the audio device output. In one or more example audio devices, the first signal processor output signal may be seen as a second signal processor input signal.

[0059] In one or more example audio devices, the first signal processor input signal is based on the decoder output signal. In one or more example audio devices, the first signal processor input signal may be based on and/or correspond to the decoder output signal. In other words, the first signal processor receives and/or obtains the decoder output signal directly from the first decoder.

[0060] In one or more example audio devices, to control the processing of the decoder output signal comprises to control, based on the receiver configuration, the first signal processor. In other words, to control the processing of the decoder output signal comprises to control a processing of the first signal processor input signal by the first signal processor based on the receiver configuration. For example, when the first signal processor comprises a bandwidth extender, to control the processing of the decoder output signal comprises to control a processing of a bandwidth extender input signal by the bandwidth extender based on the receiver configuration. A bandwidth extender may be seen as a module configured to extend a band of the input signal, such as of the decoder output signal, and/or to regenerate corrupted content within a current band of the input signal, such as of the decoder output signal. In one or more example audio devices, to control the processing of the decoder output signal comprises to control the first signal processor based on the one or more receiver configuration parameters, such as based on the first receiver configuration parameter. In one or more example audio devices, to control the processing of the decoder output signal comprises to control the first signal processor based on one or more of the codec parameter, the user parameter, and the mode parameter. In other words, it may be possible to perform informed control of the processing of the first signal processor based on the receiver configuration. For example, it may be possible to control the bandwidth extender based the signal quality of the input signal, such as based on one or more quality features of the input signal.

[0061] The first signal processor, such as the bandwidth extender, may be configured to selectively improve the quality of degraded regions of the received input signal which has been processed by a signal processor performing denoising either at the transmitter device and/or at the receiver device. The first signal processor may for example be configured to modify and/or predict low-SNR regions of the input signal, but also re-introduce missing information on the missing frequencies in the input signal, based on the first signal parameter and/or the receiver configuration. In other words, the first signal processor, such as the bandwidth extender, may be configured to regenerate corrupted content within the band of the input signal, such as of the decoder output signal. For example, the first signal parameter may provide information indicative of a range and/or a union of subset frequencies as candidate corrupted regions and/or missing frequency bands for the first signal processor to restore the quality of the input signal. For example, a quality score, such as mean opinion score, MOS, can be a matrix of T-F points, each having a different score. It may be appreciated that a quality threshold set by at the transmitter device, (e.g., related to the user, factory, environment etc.) may promote a low-score region to a corrupted region. It may be appreciated that the first signal processor, such as the bandwidth extender, may substantially restore the original signal quality of the input signal, e.g., based on information indicative of the signal bandwidth of the input signal, signal-to-noise ratio of the input signal, a confidence probability map of the input signal, a quality representation of the input signal, and/or a mean opinion score of the input signal. This may for example not be possible by using deep noise reduction, DNS, only, e.g., due to limited achievable performance of e.g., mask-based deep noise reduction, DNS, methods. The first signal processor, such as the bandwidth extender, may be configured to extend the bandwidth of the input signal from Wide-Band, WB, at 8 kHz to e.g., Super Wide Band, SWB, at 12 kHz, Semi Super Wide Band, SSWB, at 16 kHz, and/or Full-Band, FB, at 24 kHz.

[0062] In one or more example audio devices, the audio device is configured to determine a receiver output based on the first signal processor output signal.

[0063] In one or more example audio devices, to process the first signal processor input signal comprises to extend, using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal. In other words, to process the first

signal processor input signal comprises to extend, using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal for provision of a first signal processor output signal having an extended bandwidth. In one or more example audio devices, to process the first signal processor input signal comprises to extend a bandwidth of the first signal processor input signal using the bandwidth extender and based on the receiver configuration. For example, to process the first signal processor input signal comprises to extend a bandwidth of the first signal processor input signal based on the one or more receiver configuration parameters, such as based on the first receiver configuration parameter. In one or more example audio devices, to process the first signal processor input signal comprises to extend a bandwidth of the first signal processor input signal based on one or more of the codec parameter, the user parameter, and the mode parameter. To extend a bandwidth of the first signal processor input signal may comprise to extend a bandwidth of the decoder output signal, such as extend a bandwidth of the input signal.

[0064] In one or more example audio devices, to process the first signal processor input signal comprises to reduce, using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal. In other words, to process the first signal processor input signal comprises to reduce, using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal for provision of a first signal processor output signal with reduced noise. For example, to process the first signal processor input signal comprises to denoise, using the first signal processor and based on the receiver configuration, the first signal processor input signal, e.g., for provision of a denoised first signal processor output signal. It may be appreciated that to process the first signal processor input signal comprises to reduce a noise of the first signal processor input signal using the bandwidth extender and based on the receiver configuration. In one or more example audio devices, the first signal processor is configured to extend a bandwidth of the first signal processor input signal and to reduce a noise of the first signal processor input signal based on the receiver configuration. For example, the first signal processor may be configured to enhance T-F regions of the input signal which are degraded in noise and/or distortions due to the channel. This may for example not be possible by using deep noise reduction, DNS, only, e.g., due to limited achievable performance of e.g., mask-based deep noise reduction, DNS, methods.

[0065] In one or more example audio devices, the processor comprises a second signal processor configured to operate according to a non-generative model for non-generative-based signal processing. In one or more example audio devices, the second signal processor comprises a denoiser and/or an echo controller. An echo controller may be seen as a module configured to perform linear echo cancellation and/or residual echo cancellation. The second signal processor may be seen as and/or denoted a deep noise reductor, such as a module using deep noise reduction, DNS. It may be appreciated that the second signal processor may be configured to generate a time-frequency e.g., to enhance one or more characteristics of the input signal, such as enhance the decoder output signal. The second signal processor may be configured to operate according to a non-generative model comprising two Gates Recurrent Units, GRUs, and fully connected dense layers. The second signal processor may be configured to improve signal processing in wide-band mode (WB), in Super Wide-band mode (SWB), and/or in Full-Band mode (FB).

[0066] In one or more example audio devices, the second signal processor is configured to operate according to a generative model for generative based signal processing. For example, when the first signal processor is configured to operate according to a generative model based on Generative Adversarial Networks (GANs), e.g., for performing bandwidth extension, the second signal processor may be configured to operate according to a generative diffusion model, e.g., for performing denoising, such as deep noise reduction, and/or echo cancelling. Thereby, both the first signal processor and the second signal processor may be configured to operate according to generative models with different characteristics that may take into account the weaknesses of each other. For example, the first signal processor may add and/or restore missing information by using the generative model based on GANs and the second signal processor may remove Gaussian noise to reveal new information by using the generative diffusion model. In other words, the first signal processor may add and/or restore missing information by using the generative model based on GANs and the second signal processor may remove Gaussian noise in a process guided by a conditioner, e.g., a neural network configured to aim the generative model towards a desired output.

[0067] In one or more example audio devices, the second signal processor is configured to process a second signal processor input signal for provision of a second signal processor output signal. For example, when the second signal processor comprises a denoiser and/or an echo controller, the denoiser and/or an echo controller are configured to process the second signal processor input signal for provision of the second signal processor output signal. The audio device may be configured to output an audio device output based on the second signal processor output signal. In one or more example audio devices, the second signal processor output signal may be seen as the audio device output. In one or more example audio devices, the second signal processor output signal may be seen as a first signal processor input signal. In one or more example audio devices, the audio device may be configured to output an audio device output based on the first signal processor output signal and the second signal processor output signal.

[0068] In one or more example audio devices, the audio device is configured to determine a receiver output, such as an audio device output signal, based on the first signal processor output signal and/or the second signal processor output signal. By combining the processing of the first signal processor and the second signal processor the signal processing of the input signal, such as of the decoder output signal, may be improved. For example, by combining the processing of the first signal processor, e.g., comprising a bandwidth extender, and the second signal processor, e.g., comprising a denoiser and/or an echo controller, the deep noise reduction signal processing of the input signal, such as of the decoder output signal, may be enhanced. It may be appreciated that by combining the processing of the first signal processor, e.g., comprising a bandwidth extender, and the second signal processor, e.g., comprising a denoiser and/or an echo controller, the second signal processor may require less performance, such as less computational power, than currently know DNS solutions. The output from the first signal processor and second signal processor may be enhanced both in terms of residual noise and overall perceived quality in comparison with the input signal. To combine the processing of the first signal processor and the second signal processor based on the first signal parameter and/or based on the receiver configuration, may be seen as integrating bandwidth extension and deep noise reduction based on side information on the audio signal and/or input signal obtained from the transmitter device. It may be appreciated that the combination of the processing of the first signal processor and the second signal processor based on the first signal parameter and/or based on the receiver configuration may provide a synergistic combination of signal processing between the first signal processor and the second signal processor.

[0069] In one or more example audio devices, the second signal processor input signal is based on the decoder output signal. In one or more example audio devices, the second signal processor input signal may be based on and/or correspond to the decoder output signal. In other words, the second signal processor is configured to receive and/or obtain the decoder output signal directly from the first decoder.

[0070] In one or more example audio devices, the first signal processor input signal is based on a first part of the decoder output signal and the second signal processor input signal is based on a second part of the decoder output signal. In other words, the first signal processor and the second signal processor may be configured to process sub-parts of the input signal, such as sub-parts of the decoded input signal from the first decoder. In one or more example audio devices, the receiver configuration controller may be configured to determine, based on the first signal parameter, which parts of the input signal are to be processed by the first signal processor and which parts of the input signal are to be processed by the second signal processor. In other words, the receiver configuration controller may be configured to determine, based on the first signal parameter, which parts of the decoder output signal are to be processed by the first signal processor and which parts of the decoder output signal are to be processed by the second signal processor. The receiver configuration controller may be configured to determine one or more receiver configuration parameters, such as the first receiver configuration parameter, to determine which parts of the decoder output signal are to be processed by the first signal processor and which parts of the decoder output signal are to be processed by the second signal processor. In one or more example audio devices, the first signal processor and the second signal processor are configured to process sub-parts of the input signal, such as sub-parts of the decoder output signal, in parallel.

[0071] In one or more example audio devices, the first signal processor output signal and the second signal processor output signal may be combined for generating and/or determining the audio device output. In one or more audio devices, the audio device, such as the processor, comprises a mixer configured to combine the first signal processor output signal and the second signal processor output signal for provision of the receiver output signal. The mixer may for example be configured to add the first signal processor output signal with the second signal processor output signal for provision of the receiver output signal.

[0072] In one or more example audio devices, to control the processing of the decoder output signal comprises to control, based on the receiver configuration, the second signal processor. In other words, to control the processing of the decoder output signal comprises to control a processing of the second signal processor input signal by the second signal processor based on the receiver configuration. For example, when the second signal processor comprises a denoiser and/or an echo controller, to control the processing of the decoder output signal comprises to control a processing of a denoiser input signal and/or an echo controller input signal by the denoiser and/or an echo controller based on the receiver configuration. In one or more example audio devices, to control the processing of the decoder output signal comprises to control the second signal processor based on the one or more receiver configuration parameters, such as based on the first receiver configuration parameter. In one or more example audio devices, to control the processing of the decoder output signal comprises to control the second signal processor based on one or more of the codec parameter, the user parameter, and the mode parameter.

[0073] In one or more example audio devices, the first signal processor and/or the second signal processor comprise machine learning circuitry configured to operate according to a machine learning model, such as generative model and/or a non-generative model. In one or more example audio devices, to process a signal processor input signal, such as the first signal processor input

signal and/or the second signal processor input signal, comprises to process the signal processor input signal, based on the receiver configuration, using the machine learning model and/or machine learning circuitry.

[0074] In other words, the audio device may comprise one or more processors comprising a machine learning engine configured to operate according to the machine learning model. The machine learning circuitry may be seen as a predictor circuitry configured to operate according to a prediction model. The machine learning circuitry may be configured to predict, based on the decoder output signal and/or the receiver configuration, one or more signal processing steps using the prediction model.

[0075] The machine learning model may for example comprise or make use of a neural network, artificial intelligence, deep learning, and/or machine learning. The machine learning model may be seen as a model for signal processing.

[0076] In one or more example audio devices and/or audio device systems, the machine learning model comprises model layers including an input layer, one or more intermediate layers, and an output layer for processing of the decoder output signal, such as the input signal. In one or more example audio devices and/or audio device systems, the machine learning model comprises a neural network. In one or more example audio devices and/or audio device systems, the machine learning model comprises neural network layers including an input layer, one or more intermediate layers, and an output layer for processing of the decoder output signal, such as the input signal. In other words, the input layer, the one or more intermediate layers, and/or the output layer may be seen as layers of a machine learning model such as layers of a neural network. The one or more intermediate layers may be considered as hidden layers (such as hidden features). The one or more intermediate layers may include a first intermediate layer.

[0077] A model as referred to herein (such as the machine learning model) may be seen as a model and/or a scheme and/or a mechanism and/or a method configured to process, based on operational data (such as one or more receiver configurations) and/or a previous model, one or more input signals, such as decoder output signal and/or signal processor input signals.

[0078] In one or more example audio devices and/or audio device systems, a model as referred to herein may be stored on a non-transitory storage medium (for example, on the memory of the audio device). The model may be stored on a non-transitory storage medium of the audio device being configured to execute the model. In one or more example audio devices and/or audio device systems, the model may comprise model data and or computer readable instructions (for example based on the receiver configuration). The model data and/or the computer readable instructions may be used by the audio device. The model (such as model data and/or the computer readable instructions) may be used by the audio device to process the decoder output signal, such as the input signal.

[0079] In one or more example audio devices, the second signal processor is configured to process the first signal processor output signal for provision of a receiver output signal. In other words, the first signal processor output signal may be seen as the second signal processor input signal. The receiver output signal may also be seen as and/or denoted as the audio device output signal as described herein. The receiver output signal may be seen as an enhanced output signal based on the first signal parameter indicative of signal information of the audio. In one or more audio devices, the first signal processor is configured to restore the missing frequencies in the input signal, such as in the decoder output signal, and then provide the first signal processor output signal to the second signal processor. The first signal processor may be configured to use the bandwidth extender to restore the missing frequencies in the input signal, such as in the decoder output signal. Furthermore, the first signal processor may be configured to perform an initial signal enhancement, such as noise reduction and/or denoising, of the input signal before the second signal processor finalizes the noise reduction, such as denoising, e.g., using a mask-based method. Signal enhancement may be seen as beamforming, dereverberation, noise suppression/reduction, echo cancellation, artificial bandwidth extension.

[0080] In one or more example audio devices, to process the second signal processor input signal to reduce, using the second signal processor and based on the receiver configuration, a noise of the second signal processor input signal. In other words, to process the second signal processor input signal comprises to reduce, using the second signal processor and based on the receiver configuration, a noise of the second signal processor input signal for provision of a second signal processor output signal with reduced noise. For example, to process the second signal processor input signal comprises to denoise, using the second signal processor and based on the receiver configuration, the second signal processor input signal, e.g., for provision of a denoised first signal processor output signal. It may be appreciated that to process the second signal processor input signal comprises to reduce a noise of the second signal processor input signal using the denoiser and/or the echo controller and based on the receiver configuration.

[0081] In one or more example audio devices, to reduce the noise of the second signal processor input signal comprises to reduce the noise of the second signal processor input signal based on a mask-based method. For example, the second signal processor is configured to reduce the noise of the second signal processor input signal based on a mask-based method using the denoiser.

[0082] An audio device configured to act as a transmitter device is disclosed. In other words, the audio device is configured to transmit output signals to an audio device configured to act as a receiver device. The audio

device comprises an interface, an audio speaker, a microphone, a processor, and a memory. The processor may comprise a signal processor, a feature extractor, and a first encoder. The signal processor may be seen as a transmitter signal processor. The feature extractor may be seen as a transmitter feature extractor. In one or more audio devices, the feature extractor comprises a bandwidth detector. An encoder as disclosed herein, such as the first encoder and/or a second encoder, may be implemented as hardware and/or software on the audio device. An encoder as disclosed herein may be seen as a module configured to convert and/or encode an audio signal to an output signal to be transmitted to a receiver device. In other words, an encoder may be configured to compress an audio signal at the transmitter device to an output signal. For example, an encoder may be configured to convert and/or encode an audio signal to an output signal to be transmitted to an audio device.

[0083] The audio device is configured to obtain, via the microphone, a microphone input signal. The microphone input signal may be indicative of an audio signal generated by user(s) at the far-end (such as transmitter end). In other words, the microphone input signal may be indicative of speech, such as speech from the far-end transmitter device.

[0084] The audio device is configured to determine, based on the microphone input signal and using the signal processor, a signal processor output signal. In one or more embodiments or examples, the microphone input signal has undergone signal processing, such as encoding, compression, and/or enhancement, at the transmitter device, e.g., using the signal processor.

[0085] The audio device is configured to obtain, based on the signal processor output signal and using the feature extractor, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor output signal. The audio device may be configured to extract one or more transmitter signal parameters, such as the first transmitter signal parameter, from the microphone input signal and/or the signal processor output signal using the feature extractor. The audio device may be configured to include the one or more signal parameters, e.g., including the first signal parameter, in the transmitter output signal.

[0086] The audio device is configured to encode, using the first encoder, the signal processor output signal for provision of a transmitter output signal. It may be appreciated that the input signal as described herein is based on the transmitter output signal.

[0087] In one or more example audio devices, the audio device comprises a second encoder. To encode the transmitter output signal may comprise to encode a first transmitter output signal comprising the signal processor output signal using the first encoder, and to encode a second transmitter output signal comprising the first transmitter signal parameter using the second encoder.

[0088] The audio device is configured to output, via the interface to a receiver device, the transmitter output signal and the first transmitter signal parameter. To output the transmitter output signal and the first transmitter signal parameter may comprise to output the transmitter output signal and the first transmitter signal parameter to the receiver audio device. It may be appreciated that the first transmitter signal parameter may be included in the transmitter output signal and/or the first transmitter signal parameter may be outputted separately to the receiver audio device.

[0089] In one or more example audio devices, to output the transmitter output signal and the first transmitter signal parameter comprises to include the first transmitter signal parameter in the encoded transmitter output signal. In other words, the audio device may be configured to encode the first transmitter signal parameter in the transmitter output signal.

[0090] In one or more example audio devices, to output the transmitter output signal and the first transmitter signal parameter comprises to output the transmitter output signal via a first channel and to output the first transmitter signal parameter via a second channel. For example, to output the transmitter output signal and the first transmitter signal parameter may comprise to output the first transmitter output signal via the first channel as described herein and to output the second transmitter output signal via the second channel as described herein.

[0091] A method of operating an audio device configured to act as a receiver device is disclosed, such as an audio device as disclosed herein. The method comprises obtaining, e.g., via an interface and/or using a processor of the audio device, an input signal from a transmitter device, where the input signal comprises audio. The method comprises obtaining, based on the input signal and e.g., via the interface and/or using the processor of the audio device, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio. The method comprises determining, based on the first signal parameter and e.g., using a receiver configuration controller of the audio device, a receiver configuration. The method comprises controlling, based on the receiver configuration and e.g., using the receiver configuration controller of the audio device, a processing of a decoder output signal from a first decoder of the audio device.

[0092] A method of operating an audio device configured to act as a transmitter device is disclosed, such as an audio device as disclosed herein. The method comprises obtaining, e.g., via a microphone of the audio device, a microphone input signal. The method comprises determining, based on the microphone input signal and e.g., using a signal processor of the audio device, a signal processor output signal. The method comprises obtaining, based on the signal processor output signal and e.g., using a feature extractor of the audio device, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor

output signal. The method comprises encoding, e.g., using a first encoder of the audio device, the signal processor output signal for provision of a transmitter output signal. The method comprises outputting, e.g., via an interface of the audio device to a receiver device, the transmitter output signal and the first transmitter signal parameter.

[0093] It is to be understood that a description of a feature in relation to the audio device configured to act as a receiver and/or the audio device configured to act as a transmitter, is also applicable to the corresponding feature in the system(s), the method(s) of operating an audio device as disclosed herein.

[0094] Fig. 1 schematically illustrates an example system, such as an audio device system 2 according to the present disclosure. The audio device system 2 may be seen as an audio communication system. The system 2 may be seen as a communication system for performing calls, such as audio and/or video calls. The system 2, such as communication system, may be seen as a system with signal parameter-based processing. The audio device system 2 comprises an audio device 10, such as the audio device configured to act as a receiver device as disclosed herein and an audio device 20, such as the audio device configured to act as a transmitter device as disclosed herein.

[0095] The audio device 10 is configured to act as receiver device. In other words, the audio device is configured to receive input signals from the audio device 20 configured to act as a transmitter device. The audio device 10 comprises an interface, an audio speaker, a memory, and a microphone (not shown). The audio device 10 may be seen as an audio device configured to obtain audio signals, output audio signals, and process audio signals. The audio device 10 may be seen as a conference audio device, e.g., configured to be used by a party (such as one or more users at a near-end) to communicate with one or more other parties (such as one or more users at a far-end). The audio device 10 may be seen as a smart audio device. The audio device 10 may be used for communication, conference, and/or a meeting between two or more parties being remote from each other. The audio device 10 may be used by one or more users in a vicinity of where the audio device 10 is located, also referred to as a near-end. In the present examples, the receiver end may be seen as the near-end and the transmitter end may be seen as the far-end.

[0096] The audio device 10 comprises a processor 10C. The processor 10C comprises a first decoder 12A and a receiver configuration controller 18. A decoder as disclosed herein, such as the first decoder 12A and/or a second decoder 12B, may be implemented as hardware and/or software on the audio device 10. A decoder as disclosed herein may be seen as a module configured to convert and/or decode an input signal 50Afrom the transmitter device 20 to a decoder output signal. In other words, a decoder may be configured to decompress the input signal 50A from the transmitter device 20. For example, a decoder may be configured to convert and/or decode the input signal 50A from the transmitter device 20 to an audio signal.

[0097] The receiver configuration controller 18 as disclosed herein may also be denoted a parameter setup module. The receiver configuration controller 18 may be configured to determine and/or set a receiver configuration at the audio device 10. In other words, the receiver configuration controller 18 may be configured to determine a set of receiver configuration parameters that the audio device 10 is configured to operate according to. For example, the receiver configuration controller 18 may be configured to determine a receiver configuration comprising a set of receiver configuration parameters that a signal processor, such as a first signal processor 14 and/or a second signal processor 16, of the audio device 10 is configured to operate according to.

[0098] The audio device 10 is configured to obtain, such as using the processor 10C and/or via the interface, an input signal 50Afrom the transmitter device 20. In one or more example audio devices, the audio device 10 is configured to obtain the input signal from a far-end, such as a far-end party or user(s). In other words, the transmitter device 20 may be seen as an audio device at a far-end. The input signal 50A comprises audio. In one or more embodiments or examples, the input signal 50A has undergone signal processing, such as encoding, compression, and/or enhancement, at the transmitter device 20. The input signal 50A may be indicative of an audio signal generated by user(s) at the far-end. In other words, the input signal 50A may be indicative of speech, such as speech from the far-end transmitter device. The input signal 50A may be based on and/or be seen as an output signal 78A of the transmitter device 20, such as of a signal processor 22 of the transmitter device 20.

[0099] The audio device 10 is configured to obtain, such as based on the input signal 50A, one or more signal parameters. The one or more signal parameters comprise a first signal parameter indicative of signal information of the audio. The signal information may be seen as and/or denoted as side information, such as side information regarding the signal processing that the input signal 50A has undergone at the transmitter device 20. In other words, the signal parameter, such as the first signal parameter, may be indicative of information regarding the signal processing of the input signal 50A at the transmitter device 20, such as indicative of information regarding the signal processing of the audio at the transmitter device 20. The signal parameter, such as the first signal parameter, may comprise one or more features regarding the signal processing of the input signal 50A at the transmitter device 20. The signal parameter, such as the first signal parameter, may be indicative of signal information regarding an encoding, a compression, and/or an enhancement of the input signal 50A at the transmitter device 20.

[0100] The audio device 10 is configured to determine, based on the first signal parameter, a receiver configu-

ration. In one or more example audio devices, the audio device 10 is configured to determine the receiver configuration using the receiver configuration controller 18 and based on the first signal parameter. The receiver configuration may comprise a set of receiver configuration parameters that the audio device 10 is configured to operate according to. It may be appreciated that the receiver configuration may comprise at least a first receiver configuration parameter.

[0101] The audio device 10 is configured to control, based on the receiver configuration and using the receiver configuration controller 18, a processing of a decoder output signal 52 from the first decoder 12A. In other words, the audio device 10 is configured to control a processing by the processor 10C of the decoder output signal 52 from the first decoder 12A based on the receiver configuration and using the receiver configuration controller 18. The decoder output signal 52 may be based on the input signal 50A. In other words, the decoder output signal 52 may be seen as a decoded input signal. The first decoder 12A may be configured to process, such as decode, the input signal 50A for provision of the decoder output signal 52. The input signal 50A may also be seen as a decoder input signal. To control a processing of the decoder output signal 52 from the first decoder 12A may comprise to apply the receiver configuration to the controlling of the processing of the decoder output signal 52 using the receiver configuration controller 18. To control a processing of the decoder output signal 52 from the first decoder 12A may comprise to transmit control signals from the receiver configuration controller 18 to the processor 10C based on the receiver configuration. In one or more example audio devices, to control a processing of the decoder output signal 52 from the first decoder 12A may comprise to transmit control signals from the receiver configuration controller 18 to the first signal processor 14 and/or the second signal processor 16 based on the receiver configuration. By controlling the processing of the decoder output signal 52 based on the receiver configuration it may be possible to perform informed control the processing of the decoder output signal 52 based on the receiver configuration. In other words, by controlling the processing of the decoder output signal 52 based on the receiver configuration it may be possible to perform informed control the processing of the decoder output signal 52 based on the first signal parameter.

[0102] In one or more example audio devices, the audio device 10 is configured to determine a receiver output 59 based on the controlling of the processing of the decoder output signal 52.

[0103] In one or more example audio devices, the first signal parameter is a signal-to-noise ratio, a confidence probability map, a quality representation, or a mean opinion score. In one or more example audio devices, the first signal parameter is a signal-to-noise ratio of the input signal 50A, a confidence probability map of the input signal 50A, a quality representation of the input signal 50A, or a mean opinion score of the input signal 50A.

[0104] In one or more example audio devices, the input signal 50A comprises one or more audio signals and the first signal parameter. In other words, the first signal parameter may be determined at the transmitter device 20 and comprised in the input signal 50A when transmitted to the audio device 10 at receiver end. It may be appreciated that the first decoder 12A may be configured to decode, extract, and/or obtain the one or more audio signals and/or the first signal parameter from the input signal 50A.

[0105] In one or more example audio devices, the processor 10C comprises a first signal processor 14 configured to operate according to a generative model for generative-based signal processing. In one or more example audio devices, the first signal processor 14 comprises a bandwidth extender. The first signal processor 14, such as the bandwidth extender, may be configured to regenerate part of or a whole audio signal from the transmitter device 20 based on the input signal 50A and the first signal parameter. For example, the first signal processor 14, such as the bandwidth extender, may be configured to regenerate an audio signal with extended bandwidth and/or reduced level of noise.

[0106] In one or more example audio devices, the first signal processor 14 is configured to operate according to a non-generative model for non-generative based signal processing. Thereby, both the first signal processor 14 and the second signal processor 16 may be configured to operate according to non-generative models with different characteristics that may take into account the weaknesses of each other.

[0107] In one or more example audio devices, the first signal processor 14 is configured to process a first signal processor input signal 53 for provision of a first signal processor output signal 54. For example, when the first signal processor 14 comprises a bandwidth extender, the bandwidth extender is configured to process a first bandwidth extender input signal for provision of a first bandwidth extender output signal. The audio device 10 may be configured to output an audio device output 59 based on the first signal processor output signal 54. In one or more example audio devices, the first signal processor output signal 54 may be seen as the audio device output 59. In one or more example audio devices, the first signal processor output signal 54 may be seen as a second signal processor input signal 55.

[0108] In one or more example audio devices, the first signal processor input signal 54 is based on the decoder output signal 52. In one or more audio devices, example audio devices, the first signal processor input signal 53 may be based on and/or correspond to the decoder output signal 52. In other words, the first signal processor 14 may receive and/or obtain the decoder output signal 52 directly from the first decoder 12A.

[0109] In one or more example audio devices, to control the processing of the decoder output signal 52 comprises to control, based on the receiver configuration, the

first signal processor 14. In other words, to control the processing of the decoder output signal 52 comprises to control a processing of the first signal processor input signal 53 by the first signal processor 14 based on the receiver configuration.

[0110] In one or more example audio devices, the audio device 10 is configured to control the processing of the decoder output signal 52 based on the first receiver configuration parameter. In other words, the audio device 10 is configured to control a processing by the processor 10C of the decoder output signal 52 from the first decoder 12A based on the first receiver configuration parameter and using the receiver configuration controller 18. To control a processing of the decoder output signal 52 from the first decoder 12A may comprise to apply the first receiver configuration parameter to the controlling of the processing of the decoder output signal 52 using the receiver configuration controller 18. To control a processing of the decoder output signal 52 from the first decoder 12A may comprise to transmit control signals 56 from the receiver configuration controller 18 to the processor 10C based on the first receiver configuration parameter. In one or more example audio devices, to control a processing of the decoder output signal 52 from the first decoder 12A may comprise to transmit control signals 56 from the receiver configuration controller 18 to the first signal processor 14 and/or the second signal processor 16 based on the first receiver configuration parameter. The decoder output signal 52 may be seen as a receiver configuration controller input signal 57. In one or more audio devices, the first decoder 12A may be configured to output a secondary decoder output signal 52A to the receiver configuration controller 18, e.g., comprising the one or more signal parameters, such as the first signal parameter. The first decoder 12A may be configured to output the decoder output signal 52 to the receiver configuration controller 18. The receiver configuration controller 18 may be configured to determine the receiver configuration based on the decoder output signal 52 and/or the secondary decoder output signal 52A. The receiver configuration controller 18 may be configured to output a first control signal 56A to the first signal processor 14. The receiver configuration controller 18 may be configured to output a second control signal 56B to the second signal processor 16.

[0111] In one or more example audio devices, the processor 10C comprises a second signal processor 16 configured to operate according to a non-generative model for non-generative-based signal processing. In one or more example audio devices, the second signal processor 16 comprises a denoiser and/or an echo controller. The second signal processor 16 may be seen as and/or denoted a deep noise reductor, such as a module using deep noise reduction, DNS. It may be appreciated that the second signal processor may be configured to generate a time-frequency e.g., to enhance one or more characteristics of the input signal 50A, such as enhance the decoder output signal 52.

[0112] In one or more example audio devices, the second signal processor 16 is configured to operate according to a generative model for generative based signal processing. For example, when the first signal processor 14 is configured to operate according to a generative model based on Generative Adversarial Networks (GANs), e.g., for performing bandwidth extension, the second signal processor 16 may be configured to operate according to a generative diffusion model, e.g., for performing denoising, such as deep noise reduction, and/or echo cancelling. Thereby, both the first signal processor 14 and the second signal processor 16 may be configured to operate according to generative models with different characteristics that may take into account the weaknesses of each other. For example, the first signal processor 14 may add and/or restore missing information by using the generative model based on GANs and the second signal processor 16 may remove Gaussian noise to reveal new information by using the generative diffusion model.

[0113] In one or more example audio devices, the second signal processor 16 is configured to process a second signal processor input signal 55 for provision of a second signal processor output signal 58. The audio device 10 may be configured to output an audio device output 59 based on the second signal processor output signal 58. In one or more example audio devices, the second signal processor output signal 58 may be seen as the audio device output 59. In one or more example audio devices, the second signal processor output signal 58 may be seen as a first signal processor input signal 53. In other words, the position of the first signal processor 14 and the second signal processor 16 may be exchanged in Fig.1. In one or more example audio devices, the audio device 10 may be configured to output an audio device output 59 based on the first signal processor output signal 54 and the second signal processor output signal 58.

[0114] In one or more example audio devices, the audio device is configured to determine a receiver output 59, such as an audio device output signal, based on the first signal processor output signal 54 and/or the second signal processor output signal 58. By combining the processing of the first signal processor 14 and the second signal processor 16 the signal processing of the input signal 50A, such as of the decoder output signal 52, may be improved. For example, by combining the processing of the first signal processor 14, e.g., comprising a bandwidth extender, and the second signal processor 16, e.g., comprising a denoiser and/or an echo controller, the deep noise reduction signal processing of the input signal 50A, such as of the decoder output signal 52, may be enhanced. The output from the first signal processor 14 and second signal processor 16 may be enhanced both in terms of residual noise and overall perceived quality in comparison with the input signal. To combine the processing of the first signal processor 14 and the second signal processor 16 based on the first signal parameter

and/or based on the receiver configuration, may be seen as integrating bandwidth extension and deep noise reduction based on side information on the audio signal and/or input signal 50A obtained from the transmitter device 20.

[0115] In one or more example audio devices, the second signal processor input signal 58 is based on the decoder output signal 52. In one or more example audio devices, the second signal processor input signal 55 may be based on and/or correspond to the decoder output signal 52. In other words, the second signal processor 16 is configured to receive and/or obtain the decoder output signal 52 directly from the first decoder 12A. This may be the case when the second signal processor 16 is positioned right after the first decoder 12A.

[0116] In one or more example audio devices, the second signal processor 16 is configured to process the first signal processor output signal 54 for provision of a receiver output signal 59. In other words, the first signal processor output signal 54 may be seen as the second signal processor input signal 55. The receiver output signal 59 may also be seen as and/or denoted as the audio device output signal as described herein. The receiver output signal 59 may be seen as an enhanced output signal based on the first signal parameter indicative of signal information of the audio.

[0117] An audio device 20 configured to act as a transmitter device is disclosed. In other words, the audio device 20 is configured to transmit output signals to an audio device configured to act as a receiver device, such as audio device 10. The audio device 20 comprises an interface, an audio speaker, a microphone 20E, a processor 20C, and a memory. The processor 20C comprises a signal processor 22, a feature extractor 26, and a first encoder 24A. The signal processor 22 may be seen as a transmitter signal processor. The feature extractor 26 may be seen as a transmitter feature extractor. In one or more audio devices, the feature extractor 26 comprises a bandwidth detector. An encoder as disclosed herein, such as the first encoder 24A and/or a second encoder 24B, may be implemented as hardware and/or software on the audio device 20.

[0118] The audio device 20 is configured to obtain, via the microphone 20E, a microphone input signal 70. The microphone input signal 70 may be indicative of an audio signal generated by user(s) at the far-end (such as transmitter end). In other words, the microphone input signal 70 may be indicative of speech, such as speech from the far-end transmitter device 20.

[0119] The audio device 20 is configured to determine, based on the microphone input signal 70 and using the signal processor 22, a signal processor output signal 72. In one or more embodiments or examples, the microphone input signal 70 has undergone signal processing, such as encoding, compression, and/or enhancement, at the transmitter device 20, e.g., using the signal processor 22.

[0120] The audio device 20 is configured to obtain, based on the signal processor output signal 72 and using the feature extractor 26, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal 70 and/or the signal processor output signal 72. The signal processor output signal 72 may be seen as a feature extractor input signal 75. The audio device 20 may be configured to extract one or more transmitter signal parameters, such as the first transmitter signal parameter, from the microphone input signal 70 and/or the signal processor output signal 72 using the feature extractor 26. The audio device 20 may be configured to include the one or more signal parameters, e.g., including the first signal parameter, in the transmitter output signal 78A.

[0121] The audio device 20 is configured to encode, using the first encoder 24A, the signal processor output signal 72 for provision of a transmitter output signal 78A. It may be appreciated that the input signal 50A as described herein is based on the transmitter output signal 78A. The signal processor output signal 72 may be seen as a first encoder input signal 73. The feature extractor 26 may be configured to output a feature extractor output signal 76 based on the obtained transmitter signal parameters to the first encoder 24A. The feature extractor output signal 76 may be seen as a first encoder input signal 77.

[0122] The audio device 20 is configured to output, via the interface to a receiver device (such as audio device 10), the transmitter output signal 78A and the first transmitter signal parameter. To output the transmitter output signal 78A and the first transmitter signal parameter may comprise to output the transmitter output signal 78A and the first transmitter signal parameter to the receiver audio device 10. It may be appreciated that the first transmitter signal parameter may be included in the transmitter output signal 78A and/or the first transmitter signal parameter may be outputted separately to the receiver audio device 10 (as in Fig. 2 and Fig. 4).

[0123] In one or more example audio devices, to output the transmitter output signal 78A and the first transmitter signal parameter comprises to include the first transmitter signal parameter in the encoded transmitter output signal 78A. In other words, the audio device 20 may be configured to encode the first transmitter signal parameter in the transmitter output signal 78A. In other words, the first encoder 24A is configured to encode the signal processor output signal 72 and the feature extractor output signal 76 for provision of the transmitter output signal 78A.

[0124] Fig. 2 schematically illustrates an example system, such as an audio device system 2A according to the present disclosure. The system 2A is similar to the system 2 of Fig. 1 but shows another embodiment of the present disclosure. In Fig. 2, the audio device 10 comprises a second decoder 12B and the transmitter device 20 comprises a second encoder 24B.

[0125] In one or more example audio devices, to obtain the input signal 50A comprises to obtain a first input signal

50A via a first channel using a first decoder 12A and to obtain a second input signal 50B via a second channel using a second decoder 12B. In one or more example audio devices, the second input signal 50B comprises the first signal parameter. In other words, the first input signal 50A may comprise one or more audio signals and/or one or more signal parameters and the second input signal 50B may comprise the first signal parameter. It may be appreciated that the audio device 10 may obtain the first signal parameter via a dedicated channel (e.g., the second channel) different from the first channel via which the audio signals are obtained. In one or more example audio devices, the first decoder 12A may be configured to bandwidth extend the first input signal 50A from a narrow band signal to broader band signal. In one or more example audio devices, the second decoder 12B is configured to decode the second input signal 50B for providing a second decoder output signal 60. The second decoder 12B may be configured to decode one or more signal parameters based on the second input signal 50B for providing the first signal parameter. The first signal parameter may be comprised in the second decoder output signal 60. The receiver configuration controller 18 may be configured to determine the receiver configuration based on the second decoder output signal 60.

[0126] In one or more example audio devices, to output the transmitter output signal 78A and the first transmitter signal parameter comprises to output the transmitter output signal 78A via a first channel and to output the first transmitter signal parameter via a second channel. For example, to output the transmitter output signal 78A and the first transmitter signal parameter may comprise to output the first transmitter output signal 78A via the first channel as described herein and to output the second transmitter output signal 78B comprising the first transmitter signal parameter via the second channel as described herein.

[0127] In one or more example audio devices, the audio device 20 comprises a second encoder 24B. To encode the transmitter output signal 78A may comprise to encode a first transmitter output signal 78A comprising the signal processor output signal using the first encoder 24A, and to encode a second transmitter output signal 78B comprising the first transmitter signal parameter using the second encoder 24B.

[0128] Fig. 3 schematically illustrates an example system, such as an audio device system 2B according to the present disclosure. The system 2B is similar to the system 2 of Fig. 1 but shows another embodiment of the present disclosure. In Fig. 3, the audio device 10 comprises a feature extractor 19 and the transmitter device 20 does not comprise a feature extractor.

[0129] In one or more example audio devices, the processor 10C comprises a signal feature extractor 19. In one or more audio devices, example audio devices, to obtain the one or more signal parameters comprises to extract the one or more signal parameters from the input signal 50A by using the signal feature extractor 19. It may be appreciated that the audio device 10 may be configured to extract the first signal parameter from the input signal 50A by using signal feature extractor 19. In one or more example audio devices, to obtain the one or more signal parameters comprises to extract the one or more signal parameters from the decoder output signal 52 by using the signal feature extractor 19. In other words, words, the feature extractor 19 is configured to receive the decoder output signal 52 as a feature extractor input signal 62 for providing a feature extractor output signal 64. The feature extractor output signal 64 may then be transmitted to the receiver configuration controller 18. In other words, the audio device 10 may be configured to determine the receiver configuration based on the feature extractor output signal 64 by using the receiver configuration controller 18. In one or more audio devices, the first decoder 12A may be configured to output a tertiary decoder output signal 52B to the signal feature extractor 19. The tertiary decoder output signal 52B may for example be a targeted portion of the input signal 50A that the signal feature extractor 19 may extract signal parameters from.

[0130] Fig. 4 schematically illustrates an example system, such as an audio device system 2C according to the present disclosure. The system 2C is similar to the system 2 of Fig. 1 but shows another embodiment of the present disclosure. In Fig. 4, the first signal processor input signal 53 is based on a first part of the decoder output signal 52 and the second signal processor input signal 55 is based on a second part of the decoder output signal 52. In other words, the first signal processor 14 and the second signal processor 16 may be configured to process sub-parts of the input signal 50A, such as sub-parts of the decoded input signal 52 from the first decoder 12A. In one or more example audio devices, the receiver configuration controller 18 may be configured to determine, based on the first signal parameter, which parts of the input signal 50A are to be processed by the first signal processor 14 and which parts of the input signal are to be processed by the second signal processor 16. In other words, the receiver configuration controller 18 may be configured to determine, based on the first signal parameter, which parts of the decoder output signal 52 are to be processed by the first signal processor 14 and which parts of the decoder output signal 52 are to be processed by the second signal processor 16. The receiver configuration controller 18 may be configured to determine one or more receiver configuration parameters, such as the first receiver configuration parameter, to determine which parts of the decoder output signal 52 are to be processed by the first signal processor 14 and which parts of the decoder output signal 52 are to be processed by the second signal processor 16. In one or more example audio devices, the first signal processor 14 and the second signal processor 16 are configured to process sub-parts of the input signal 50A, such as sub-parts of the decoder output signal 52, in parallel.

[0131] In one or more example audio devices, the first

signal processor output signal 54 and the second signal processor output signal 58 may be combined for generating and/or determining the audio device output 59. In one or more audio devices, the audio device 10, such as the processor 10C, comprises a mixer 17 configured to combine the first signal processor output signal 54 and the second signal processor output signal 58 for provision of the receiver output signal 59. In other words,

[0132] Fig. 5 schematically illustrates an example system, such as an audio device system 2D according to the present disclosure. The system 2D is similar to the system 2 of Fig. 1, the system 2A of Fig. 2, and the system 2C of Fig. 4 but shows another embodiment of the present disclosure. Fig. 5 shows the use of a first channel and a second channel as described in Fig. 2 in combination with the parallel signal processing of the first signal processor 14 and the second signal processor 16.

[0133] The audio device 10 may be configured to perform any of the methods disclosed in Figs. 6A-6B.

[0134] The processor 10C is optionally configured to perform any of the operations disclosed in Fig. 6A-6B (such as any one or more of S102A, S102B, S103, S105, S106A, S106B, S108A, S108B, S109, S110, S110A, S110B, S112, S114, S14A, S115, S116).

[0135] The operations of the audio device 10 may be embodied in the form of executable logic routines (for example, lines of code, software programs, etc.) that are stored on a non-transitory computer readable medium (for example, memory) and are executed by the processor 10C).

[0136] Furthermore, the operations of the audio device 10 may be considered a method that the audio device 10 is configured to carry out. Also, while the described functions and operations may be implemented in software, such functionality may as well be carried out via dedicated hardware or firmware, or some combination of hardware, firmware and/or software.

[0137] Memory of the audio device may be one or more of a buffer, a flash memory, a hard drive, a removable media, a volatile memory, a non-volatile memory, a random access memory (RAM), or other suitable device. In a typical arrangement, memory may include a non-volatile memory for long term data storage and a volatile memory that functions as system memory for the processor 10C. The memory may exchange data with the processor 10C over a data bus. Control lines and an address bus between the memory and the processor 10C also may be present (not shown in Fig. 1). The memory is considered a non-transitory computer readable medium.

[0138] The memory may be configured to store information such as input signal(s), signal parameter(s), receiver configuration(s), model(s), and/or receiver configuration parameter(s) as disclosed herein in a part of the memory.

[0139] The audio device 20 may be configured to perform any of the methods disclosed in Fig. 7.

[0140] The operations of the audio device 20 may be embodied in the form of executable logic routines (for example, lines of code, software programs, etc.) that are stored on a non-transitory computer readable medium (for example, memory) and are executed by the processor 20C).

[0141] Furthermore, the operations of the audio device 20 may be considered a method that the audio device 10 is configured to carry out and vice-versa. Also, while the described functions and operations may be implemented in software, such functionality may as well be carried out via dedicated hardware or firmware, or some combination of hardware, firmware and/or software.

[0142] The systems 2, 2A, 2B, 2C, 2D may be configured to perform any of the methods disclosed in Figs. 6A-6B and Fig. 7.

[0143] Furthermore, the operations of the system 2 may be considered a method that the system 2 is configured to carry out. Also, while the described functions and operations may be implemented in software, such functionality may as well be carried out via dedicated hardware or firmware, or some combination of hardware, firmware and/or software.

[0144] Figs. 6A-6B show a flow diagram of an example method, such as a method 100.

[0145] A method 100 of operating an audio device configured to act as a receiver device is disclosed. The method 100 comprises obtaining S102, such as via an interface and/or using a processor of the audio device, an input signal from a transmitter device, where the input signal comprises audio.

[0146] The method comprises obtaining S104, based on the input signal and e.g., via the interface and/or using the processor of the audio device, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio.

[0147] The method comprises determining S106, based on the first signal parameter and e.g., using a receiver configuration controller of the audio device, a receiver configuration. The method comprises controlling S108, based on the receiver configuration and e.g., using a receiver configuration controller of the audio device, a processing of a decoder output signal from a first decoder of the audio device.

[0148] In one or more example methods, the method comprises operating S109 a first signal processor of the audio device according to generative model for generative-based signal processing.

[0149] In one or more example methods, the method comprises processing S110, using the first signal processor, a first signal processor input signal for provision of a first signal processor output signal, wherein the first signal processor input signal is based on the decoder output signal.

[0150] In one or more example methods, controlling S108 processing of the decoder output signal comprises controlling S108A, based on the receiver configuration, a first signal processor.

[0151] In one or more example methods, processing S110 the first signal processor input signal comprises extending S110A, e.g., using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal.

[0152] In one or more example methods, processing S110 the first signal processor input signal comprises reducing S110B, using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal.

[0153] In one or more example methods, obtaining S104 the one or more signal parameters comprises extracting S104A the one or more signal parameters from the input signal e.g., by using a signal feature extractor of the audio device.

[0154] In one or more example methods, obtaining S102 the input signal comprises obtaining S102A a first input signal via a first channel using a first decoder of the audio device.

[0155] In one or more example methods, obtaining S102 the input signal comprises obtaining S102B a second input signal via a second channel using a second decoder of the audio device, where the second input signal comprises the first signal parameter.

[0156] In one or more example methods, the method comprises obtaining S103, based on the first input signal, one or more signal parameters indicative of input signal information, the one or more signal parameters comprising a second signal parameter.

[0157] In one or more example methods, the method comprises determining S105 the receiver configuration based on the second signal parameter.

[0158] In one or more example methods, determining S106 the receiver configuration comprises determining S106A one or more receiver configuration parameters including a first receiver configuration parameter.

[0159] In one or more example methods, determining S106 the receiver configuration comprises controlling S106B the processing of the decoder output signal based on the first receiver configuration parameter.

[0160] In one or more example methods, the method comprises operating S112 a second signal processor according to a non-generative model for non-generative-based signal processing.

[0161] In one or more example methods, the method comprises processing S114, using the second signal processor, a second signal processor input signal for provision of a second signal processor output signal.

[0162] In one or more example methods, controlling S108 the processing of the decoder output signal comprises controlling S108B, based on the receiver configuration, the second signal processor.

[0163] In one or more example methods, processing S114 the second signal processor input signal comprises reducing S114A, using the second signal processor and based on the receiver configuration, a noise of the second signal processor input signal.

[0164] In one or more example methods, reducing S114A the noise of the second signal processor input signal comprises reducing S115 the noise of the second signal processor input signal based on a mask-based method.

[0165] In one or more example methods, the method comprises processing S116, using the second signal processor, the first signal processor output signal for provision of a receiver output signal.

[0166] Examples of audio devices, systems, and methods according to the disclosure are set out in the following items:

Item 1. An audio device configured to act as a receiver device, the audio device comprising an interface, an audio speaker, and a microphone, the audio device comprising a processor and a memory, the processor comprising a first decoder and a receiver configuration controller, wherein the audio device is configured to:

obtain (S102) an input signal from a transmitter device, where the input signal comprises audio;
obtain (S104), based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio;
determine (S106), based on the first signal parameter, a receiver configuration; and
control (S108), based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder.

Item 2. The audio device according to item 1, wherein the processor comprises a first signal processor configured to operate according to a generative model for generative-based signal processing, the first signal processor being configured to process (S110) a first signal processor input signal for provision of a first signal processor output signal, wherein the first signal processor input signal is based on the decoder output signal, and wherein to control processing of the decoder output signal comprises to control (S112), based on the receiver configuration, the first signal processor.

Item 3. The audio device according to item 2, wherein to process the first signal processor input signal comprises to extend (S110A), using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal.

Item 4. The audio device according to any of items 2-3, wherein to process the first signal processor input signal comprises to reduce (S110B), using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal.

Item 5. The audio device according to any of the previous items, wherein the input signal comprises one or more audio signals and the first signal parameter.

Item 6. The audio device according to any of the previous items, wherein the first signal parameter is a signal-to-noise ratio, a confidence probability map, or a mean opinion score.

Item 7. The audio device according to any of the previous items, wherein the processor comprises a signal feature extractor, and wherein to obtain the one or more signal parameters comprises to extract (S104A) the one or more signal parameters from the input signal by using the signal feature extractor.

Item 8. The audio device according to any of the previous items, wherein to obtain the input signal comprises to obtain (S102A) a first input signal via a first channel using a first decoder, and
to obtain (S102B) a second input signal via a second channel using a second decoder, where the second input signal comprises the first signal parameter.

Item 9. The audio device according to item 8, wherein the audio device is configured to:

obtain, based on the first input signal, one or more signal parameters indicative of input signal information, the one or more signal parameters comprising a second signal parameter; and
determine the receiver configuration based on the second signal parameter.

Item 10. The audio device according to any of the previous items, wherein to determine the receiver configuration comprises to determine one or more receiver configuration parameters including a first receiver configuration parameter, and wherein the audio device is configured to control the processing of the decoder output signal based on the first receiver configuration parameter.

Item 11. The audio device according to item 10, wherein the one or more receiver configuration parameters comprise one or more of: a codec parameter, a user parameter, and a mode parameter.

Item 12. The audio device according to any of the previous items, wherein the audio device comprises a second signal processor configured to operate according to a non-generative model for non-generative-based signal processing, the second signal processor being configured to process a second signal processor input signal for provision of a second signal processor output signal, wherein the second signal processor input signal is based on the decoder output signal, and wherein to control the processing of the decoder output signal comprises to control, based on the receiver configuration, the second signal processor.

Item 13. The audio device according to item 12, wherein to process the second signal processor input signal to reduce, using the second signal processor and based on the receiver configuration, a noise of the second signal processor input signal.

Item 14. The audio device according to item 13, wherein to reduce the noise of the second signal processor input signal comprises to reduce the noise of the second signal processor input signal based on a mask-based method.

Item 15. The audio device according to item 2 and any of items 13-14, wherein the second signal processor is configured to process the first signal processor output signal for provision of a receiver output signal.

16. An audio device configured to act as a transmitter device, the audio device comprising an interface, an audio speaker, a microphone, a processor, and a memory, the processor comprising a signal processor, a feature extractor, and a first encoder, wherein the audio device is configured to:

obtain, via the microphone, a microphone input signal;
determine, based on the microphone input signal and using the signal processor, a signal processor output signal;
obtain, based on the signal processor output signal and using the feature extractor, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor output signal;
encode, using the first encoder, the signal processor output signal for provision of a transmitter output signal;
output, via the interface to a receiver device, the transmitter output signal and the first transmitter signal parameter.

Item 17. The audio device according to item 16, wherein to output the transmitter output signal and the first transmitter signal parameter comprises to include the first transmitter signal parameter in the encoded transmitter output signal.

Item 18. The audio device according to any of items 16-17, wherein to output the transmitter output signal and the first transmitter signal parameter comprises to output the transmitter output signal via a first chan-

nel and to output the first transmitter signal parameter via a second channel.

Item 19. Method (100) of operating an audio device configured to act as a receiver device, the method comprising:

obtaining (S102) an input signal from a transmitter device, where the input signal comprises audio;
obtaining (S104), based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio;
determining (S106), based on the first signal parameter, a receiver configuration; and
controlling (S108), based on the receiver configuration and using a receiver configuration controller of the audio device, a processing of a decoder output signal from a first decoder of the audio device.

Item 20. The method (100) according to item 19, the method comprising:

operating (S109) a first signal processor of the audio device according to generative model for generative-based signal processing;
processing (S110), using the first signal processor, a first signal processor input signal for provision of a first signal processor output signal, wherein the first signal processor input signal is based on the decoder output signal; and
wherein controlling (S108) processing of the decoder output signal comprises controlling (S108A), based on the receiver configuration, a first signal processor.

Item 21. The method (100) according to item 20, wherein processing (S110) the first signal processor input signal comprises extending (S110A), using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal.

Item 22. The method (100) according to any of items 20-21, wherein processing (S110) the first signal processor input signal comprises reducing (S110B), using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal.

Item 23. The method (100) according to any of items 19-22, wherein obtaining (S104) the one or more signal parameters comprises extracting (S104A) the one or more signal parameters from the input signal by using a signal feature extractor of the audio device.

Item 24. The method (100) according to any of items 19-23, wherein obtaining (S102) the input signal comprises:

obtaining (S102A) a first input signal via a first channel using a first decoder of the audio device; and
obtaining (S102B) a second input signal via a second channel using a second decoder of the audio device, where the second input signal comprises the first signal parameter.

Item 25. The method (100) according to item 24, the method comprising:

obtaining (S103), based on the first input signal, one or more signal parameters indicative of input signal information, the one or more signal parameters comprising a second signal parameter; and
determining (S105) the receiver configuration based on the second signal parameter.

Item 26. The method (100) according to any of items 19-25, wherein determining (S106) the receiver configuration comprises:

determining (S106A) one or more receiver configuration parameters including a first receiver configuration parameter; and
controlling (S106B) the processing of the decoder output signal based on the first receiver configuration parameter.

Item 27. The method (100) according to any of items 19-26, the method comprises:

operating (S112) a second signal processor according to a non-generative model for non-generative-based signal processing;
processing (S114), using the second signal processor, a second signal processor input signal for provision of a second signal processor output signal; and wherein
controlling (S108) the processing of the decoder output signal comprises controlling (S108B), based on the receiver configuration, the second signal processor.

Item 28. The method (100) according to item 27, wherein processing (S114) the second signal processor input signal comprises reducing (S114A), using the second signal processor and based on the receiver configuration, a noise of the second signal processor input signal.

Item 29. The method (100) according to item 28, wherein reducing (S114A) the noise of the second

signal processor input signal comprises reducing (S115) the noise of the second signal processor input signal based on a mask-based method.

Item 30. The method (100) according to item 20 and any of claims 28-29, the method comprising processing (S116), using the second signal processor, the first signal processor output signal for provision of a receiver output signal.

Item 31. Method (200) of operating an audio device configured to act as a transmitter device, the method comprising:

obtaining (S202), via a microphone of the audio device, a microphone input signal;
determining (S204), based on the microphone input signal and using a signal processor of the audio device, a signal processor output signal;
obtaining (S206), based on the signal processor output signal and using a feature extractor of the audio device, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor output signal; and
encoding (S208), using a first encoder of the audio device, the signal processor output signal for provision of a transmitter output signal;
outputting (S210), via an interface of the audio device to a receiver device, the transmitter output signal and the first transmitter signal parameter.

[0167] The use of the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. does not imply any particular order, but are included to identify individual elements. Moreover, the use of the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. does not denote any order or importance, but rather the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. are used to distinguish one element from another. Note that the words "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. are used here and elsewhere for labelling purposes only and are not intended to denote any specific spatial or temporal ordering. Furthermore, the labelling of a first element does not imply the presence of a second element and vice versa.

[0168] It may be appreciated that the Figures comprise some circuitries or operations which are illustrated with a solid line and some circuitries, components, features, or operations which are illustrated with a dashed line. Circuitries or operations which are comprised in a solid line are circuitries, components, features or operations which are comprised in the broadest example. Circuitries, components, features, or operations which are comprised in a dashed line are examples which may be comprised in, or a part of, or are further circuitries, components, features, or operations which may be taken in addition to circuitries, components, features, or operations of the solid line examples. It should be appreciated that these operations need not be performed in order presented. Furthermore, it should be appreciated that not all of the operations need to be performed. The example operations may be performed in any order and in any combination. It should be appreciated that these operations need not be performed in order presented. Circuitries, components, features, or operations which are comprised in a dashed line may be considered optional.

[0169] Other operations that are not described herein can be incorporated in the example operations. For example, one or more additional operations can be performed before, after, simultaneously, or between any of the described operations.

[0170] Certain features discussed above as separate implementations can also be implemented in combination as a single implementation. Conversely, features described as a single implementation can also be implemented in multiple implementations separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations, one or more features from a claimed combination can, in some cases, be excised from the combination, and the combination may be claimed as any sub-combination or variation of any sub-combination.

[0171] It is to be noted that the word "comprising" does not necessarily exclude the presence of other elements or steps than those listed.

[0172] It is to be noted that the words "a" or "an" preceding an element do not exclude the presence of a plurality of such elements.

[0173] It should further be noted that any reference signs do not limit the scope of the claims, that the examples may be implemented at least in part by means of both hardware and software, and that several "means", "units" or "devices" may be represented by the same item of hardware.

[0174] Language of degree used herein, such as the terms "approximately," "about," "generally," and "substantially" as used herein represent a value, amount, or characteristic close to the stated value, amount, or characteristic that still performs a desired function or achieves a desired result. For example, the terms "approximately", "about", "generally," and "substantially" may refer to an amount that is within less than or equal to 10% of, within less than or equal to 5% of, within less than or equal to 1% of, within less than or equal to 0.1% of, and within less than or equal to 0.01 % of the stated amount. If the stated amount is 0 (e.g., none, having no), the above recited ranges can be specific ranges, and not within a particular % of the value. For example, within less than or equal to 10 wt./vol. % of, within less than or equal to 5 wt./vol. % of, within less than or equal to 1 wt./vol. % of, within less than or equal to 0.1 wt./vol. % of, and within less than or equal to 0.01 wt./vol. % of the stated amount.

[0175] Although features have been shown and described, it will be understood that they are not intended to limit the claimed disclosure, and it will be made obvious to those skilled in the art that various changes and modifications may be made without departing from the scope of the claimed disclosure. The specification and drawings are, accordingly, to be regarded in an illustrative rather than restrictive sense. The claimed disclosure is intended to cover all alternatives, modifications, and equivalents.

Claims

1. An audio device configured to act as a receiver device, the audio device comprising an interface, an audio speaker, and a microphone, the audio device comprising a processor and a memory, the processor comprising a first decoder and a receiver configuration controller, wherein the audio device is configured to:

obtain an input signal from a transmitter device, where the input signal comprises audio;
obtain, based on the input signal, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio;
determine, based on the first signal parameter, a receiver configuration; and
control, based on the receiver configuration and using the receiver configuration controller, a processing of a decoder output signal from the first decoder.

2. The audio device according to claim 1, wherein the processor comprises a first signal processor configured to operate according to a generative model for generative-based signal processing, the first signal processor being configured to process a first signal processor input signal for provision of a first signal processor output signal, wherein the first signal processor input signal is based on the decoder output signal, and wherein to control the processing of the decoder output signal comprises to control, based on the receiver configuration, the first signal processor.

3. The audio device according to claim 2, wherein to process the first signal processor input signal comprises to extend, using the first signal processor and based on the receiver configuration, a bandwidth of the first signal processor input signal.

4. The audio device according to any of claims 2-3, wherein to process the first signal processor input signal comprises to reduce, using the first signal processor and based on the receiver configuration, a noise of the first signal processor input signal.

5. The audio device according to any of the previous claims, wherein the input signal comprises one or more audio signals and the first signal parameter.

6. The audio device according to any of the previous claims, wherein the first signal parameter is a signal-to-noise ratio, a confidence probability map, a quality representation, or a mean opinion score.

7. The audio device according to any of the previous claims, wherein the processor comprises a signal feature extractor, and wherein to obtain the one or more signal parameters comprises to extract the one or more signal parameters from the input signal by using the signal feature extractor.

8. The audio device according to any of the previous claims, wherein to obtain the input signal comprises to obtain a first input signal via a first channel using the first decoder and to obtain a second input signal via a second channel using a second decoder, where the second input signal comprises the first signal parameter.

9. The audio device according to claim 8, wherein the audio device is configured to:

obtain, based on the first input signal, one or more signal parameters indicative of input signal information, the one or more signal parameters comprising a second signal parameter; and
determine the receiver configuration based on the second signal parameter.

10. The audio device according to any of the previous claims, wherein to determine the receiver configuration comprises to determine one or more receiver configuration parameters including a first receiver configuration parameter, and wherein the audio device is configured to control the processing of the decoder output signal based on the first receiver configuration parameter.

11. The audio device according to claim 10, wherein the one or more receiver configuration parameters comprise one or more of: a codec parameter, a user parameter, and a mode parameter.

12. The audio device according to any of the previous claims, wherein the audio device comprises a second signal processor configured to operate according to a non-generative model for non-generative-based signal processing, the second signal processor being configured to process a second signal processor input signal for provision of a second signal processor output signal, wherein the second signal processor input signal is based on the decoder output signal, and wherein to control the processing

of the decoder output signal comprises to control, based on the receiver configuration, the second signal processor.

13. The audio device according to claim 2 and claim 12, wherein the second signal processor is configured to process the first signal processor output signal for provision of a receiver output signal.

14. An audio device configured to act as a transmitter device, the audio device comprising an interface, an audio speaker, a microphone, a processor, and a memory, the processor comprising a signal processor, a feature extractor, and a first encoder, wherein the audio device is configured to:

obtain, via the microphone, a microphone input signal;
determine, based on the microphone input signal and using the signal processor, a signal processor output signal;
obtain, based on the signal processor output signal and using the feature extractor, one or more transmitter signal parameters comprising a first transmitter signal parameter indicative of signal information of the microphone input signal and/or the signal processor output signal;
encode, using the first encoder, the signal processor output signal for provision of a transmitter output signal;
output, via the interface to a receiver device, the transmitter output signal and the first transmitter signal parameter.

15. Method of operating an audio device configured to act as a receiver device, the method comprising:

obtaining, via an interface and/or using a processor of the audio device, an input signal from a transmitter device, where the input signal comprises audio;
obtaining, based on the input signal and via the interface and/or using the processor of the audio device, one or more signal parameters, the one or more signal parameters comprising a first signal parameter indicative of signal information of the audio; and
determining, based on the first signal parameter and using a receiver configuration controller of the audio device, a receiver configuration; and
controlling, based on the receiver configuration and using the receiver configuration controller of the audio device, a processing of a decoder output signal from the first decoder of the audio device.

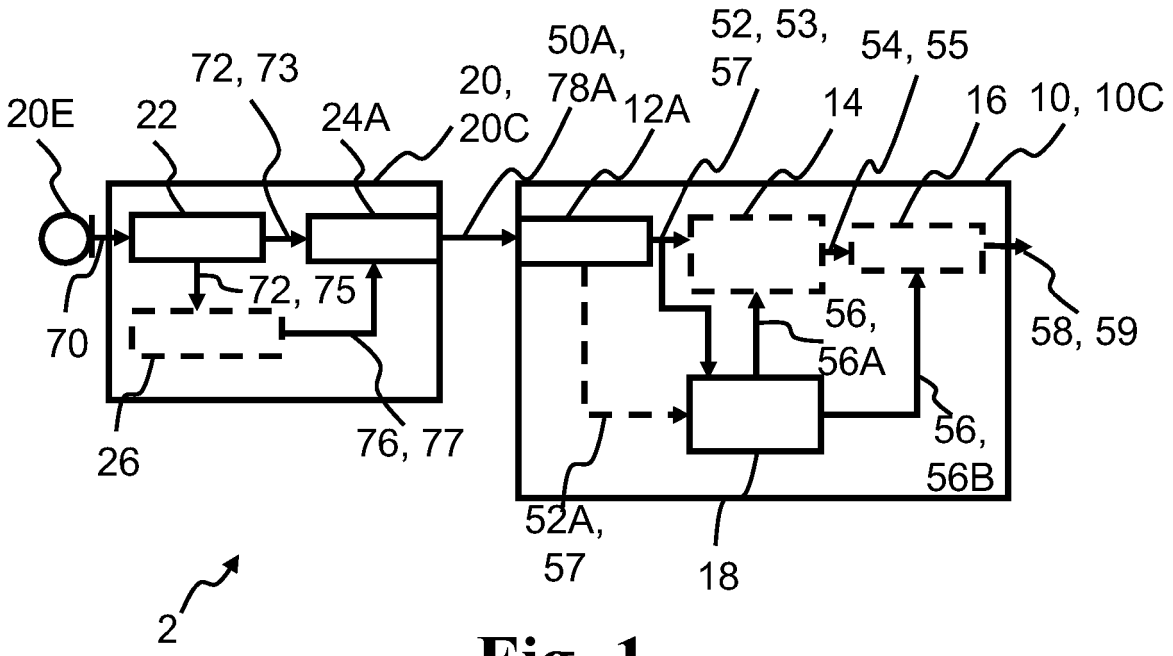
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Fig. 1

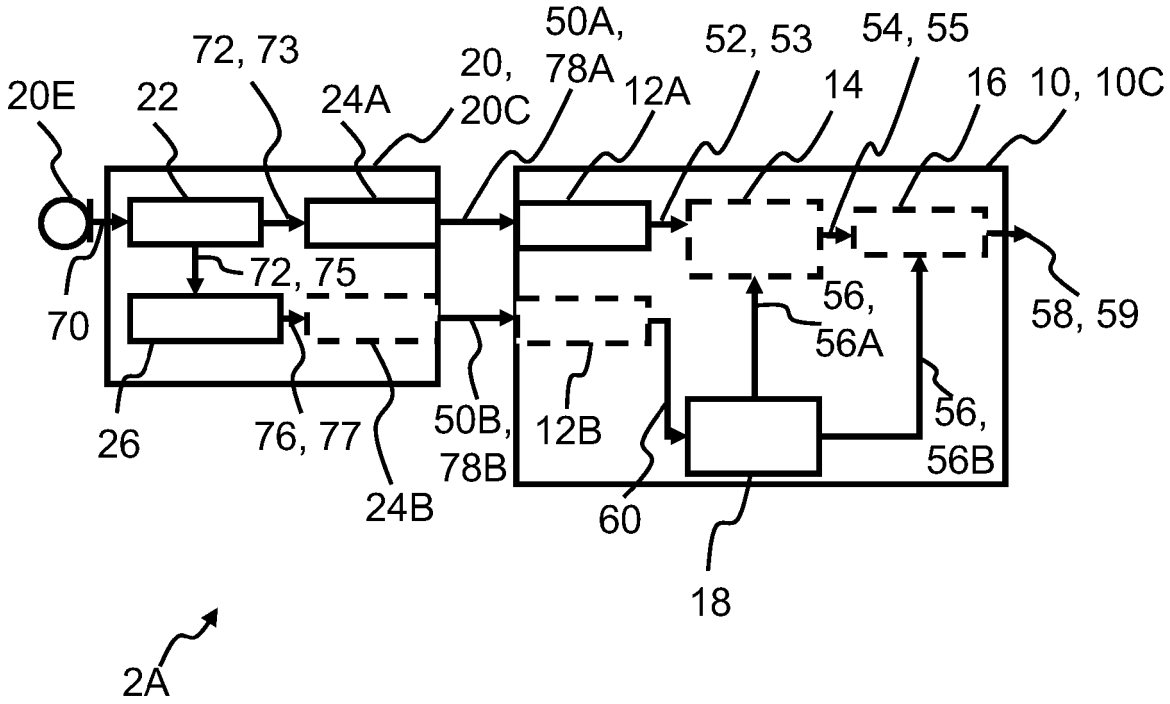
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Fig. 2

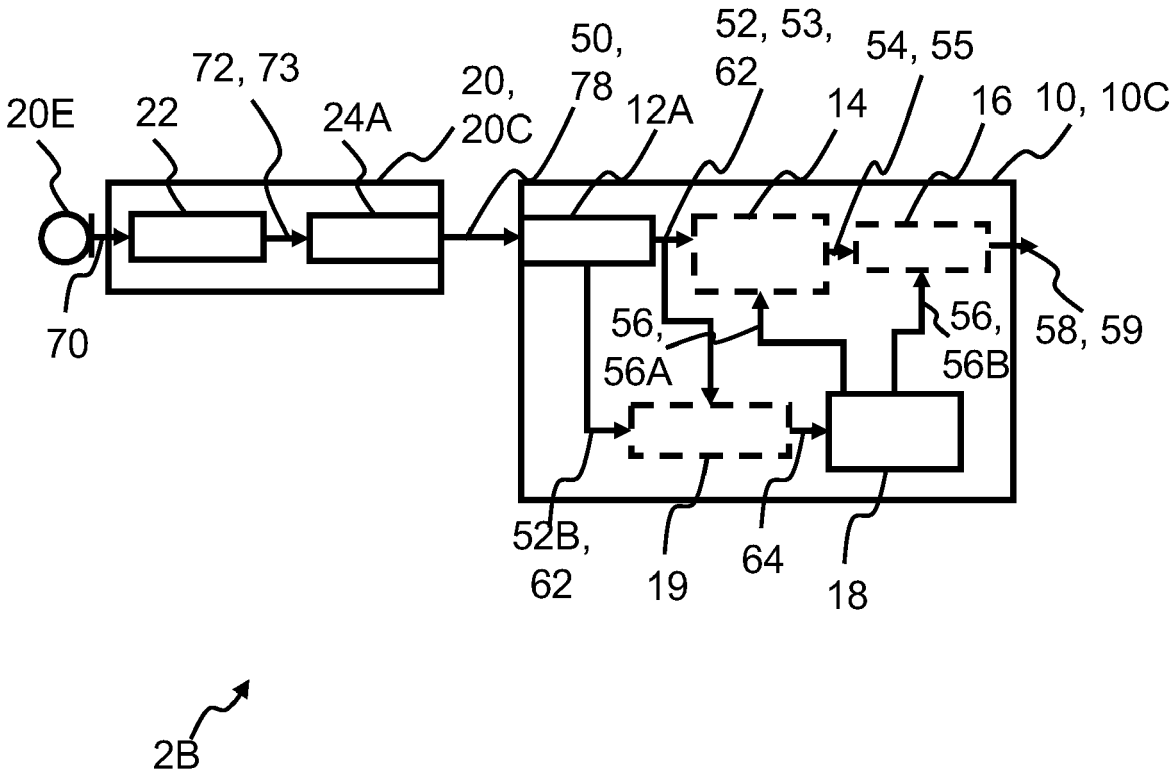
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Fig. 3

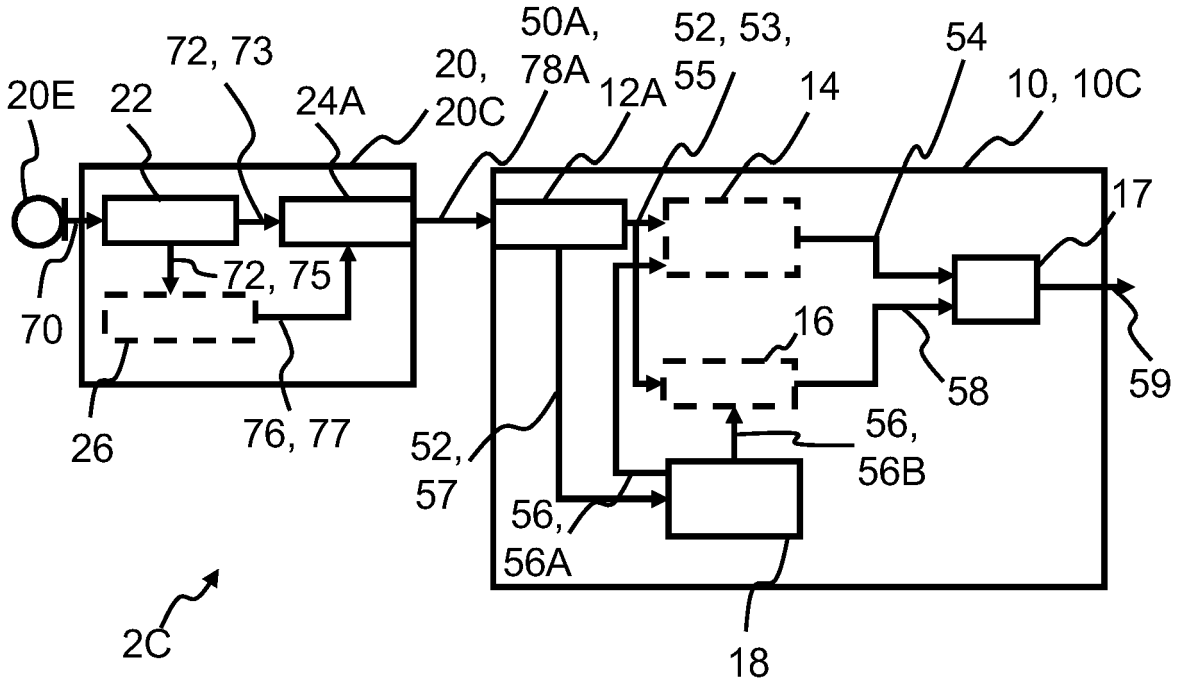
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Fig. 4

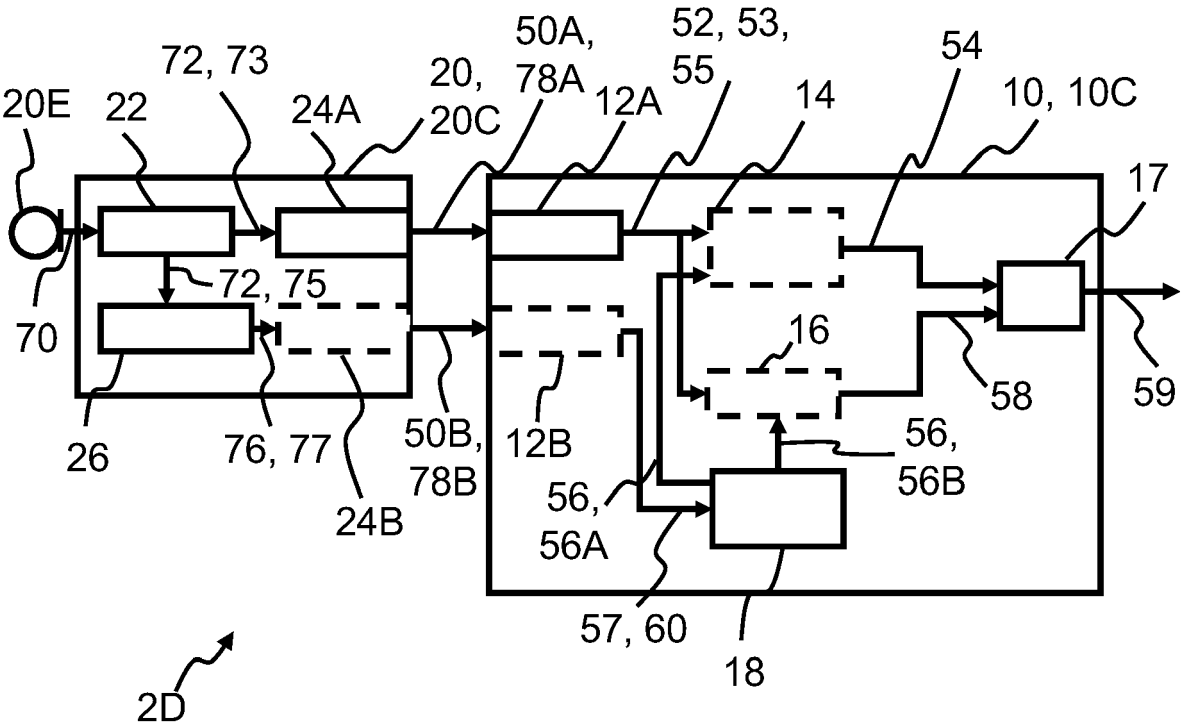
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Fig. 5

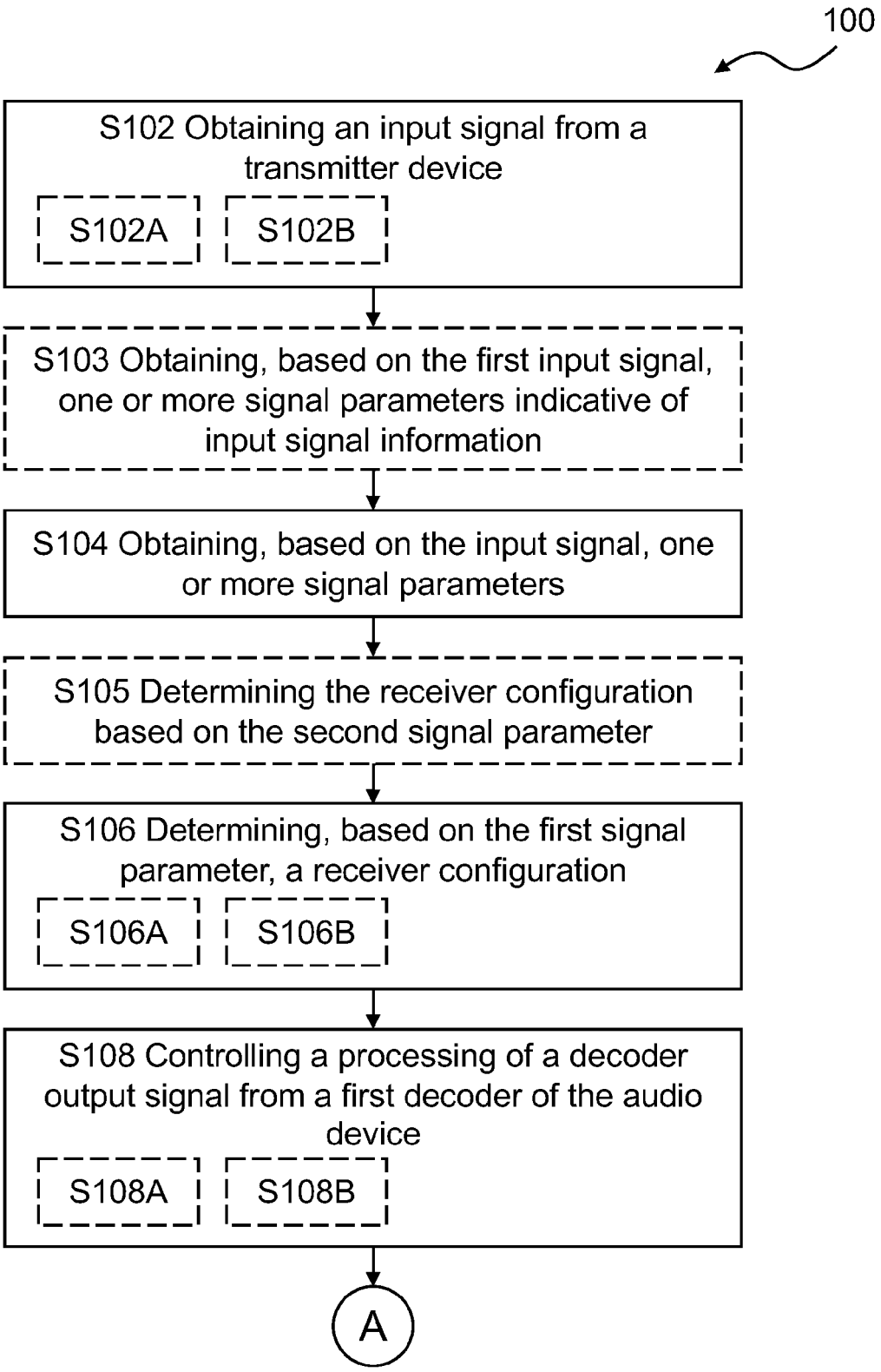
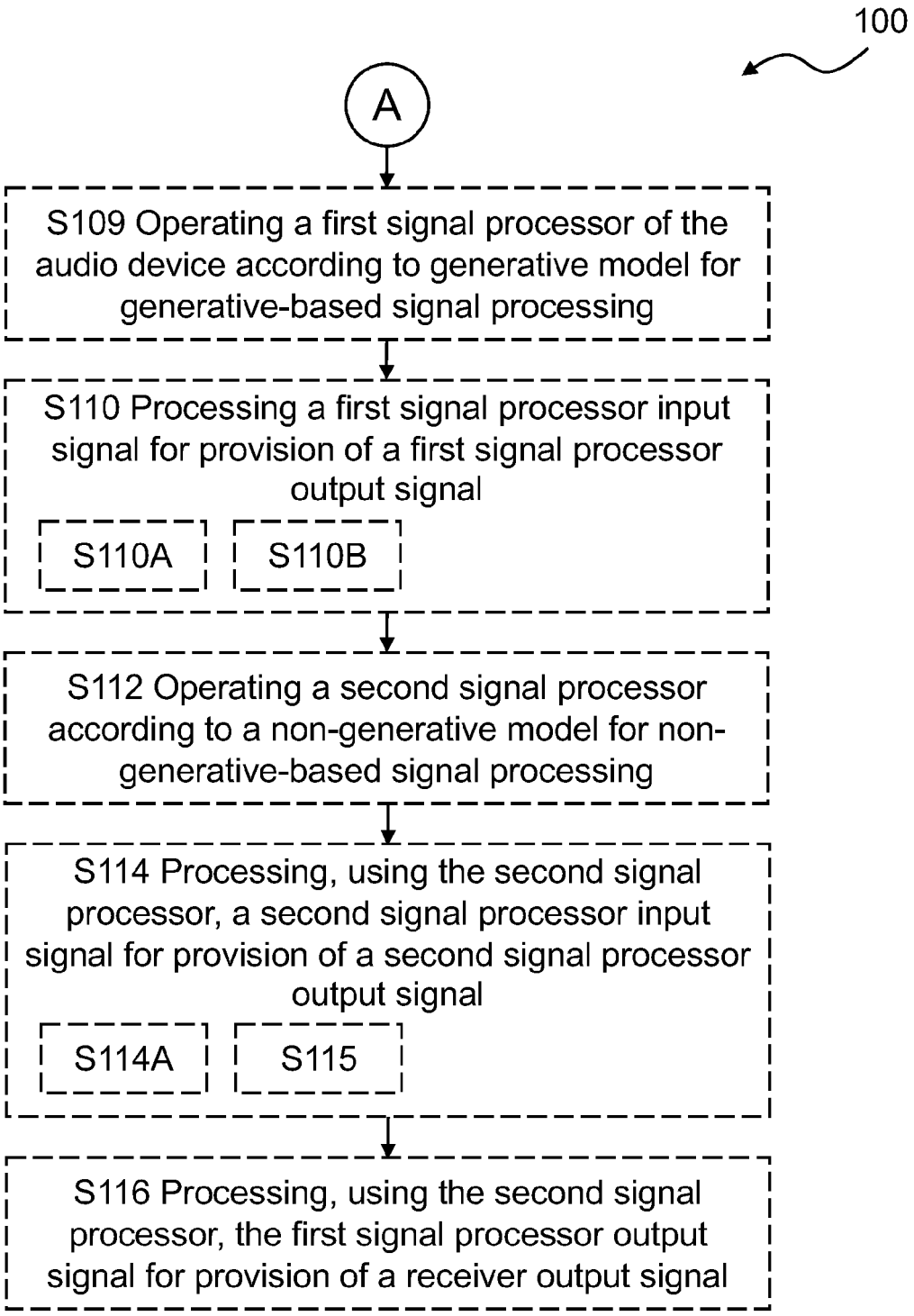

100
S102 Obtaining an input signal from a transmitter device
S102A
S102B
S103 Obtaining, based on the first input signal, one or more signal parameters indicative of input signal information
S104 Obtaining, based on the input signal, one or more signal parameters
S105 Determining the receiver configuration based on the second signal parameter
S106 Determining, based on the first signal parameter, a receiver configuration
S106A
S106B
S108 Controlling a processing of a decoder output signal from a first decoder of the audio device
S108A
S108B
A

Fig. 6A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A
S109 Operating a first signal processor of the audio device according to generative model for generative-based signal processing
S110 Processing a first signal processor input signal for provision of a first signal processor output signal
S110A
S110B
S112 Operating a second signal processor according to a non-generative model for non-generative-based signal processing
S114 Processing, using the second signal processor, a second signal processor input signal for provision of a second signal processor output signal
S114A
S115
S116 Processing, using the second signal processor, the first signal processor output signal for provision of a receiver output signal

Fig. 6B

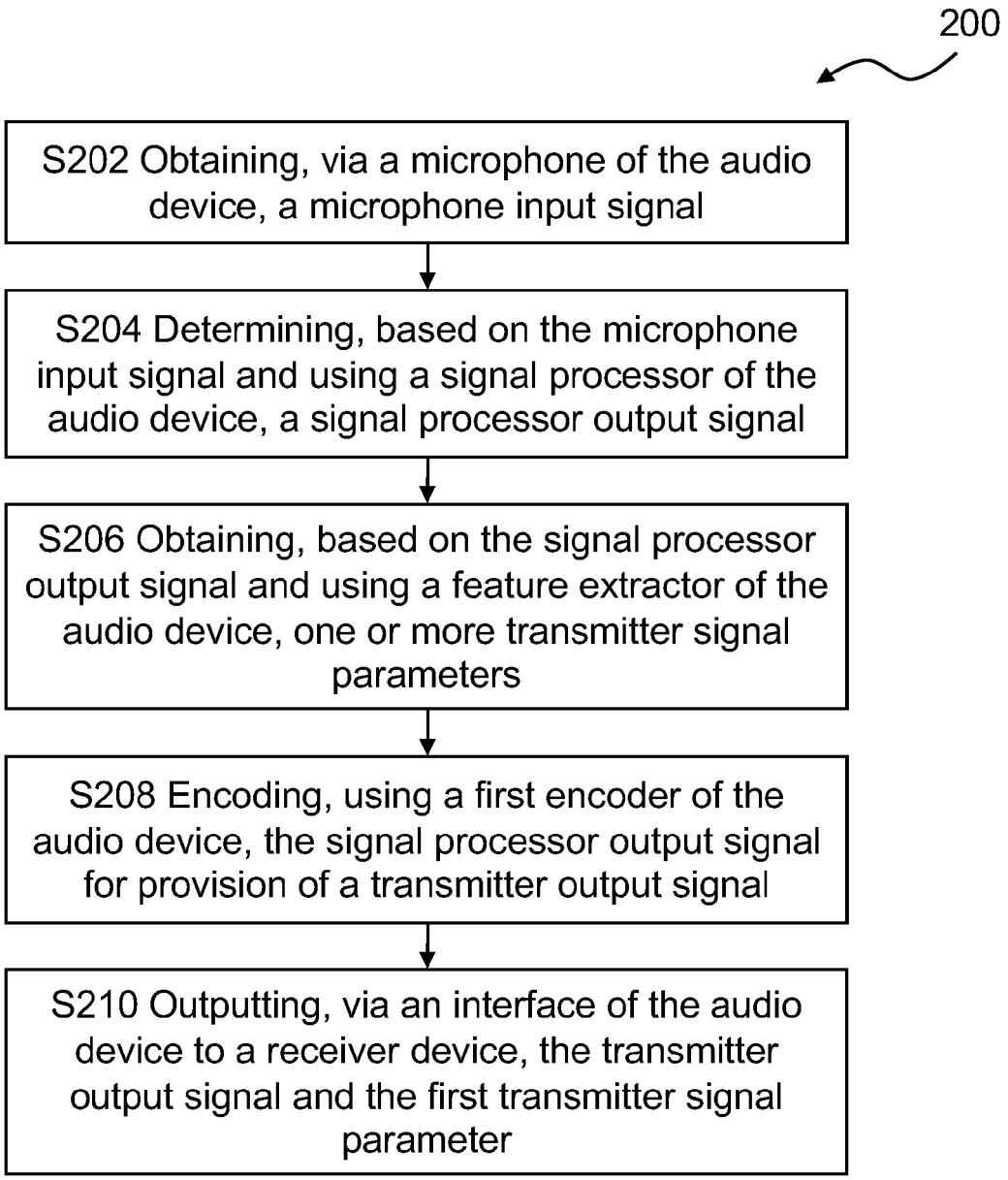
200
S202 Obtaining, via a microphone of the audio device, a microphone input signal
S204 Determining, based on the microphone input signal and using a signal processor of the audio device, a signal processor output signal
S206 Obtaining, based on the signal processor output signal and using a feature extractor of the audio device, one or more transmitter signal parameters
S208 Encoding, using a first encoder of the audio device, the signal processor output signal for provision of a transmitter output signal
S210 Outputting, via an interface of the audio device to a receiver device, the transmitter output signal and the first transmitter signal parameter

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 9856

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2015/088919 A1 (QUALCOMM INC [US]) 18 June 2015 (2015-06-18) * abstract; figures * * paragraphs [0011] - [0024], [0038] - [0052], [0058] - [0078], [0084] - [0115] * -----	1-5, 7-11,14, 15	INV. G10L19/16 G10L19/24 G10L21/038
X	WO 2015/077641 A1 (QUALCOMM INC [US]) 28 May 2015 (2015-05-28) * abstract; figures * * paragraphs [0002], [0007], [0016] - [0028], [0049] - [0056], [0123], [0135] - [0140], [0157] - [0170] * -----	1,2,4,6, 8-10,14, 15	
X	US 2021/327445 A1 (BISWAS ARIJIT [DE] ET AL) 21 October 2021 (2021-10-21) * abstract; figures * * paragraphs [0002] - [0012], [0025] - [0026], [0038] - [0044], [0079] - [0096] * -----	1-3, 8-10, 12-15	TECHNICAL FIELDS SEARCHED (IPC) G10L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 March 2023	Scappazzoni, E

CATEGORY OF CITED DOCUMENTS

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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 20 9856

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31-03-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82