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(54) **Wireless transmission principle**

(57) This invention relates to a hearing aid system having a communication unit for inductively transmitting and receiving signals. The communication unit comprises an active unit, which is excited by a data stream signal. The data stream drives an inductive antenna in a transmission state by means of a first inductor coupled to the

antenna. Further, the communication unit comprises a frequency determining unit coupled to the antenna by means of a second inductor and controlling transmission frequency in the transmission state and to provide received signals to a receiver front end in a reception state. The data stream signal is disabled during said reception state.

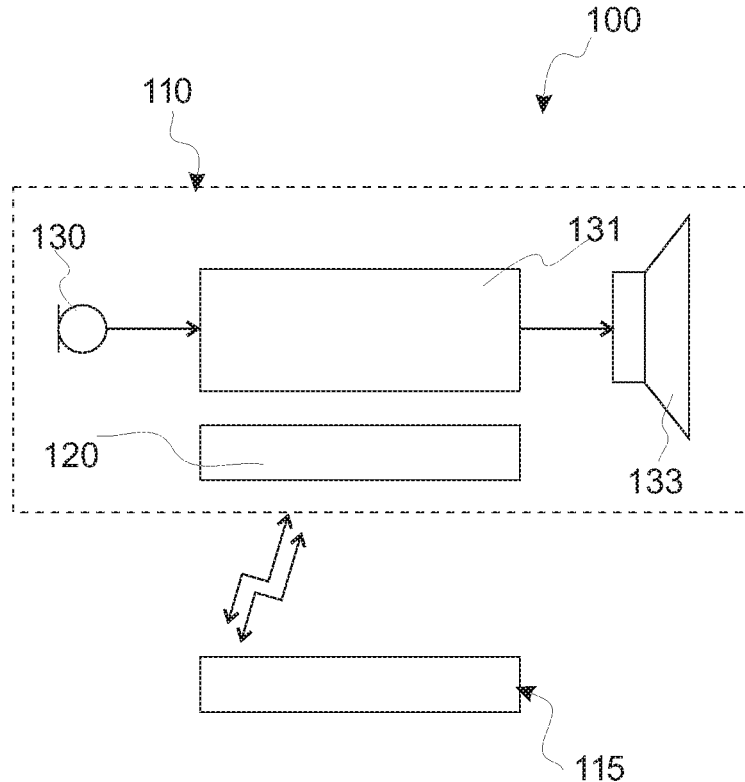


Fig. 1

Description

Field of the invention

[0001] This invention generally relates to a hearing aid, such as a behind-the-ear (BTE), in-the-ear (ITE), receiver-in-the-ear (RITE), or completely-in-canal (CIC) hearing aid. More particularly, the invention relates to a hearing aid comprising a wireless communication unit for communicating RF signals, said wireless communication unit comprising an active unit comprising at least one inductor and an oscillator circuit.

Background of the invention

[0002] Wireless devices for hearing aids are becoming increasingly popular. An example of a wireless device for a hearing aid is a first hearing aid (e.g. positioned in a left ear) enabled to transmit to a second hearing aid (e.g. positioned in a right ear) such that a programming of said first hearing aid may be transmitted simultaneously to the second hearing aid and thus both hearing aids may be programmed simultaneously to e.g. change setting. Another example of a wireless device for a hearing aid is a FM listening system with a wireless receiver integrated in a hearing aid. Yet another example of a wireless device for a hearing aid is a separate wireless microphone which can be given to a partner to wear e.g. in a restaurant to transmit voice wirelessly to the hearing aid thereby reducing the effects of distance between the partner and the hearing aid and/or background noise.

[0003] Wireless devices for hearing aids are exposed to the noise in the hearing aids digital units. Especially, if the digital clock of the hearing aid and the wireless transmission frequency are related to the same master clock generator, then the noise will add and thereby undermine the sensitivity of the wireless receiver in the hearing aid.

[0004] In certification of a wireless system the emission limits of a wireless device depend on the frequency used and therefore, the difficulty in obtaining a certification depends mainly on the frequency chosen for the wireless system. This problem will strongly influence the construction of the hearing aids when the clock frequency must fit a set of frequencies given in the certification standards of the hearing aid.

[0005] US 2004/0131213 discloses a wireless system for hearing instruments operating in the long wave frequency range. The wireless transmission is frequency modulated.

[0006] US 6,088,339 discloses a method and circuit for communication between a programming apparatus and a user apparatus to be programmed, such as a hearing aid. Data as well as clock pulses are transmitted by the programming apparatus to the user apparatus for individual adjustment of the user apparatus. The data and clock pulses are transmitted in half duplex operation using a single line.

[0007] US 2004/0175009 discloses an inductor in an oscillator simultaneously used as an antenna for example in a hearing aid.

[0008] US 2005/0105752 discloses a miniaturization and cost-effective making of a magnetic field sensor in a hearing aid by use of a ferrite component as the magnetic field sensor.

[0009] US 2004/0156520 discloses a miniature transducer assembly having a plurality of external terminals on an assembly housing wherein at least one of the plurality of external terminals is adapted to receive and/or transmit at least two electrical signals so as to reduce the number of external terminals on the housing.

[0010] US 2004/0109577 discloses a jitter unit in connection with a clock generator in a hearing aid device in order to prevent disruption in transmission between a hearing aid device and a second device. The jitter unit provides frequency oscillations in the clock signal from the clock generator thereby enabling interference-free transmission between a transmitting and/or receiving unit connected with a hearing aid device and a second device.

[0011] DE 103 04 479 discloses reduction of the size of a device used to transmit and receive data for remote controlling of hearing devices by winding a transmitter coil of a transmitter and a receiver coil of a receiver around a common shared core. Additionally, a protective capacitor used to protect the receiver is at the same time used as a correction capacitor to correct the resonant frequency of a reception oscillator circuit.

[0012] However, it remains a problem to reduce/limit/remove noise induced in a wireless receiver of a hearing aid device by a wireless device. More specifically, it remains a problem to reduce/limit/remove noise induced in a wireless receiver of a hearing aid device by a wireless device, wherein the transmission frequency of the wireless device and the clock frequency of the hearing aid device are related to a common clock generator.

[0013] It further remains a problem to certify wireless devices for hearing aids due to the difficulty in choosing a suitable frequency complying with one or more certification standards of hearing aids.

Summary

[0014] A hearing aid is disclosed, which may comprise a wireless communication unit for communicating signals, said wireless communication unit comprising an active unit comprising at least one inductor, an oscillator circuit, wherein the wireless communication unit is adapted to operate at an operating frequency controlled by an operating frequency of said oscillator circuit.

[0015] Further, a hearing aid is disclosed, which has a communication unit for inductively transmitting and receiving signals, and said communication unit comprising: an active unit adapted to be excited by a data stream signal driving an inductive antenna in a transmission state by means of a first inductor coupled to said antenna; a frequency determining unit coupled to said antenna by

means of a second inductor and adapted to control transmission frequency in said transmission state and to provide received signals to a receiver front end in a reception state; and wherein said data stream signal is disabled during said reception state.

[0016] Consequently, it is an advantage that the operating frequency of the wireless communication unit is determined by an operating frequency of the oscillator circuit because the hearing aid is thereby enabled to perform wireless communication with a wireless device at a frequency independent of a clock signal in said hearing aid. Thus, disturbance from the digital operation of the hearing aid may be avoided in the wireless communication between the hearing aid and a wireless device.

[0017] Further, the hearing aid may operate at any arbitrarily chosen frequency, for example determined by the components of the oscillator circuit, and thereby the hearing aid may be made to comply with any certification standard.

[0018] Still further, the oscillator circuit of the hearing aid may automatically operate at an optimum frequency in its free running mode and is self-biasing. Therefore, the power consumption of the hearing aid is low.

[0019] Further disclosed is the hearing aid wherein said oscillator circuit may comprise an inductor and a capacitance.

[0020] Thereby, the oscillator circuit may be a resonant type oscillator.

[0021] Further disclosed is the hearing aid wherein at least one inductor of the active unit and an inductor of the oscillator unit may be coupled via a ferromagnetic element.

[0022] Thereby it is achieved that a signal from the active unit may be transmitted to the oscillator circuit and vice versa via voltages inducted in the inductor of the oscillator circuit/active unit, respectively.

[0023] Further disclosed is the hearing aid wherein the oscillator circuit may be powered by a bit stream from said active unit.

[0024] Thereby, it may be achieved that the oscillator circuit (and thus the wireless communication unit) substantially consumes energy when it receives a high bit from a data stream i.e. the wireless communication unit is powered by the data stream.

[0025] Further disclosed is a hearing aid, which may comprise a receiver input being grounded during transmission.

[0026] Thereby the receiver input may be protected against high voltage built up across the LC tank during transmission.

[0027] Further disclosed is the hearing aid wherein data transmission between said wireless communication unit and a wireless device may be pulse modulated.

[0028] Further disclosed is the hearing aid wherein said pulse modulation may correspond to the data stream powering said oscillator circuit.

[0029] Further disclosed is the hearing aid wherein the hearing aid may comprise a transmitter and receiver an-

tenna.

[0030] Thereby it is achieved that the hearing aid may communicate with a wireless device in half duplex.

5 [0031] Further disclosed is the hearing aid wherein the inductor of the oscillator circuit may be inductively connected to two windings of the active unit providing feedback to the active unit.

10 [0032] Thereby the oscillator circuit may be able to determine the frequency of the wireless communication unit.

Brief description of the drawings

15 [0033] The above and/or additional objects, features and advantages of the present invention, will be further elucidated by the following illustrative and nonlimiting detailed description of embodiments of the present invention, with reference to the appended drawings, wherein:

20 Figure 1 shows a hearing aid in wireless communication with a wireless device.

Figure 2 shows a wireless communication unit of the invention.

Detailed description

30 [0034] In the following description, reference is made to the accompanying figures, which show by way of illustration how the invention may be practiced.

35 [0035] Figure 1 shows a hearing aid system designated in entirety by reference numeral 100. The hearing aid system 100 comprises a hearing aid 110 in wireless communication with a wireless device 115. The hearing aid comprises a microphone 130, a signal processing circuit 131, a loudspeaker 133 and a wireless communication unit 120, for receiving and/or transmitting one or more wireless signals from/to the wireless device.

40 [0036] The wireless communication unit may be implemented as an add-on module to the hearing aid 110 or be an integral part of a hearing aid 110.

[0037] The hearing aid 110 may be any type of hearing aid device such as for example a behind-the-ear (BTE), a receiver-in-the-ear (RITE), an in-the-ear (ITE), or a completely-in-canal (CIC) hearing aid.

45 [0038] The wireless device 115 may comprise microphone, an FM receiver, Bluetooth device, IR device, a remote control for hearing aids and any combination thereof.

50 [0039] The wireless communication unit 120 is shown in further detail in figure 2. The wireless communication unit 120 comprises a data stream input unit 205, an active unit 210, a frequency determining unit 215, an inductive antenna 220 and a receiver front end 225.

55 [0040] The data stream input unit 205 communicates digital data information to the active unit 210, which data information drives the active unit 210 to induce a magnetic signal in the inductive antenna 220, thereby trans-

mitting the data information from the hearing aid 110.

[0041] The frequency determining unit 215 is excited by the active unit 210 communicating a data stream from the data stream input 205. Any data rate of the data stream may be transmitted by the wireless communication unit 120 by selecting an appropriate oscillation frequency determined by frequency determining unit 215. Hence the frequency determining unit 215 is not synchronized with the data except for powering of the transmission/reception of the wireless communication unit 120.

[0042] The active unit 210 comprises a capacitor, 250, two resistors 251 and 252, a transistor 253 and two inductors 254 and 255.

[0043] The capacitor 250 may, for example, be a substantially 1 nF capacitor.

[0044] The resistor 251 may, for example, be a substantially 1 k Ω resistor.

[0045] The resistor 252 may, for example, be a substantially 1 M Ω resistor.

[0046] The transistor 253 may be any type of transistor such as for example a bipolar junction transistor or a junction gate field effect transistor.

[0047] The inductors 254 and 255 may be any type of inductors such as for example an inductor comprising a copper wire coiled around a ferromagnetic material.

[0048] The frequency determining unit 215 may comprise an inductor 256 on the same ferromagnetic core as the inductors 254 and 255, two capacitances 257 and 258, and a resistor 259.

[0049] The capacitor 257 may, for example, be a substantially 47 pF capacitor.

[0050] The capacitor 258 may, for example, be a substantially 10 pF capacitor.

[0051] Alternatively, the capacitor 258 may have any (electrical) capacitance. The capacitor 258 may couple a signal received by the frequency determining unit 215 to the receiver front end 225.

[0052] The resistor 259 may, for example, be a substantially 500 Ω resistor. The resistor 259 is connected in series with resistor 260, which may be substantially 1 M Ω . This resistor 260 may be bypassed by activating switch 262. This may be implemented in order to achieve a fast initiation and termination of oscillations.

[0053] A high bit ("1") of a data stream arriving at the data stream input unit 205 may be transmitted to the active unit 210. The high bit may excite the inductor 255, which in turn may generate a voltage and/or current in the inductor 256. Thereby, the frequency determining components 256 and 257 may start to oscillate at a frequency determined by the capacitor 257 and the inductor 256. A high bit thus may generate a current through the inductor 255 which in turn generates a voltage and/or current signal in the inductor 256. Thereby, a signal is induced in the inductor 254. The inductor 254 controls the transistor and thus the current/voltage through the coil 255. Thereby, the operating frequency of the wireless communication unit 210 is substantially determined by frequency determining unit 215 through the inductors

254, 255 and 256 and therefore, the wireless communication unit 120 may be un-synchronized with the data signal.

[0054] The inductor 254 may excite the inductors 255 and 256 through the common ferrite core and may in addition provide feedback to the active unit 210.

[0055] The oscillating signal in the frequency determining unit 215 may generate a voltage and/or current signal in the inductor 254. This signal may control the transistor 253 such that the signal of the active unit 210 oscillates at the frequency determined by the frequency determining unit 215.

[0056] A low bit ("0") of a data stream arriving at the data stream input unit 205 may be transmitted to the active unit 210. A low bit will not supply power to the active unit 210 and therefore no signal is induced in the inductor 256 of the frequency determining unit 215, which therefore stops when a low bit is transmitted e.g. to a wireless device 115.

[0057] Thereby, the frequency determining unit 215 is driven in a self-biasing manner at a frequency substantially equal to its own resonance frequency and thus, the frequency determining unit 215 is substantially automatically running at optimum frequency.

[0058] Further, the frequency of the signal output at the oscillator circuit 215 e.g. at the transmitter and receiver antenna 220 will be determined by the oscillator circuit 215 and thus, the wireless communication unit 200 may communicate with a wireless device 115 at a frequency independent of a clock signal in the hearing aid.

[0059] Thereby, the operating frequency of the communication unit 200 may substantially be determined by the oscillator circuit 215. Thus, the frequency used to transmit data to/from the wireless communication unit 120 may be chosen to any frequency without influencing other systems and/or devices and/or components in the hearing aid 110 and vice versa.

[0060] The operating frequency of the wireless communication unit 120 used to transmit data between the hearing aid 110 and the wireless device 115 may be controlled e.g. by changing the value of the inductance L of the inductor 256 and/or the capacitance C of the capacitor 257 of the oscillator circuit 215.

[0061] Thus, the frequency used to transmit data to the wireless device 115 from the wireless communication unit 120 of the hearing aid 110 and vice versa may be independent of a computation clock frequency used in the hearing aid 110. Therefore, the frequency used for the wireless transmission between the hearing aid 110 and the wireless device 115 may be chosen such as to generate minimum interference with the computing noise of the hearing aid.

[0062] Further, the frequency used for the wireless transmission between the hearing aid 110 and the wireless device 115 may be chosen to any frequency that conforms to the requirements for certification without influencing other systems/devices in the hearing aid.

[0063] The inductor 256 may, for example, comprise

a solenoid on a ferrite rod of small dimensions, e.g. approximately 3mm x 1 mm x 1 mm.

[0064] Because the frequency determining unit 215 may automatically run at its optimum frequency and to be self-biased, the unit 215 is able to provide a well defined amplitude with a high efficiency. Further, the power consumption of the wireless communication unit 120 is low as the unit 215 runs at its optimum frequency and bias condition.

[0065] The active unit 210 and the frequency determining unit 215 are powered by the input bit stream i.e. when the communication unit 200 receives a high bit ("1") from the data stream input 205, it is "active" and when the active unit receives a low bit ("0") from the data stream input 205, it is "passive".

[0066] Further, during transmission the receiver front end 225 is grounded in order to protect the front end against the high voltage that built up across the frequency determining unit 215. The frequency determining unit 215 frequency may therefore vary slightly from a transmitting mode to a receiving mode so the receiver bandwidth is fit for that.

[0067] When the wireless communication unit 120 receives data e.g. from a wireless device 115, the active unit 210 and the frequency determining unit 215 are not powered by a data stream from the data stream input unit 205 and thereby the frequency determining unit 215 in connection with the transmitter and receiver antenna, 220, may receive data from the wireless device 115.

[0068] Further, during reception, the frequency determining unit 215 in connection with the antenna, 220, generates a high voltage output due to the large inductance of the inductor 256. During reception, the active unit 210 does not load the frequency determining unit 215 as the voltage levels that are induced from the inductor 256 to inductors 254 and 255 are small and the transistor 253 has no supply voltages in the active unit 210.

[0069] The data signal received by the antenna 220 is transmitted to the frequency determining unit 215 and further to the receiver front end 225 via a small capacitor 258.

[0070] Because the data stream powers the active unit 210 and the frequency determining unit 215, transfer of data from the hearing aid to the wireless device and/or vice versa may be pulse modulated corresponding to the bit stream powering the active unit 210 and the frequency determining unit 215.

[0071] Generally, the frequency determining unit 215 may operate at any frequency determined by the inductance of the inductor 256 and the capacitance of the capacitor 257. For example, the frequency determining unit 215 may operate at frequencies between 2 and 6 MHz and transmission/reception of data with a rate of 120kBit/s. Alternatively, any transmission and/or reception frequency may be utilized and/or any data rate may be utilized.

[0072] The data received by the hearing aid from the wireless device and/or vice versa may be detected via

AM detection.

[0073] The active unit 210 may excite the frequency determining unit 215 at a low voltage while the unit 215 may resonate at a high voltage due to the inductance of the inductor 256.

[0074] The transmission of data between the hearing aid 110 and the wireless device 115 may be half duplex i.e. communication in both directions (from hearing aid to wireless device and vice versa), but only one direction at a time.

[0075] Hence the wireless communication unit 120 for a hearing aid includes an active unit 210 for exciting an inductive antenna 220 (a ferrite core) at a transmission frequency determined by a frequency determining unit 215 couple to the active unit 210 through the antenna 220 in accordance with a data stream, which may be a pulse modulated signal. The high bits ("1") of the data stream excites the active unit 210, in particular the transistor 253, which enables current to induce a magnetic signal coupled to the frequency determining unit 215 controlling the resonance frequency in the transmission mode of the wireless communication unit 120. During reception mode the data stream is disabled thus providing the transistor 253 in a non-conductive state and ensuring that the received signal is picked up by the inductor 256 and converted into an electrical signal to be communicated to the receiver front end 225. It should be noted that the switch 262, switches in a closed state when the wireless communication unit 120 is transmitting and in an open state when the wireless communication unit 120 is receiving.

[0076] During reception the difference in the number of windings of the inductor 256 and the inductors 254 and 255 ensures that the received signal does not drive the active unit 210, in particular the transistor 253 in to a conductive state, and thus the active unit 210 does not substantially affect the reception of signals.

[0077] The system may replace other half duplex wireless systems for short and/or medium and/or long range operation as the oscillator starts when data is high and stops when data is low.

[0078] Although some embodiments have been described and shown in detail, the invention is not restricted to them, but may also be embodied in other ways within the scope of the subject matter defined in the following claims. In particular, it is to be understood that other embodiments may be utilised and structural and functional modifications may be made without departing from the scope of the present invention.

[0079] In device claims enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims or described in different embodiments does not indicate that a combination of these measures cannot be used to advantage.

[0080] It should be emphasized that the term "comprises/comprising" when used in this specification is tak-

en to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

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Claims

1. A hearing aid system having a communication unit for inductively transmitting and receiving signals, and said communication unit comprising: 10

an active unit adapted to be excited by a data stream signal driving an inductive antenna in a transmission state by means of a first inductor coupled to said antenna; 15

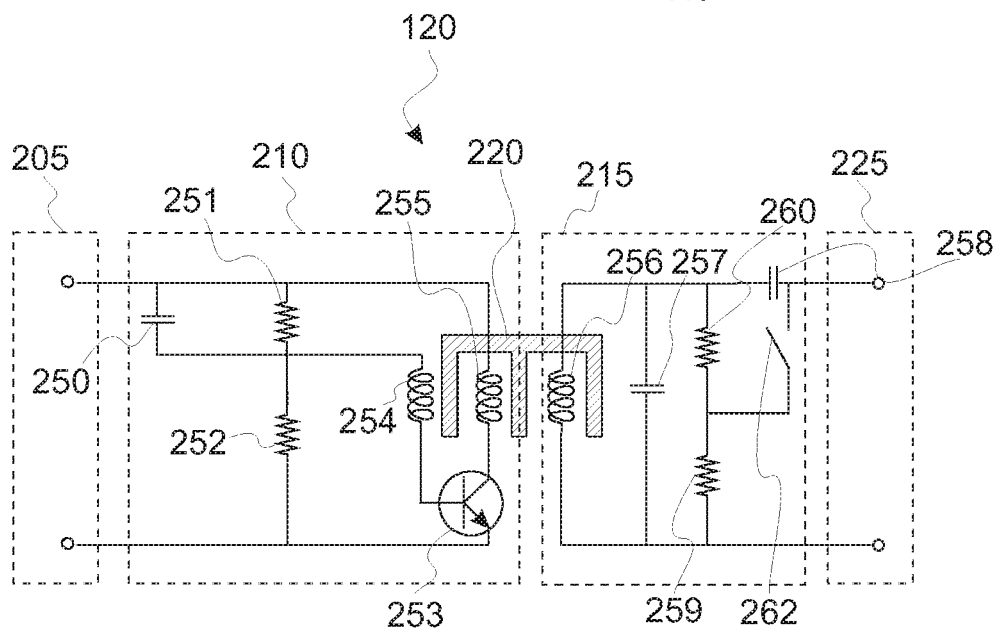
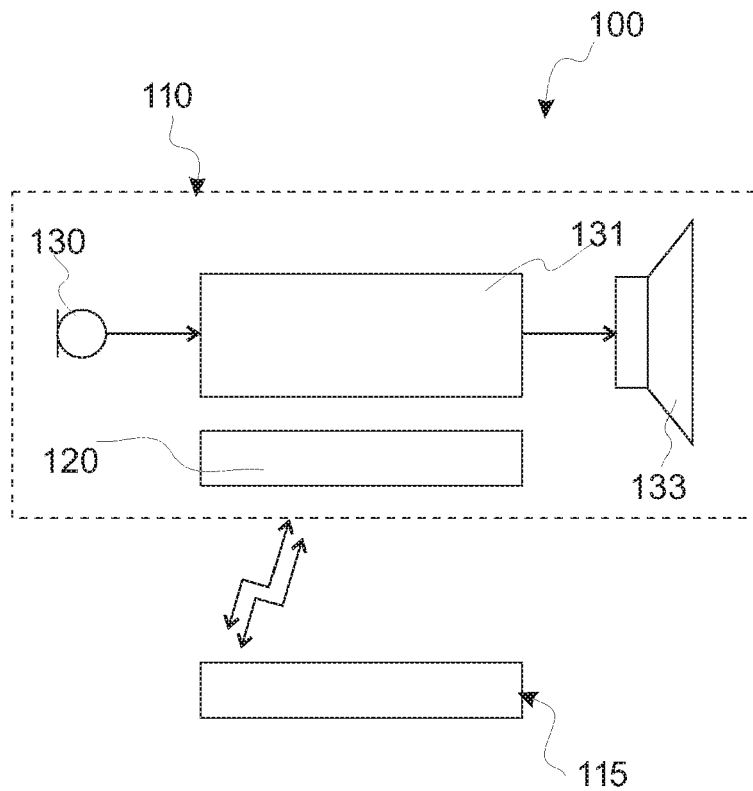
a frequency determining unit coupled to said antenna by means of a second inductor and adapted to control transmission frequency in said transmission state and to provide received signals to a receiver front end in a reception state; 20

and wherein

said data stream signal is disabled during said reception state. 25

2. A hearing aid according to claim 1, wherein said frequency determining unit comprises an inductor and a capacitance.
3. A hearing aid according to claim 1, wherein said antenna comprises a ferromagnetic element for coupling said first and second inductor. 30
4. A hearing aid according to any of claims 1 to 3, wherein the data stream signal during reception is grounded. 35
5. A hearing aid according to any of claims 1 to 4, wherein transmission between said wireless communication unit and a wireless device is pulse modulated. 40
6. A hearing aid according to claim 5, wherein said pulse modulation corresponds to the data stream exciting said active unit. 45
7. A hearing aid according to any of claims 1 to 6, wherein the active unit comprises a third inductor couple to said antenna and adapted to provide feedback to the active unit from the frequency determining unit. 50

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European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 11 9861

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
Munich		15 February 2008	Righetti, Marco
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 11 9861

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