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Magnetic Resonance Charging Receiver System Integration Design for Hearing Instrument

The invention concerns a receiver system for wireless charging as well as a hearing instrument with such a receiver. In particular, the invention concerns a motherboard and holding frame for a hearing instrument.

A small form factor design is a major priority for a hearing instrument, in particular hearing aid, especially for an In-The-Ear (ITE) hearing instrument for catering to a wide range of shell shapes to be produced as a custom product in the market. A high charging freedom for wireless charging is also preferred compared to contact charging for a custom hearing instrument device due to the inconsistency of shell shape from one device to another.

Objectives of the present invention include, in particular, providing an improved hearing instrument. Further objectives can be derived from the following text.

One or several objectives are solved by the subject matter as claimed in the claims and as described in the following text. Further solutions and preferred embodiments are described in the following text as well.

The invention is described in detail below and with reference to the following figures, showing preferred embodiments of the invention:

Fig. 1 Motherboard Sandwiching battery coil module design,

Fig. 2 Motherboard Copper trace cover battery coil module ferrite,

Fig. 3 Inconsistent distances from the motherboard from one device to another,

Fig. 4 BTE/RIC battery coil module positioning,

Fig. 5 The motherboard copper trace trimming region,

Fig. 6 The result of motherboard PCB copper trace being trimmed off,

Fig. 7 Holding frame to the hearing instrument.

Wireless charging with a high charging freedom is preferably realized by the utilization of Magnetic Resonance (MR) charging technology for the hearing instrument. The hearing instrument has a battery coil module as a receiver of magnetic energy. Furthermore, the hearing instrument has one or more of the following features and corresponding components: a microphone, acoustic amplification, Bluetooth low energy (BLE), Near Field Magnetic Induction (NFMI) communication, charging-discharging feature, switch-off feature, signal processing, etc. These features are potentially required to be present in a motherboard of the hearing instrument. As such, a design, that comes to the surface using a main motherboard that contains various feature chipsets, is sandwiching the battery coil module to achieve a small form factor design and high charging freedom. A suitable sandwiching design of the motherboard for the battery coil module is shown in Fig. 1.

However, this sandwiching design has the disadvantages of a high reduction of the quality factor for the battery coil module, constraint magnetic field, and inconsistency in resonance frequency. A high reduction of quality factor is due to the reduction of inductance with the effect of the copper trace in the motherboard if placed close to the battery coil module. A high-quality factor reduction is also caused by the resistance increase due to the eddy current generated in the motherboard copper trace when it is immersed into the magnetic field. As a result, the resonance frequency of the battery coil module will be shifted to a higher frequency value. For the magnetic field constraint, the copper trace of the

motherboard covers the ferrite of the battery coil module as shown in Fig. 2, which has the result of blocking the penetration of magnetic field flow over. The ferrite has the property of a high permeability that can concentrate the magnetic field and redirect the flux flow. The blocking magnetic field flow is due to the copper material that has a conductive property that has a magnetic field shielding characteristic. The inconsistency of shifting in the resonance frequency after the device is assembled is due to the inconsistency of the distance (d1 and d2) from the motherboard to the battery coil module as shown in Fig. 3 from one device to another. The distance d1 is the distance from the ferrite's lowest end to the motherboard and the distance d2 is the distance from the upper end to the Radio Frequency (RF) communication antenna.

It is preferable, to enable wireless charging for an ITE hearing aid device, especially for a custom shell device. Hence, an embodiment of the present invention comprises a battery coil module for integration into a hearing instrument, preferably an ITE hearing aid, and a hearing instrument, in which such a battery coil module is integrated. For a wirelessly chargeable Behind-The-Ear (BTE) hearing aid or Receiver-In-Canal (RIC) hearing aid, the size constraint is much bigger than for an ITE device. Hence, the BTE/RIC Hearing Aid is preferably designed by placing the battery coil module far apart from the motherboard and usually at the back end of the hearing instrument as shown in Fig. 4. The positioning of the battery coil module at the back end neither influences the wireless charging nor blocks the magnetic field.

This application discloses a Magnetic Resonance Charging Receiver System Integration Design for a Hearing Instrument. Objectives of the integration design are, in particular, to enhance the quality factor, reduce the shielding of the magnetic field, and increase the consistency of resonance frequency shifting. A first aspect of the invention is a motherboard PCB copper trace trimming. A second aspect of the invention is a holding frame for the hearing instrument structure. The first and second aspects are independent from each other and may be realized alone or in combination.

The motherboard PCB copper trace trimming is realized by trimming out only the ferrite blocking region and preserving the remaining motherboard PCB copper trace as a big, plane ground trace for noise reduction. Fig. 5 shows the shaded blue color (C-shaped on the left side, open to the right side in Fig. 5) as the trimmed-out region of the motherboard PCB copper trace. Fig. 6 shows the result of the copper trace being trimmed. The trimmed copper trace region is preferably trimmed off entirely or replaced with a non-conductive material such as an FR4 PCB. The copper trace trimming has the benefit of minimizing the reduction of inductance to the integrated battery coil module and quality factor. Furthermore, this trimmed motherboard PCB copper trace allows the ferrite to appear without the flow of generated magnetic field being blocked. So, the generated magnetic field can directly reach the ferrite of the battery coil module.

A high tolerance accuracy holding frame is introduced to the hearing instrument as a support and positioning of the whole structure. Fig. 7 shows the high accuracy tolerance holding frame of the hearing instrument. The invented high tolerance accuracy holding frame has the benefit of always keeping the position of the motherboard, RF antenna, microphone, and battery coil module at a similar position from one device to another. By keeping the position to be the same for all the devices, the resonance frequency of the devices is consistently shifted and results in a small distribution value. Furthermore, the holding frame preferably also prevents the hearing instrument from dispersion when there is an external force, such as dropping the device to the floor, strong shaking in the event of transportation or heavy sport, etc. A dispersion could lead to the motherboard being flipped up and the resonance frequency of the hearing instrument deviating from a target resonance frequency. The consequences of a resonance frequency deviation could cause the hearing instrument to not be able to charge.

The features and embodiments described in this application and in connection with the figures are not restricted to the specific combinations and values as described and shown therein. Rather, further advantageous embodiments of the invention result from omitting some features and/or from different combinations of the mentioned features and/or by selecting different values.

Claims

1. Hearing instrument, in particular ITE hearing aid.

2. Hearing instrument according to claim 1,
   comprising a motherboard with a trimmed PCB copper trace.

3. Hearing instrument according to claim 1 or 2,
   comprising a holding frame.

4. Holding frame for integration into a hearing instrument according to claim 3.

5. Motherboard for a hearing instrument according to claim 2.