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Antennas Embedded in the Front Frame of Smart Glasses

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ABSTRACT

Ergonomic head-up display is enabled by reliable, low latency, radio frequency (RF) communication between smart glasses and smartphones. The form factor of antennas on head-worn frames is impacted by the proximity of the frame to the human head and by cross-body interference. In addition, the large bandwidth required on the glass-to-phone link entails the use of multiple antennas, limiting the space available to route signals. The presence of antennas also restricts the choice of material for the front frames. This disclosure describes a multi-element, front-frame structure for smart glasses that enables metallic front-frame materials that enable superior cosmetic, structural, and communication design options. The described structure reduces the space occupied by antennas and reduces the complexity of assembly of multiple discrete antennas. The propagation loss presented by the human head is nullified, enabling lower radiated power, lower power consumption, and smaller and/or lighter smart glasses.

KEYWORDS

- Smart glasses
- Head-up display (HUD)
- AR goggles
- VR goggles
- In-frame antenna
- Additive manufacturing
- 3-D printing
- Eyewear
- Overmolding
- Color, material, finish (CMF)

BACKGROUND

Ergonomic head-up display is enabled by reliable, low latency, radio frequency (RF) communication between smart glasses and smartphones (or other mobile devices or peripherals). The form factor of antennas on head-worn frames is impacted by the proximity of the frame to the head and by cross-body interference. In addition, the large bandwidth required on the glasses-to-phone link entails the use of multiple antennas, limiting the space available to route signals. The presence of antennas also restricts the material properties of the front frames; for example, metal may not be used. The cosmetic and structural design choices for front-frame smart glasses are thus constrained.

Currently, discrete coaxial cables or flexible printed circuits are used to isolate RF signals and to create antennas. These are assembled into front frame enclosures that are limited to non-electrically conducting materials. The resulting smart glass designs tend to be bulky, their materials limited to plastic or glass. Flex circuits or coaxial cables also present difficulties in assembly.

DESCRIPTION

This disclosure describes a multi-element, front-frame structure for smart glasses that enables metallic front-frame materials that provide superior cosmetic and structural design options. The described structure reduces the space occupied by the antennas and reduces the complexity of assembly of multiple discrete antennas. By unifying the radiating function of the antenna into the front frame, the RF path between the smart glasses and the mobile device becomes line-of-sight (LoS) or nearly so. The substantial propagation loss presented by the human head is nullified (due to the head not being in the communications pathway), enabling lower radiated power, lower power consumption, and lighter smart glasses.

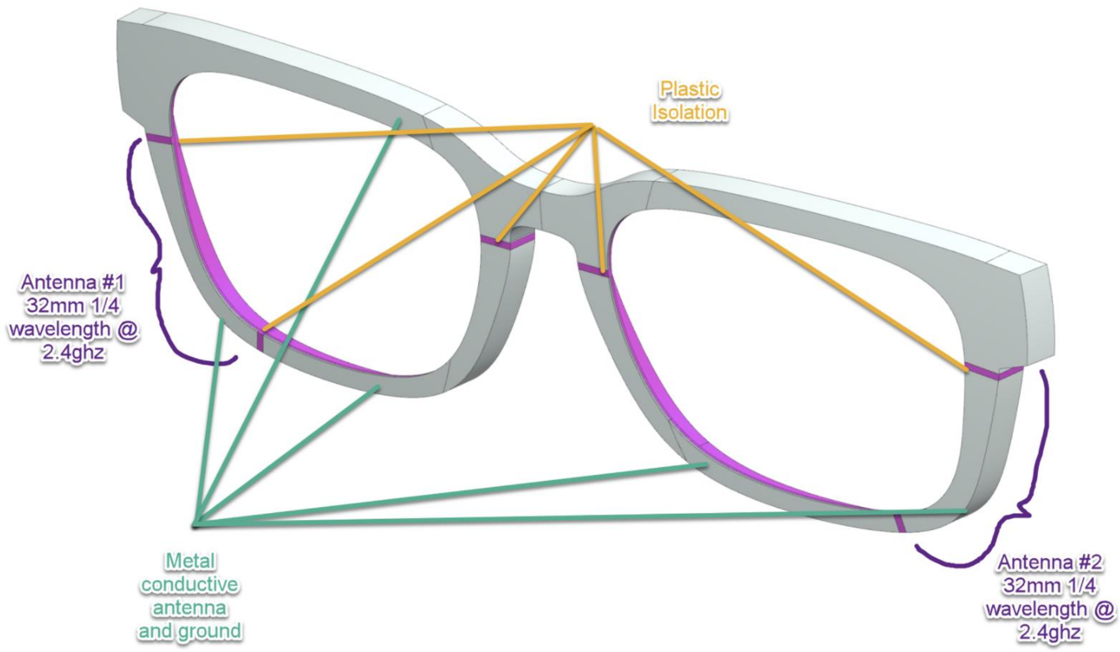

Fig. 1: Front frame of a pair of smart glasses, comprising metal elements punctuated by plastic breaks. The overall structure serves as antennas for RF communication between the glasses and mobile devices or peripherals. The dominant cosmetic element is metal.

Illustrated in Fig. 1, the front frame of a pair of smart glasses is fabricated with metals (illustrated in gray) such as aluminum, stainless steel, titanium, etc. using procedures such as additive manufacturing, casting, sheet-metal stamping, Computerized Numerical Control (CNC) machining, etc., such that the metal front frame has non-conductive (e.g., plastic, in purple) segmentation breaks at specific locations around the orbitals. The breaks in metal define the radiating antenna and the ground isolation segments at appropriate lengths (e.g., a quarter-wavelength antenna at 2.4 GHz has a metal of length 31.23 mm between breaks). The lengths of the radiating segments can be tuned for performance. In this example, metal is the dominant cosmetic element, e.g., the color-material-finish (CMF) is metallic.

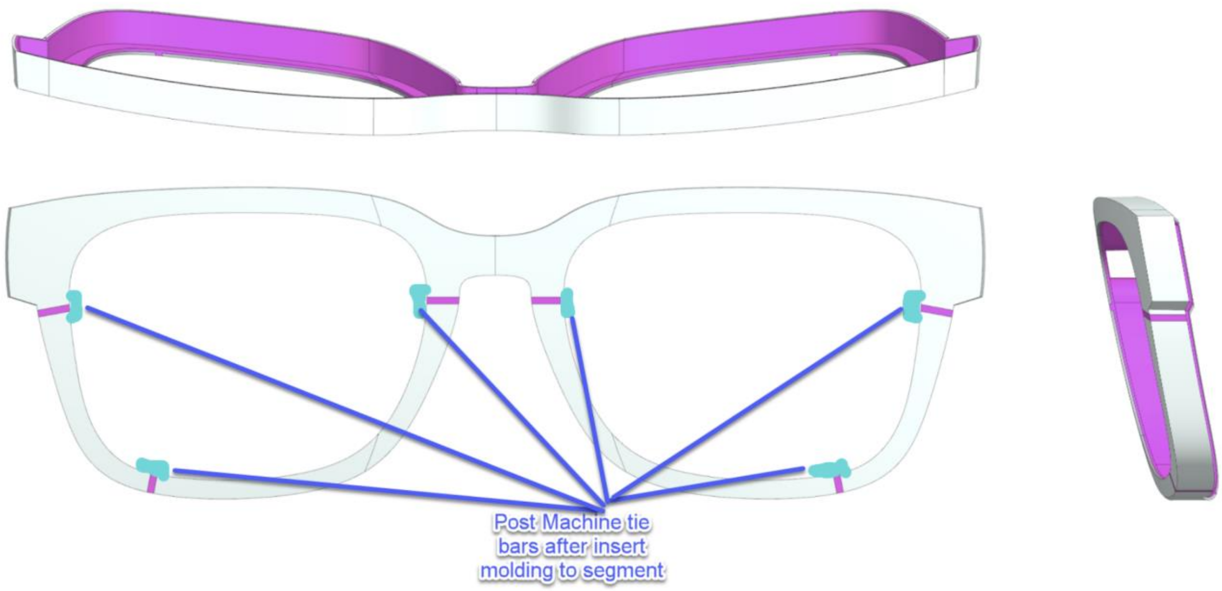

Fig. 2: Cutting off conductive tie bars to electrically isolate metallic segments of the frame structure

The segmented frame can be joined outside the frame volume to keep all segments together during secondary overmolding, where electrically non-conductive material (e.g., plastic) is used to keep the metal segments together yet electrically isolated. As illustrated in Fig. 2, after secondary molding, the conductive tie bars are cut off to electrically isolate the segments of the metal frame structure. The remaining metal frame components are electrically tied to active electronics via a single solder wire or pogo-pin contacts. Separated by plastic breaks, the metal frame components act as radiating antennas while being part and parcel of the cosmetics and the structure of the metal frame.

Fig. 3: Another example of front frames acting as antennas. In this case, metal elements (gray) are overmolded on a plastic frame. The structure acts as antennas for RF communication between the glasses and mobile devices or peripherals. The dominant cosmetic or aesthetic element is plastic.

Fig. 3 illustrates another configuration of metallic elements (gray) on the front frames of a pair of smart glasses with plastic (blue) front frames. In this example, plastic is the dominant cosmetic element, e.g., the CMF is plastic. The glasses in the example of Fig. 3 use structured metal antennas overmolded to keep the metal segments internal to the frame structure, thus saving space while having a plastic external appearance. The metallic elements form a pair of antennas that serve as communication channels between the smart glasses and a mobile device or other peripherals.

In this manner, the described techniques leverage the front-frame location of smart glasses to place RF antennas that serve the purposes of both communications as well as aesthetics. The front frame, traditionally functioning only as a lens holder, acts as a communicative and radiating element without impacting aesthetics. Designers of smart glasses are thereby provided increased flexibility in shaping cosmetics and in choosing materials. The reduced RF propagation loss (due to the human head not being in the communications pathway) results in lower power consumption and lighter smart glasses.

CONCLUSION

This disclosure describes a multi-element, front-frame structure for smart glasses that enables metallic front-frame materials that enable superior cosmetic, structural, and communication design options. The described structure reduces the space occupied by antennas and reduces the complexity of assembly of multiple discrete antennas. The propagation loss presented by the human head is nullified, enabling lower radiated power, lower power consumption, and smaller and/or lighter smart glasses.

REFERENCES

[1] Moore, Joshua, Kai Xu, and George Shaker. “Antenna designs for wearable heads-up displays.” U.S. Patent Application Number: 16/231,279. Filed Dec. 21, 2018.