

Small GNSS Antenna for Wearable Devices

Design and Integration of a Miniaturized Dual-Band IFA

Students



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Introduction: Global Navigation Satellite Systems (GNSS) such as GPS are integral to both safety-critical applications and everyday consumer devices. Products such as smartwatches continue to shrink and therefore require highly miniaturized GNSS antennas. However, antenna size is fundamentally limited by electromagnetic principles, requiring careful optimization between physical dimensions, performance, and design complexity. This project focuses on the design of a compact GNSS antenna suitable for integration into a smartwatch. The antenna must operate in the L1 and L5 frequency bands and employ either two linear-polarized antennas, a dual-band linear or a circular polarized antenna configuration. Based on the u-blox UBX-F10 series GNSS chip a functional demonstrator is developed and evaluated both in simulation and measurements.

Approach: A comprehensive literature review was conducted to identify suitable antenna concepts for smartwatch integration. Promising candidates were modeled in Ansys HFSS, with simulations performed both in the full smartwatch assembly and in the presence of a human-hand phantom as can be seen in Fig. 1. Key performance metrics included impedance matching, radiation characteristics, and power-loss distribution. Based on these analyses and in consultation with the project partner, a dual-band meandered inverted-F antenna was selected. Three implementation approaches were pursued: rapid prototyping with copper tape, fabrication on flexible PCBs as shown in Fig. 2 and additive manufacturing using conductive ink. The copper-tape and flex-board prototypes achieved acceptable matching in the L1 and L5 bands and demonstrated gains in the expected range for a compact wearable antenna. Measurements with a real human hand yielded peak gains of approximately -2.6 dBi (L1) and -4.4 dBi (L5). Outdoor field tests - including cold-start acquisition, route-tracking, and static-position measurements - were performed with the copper-tape and flex-board designs. Both prototypes demonstrated reliable position fixes and satisfactory tracking performance as can be seen in Fig. 3.

Conclusion: The results show that the dual-band meandered inverted-F antenna provides stable GNSS performance within the constraints of a smartwatch-sized device. Although the achievable gain is inherently limited by the compact form factor and linear polarization, both prototypes demonstrated reliable reception in both the L1 and L5 bands. Regarding manufacturing process, the flex-board variant a more robust compared to the copper-tape variant. Outdoor field tests confirmed that the antenna delivers sufficient performance for accurate positioning when integrated with the u-blox GNSS module. Further improvements regarding gain or polarization likely requires and alternative concept

such as bezel-integrated antennas. Nevertheless, the developed design successfully meets the project requirements and highlights the feasibility of implementing a compact dual-band GNSS antenna in a smartwatch platform.

Figure 1: Simulation of the radiation pattern of the smartwatch worn on the human hand model.
Own presentation

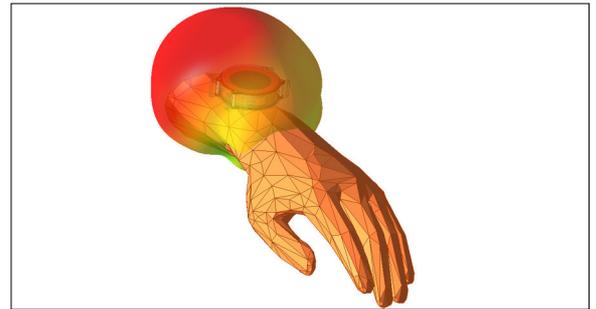


Figure 2: The dual-band flex-board antenna mounted inside the smartwatch prototype.
Own presentation



Figure 3: Outdoor field test of the proposed antenna in Rapperswil.
Own presentation



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Subject Area

Wireless Communications

Project Partner

u-blox AG, Thalwil, ZH