High-gain Sectorial Antenna for Localization Applications

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This paper presents a new sectorial, high-gain directive antenna operating in the 2.45 GHz band. The purpose of this antenna is to improve the performances of in-door localisation and navigation applications by providing non overlapping reception zones. This antenna was designed to operate indoors and demonstrated very good performances during practical testing. It can be easily optimized for other operational frequencies and applications (e.g. 5G, WiFi, Radio Frequency Identification, radar).

Today, robust indoor positioning is a demanded technology. Monitoring the position of objects is useful to track mobile devices and work equipment, to monitor room occupancy, for logistics, etc. We will focus here only on radio frequency (RF) based methods which, compared to vision-based systems, present the advantage to be independent of lighting conditions.

RF-based indoor localization typically requires two types of RF devices: One affixed to the things to be tracked, and another acting as fixed base stations, the anchors. The system performances of such a system are very dependent of the antenna design, especially on the anchor side.

CSEM has designed and prototyped a high-gain sectoral multi-beam antenna (Figure 1). The antenna is designed to operate at 2.45 GHz with a gain of 10 dBi. This design is based on three optimized high-gain Yagi-Uda antennas, which are geometrically offset by 60 degrees and are excited uniformly through three identical coaxial cables. A standard inexpensive 1.6 mm thick FR-4 substrate has been selected for the antenna prototyping. A metallic reflector placed behind the antennas to improves antenna performance and reduce sidelobe radiation. The final antenna characteristics are summarized in Table 1.

Table 1: High-gain sectorial antenna parameters.

Parameter		Value
Operational frequency	[GHz]	2.45
S_{11}	[dB]	-12 @2.45 GHz
BW	[MHz]	250 @-10dB level
Gain (single antenna)	[dBi]	~10
Phase center		Common
Dimension (*w* x *l* x *h*)	[cm]	34 x 19 x 6

Figure 1 shows one of the basic elements of the antenna (computational model) and the prototyped antenna. The CAD tool used to design and optimize this antenna is HFSS (commercial EM solver from Ansys).

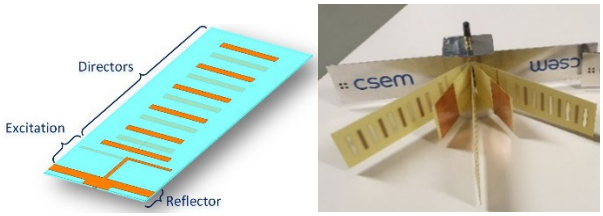

Figure 1: Antenna element model (left) and realized sectorial antenna (right).

The key challenges in such a design are to achieve a common phase reference and a uniform gain of all elements. To meet these challenges, two parasitic elements or back side reflectors were designed and optimized together with the other antenna elements.

Figure 2 shows the simulation and measurement results of the radiation pattern. The gain of the main lobes are about 10 dBi at 2.45 GHz. The left and the right main lobes are tilted at 45 degree from the central one. Thus, the antenna can monitor three different areas at the same time. The angle between the lobes i can easily be adjusted by shifting the antenna elements position.

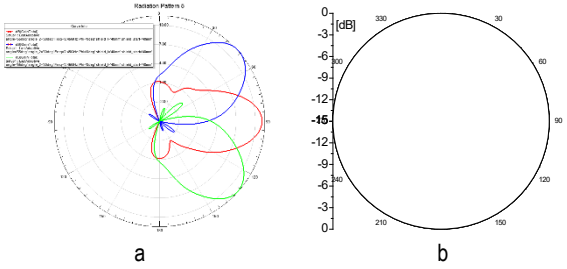

Figure 2: Antenna radiation pattern comparison (@2.45 GHz): HFSS simulation (a) and measured (b).

The sectorial antenna is connected to a Nordic nRF51 DK board Bluetooth evaluation board (EVB) through RF switches. It communicates with an iPad, acting as the monitored thing, and using Bluetooth Low Energy. The EVB measure the received signal strength indication (RSSI) for the three sectorial antenna and transmit them back to the iPad which uses this data to estimate its own position in the room. As shown during a real-time demonstration, a person walking around the room can accurately be monitored between three pre-defined zones (see Figure 3).

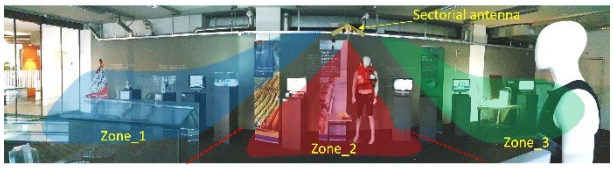

Figure 3: Sectorial antenna indoor test @ CSEM showroom.

The proposed antenna solution can be used with different RF-based localisation systems in order to improve their accuracy and robustness. In addition, the antenna can be successfully used in wireless communication systems (e.g. 5G, WiFi.) as a MIMO antenna.

This antenna was developed for Semtech Sàrl as a part of an Innosuisse Project in the field of indoor localisation.