Simple low-cost planar antenna for indoor communication under the Bluetooth protocol

G. Vermeeren, H. Rogier, F. Olyslager and D. De Zutter

A single-feed rectangular-ring microstrip antenna is proposed for indoor communication under the Bluetooth protocol. The dimensions of the antenna together with the location of the feed point are optimised through field simulations in order to cover the Bluetooth bandwidth and to avoid linear polarisation. The performance and the efficiency of the antenna are illustrated in a real indoor environment.

Antenna geometry and design: The introduction of new wireless protocols for indoor communication such as Bluetooth [1], IEEE 802.11 and HiperLAN present real challenges to antenna design. In addition to the performance issue, one of the main concerns for the deployment of Bluetooth products is the cost of the system. In this respect, the availability of a simple and low-cost antenna is a very important feature of a Bluetooth interface. Single-feed planar antennas [2 – 4] offer attractive solutions that can be easily integrated into a Bluetooth system. However, it is well known that microstrip antennas can have a rather narrow bandwidth and low efficiency. Moreover, single-feed solutions are often linearly polarised, making the antenna very polarisation-sensitive. In Fig. 1, we propose a single-feed rectangular-ring microstrip antenna for operation under the Bluetooth protocol. The dimensions of the antenna are specified in Table 1. The structure is implemented on a standard Rogers RT/5870 Duroid substrate, the thickness and permittivity of which were chosen in order to optimise the antenna efficiency. A 50 Ω coaxial feed is used to excite the antenna. In order to obtain a –10 dB return loss in the Bluetooth (ISM) band (2.4–2.483 GHz) and in order to avoid linear polarisation, the geometry of the antenna patch and the location of the feed-point were carefully optimised. Several designs were evaluated with the commercial field simulator Momentum from Agilent Technologies. Linear polarisation is avoided by placing the feed point on a diagonal of the patch, so that two orthogonally polarised modes, TM01 and TM10, are excited. The bandwidth of the design increases by choosing slightly different values for the patch length L and width W and by making a suitable choice of the slot parameters l and w, so that the TM01 and TM10 modes resonate at different frequencies. Increasing the parameter l, for example, results in a lower resonance frequency for the TM01 mode. Once the simulations gave a suitable design, a prototype was built and measured.

Simulation and measurement results: In Fig. 2 the simulation results for the return loss are compared with measurements. As seen, there is excellent agreement between the simulation data, obtained using Momentum, and the measured data. The measured bandwidth of the antenna equals 108 MHz, which is sufficient to cover the Bluetooth band. Fig. 3 shows the radiation patterns in the *xz*- and *yz*-planes for the RHCP and LHCP field components at 2.44 GHz. The polarisation of the antenna is nearly circular, assuring good reception for all kinds of transmitter-receiver orientations. Furthermore, the antenna has a high efficiency ($\eta_{simulated}$ = 84%) and the simulated antenna gain equals 6.54 dB.

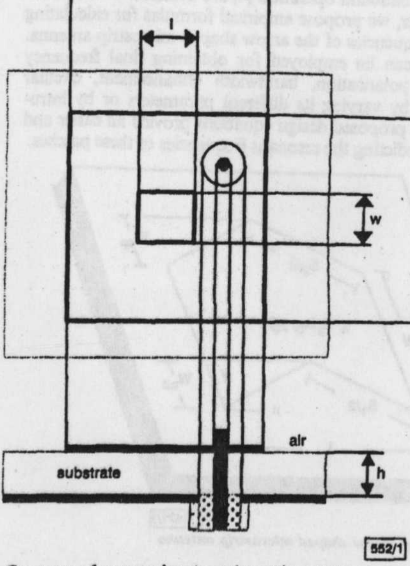

Fig. 1 *Geometry of rectangular-ring microstrip antenna*

Table 1: Dimensions of the rectangular-ring antenna for Bluetooth

Patch		Substrate	
L mm	38.6	h mm	1.5748
W mm	37	ε_r	2.35
Feed point mm	(5.3, 5.3)	tan δ	0.0012
Slot			
l mm	6.4		
w mm	15.6		

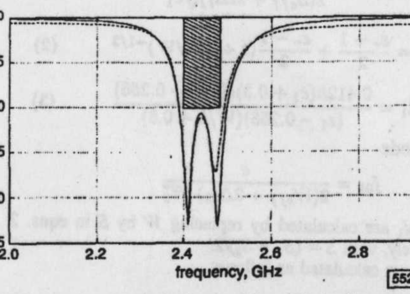

Fig. 2 *Measured and simulated return loss (S_{11}) of rectangular-ring microstrip*

——— measurement
- - - - simulation

To obtain an estimate of the average signal levels in a complex indoor environment, we tested the transmission characteristics of a receiver-transmitter pair in a real indoor environment, shown in Fig. 4. We considered both a line-of-sight (TX1-RX) and a non-line-of-sight (TX2-RX) transmission, with the antenna axes oriented either parallel or perpendicular to each other. In Fig. 4, we have shown the walls and two metallic objects that influence the signal propagation. Smaller furniture is not shown. Both transmitter and receiver antennas are placed vertically 90 cm above the ground. In Fig. 4 the average received power levels when the transmitter emits a 0 dBm continuous wave signal are presented, for the two transmitter-receiver pairs and for both orientations. For the line-of-sight situation, the in-band reception is better than −40 dBm for an antenna separation of 156 cm in both orientations. For the non-line-of-sight case, reception is clearly worse, with all kinds of obstacles blocking the propagation path. Yet signals