Horn antenna design for BAN millimeter wave onbody communication
Solofo Razafimahatratra, Julien Sarrazin, Philippe de Doncker, Aziz Benlarbi-Delai

To cite this version:
Solofo Razafimahatratra, Julien Sarrazin, Philippe de Doncker, Aziz Benlarbi-Delai. Horn antenna design for BAN millimeter wave onbody communication. Conference IEEE APS 2014, Jul 2014, Memphis, United States. pp.204.2. hal-01005423

HAL Id: hal-01005423
https://hal.sorbonne-universite.fr/hal-01005423
Submitted on 12 Jun 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Horn antenna design for BAN millimeter wave on-body communication

Solofo Razafimahatratra, Julien Sarrazin, Aziz Benlarbi-Delaï
Laboratoire d’Electronique et d’Electromagnétisme
Sorbonne Universités, UPMC Univ Paris 06, UR2, L2E, F-75005 Paris, France
solofo.razafimahatratra1@etu.upmc.fr, julien.sarrazin@upmc.fr, aziz.benlarbi_delaï@upmc.fr

Philippe De Doncker
Université libre de Bruxelles
Bruxelles, Belgique
pdedonck@ulb.ac.be

Abstract—In this paper, a 60-GHz H-plane horn antenna is designed and studied in the context of Body Area Network (BAN). Targeting both size reduction and bandwidth widening, we obtain an optimal design that meet a good tradeoff between compactness, matching, bandwidth and multimode propagation. The study of return loss is conducted considering the dimensions of the horn antenna.

I. INTRODUCTION

The 60-GHz band is attractive for Body Area Networks (BANs) application for its high atmospheric attenuation, low interference with other networks, component compactness, large available bandwidth and low human body skin penetration [1] [2]. However, as far as we know, there is no accurate propagation model characterizing on-body communication at 60 GHz. To establish such a model, we need realistic measurement which requires low profile antenna.

In this paper, a planar H-plane horn antenna is considered. An H-plane horn antenna has a high directivity in the H-plane of the antenna and is loosely wide beam in the E-polarization [3]. Using such antenna is suitable to make measurement for on-body BANs without requiring unsafe high level of emitted power. Our study deals with matching, band widening, compactness and reduction of multimode propagation. Resonance and matching were evaluated using CST Microwave studio by means of horn dimensions study.

II. THEORY AND DESIGN

The simulated geometry of the antenna is illustrated in Fig. 1 and Fig. 2.

The relation between a mode TE_{mn} cutoff frequency \( f_c \) and waveguide dimensions [4] is given in (1).

\[
  f_c = \frac{1}{2\pi\sqrt{\mu_0\varepsilon_0}} \left( \frac{m\pi}{a} \right)^2 + \left( \frac{n\pi}{b} \right)^2
\]

The TE10 mode cutoff frequency is chosen under 50 GHz. Considering a dielectric constant of air, we can infer from (1) the following waveguide dimensions: width \( a = 3.2 \) mm, thickness \( b = 0.7 \) mm. The thickness \( b \) is set to standard value. The horn dimensions (\( D, w \)) are discussed in the next paragraphs.

III. PARAMETER STUDIES

The horn antenna return loss can be regulated by either varying the length \( D \) of the horn, for resonance issue, or varying the horn aperture width \( w \) to achieve matching to the air. This paper presents a horn antenna design evaluating the influence of these two dimensions. The concepts are verified by simulating the design with different dimensions with CST Microwave Studio.

To widen the bandwidth centered at 60 GHz, many solutions involving different values of \( D \) and \( w \) are possible and
one must define the optimum couple of $D$ and $w$. In the following paragraph, we study the impact of $D$ and $w$ on the performance of the antenna.

A. Dependence on horn length

The length enables to adjust the reflection. As shown in Fig. 3, central frequency decreases with the horn length $D$. The return loss is better than -10 dB throughout 5 GHz. It is due to resonance phenomenon.

The best performance in terms of S11 is obtained for $D = 2.3$ mm.

Therefore, the overall dimensions of the horn antenna are $11.2 \times 3.8 \times 0.7$ mm$^3$.

B. Dependence on horn aperture width

The width is varied to obtain a good matching at the horn front edge to the air. Fig. 4 shows the return loss for different aperture widths. The central frequency decreases with the horn aperture width $w$ due to impedance at the horn edge. The best performance in terms of S11 is obtained for horn aperture width $w = 11.3$ mm. We converge to the final dimensions of the horn : width $w = 11.2$ mm and length $D = 2.3$ mm.

Therefore, the return loss is better than -10 dB throughout 5 GHz. It is due to resonance phenomenon.

The best performance in terms of S11 is obtained for $D = 2.3$ mm.

C. Reducing higher mode

According to theory and simulation, the presence of mode TE30 persists at 60 GHz for width $w$ above 7.5 mm. However, the TE10 mode is dominant for $w < 9$ mm. We propose the following design in Fig. 5 to reduce TE30 mode amplitude.

IV. CONCLUSION AND FUTURE WORK

A 60-GHz horn antenna was designed and studied. The optimal design, with regard to bandwidth and matching is obtained by varying horn dimensions. The resulting antenna size is $11.2 \times 3.8 \times 0.7$ mm$^3$, which is compatible with applications dealing with BAN context. The 10-dB bandwidth is around 5 GHz centered at 60 GHz. At this center frequency the matching is maximum and equal to -16 dB. TE30 mode overlaps to TE10 at the horn front edge to the air for horn width above 7.5 mm. However, we can keep the TE10 mode dominant.

This paper presents a conventional horn antenna where compactness and matching issues are undertaken. For the conference, we will also analyze the equivalent Substrate Integrated Waveguide (SIW), the horn taper design and human body influence on matching and radiation patterns.

ACKNOWLEDGEMENT

This work was performed within the Labex SMART supported by French state funds managed by the ANR within the Investissements d’Avenir programme under reference ANR-11-IDEX-0004-02.

REFERENCES


