UWB antenna design and ray tracing method for robot localization

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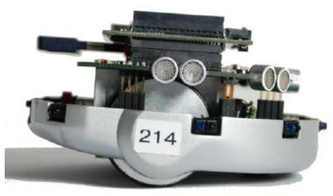
Abstract

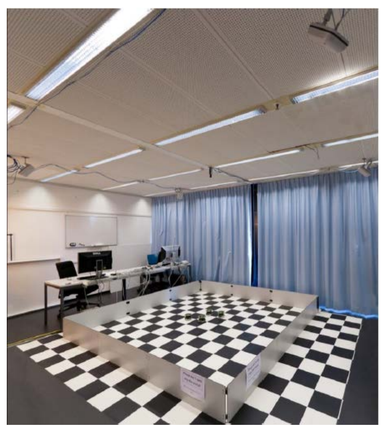
This poster presents a new base station antenna design and preliminary results on electric field mapping for localizing a UWB-MICS robot in an arena. A batch of new base station antenna prototypes, was built and measured at EPFL - LEMA. A microstrip-fed compact monopole design, built in the inexpensive FR4 substrate, was chosen. Reflexion coefficient measurements and radiation pattern simulations meet the project specifications. The presented prototype is electrically small and therefore affected by the feeding and surroundings – the final revision will take the actual deployment points into account. An existing LEMA ray-tracing code was adapted for use in the project. A simple scenario was tested as proof-of-concept, estimating the electric field in the arena taking into account three reflections. The model will be improved by using the real radiation pattern from the base station antenna and improving the boundary conditions.

1. Introduction

Project goal:
To build a system that allows a team of mobile robots to locate themselves with high precision.
Scenario:
1 robot in an arena (Tx) and 4 base stations (Rx).

EPFL – LEMA contributions:
- To design UWB antennas for the robot and base station.
- To provide a field mapping of the arena.





2. UWB base station (Rx) antenna design

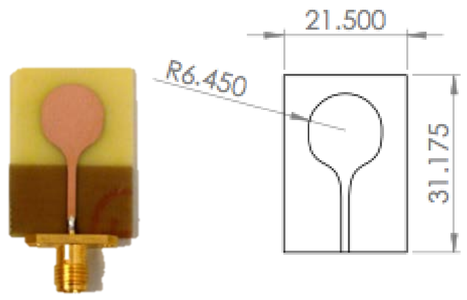
Requirements

➲ [4, 4.5] GHz bandwidth, S_{11} < -10 dB.

➲ Stable gain across the band. Target: 2.5 dBi.

➲ As small as possible.

➲ Built in inexpensive substrate.



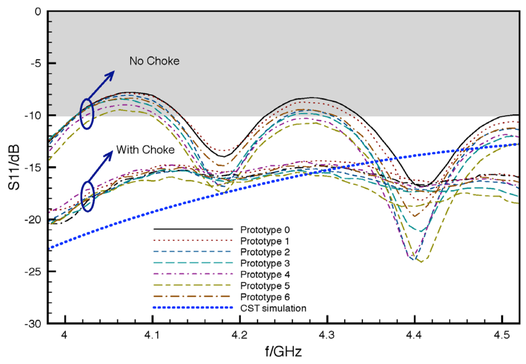
Reflection coefficient, S_{11}

➲ Batch of 7 prototypes built in FR4 and tested.

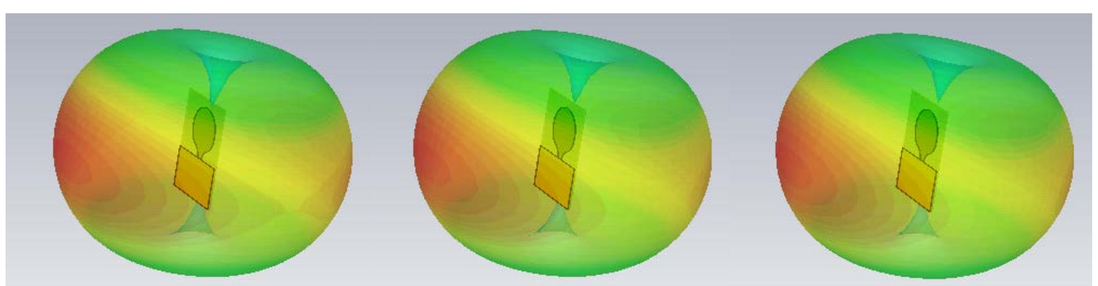
➲ Small fabrication deviations considering high substrate tolerances.

➲.Antenna S_{11} within specifications and close to simulation when measured with choke.

➲.Antenna electrically small and affected by surroundings: final prototype will take this into account.



Simulated radiation patterns

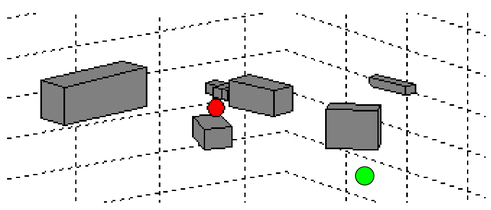


4 GHz – D=2.7dBi 4.25 GHz - D=2.8dBi 4.5 GHz - D=2.9dBi

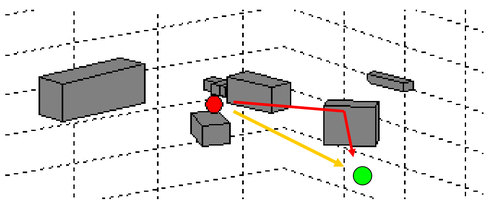
3. 3D Ray Tracing Method

➲ To provide a mapping of the EM field at the surface of the robot's arena in order to further help to better localize the robots.

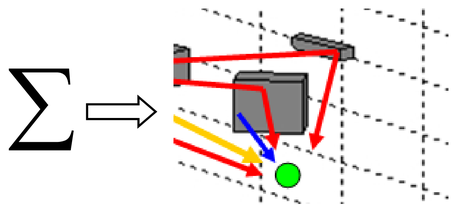
Principles



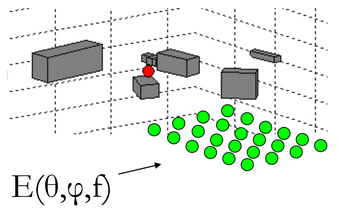
Direct Ray



Direct Ray + Reflections

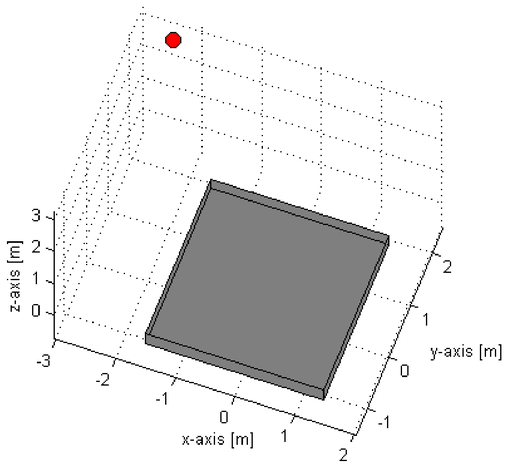


Total field



Field mapping

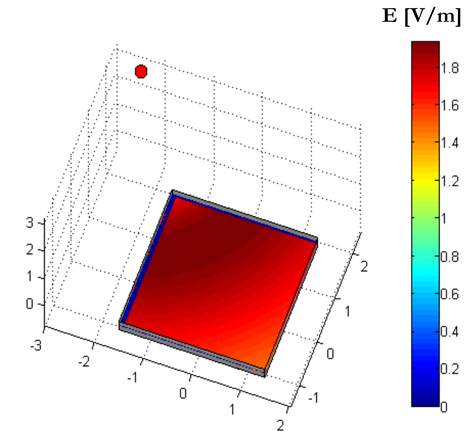
Results



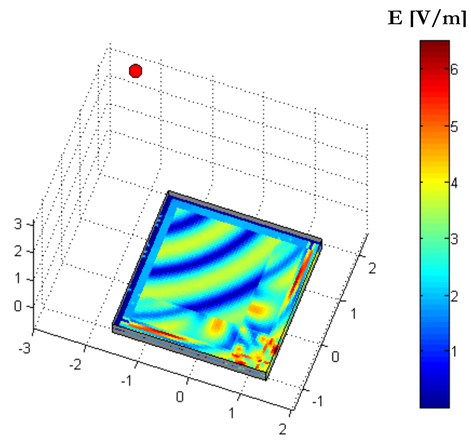
Investigated scenario

Arena dimensions	3 x 3 x 0.3 [m]
Near field plane height	15 cm
Frequency	4.25GHz
Base station antenna height	2.45m
Sampling step	5 cm (61 x 61 points in total)
Computation time (/ant /fq)	≈ 45 s

- Analytical radiation pattern (dipole type).
- Antenna gain of 1.5dBi.
- Metallic boundary conditions.



Direct ray



After 3 reflections

4. Next steps

☑ Antenna design:
To take into account the base station receiver feeding, geometry and materials.

☑ Ray tracing method:
- To take into account real antenna radiation patterns.
- To refine the arena description.