LELEC2910

Two mini-mini projects regarding antennas

October 2023

The projects can be carried out with 1 or 2 persons (not 3).

A ~5 pages report (1 report for the 2 parts) is due by November 14, 11:59 pm. The report will be marked on 3.33 points (on a total of 20 points for the exam).

Project 1

The goal of the first mini-project consists of:

- Processing the measurement data of a metasurface antenna realized at UCLouvain and illustrated in Figure 1. Measurements took place for a frequency of 24 GHz.
- Establish a link budget between the metasurface and a Yagi antenna in a communication scenario.

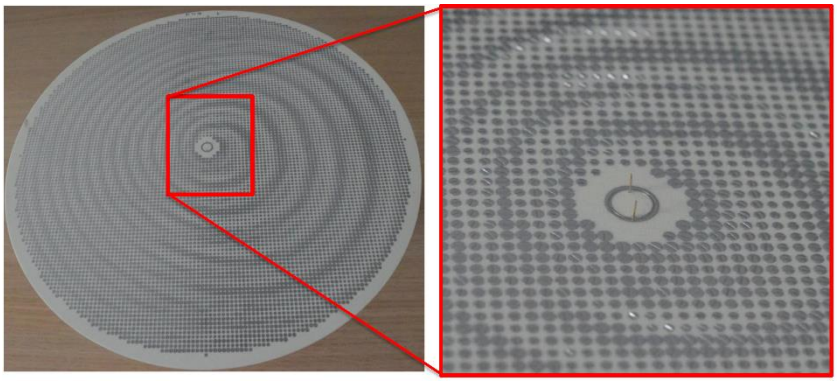

Figure 1: the metasurface antenna fabricated at UCLouvain

The measurements data set is composed of four matrices: 'Theta_grid_matrix', 'phi_grid_matrix', 'S12_grid_matrix_TE', 'S12_grid_matrix_TM'.

S12_grid_matrix_TE and S12_grid_matrix_TM correspond to the measured complex transmittance between the metasurface and a reference antenna for different directions (θ, ϕ). θ is the elevation angle taken from broadside (θ ranges from 0 to $\pi/2$ with a sampling step of 4^o). ϕ is the azimuth taken in the range 0 to 2π, with a sampling step of 5^o.

1- From the measured data, find the polarization of the antenna near its maximum: LHCP or RHCP ?
2- Compute and represent the co-pol and cross-pol directivity in the uv plane (direction cosines plane).

The receiving antenna is a Yagi antenna with 10 dB gain. It points exactly toward the metasurface antenna. The wires are in the YZ plane (see Figure 2). The metasurface antenna is not pointing exactly toward the Yagi antenna. From the perspective of the metasurface antenna (see Figures), the Yagi

antenna is located at (θ, ϕ)=(30°,90°) and the distance between antennas is 100 meter. The frequency is 24 GHz.

3- Considering an emitted power of 1mW and a radiation efficiency of 80% for both the metasurface and the Yagi antenna, what is the received power? We assume that the antennas are satisfactorily impedance-matched to the transmitter and receiver.

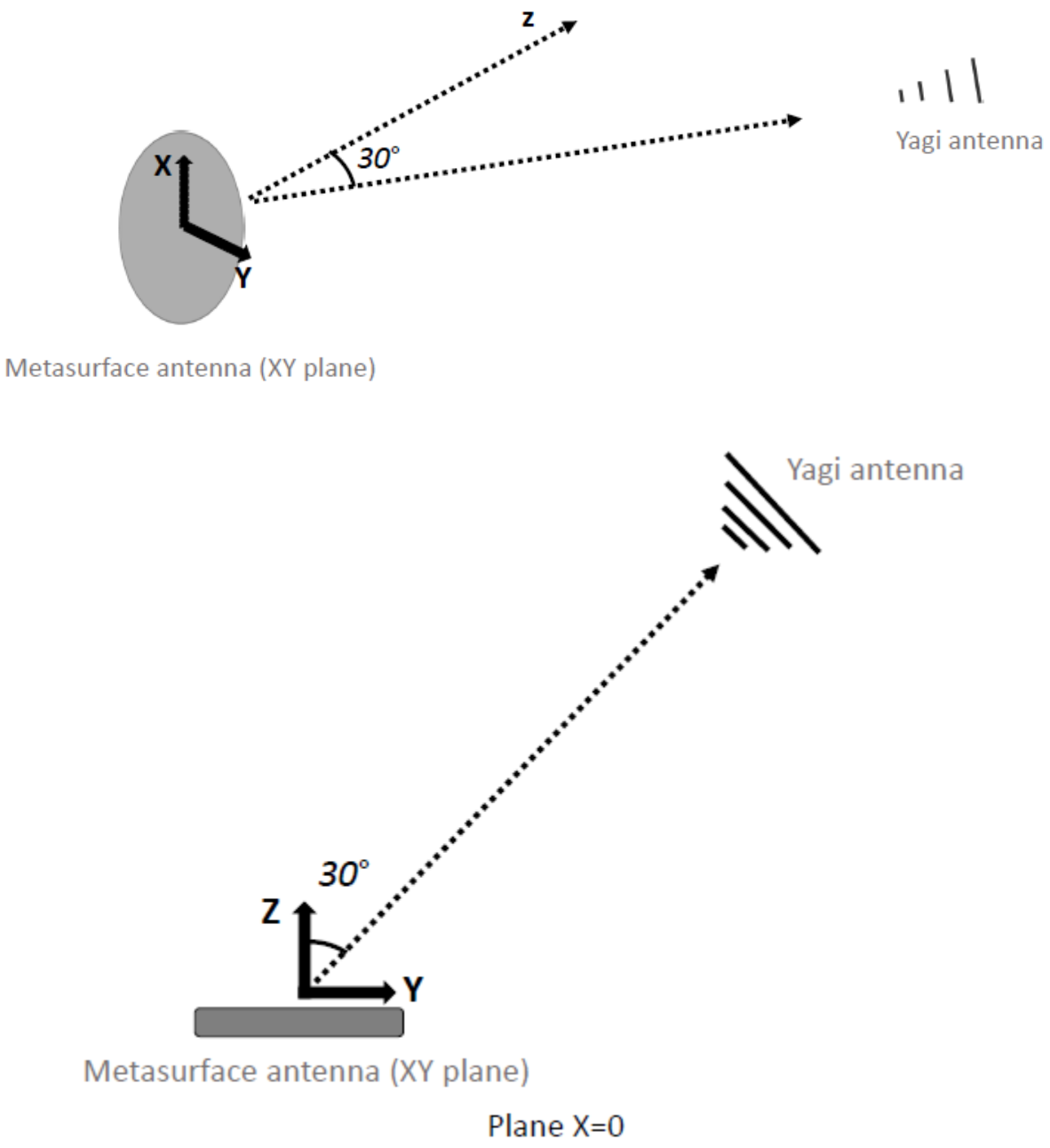

Figure 2: relative positions and orientation of Yagi and metasurface antennas

Project 2

The second mini-project consists of optimizing the directivity of a Yagi antenna using a method-of-moments code provided by the antenna team (see installation instructions below).

The parameters are:

f: the frequency, which is fixed to 0.5 (in GHz)
d: the distance d between wires (in meters)
N: the number of antennas
L: the length of the shortest wire (in meters)
dL: the increment of length between consecutive wires (in meter)
zg: the load attached to each wire (in Ohm, set to zero here)

Figure 3: Yagi antenna with its characteristic dimensions

The code, named int_pat2.exe, is provided in executable form, it takes as an input the params.txt file, which contains the above-mentioned parameters and which can be modified by the user.

As an output, the code provides the N embedded patterns, in the form of 4 columns
i_θ j_ϕ real(F) imag (F)

where i_θ and j_ϕ correspond to the elevation and azimuth indices.

The elevation θ is the angle from the wires axis. Regarding θ, the 0 to 180 degrees domain is divided into 60 equal subdomains and the corresponding angle θ is taken in the middle of each subdomain (so the first value is at 180/120 deg and the next one at 3*180/120 deg). Regarding ϕ, the 80 values are evenly covering the domain from 0 to 360*(1-1/80) degrees. The radiation pattern is complex, but it has only one polarization, along $\hat{e}_\theta$.

In a first instance, load such a radiation pattern, plot it and compute its directivity. Then, play with the free parameters in order to optimize the directivity of one of the patterns.

Another output is an error index, it verifies that the power fed to the input impedance of the antenna corresponds to the radiated power. This can be done for excitation at any of the N ports. What is provided is the relative error. Check that the error is below 1%.

Matlab Runtime installation

The code can be executed through a file named … .exe, which has been compiled with Matlab. In order to run this file, you need to install the Matlab Runtime libraries by following these steps:

- Download the R2022a (9.12) Matlab Runtime version at https://nl.mathworks.com/products/compiler/matlab-runtime.html .
- After that, follow the instructions 1 to 7 at https://nl.mathworks.com/help/compiler/install-the-matlab-runtime.html .
- Restart your computer.

At this point you can simply click on the .exe file to run it. You can also open a command prompt window and run the exe file from there.

Note that, if you use a computer on which Matlab is already installed (in computer rooms such as CANDIX,…), you do not need to install the Matlab Runtime libraries.