UCLouvain
École polytechnique de Louvain

LELEC2350 - Lab 1

Colin Renard (5001200) - Mathieu Reniers (30322000)

April 28, 2024

1 Transmittance through a periodic grid

This section investigates the effect of a periodic grid on the transmittance between the two antennas. Figure 1 shows the forward voltage gain S_{21} with ($S_{21,g}$) and without ($S_{21,0}$) the grid. The former is, as expected, globally lower than the latter as the grid blocks the line of sight for the electric field in the first case. However, while the scattering parameter without grid remains globally constant on the considered band, a peak exceeding the value of $S_{21,0}$ can be observed at 11.43 GHz for $S_{21,g}$. This shows that at this frequency, the setup behaves as though there was no grid between the two antennas.

This phenomenon can be further observed on Figure 2, showing the transmittance of the grid, simulated and measured. This quantity is computed as

$$T = \frac{|S_{21,g}|}{|S_{21,0}|} \quad , \tag{1}$$

The peak at 11.43 GHz is again observed in the measurement, whereas it is obtained at 11.36 GHz in the simulation. In spite of the measurement noise, the shape of the two curves match quite closely, showing the agreement between measurements and theory.

It can be observed that the transmittance observed at the peak in the measurements is larger than 1 (or 0 dB). This is not physical, and may result from calibration errors or measurement inaccuracies. It is also observed in Figure 1, where $S_{21,g} > S_{21,0}$.

To conclude, it has been shown in this section that at a specific frequency, the periodic grid is almost invisible from the two antennas. While it is the case in the far-field, fields very close to the grid behave differently than in free space.

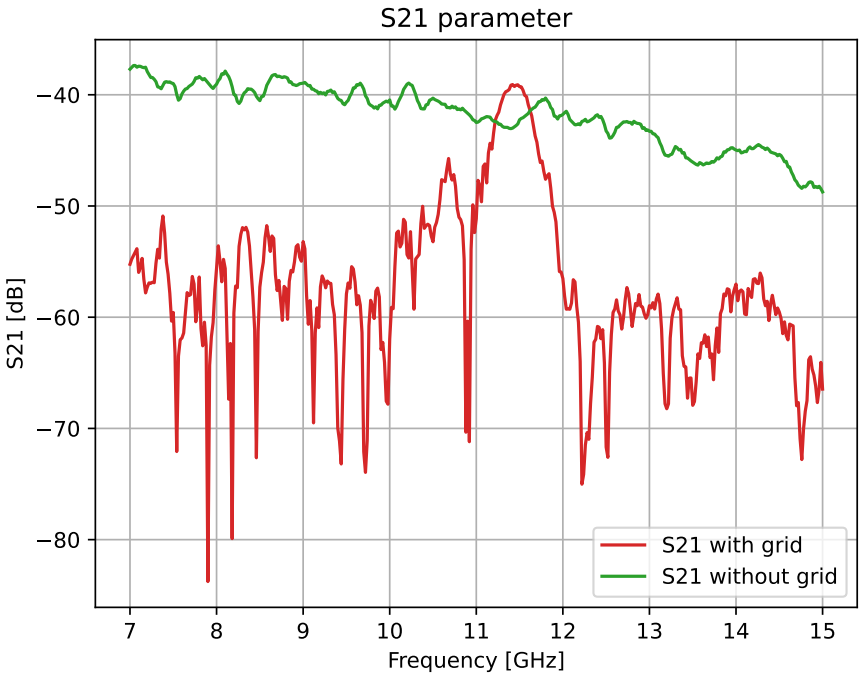

Figure 1: S_{21} measured parameter, with and without the grid

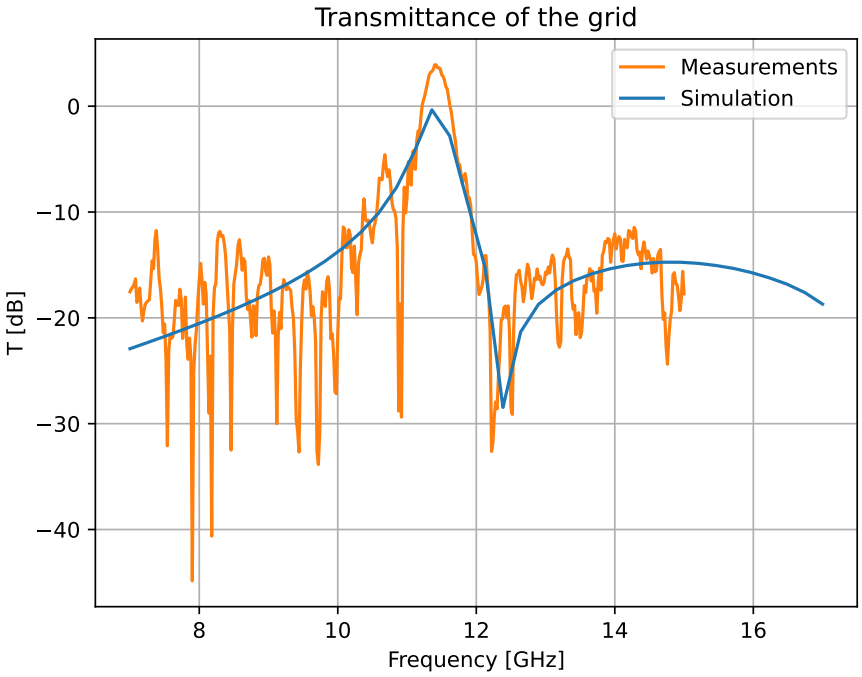

Figure 2: Transmittance through the periodic grid

2 Experimental demonstration of the Arago Spot

This section presents the results of the second experiment designed to experimentally observe the Arago Spot. It is a bright point that appears at the center of the shadow of a circular object. It was used to prove the wavelike behavior of the light.

A circular metallic disk is placed on the axis between the antennas and perpendicularly to this axis. The transmittance is then measured for different position of the disk to the left and right of this axis, and is depicted in Figure 3. It is represented here for a frequency of 13 GHz (arbitrarily chosen) but the shape of the curve should be the same for all frequencies.

It was shown during the lecture that the field radiated by a circular aperture of radius a is

$$E_a^a = E_a^\infty \cdot \left(1 - e^{-jqa^2}\right), \tag{2}$$

where E_a^∞ is the field without the obstacle and $q = \frac{k}{2}\left(\frac{1}{d_1} + \frac{1}{d_2}\right)$, with d_i being the distance between antenna i and the obstacle. Therefore, the on-axis field in presence of the obstacle is obtained as the difference between E_a^a and E_a^∞:

$$E^0 = E_a^\infty e^{-jqa^2}. \tag{3}$$

The field value in the axis behind the obstacle is the Arago spot.

The transmittance shown in Figure 3 corresponds to what was expected with the theory. At $z = 0$, a local maximum is observed, and this point corresponds to the Arago spot. When the obstacle is shifted slightly to the right or left, the transmittance decreases due to the obstacle no longer being perfectly aligned with the transmitting antenna (no longer on the maximum of the radiation pattern). Moreover, the new Arago spot is no longer aligned with the RX antenna, which therefore receives a weaker field. If the obstacle is moved further away ($|z| > 7$ cm), the transmittance increases because the obstacle is no longer in the line of sight of the two antennas. It can be reasonably deduced that the diameter of the disk should be approximately 20 cm.

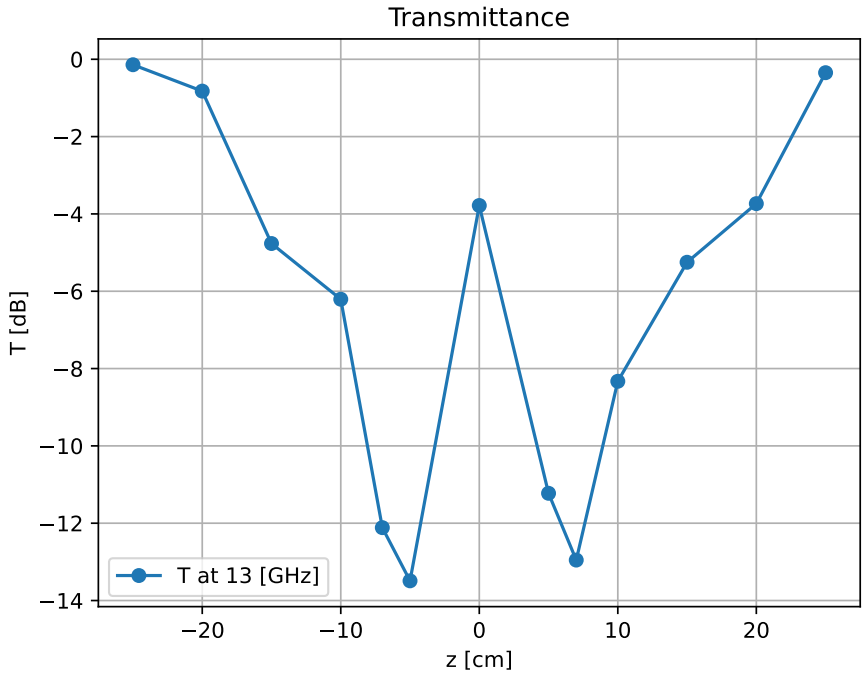

Figure 3: Transmittance versus position. $z = 0$ indicates that the disk is located on the axis. $z > 0$ indicates moving the disk to the right.