A Wideband Series Fed Patch Array with Side Lobe Level Control

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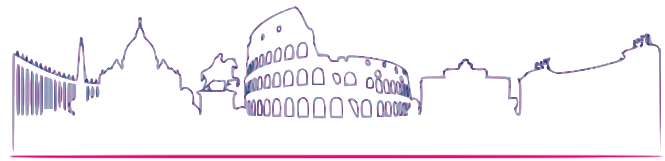
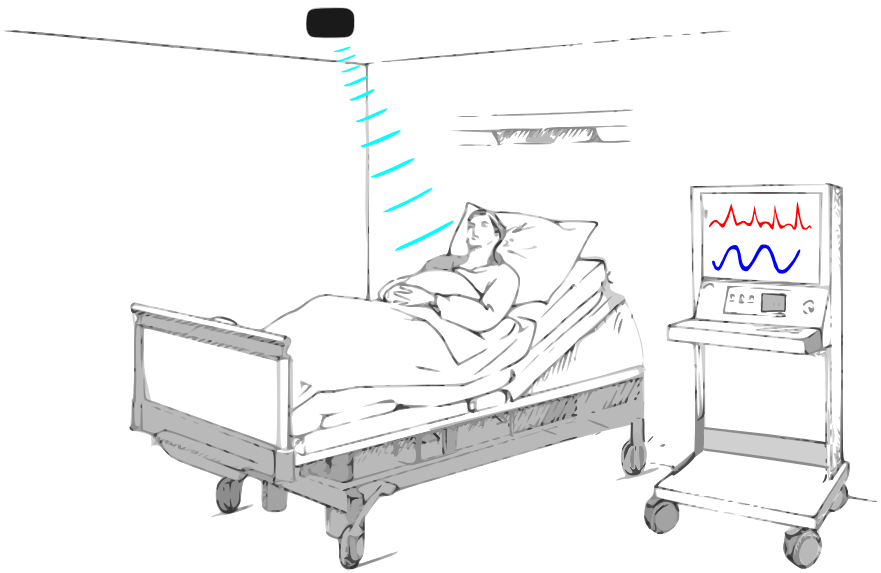


URSI GASS 2020

Outline

Introduction: Radar technique

Radar systems can perform **non-contact sensing** of cardiorespiratory activity and position. These results are useful for:



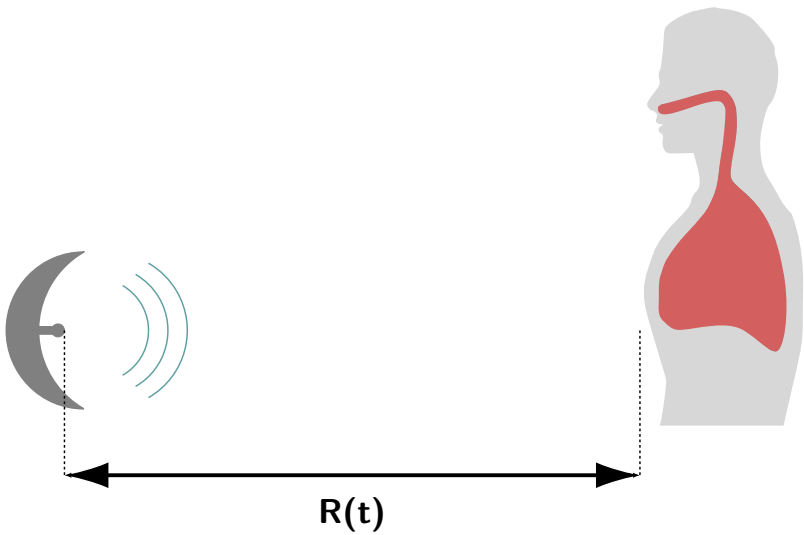
- monitoring patients with **compromised skin** (burns or chemical contaminations),
- **home therapy**,
- **sleep monitoring**,
- detection of **humans behind walls** or **under rubble**,
- monitoring people in case of risk of infection or during **pandemics** (e.g. COVID-19 crisis).

Problem Geometry

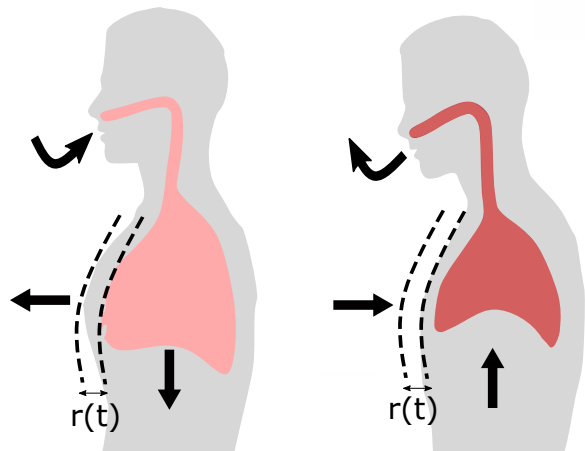
The system must be able to detect information about the subject **position** $\mathbf{R(t)}$ and the **small movements** of his chest $\mathbf{r(t)}$.

$$\mathbf{R_T(t)} = \mathbf{R(t)} + \mathbf{r(t)}$$

Position



Small Movements



Outline

Antenna Design

For radar applications antenna requirements are:

- **low-cost**
- **compactness**

→ **Planar Antennas**

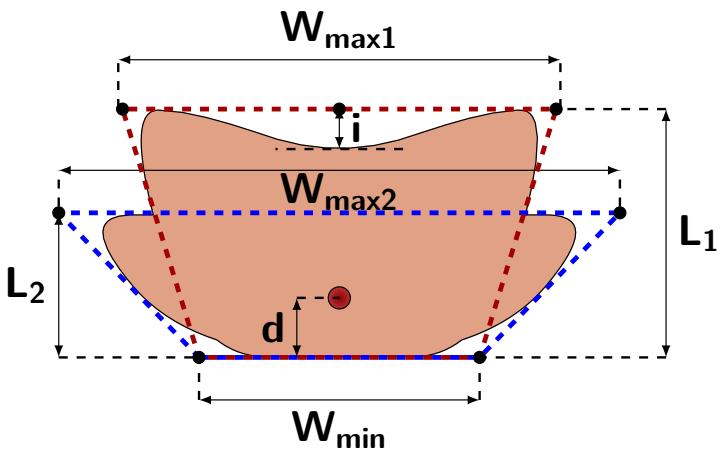
For a good detection the antenna should exploit the **entire available bandwidth** not to lower the range resolution and to have a **high gain** and **low SLL** to concentrate the main beam on the patient chest and to filter the clutter. Inside the 5.8 GHz ISM band fractional bandwidth is of about 2.6%. Possible solutions:

- **stacked structures** → Complex ×, Large bandwidth ✓
- **hybrid configuration involving series-corporate feed techniques** → Large area occupation ×, Large bandwidth ✓
- **series fed arrays** → Small bandwidth ×, Simple and compact ✓

A new **dual band** patch antenna with **side lobe control** has been proposed.

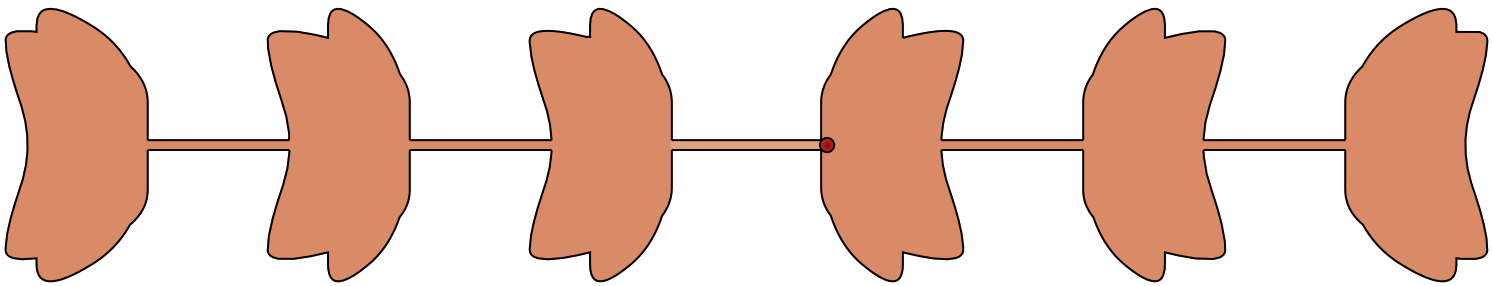
Antenna Design

Antenna Parameters



Parameter	Dimension (mm)
W_{min}	16.7
W_{max1}	25
W_{max2}	30.7
L_1	14.6
L_2	7.15
i	3.6
w_{line}	1
l_{line}	14.34

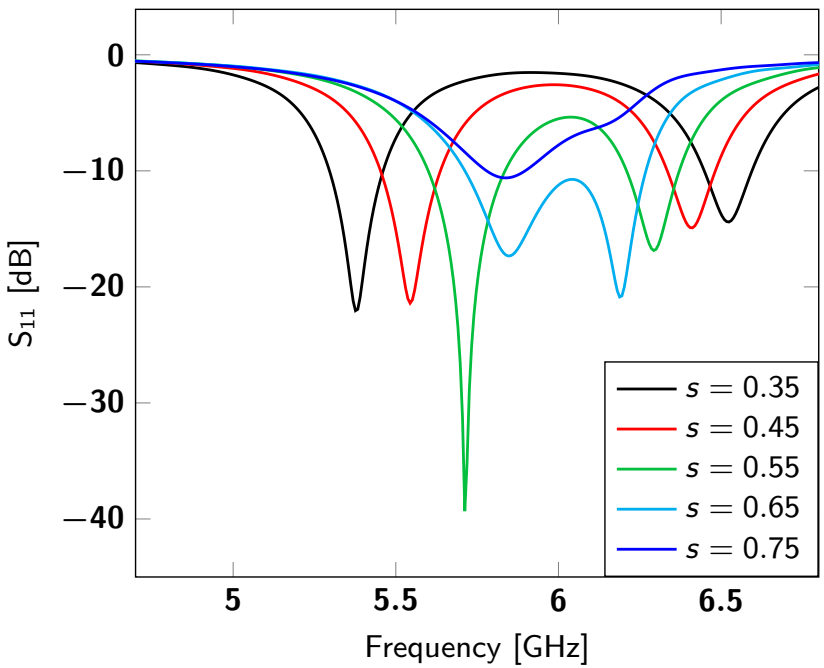
Complete Array

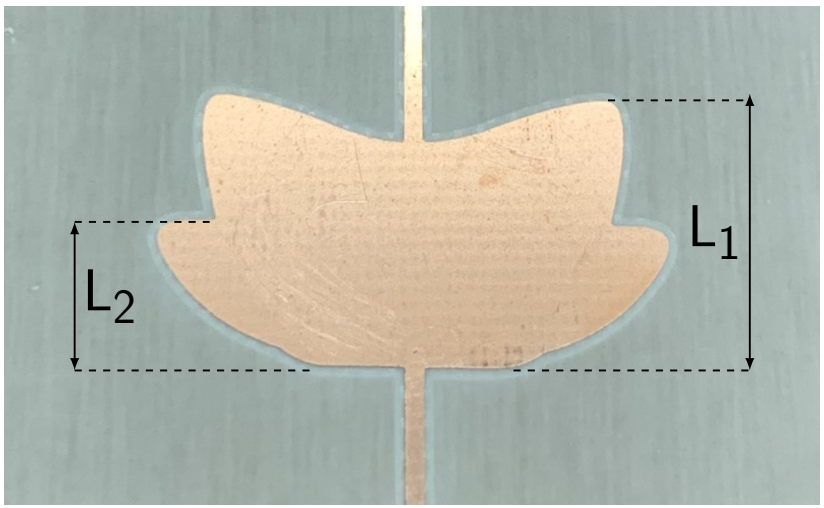


Antenna Design

Bandwidth

Two resonances are related to the lengths L_1 and L_2 and they can be made closer or more distant by varying the degree of superposition $s = L_2/L_1$.

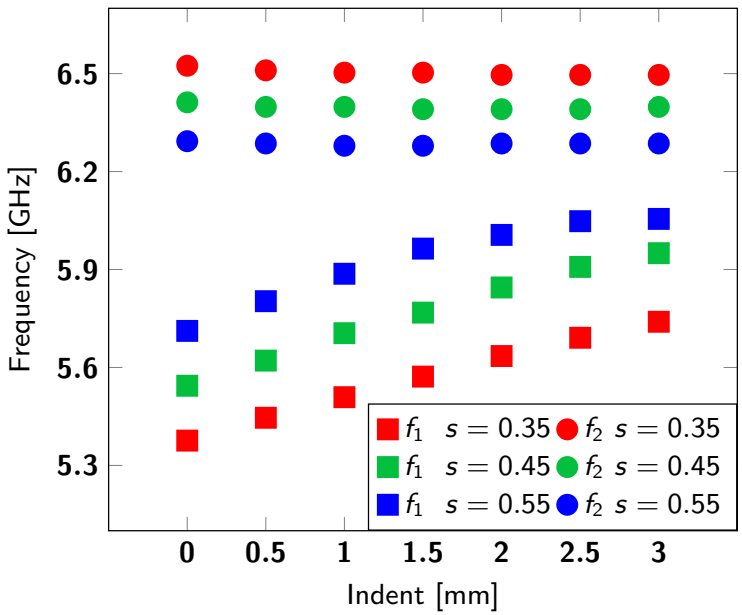


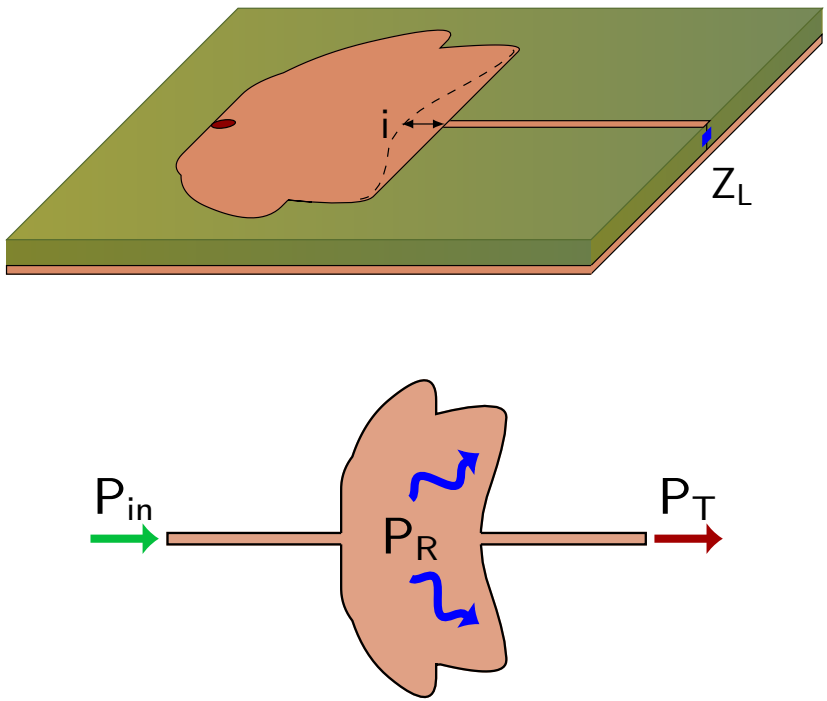


Antenna Design

SLL Control

The accepted power at the feeding point of the patch is P_{in}. A portion of this power is radiated (P_R), while the remaining is transmitted to the next elements (P_T). The specific amplitude distribution and correspondingly the side lobe suppression are controlled by the indent degree i.

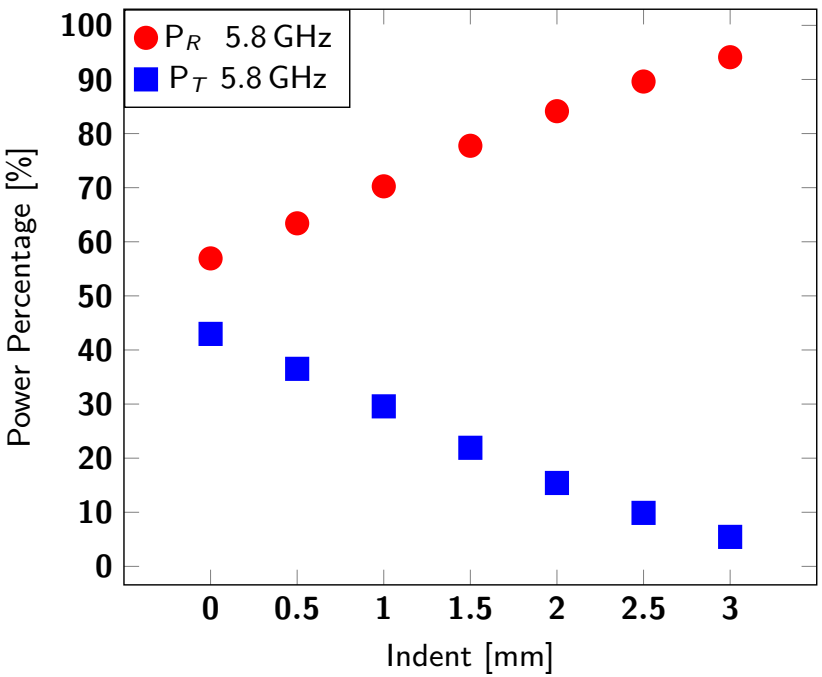


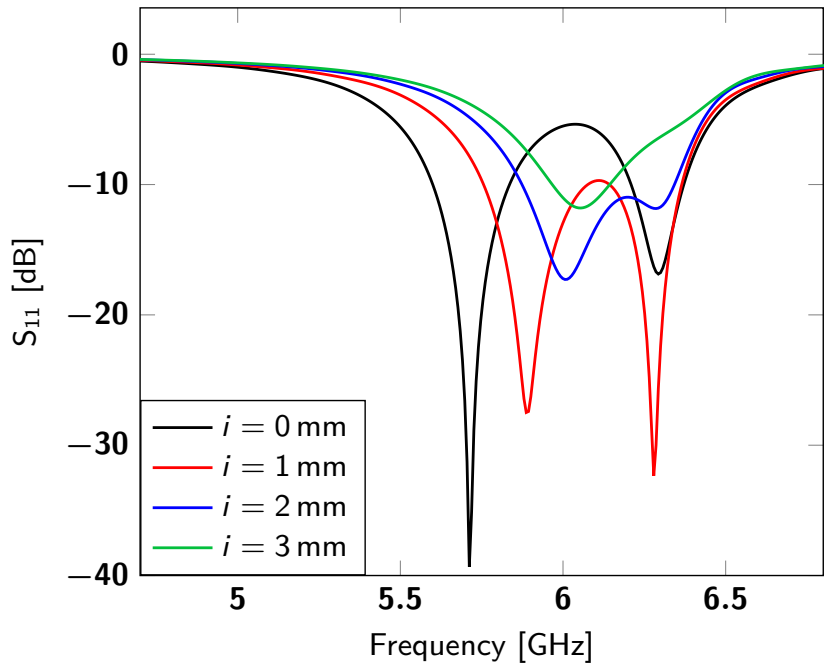


Antenna Design

Parameter interaction

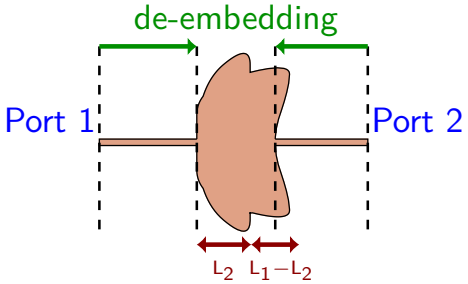
The effect of the indent of the upper edge of the patch (i) is not only limited to the control of the side lobe level. If i increases, the overall patch length (L_1) is decreased, with a consequent reduction of the corresponding resonant frequency.

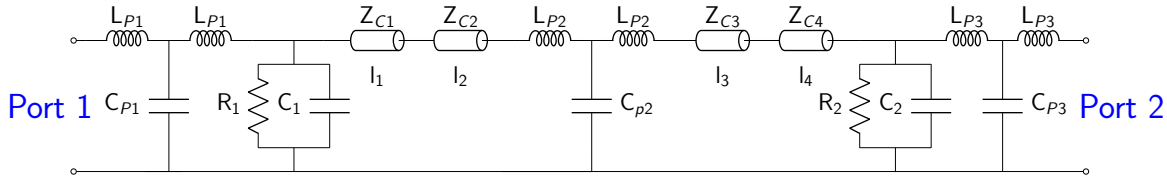




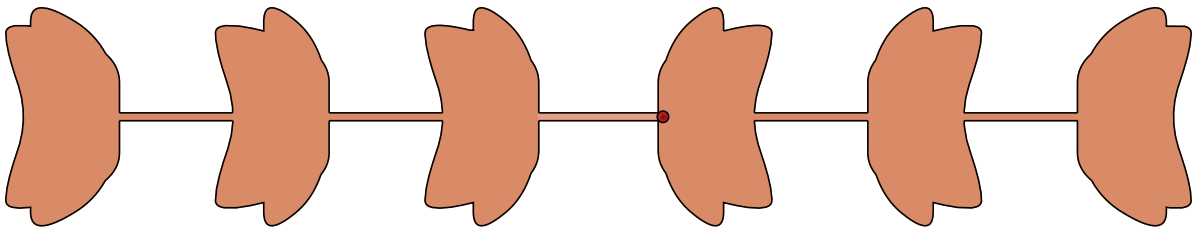
Electrical model

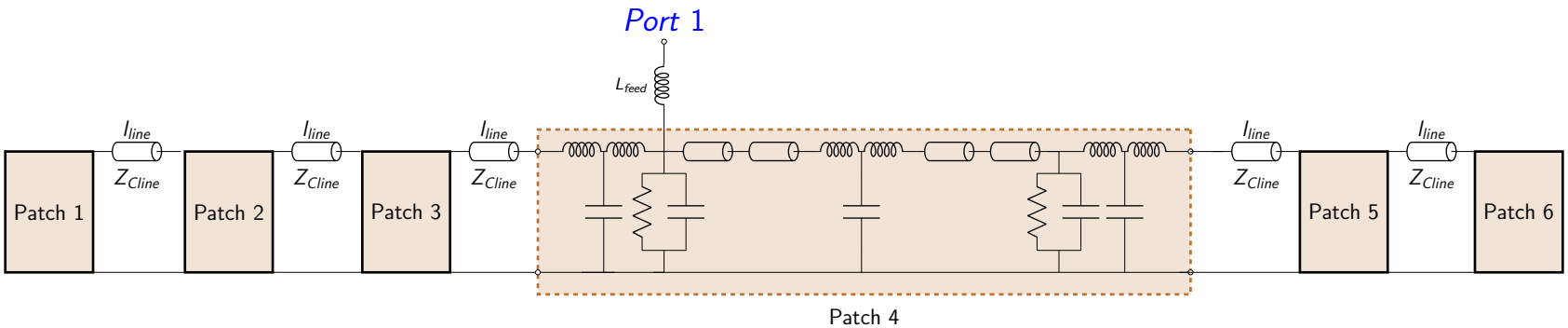
Single patch



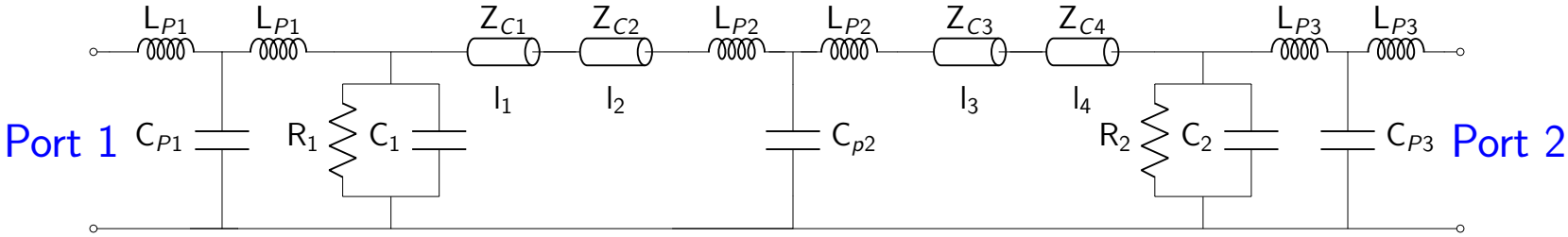


Complete Structure



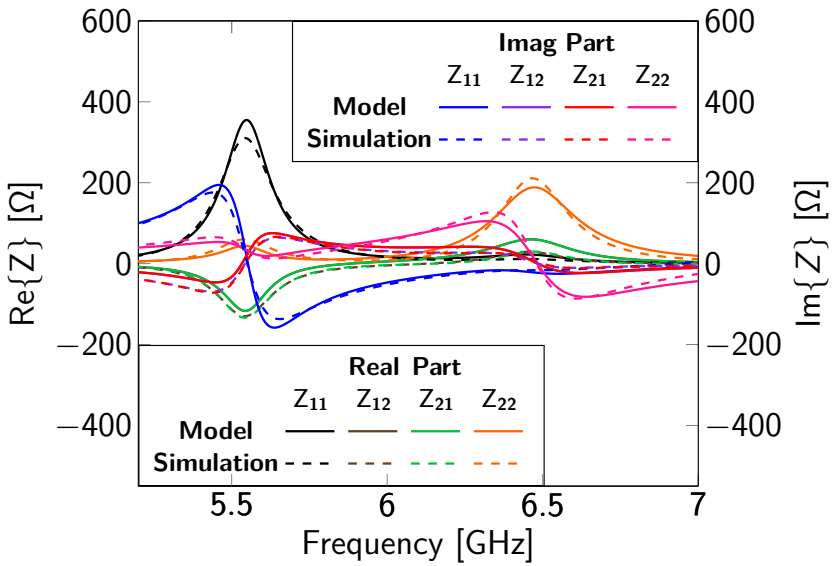


Electrical Model

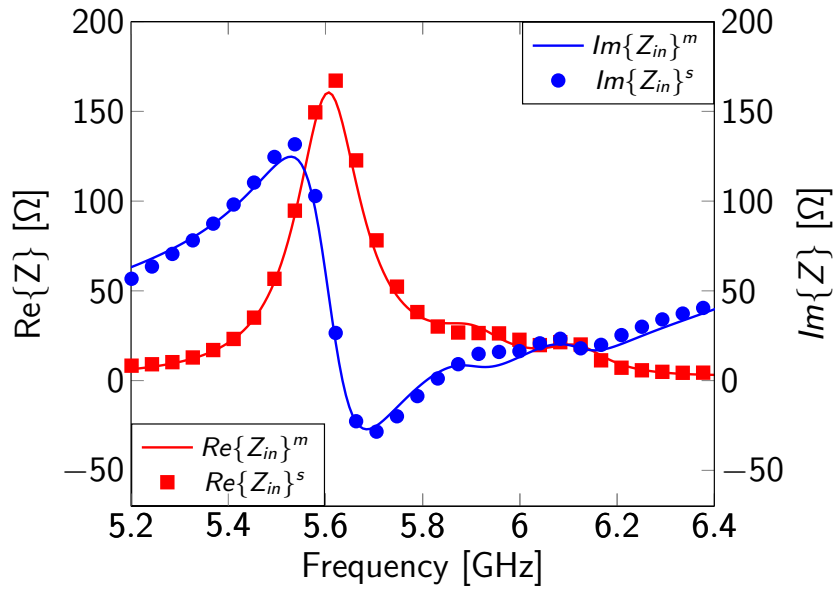


$L_{P1} = 0.16\,\text{pH}$, $C_{P1} = 1\,\text{fF}$, $R_1 = 450\,\Omega$, $C_1 = 10.01\,\text{fF}$, $Z_{c1} = 13\,\Omega$, $l_1 = 56.13\,\text{deg}$, $Z_{c2} = 6.50\,\Omega$, $l_2 = 60.13\,\text{deg}$, $C_{p2} = 39.37\,\text{pF}$, $L_{P2} = 8.00\,\text{pH}$, $Z_{c3} = 14.50\,\Omega$, $l_3 = 25.72\,\text{deg}$, $Z_{c4} = 7\,\Omega$, $l_4 = 24.42\,\text{deg}$, $R_2 = 165.10\,\Omega$, $C_2 = 0.70\,\text{pF}$, $L_{P3} = 0.17\,\text{nH}$ and $C_{P3} = 30.59\,\text{pF}$.

Single Patch



6 Patch Array



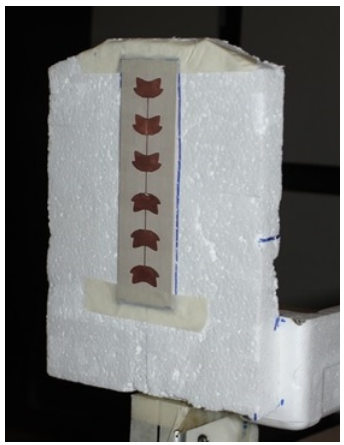
Outline

Anechoic Chamber Set-Up

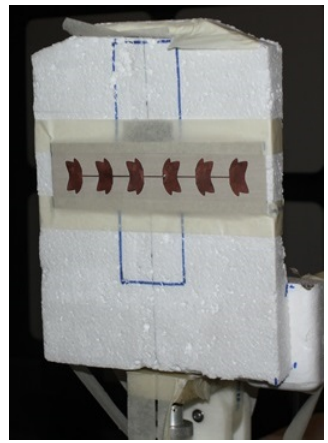
Set-up

Measuring Antenna: ETS-Lindgren's Model 3117 Double-ridged Waveguide antenna 0 GHz – 18 GHz range
Distance: 2.58 m ($2D^2/\lambda = 0.88$ m at 5.875 GHz)

Dielectric easel for H-plane measurements



Dielectric easel for E-plane measurements

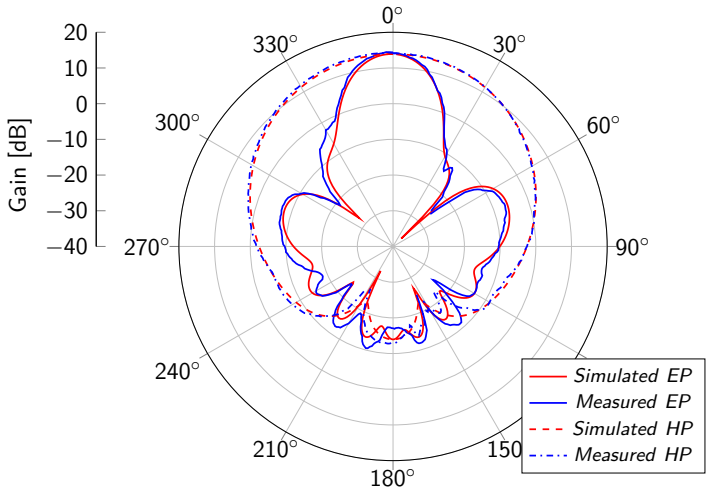


Measurements performed in the semi-anechoic chamber of **ENEA Centro Ricerche Casaccia**, Via Anguillarese, 301, 00123 Santa Maria di Galeria (RM), Italy

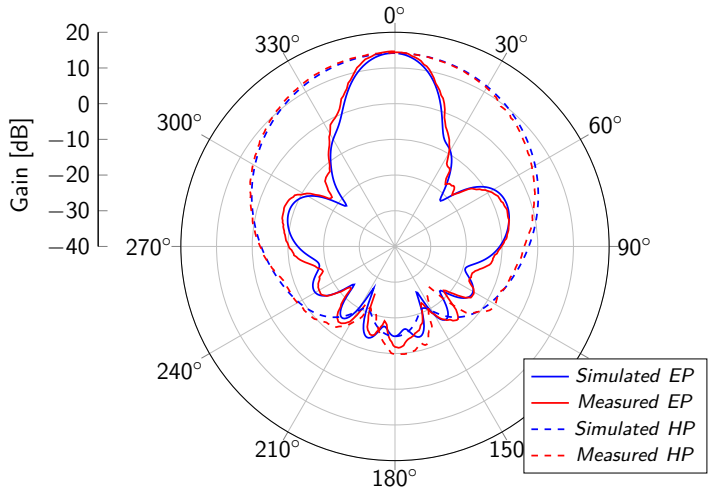
Measurement Results

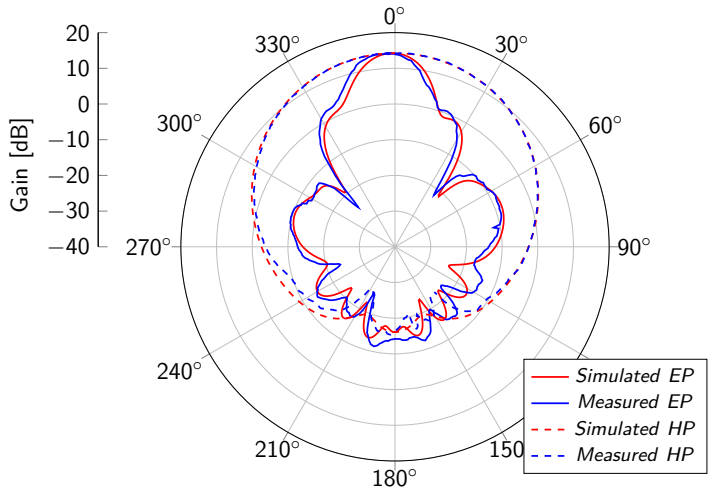
Radiation Pattern

5.725 GHz



5.8 GHz

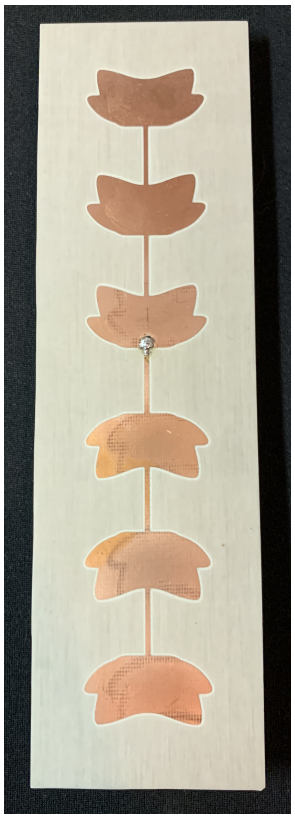


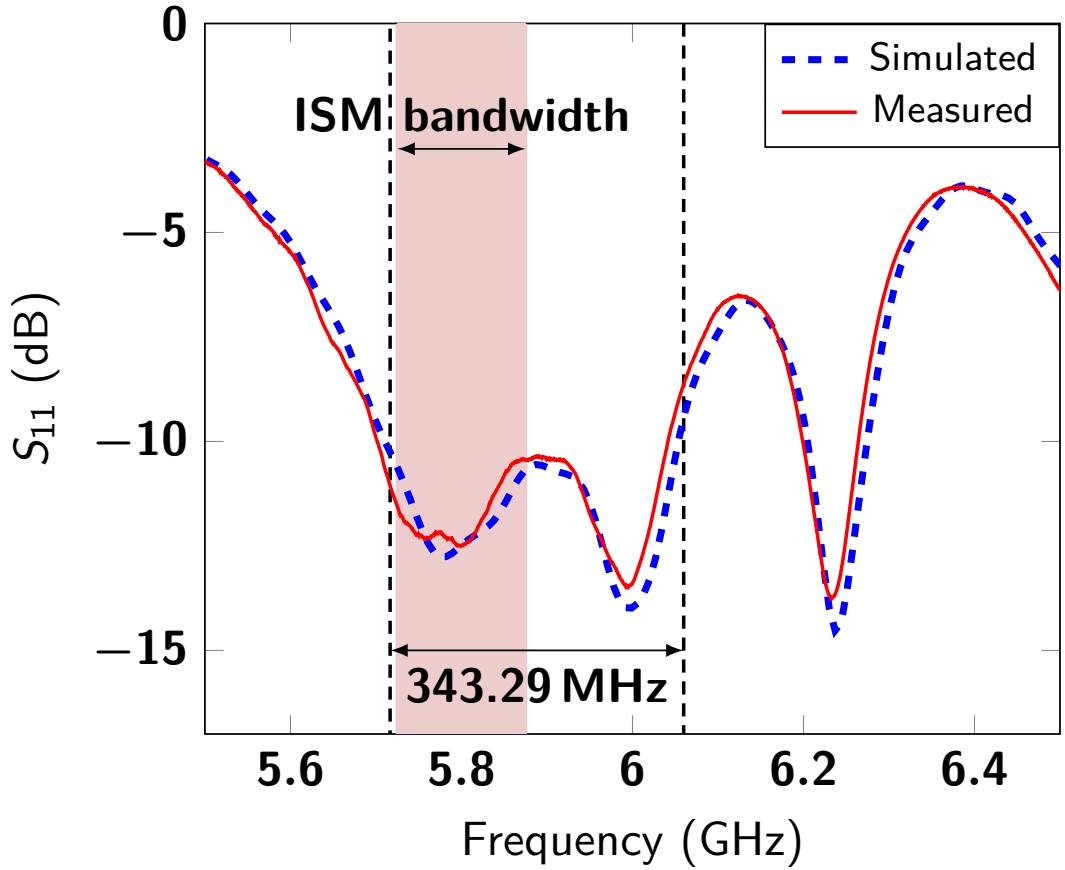


5.875 GHz

Measurement Results

Reflection Coefficient





The deigned antenna has a **fractional bandwidth** of about **5.92 %**.

Measurements performed in the **Department of Information Engineering, Electronics and Telecommunications (DIET)**, Via Eudossiana, 18, 00184 Rome (RM), Italy

Outline

Conclusions

- A new patch geometry has been proposed to overcome the limitations of the conventional patch arrays:
  - a dual band structure with overlapping bands can assure a bandwidth enhancement;
  - the indent of the patch upper edge allows the control of the side lobe level and. With this technique a low SLL is assured with patches with the same shape.
- The designed antennas have been realised and measured, showing an excellent agreement between measurements and simulations, both for the scattering parameters and the radiation pattern.