A CPW-SIW Planar Dual-Band Antenna for ISM Applications

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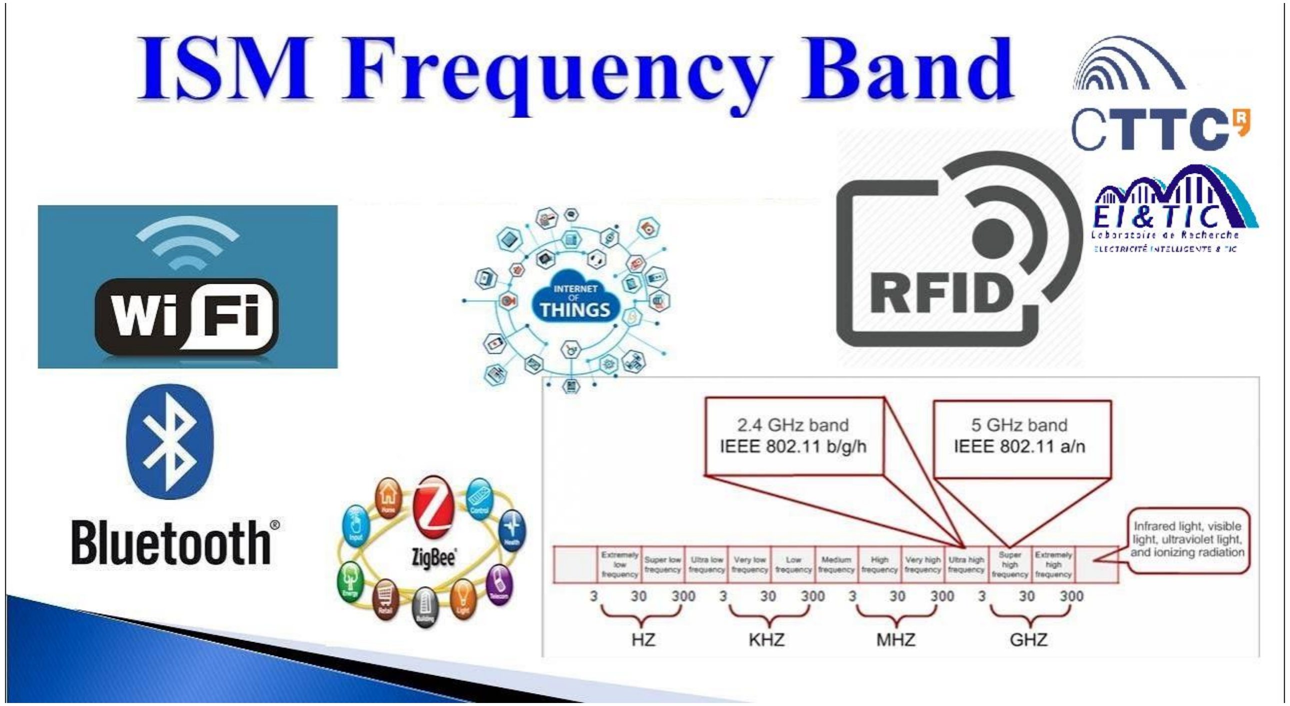
Radhoine Aloui

RADHOINE ALOUI received the master's degrees in electronics engineering from the University of Carthage, Tunis, in 2015, and 2020, respectively, and the Ph.D. degree in design and modeling of SIW circuits from the University of Carthage in 2020. he was with [1] Research Laboratory Smart Electricity ICT, SEICT, LR18ES44 University of carthage and Centre Tecnologic de Telecomunicacions de Catalunya (CTTC/CERCA)) Castelldefels, Barcelona, from 2018 until 2021, where his work was the design of SIW antennas for ISM and Sensor devices. he is currently a fellow at the Centre Tecnologic de Telecomunicacions de Catalunya developing printed antennas for terahertz and ISM bands.

Motivation

- **ISM applications :** Industrial scientific and medical applications utilize unlicensed band. In this work the ISM antenna is used for wireless sensor nodes.

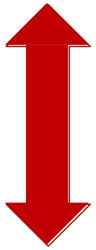


ISM bands classification

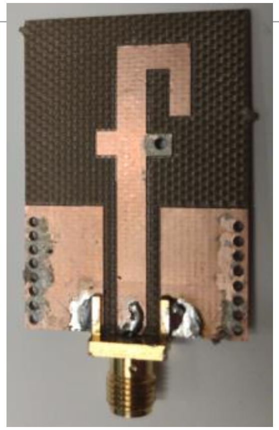
Frequency classification and characteristics

Classification	Frequency	Characteristic
High Frequency (HF)	83,996-84,004 MHz	Wave length ~3,5m
Ultra High Frequency (UHF)	886-906 MHz	Wave length ~0,4 m
Microwave	2,4 and 5,8 GHz	Wave length ~0,125m

Lower Bit-Rate
Higher Size

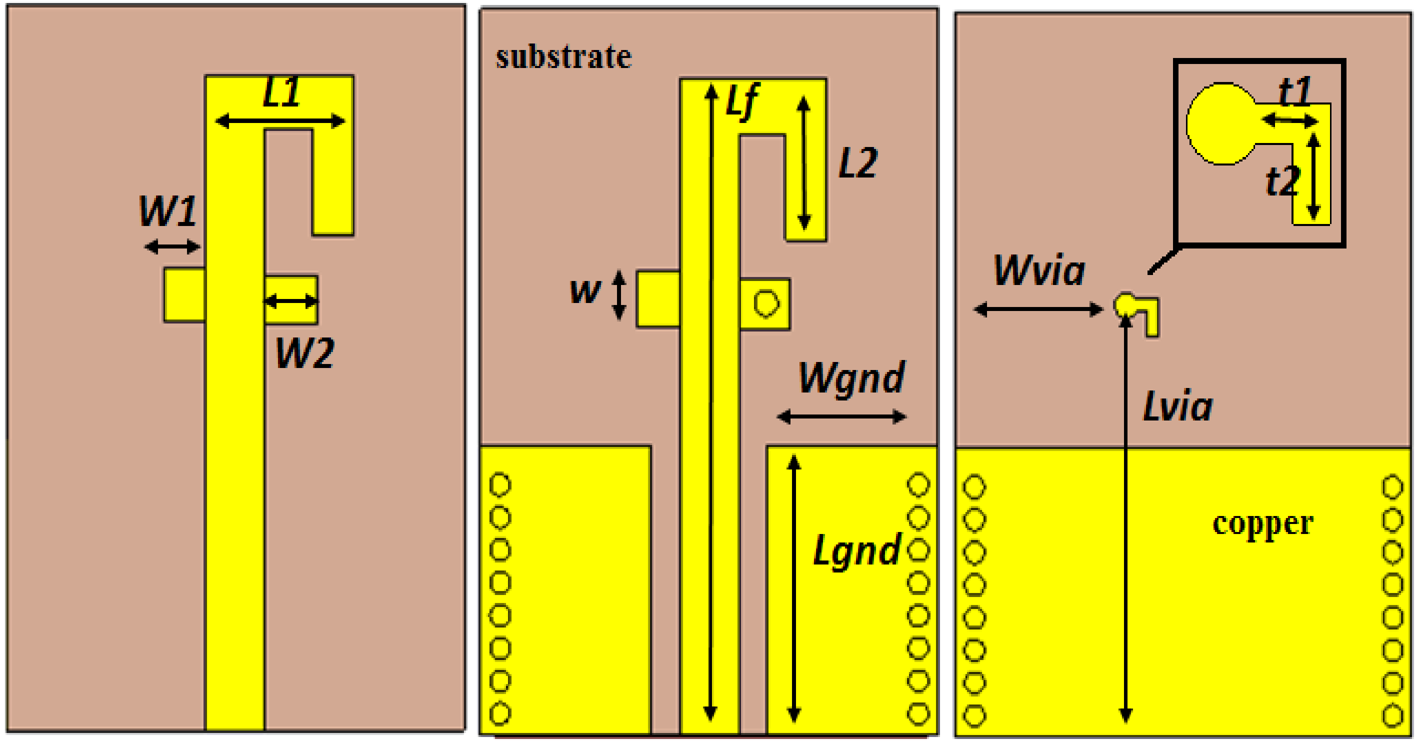


Higher Bit-Rate
Smaller Size
Affected by liquids and metals



ISM Antenna

Sensor Design Antenna

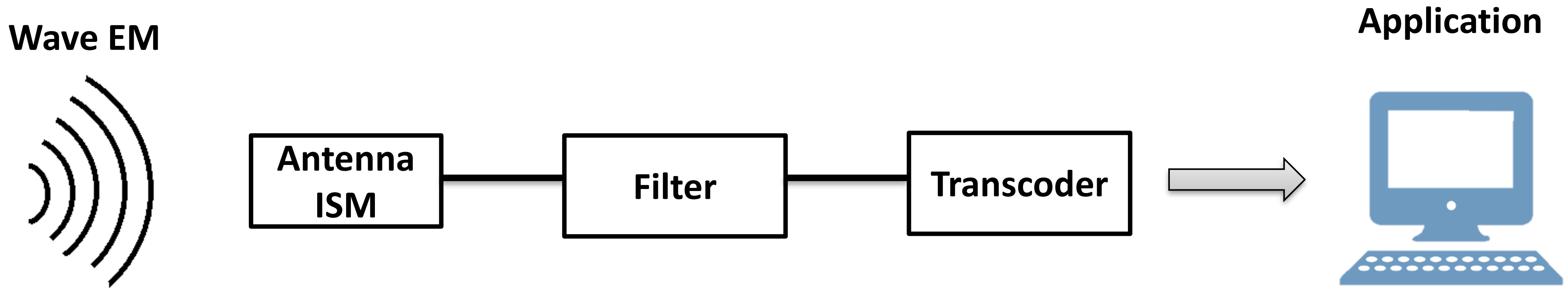


(a) Antenna1 (b) Antenna2 (c) Ground

Dimension of structure

Parameters	L_{gnd}	W_{gnd}	L1	L2	Lf	W
Value [mm]	24.2	10.4	9	8.8	34	2
Parameters	t1	t2	L_{via}	W_{via}	W1	W2
Value [mm]	1.4	2.05	22.15	10.2	3	3.7

Working principle

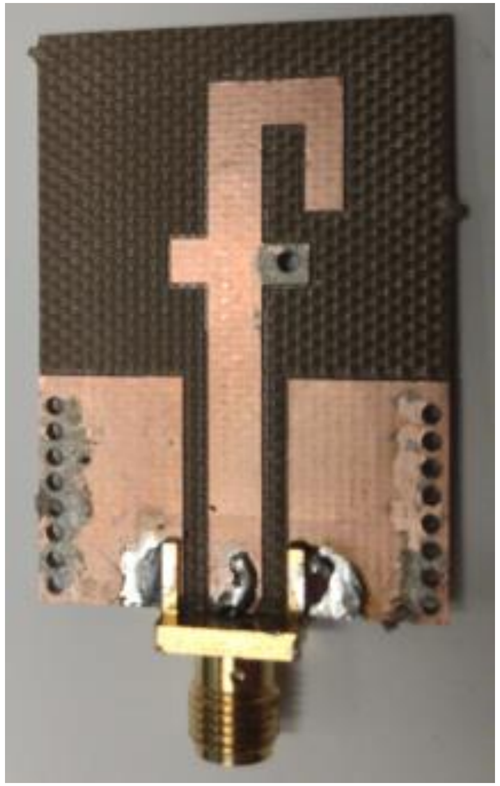


Materials

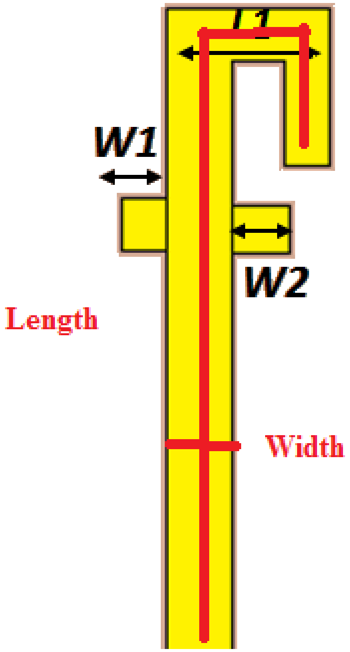
- Substrate→ Rectangular dielectric RF35 (value of dielectric 3,35, tangent loss 0,001 and 1,52 of thickness)

- Top patch→ Copper

- Connector → SMA connector for Microwave band



Structure optimization

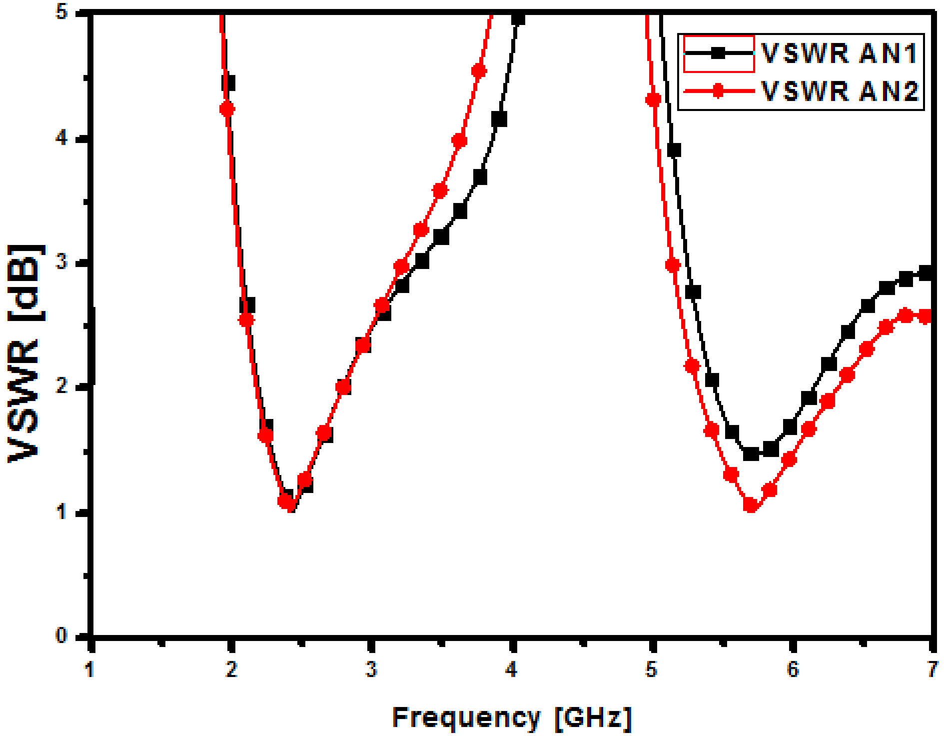


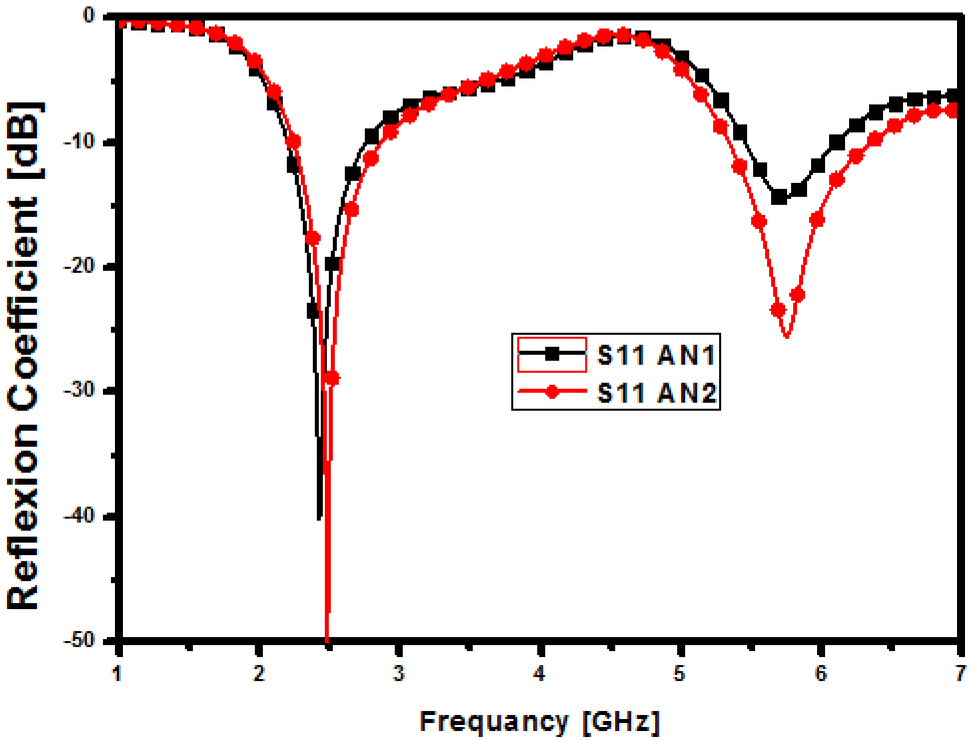
- **Calculating the width and length of the microstrip line**

$$Width = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

$$Length = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} - 0.824h\left[\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}\right]$$

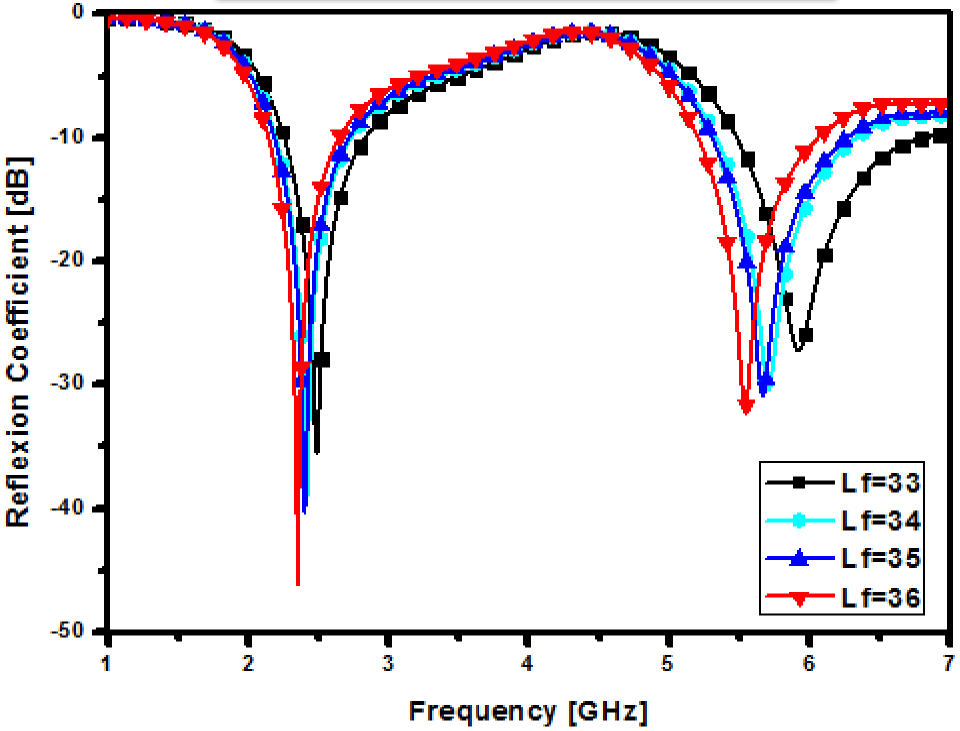
Initial design



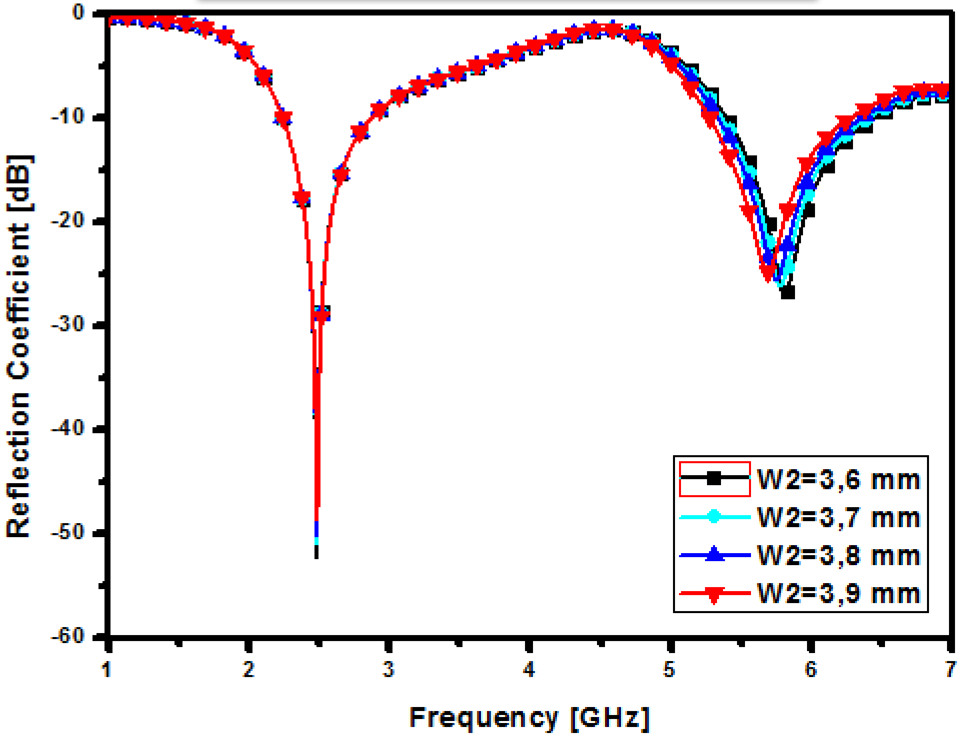


Band tuning technique analysis

Lf parameters

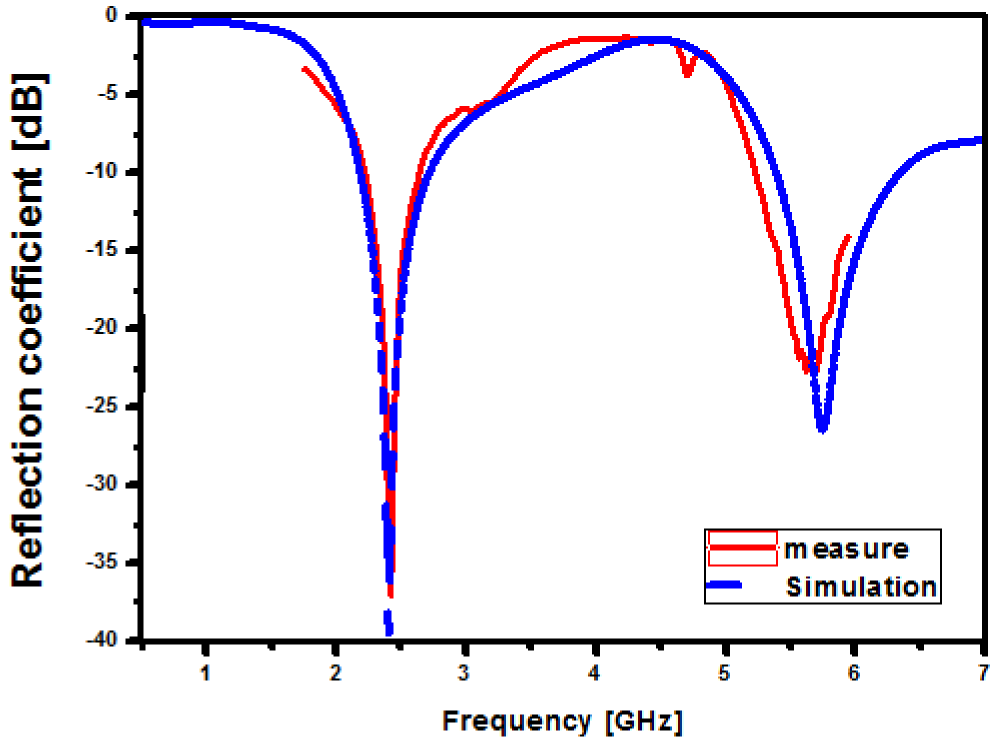


W2 parameters



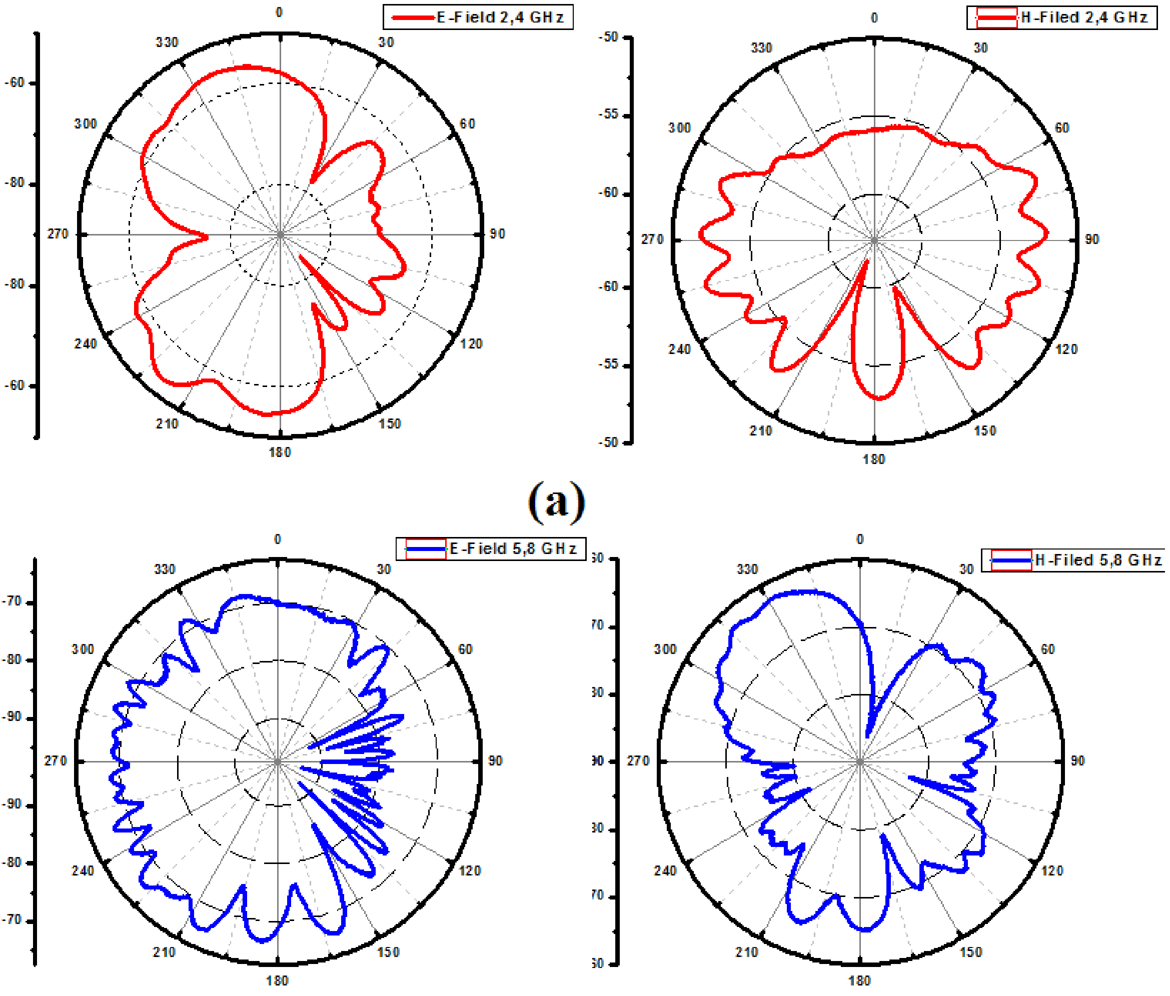
We can tuned the two frequencies by the two parameters Lf and W2 is can be shown in the dimension of design.

Experiment Results



- The proposed ISM antenna is simulated using CST studio software, the the antenna was mesured in the frequency range from 2 to 6 GHz.
- The antenna prototype is fabricated and measured in an anechoic chamber after optimization performed through simulations.
- The simulated and measured reflection coefficient results are shown in this figure. Then the measured and simulated results show a good agreement, except for slight frequency shift at 5.8 GHz, which may be caused to the probe-feed position after fabrication, fabrication tolerances and soldering.

Experiment Results

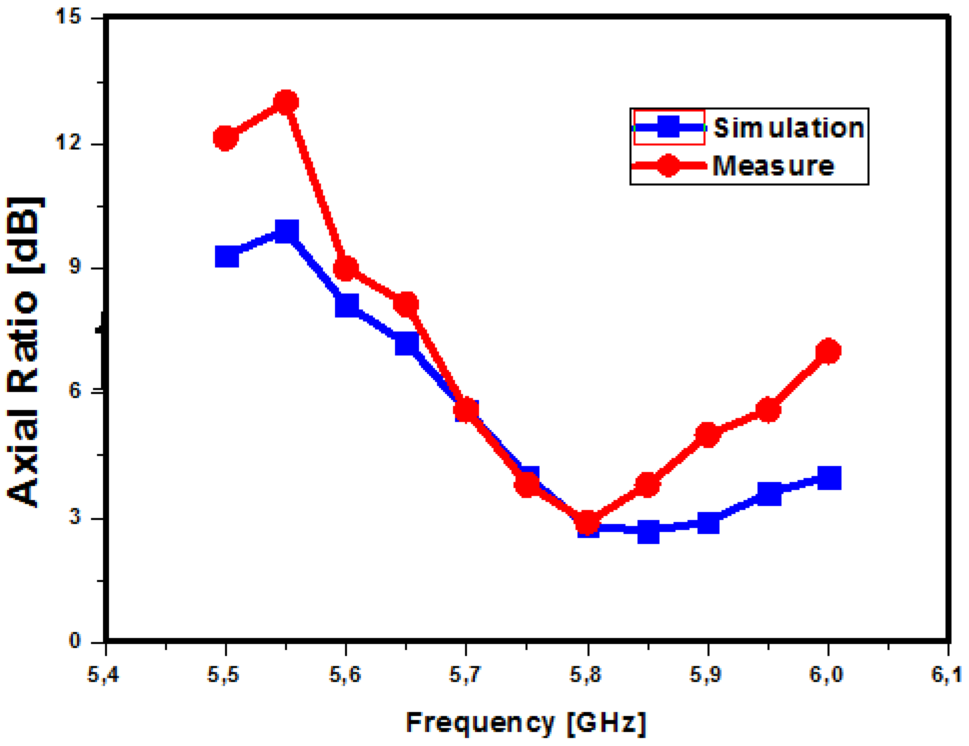


(a)

(b)

- Antenna radiation patterns are shown in the following figure, corresponding to the frequencies of 2.4 GHz and 5.8 GHz. (E-plane and H-plane).
- Good agreement with the simulation results and measured.

Experiment Results



- To make this antenna useful, for the second ISM band the Axial Ratio is below 3dB, finally the proposed antenna has a circular polarization in 5,8 GHz.
- Simulation and measured results show a good agreement for range frequencies 5,4 to 6,1 GHz.

Comparaison the prototype antenna with others

Parameter	Frequency	[15]	[16]	[17]	[18]	Proposed antenna
Gain [dB]	F1=2.4	1.73	2.07	2.02	2.01	2.72
	F2=5.8	5.4	1.17	4.06	3.45	3.22
Bandwidth [MHz]	F1=2.4	48.7	250	200	350	350
	F2=5.8	200	250	650	1000	1000
Polarization Linear/Circualar	F1=2.4	L.	L.	L.	L.	L.
	F2=5.8	L.	L.	L.	L.	Cir.

The antenna was compared with others antennas, this antenna have a good feature in the two bands.

The gain of antenna is 2,72 dB in first frequency, while is better compared the others.

In add the independently adjustment for the two resonance frequencies, the proposed antenna has a circular polarization. This antenna presents advantages over other antennas.

Conclusions

- We demonstrate the possibility of designing a ISM antenna with a good feature and simple layer.
- In this paper, a circular polarization, dual-band antenna for ISM band is reported.
- The CPW-SIW structure improves the antenna response S-parameters.
- The antenna bands have been adjusted independently.

Future work

- Make this antenna integrated in the ISM band and the RFID application.
- Make the another low band frequency in the same design for example in MHz frequencies.
- Improvement about the gain for a better design.

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