University of Cyprus
Photovoltaic Technology

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Prepared in fulfilment of deliverables D12 of Work Package 4, “Design and Implementation of a Novel Wireless Receiver Chain using Metamaterial Quad Band Devices”, ΤΠΕ/ΕΠΙΚΟΙ/0609(ΒΕ)

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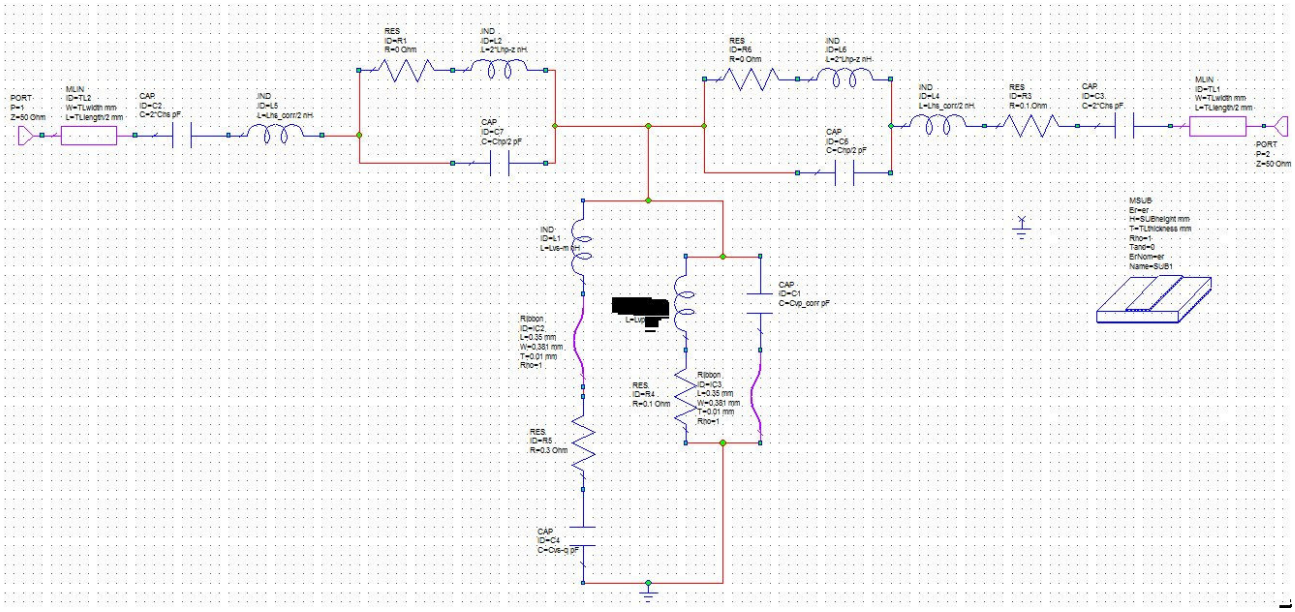
Summary

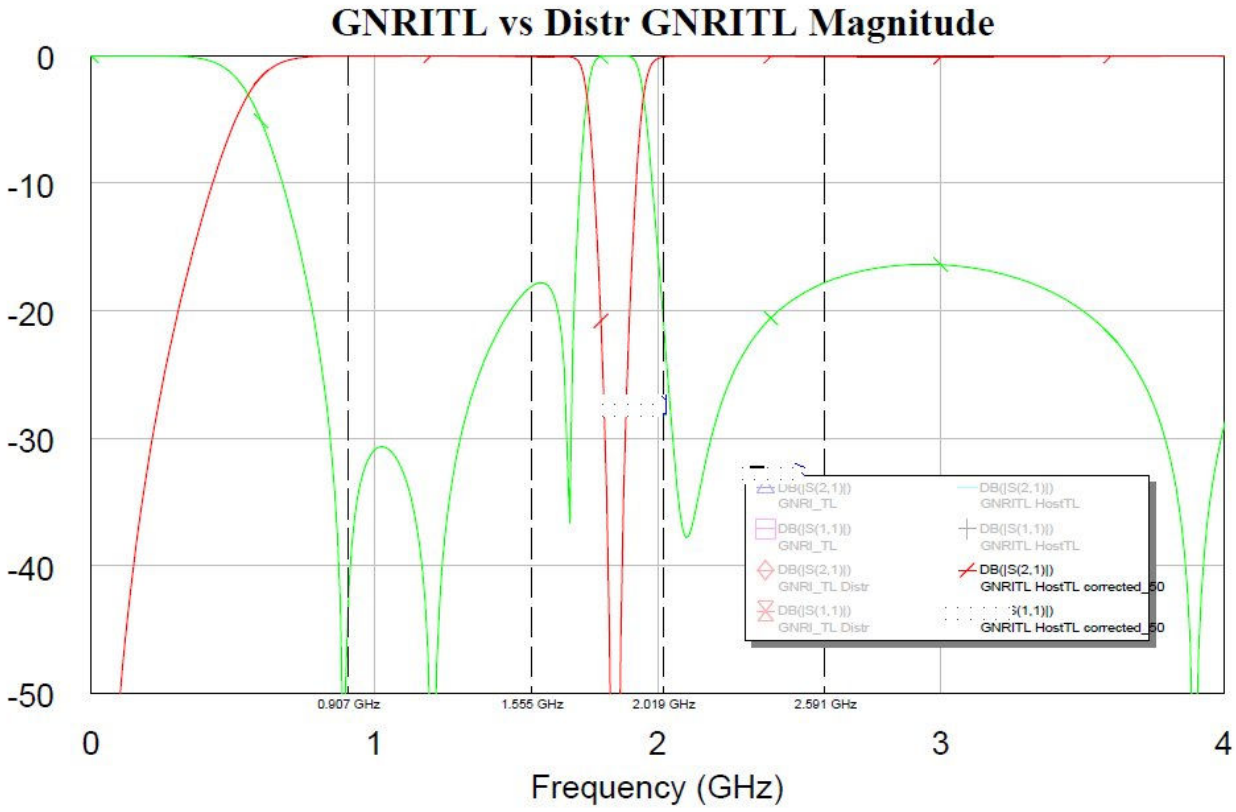
The objective of this work package was to develop full wave EM simulations for the quad band unit cells that will be used as building blocks for the quad-band devices that will be fabricated for this research work. Deliverable 12 (D12) deals with the fabrication of these building blocks which are fully printed NRI-TL unit cells with characteristic impedances of 50 ohms, 35.35 ohms and 70.7 ohms. For their design, the Theory developed in WP3 was used to realize the optimum band location and width. Full wave EM simulations were performed and their equivalent circuit parameters was extracted. The goal was to be able to design and fabricate the unit cells for the set of frequencies set fourth by WP3 and a corresponding insertion phase of $\beta d=\pi/2$ at these frequencies. Test data will be taken using the labs Vector Network Analyzer.

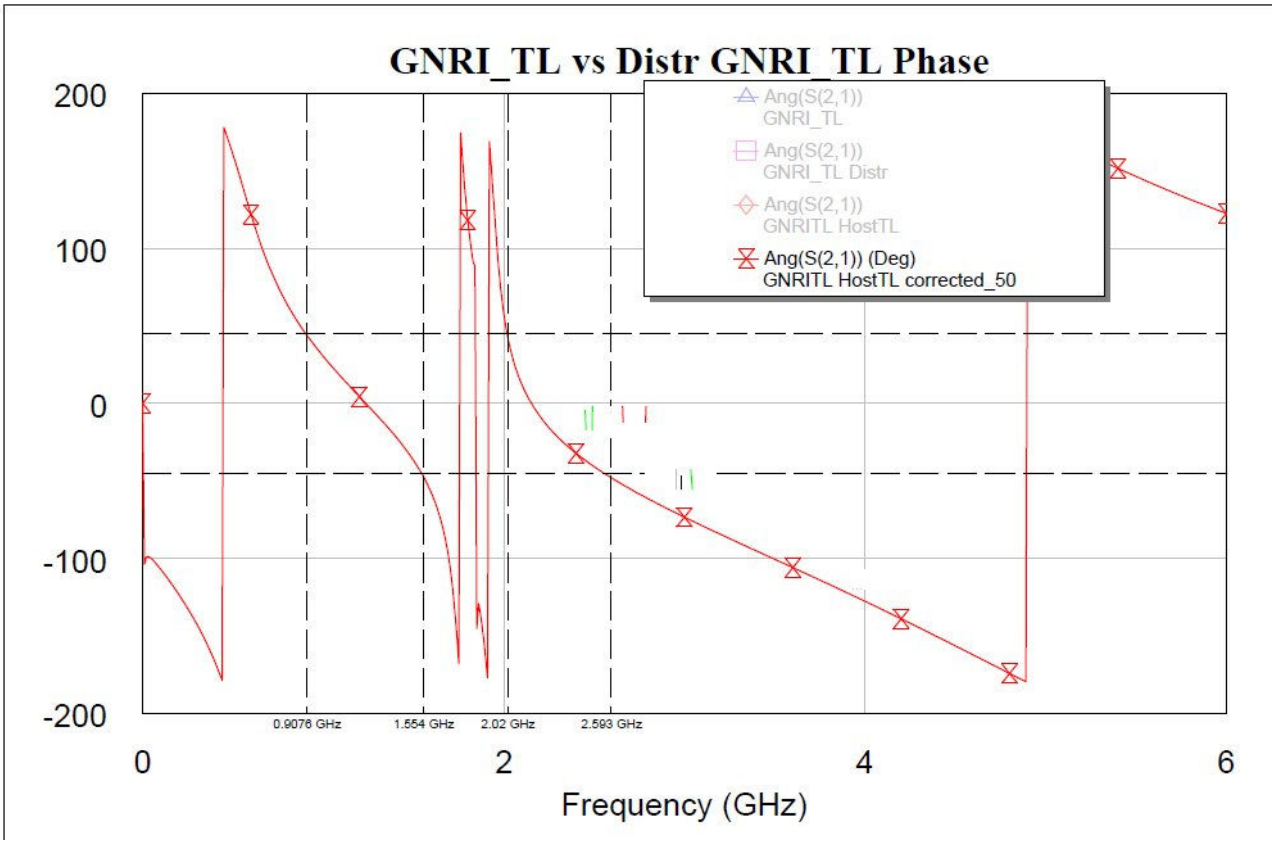
Design and fabrication process

The four frequencies of operation that were chosen were f1=900MHz, f2=1.55GHz, f3=2.017GHz and f4=2.592GHz. The desired phase shift that we wish to be incurred by each unit cell at these four frequencies is 45 degrees. Using the equations and the software developed in WP3, the 50ohm, 35.35ohm and 70.7 ohm unit cells were designed in the circuit simulator. The schematic of the 50 ohm unit cell is shown below:



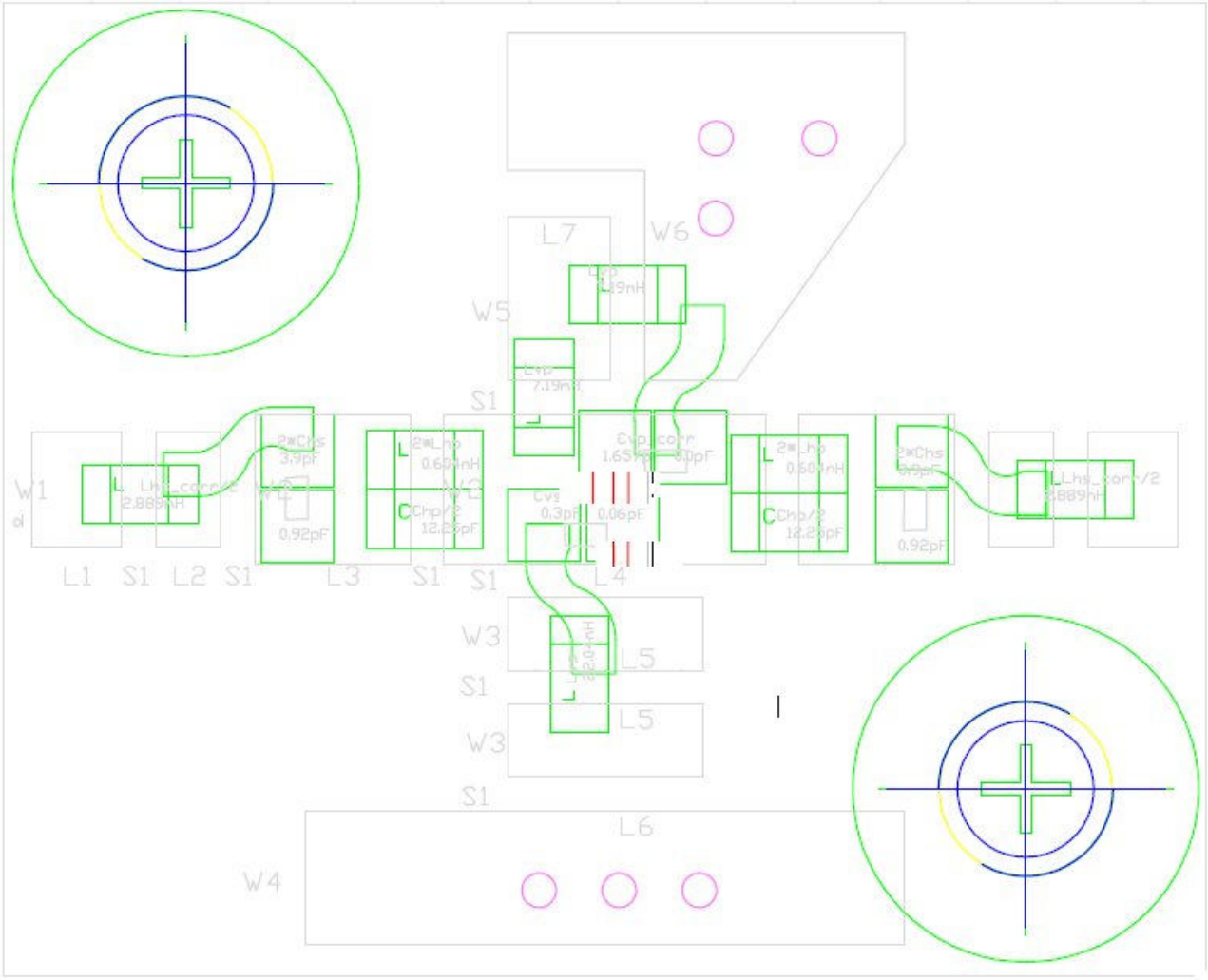
This unit cell has its host Transmission Line length included in it and its effects are taken into account in the calculation of the required component values. The figures below show the magnitude and phase data of these unit cells


GNRITL vs Distr GNRITL Magnitude
0
-10
-20
-30
-40
-50
0.907 GHz
1.555 GHz
2.019 GHz
2.591 GHz
0
1
2
3
4
Frequency (GHz)
DB(|S(2,1)|)
GNRI_TL
DB(|S(2,1)|)
GNRITL HostTL
DB(|S(1,1)|)
GNRI_TL
DB(|S(1,1)|)
GNRITL HostTL
DB(|S(2,1)|)
GNRI_TL Distr
DB(|S(2,1)|)
GNRITL HostTL corrected_50
DB(|S(1,1)|)
GNRI_TL Distr
GNRITL HostTL corrected_50

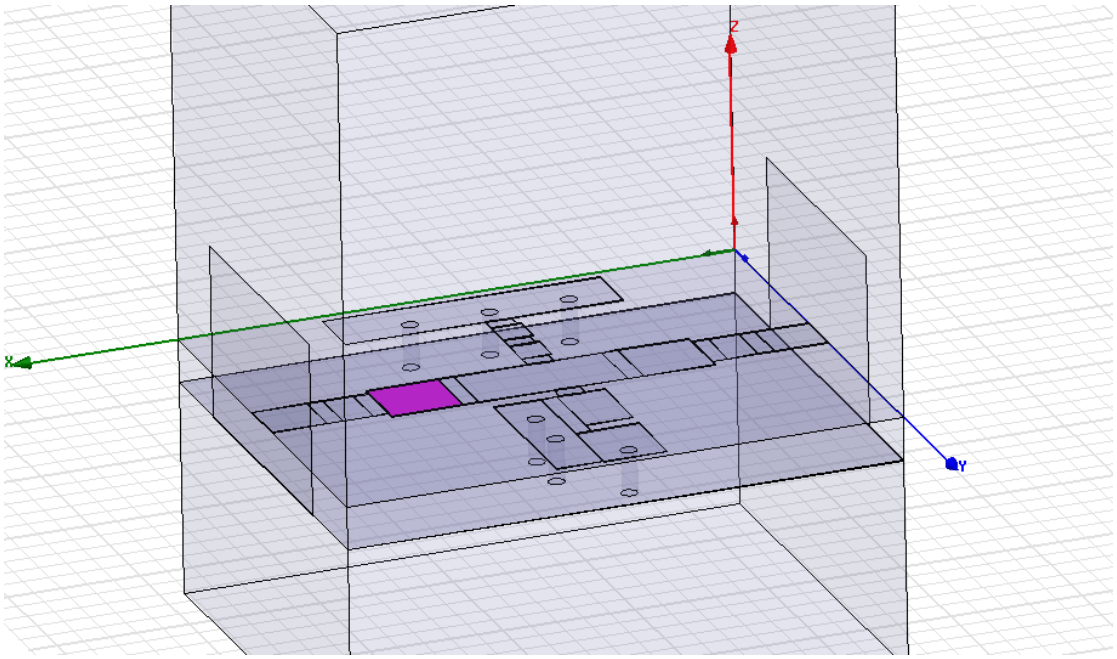

GNRI_TL vs Distr GNRI_TL Phase
200
100
0
-100
-200
0.9076 GHz
1.554 GHz
2.02 GHz
2.593 GHz
0
2
4
6
Frequency (GHz)
Ang(S(2,1))
GNRI_TL
Ang(S(2,1))
GNRI_TL Distr
Ang(S(2,1))
GNRITL HostTL
Ang(S(2,1)) (Deg)
GNRITL HostTL corrected_50

It can be seen from the figures above that at the four design frequencies, the phase is + or – 45 degrees and the insertion loss at the passbands is minimum. Similar performance is also seen on the 70.7 ohm unit cell and the 35.35 ohm unit cell. Even though the 70.7 ohm unit cell was not specified in the proposal of this research work, it was deemed necessary to design and fabricate it since the performance of the Rat-race coupler using NRI-TL unit cells will be slightly better to the performance of the Branch-Line Coupler, after some preliminary simulations in the circuit simulator.

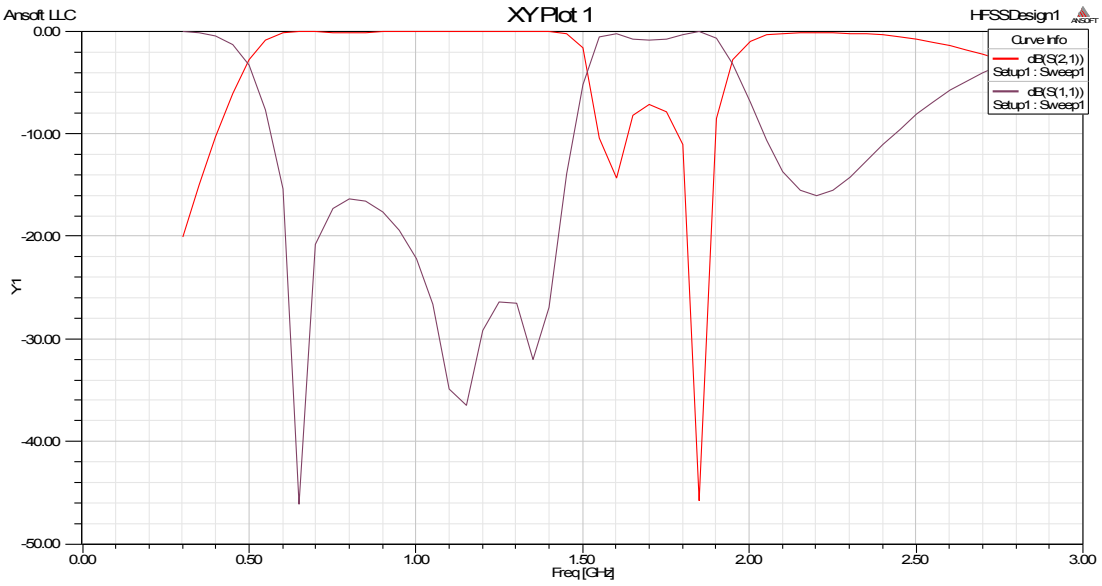
The next step in the design process was to design the unit cells in a CAD software in order to set the topology and the structure of the unit cell and its components. Below, an image from AutoCAD shows this design for the 50 ohm unit cell.



The next step in the design process was to design the unit cells in the full-Wave EM simulator to verify the magnitude and phase performance. This is the final step before the generation of the gerber layout files that are used for the board fabrication of the unit cells.



The magnitude data below shows the similarity between the response of the circuit simulator and the full-wave EM simulator, which allows for the creation of th gerber layout files.



In the next few weeks, the fabrication will be completed, since the capacitors ordered for the unit cells have not yet arrived. Once the capacitors are in the lab and the unit cell fabricated, the measured data will also be presented.

References

[1]. G.V Eleftheriades, “Design of Generalized Negative-Refractive-Index Transmission Lines for Quad-Band Applications”, IET Microwaves, Antennas and Propagation, 2009

[2] M. Pozar, “Microwave Engineering, 3rd Ed.”