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RESEARCH ARTICLE

MISMATCH STUDY OF META-LINE STRUCTURES RELATED TO DISPERSIVE PROPERTIES

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Abstract

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The study focuses on coplanar metamaterial lines and resonators and the possibility to increase their performances. To achieve our goal, we studied these structures accesses for a better adaptation. This study allowed us to optimize the accesses of meta-lines components. We thus obtain a possibility of cells which it is necessary to decrease the losses in meta-lines structures.

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Introduction:-

The concept of metamaterials [1] lies in the idea of artificially structuring matter to obtain innovative electromagnetic properties [2] [3]. This approach has been used in the field of propagation lines, showing a lot of interest for the realization of components, especially in the microwave field [4][5].

To meet the needs of the telecommunications sector, many authors have studied the possibility of making these devices frequency fexibleby mechanical control of the MEMS type [6], using active elements [7], by means of a ferroelectric film [8]or by the use of solid magnetic materials [9].Our approach consists in using the materials magnetic properties to obtain the desired agility. Previous works [10] have already approached this issue by realizing coplanar metamaterial components and sol-gel composites based on magnetic nanoparticles. Agility has been demonstrated, but it is accompanied by significant losses in the devices due to component accesses. The objective is therefore to study the accesses of the meta-lines in order to optimize their performance.

Description:-

In this work, we have therefore taken the devices that were presented in [7] (figure 1 and 2). The measurement accesses of these structures must be studied to improve their performance.

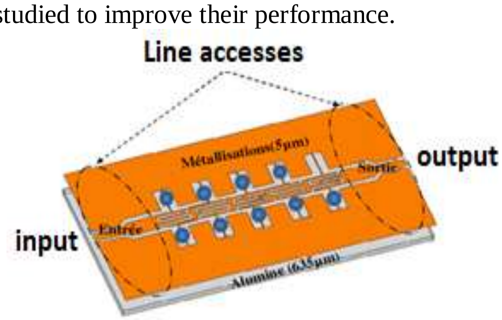

Figure 1:- Meta-line.

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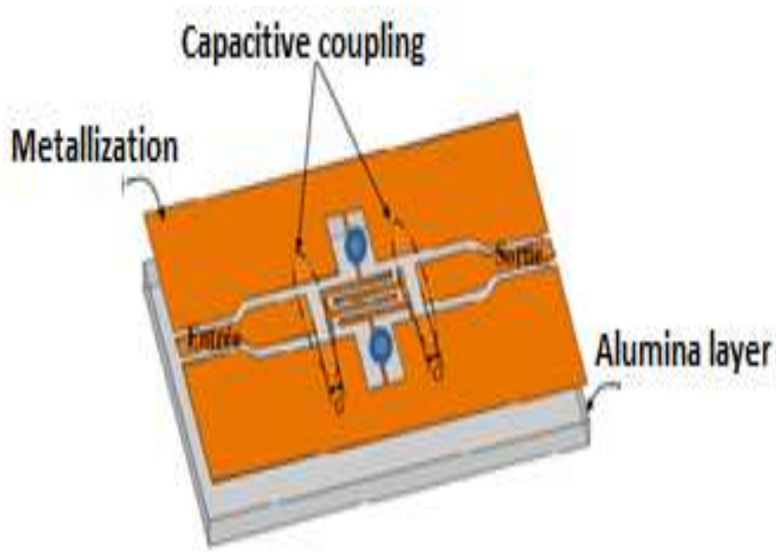

Figure 2:- Zero order resonator

AccessesStudy:-
The objective is to study the influence of some parameters to obtain an impedance close to 50Ω. So, we shall study:
- The impact of the elbow angle;
- The impact of the gap;
- The impactof the arm width.

Presentation of the studied cellure:
Figure 3 shows the studied cell.

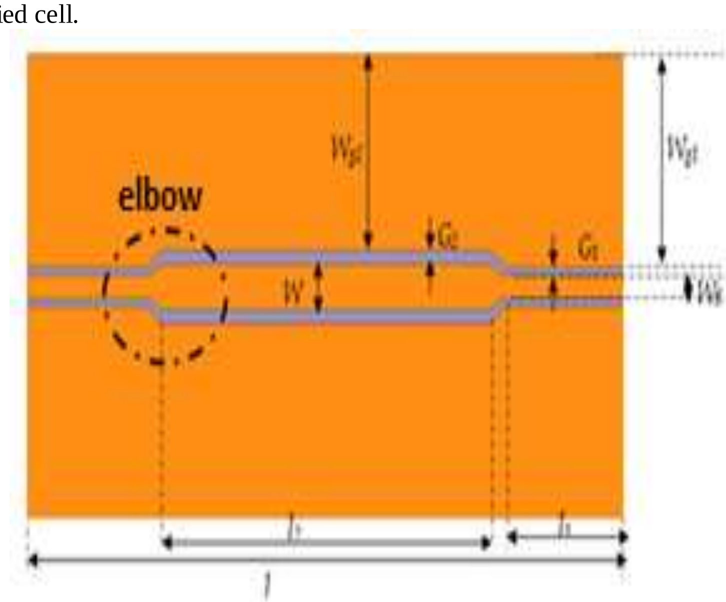

Figure 3:- Studied cell under HFSS Software.

The geometric parameters of the structure are presented intable1:

Table 1:- Geometric parameters of the cell.

Metal thickness (Cu)	5µm
Thickness of the substrate	635µm
Length of the structure *l*	23.5mm

Length of the line arm l_1	4.75mm
Length of the line body l_2	13mm
Width of the line arm *Ws*	0.7mm
Width of the line body *W*	1.4mm
Width of the outer gap G_1	0.25mm
Width of the inner gap G_2	0.4mm
External width of the mass W_{g1}	6.4mm
Inside width of the mass W_{g2}	5.9mm

Study of the cell elbow:
In this part, we study the influence of the elbow angle. Wevary the angle by 50°, 45° and 30°. Figure 4represents azoom of the bend.

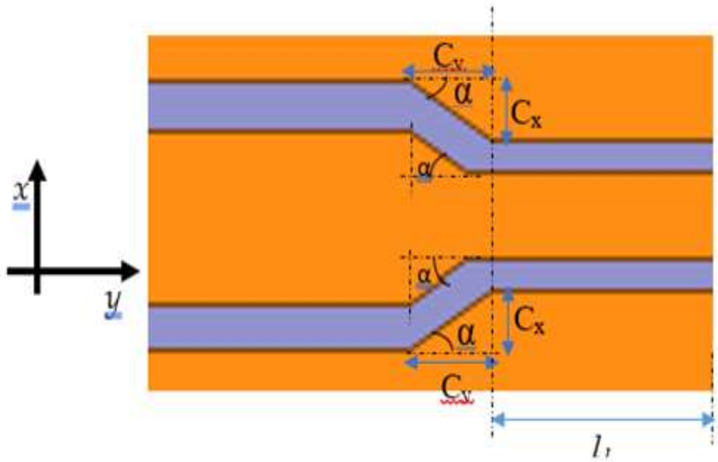

Figure 4:- Zoom of the bend.

The angle α is determined by the following relationship:

$$\alpha = tan^{-1}\left(\frac{opposite\ side}{adjacent\ side}\right) \quad (1)$$

$$\alpha = tan^{-1}\left(\frac{C_x}{C_y}\right) \quad (2)$$

Table 2 shows the geometric parameters of each bend.

Table 2:- Parameters of each bend.

Angle α	x-side (Cx)	y-side (Cy)	Length of the legl_1
α=50°	0.5mm	0.419mm	4.83mm
α=45°	0.5mm	0.500mm	4.75mm
α=30°	0.5mm	0.866mm	4.38mm

Study of the gap:
We consider the cell bent by 45° and we vary the gap (200µm, 250µm and 300µm). The characteristic impedancesobtained during the simulation are shown in figures5 and 6. Forthe gap values of 300 µm and 250 µm, the impedance increases respectively to 53.5 Ω and 50.5 Ω but shows a peak around 3 GHz. For the gap value of 200µm, the impedance decreases to 49.5Ω and theobserved peak disappears. This allows us to retain the cellfor gap of 200 µm. The width of line arm (Ws) is equal to 700µm.

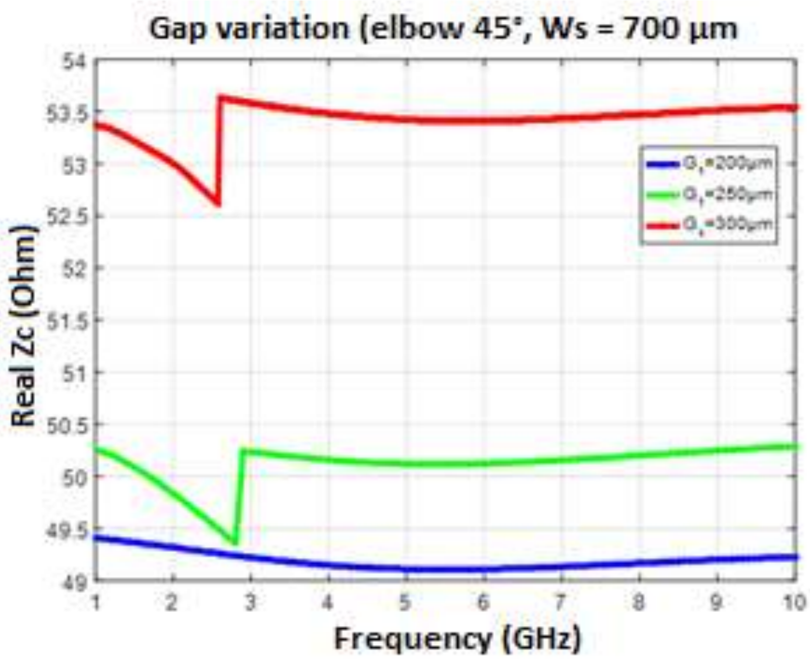

Figure 5:- Characteristic impedance versus gap (real part).

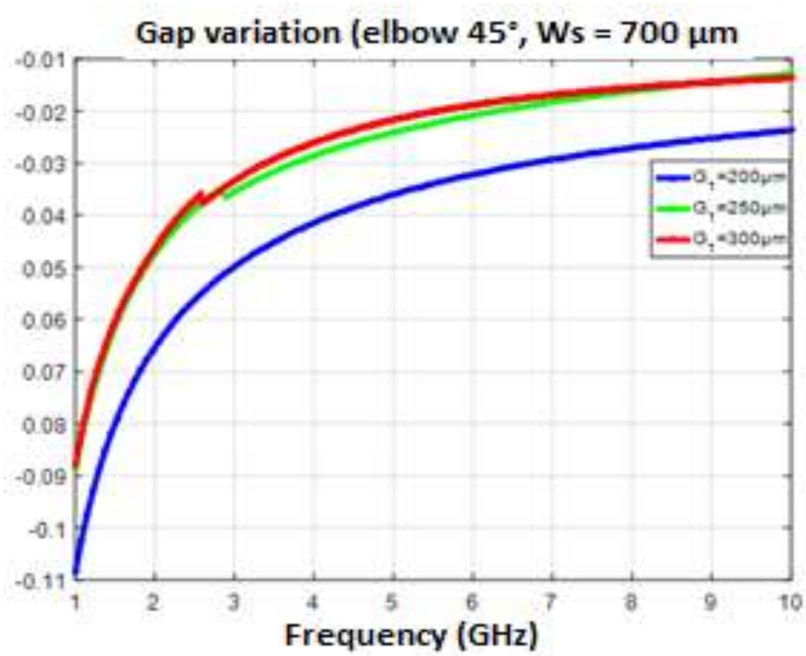

Figure 6:- Characteristic impedance as a function of the gap (imaginarypart).

Study of the width of the elbow:

The objective is to vary the width Ws for this selected celland observe its influence on the characteristic impedance.The characteristic impedance as a function of the width Wsis represented by figure 7 (real part) and 8 (imaginary part).

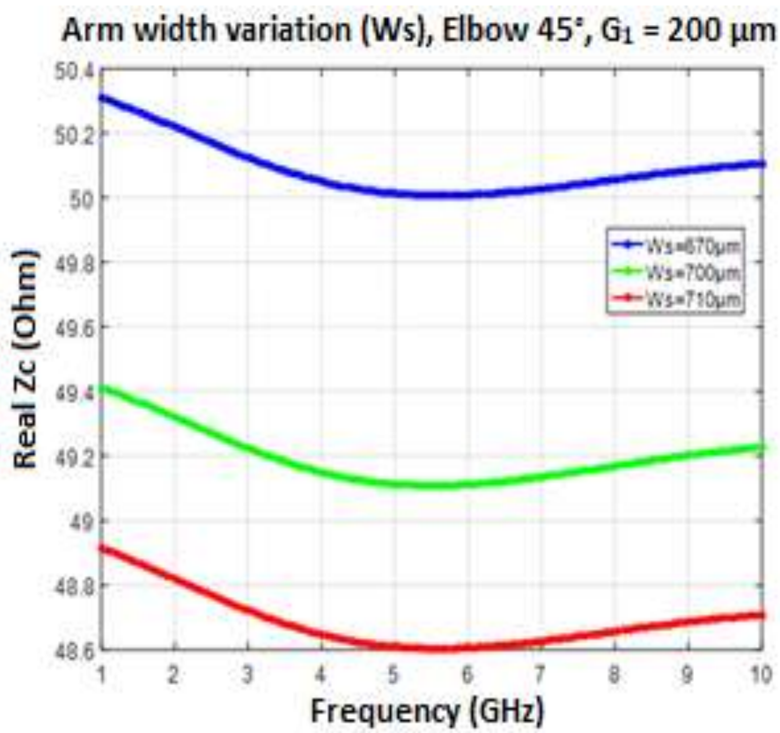

Figure 7:- Characteristic impedance versus gap (real part).

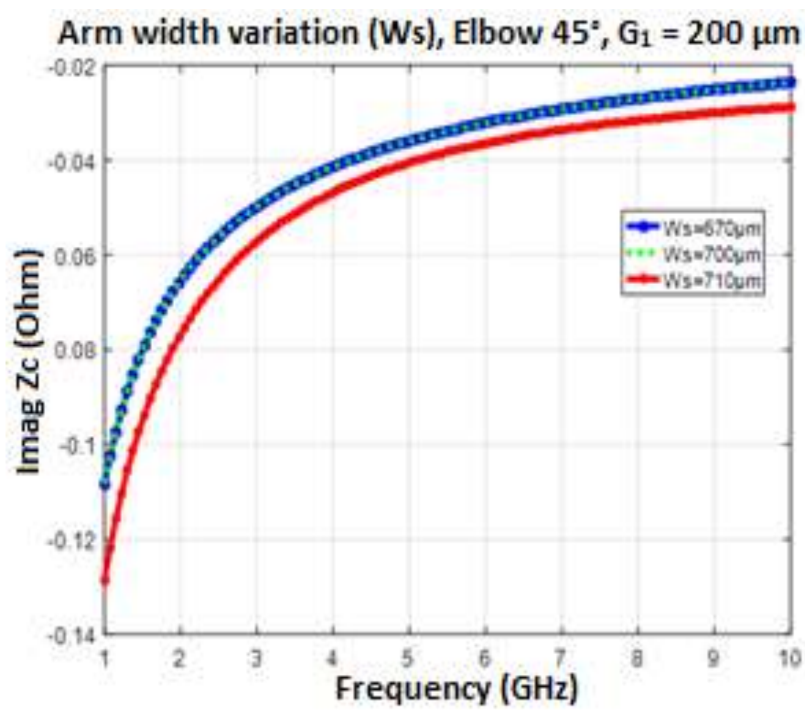

Figure 8:- Characteristic impedance as a function of the gap (imaginarypart).

We also observe some parameters such as effective permittivity, phase constant and attenuation and the phases of transmission parameters of the studied structure (figures 9-13).

The effective permittivity as a function of width Wsisshown in Figure 9.

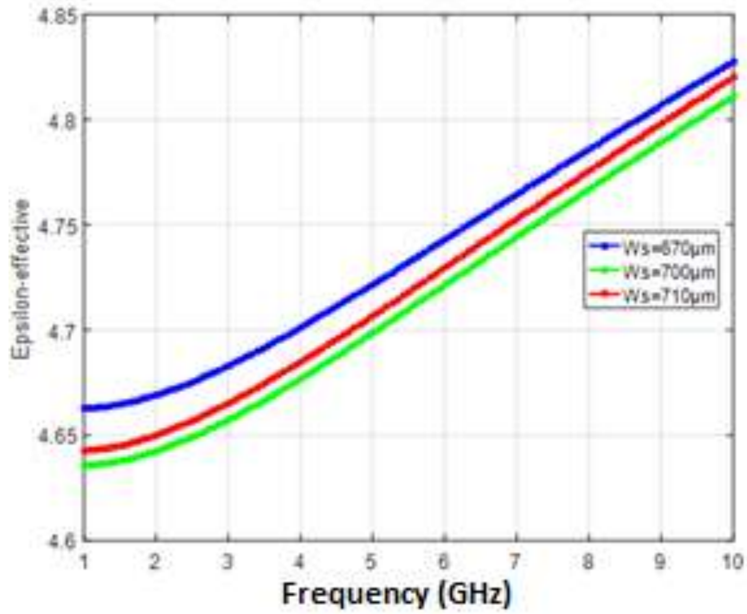

Figure 9:- Effective Permittivity versus Ws.

The phase constant and attenuation as a function of width(Ws) are shown respectively in Figures 10 and 11.

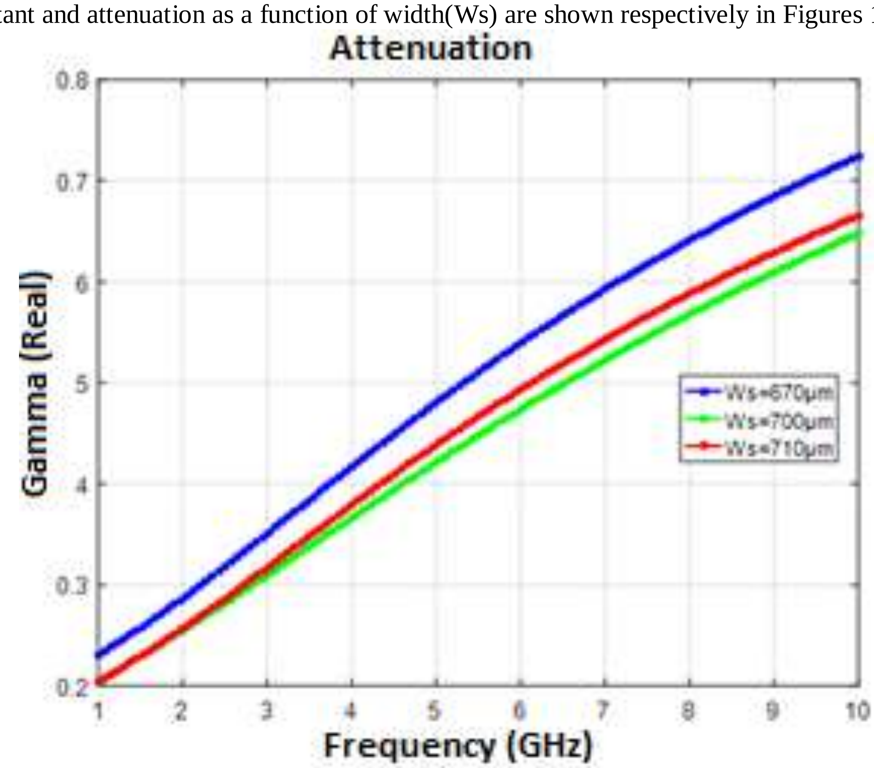

Figure 10:- Attenuation as a function of Ws.

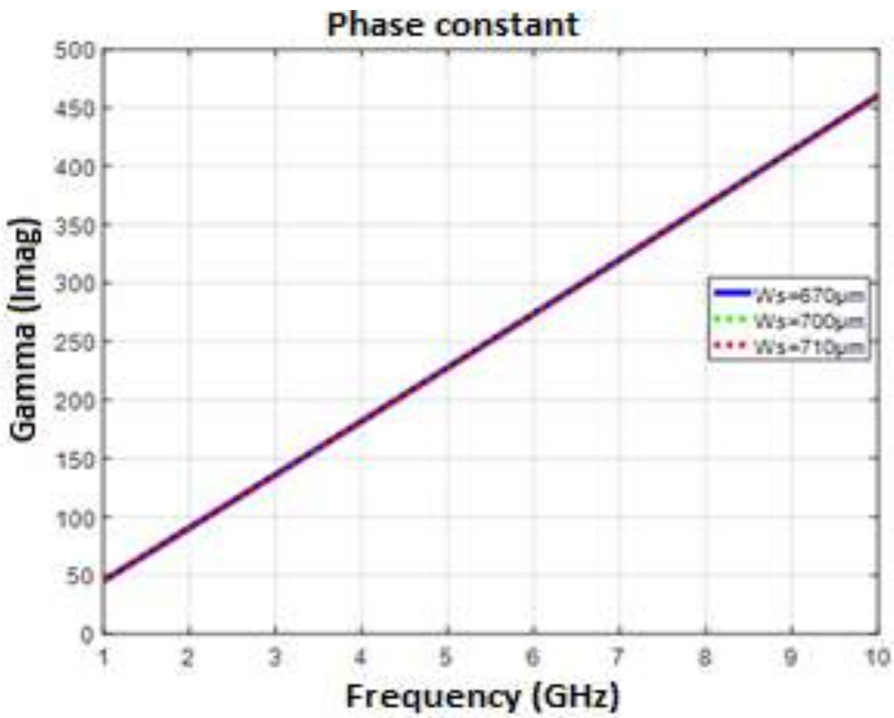

Figure 11:- Phase constant as a function of Ws.

The phases for the transmission and reflection parameter areshown in Figures 12 and 13.

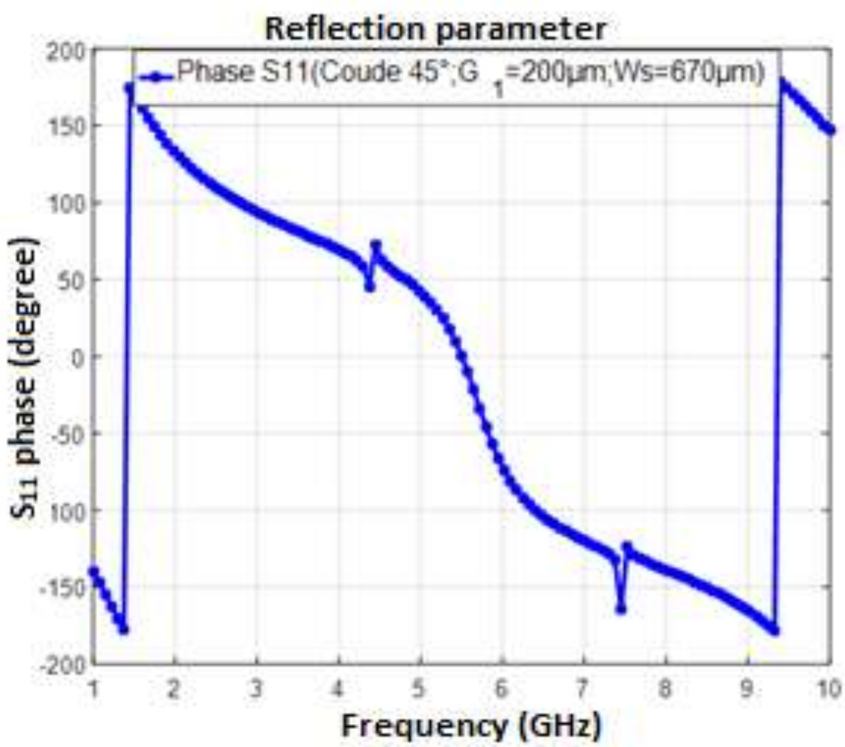

Figure 12:- S_{11} phase.

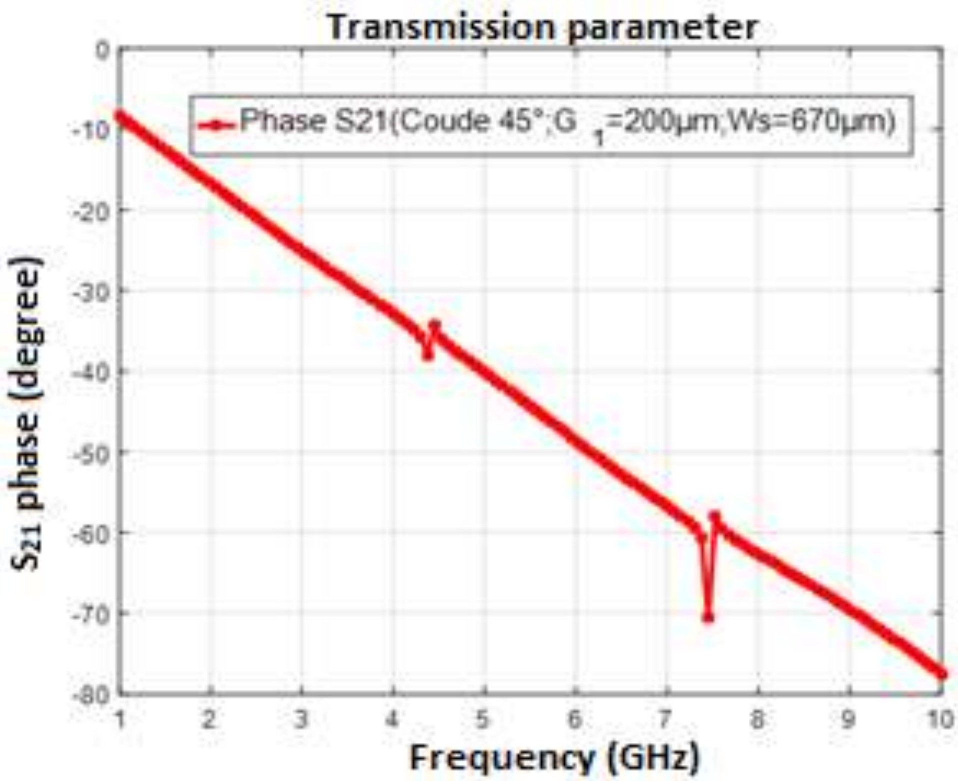

Figure 13:- S_{21} phase.

We observe that the variation of the width Ws implies a modification of the characteristic impedance of the studied structure (figures 8 and 9). For Ws = 670 µm, the characteristic impedance of the structure is close to 50 Ω. We also note that the effective permittivity varies with the width Ws (figure 10).

For figures 11 and 12 showing respectively the attenuation and phase constants, we note that for Ws = 670 µm, the attenuation is low.

In conclusion, we will choose a 45° bend with a gap of 200 µm and a width Ws of 670 µm. Results of figures 12 and 13 show that the signal is well transmitted, and therefore we have a good adaptation of the structure.

Conclusion:-

The objective of this study was to design the matrix that will serve as a basis for the realization of the meta-line structure. We studied the influence of some geometrical parameters to obtain a characteristic impedance close to 50Ω. Thus, three studies were performed.

The first is to study the influence of the elbow angle on the line parameters. We found that in all cases, the impedance remains close to 50Ω but shows a peak at 3GHz. Its origin remains to be determined.

The second part consists in studying the influence of the gap on the parameters of the line. In this part we notice that the impedance decreases with the increase of the gap width. The peak at 3GHz disappears for G1 =200µm. This peak is therefore due to the width of the gap.

In the last part we have retained the 45° bend cell with G=200µm.We have studied the influence of the width of the output arm (Ws). Indeed, we notice that if we increase the width Ws the impedance decreases. For Ws=670µm, the impedance is very close to 50Ω.We have an adapted structure. After validating the selected cell (α=45°, G1=200µm and Ws=670µm), we need to insert the meta-line structures on it for better component performances.

References:-

[1] D. R. Smith, W. J. Padilla, D. C. Vier, S. C. Nemat-Nasser, and S. Schultz "Composite medium with simultaneously negative permeability and permittivity" , Phys. Rev. Lett. 84 (18), 4184-4187 (2000).

[2] A. Sanada, M. Kimura, I. Awai, H. Kubo, C. Caloz and T. Itoh, "*A planar zeroth order resonator antenna using left-handed transmission line*", European Microwave Conference, pp 1341-1344, Amsterdam, Netherlands, 2004.

[3] N. Engheta and R. W. Ziolkowski. A positive future for double- negative metamaterials. *IEEE Trans. Microw. Theory Tech*, 53(4) :1535–1556, 2005.

[4] D. Schurig, J. J. Mock, B. J. Justice, S. A. Cummer, J. B. Pendry, A. F. Starr, and D. R. Smith, "Metamaterial electromagnetic cloak at microwave frequencies," Science 314 (5801), 977-980 (2006).

[5] C. Caloz and T.Itoh, "Electromagnetic metamaterials transmission theory and microwave applications", pp 128,301, Wiley-Interscience, 2006.

[6] J. Perruisseau-Carrier, T. Lisecand A.K. Skrivervik, "Circuit model and design of silicon-integrated CRLH-TLS analogically controlled by MEMS," Microw. Opt. Technol. Lett. 48: 2496-2499. 2006.

[7] A. Vélez, J. Bonache, F. Martín, "Varactor-Loaded Complementary Split Ring Resonators (VLCSRR) and Their Application to Tunable Metamaterial Transmission Lines" Microwave and Wireless Components Letters, IEEE , vol.18, no.1, pp.28-30, Jan. 2008 .

[8] G. Houzet, X. Mélique, D. Lippens, L. Burgnies, G. Velu, and J.-C. Carru, "Microstrip Transmission Line Loaded by Split-Ring Resonators Tuned by Ferroelectric Thin Film",Progress In Electromagnetics Research C, Vol. 12, 225-236, 2010.

[9] A. Zermane, B. Sauviac, B. Bayard, B. Payet-Gervy, J.J Rousseau and A. Benghalia , "Experimental verification of tunable property of a zeroth- order resonator on ferrite substrate ", Microwave Optical and Technology Letters , vol. 56, N° 12, pp. 2805–2809, december 2014 .

[10] B. Mahamout Mahamat and B. Sauviac "Tunability of CRLH metamateriel components using magnetic sol-gel",Proceeding of the IEEE (EuMC), Vol.62, 2015, pp.1108-1111.