IOSR Journal of Engineering (IOSR JEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 26-31

Multilayer fibonacci Structures Containing Single-Negative Metamaterials Conditioned in Photonic Transmission Spectra

Vishal Kumar Singh[1,2*], Vishal Singh Chandel[1,3]
[1]*Department of Physics, Integral University, Lucknow-226026, INDIA.*
[2]*Department of Applied Physics, SITM, Barabanki-225001, INDIA.*
[3]*Department of APSH, Rajkiya Engineering College, Ambedkar Nagar-224122,* INDIA.

Abstract: *In this work we studied transmission properties of the Fibonacci semi periodic layered structure comprising of a couple of two fold/double positive (DPS), epsilon-negative (ENG) and mu-negative (MNG) materials. Frequently electrically thinMNG and ENG meta-materialslayers considered in microwave reduplication location. It is observed that there exist the polarization-subordinate with invariant transmission gap with a difference in layer scale and angle of incident (approximate negligent angle). The successful medium hypothesis has been utilized to clarify the properties of transmission spectra of DPS-MNG, DPS-ENG and ENG-MNG multilayerFibonacci structures.*
Keywords:*Meta material,Photonic crystal, transmittance, band gap and Fibonacci.*

I. Introduction

As of late, the meta-materials that display negative permittivity and permeability μ in a frequency band have pulled in concentrated examinations at the same time because of their one of a kind electro-magnetic (EM) property.

They are likewise called the twofold negative (DNG) materials or left-gave materials in light of the fact that the attractive field (electric field) and the wave vector of an EM wave spreading in such a medium shape a left-gave triplet. Other meta-material in which just a single of the material parameters has been a negative merit unique consideration is called the single-negative (SNG) material. The SNG materials comprise of the mu-negative (MNG) materials with negative permeability ($\mu<0$) yet positive permittivity ($\varepsilon > 0$), and the epsilon-negative (ENG) materials with negative permeability ($\varepsilon < 0$) however positive permittivity ($\mu > 0$).

The vast majority of past deals with the meta-materials concentrated on the specific abnormal properties of wave engendering in a Photonic precious stone. It was demonstrated that a one-dimensional Photonic precious stone (1DPC) made out of exchanging chunks of customary twofold positive (DPS) and DNG media can have a sort of Photonic band hole (PBG) comparing to zero found the middle value of the refractive index file (n). In addition, it is outstanding that a 1-DPC constituted by an intermittent reiteration of MNG and ENG structured layers can have another kind of Photonic hole with viable stage (ϕ_{eff}) of zero. At the point when the periodicity of the Photonic precious stone structure is broken, wave propagation is not described by Bloch states. The contrary outrageous of an occasional design is a completely irregular structure. In the irregular design waves experience a numerous diffusing procedure and are liable to sudden impedance impacts. Different waves are diffusing in disarranged materials demonstrates numerous similitude with the spread of electrons in semiconductors. One of the primary marvels contemplated in this setting was coherent backscattering or powerless confinement of the wave. Learning about the spread of waves in totally requested and disarranged structures is currently quickly enhancing; little is thought about the conduct of waves in the tremendous middle of the road administration between adding up to request and turmoil. This moderate administration is legitimate in semi occasional structures.

Semi intermittent structures are non-occasional structures that are built by a basic deterministic age run the show. In a semi occasional design at least two in comparable periods are superimposed, with the goal that it is neither an intermittent nor an arbitrary design and along these lines can be considered as middle of the road the two. At the end of the day, because of a long-run arrange a semi intermittent design can shape illegal frequency districts called pseudo band holes like the band-holes of a Photonic precious stone and at the same time have confined states as in confused media. Among the different semi intermittent structures, the Fibonacci twofold semi occasional structure has been the subject of broad endeavors over the most recent two decades. The multilayer Fibonacci structure is the notable 1D semi occasional structure; its electronic properties have all around been examined since the revelation of the semi crystalline stage in 1984. Wave through a structure in the Fibonacci grouping had additionally been examined in the past decade, and as of late, the full states on the band edge of a Photonic structure in the Fibonacci succession are contemplated tentatively. Investigations of different parts of wave spread in the Fibonacci semi occasional structures completed. We have significantly enhanced our comprehension of wave transport in the Fibonacci semi intermittent structures.

In this paper, we work on the analysis of Photonic transmission spectra in the Fibonacci semi intermittent layered structures comprising of single negative meta-materials. We think about three sorts of the Fibonacci semi intermittent layered structures of DPS-MNG, DPS-ENG and ENG-MNG, with dispersion & lossless multilayer stacks. In these structures, with the assistance of exchange network strategy and viable medium hypothesis, we demonstrate TE and TM wave transmission spectra for both typical and slanted rates and for various layer scaling. It is demonstrated that the polarizationfor both TE and TM with ordinary and slanted frequencies, there exist the transmission holes which are invariant with a difference in scale and insensitive to the incident angle.

II. Model And Numerical Strategies

Semi occasional Photonic structures are characterized by basic scientific guidelines which produce non-intermittent structures. The Fibonacci grouping is the central case of long-extend arrange without periodicity, and can be built from simply connecting two building obstructs A and B, as indicated by the accompanying deterministic generation rule: $S_{N+1} = [S_{N-1}S_N]$ for $N \geq 1$, as $S_0 = [B]$; $S_1 = [A]$, and the manages is more than once connected to get: $S_2 = [BA]$; $S_3 = [ABA]$; $S_4 = [BAABA]$; and so forth. The quantity of layers is given by F_N, where F_N is the Fibonacci number got from recursive connection $F_N = F_{N-1}+F_{N-2}$, with $F_0=F_1=1$. Geometrical plan of 1Dmultilayer Fibonacci structure, implanted in the air, appears in Fig.1. In this multilayer structure, d_A and $d_B$the thicknesses of two building obstructs A and B individually.

We expect to explore the transmission properties of 1D multilayer Fibonacci structure constituted by the multilayer of DPS, MNG and ENG materials. For the most part, ε and μ are frequency subordinate, i.e., the meta-materials are dispersive. These meta-materials have distinctive articulations of ε and μ in like manner. For MNG material, we assume that ε and μ can be communicated as.

$$\varepsilon=1, \quad \text{and} \quad \mu(\omega)= 1 + \frac{3^2}{0.902^2-\omega^2} \quad (1)$$

Where ω is frequency in GHz.

Similarly, we can consider ε and μ for ENG material as,

$$\varepsilon= 1 + \frac{5^2}{0.9^2-\omega^2} + \frac{10^2}{11.5^2-\omega^2}, \quad \text{and} \quad \mu(\omega)= 1 \qquad (2)$$

For DPS material, ε and μ both behave like being constants. In Fig. 2 demonstrates the optical constants parameter permittivity and permeability of MNG and ENG materials. As should be obvious from Fig. 2, in the frequencies run 0.9– 3.2 GHz, μ is negative and in the frequencies extend 0.9– 3.9 GHz, ε is negative. Additionally, for the frequencies more prominent than 3.9 GHz, both ε and μ are sure.

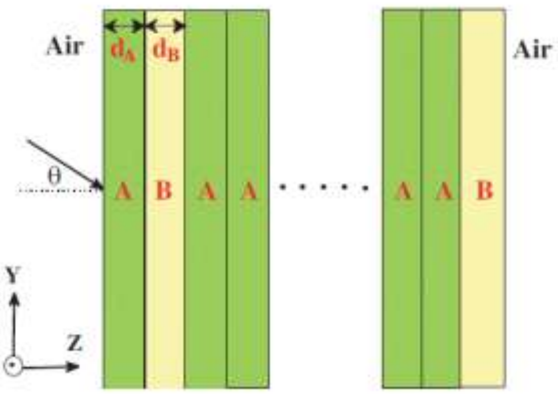


Figure1.A Schematic drawing of the one-dimensional quasi-periodic Fibonacci structure embedded in air with thicknesses d_A and d_B of A and B respectively.

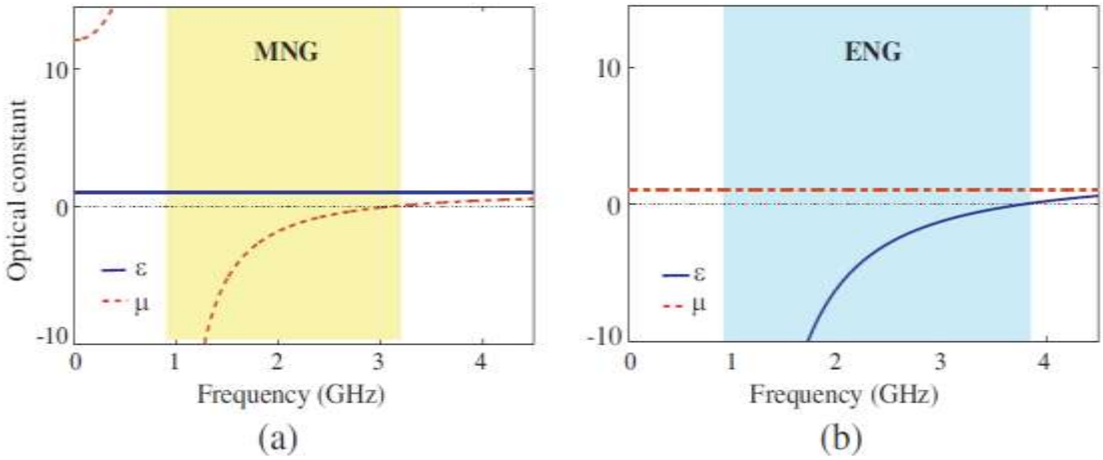


Figure 2. The permittivity ε (strong line) and the penetrability μ (dashed line) of (a) MNG and (b) ENG materials as a function of frequency.

In this research, considered microwave frequency locale in MNG and ENG meta-materials layers structure, these structure are frequently electrically thin, i.e.,

$$|k_A|\, d_A = \left| d_A \sqrt{\frac{\omega^2}{C^2}\left(\epsilon_A \mu_A - \sin^2\theta\right)} \right| \ll 1$$

(3)

$$|k_B|\, d_B = \left| d_B \sqrt{\frac{\omega^2}{C^2}\left(\epsilon_B \mu_B - \sin^2\theta\right)} \right| \ll 1$$

Where c is the speed of e.m.wave in the vacuum,ϵ_A&$\epsilon_B$are respectively permittivity andμ_A& $\mu_B$arepermeability of two building obstructs A and B. As a result, in the large-wavelength constrain, we workable on enfold Fibonaccimultilayered medium estimate by presenting powerful permittivity ϵ_{eff} and permeability μ_{eff}.ϵ_{eff}& μ_{eff} of this non-periodic structure are followed by-

$$\mu_{eff} = \frac{N_A d_A}{d}\mu_A + \frac{N_B d_B}{d}\mu_B \,,$$

(4)

$$\epsilon_{eff} = \frac{N_A d_A}{d}\epsilon_A + \frac{N_B d_B}{d}\epsilon_B - \sin^2\theta\left(\frac{N_A d_A}{d}\frac{1}{\mu_A} + \frac{N_B d_B}{d}\frac{1}{\mu_B}\right) + \sin^2\theta\left(\frac{1}{\frac{N_A d_A}{d}\mu_A + \frac{N_B d_B}{d}\mu_B}\right)$$

for TE polarization and

$$\epsilon_{eff} = \frac{N_A d_A}{d}\epsilon_A + \frac{N_B d_B}{d}\epsilon_B \,,$$

(5)

$$\mu_{eff} = \frac{N_A d_A}{d}\mu_A + \frac{N_B d_B}{d}\mu_B - \sin^2\theta\left(\frac{N_A d_A}{d}\frac{1}{\epsilon_A} + \frac{N_B d_B}{d}\frac{1}{\epsilon_B}\right) + \sin^2\theta\left(\frac{1}{\frac{N_A d_A}{d}\epsilon_A + \frac{N_B d_B}{d}\epsilon_B}\right)$$

for TM polarization.

In Equations (4) and (5),
$d = N_A d_A + N_B d_B$

Where N_A and N_B are the quantity of type-A and type-B slabs, individually.
Equations. (4) and (5) demonstrate that multilayer structure is anisotropic basically in light of the fact that ϵ_{eff} and μ_{eff}depend upon the incident edge θ.

In this paper, we consider a specific 1D structure the Fibonacci multilayer.Determine the spectra of transmittance of this issue structure. The spectra of transmittance of a layered design can be determined by utilizing an exchange lattice strategy. Due to this reason, we accept that episode from air medium with incident angle θ with the multilayerFibonacci structure, appeared in Fig.1. For the TE wave, the direction of electric field E is expected along the x direction (dielectric layers projected in the x-y plane), and the z heading is typical to the interface of each layer. At the point, when such an e.m. wave transmits in the multilayer structure, the episode,transmitted and reflected electric fields are associated by means of an exchange design M as-

$M = \begin{pmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{pmatrix}$ (6)

Where m_{ij} (i, j = 1, 2) is the component of the exchange latticeFor the Fibonacci multilayered structure. With certain age number (N), M can be computedFor the Fibonacci multilayered structure by a consecutive result of the exchange design for each progressive interface:

$M_N = T_{air\,A}\, T_A\, T_{AB}\, T_B\, T_{BA} T_A\, T_A\, T_{AB}\, T_B\, T_B\, T_{Bair},$ (7)

Where T_A and T_B speak to the spread of light inside layers A and B, separately. T_{airA} and T_{Bair} speak to the engendering of light through air → A and B → air interface, individually. Additionally T_{AB} and T_{BA} speak to the spread of light through the interface A → B and B → A, separately. Equation (8) can be arrange any request form the Fibonacci arrangement S_N (N>> 3) as

$M_N = T_{airA} T_N\, T_{Bair},$ for N_{even}, (8)

$M_N = T_{airA} T_N T_{Aair},$ for N_{odd}, (9)

with,

$T_N = T_{N-1} T_N - 2,$ for N_{even}, (10)

$T_N = T_{N-1} T_{BA} T_{N-2},$ for N_{odd}, (11)

The primary structures are

$T_1 = T_A,$

$T_2 = T_A T_{AB} T_B.$ (12)

The coefficient of transmittance is given by-

$$t = \left|\frac{1}{m_{11}}\right|^2 \quad (13)$$

The behaviour of TM waves is similar to that for a TE waves.

III. Results And Discussion

Now, we explore three distinct blends, DPS-MNG, DPS-ENG and MNG-ENG of dispersive and lossless materials as the multilayerFibonacci structures. We discover some band holes whose properties are examined in this area in detail. We consider DPS-MNG multilayerFibonacci structure, i.e., each of the A-type and B-type layers are DPS and MNG materials, individually. In the accompanying computation, we pick $\epsilon_A = \mu_A = 1$,d_A= 8 mm, d_B = 4 mm and the Fibonacci age number N = 14. The frequency of the permittivity ε_{eff} (strong line) and the permeability μ_{eff} (dashed line) of considered DPS-MNG structure are plotted in the Fig.3 for both TE waves comparing to the incident angle 0°, 20° (Figs.3(a) and (b)) and TM waves with the incident angle 0°, 45° (Fig.3(c)). The impact of the incident angle on the successful parameters ϵ_{eff} and μ_{eff} in the figure (3).

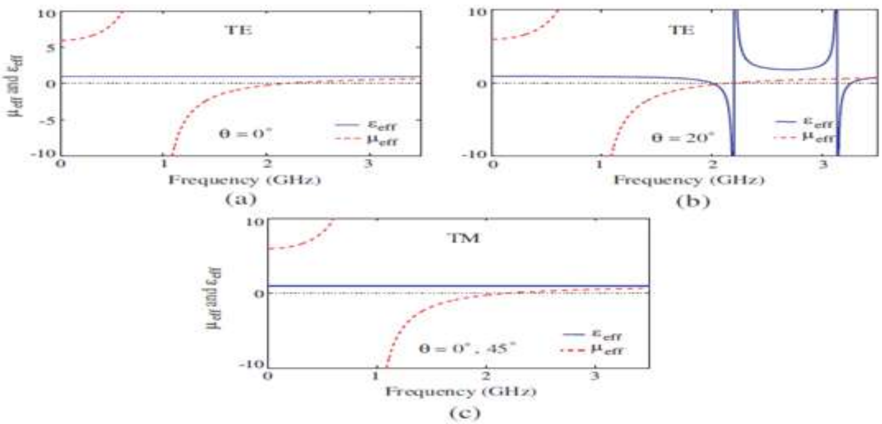
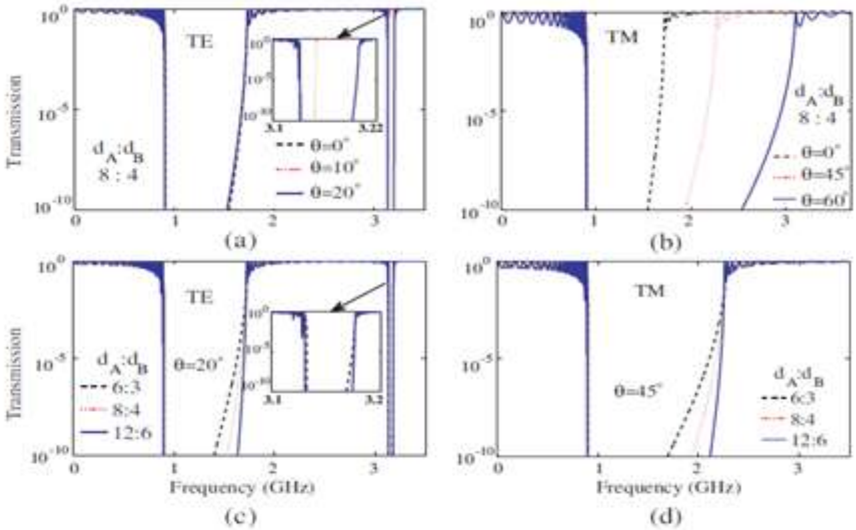


Figure3.For TE and TM wavesthe successful permeability μ_{eff} (dashed line) and the viable permittivity ϵ_{eff} (strong line)of DPS-MNG Fibonacci structure, comparing with angle of incident 0°, 20° and 45° as demonstrated in plots.



Figure(4). For fourteenth Fibonacci level spectra of transmittance of DPS-MNG Fibonacci structure as a component of frequency of TE and TM waves with various incident angle; (a) θ = 0˚, 10˚ and 20˚, (b) θ = 0˚, 45˚ and 60˚ and with various thickness sizes of 6: 3, 8: 4 and 12: 6 mm at (c) θ = 20˚, (d) θ = 45˚.

Powerful medium hypothesis is presented by articulation $\sin^2\theta$ in Eqs.(4) and (5) for TE and TM modes, separately. In our counts for DPS-MNG Fibonacci structure when $\epsilon_A = \epsilon_B = 1$ the terms incorporating $\sin^2\theta$ in Eq. (5) will drop for TM modes, so ε_{eff} and μ_{eff} of DPS-MNG structure are free of the incident angle for TM polarization (see Fig. 3(c)), while they are the incident angle just for TE polarization (see Figures.3 (a) and (b)).

The transmission spectra of TE and TM polarizations in DPS-MNG are spoken to for various incident angle of θ = 0˚, 20˚ and 45˚ and for various thickness scales as d_A: d_B = 6 : 3, 8 : 4 and 12 : 6 mm in Fig.4. It is obvious from Fig. 4(a) that there are two band gapes in the transmission spectra of TE waves. The main gap exists in the frequencies where the viable permeability μ_{eff} of structure is negative, while, the second gap is happened in the frequencies where the effective permeability μ_{eff} of the structure is sure (see Fig. 3(a)).

We can see from Fig.4(a) that for TE polarization, the spectral widthof the first gap in this structure is invariant with an adjustment in the incident angle, while, the ghastly width of the second gap increments with the episode point keeping left edge steady. Sinceϵ_{eff} and μ_{eff} are autonomous of the episode edge (see Fig. 3(c)), so the reliance of the transmission hole on the incident angle is sensible as demonstrated in Fig. 4(b). Conversely with the TM modes,for TE modes the reliance of wave vector on the occurrence edge is presented by means of ϵ_{eff} (θ) and $\sin^2\theta$, so the last outcome for k is autonomous (subordinate) of episode point in first (second) gap, thus transmission gap for TE mode will be free (subordinate) of incident angle in the primary (second) gap as appeared in Fig. 4(a).

IV. Conclusion

Taking everything into account, in view of the exchange network strategy and successful medium hypothesis, we have hypothetically examined the transmission spectra of three semi occasional Fibonacci layered structures comprising of dispersive and lossless MNG and ENG materials. In DPS-MNG, DPS-ENG, and ENG-MNG Fibonacci layered structures for both TE and TM waves, it is demonstrated that there exist the transmission gapes which are invariant with a difference in layer scale and uncaring to the incident angle. In addition, for both TE and TM waves we have demonstrated that, there is a gap which is just found at the slanted frequency, i.e., it vanishes at the ordinary rate.

References

[1]. Fredkin, D. R. and A. Ron, “Effectively left-handed(negative index) composite material,” Appl. Phys. Lett., Vol. 81, 1753, 2002.

[2]. Li, J., L. Zhou, C. T. Chan, and P. Sheng, “Photonic band gap from a stack of positive and negative index materials,” Phys. Rev. Lett., Vol. 90, 083901, 2003.

[3]. Srivastava, S. K. and S. P. Ojha, “Enhancement of omnidirectional reflaction bands in one-dimentionalphotonic crystals with left-handed materials,” Progress In Electromagnetics Research, PIER 68, 91–111, 2007.

[4]. Srivastava, R., S. Pati, and S. P. Ojha, “Enhacement of omnidirectional reflection in photonic crystal hetro structures,” Progress In Electromagnetics Research B, Vol. 1, 197–208, 2008.

[5]. Srivastava, S. K. and S. P. Ojha, "Omnidirectional reflection bands in one-dimensional photonic crystal structure using fullerene films," Progress In Electromagnetics Research, PIER 74,181–194, 2007.

[6]. Wang, L. G., H. Chen, and S. Y. Zhu, "Omnidirectional gap and defect mode of one-dimensional photonic crystals with single-negative materials," Phys. Rev. B, Vol. 70, 245102,2004

[7]. Hadi Rahimi, " Transmittance gap in one- dimensional Fibonacci quasiperiodic structure containing epsilon-negative materials",Pramana,2010