ПЛЕНАРНОЕ ЗАСЕДАНИЕ

UDC 539.51; 621.396.2

EXPLORING THE PROPERTIES AND APPLICATIONS OF METAMATERIAL STRUCTURES

Dipak Patil[1], Suyog Pande[2], Akhilesh Kuma[1]

[1]Sandip Institute of Engineering and Management
Nashik, Maharashtra, India
[2]SVKM's NMIMS MPSTME Shripur Campur
Mumbai, Maharashtra, India

Abstract. A structure inspired by double-negative metamaterials is reviewed in this study. By employing the Nicolson-Ross-Weir (NRW) method, we determine the permittivity and permeability of the review metamaterial unit cell. In the literature survey we had analyzed and characterized metamaterial and revealing a negative real permittivity (ε*r*). The findings suggest that the existing structure demonstrates double-negative properties for different resonating frequencies.

Key words: NRW method, metamaterial, permittivity, permeability.

ИЗУЧЕНИЕ СВОЙСТВ И ПРИМЕНЕНИЕ МЕТАМАТЕРИАЛЬНЫХ КОНСТРУКЦИЙ

Дипак Патил[1], Суйог Панде[2], Ахилеш Кума[1]

[1]Институт инженерии и менеджмента Сандип
Нашик, Махараштра, Индия
[2]Школа управления технологиями и инженерии им. Мукеша Пателя (Институт управленческих исследований Нарси Монджи) при образовательной организации Шри Виле Парле Келафани
Мумбаи, Махараштра, Индия

Аннотация. В этом исследовании рассматривается структура, основанная на двойных отрицательных метаматериалах. Используя метод Николсона-Росса-Вейра (NRW), определена диэлектрическая проницаемость и проницаемость элементарной ячейки рассматриваемого метаматериала. Теоретически проанализирован метаматериал и выявлена отрицательная активная диэлектрическая проницаемость (εr). Полученные результаты позволяют предположить, что существующая структура демонстрирует двойные отрицательные свойства для разных резонансных частот.

Ключевые слова: метод NRW, метаматериал, диэлектрическая проницаемость, проницаемость.

Address for correspondence: Sandip Institute of Engineering and Management (*SIEM*)*, Nashik, Maharashtra, India, e-mail: dipak.patil@siem.org.in*

Introduction. Today's advanced communication systems offer a variety of features such as multiband performance, higher data rate transmission, various diversities but also need to be compact and simple in use [1]. By performing multiple functions within a single system, the system's complexity can be reduced. A promising solution to improve system performance is the use of reconfigurable antennas, which can provide diversity at various levels [2]. Reconfigurable MTM offers the necessary features for smart antennas. We have been motivated to conduct comprehensive research in the field of reconfigurable MTM antennas due to various challenges reported in the literature such as complex structures [3–5], limited tunability [3], lower gain [5], lower bandwidth, large size [6] and use of complex biasing circuity.

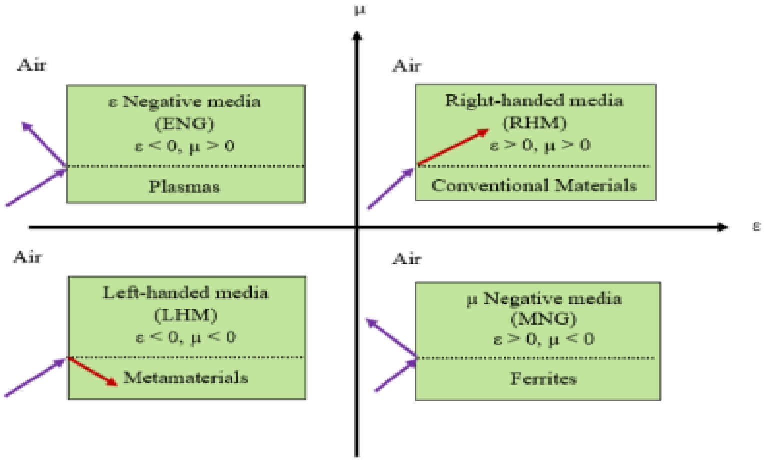

Figure 1 – Classification of Materials

A material's response to electromagnetic radiation is characterized by its electric permittivity (Ɛ) and magnetic permeability (μ). Recent studies [7] suggest that by tuning these properties to negative values, a negative refractive index can be achieved. Materials exhibiting both negative permittivity (Ɛ < 0) and permeability (μ < 0) are classified as double-negative [8]. To form a double negative metamaterial, both permittivity (Ɛ) and permeability (μ) need to be negative, achieved by merging specific materials with these properties.

We studyed existing metamaterial-inspired structure [10] with double-negative characteristics for use in wireless applications. The permeability and permittivity of the structure were calculated through the NRW method. Figure 2 illustrateds the classfications of material and also properties of metamaterilas structures.

Study and analysis of Metamaterials structures:

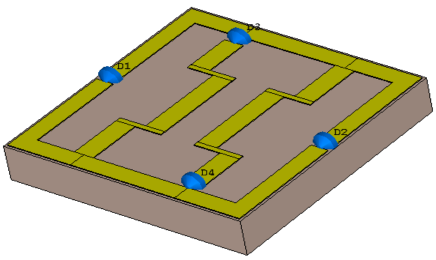

Fig 2 – Prospective View [10]

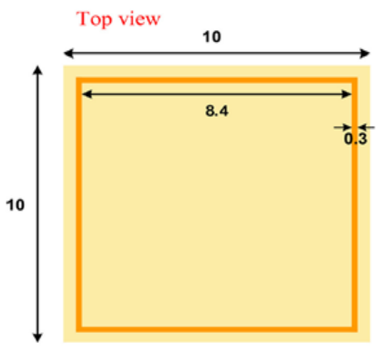

Fig 3 – Top View [10]

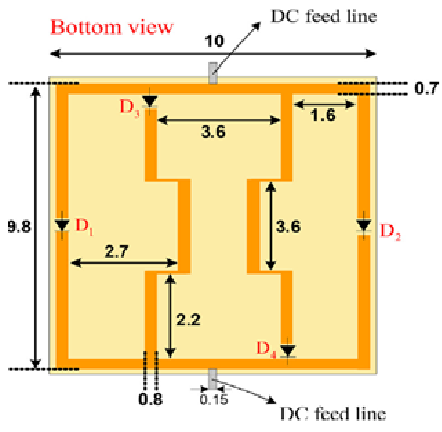

Fig 4 – Bottom View [10]

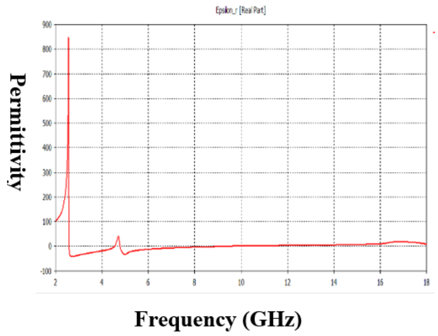

Fig 5 – Epsilon Curve

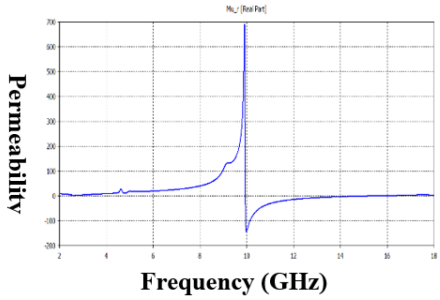

Figure 6 – Mu Curve

Figure 2 illustrated the the 3D Perspective view of the metamaterial base antenna [10]. While the Figs. 3 and 4 shows the top and bottom views of the antenna design by aouthers in [10] suggested antenna. Furthermore, the Figure 5 illustrated the frequency vs. permitivitty curves. As we can observed from Figure 4 the permitivettvity curves achived the negative values, which justify the characteristics of metametarials properties. However, Figure 6 shows the permeability vs frequency plot. Which is also provides the justification of metamaterials properties.

Conclusion. This literature survey proposes a metamaterial-inspired structure with double-negative properties for potential wireless applications. The permeability and permittivity were measured using the NRW method. Simulation results, carried out across a frequency range of 2 to 10 GHz and analyzed in HFSS, reveal negative real values for permittivity and permibility.

References

1. Compact ness and performance enhancement techniques of ultra-wideband tapered slot antenna: A comprehensive review / S. Saleh [et al.] // Alexandria Engineering Journal. – 2023. – V. 74, № 1. – P. 195–229.

2. Reconfigurable Antennas: Switching Techniques – A Survey / O. P. Naser [et al.] // Electronics. – V. 9, № 2. – P. 1–14.

3. Minakshmi Shaw. Analysis of frequency reconfigurable microstrip patch antenna with unidirectional radiation pattern for IRNSS band / Minakshmi Shaw, Yogesh Kumar Choukiker // AEU – International Journal of Electronics and Communications. – 2021. – V. 141, Article ID 153962. – P. 1–11.

4. Nguyen-Trong, N. A Frequency-Reconfigurable Dual-Band Low Profile Monopolar Antenna / N. Nguyen-Trong, A. Piotrowski, and C. Fumeaux // IEEE Transactions on Antennas Propagation. – V. 65, №. 7. – P. 3336–3343.

5. Singh, D. Miniaturization and Gain Enhancement of Microstrip Patch Antenna Using Defected Ground with EBG / D. Singh, A. Thakur, and V. M. Srivastava // Journal of Communications. – 2018. – V. 13, – № 12. – P. 730–736,

6. Sharjeel Riaz. A Miniaturized Frequency Reconfigurable Patch Antenna for IoT Applications / Sharjeel Riaz, Khan M., Javed U., Zhao X. // Wireless Personal Communications. – 2022. – V. 123. – P. 1871–1881.

7. Filtenna with Frequency Reconfigurable Operation for Cognitive Radio and Wireless Applications / M. A. Abdelghany [et al.] // Micromachines (Basel). – 2023. – V. 14, № 1. – P. 1–13.

8. V. V. Fisanov // Russ. Phys. J. – 2018. – V. 61, № 6. – P. 1129. – DOI: 10.1007/s11182-018-1506-3.

9. C. Milias, R. B. Andersen, P. I. Lazaridis, Z. D. Zaharis, B. Muhammad, J. T. B. Kristensen, A. Mihovska, and D. D. Hermansen // IEEE Access, X, 1. – 2021. 9. – DOI: 10.1109/ACCESS.2021.3091479.

10. Maryam Majidzadeh. Novel single layer reconfigurable frequency selective surface with UWB and multi-band modes of operation / Maryam Majidzadeh, Changiz Ghobadi, Javad Nourinia / International Journal of Electronics and Communications (AEU). – 2016 – V. 70, № 2. – P. 151–161.

UDC 378

RESEARCH AND EDUCATION OPPORTUNITIES IN PARTNERSHIP BETWEEN HARARE INSTITUTE OF TECHNOLOGY AND BNTU

Musiiwa P.[1], Tyavlovsky A.[2], Zizhou C.[1]

[1]Harare Institute of Technology, Harare, Republic of Zimbabwe
[2]Belarusian National Technical University, Minsk, Republic of Belarus

Abstract. The current state of education and research and development (R&D) work in Harare Institute of Technology (HIT) is briefly reviewed, as well as opportunities in partnership between HIT and Belarussian National Technical University (BNTU). The proposed roadmap of cooperation between HIT and BNTU includes correspondence training of HIT teachers in the postgraduate program of the Belarusian National Technical University in English, organization of short advanced training courses in English for HIT teachers at BNTU, lecturing by BNTU teachers at HIT during short visits, implementation of joint R&D between the Innovation Hub of the Harare Institute of Technology and the BNTU Science and Technology Park "Polytechnic" and others.

Key words: education; research and development; scientific cooperation; postgraduate studies; educational programs.

ПЕРСПЕКТИВНЫЕ НАПРАВЛЕНИЯ СОТРУДНИЧЕСТВА ТЕХНОЛОГИЧЕСКОГО ИНСТИТУТА ХАРАРЕ И БНТУ В ОБЛАСТИ НАУКИ И ОБРАЗОВАНИЯ

Мусиива П. Б.[1], Тявловский А. К.[2], Зижу Ч.[1]

[1]Технологический институт Хараре, Хараре, Республика Зимбабве
[2]Белорусский национальный технический университет, Минск, Республика Беларусь

Аннотация. Кратко рассматривается текущее состояние образовательной и научно-исследовательской (НИОКР) работы в Технологическом институте Хараре (HIT), а также возможности партнерства HIT и Белорусского национального технического университета (БНТУ). Предлагаемst направления сотрудничества HIT и БНТУ включают заочную подготовку преподавателей HIT в аспирантуре Белорусского национального технического университета на английском языке, организацию краткосрочных курсов повышения квалификации на английском языке для преподавателей HIT в БНТУ, чтение лекций преподавателями БНТУ в HIT во время краткосрочных визитов, реализацию совместных НИОКР между Инновационным хабом HIT и Научно-технологическим парком БНТУ «Политехник» и др.

Ключевые слова: образование, научные и опытно-конструкторские работы, научное сотрудничество, аспирантура, образовательные программы.

Адрес для переписки: Тявловский А. К., пр. Независимости, 65, г. Минск 220113, Республика Беларусь
e-mail: tyavlovsky@bntu.by

In April 2024, a representative of BNTU Andrey K. Tyavlovsky completed an internship at the Harare Institute of Technology (HIT), Republic of Zimbabwe. During the internship, a wide range of issues on possible cooperation between HIT and BNTU were discussed.

The main profiles of students training at HIT, provided by the relevant departments, are: biomedical technologies; chemical production technology (including food production technology); electronics, including programmable digital devices based on microcontrollers, industrial automation systems, power electronic devices; information technology; mechanics; metalworking technologies. Training is carried out at the first (bachelor's) and second (master's) levels of higher education on a fee-paying basis. The term of study in the bachelor's degree is 4 years, in the master's degree is 2 years. The schedule of the educational process in Zimbabwe is somewhat different from the schedule of the educational process in the Republic of Belarus: e.g., the academic year in Zimbabwe begins on August 5.

The Harare Institute of Technology has a sufficiently high scientific and technical level to develop cooperation with technical universities in Belarus, particulary with BNTU. It is also noticed that HIT has an urgent need to train highly qualified scientific personnel due to the lack of a system for training and certification of scientific personnel in Zimbabwe,