IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 6, June 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.18

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

Design of Miniaturized Mutliwideband Patch Antenna for Multiple Terahertz Applications

Boddukuri Jahnavi, Darisi Anantha Lahari, Eshwaree Durga Lanka, Chava Rajya Lakshmi, Sri. B. V. Sathish Kumar

U.G Students, Department of Electronics and Communication Engineering, Vasireddy Venkatadri Institute of Technology. (VVIT), Nambur, Guntur, Andhra Pradesh, India

Assistant Professor, Department of ECE, Vasireddy Venkatadri Institute of Technology. (VVIT), Nambur, Guntur, Andhra Pradesh, India

ABSTRACT: The High -speed wireless communication requirements are increasing day-by-day, so researchers from both the academic community and industry have started research into higher frequency bands and attempted to deliver wireless communication within the unassigned terahertz frequency range. After knowing this wide range of applications, there is a need to develop a new highly efficient multiband and wire band antenna that can support these terahertz frequencies efficiently. In this project, a highly efficient multiband optimized slotted pentagonal terahertz patch antenna and its 2*2 multi-input and multioutput (MIMO) planar array is proposed for multiple terahertz (THz). Applications like high-speed indoor communications, explosive detections, arms detection etc.... Here the proposed patch antenna is developed from the simple rectangular patch antenna (SRPA) by optimizing the shape of radiating patch and ground plane. The particle swarm optimization (PSO) technique is used to enhance performance parameters of antenna like reflection coefficient, gain, directivity, radiation pattern etc. Also, a 2*2 MIMO antenna array is designed using an optimized antenna element for more effective terahertz communication. The proposed antenna expected to achieve a maximum gain and radiation efficiency within the resonating band.

KEYWORDS: MIMO, Terahertz, Pentagonal, Band width.

I. INTRODUCTION

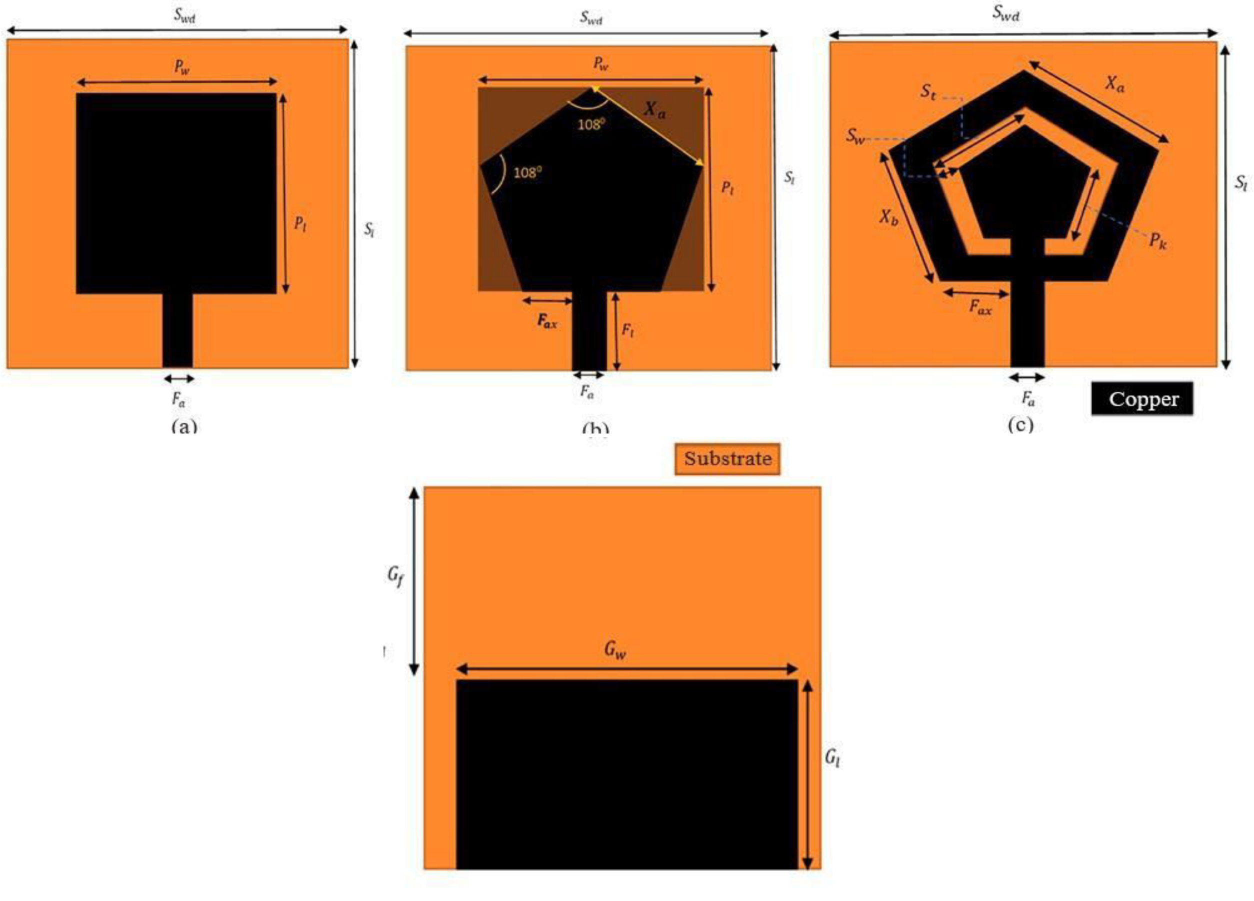
Terahertz (THz) identifies the segment of the electromagnetic spectrum between the microwave region and the infrared field. It ranges within the 0.1–30 THz frequency band. The huge bandwidth delivered by the THz band opened the door to several applications that require high data speeds. The high-speed wireless communication requirements are increasing day by day, so researchers from both the academic community and industry have started research into higher frequency bands and attempted to deliver wireless communication within the unassigned terahertz frequency range. Besides providing high-speed and broadband communications, THz radiation is helpful in a wide variety of fields including explosive detections, weapons detection, medical imaging, pharmaceutical research, and industrial inspections. Devices based on THz technologies can see through hurdles such as plastic, clothes, and creased cardboard. These radiations help to detect dangerous materials, conceal arms, and synthetic drugs. THz radiations are effectively reflected by non-metals and non-polar devices upon exposure, and this property of THz radiations makes it ideal for many security and informatics applications. So, after knowing this wide range of applications in the THz spectrum, there is a need to develop a new highly efficient multiband and wideband antenna that can support these high THz frequencies efficiently. But there is always some obstacle for wireless communication in the high THz regime like high attenuation, Multipath fading, absorptions, and path loss are the factors limiting the boundless use of THz technology. These obstacles diminish the quality of the signal and cause serious errors in any communication channel. Due to its unique features, including compact size, minimal volume, and ease of production, printed antennas are widely used in wireless connectivity components. Given these highlights, scientists concentrated on printed planar antennas which can be utilized for wireless communication purposes in the

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

THz zone. Printed planar antennas did a tremendous job in advancing antenna innovations in wireless communications networks [8,9]. Many terahertz single-band antennas and arrays have already been developed to combat the attenuation effects with good signal efficiency and wide spatial.



(d)

Fig.. Evolution of proposed optimized slotted pentagonal patch antenna (a) SRPA antenna (b) Pentagonal patch antenna (Antenna design A) (c) Slotted pentagonal patch antenna (Antenna design B) (d) DGS of proposed Antenna.

Table 1
Various dimension of proposed antenna.

P_l	65.11 μm	S_w	5 μm	S_l	90 μm	G_l	90 μm
P_w	68.47 μm	S_t	29.39 μm	F_l	26.45 μm	G_f	51.54 μm
F_a	7.64 μm	P_k	23.51 μm	F_{ax}	26.72 μm	X_b	42.32 μm
S_{wd}	90 μm	G_w	90 μm	X_a	42.32 μm		

II. EVOLUTION AND OPTIMIZATION PROPOSED MULTI-WIDE BAND PATCH ANTENNA

The multiband optimized slotted pentagonal patch antenna is developed in this section from a simple rectangular patch antenna (SRPA) for multi-wideband THz operation. The proposed antenna is modeled with the polyimide transparent substrate material having a dielectric constant of 3.5 and a thickness of 21.5 μm. The copper patch is used as a conducting material with conductivity $5.8 \times 10^7 s/m$.

The square shape substrate material having a size (90 × 90) μm and copper patch with a thickness of 0.5 μm

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

is used. If one talks about the mathematical modeling of the proposed antenna. First, the SRPA is developed at terahertz frequency in which a simple rectangular patch is used . The dimensions of a rectangular patch are computed by using the equations below for 3 THz. The length of the con- ducting patch $P_l$can be calculated by using and width of patch $P_w$can be calculated by using for terahertz frequency and further the length of patch is modified to achieve the target resonance.

$$P_l = \frac{(2N+1)}{\sqrt{\varepsilon_{eff}}} \times \frac{\lambda}{2} - \Delta L$$

$$P_w = \frac{(2N+1)}{\sqrt{\frac{\varepsilon_r+1}{2}}} \times \frac{\lambda}{2}$$

where N is an integer. The wavelength, effective dielectric constant, and dielectric constant are represented by λ, εeff, and εr respectively. To provide proper impedance matching between the load and source a 50- ohm transmission line is used. The most common and easy to fabricate, the strip line feed is used. In this kind of feeding technique, a conducting strip is linked directly to the edge of the patch.

Further, to improve the performance of antenna, in second step the developed SRPA is transformed into the regular pentagonal patch antenna A as shown in Fig. 1(b). The dimension of pentagonal patch antenna A is inspired by the SRPA as represented by Eqs. (3) and (4) [31]. Where Xa and Xb are the side length of pentagonal patch antenna A, which will have the same values for a regular pentagonal patch. To check the validity between mathematical approach and CST software for developing a THz antenna, the various dimension of SRPA is computed for 3 THz and simulated by using CST software.

MIMO

In comparison to single port antennas, MIMO antennas manage multi-path propagation with a higher data rate, greater performance and more reliability. MIMO system has multiple antennas for transmitting and receiving sides to increase the efficiency of radio link. It overcomes the consequences of multipath fading in various communications.The two similar antenna elements are placed on a single substrate and having the same geometry.

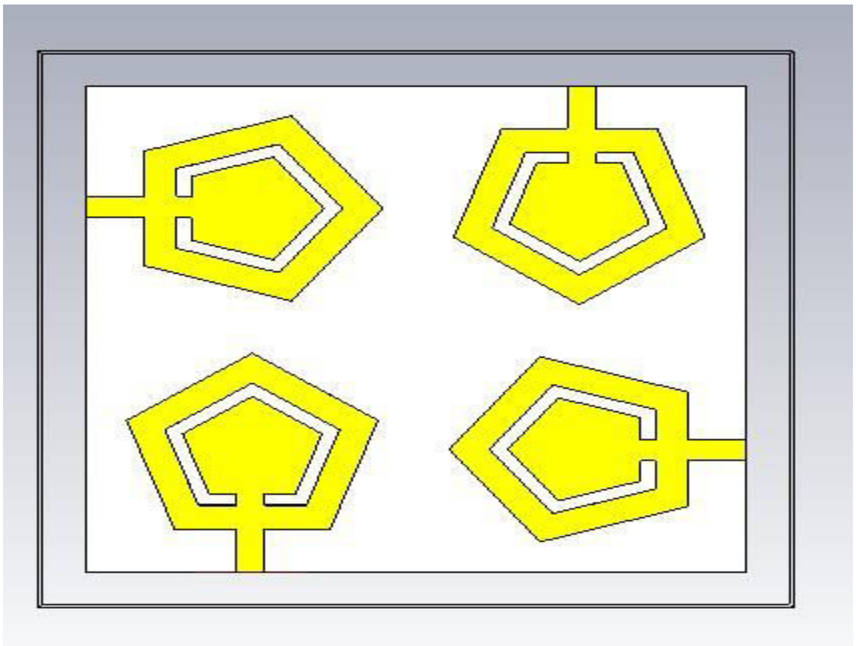


Fig: Design of proposed MIMO antenna

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

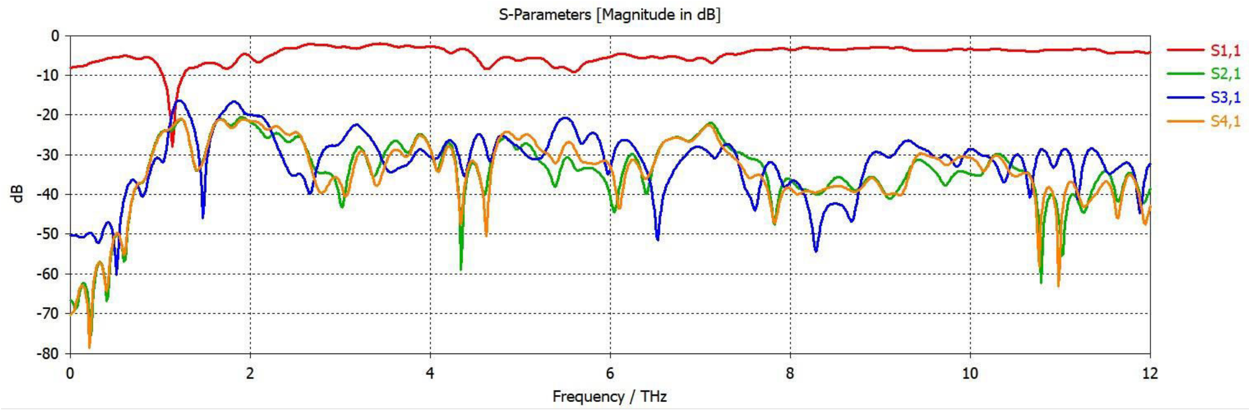


Fig. S-parameters results

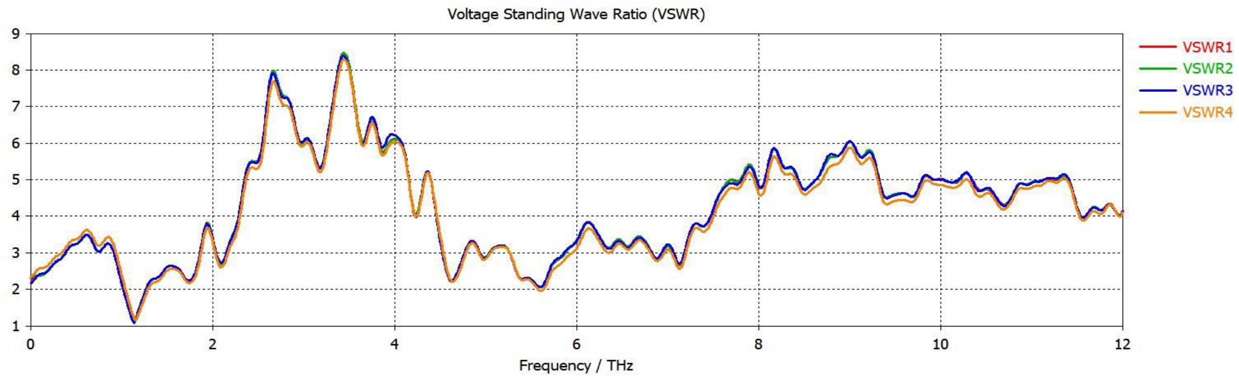


Fig. VSWR results

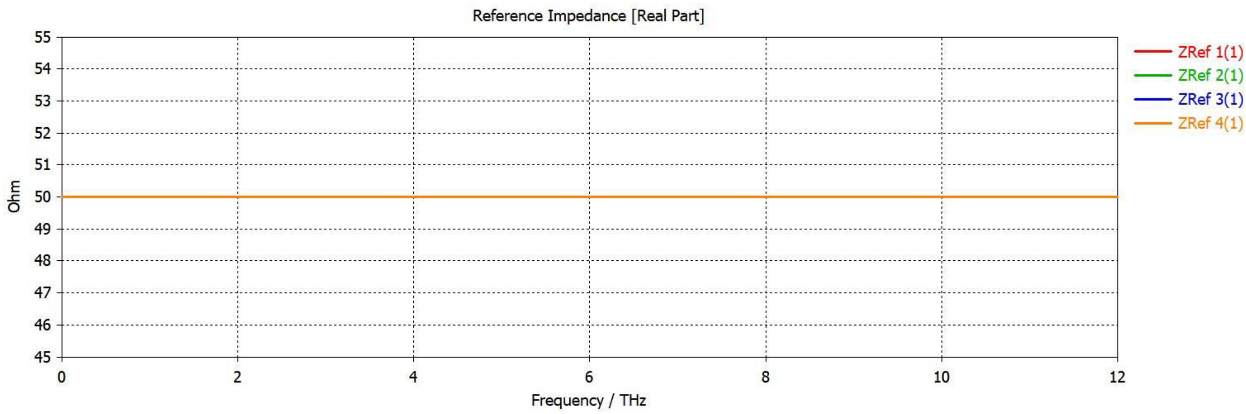


Fig. Reference Impedance

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

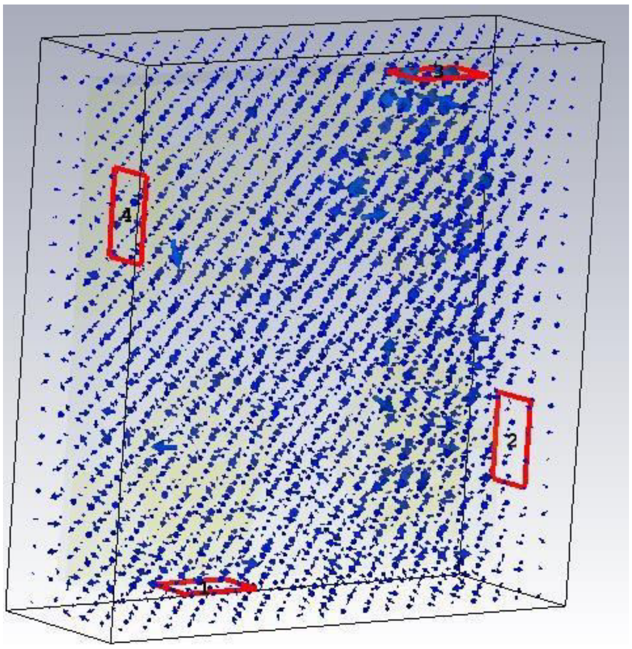


Fig. E-field distribution

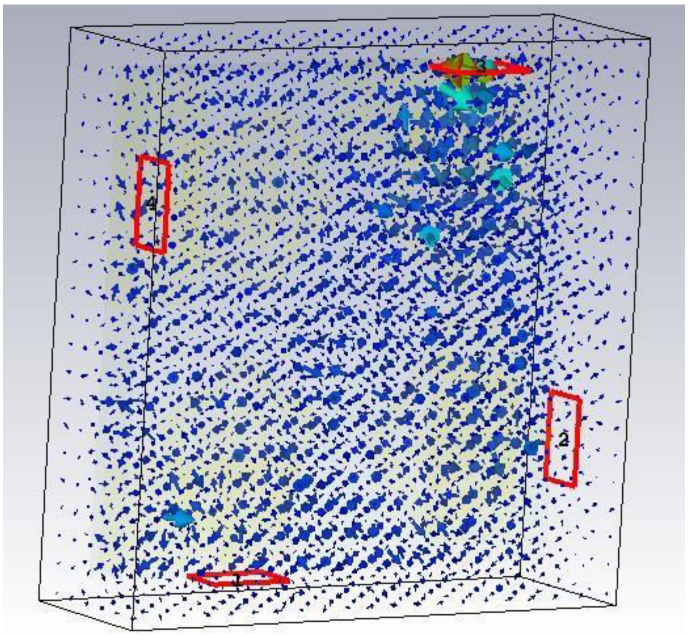


Fig. H-Field distribution

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

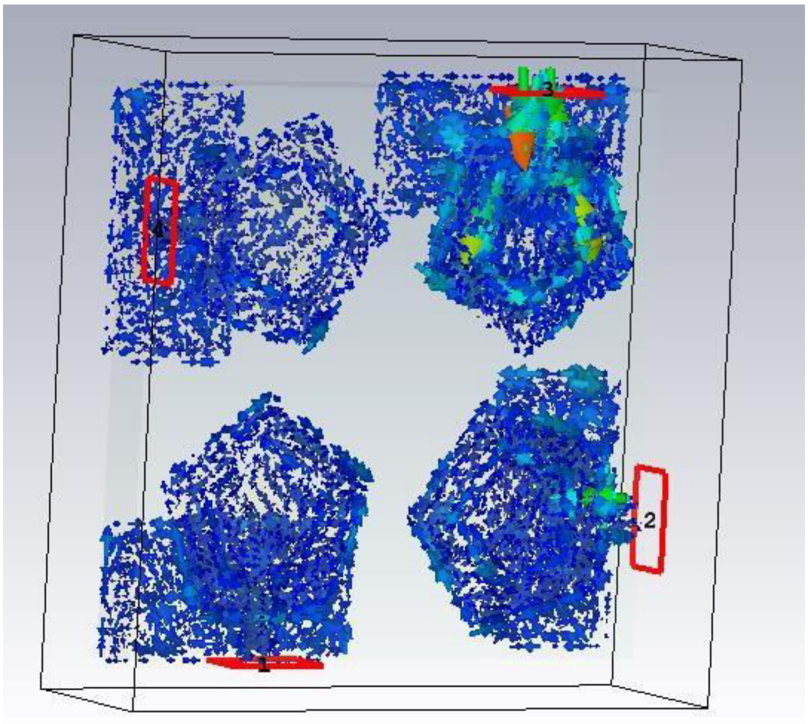


Fig. Surface Current distribution

III. CONCULSION

Current design focused on the multi-band, small scale, large gain, and broad bandwidth THz frequency band antennas. Multi-band THz antenna can be used in applications like the detection of explosive material, sensing, spectroscopy, spacecraft, automobiles, and aerospace, etc. In this research, a compact-sized (µm) THz antenna is recommended which has been packed with high efficiency, gain, and directivity. In first designed antenna A, a planar pentagonal shape antenna is proposed having multiple narrow-band resonances between 2THz to 11THz band, then to enhance the performance a second antenna design B is with pentagonal shape slot is proposed which enhanced the reflection coefficient and bandwidth of the antenna. Also, to increase the quality of service of THz links, a 2 × 2 MIMO antenna array is developed and investigated by using efficient antenna design C for the THz regime to tackle the lossy environment. The developed antenna can be a good candidate for multiple THz applications.

IV. FUTURE SCOPE

Multi wide band patch antenna gains much attention to fulfil demands of wireless communication application for operation on multiple frequency bands. Microstrip patch antenna suffers from some short comings like small gain and less bandwidth.

1. In coming days, work will be carried out on antenna gain, bandwidth and compact dimensions using fractal and defected geometry. In future, further gain can be improved using concept of array for wireless applications.
2. Antenna prototype is simulated and tested for frequencies from 1GHz to 15GHz, but its performance can be analysed on higher frequencies in terms of return loss, gain, bandwidth and radiation pattern.
3. Proposed antenna covers ISM frequency bands for WBAN applications, so Specific Absorption Rate (SAR) analysis can be done for WBAN products.

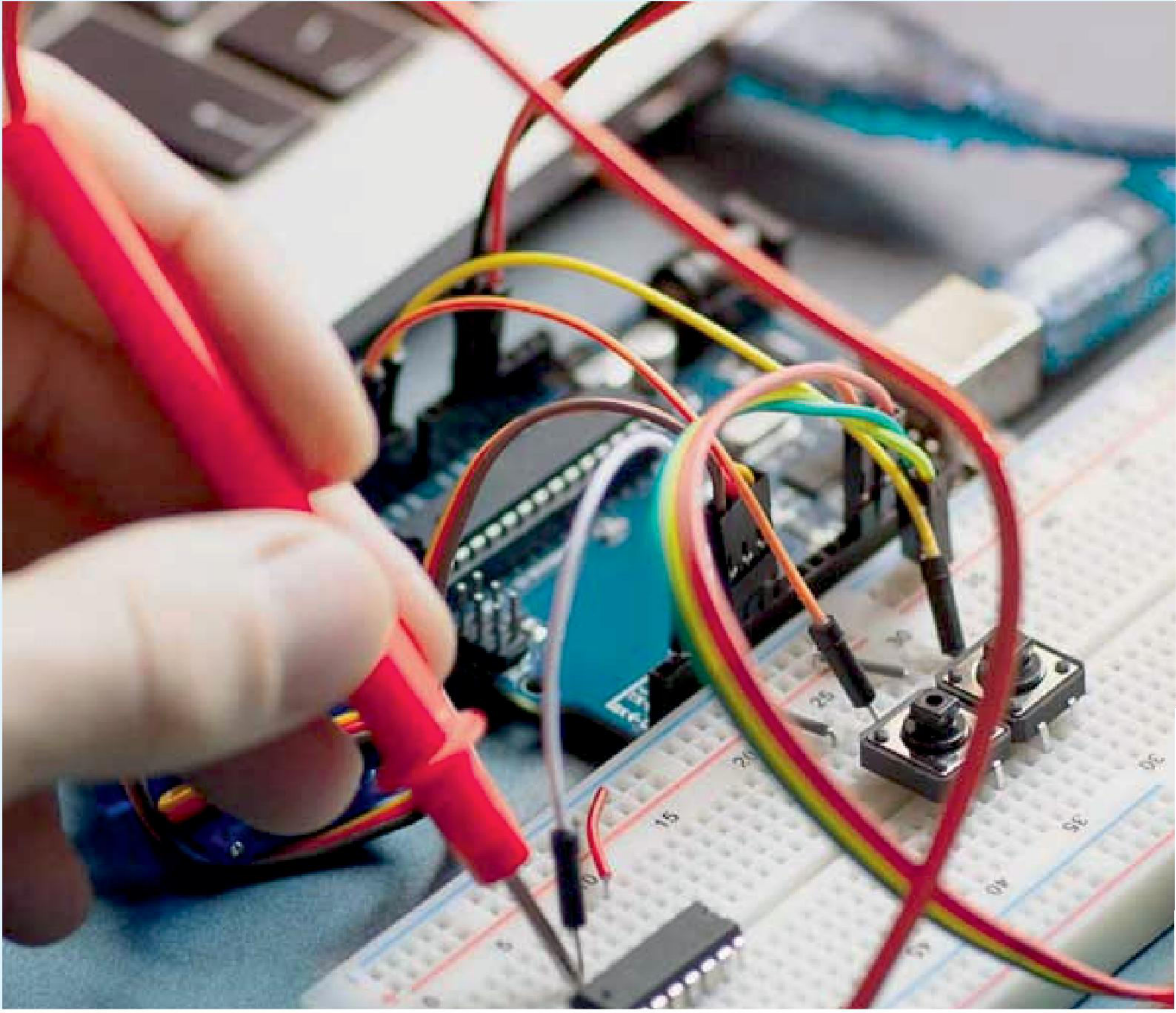
| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 6, June 2022||

|DOI:10.15662/IJAREEIE.2022.1106009 |

REFERENCES

1. S. Koenig, D. Lopez-Diaz, J. Antes, F. Boes, R. Henneberger, A. Leuther, A. Tessmann, R. Schmogrow, D. Hillerkuss, R. Palmer, T. Zwick, C. Koos, W. Freude, O. Ambacher, J. Leuthold, I. Kallfass, Wireless sub-THz communication system with high data rate, Nat. Photonics 7 (12) (2013) 977–981.
2. Akyildiz, J. Jornet, C. Han, Terahertz band: Next frontier for wireless communications, Phys. Commun. 12 (2014) 16–32.
3. K. Jha, G. Singh, Terahertz planar antennas for future wireless communication: a technical review, Infrared Phys. Technol. 60 (2013) 71–80.
4. A. Pawar, D. Sonawane, K. Erande, D. Derle, Terahertz technology and its applications, Drug Invent. Today 5 (2) (2013) 157–163.
5. D. Woolard, Terahertz Science and Technology for Military and Security Applications, World Scientific, Singapore, 2007.
6. J. Yinon, Counterterrorist Detection Techniques of Explosives, Elsevier Science, 2011. [7] M. Tamosiunaite, S. Tamosiunas, M. Zilinskas, G. Valusis, Atmospheric attenuation of the terahertz wireless networks, in: A. Haidine, A. Aqqal (Eds.), Broadband Communications Networks – Recent Advances and Lessons from Practice, first ed., IntechOpen, 2017. [8] M. Islam, F. Ashraf, T. Alam, N. Misran, K. Mat, A compact ultrawideband antenna based on hexagonal split-ring resonator for pH sensor application, Sensors 18 (9)



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.18

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering