A new frequency reconfigurable microstrip patch antenna based on implanting tuning capacitors

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ABSTRACT

The research proposed a new electrically reconfigurable microstrip antenna via a lumped capacitor. Instead of using a varactor diode as a switching circuit which leads to a more complicated design by adding biasing circuits, our suggested antenna design has offered straightforward tuning skills. The projected design has resolved many issues such as a reduction in system complexity by eliminating the biasing circuit, limiting the use of advanced manufacturing devices through using the external circuit to implant or detach the capacitor into or from the antenna main structure, and impedance matching supported with optimum physical structure calculations. The reconfigurable antenna has been modeled and designed using computer simulation technology (CST) software, the prototype antenna has been implemented practically and tested using a spectrum analyzer. The suggested compact antenna has a size of 42×33×0.53 mm^3, and supports multi-operational frequency bands (C, X, Ku, and K) which is suitable for modern communication technologies such as Wi-Fi, 5G, and satellite communication.

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1. INTRODUCTION

An antenna is required for many emerging technologies to function at different bands (frequencies) that support various applications. The need for an antenna with a singular structure that is functional at multi-band has been suggestively adopted [1]–[3]. A microstrip patch antenna is most common and preferred to use due to its unique characteristics such as compact profile, inexpensive, and lightweight. Also, it is suitable to use in flexible technology as well as plastic technology [4], [5]. When the current is redistributed along the surface of the antenna, then a reconfiguration occurs. The reconfiguration techniques are classified into three main mechanisms [6]: mechanically [7], electrically [8], and optically [9]. Thus, the reconfigurable antenna has unique skills to alter its frequency, pattern, and polarization [10]. The electrically reconfiguration technique is commonly used by means of radio frequency (RF) switches being PIN diode, RF-microelectromechanical system (MEMS), and varactor diode [6].

Nadeem *et al.* [11] provided metamaterial and metasurface using printed circular polarized (CP) approach microstrip antenna for 5G applications. According to Ullah *et al.* [12], an artificial switch to perform on-off situations. Zhou *et al.* [13] has subjected a method of using liquid material movement to achieve certain polarization and frequency. According to Nazir *et al.* [14], a frequency-reconfigurable antenna by placing PIN diodes between the patches of the implemented antenna. Singh *et al.* [15] has presented an electrically reconfigurable patch antenna via PIN diode which made it capable of operating at different operational frequencies and three polarization states. Shuriji and Thaher [16] has produced a frequency reconfigurable antenna using two PIN diodes that operate in four modes to support multi-band that is eventually suitable to work with various applications with only one singular structure. Tamimi and Thaher [17] has exhibited a compound reconfigurable antenna that has the ability to alter both the frequency of operation and pattern direction using a PIN diode. Tawk *et al.* [18] has used a varactor diode to reconfigure a two-sided Vivaldi patch antenna. Biasing the varactor diode gives a certain capacitor value by changing the biasing voltages. The result was a frequency-reconfigurable microstrip that operates at c-band only. Bai *et al.* [19] has illustrated a pattern reconfigurable antenna using varactor diodes.

The presented design operates at 2.9 GHz and has the ability to alter the radiation pattern, while it has a fairly large structure. Onodera *et al.* [20] presented a frequency reconfigurable antenna operated at dual-band (1.6-1.91 GHz and 3.2-3.7 GHz) via varactor diodes. It has been noted that limited gain was espoused. Christodoulou *et al.* [21] has demonstrated a reconfigurable antenna using varactor diodes that has the ability to operate at 0.95-1.8 GHz with single and dual polarized. A large antenna design was presented. Ramadan *et al.* [22] has verified a reconfigurable antenna via a varactor diode with pattern and polarization ability, while limited gain was noted. Awan *et al.* [23] has exhibited a frequency reconfigurable microstrip using PIN diodes with a flexible muti-band ability. Notable, limited radiation efficiency and low gain were found. Furthermore, many recent researches have adopted the electrically reconfigurable microstrip patch using RF switches [24], [25]. After an extensive literature survey, a novel solution has been carried out to eliminate the complexity of using biasing circuits that are essential for RF switches. Also, to make the tuning of the reconfigurable microstrip much easier without any advanced industrial devices that needed to print the varactor diode inside the patch itself. While we endure a very good matching impedance.

2. THE PROPOSED RECONFIGURABLE DESIGN

The planned structure and geometry of the antenna are presented in Figures 1(a) and (b). The shape of the microstrip patch has been planned and calculated using (1) and (2) [26]. In (3)-(5) [16], [17] were used to calculate the circular patch radius and the width of the feedline.

$$L = \frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (1)$$

Where L is the length of the patch, f_r is resonant frequency, ΔL is the length due to the fringing field effect, ε_{reff} is the effective permittivity, μ_o is the permeability, and ε_o is the permittivity.

$$W = \frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (2)$$

where W is the width of the patch and ε_r is the related permittivity.

$$R = \frac{F}{\{1+\frac{2h}{\pi\varepsilon_r F}[ln(\frac{\pi F}{2h}+1.77726)]\}^{1/2}} \quad (3)$$

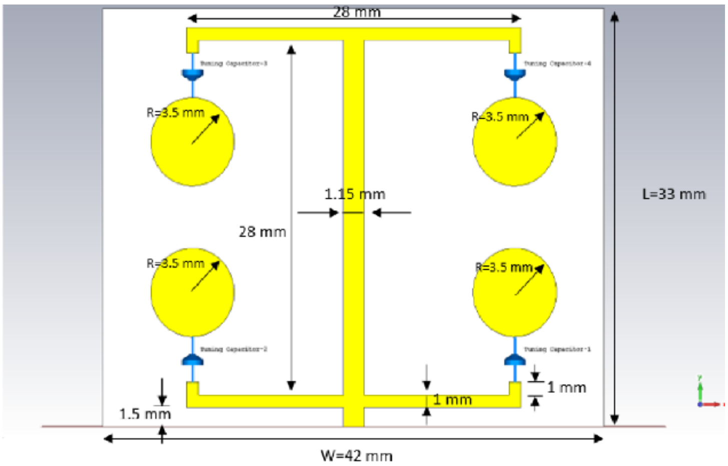
Where R is the radius of the circular patch, F is constant and calculated using (4), and h is the thickness of the substrate.

$$F = 8.791 \times \frac{10^9}{f\sqrt{\varepsilon_r}} \quad (4)$$

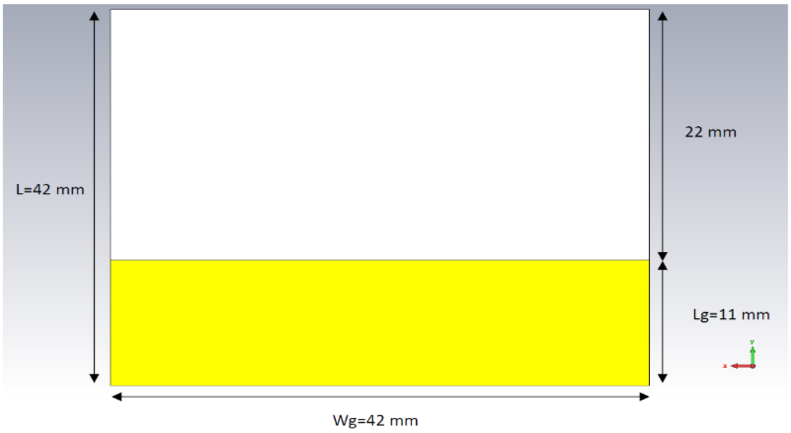
$$W_f = \frac{7.48\times h}{e^{\left(z_o\frac{\sqrt{\varepsilon_r+1.41}}{87}\right)-1.25\times t}} \quad (5)$$

Where W_f is the width of the feedline, z_o is the reference impedance, and t is the thickness of the patch sheet.

The planned microstrip patch antenna has been calculated optimally and selected wisely being 42×33×0.8 mm in size. A lossy copper has a thickness of 0.035 mm used for the ground plane. The length of the ground was selected to be one third of the total length of the antenna which is equal to 11 mm for maximum performance. A roger hydrocarbon ceramic laminates (RO4003c) has been chosen as a substrate layer with a related permittivity of 3.4, a loss tangent of 0.0027, and a thickness of 0.53 mm. Generally, roger RO4003c is rarely used, it's been considered in our design for the following benefits: high thermal conductivity, low price, great performance for sensitive applications, very good construction in multi-layer printed circuits, leed-free soldering, maintain a high bandwidth when the thickness is decreased, and high performance at high frequencies (>10 GHz) [27], [28]. The patch layer has four circular shapes each with a size of 3.5 mm, and the feedline has connected with two symmetrical arms each arm has a total length of 28 mm and a width of 1 mm as illustrated in Figure 1. The feedline length was calculated being 28 mm and width of 1.71 mm. The design has carried out an uncomplex structure and optimally calculated to meet a high level of matching, while maintaining topmost antenna performance. Figures 2(a) and (b) presented the manufactured microstrip patch antenna

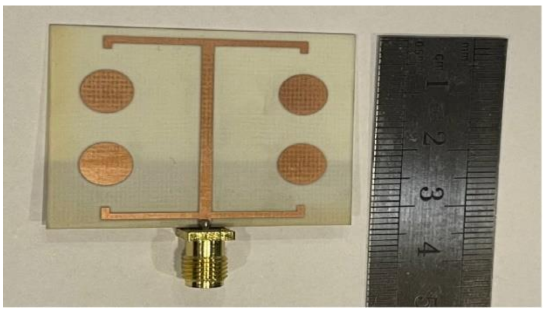


(a)

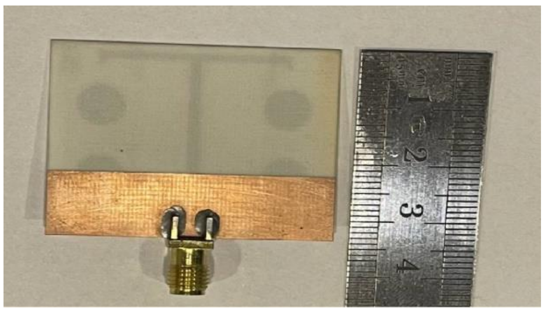


(b)

Figure 1. Antenna geometry of (a) front view and (b) back view



(a)



(b)

Figure 2. Factory-made antenna of (a) front view and (b) back view

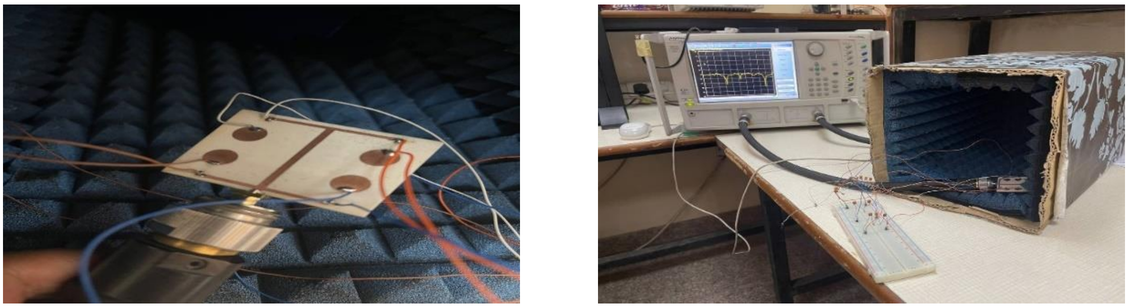
3. LUMPED CAPACITOR RECONFIGURATION

Electrically reconfigurable technique uses one of three RF switches PIN diode, varactor diode, and MEMS. The significant issue with those switched is adding another level of complexity to the process as well as to the designing antenna structure. The complexity comes from using a biasing circuit that makes the microstrip reconfigured via switching and tuning to alter the antenna polarization, pattern, and frequency. In this research, a frequency reconfigurable microstrip using a novel technique via a tuning capacitor is skilled in easy tuning for a desired operating frequency. Four tuning capacitors have been added to the patch antenna in each four-ended arm with each circular patch using external connections that reduce the need for precise printed instruments, consequently the manufacturing cost. This new technique will eliminate the biasing circuit completely, consequently antenna manufacturing complications. The four capacitors' values have been selected and added optimally in the computer simulation technology (CST) lumped elements as it shown in Figure 1(a). The capacitors values are shown in Table 1. This new technique has been implemented and tested practically using spectrum analyser.

Table 1. Values of the tuning capacitors

Tuning capacitor number	Value (pF)
Tuning capacitor-1	0.6
Tuning capacitor-2	0.1
Tuning capacitor-3	0.1
Tuning capacitor-4	0.4

Figures 3(a) and (b) demonstrated the testing of the new reconfigurable microstrip antenna. The reconfiguration technique has sixteen different scenarios by simply implanting or, and detaching the tuning capacitors. Table 2 shows the different scenarios (mode of operation) that have been provided using this method.



(a) (b)

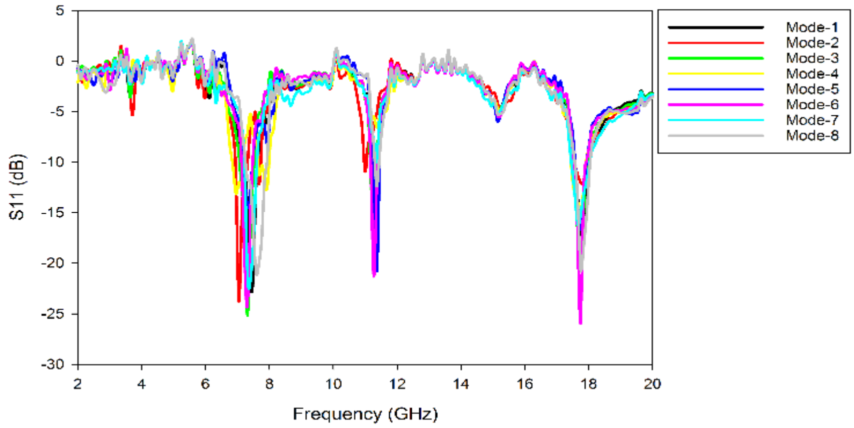
Figure 3. The new reconfigurable antenna (a) during test inside the chamber and (b) test connected to the vector network analyzer (VNA)

Table 2. Scenarios of the reconfiguration technique

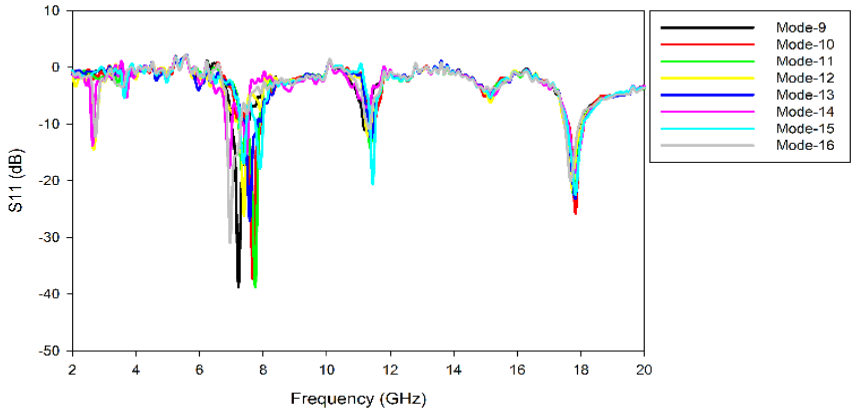
Scenario	Implanted capacitor	Detached capacitor
Mode-1	Zero implant	all
Mode-2	C1	C2, 3, and 4
Mode-3	C2	C1, 3, and 4
Mode-4	C3	C1, 2, and 4
Mode-5	C4	C1, 2, and 3
Mode-6	C1 and 2	C3 and 4
Mode-7	C1 and 3	C2 and 4
Mode-8	C1 and 4	C2 and 3
Mode-9	C2 and 3	C1 and 4
Mode-10	C2 and 4	C1 and 3
Mode-11	C3 and 4	C1 and 2
Mode-12	C1, 2, and 3	C4
Mode-13	C1, 3, and 4	C2
Mode-14	C2, 3, and 4	C1
Mode-15	C1, 2, and 4	C3
Mode-16	C1, 2, 3, and 4	Zero detach

4. RESULTS AND DISCUSSION

Our frequency reconfigurable microstrip antenna is designed to support multi-frequencies. The antenna has been tested practically using a spectrum analyzer for all modes of operation (mode 1-16) and the s11 is shown in Figures 4(a) and (b). The operating frequencies at each mode with the s11 are presented in Table 3. The presented antenna operates at multi-band with frequency switching ability, the supported bands are S, C, X, and Ku bands. The return loss is very acceptable with a high bandwidth offering. The reference impedance (Zref) for all modes is exposed in Figure 5, it shows that under all modes of operation, the measured impedance was perfectly matched and equal to around 50 ohms.



(a)



(b)

Figure 4. s11 vs. frequency for: (a) mode-1 to mode-8 and (b) mode-9 to mode-16

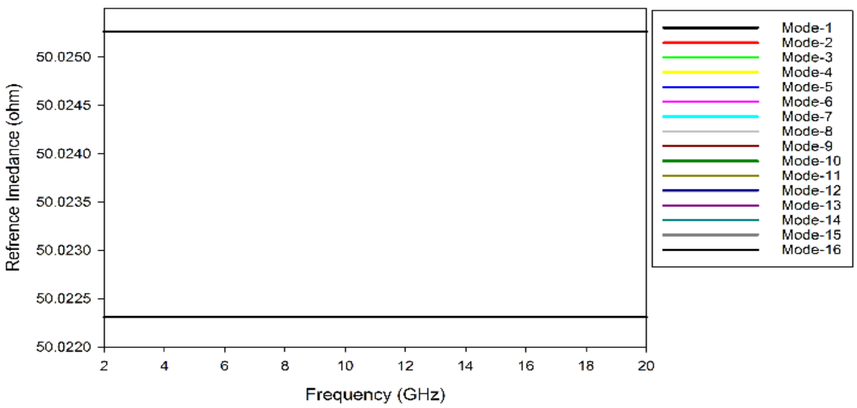


Figure 5. Reference impedance vs. frequency for all modes

Table 3. The operating frequencies and s11 at each mode

Scenario	Operating frequency (GHz)	Return loss (S11) dB
Mode-1	7.4, 11.3, and 17.8	-21.8, -10.9, and -17.3
Mode-2	7, 7.6, 11, and 17.8	-23.8, -23.8, -10.9, and -12
Mode-3	7.3, 11.2, and 17.7	-25.1, -17.7, and -24.6
Mode-4	6.9, 7.9, and 17.7	-13.1, -12.1, and -14.8,
Mode-5	7.3, 11.3, and 17.5	-14.3, -20.8, and -16.6
Mode-6	7.3, 11.2, and 17.5	-24.2, -21.3, and -25.9
Mode-7	7.4 and 17.6	-21.8 and -16.1
Mode-8	7.5, 11.3, and 17.5	-21, -12.3, and -20.5
Mode-9	7.2, 11.1, and 17.6	-38.7, -11, and -18.7
Mode-10	7.6, 11.4, and 17.8	-37.3, -12.8, and -25.7
Mode-11	7.7, 11.3, and 17.7	-38.4, -14.1, and -21.7
Mode-12	2.6, 7.4, 11.3, and 17.7	-13.3, -26.1, -11.8, and -21.6
Mode-13	7.5,11.3, and 17.8	-27, -12, and -23
Mode-14	2.6, 6.9, 7.4, and 17.8	-13.7, -17.3, -15, and -18.6
Mode-15	7.4, 7.9, 11.4, and 17.8	-16.4, -16.4, -20.5, and -22.4
Mode-16	2.7, 6.9, 11.3, and 17.7	-12.2, -30.7, -10.6, and -18

The voltage standing wave ratio (VSWR) has been tested practically to check the matching. Under all modes, the VSWR was around 1 (<2), thus we have an optimum matched antenna. Figure 6 is demonstrated the VSWR under all modes of operation. The simulated power gain of the proposed antenna using CST is illustrated in the summarized Table 4 for all operating frequencies under all modes. A summarized comparison between the designed reconfigurable antenna and other related works is demonstrated in Table 5.

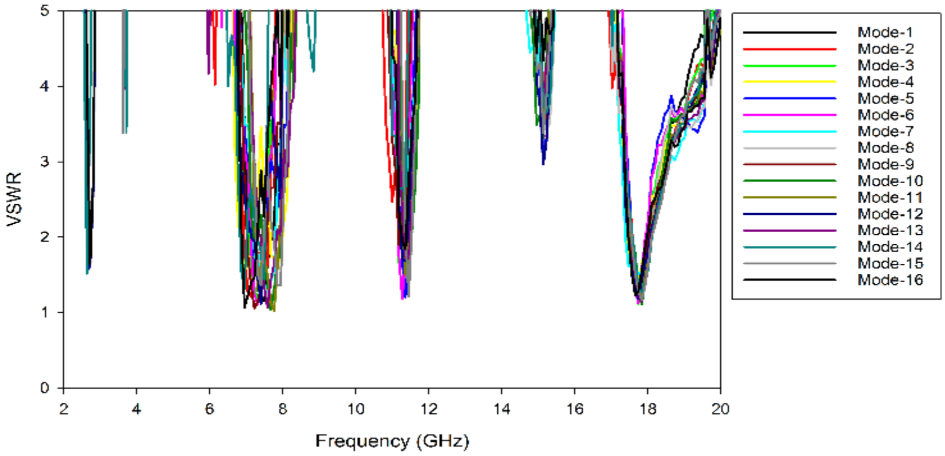


Figure 6. VSWR vs. frequency for all modes

Table 4. Antenna gains for all modes

Scenario	Operating frequency (GHz)	Gain (G) dB
Mode-1	7.4, 11.3, and 17.8	2.2, 2.5, and 2.9
Mode-2	7, 7.6, 11, and 17.8	2.3, 2.3, 2, and 2.8
Mode-3	7.3, 11.2, and 17.7	1.5, 4, and 2.9
Mode-4	6.9, 7.9, and 17.7	1.8, 1.1, and 3.3
Mode-5	7.3, 11.3, and 17.5	1.7, 1.5, and 3.1
Mode-6	7.3, 11.2, and 17.5	3.2, 4.2, and 2.5
Mode-7	7.4 and 17.6	2.4, and 2.4
Mode-8	7.5, 11.3, and 17.5	3.8, 2.8, and 2.6
Mode-9	7.2, 11.1, and 17.6	2.5, 3.4, and 2.6
Mode-10	7.6, 11.4, and 17.8	2, 4.2, and 2.1
Mode-11	7.7, 11.3, and 17.7	2.8, 2.1, and 2.5
Mode-12	2.6, 7.4, 11.3, and 17.7	1.3, 2.7, 4, and 3.1
Mode-13	7.5, 11.3, and 17.8	3.5, 2.8, and 2.2
Mode-14	2.6, 6.9, 7.4, and 17.8	1.6, 4, and 2.1, and 3
Mode-15	7.4, 7.9, 11.4, and 17.8	2.2, 2.1, 4.6, and 2.5
Mode-16	2.7, 6.9, 11.3, and 17.7	1.2, 3.2, 3.5, and 3

Table 5. Summarized comparison with related works

Ref.	Size (mm)	Bands	Technique	Complexity level
[7]	45×41.8×0.8	dual	RF-MEMS	high
[8]	33×16×1.6	dual	PIN diode	high
[12]	40×35×1.6	Single and dual	PIN diode	high
[14]	86×50×1.5	single	PIN diode	high
[15]	65×60×2.2	single	PIN diode	high
[18]	59.8×30×1.6	single	Varactor diode	high
[19]	70×40×1.5	single	Varactor diode	high
[23]	32×25×0.25	single	PIN diode	high
This work	42×33×0.53	Multi	Tuning capacitor	low

5. CONCLUSION

In this article, a new reconfigurable microstrip antenna has been analyzed, modeled, designed, and manufactured for a different mode of operation. This research has carried out a simple idea yet very effective by replacing the common RF switching that needs biasing circuit with a tuning capacitor. This technique has significantly reduced the complexity of the system design fabricated process and cost. Implanting or detaching the lumped capacitor made the antenna capable of altering the operating frequencies with minimum tuning effort. The designed antenna with a very good matching operates in multi bands (S, C, X, and Ku) and is suitable to function in several modern applications such as industrial, scientific and medical (ISM) band applications (Wi-Fi, WLAN, and WiMAX), 5G applications, and satellite communication.

REFERENCES

[1] A. Ali *et al.*, "Optically reconfigurable planar monopole antenna for cognitive radio application," *Microwave and Optical Technology Letters*, vol. 61, no. 4, pp. 1110–1115, 2019, doi: 10.1002/mop.31678.

[2] M. Ikram, E. A. Abbas, N. N. -Trong, K. H. Sayidmarie, and A. Abbosh, "Integrated Frequency-Reconfigurable Slot Antenna and Connected Slot Antenna Array for 4G and 5G Mobile Handsets," *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 12, pp. 7225–7233, 2019, doi: 10.1109/TAP.2019.2930119.

[3] L. A. Bronckers, A. Roc'h, and A. B. Smolders, "A New Design Method for Frequency- Reconfigurable Antennas Using Multiple Tuning Components," *IEEE Transactions on Antennas and Propagation*, vol. 67, no. 12, pp. 7285–7295, 2019, doi: 10.1109/TAP.2019.2930204.

[4] Y. G. Rabobason *et al.*, "Design of flexible passive antenna array on kapton substrate," *Progress In Electromagnetics Research C*, vol. 63, pp. 105–117, 2016, doi: 10.2528/PIERC15120906.

[5] Y. G. Rabobason *et al.*, "Design and synthesis of flexible switching 1×2 antenna array on Kapton substrate," *EPJ Applied Physics*, vol. 74, no. 3, pp. 1–10, 2016, doi: 10.1051/epjap/2016160082.

[6] N. O. Parchin, H. J. Basherlou, Y. I. A. A. -Yasir, R. A. A. -Alhameed, A. M. Abdulkhaleq, and J. M. Noras, "Recent developments of reconfigurable antennas for current and future wireless communication systems," *Electronics*, vol. 8, no. 2, pp. 1–17, 2019, doi: 10.3390/electronics8020128.

[7] A. Zohur, H. Mopidevi, D. Rodrigo, M. Unlu, L. Jofre, and B. A. Cetiner, "RF MEMS reconfigurable two-band antenna," *IEEE Antennas and Wireless Propagation Letters*, vol. 12, pp. 72–75, 2013, doi: 10.1109/LAWP.2013.2238882.

[8] I. A. Shah *et al.*, "Design and analysis of a hexa-band frequency reconfigurable antenna for wireless communication," *AEU-International Journal of Electronics and Communications*, vol. 98, pp. 80–88, 2019, doi: 10.1016/j.aeue.2018.10.012.

[9] S. Pendharker, R. K. Shevgaonkar, and A. N. Chandorkar, "Optically controlled frequency-reconfigurable microstrip antenna with low photoconductivity," *IEEE Antennas and Wireless Propagation Letters*, vol. 13, pp. 99–102, 2014, doi: 10.1109/LAWP.2013.2296621.

[10] M. S. Shakhirul, M. Jusoh, Y. S. Lee, and C. R. N. Husna, "A Review of Reconfigurable Frequency Switching Technique on Micostrip Antenna," *Journal of Physics: Conference Series*, vol. 1019, pp. 1–7, 2018, doi: 10.1088/1742-6596/1019/1/012042.

[11] I. Nadeem *et al.*, "A comprehensive survey on 'circular polarized antennas' for existing and emerging wireless communication technologies," *Journal of Physics D: Applied Physics*, vol. 55, no. 3, pp. 1–15, 2022, doi: 10.1088/1361-6463/ac2c36.

[12] S. Ullah, S. Ahmad, B. A. Khan, and J. A. Flint, "A multi-band switchable antenna for Wi-Fi, 3G Advanced, WiMAX, and WLAN wireless applications," *International Journal of Microwave and Wireless Technologies*, vol. 10, no. 8, pp. 984–990, 2018, doi: 10.1017/S1759078718000776.

[13] Y. Zhou, G. Zhao, X. Y. Li, and M. S. Tong, "A Liquid-Metal-Based Crossed-Slot Antenna With Polarization and Continuous-Frequency Reconfiguration," *IEEE Open Journal of Antennas and Propagation*, vol. 3, pp. 1102–1108, 2022, doi: 10.1109/OJAP.2022.3206899.

[14] I. Nazir, I. E. Rana, N. u. A. Mir, and K. Afreen, "Design and analysis of a frequency reconfigurable microstrip patch antenna switching between four frequency bands," *Progress In Electromagnetics Research C*, vol. 68, pp. 179–191, 2016, doi: 10.2528/PIERC16052405.

[15] R. K. Singh, A. Basu, and S. K. Koul, "A novel reconfigurable microstrip patch antenna with polarization agility in two switchable frequency bands," *IEEE Transactions on Antennas and Propagation*, vol. 66, no. 10, pp. 5608–5613, 2018, doi: 10.1109/TAP.2018.2860118.

[16] M. A. Shuriji and R. H. Thaher, "Design of Frequency Reconfigurable Patch Antenna for C, X, Ku, and K Bands Applications Controlled by PIN-Diode," in *2022 International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*, 2022, pp. 1–6, doi: 10.1109/ISMSIT56059.2022.9932811.

[17] M. A. -Tamimi and R. H. Thaher, "Design of New Compound Reconfigurable Microstrip Antenna for C and Ku Bands Applications," *Journal of Engineering and Sustainable Development*, vol. 27, no. 2, pp. 196–203, 2023, doi: 10.31272/jeasd.27.2.4.

[18] Y. Tawk, J. Costantine, and C. G. Christodoulou, "A varactor-based reconfigurable filtenna," *IEEE Antennas and Wireless Propagation Letters*, vol. 11, pp. 716–719, 2012, doi: 10.1109/LAWP.2012.2204850.

[19] Y. Y. Bai, S. Xiao, C. Liu, X. Shuai, and B. Z. Wang, "Design of pattern reconfigurable antennas based on a two - Element dipole array model," *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 9, pp. 4867–4871, 2013, doi: 10.1109/TAP.2013.2270175.
[20] S. Onodera, R. Ishikawa, A. Saitou, and K. Honjo, "Multi-band reconfigurable antennas embedded with lumped-element passive components and varactors," in *2013 Asia-Pacific Microwave Conference Proceedings (APMC)*, 2013, pp. 137–139, doi: 10.1109/APMC.2013.6695216.
[21] C. G. Christodoulou, Y. Tawk, S. A. Lane, and S. R. Erwin, "Reconfigurable antennas for wireless and space applications," *Proceedings of the IEEE*, vol. 100, no. 7, pp. 2250–2261, 2012, doi: 10.1109/JPROC.2012.2188249.
[22] A. H. Ramadan, J. Costantine, M. A. -Husseini, K. Y. Kabalan, Y. Tawk, and C. G. Christodoulou, "Tunable filter-antennas for cognitive radio applications," *Progress In Electromagnetics Research B*, no. 57, pp. 253–265, 2014, doi: 10.2528/PIERB13112005.
[23] W. A. Awan, N. Hussain, S. Kim, and N. Kim, "A Frequency-Reconfigurable Filtenna for GSM, 4G-LTE, ISM, and 5G Sub-6 GHz Band Applications," *Sensors*, vol. 22, no. 15, pp. 1–15, 2022, doi: 10.3390/s22155558.
[24] I. Ahmad, W. Tan, Q. Ali, and H. Sun, "Latest Performance Improvement Strategies and Techniques Used in 5G Antenna Designing Technology, a Comprehensive Study," *Micromachines*, vol. 13, no. 5, pp. 1–28, 2022, doi: 10.3390/mi13050717.
[25] H. C. Mohanta, A. Z. Kouzani, and S. K. Mandal, "Reconfigurable antennas and their applications," *Universal Journal of Electrical and Electronic Engineering*, vol. 6, no. 4, pp. 239–258, 2019, doi: 10.13189/ujeee.2019.060406.
[26] C. A. Balanis, *Antenna Theory: Analysis and Design*. Hoboken, New Jersey: John Wiley & Sons, 2016.
[27] L. C. Paul, "The Effect of Changing Substrate Material and Thickness on the Performance of Inset Feed Microstrip Patch Antenna," *American Journal of Networks and Communications*, vol. 4, no. 3, pp. 54–58, 2015, doi: 10.11648/j.ajnc.20150403.16.
[28] "RO4003C™ Laminates," *Rogers Corporation*. [Online]. Available: https://www.rogerscorp.com/advanced-electronics-solutions/ro4000-series-laminates/ro4003c-laminates. Access date: May 10, 2023.

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