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A Review on Multiband Antennas for Portable Wireless System Applications

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Abstract— ***In modern wireless communication, multiband microstrip antennas are widely equipped in mobiles, laptops and other portable devices due to their advantages like the small size, light weight, low cost and easy integration with planar structures. Moreover, the research evolution in these antennas, which are required for portable wireless communication system applications, is advancing day by day. So, it is essential to notice the research and improvements happening in the area of multiband antennas for the intended applications. The main objective of this paper is to discuss numerous multiband antennas for GSM, Wi-Fi and WiMAX 2500 applications. The GSM applications cover GSM 900, GSM 1800 (DCS 1800) and GSM 1900 (PCS 1900) bands while the Wi-Fi applications cover 2.4GHz and 5.8GHz bands. Sometimes, these antennas also operate in various bands of GPS, LTE 2300, LTE 2600, UMTS and WiMAX 3500 along with the GSM, Wi-Fi and WiMAX 2500 bands. This paper presents various conventional microstrip antennas that include single, dual, triple and multiband antennas. In this, it reports various shapes of slots and technique to achieve multiband antennas and also explains merits and demerits of all antenna. Finally, this paper helps to explore and design suitable multiband antennas for the required applications.***
Keywords— multiband antennas, GPS, DCS, GSM, LTE, PCS, UMTS, Wi-FI, WiMAX.

I. INTRODUCTION

In today's wireless communication, GSM, Wi-Fi, and WiMAX applications are highly preferred due to their services like SMS, voice and video calls, high-speed data transfer and any time anywhere internet access. Basically, these applications are associated with mobiles, laptops and other portable devices. In these devices, various antennas are integrated to support the required wireless applications. However, in modern wireless communication systems, microstrip antennas are extensively employed due to their advantages in spite of drawbacks like narrow bandwidth, low power handling capacity and low gain. The name microstrip antenna (MSA) was initially coined by Deschamps in 1953. But, the development of these antennas came into existence by the efforts of Munson and Howell in 1970s. From those days onwards a tremendous research evolution had been occurring in the area of microstrip antennas. Various frequency bands allotted to different portable wireless communication system applications are listed in Table I [1]-[2].

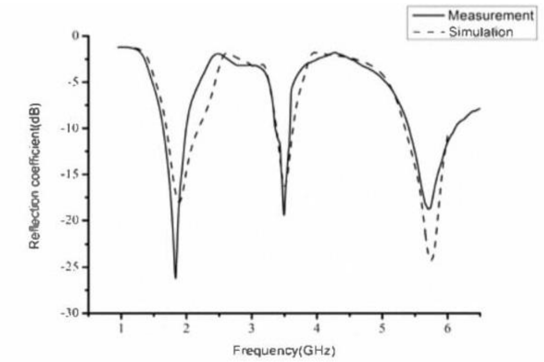
TABLE-I: Frequency Allocations of various Wireless Systems

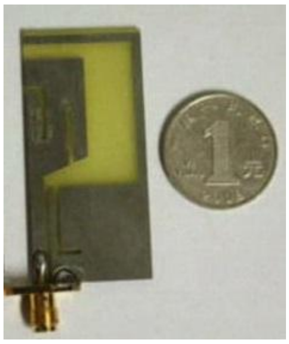
Wireless Application	Frequency Band (MHz)
GSM 850 (AMPS)	824-894
GSM 900	890-960
GPS	1565-1585
GSM 1800 (DCS 1800)	1710-1885
GSM 1900(PCS 1900 ,CDMA 1900)	1850-1990
UMTS (W-CDMA, IMT 2000)	1885-2200
LTE 2300 (Band-40)	2300-2400
Wi-Fi/WLAN (ISM 2450) (IEEE 802.11 b/g/n)	2400-2495
Extended UMTS (LTE 2600, WiMAX 2500)	2500-2690
WiMAX 3500	3300-3600
Wi-FI/WLAN (IEEE 802.11 y)	3650-3700
Wi-Fi/WLAN (HiperLAN, U-NII) (IEEE 802.11 a/h/j)	5150-5825

This paper is organized into III sections. In section II, numerous conventional multiband microstrip antennas are reported. Finally, in section III some concluding points are mentioned.

II. CONVENTIONAL MULTIBAND ANTENNAS

The section focuses on different conventional microstrip antennas operating in single, dual, triple, and multi-bands of various slots and shapes for various portable wireless applications. Initially, numerous single band microstrip antennas are reported. In order to support many applications, these antennas must have wide operating band. But, as pointed out earlier conventional patch antennas are having a drawback of lower bandwidth. However, in the literature [3]-[10] few techniques are presented to enhance the impedance bandwidth. We studied various single band microstrip antennas reported in [11]-[17]. A design of a narrow-size planar monopole multi-band antenna with double L-shaped slots is reported in [3]. The slot is incorporated on the active patch to widen the impedance bandwidth and to reduce the patch size. The proposed antenna covers a frequency band of 1850-1990 MHz (PCS), 3400-3600 MHz (WiMAX) and 5725-5850 MHz (WLAN). In the paper, authors also presented a performance of the antenna for various lengths of slots on the ground plane.



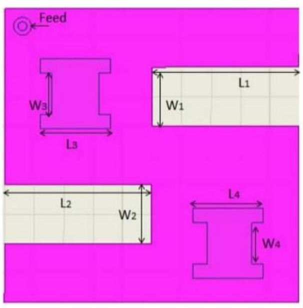


(a) (b)

Figure 1. (a) Measured and simulated reflection coefficient of the proposed antenna [3]
(b) Photograph of the proposed narrow-size multiband planar monopole antenna [3].

In this, authors also presented the performance of the antenna for various lengths of slots on the ground plane. The lower notched band, which, as noted in [6], depends on the length and position of the L-shaped slot cut out of the patch, is approximately from 2.0 to 3.3GHz. In addition, the higher notched band, which, as noted in [6], is controlled predominantly by the length and position of the L-shaped slot cut out of the ground, is approximately from 3.6 to 5.4 GHz.

In [4], a compact multiband antenna with symmetrical I and S-shaped slots for wireless applications is discussed. This antenna is covering frequencies 1.37-1.42, 2.43-2.57, 2.76- 2.81 and 3.51-3.61 GHz. A coaxial-fed quad-band model is considered for microwave access. It can be employed for L and S-band applications which include WLAN, GPS, and WiMAX. The designed model has a dimension of 65 × 65 × 1.6 mm3 and dielectric substrate of FR-4 epoxy with relative permittivity 4.4 and also has symmetrical I-shaped slots above the substrate to generate multiband. It is modeled to work within (0.5- 4.0 GHz). The designed model is simulated by High-Frequency Structure Simulator (HFSS). To allow low band access different shapes are utilized like I, S and U-shaped microstrip antennas and among various low band designs, I-shaped is mainly utilized for L-band microwave access [18]-[19].



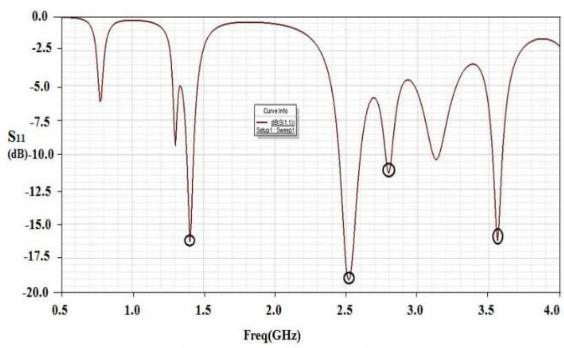
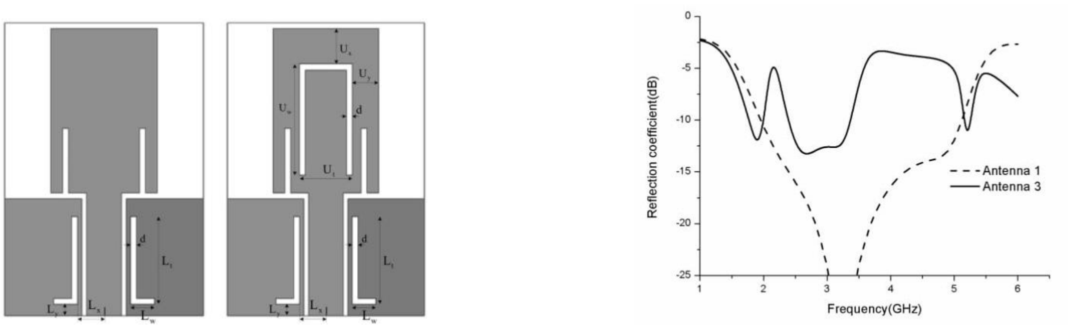


Figure 2. (a) Design for I and S shape [4]. (b) Return loss (S11) of antenna [4].

For better performance of antennas, perfect impedance matching is required through feed line so that maximum power can be transferred to the conducting patch for proper radiation around its surrounding [19]. The prime concern of microstrip antennas is its narrow bandwidth however, it can be compensated by cutting the resonant slot of either quarter wave or half wave in length inside the patch [20]. A broadband antenna has been designed with U-slot and pair of rectangular slots [21]-[22], these resonant half U slots of a rectangular slot has increased overall bandwidth of the antenna and by combining both the slots, gives further rise to the bandwidth, however narrow bandwidth is major concern of microstrip antennas. The return loss (S11) of the model is depicted in Fig. 2(b) The minimum return loss (S11) of -19.20 dB is obtained at 2.5 GHz and -16.33 dB at 1.4 GHz. Also has considerable VSWR of 1.37 as well at 2.5 GHz, which is suitable for L and S-band application.

In [5], authors reported the design of a planar monopole multiband antenna with U and L-shaped slots. The antenna consists of an E-shaped patch fed through a coplanar waveguide (CPW) transmission line, which was in turn connected to a coaxial cable through a standard 50Ω SMA connector. The antenna was designed on a low-cost, durable FR-4 substrate with relative dielectric constant ε_r=4.4, loss tangent tanδ=0.02 and height h=1.6 mm. The overall size of the antenna is 33.5 × 50 mm^2 while the patch is 18mm × 28mm. To achieve the multiple band-notched characteristics, we make some changes to the initial antenna. The modified structures are shown in the Fig. 3(a and b) contain two L-shaped slots in the ground and one U-shaped slot in the patch. The author focused on a novel planar monopole antenna design based upon the E-shaped antenna with the L-shaped slots cut out of the ground and the U-shaped out of the patch, which covers the personal communication system (PCS,1850–1990 MHz), Bluetooth/WLAN (2400–2480 MHz), WiMAX (2500–2690 MHz), and an additional band (5000–5200 MHz).



(a) (b) (c)

Figure 3. Structure of the antenna 2 with L-shaped slots (a) and antenna 3 with U- and L-shaped slots (b) [5].
(c) Simulated reflection coefficient of antenna 1 and antenna 3 [5].

The L-shaped slots on the ground make a notched frequency. As the Fig. 3(a and b) shows, the length of the Lt mainly determines the center of the notched frequency. The L-shaped slot creates an alternate path for the current on the ground plane. When the total length of the L-shaped slots is approximately equal to the half-wavelength at the desired notched frequency, the slots block the current on the ground to create a stop band. At other frequencies, the L-shaped slot filter has few effects. Based on the concept as above, we changed the Lt to get two passbands (2.4-3.3 GHz, 5-5.2 GHz) which we need. The U-shaped slot in the E-shaped patch improves the lower frequency bandwidth; meanwhile, it makes a stop band at the lower frequency, as shown in Fig. 3(c) With the increase of the length Uw, a new notched band is achieved, and we get the passband from 1.8 GHz to 2.0 GHz.

Fig. 3(c) shows the simulated reflection coefficients of the antenna 1. It can be observed that the antenna exhibits resonances around 3.3 GHz, and a wideband reflection coefficients performance below -10 dB from 2.0 GHz to 5.2 GHz. The length of W1 and the width of T1 control the width of the band and the centre frequency. The reflection coefficients of the antenna 3 with one U-shaped slot cut out of the E-shaped patch and two L-shaped slots out of the ground are shown in the Fig. 4. By etching an L-shaped slot on the ground, a band notched frequency is created, which is from 3.8 to 4.8 GHz. The shape and position of the L-shaped can be changed to control the width of the band and the centre frequency of the upper notch frequency. The U-shaped slot creates a stop band at the lower frequency. We can change the length of the Uw and Ut to tune the bandwidth and the centre frequency of the stop band. The photograph of the fabricated proposed antenna for multiband operation is shown in Fig. 4.

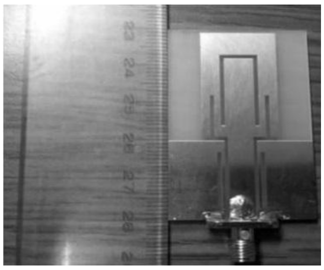
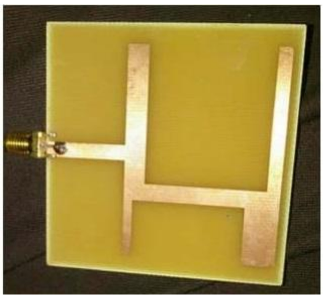


Figure 4. Photograph of the fabricated antenna [5]

In [6], authors discussed on design and analysis of a triple band inverted-H antenna for DCS, WiMAX and WLAN applications. This antenna is printed on an FR-4 substrate of dimensions 54.20mm×42.30mm×1.6mm. It functions in frequency bands 1.7 GHz, 2.6 GHz and 3.1 GHz. These bands cover DCS, WiMAX and WLAN applications. This antenna consists of an inverted-H shaped patch antenna fed by a 50 Ω microstrip line which are printed on the front side of the substrate and full ground plane on the back side of the substrate. The inverted-H shaped leads to a strong electromagnetic coupling to the feeding structure. Which then leads to the generation of multiband operation of the antenna. Generating triple frequency bands at DCS, WiMAX and WLAN by using inverted-H structure is an important thing to note. To fully reveal the working mechanism of the three bands based on the inverted-H structure, the first band for DCS; is generated based on the conventional width (W) and length (L) of the antenna. The second band which is for WiMAX application; is created based on the width (W1) and length (L1) of the left part of the inverted-H structure of the patch antenna. While the third band of WLAN application is generated based on the width (W2) and length (L2) of the right part of the inverted-H structure of the patch antenna. The proposed antenna is designed in commercially available Computer Simulation Technology (CST) at three operating frequencies of 1.7 GHz, 2.6 GHz, and 3.1 GHz.



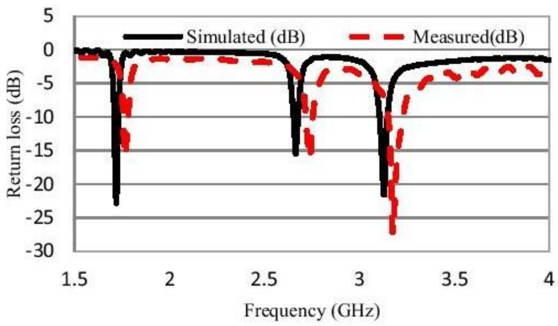
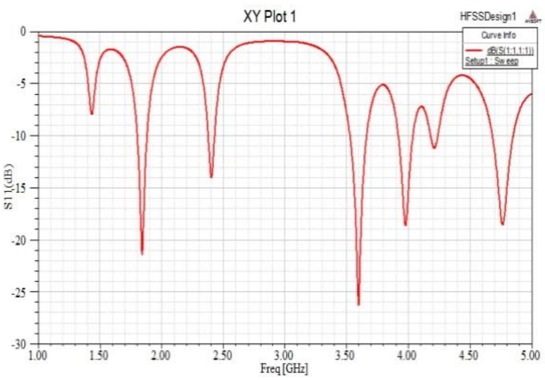


Figure 5. (a) Fabricated inverted-H antenna [6]. (b) Return loss of the inverted –H antenna [6].

A compact design of multiband microstrip patch antenna for GSM, Bluetooth and WiMAX applications in [7]. This antenna consists of a microstrip line fed rectangular patch is printed over an FR-4 substrate of thickness 3 mm and permittivity of the substrate is 4.4. The substrate size is selected as 65.2mm×76.6mm to provide enhanced bandwidth response. The antenna can efficiently support for 6 different bands with their centre frequencies as 1.84 GHz, 2.4 GHz, 3.6 GHz, 3.98 GHz, 4.22 GHz and 4.76 GHz coming under the bands of different wireless applications as GSM 1800, Bluetooth, WLAN/WiFi, WiMAX II and some defense applications such as radio navigation. Fig. 6(b) shows the fabricated antenna.



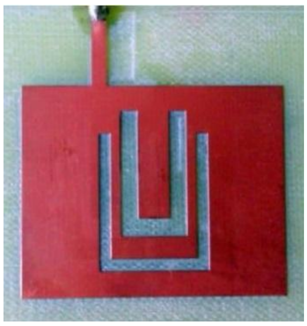
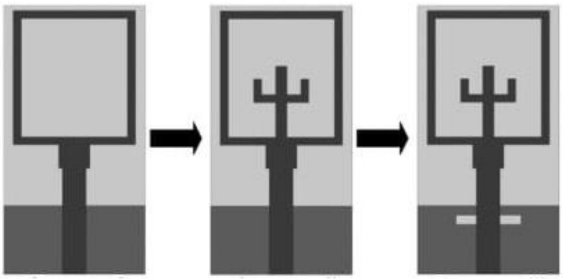


Figure 6. (a) Simulated reflection coefficient [7]. (b) Photograph of the fabricated antenna [7].

first, the simple rectangular patch is designed for the resonant frequency of 1.88 GHz. Then, two U- slots are introduced one by one and optimized so that to provide the multiband response. Since edge feeding is used, the impedance matching is provided by varying the feed position along the y-axis. Thus, the antenna exhibits good reflection response for the 6 different bands, exhibiting the reflection coefficient to be less than - 10 dB. The simulated results (the reflection coefficient) obtained using ANSYS HFSS are shown in Fig. 6(a).

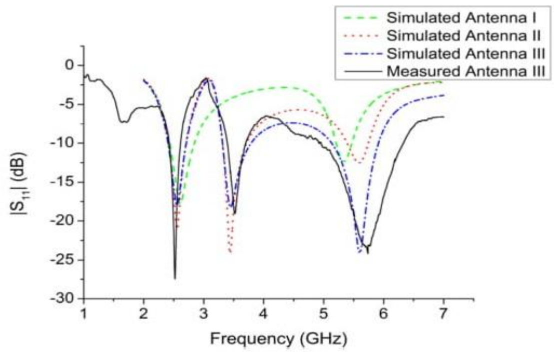
A compact triple-band printed monopole antenna for WLAN/WiMAX applications is discussed in [8]. A new microstrip-fed modified rectangular ring antenna is presented for WLAN and WiMAX applications in this letter. It has a smaller size than the antenna mentioned above. This antenna is printed on an FR-4 substrate of dimension 18mm×34mm×1.6mm. It functions in frequency bands ranging from 2.4 GHz to 2.7 GHz and 3.4 GHz to 3.7 GHz and 5.0 to 6.0 GHz with peak gains are 0.10–0.28, 0.24–1.42, and 2.67–4.76 dBi respectively.

The compact radiator is connected with a 50 Ω microstrip line and is composed of a modified rectangular ring and a fork-shaped strip. By introducing a modified rectangular ring strip and adding a fork-shaped strip and a defected ground, a significant triple band is obtained, which can satisfy both WLAN and WiMAX system. The parameters of the designed antenna are simulated and optimized by ANSYS HFSS software. The design process is presented in Fig. 7(a) and its corresponding |S11| curves are presented in Fig. 7(b). The antenna I is a modified rectangular ring printed monopole antenna, which has a strip printed under the rectangular ring. It is a common compact antenna with a simple structure and has two operating bands 2.43–2.84 and 5.21–5.47 GHz. By attaching a fork-shaped strip, another resonant mode is excited, which makes the antenna achieve three bands. Three frequency bands of Antenna II are observed as follows: 2.41–2.70, 3.32– 3.72, and 5.39–5.74 GHz. To make the antenna achieve better impedance matching at the higher band, a rectangular slot is etched on the ground plane. The antenna was fabricated and measured.



Antenna I Antenna II Antenna III

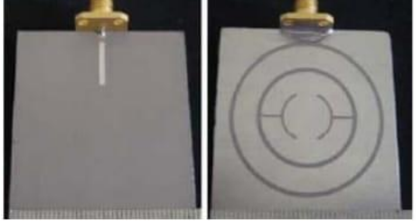
(a)



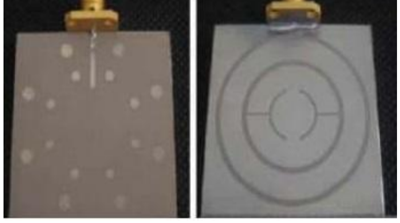
(b)

Figure 7. (a) Design process of the proposed antenna [8].
(b) Simulated |S11| and measured|S11|of the proposed antenna [8].

In [9], authors focus on two compact triple band microstrip annular ring slot antennas for PCS 1900, WLAN 2.4 GHz and 5 GHz band applications. In the two antennas, radiation performance of the first one (Antenna I) is improved by inserting circular Photonic Bandgap (PBG) structures on the second one's top layer. These structures also help in reduction of antenna sizes. In the proposed antennas, ground planes consist of three annular ring slots as shown in Fig. 8. The outer rings are responsible to generate the first resonating mode, whereas the middle rings yield the second resonating mode. The inner rings produce a wide upper operating band by combining the third and fourth resonating modes.



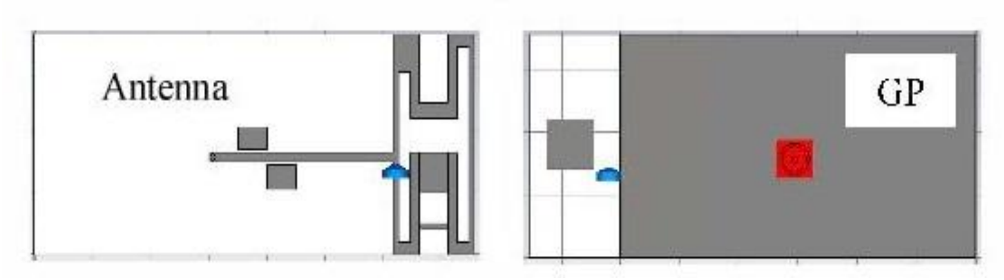
(a) Antenna I



(b) Antenna II

Figure 8. Structures of annular ring slot antennas [9].

In [10], the design of a wideband planar monopole antenna for GSM 1800 and 1900, GPS, Wi-Fi, WiMAX, UMTS and LTE applications is discussed. This antenna is covering –6 dB impedance bandwidth frequencies ranging from 1.33 GHz to 4.76 GHz as shown in Fig. 10. It yields a peak gain of 3.85 dBi and a peak directivity of 5.04 dBi at 2.7 GHz. The proposed antenna is printed on a dielectric substrate of dimensions 35.5mm×75.5mm×0.87mm. In this antenna design, the impedance bandwidth is enhanced by adding two parasitic elements near the feeding line for capacitive effect and a series capacitor on the loop monopole to maintain the impedance matching.



(a) Top view (b) Bottom view

Figure 9. Structure of the proposed monopole antenna [10].

Fig. 9 present the top view and bottom view of the antenna. For feeding arrangement, coaxial connector is used and the antenna feeding is comes from the bottom of the antenna, shown in Fig. 9. Overall dimension of the substrate is 35.5 mm x 60.5 mm and the antenna radiator dimension is 44.9 mm x 35.5 mm. Dimension of the feeding arrangement is 10.5 mm x 31.4 mm; here all values are in mm. The values of the capacitor C is 2 nF and is placed by creating a gap of I mm.

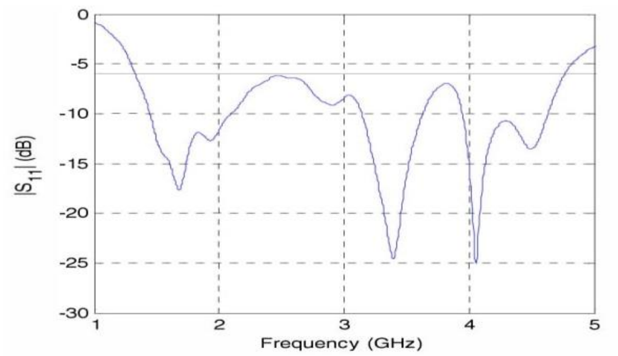
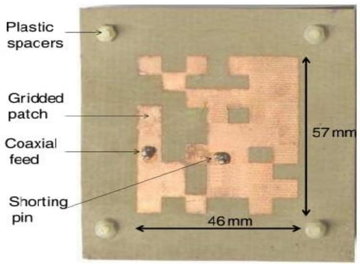
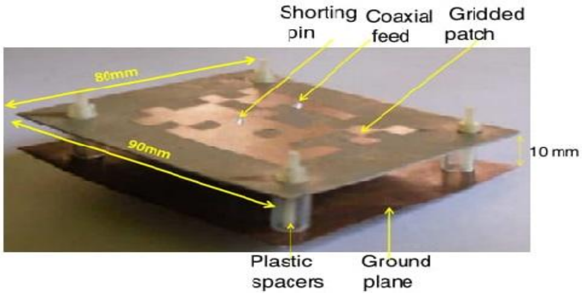


Figure 10. Reflection coefficient curve of the antenna [10].

In general, wideband microstrip antennas also cover frequencies other than the required ones. For example, the proposed antenna [14] is operating in a frequency band ranging from 1.61 GHz to 14.7 GHz, which includes many unnecessary frequencies for portable system applications. Hence, these kinds of antennas may face a problem of interference. So, to overcome these problems and to cover many wireless applications dual, triple and multiband antennas may be preferred. We investigated numerous dual, triple and multiband microstrip antennas reported in [24]-[61]. Among them, various dual band antennas are studied in [24]-[36] for different wireless applications. In [25], authors discussed a simple design of multiband microstrip patch antenna by using genetic algorithm optimization method. This antenna is able to obtain dual bands from 880 MHz to 960 MHz and 1700 MHz to 2520 MHz, which can be used for GSM, UMTS, LTE and Bluetooth applications. In the paper, authors initially presented a single band rectangular patch antenna that covers a frequency band of 2090 MHz to 2300 MHz. Then, it is modified by using a generic algorithm optimization procedure to obtain the proposed antenna. In this method, the patch area is divided into a number of small overlapping cells as shown in Fig. 11. A shorting pin is also inserted in the proposed structure for better impedance matching.



(a) Top view

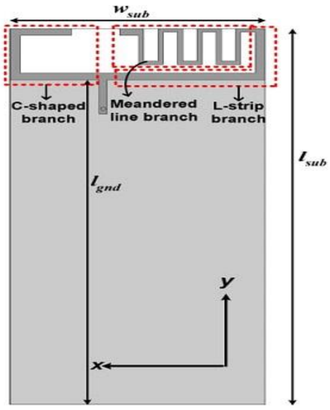


(b) 3D view

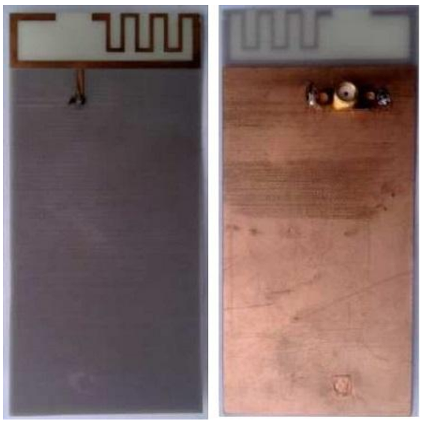
Figure 11. Photo of the fabricated antenna [25].

In [26], authors focussed on a compact multiband planar monopole antenna for ultra slim mobile handset applications. This antenna is printed on an FR-4 substrate of dimensions 50mm×110mm×0.8mm. It functions in frequency bands ranging from 0.885 GHz to 0.962 GHz and 1.69 GHz to 3.8 GHz with −6 dB as impedance bandwidth cut-off. These bands cover GSM 900, GSM 1800, GSM 1900, UMTS, IMT 2100, WLAN, WiMAX along with the LTE bands of modern mobile phone applications.

This antenna consists of two resonating branches, one is a C-shaped branch and another one has meandered line branch connected with L-strip as shown in Fig. 12(a). The C-shaped branch is responsible to obtain the higher frequency band while the meandered line branch with L-strip is responsible for the lower frequency band. The electrical length of the C-shaped branch is approximated as λ/4 at the lower edge of a higher frequency band and the electrical length of the meandered line branch is approximated as 3λ/8 at the lowest resonant frequency [62]. The shape parameters of the antenna are optimized using FEM (Finite Element Method) based ANSYS HFSS [73]. The proposed antenna performance is investigated in free space as well as in actual mobile environment consisting of mobile plastic housing along with large metallic display screen and battery.



(a)



(b)

Figure 12. (a) Configuration of the proposed antenna [26].
(b) Photograph of the fabricated prototype [26].

The authors presented a classical multiband antenna for LTE/GSM/UMTS bands in [32]. It incorporates a multiband antenna that tunes over the hepta-band in LTE/GSM/UMTS services. The proposed antenna is modeled and fabricated on an FR-4 substrate (ε_r = 4.4; tan δ = 0.02). The antenna is designed on an FR-4 substrate of (ground plane) dimension is 55 × 110 × 1 mm^3, and that of the patch dimension is 55× 12 × 4 mm^3. The patch is composed of a folded-loop and a meandered planar inverted-F antenna (MPIFA) with an additional branch line. The folded-loop has large thickness of 4 mm [69]-[71], due to this it has a wide bandwidth characteristics and operates at the high resonances, which covers GSM1800 (1710–1880 MHz), GSM1900 (1850–1990 MHz), UMTS (1920–2170 MHz), LTE2300 (2305–2400 MHz) and LTE2500 (2500–2690 MHz).

On the other hand, the right side structure shown in Fig. 13 that made up of an MPIFA with an additional branch line and operates at the lower resonances, which covers GSM850 (824–894 MHz) and GSM900 (880–960 MHz) [64]–[68]. The traditional PIFA suffers from lack of frequency bandwidth for wireless communication. To overcome the drawback of traditional PIFA, the proposed MPIFA introduces a supplementary branch line in the patch which can further increase the bandwidth of the antenna. The parallel capacitance is placed between the supplementary branch line and the ground, due to this parallel capacitance the structure creates extra resonance [72]. The reported antenna fulfills the return loss bandwidth of 6 dB in all operating frequency bands and it reveals near-omnidirectional radiation patterns. In this work, the author used the software HFSS v.14.0.0 by ANSYS for the modeling and simulation of the proposed antenna [73].

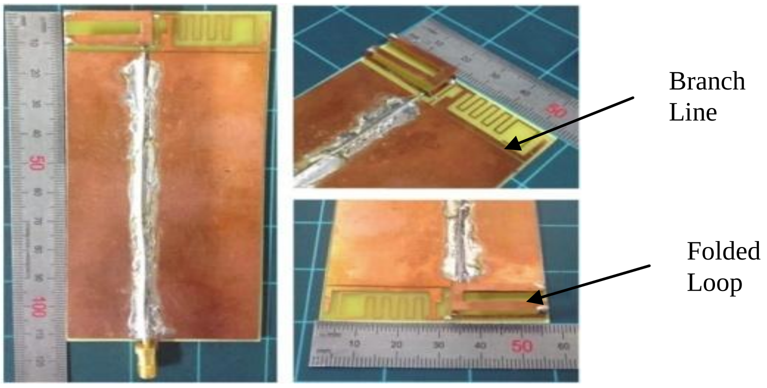


Figure 13. Photograph of the fabricated antenna [32].

. We also studied different multiband patch antennas reported in the literature [53]-[61]. These patch antennas basically operate in more than three bands. A microstrip-fed hybrid slot and strip antenna are proposed for GSM, GPS, UMTS, LTE, WLAN and WiMAX applications in [53]. The proposed patch antenna is printed on a dielectric substrate of dimensions 40mm×120mm×0.8mm. This antenna is achieving four bands between a frequency spectrum of 0.8 GHz to 6 GHz, which includes GSM, GPS, LTE 2300, WLAN 2.4 GHz, UMTS and WiMAX applications as shown in Fig. 14. In the antenna design, three monopole slots on the ground plane and two parasitic strips on the microstrip structure are used to achieve required multibands. Lengths of the three monopole slots are equal to the quarter of a guided wavelength, while lengths of parasitic strips are about half of the guided wavelength at respective resonant frequencies.

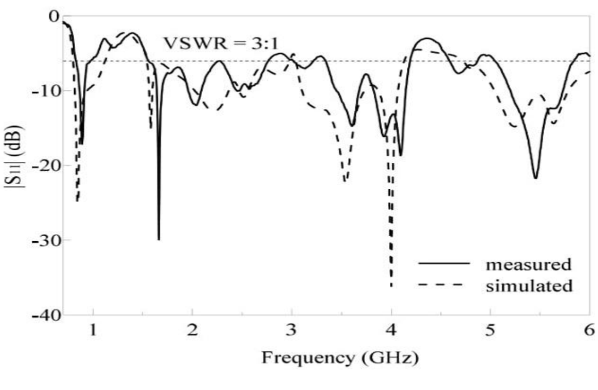
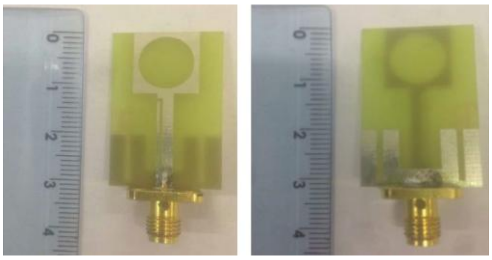


Figure 14. Measured and simulated reflection coefficient curve of the proposed antenna [53].

In [54], a compact quad-band slot antenna for integrated mobile devices is proposed. This antenna is printed on an FR-4 substrate of dimensions 30mm×20mm×1.6mm. It consists of a dielectric substrate, T-shaped microstrip patch with a circle slot and an inverted L-slot, and a comb-shaped ground on the back of the substrate as shown in Fig. 15. These all structures are adapted to produce four different bands while maintaining a small size and a simple structure. This antenna can operate over the 1.79 GHz to 2.63 GHz, 3.46 GHz to 3.97 GHz, 4.92 GHz to 5.85 GHz, and 7.87 GHz to 8.40 GHz bands. These bands cover PCS, UMTS, WCDMA, Bluetooth, Wi-Bro, WLAN, WiMAX, and X-band. The T-shaped radiating patch without slots and a comb-shaped ground structure are capable of producing two wide bands ranging from 1.92 GHz to 3.09 GHz and 4.77 GHz to 6.81 GHz. The 3.5 GHz resonant mode is accessed by an inverted L-slot on the narrow rectangle of the T-shaped radiation patch. A circular slot is designed on the broad rectangle of the T-shaped patch to yield a resonance operating in 8 GHz band.



(a) Top view (b) Bottom view

Figure 15. Fabricated prototype [54].

In [55], a quad-band microstrip antenna for GSM 900, DCS 1800, LTE 2300, WLAN 2.4 GHz and WiMAX 3.5 GHz applications is discussed. This antenna is fabricated on an FR-4 substrate of dimensions 60mm×50mm×1.6mm as shown in Fig. 16. The top layer consists of three monopoles in which the first one is loaded with an inverted U-shaped stub to work in GSM and DCS bands. The second and third ones are L-shaped monopoles responsible to generate WLAN and WiMAX bands, respectively. The antenna is achieving quad bands ranging from 860 to 938 MHz, 1.75 to 1.91 GHz, 2.26 to 2.6 GHz and 3.46 to 3.55 GHz. In the paper, authors also reported reconfigurable patch and MIMO antennas for the intended applications.

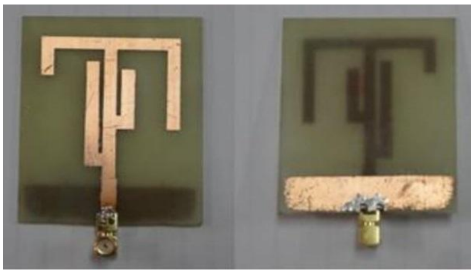


Figure 16. Photograph of the fabricated prototype [55].

A novel multiband planar antenna with a compact size of dimensions 40mm×24mm is proposed in [56] for mobile terminals. In the proposed antenna, the top layer consists of a monopole patch with two slots and a meandering strip. The bottom layer consists of two parasitic stubs and a branch. These structures are used to adjust and widen the impedance bandwidth. The slots on the active patch are employed to access multiband characteristics. The simulated and measured S11 of the proposed antenna is shown in Fig.17. The antenna operates in frequency bands ranging from 450 MHz to 474 MHz, 860 MHz to 1040 MHz, 1705 MHz to 2428 MHz, and 2500 MHz to 2710 MHz as shown in Fig. 17. These bands cover GSM 900, DCS, PCS, UMTS, LTE 2500, and the LTE low-frequency band of 450 MHz to 470 MHz. The monopole patch with two L-form slots is used to generate three resonating bands. The LTE low-frequency band is accomplished by using a meandering line loaded on the monopole patch.

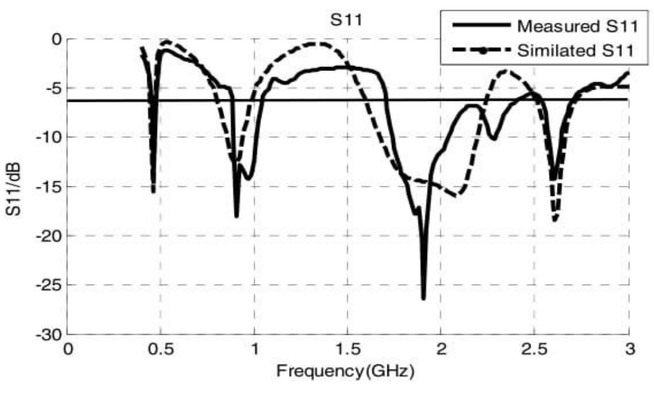


Figure 17. Simulated and measured S11 of the proposed antenna [56].

In fact triple, quad and other multi-band antennas serve very well for multiple wireless applications. However, as the number of operating bands increase antenna designers may lose control over the bandwidths. It means that they may get bands more or less than the actual bands. For example, the proposed quad-band antenna in [55] is supposed to cover GSM 900 band. Here, this antenna is operating from 860 to 938 MHz. But, the actual GSM 900 band is from 890 to 960 MHz. Therefore, the antenna lost few channels in the higher band. The same antenna is able to obtain 1.75 to 1.91 GHz operating band for GSM 1800. But, the actual GSM 1800 band is from 1710 to 1885 MHz. In this case, the antenna is achieving more band than the required one at the higher end. However, this is not a drawback of multiband antennas but an example to explain the limitation on control over the bands.

III. CONCLUSION

This paper investigates various kinds of multiband microstrip antennas for portable wireless communication system applications, which include GSM, WLAN, LTE, and WiMAX. In the first section, basic concepts of portable systems and their frequency bands are discussed. In the second section numerous single, dual, triple and multi-band conventional microstrip antennas are studied. In this study, different techniques to obtain single and multi-bands are also discussed. The study also explains advantages and limitations of all the antennas. In the end, it is observed that multiband antennas are good candidates for multiple applications. In today's wireless communication systems multiple applications adopt multiple antennas at various locations of portable systems. Finally, this paper provides a strong background for the antenna researchers to explore and design suitable multiband microstrip antennas for portable wireless system applications.

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