A compact dual band PIFA antenna for GPS and ISM BAND applications

Samir El Kilani¹, Larbi El Abdellaoui², Jamal Zbitou³, A.Errkik⁴, Mohamed Latrach⁵
¹,²,³LMEET FST of Settat, University of Hassan 1st, Morocco
⁴Microwave group, ESEO ANGERS, France

ABSTRACT
This work deals with design of a novel compact Dual band PIFA Antenna structure. The proposed antenna is validated for GPS and WIFI applications. The antenna is achieved on a lossy FR4 substrate. The final size of the antenna is 100×55×13.235 mm³. The final antenna structure was optimized and validated into simulation, fabrication and test. The proposed multiband PIFA is optimized by using solts technique. The fabricated antenna is validated to cover the operating frequencies of GPS (1.535-1.7GHz) and BLUTOOTH/WIFI (2.54-2.47GHz) bands.

Keywords: Bluetooth/wifi, GPS, Microstrip patch antenna, Multiband antennas, PIFA

1. INTRODUCTION
Actually, the developpement of mobile stations and equipment for wireless communications have known many update working in many frequency bands. The demand then for multiband components is increasing which will permit to miniature the final wireless device. Among the critical circuits for wireless communications we find the antenna, thererfore to communicate in serveral frequency bands we need to have a multiband antenna which reduce significantly the seize of a mobile wireless device. To achieve such circuit, we can find different methods and techniques which can be used like the use of slot techniques [1]-[3] and fractal technique [4]. Among the common multiband antennas we find the IFA [5]-[9]. In this paper we have conducted a study on the design of a new antenna structure which can operate in the GPS and ISM “Industrial and Medical Bands”. The following sections will describe how to design such circuit.

2. PLANAR INVERTED F ANTENNAS
The Inverted F Antenna (IFA) as shown in Figure 1, typically consists of a rectangular planar element located above a ground plane, a short circuiting plate or pin, and a feeding mechanism for the planar element.
A compact dual band PIFA antenna for GPS and ISM BAND applications (Samir El Kilani)

The substrate used is usually the air in order to improve the performances of the antenna. This is in fact placed at a point where the electric field of the fundamental mode is zero. Now for the PIFA as depicted in Figure 2, the principle of these antenna has been widely exploited in the literature. This kind of Antennas is Multi-band and have been developed for mobile phone applications. As mentioned in Figure 2, the PIFA Antennas are then associated with slots, capacitive loads and parasitic patches Short-circuited to achieve a multiband behavior.

The input impedance matching is adjusted by positioning the feed point and the shorting pin.

3. DESIGN PROCEDURES

In order to design the PIFA proposed antenna, we have started this study by using the optimization methods integrated in the electromagnetic solver. The antenna is designed and mounted on a lossy FR4 substrate with a thickness of 1.6 mm, a dielectric relative permittivity, $\varepsilon_r = 4.4$, and loss tangent of 0.025. After many series of optimization we have developed and validated the antenna presented in Figure 3. This figure illustrates the different views.
The radiator the position the feed probe was optimized following a parametric study on the position of the probe and the height of P11 face. The input impedance is matched for 50 Ohm. The radiating element and the short-circuit plate are all having 0.035 mm as a metal thickness the different optimized parameters are listed in Table 1.

| Parameter | Value | Parameter | Value |
|-----------|-------|-----------|-------|
| L         | 100   | P7        | 20    |
| W         | 55    | P8        | 3     |
| P1        | 38.4  | P9        | 13.235|
| P2        | 3     | P10       | 26.765|
| P3        | 38    | P11       | 4     |
| P4        | 32    | P12       | 13.5  |
| P5        | 3     | P13       | 23    |
| P6        | 23    | P14       | 13.235|

As presented in Figure 4, the optimized proposed antenna presents a good matching input impedance for three bands GPS at 1.57 GHz, ISM at 2.45 GHz and Wlan at 3.8 GHz with level of the reflection coefficient which is below -10dB.

![Figure 4](image-url)

Figure 4. Reflection coefficient of the proposed multiband PIFA Antenna versus frequency

Figure 5 shows the simulated three-dimensional 3D radiation patterns of the proposed antenna at three resonant frequencies 1.65 GHz and 2.458GHz. We can conclude that the proposed antenna can radiate Bidirectional pattern at all the operating frequency bands.

![Figure 5](image-url)

Figure 5. The simulated radiation patterns of the proposed multiband PIFA antenna at different resonant frequencies
And for the surface current density, Figure 6 shows the simulated surface current distributions of the multiband planar antenna at three resonant frequencies 1.65 and GHz, 2.458 GHz. As we can see the surface current are concentrated around the radiating element.

![Simulated surface current distributions of the multiband planar antenna at different resonant frequencies](image)

**Figure 6. Simulated surface current of the proposed multiband PIFA antenna at different resonant frequencies**

### 4. FABRICATION AND TEST

After the validation of the PIFA antenna into simulation, we have conducted the achievement and fabrication of the final circuit as depicted in Figure 7. The fabrication of such volume isn’t easy because we have fabricated each face separately and after that we have associated them.

![Photograph of the fabricated PIFA antenna](image)

**Figure 7. Photograph of the fabricated PIFA antenna**

The problem of such realization is that we have a 3D structure which can influence the precision. After the association of each face we have tested this antenna by using a Vector Network Analyser from Agilent with 3.5 mm calibration Kit. As shown in Figure 8, the antenna operates in three bands, the first one is [1.535-1.7 GHz] the second one is [2.54-2.47 GHz], and the third one is reserved for the WLAN around 3.8 GHz. As illustrated in the comparison between simulation and measurement results we can conclude that we have a good agreement which valid the multiband behavior of the proposed PIFA antenna.

![Comparison between simulation and measurement of the reflection coefficient](image)

**Figure 8. Comparison between simulation and measurement of the reflection coefficient**
The radiating pattern of the manufactured antenna has been measured inside the anechoic chamber for the frequencies: 1.45, 1.535, 1.657, 2.363, 2.485 GHz in E-plane and H-plane. In the H-plane the antenna presents a bidirectional pattern, in all frequencies existing in the operating spectrum, due to ground chosen in the bottom of the substrate. Also the radiation is bidirectional in E-plane in the frequencies 1.45, 1.535, 1.657 GHz. Radiating pattern as shown in Figure 9 and 10.

![Radiating pattern of 1.45, 1.535, 1.657, 2.363, 2.485 GHz in H-plane](image1)

![Radiating pattern of 1.45, 1.535, 1.657, 2.363, 2.485 GHz in E-plane](image2)

Figure 9. Radiating pattern of 1.45, 1.535, 1.657, 2.363, 2.485 GHz in H-plane

Figure 10. Radiating pattern of 1.45, 1.535, 1.657, 2.363, 2.485 GHz in E-plane

5. CONCLUSION

This work has presented a new study on a new configuration of PIFA, the proposed antenna was validated in simulation, by fabrication and test. The final circuit operates in three frequency bands (1.535 - 1.7 GHz), (2.54 - 2.47 GHz) bands which covers GPS / BLUETOOTH / WIFI for mobile communications and for Wlan. The fabricated antenna is tested in Anechoic chamber which validate the radiation pattern of the antenna which is bidirectional for the different frequency band. This antenna can be designed following the same steps for other frequency bands.

REFERENCES

[1] K. Rama Krishna, G Sambasiva Rao, P.R.Ratna Raju, " Design and Simulation of Dual Band Planar Inverted F Antenna (PIFA) For Mobile Handset Applications” International Journal of Antennas (JANT) Vol.1, No.1, October 2015.

[2] I. Zahraoui, A. Errkik, M. C. Abounaima, A. Tajmouati, L. E. Abdellaoui, M. Latrach” A New Planar Multiband Antenna for GPS, ISM and WiMAX Applications” International Journal of Electrical and Computer Engineering (IJEC), Vol. 7, No. 4, August 2017, pp. 2018-2026.

[3] S. Yang, C. Zhang, H. Pan, A. Fathy and V. Nair, “Frequency-reconfigurable antennas for multiradio wireless platforms,” IEEE Microwave Magazine, vol. 10, pp. 66-83, 2009.
A compact dual band PIFA antenna for GPS and ISM BAND applications

(Received: 10 November 2019; Revised: 24 February 2020; Accepted: 24 February 2020)

Samir El Kilani was born in Oued Zem, Morocco, in 1 of June 1988. He received the Master degree in Electronics Electrical Engineering Automatics Industrial Computing from the Faculty of AIN CHOCH, Casablanca in Morocco. He is currently working toward the Ph.D. degree in communication engineering at Faculty of Sciences and Techniques, University Hassan 1st in Settat, Morocco. He is involved in the design of microwave hybrid circuits and antennas.

Larbi El Abdellaoui was born in Tiflet, Morocco, in 1961. He received the Ph.D. degree in electronics from the University of Metz, in 1994, France. He is currently an associate Professor of physics in Faculty of Sciences and Techniques, University Hassan 1st, Settat, Morocco. He is involved in the design of hybrid, monolithic active and passive microwave electronic circuits.

Jamal Zbitou was born in Fes, Morocco, in June 1976. He received the Ph.D. degree in electronics from Polytech of Nantes, Nantes, France, in 2005. He is currently an associate Professor of Electronics in FST, University of Hassan 1st, Settat, Morocco and the head of Computing Networks and telecommunication in LMEET Laboratory in FSTS. He is involved in the design of hybrid, monolithic active and passive microwave electronic circuits.

Ahmed Errkik was born in July 1960 in Morocco. He received the Ph.D. degree in physics from the University of Technology Compiègne (UTC), Compiègne, France. He is currently an associate Professor of physics in FST University Hassan 1st, Settat, Morocco, and he is the head of the laboratory LMEET. He is involved in the design of hybrid, monolithic active and passive microwave electronic circuits.

Mohamed Latrach was born in Douar Ksiba, Sless, Morocco, in 1958. He received the Ph.D. degree in electronics from the University of Limoges, Limoges, France, in 1990. He is currently a Professor of microwave engineering with the Ecole Supérieure d’Électronique de l’Ouest (ESEO), Angers, France, where his research involves RF and microwaves. His field of interest is the design of hybrid, monolithic active, and passive microwave circuits, metamaterials, LH materials, antennas and their applications in wireless communications, and wireless power transmission.