Design of A Filtering Monopole Antenna with Wideband Harmonic Rejection

Jiaxu Li, Junhao Shi, Zhenghang Nie
School of Electronic Engineering, Xidian University
No. 2 Taibai South Road, Xi'an 710071, Shaanxi, China
ljx_0215@163.com

Shaobo Ma, Huiqing Zhai
School of Electronic Engineering, Xidian University
No. 2 Taibai South Road, Xi'an 710071, Shaanxi, China

***Abstract*—This paper proposes a novel filtering monopole antenna with wideband harmonic rejection, which is realized by a monopole antenna based on a compact lowpass filter (LPF). The proposed filtering antenna has a wideband harmonic rejection from 2.68GHz up to 15GHz. The antenna with 3dB cutoff frequency at 2.68GHz operates normally from 1.95GHz to 2.45GHz. The designed filtering monopole antenna effectively exhibits 6.8 times of the central operating frequency and its attenuation level is less than -15dB.**

***Keywords*—lowpass filter (LPF); wideband harmonic rejection; filtering monopole antenna.**

I. INTRODUCTION

With more and more scientific and technological needs, devices that have been applied to various frequency bands have been emerged. At present, traditional single-function antennas can no longer meet the increasingly complex and diverse needs. In order to adapt to the development of modern communication equipment, filtering antennas have gradually gained people's attention.

In addition, many kinds of filters and simple monopole antenna are designed in [1]-[6]. An effective way to achieve a filtering antenna is to add a filter to the feedline of a antenna. This method does not affect the radiating structure of the antenna, so it has little effect on the antenna's radiation characteristics. At the same time, the filter and the antenna can be designed independently, and it is easy to achieve flexible and variable filter characteristics. Such as antenna-loaded resonators implement filter antennas in [7]-[8], but these antennas cannot suppress the interference of the higher frequency band. In [9], loading of a microstrip resonator element with filtering characteristics on a coplanar waveguide to achieve a filtering antenna.

In this paper, a filtering antenna cascaded by a novel compact lowpass filter and a monopole antenna with wideband harmonic rejection and high selectivity is presented.

II. DESIGN AND ANALYZE OF THE PROPOSED LOWPASS FILTER

The structure of the compact lowpass filter is shown in Fig.1. The filter is composed of three resonators including resonator1, resonator2 and resonator3. In addition, the recommended parameters of the filter are shown in Table Ⅰ. The substrate has a relative dielectric constant of 3.38. The size of the proposed filter is 17.2mm×16mm×0.508mm.

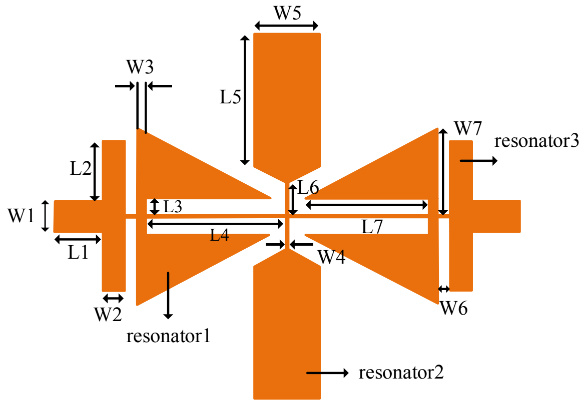
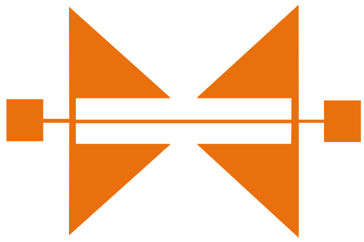


Fig.1. Layout of the lowpass filter using three resonators

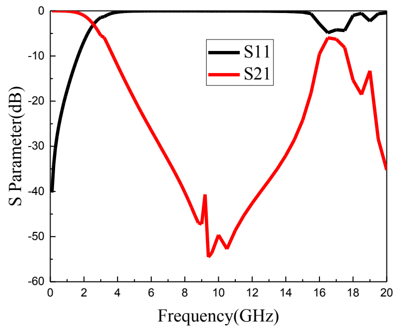
TABLE I
The Recommended Parameters(unit: mm)

Parameter	W1	W2	W3	W4	W5
Value	1.16	0.8	0.32	0.08	2.4
Parameter	W6	W7	L1	L2	L3
Value	0.48	0.8	1.76	2.22	0.64
Parameter	L4	L5	L6	L7	
Value	5.2	4.92	1.22	4.59	

The Fig.2(a) shows the structure of the filter which only has resonator1. Fig.2(b) shows the result of the structure in Fig.2(a).



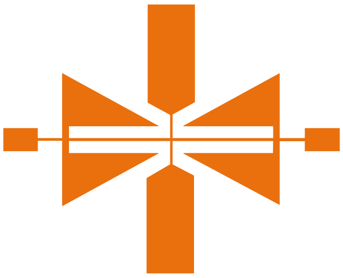
(a)



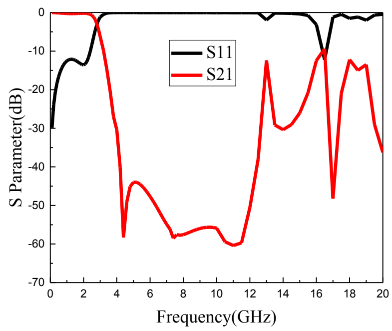
(b)

Fig.2 (a) Layout of filter with only resonator1 (b) Simulation result

Fig.3(a) is the filter with both resonator1 and resonator2. As can be seen in Fig.3(b) that the selectivity of the filter in Fig.3(a) is significantly improved.



(a)



(b)

Fig.3 (a) Layout of filter with both resonator1 and resonator2 (b) Simulation result

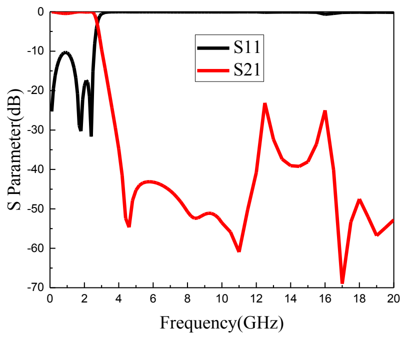


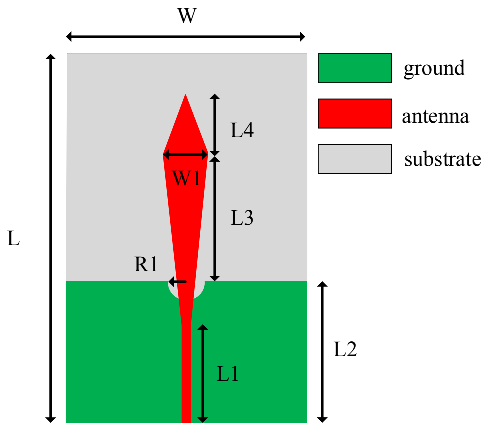
Fig.4 Simulation result of LPF

Furthermore, the simulation result of the proposed filter with three resonators is shown in Fig.4 which shows that the resonator3 enable suppress high-frequency signal and expand the bandwidth of the stopband.

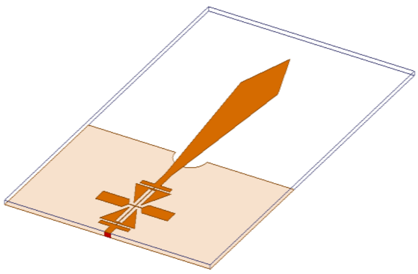
The proposed lowpass filter has compact size, high selectivity and wide stopband. The attenuation level of the wide stopband from 3.43GHz up to 20GHz is less than -15dB.

III. Design and Analysis of the Proposed Filtering Antenna

The commom monopole antenna (MA) generally has a simple structure, narrow working bandwidth and higher harmonics. It is difficult for the common monopole antenna to achieve a wideband harmonic rejection unless some new structures are added. In this paper, a common monopole antenna and the proposed filter are cascaded to obtain a novel filtering monopole antenna (FA) with wideband harmonic rejection. The Fig.5 (a) is a common monopole antenna which has higher harmonics and its recommended parameters are listed in Table II .The Fig.5(b) shows the structure of the filtering monopole antenna.



(a)



(b)

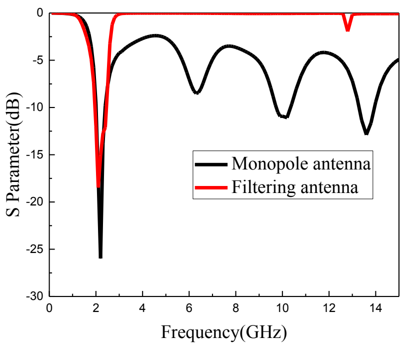
Fig.5 (a) Structure of the monopole antenna (b) Structure of the filtering monopole antenna

TABLE II
The Recommended Parameters (unit: mm)

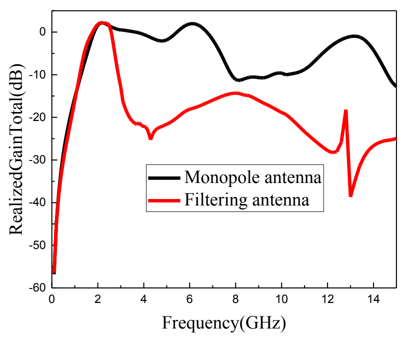
Parameter	W	L	W1	L1
Value	39	60	7	16
Parameter	R1	L2	L3	L4
Value	3	23	21	9.5

The lowpass filter (LPA) is loaded on the feedline of monopole antenna in order to miniaturize the filtering antenna. Both the filter and the monopole antenna have the same substrate with a relative dielectric constant of 3.38. The size of the proposed filtering monopole antenna is 62.8mm×39mm×0.508mm.

The Fig.6(a) is the comparison of the S11 between the monopole antenna and the filtering antenna. Both antennas work at the frequency from 1.95GHz up to 2.45GHz. It is obvious that the monopole antenna has three higher harmonics respectively at 6.3GHz, 10GHz and 13.6GHz. However, the proposed filtering antenna eliminates the three higher harmonics.



(a)



(b)

Fig.6 (a) S11 of the two antennas (b) RealizedGain of the two antennas

In Fig.6(b), the proposed antenna has a high seclectivity and its the attenuation level of the stopband from 2.68GHz up to 15GHz is less than -15dB. The novel filtering monopole antenna decreases average 10dBi comparing with the common monopole antenna.

IV. Conclusion

In this paper, a novel filtering antenna with wideband harmonic rejection from 2.68GHz up to 15GHz based on a compact lowpass filter is presented. The novel antenna decreases average 10dBi comparing with the common monopole antenna and its the attenuation level of the stopband is less than -15dB. The wideband harmonic rejection of the designed antenna effectively exhibits 6.8 times of the central operating frequency.

References

[1] Haifei Cui, Jianpeng Wang and Gang Zhang, "Design of microstrip lowpass filter with compact size and ultra-wide stopband," ELECTRONICS LETTERS, Vol. 48, pp. 14-15, 2012.

[2] Qun Li , Yonghong Zhang, Daotong Li, Kaida Xu, "Compact low-pass filters with deep and ultrawide stopband using tri- and quad-mode resonators," IET Microwaves, Antennas & Propagation, Vol. 11,pp. 734-748, 2017.

[3] Akram Sheikhi, Abbas Alipour, and Abdolali Abdipour, "Design of Compact Wide Stopband Microstrip Low-pass Filter using T-shaped Resonator". IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, Vol. 27, pp. 2-3, 2017.

[4] Sunil Kumar Singh, Mahaveer Prasad Sharma and Nitesh Kumar Kashyap, "A modified planar triangular monopole antenna for wide band applications," International Conference on Industrial Conference on Industrial and Information Systems(ICIIS), pp. 598-602, 2016.

[5] Oindrila Bhunia and Budhadeb Maity, "Design of Compact Microstrip Omnidirectional Wideband Monopole Antenna," International Conference on Communication and Signal Processing, pp. 6-8, 2017.

[6] Hamidreza Dalili Oskouei and Alireza Mirtaheri, "A Monopole Super Wideband Microstrip Antenna with Band-notch Rejection," Progress In Electromagnetics Research Symposium, pp.2019-2023, 2017.

[7] X. H. Wu, Q. X. Chu, "Compact ultra-wideband antenna with dual sharp notch-bands using integrated bandstop filter, IEEE Asia-Pacific Conference on Antennas and Propagation, pp. 255-256,2012.

[8] D. Feng, H. Q. Zhai, L. Xi, K. D. Zhang, D. Yang, "A new filter antenna using improved stepped impedance hairpin resonator," Microwave and Optical Technology Letters, pp. 2934-2938, 2017.

[9] Z. Ma, G. A. E. Vandenbosch, "Wideband Harmonic Rejection Filtenna for Wireless Power Transfer," IEEE Transactions on Antennas and Propagation, vol. 62, pp. 371-377, 2014.