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A Novel Microstrip Dual-Mode Band-pass Filter For 2^{nd} Harmonic Suppression

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Abstract

A novel design scheme has been introduced in this paper to suppress 2^{nd} harmonic from response of band-pass filter (BPF) which appears at about $2f_o$. The filter is composed of perturbed, square-ring resonator and $\frac{\lambda_{g2}}{4}$ open end stup length where λ_{g2} wavelength for 2^{nd} harmonic located on the output feeder port work as Band Stop Filter. The 2^{nd} harmonic suppression of the BPF may be realized by choosing a proper length of the open stup which is equal to $\frac{\lambda_{g2}}{4}$. The BPF investigated is for more frequencies such as (GPS, ISM, RFID, and GSM).

The performance of BPFs with open stup structures has been analyzed using method of moments (MoM) based software microwave office, which is widely adopted in microwave research and industry.

Keywords: Microstrip band-pass filters (BPF), dual-mode resonator, Square ring resonator, second harmonic suppression.

المايكروسترب المبتكر لمرشح الإمرار ألنطاقي ثنائي النمط لإخماد توافقي من الدرجة الثانية

الخلاصة

يقدم في هذا البحث تقنية تصميمية مبتكرة لإخماد 2^{nd} harmonic من استجابة مرشـح الإمـرار ألنطاقي الذي يظهر عند تردد ضعف التردد الرئيسي $2f_o$. الفلتر مكون من مرنان, مربع حلقـي و stup ذو نهاية مفتوحة طولها مساو الى $\frac{\lambda_{g2}}{4}$ بحيث λ_{g2} الطول المـوجي حسـب 2^{nd} harmonic موضوعة على طرف الإخراج كمرشح طاقي. يحقـق اختفـاء 2^{nd} harmonic لمرشـح الإمـرار ألنطاقي باختيار الطول المناسب لقطعة النهاالوقف ألنية المفتوحة الذي يكون مساوي تقريبا الى ربـع طول الموجة $\frac{\lambda_{g2}}{4}$. حقق BPF لمجموعـة مـن التـرددات مثـل (GPS , ISM, RFID و GSM). تم تحليل أداء مرشحات الإمرار ألنطاقي و stup مفتوح النهاية باسـتخدام طريقـة إيجاد العزوم (MoM) المعتمدة على محاكاة الحقيبة البرمجية microwave office). التـي تُتبنّـى على نحو واسع في البحث وصناعة المايكروويف.

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1. Introduction

Microstrip band-pass filters using dual-mode resonators have been receiving much attention because the number of resonators required for a given filter may be reduced by half, resulting in a compact filter configuration. The dual-mode means two degenerate resonant modes of a geometrically symmetrical resonator. The two degenerate resonant modes may be split by introducing a perturbation element in the resonator; therefore, the perturbed resonator may be used as a doubly tuned resonant circuit. Wolff first presented a microstrip dual-mode ring filter in 1972 [1]. Since then, many types of microstrip dual-mode BPF have been proposed [2]. A main drawback of the filters is relatively the high insertion loss introduced by several different losses such as conductor loss, dielectric loss, and radiation loss. The other is their limited rejection bandwidth. The limitation is introduced by higher order resonance of the microstrip ring resonators.

The rejection bandwidth could be improved by suppressing the second-order harmonic, which appears at about $2f_o$ ($f_o$is the central frequency of the designed passband) in a microstrip ring-based BPF. Several techniques have been proposed for harmonic suppression of the ring-based filters. The techniques may be classified into two types. One is adding series band-stop filters or frequency-notched structures in the input/ output (I/O) microstrip lines of a filter such as a spur-line filter [3], [4], defected ground structures [5], and photonic band-gap structures [6]. The other is using modified ring resonators with characteristic of mode suppression [7]. However, the first solution adds additional circuit elements against compact filter design and the second impacts on the fundamental pass-band responses and increases the circuit design complexity.

In this paper, a novel dual-mode BPF with harmonic suppression is proposed, in which a perturbed square-ring is used as the resonator, and one open end stup microstrip lines, rather than conventional T-shaped line, is used to output power by coupling between the microstrip lines and the resonator.

The feeding scheme was originally proposed to suppress the harmonic for a single-mode ring-based BPF. This harmonic suppression technique is based on controlling the electromagnetic field distribution of the modes that cause the second harmonic. It is relatively simple and effective for the harmonic suppression of a single-mode ring-based BPF [8].

In this paper, the technique is improved and developed for the harmonic suppression of ring-based dual-mode BPFs. Details of the filter design are presented and given to demonstrate the effectiveness of the novel filter structure for harmonic suppression. Simulation of the filter design was perfumed on microwave office 2007, which is a commercial electromagnetic simulator based on integral equation method and moment method.

Filter scheme design with 2^{nd} harmonic:

The configuration of layout a dual-mode BPF without harmonic suppression is shown in Fig. 1, which is composed of a square-ring resonator and a pair of orthogonal feed microstrip lines for its input and output. The filter is constructed on a substrate with thickness of 1.27mm and relative permittivity of 10.8.

L represents the length of side; l_f represent the feeder length for each input/output, and g represents the gap size between the resonator and the I/O coupling designed [9].

The response of Fig. 1 according to different lengths (L) as shown in Table 1 will generate different frequencies (Industrial Scientific and Medical (ISM), Global

Positioning System (GPS), Global System Mobile (GSM), and Radio Frequency Identification (RFID) shown in Fig. 2 (a), (b), (c) and (d). The length L is related to λ_g guided wave length according to fundamental central frequency given by [2],

$$4L = n\lambda_g \quad \text{….(1)}$$

The filters are simulated on microwave office, a commercial electromagnetic simulator based method of moment.

Table 1

Filter scheme design without 2^{nd} harmonic (suppressed):

The configuration of a dual-mode BPF using square-ring resonator and open end stup line located on the output feeder is shown in Fig. 3. The filter is constructed on the same substrate used above and the square-ring is the same too. $\frac{\lambda_{g2}}{4}$ open end stup lines are folded parallel to the side of the square-ring to reduce the space of the I/O. In Fig. 4, the length is

$$L_T = L_1 + L_2 + L_3 = \frac{\lambda_{g2}}{4}, \quad \text{….(2)}$$

λ_{g2} Represents the guided wave length according to 2^{nd} harmonic frequency. Here open end stup works as a band stop filter as illustrated in [10]. The simulated results for Fig. 3 according to frequency and length of open end stup are shown in Fig. 5 (a), (b), (c) and (d). The simulated results show that the amplitudes of the second-order harmonic reduce as tabulated in Table 2.

Table 2where S_{21} are transmission responses of the filter

Conclusions

A novel microstrip dual-mode BPF with 2^{nd} harmonic suppression has been demonstrated. The filter is composed of perturbed square-ring resonator and one end-open folded stup located on output feeder. The second-order harmonic of the square-ring resonator may be effectively suppressed by choosing a proper length for the open end stup microstrip line. In this case, the rejection bandwidth of the BPF may be significantly increased according to the given number.

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System	F (GHz)	L mm	2nd Harmonic
RFID	5.8	5.85	12.1
ISM	2.4	13.5	4.85
GPS	1.57	20.5	3.25
GSM	0.82	37.5	1.69

System	F (GHz)	2nd H	L_T mm	S_{21} (dB)
RFID	5.8	12.1	3	16
ISM	2.4	4.85	6.75	21
GPS	1.57	3.25	10	21.1
GSM	0.82	1.69	19	15

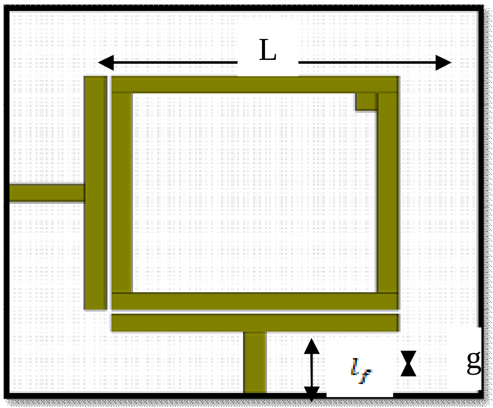
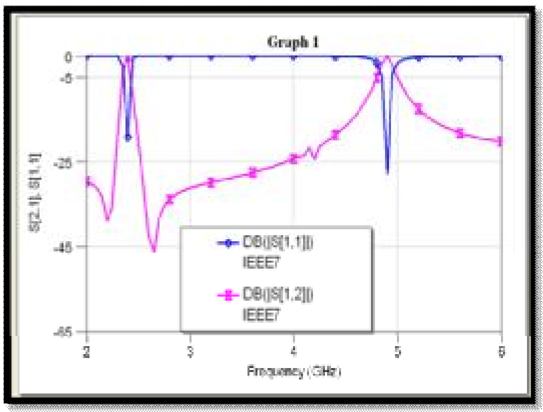
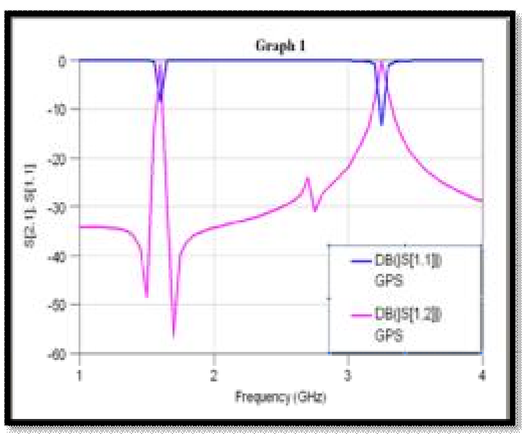


Figure (1) dual mode square ring resonator.



(a)



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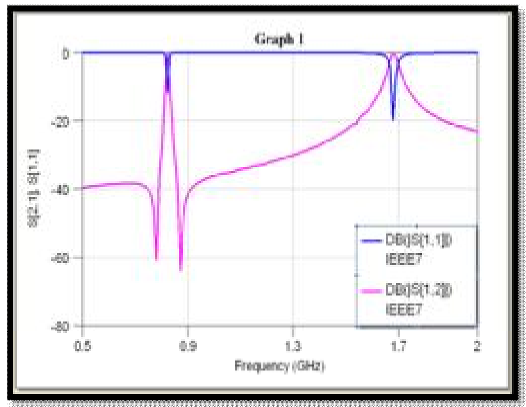

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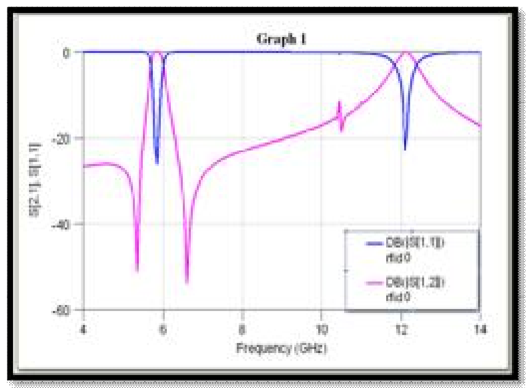


(d)

Figure (2) 2nd harmonic of BPF for (a) ISM, (b) GPS, (c) GSM, (d) RFID.

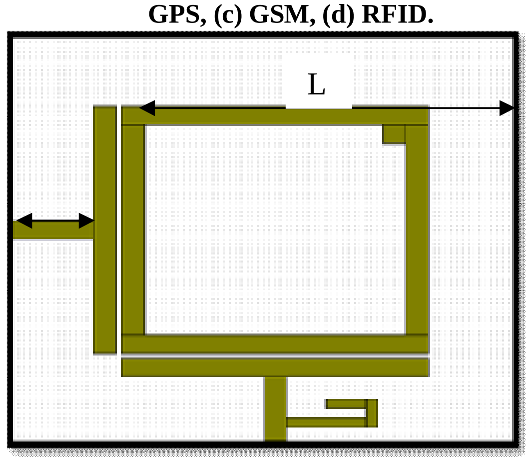


Figure (3) new layout dual-mode square ring resonator with $\frac{\lambda_{g2}}{4}$ open end stup lines located on output feeder port.

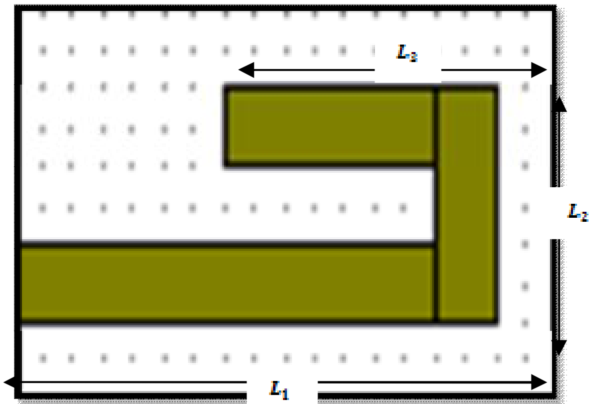
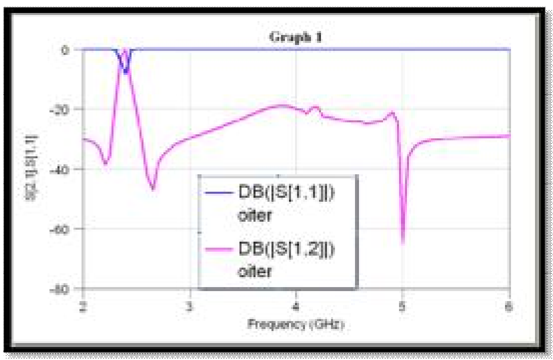
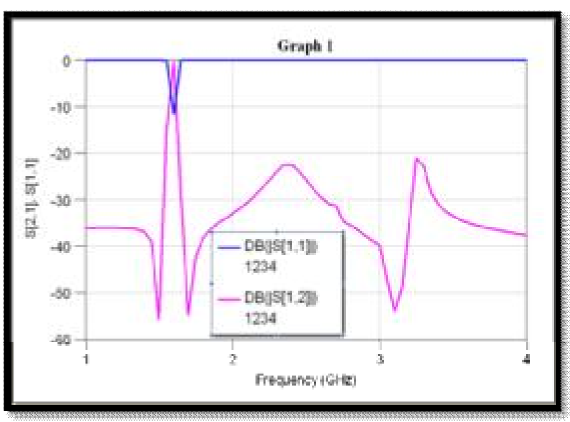


Figure (4) new layout of the total length of folded $\frac{\lambda_{g2}}{4}$ open end stup.



(a)



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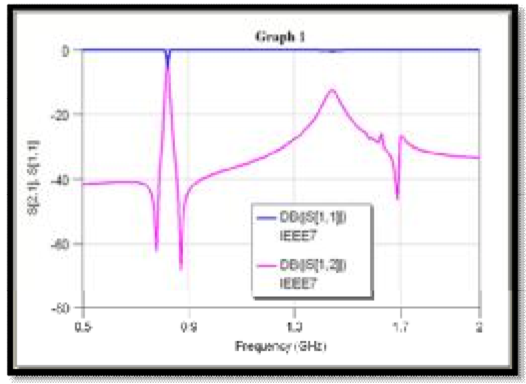
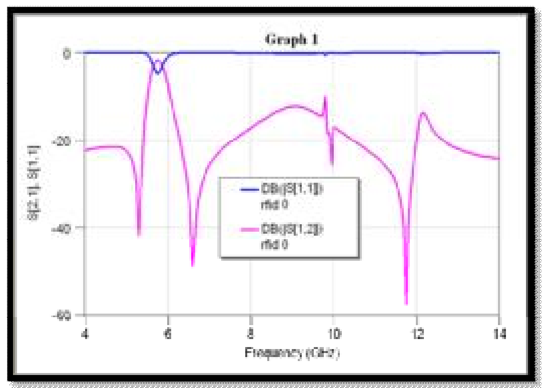


(c)



(d)

Figure (5) 2nd harmonic suppressed for (a) ISM, (b) GPS, (c) GSM, and (d) RFID