Integrated Planar Monopole Antenna with Microstrip-Ring Resonators

Jin-Hyun Kim [1],Wang-Ik Son[1],Wang-Sang Lee[2] and Jong-Won Yu [1]

[1] Department of Electrical Engineering, Korea Advanced Institute of Science and Technology (KAIST)

Guseng-Dong, Yuseng-Gu, Deajeon, 305-701, Korea ,drjwyu@ee.kaist.ac.kr

[2] U-Health Division, Convergence Business Unit, KT, Seoul, 137-792, Korea

Abstract

The new antenna with microstrip ring-resonators is presented. This device integrates a planar monopole antenna with microstrip ring-resonator band-stop filters. This new device is suitable for creating wideband antenna with narrowband interferer rejection characteristics.

1. Introduction

The increasing demand for communication systems has called for the design of low-cost and small-size radio frequency (RF)/microwave transceivers. One of the design approaches is to integrate different parts of components into a single element such that fewer components are to be used.

Integrated and active integrated antenna receive a great deal of attention because they can reduce the size, weight, and cost of many transmit and receive systems. Passive devices and active solid-state devices can be configured to provide several component functions at the terminals of the antenna. Active solid-state devices, for example, can be used to design active integrated antenna oscillators, amplifiers, and multipliers. Also, Passive devices can be used to design bandpass frequency-selective surfaces [1], rectifying antenna [2] and frequency-notched antennas [3-5].

In this paper, we develop a new integrated antenna, which integrates a planar monopole antenna with microstrip ring-resonator band-stop filters.

2. Antenna-Filter Design

Microstrip closed or open-loop resonators with annular or square configuration have been tremendously utilized in the design of planar filters, oscillators, mixers and antennas. Fig. 1 shows the geometry of the microstrip closed or open-loop resonator and excitation schemes. The main transmission line is electromagnetically coupled the microstrip closed or open-loop resonator. Fig. 2 shows the simulated frequency responses of a microstrip-ring band pass filter, which is composed of a rectangular-ring resonator and a pair of symmetrical end-open T-shaped microstrip lines for its input and output.

Fig. 3 shows the geometry of the proposed planar monopole antenna with a microstrip ring resonator. A planar monopole with a rectangular patch size $18 \times 20mm^2$, and a 50Ω microstrip feed line are printed on the same side of the dielectric substrate (in this study, the Taconic's RF35 substrate

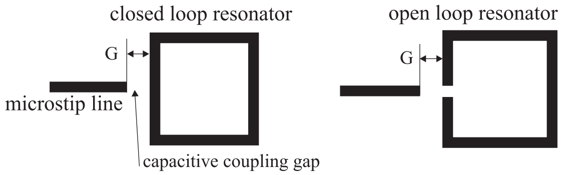

Fig. 1: The microstrip-ring capacitively coupled a microstrip feed line

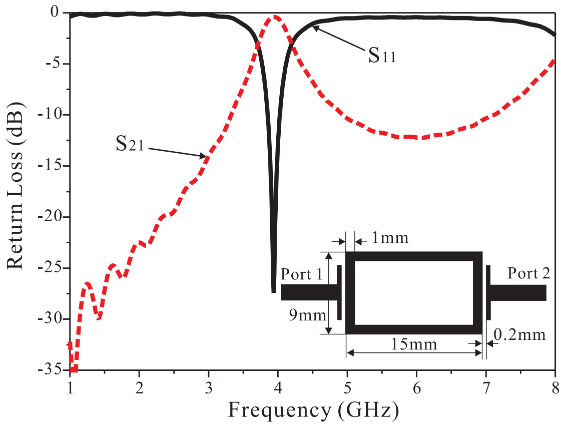

Fig. 2: Simulated frequency response of a microstrip close-loop resonator filter

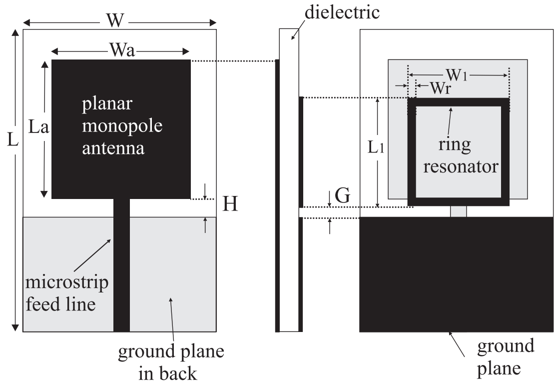

Fig. 3: The proposed planar monopole antenna with a microstrip closed-loop resonator

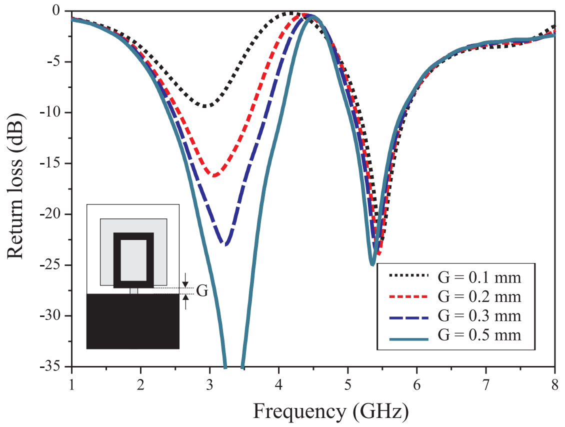

Fig. 4: Simulated return loss against frequency of type 1 ($W_1 = 9mm, L_1 = 15mm, W_r = 1mm$) with different G

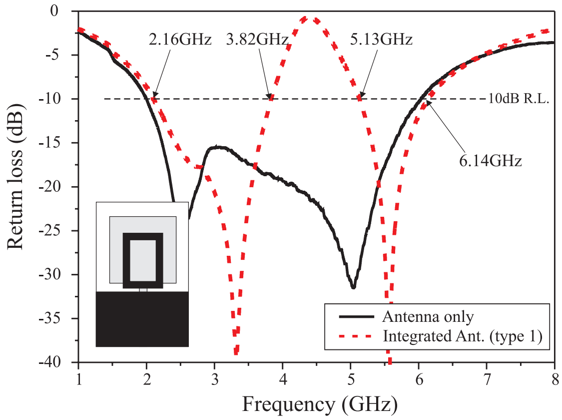

Fig. 5: Measured return loss against frequency of type 1 ($W_1 = 9mm, L_1 = 15mm, W_r = 1mm, G = 0.2mm$)

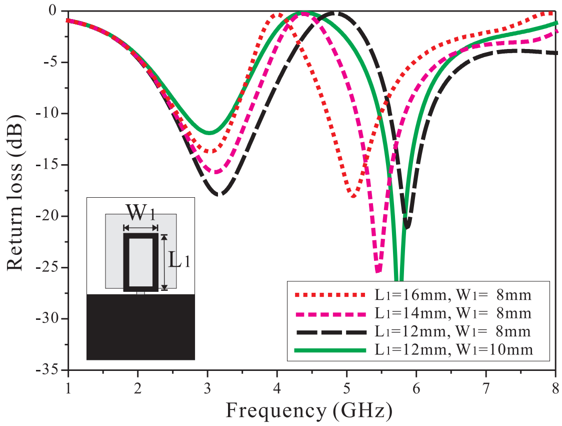

Fig. 7: Simulated return losses for the proposed antenna with different closed-loop resonator

of thickness $0.76mm$ and the relative permittivity 3.5 was used). $L(= 45mm)$ and $W(= 28mm)$ denote the length and the width of the dielectric substrate, respectively.

On the other side of the substrate, the conducting ground plane with a length of $L_g(= 22.5mm)$ only covers the section of the microstrip feed line. H is constant at $2.5mm$ in this study. Also, the microstrip ring-resonator element is introduced on the opposite side of the dielectric substrate and is coupled to the ground part (or imaging part) of the main planar monopole antenna. G is the height of the coupling gap. W_r denote the width of the resonator.

A microstrip-ring structure resonates when its electrical length is about an integral multiple of the guide wavelength. The size of the coupling gap determines the coupling degree between the feed line and the ring resonator. Due to the field interactions in the coupling-gap region, the actual resonant frequency will have some deviation from that of a stand-alone microstrip-ring resonator. Coupling between the feed line and the resonator may be increased by decreasing the size of the coupling gap (thereby increasing the gap capacitance), by increasing the coupling periphery and by a combination of previous two. The addition of a coupled microstrip ring-resonator makes a band-stop characteristic.

3. Results and Discussion

The simulations are performed using the CST Microwave Studio package which utilizes the finite integration technique for electromagnetic computation. Fig. 4 shows the return loss curves with different coupling gap (G=0.1,0.2,0.3 and 0.5). For prototype antenna, G is constant at 0.2mm in this study.

Fig.5 shows the measured return loss for the proposed planar monopole antenna with a microstrip closed-loop resonator. For the antenna without resonator(reference antenna), the measured operating bandwidth of -10dB return loss is from 2.1GHz to 6.0GHz. It is noted that the coupled closed-loop resonator creates a notch-band.

Fig. 6 shows the simulated return loss for the proposed antenna with various value of W_1 and L_1. It can be concluded that the notch band for the proposed antenna is indeed controlled by the length of resonator.

Fig. 7 shows the simulated surface current distributions at the pass-band and stop-band. At the stop-band, the strong electric coupling occurs at the bottom edge. The surface currents are concentrated at the closed-loop resonator and the antenna does not work. However, at the pass-band, the electric coupling does not occur at the bottom edge. The resonator does not work and the antenna returns to the normal operation.

Figs. 8-9 show the measured return losses for the planar monopole antenna with an open-loop circular and rectangular resonator, respectively.

Fig. 10 shows the measured VSWR for the the planar monopole antenna with dual open-loop rectangular resonators. It is noted that by using two open-loop rectangular resonators, we can make triple-band antenna having dual-band rejection characteristic.

Fig. 11 shows the radiation patterns of the proposed planar monopole antenna with a rectangular closed-loop resonator.

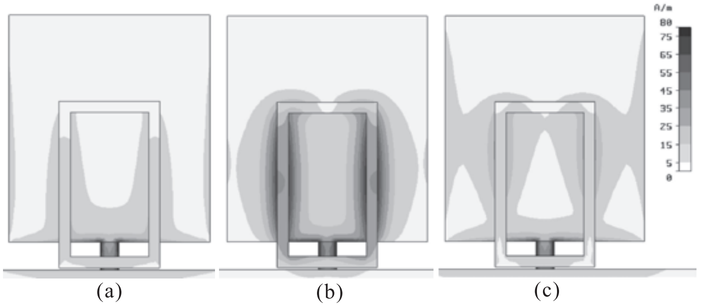

Fig. 6: Simulated surface current distributions (a) at 3GHz(pass-band), (b) 4.4GHz (stop-band) and (c) 6.0GHz (pass-band)

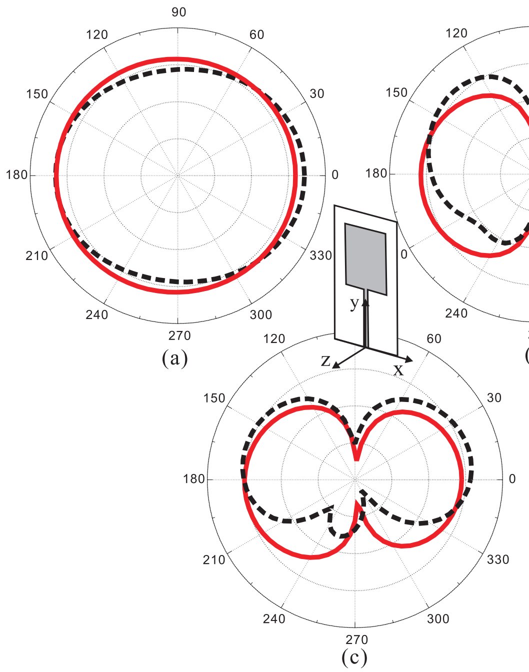

Fig. 11: Radiation pattern of 3GHz (solid line) and 6GHz (dotted line) : (a)x-z plane, (b)x-y plane, and (c) y-z plane

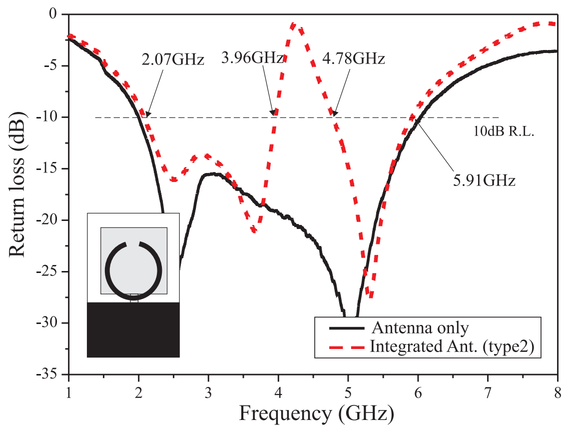

Fig. 8: Measured return losses for the proposed antenna with open-loop circular resonator

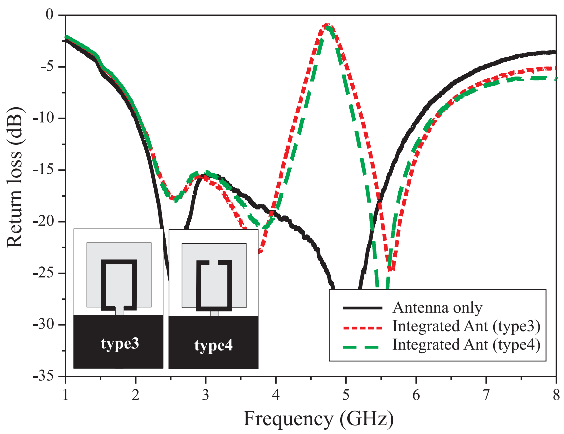

Fig. 9: Measured return losses for the proposed antenna with open-loop rectangular resonator

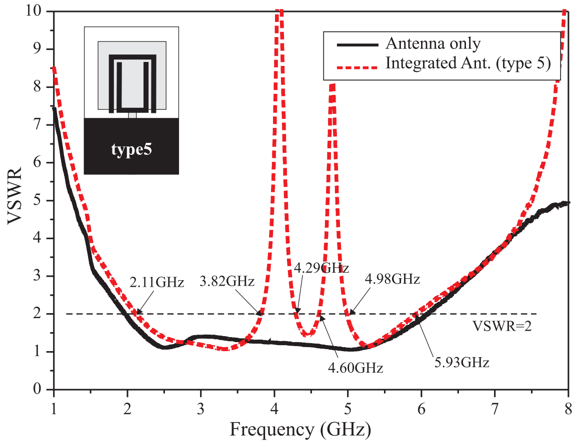

Fig. 10: Measured VSWR for the proposed antenna with dual open-loop rectangular resonator

4. Conclusion

In this paper, we investigate the wideband planar monopole antenna with microstrip closed and open-loop resonators. The ability to integrate filter into the antenna can significantly relax the requirements imposed upon the filtering electronics within the wireless device, such as reconfigurable radio and SDR (software defined radio) systems.

References

[1] A.A.Tamijani, K.Sarabandi,G.M.Rebeiz, "Antenna-Filter-Antenna Arrays as a Class of Bandpass Frequency-Selective Surfaces", *IEEE Trans. Microwave Theory and Tech.*, Vol. 52, No. 8, 2004, pp. 1781-1788.

[2] C.H.K.Chin, Q.X.Xue, C.H.Chan, "Design of a 5.8-GHz Rectenna Incorporating a New Patch Antenna",, *IEEE Antennas and Wireless Propagation Letters*, Vol. 4, 2005, pp. 175-178.

[3] W.S.Lee, D.Z.Kim, K.J.Kim,J.W.Yu, "Wideband Planar Monopole Antenna with Dual Band-Notched Characteristics", *IEEE Trans. Microwave Theory Tech.*, Vol. 54, No. 6,2006,pp. 2800-2806.

[4] W.S.Lee, W.G.Lim,J.W.Yu, "Multiple Band-Notched Planar Monopole Antenna for Multiband Wireless Systems", *IEEE Microwave and Components Letters,*.Vol. 15,No. 9,2005,pp. 576-578.

[5] W.S.Lee, J.H.Kim and J.W.Yu, "Capacitively Coupled Band-Stop Filter with An Integrated Antenna", In:*Proc. 2006 IEEE MTT-S, Int.Microwave Symposium* ,USA,2006, pp. 2019-2022

[6] K.Chang, L.H.Hsieh, Microwave Ring Circuits and Related Structures, 2nd ed., John Wiley & Sons, New Jersey, 2004.