# Cascaded Dual-mode Ring Resonator Switch in WiMax Band using Transmission Line λ/4

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## Abstract

A band-rejection type RF switch, which has very high off-isolation, on-state insertion loss, and adjustable bandwidth, is proposed using cascaded dual ring resonator, λ/4 transmission line and four PIN diodes. To dual-mode transmission, the ring resonator is directly fed using non-orthogonal feeding. Also we can wide of bandwidth about 181 MHz than dual-mode ring resonator switch using shunt-mounted PIN diode. The switch operates at the bias condition of 6.9 V and 396 mA. It performs with a isolation of 68.125 dB @ 2.502 GHz, 68.482 dB @ 2.683 GHz, and 68 dB bandwidth is 181 MHz. Insertion loss in bandwidth is measured below 0.45 dB.

**Keywords :** Cascaded Ring Resonator, Dual-mode, RF-Switch, PIN-Diode

## 1. Introduction

Recently, a mobile broadband system using TDD(Time division duplex) has come under the spotlight because of a dramatic increase in mobile internet usage. In TDD systems, such as WiMax and the long term evolution(LTE) system, the same carrier frequency is used for the uplink and downlink transmissions, and therefore, receiver circuits must be protected from the reflected transmitted power from the antenna. To facilitate this, a high performance switching circuit that has high off-state isolation, low on-state insertion loss, and high-power handling capability is an essential component for the safety of a receiver circuit.[1-2]

The conventional RF switch, which is based on multiple PIN diodes and quarter-wavelength transmission lines, has some defects.[3-4] To obtain high off-state isolation with this topology, many PIN diodes would be required with quarter-wavelength transmission lines. In this case, the overlapped parasitic elements, such as the junction capacitance of the PIN diode, the inductance of the bond-wire, and the inductance of an RF chock, would increase the signal loss. Moreover, the size of the switch is substantially increased in accordance with the number of added PIN diodes. A number of design methods using various microstrip resonators have been reported in the literature[5-6] that claim to enhance the performance of a switch. However, their bandwidths are too narrow and the off-state isolations and on-state insertion losses are not particularly good. Currently, RF switch using dual-mode ring resonator has high isolation, low insertion loss and wide bandwidth, adjustable bandwidth.[7]

In this article, a band-rejection type RF switch that has high off-state isolation, low on-state insertion loss, and adjustable bandwidth is proposed using a transmission line $\lambda_g/4$ and two dual-mode microwtrip ring resonator and four wire-boned PIN diodes. As a result, a band-rejection type RF switch is designed in the 2.50 ~ 2.69 GHz range for WiMax applications.

## 2. Cascaded dual-mode ring resonator

Fig. 1 show the structure of the cascaded a dual-mode ring resonator, which consist of two dual-mode ring resonator and transmission lines $\lambda_g/4(\theta_c)$. The resonance frequency( $f_{r1}, f_{r2}$ ) of two dual-mode resonator are determined by radius of the ring( $r_{f1}, r_{f2}$ ) and angle of feeding( $\theta_{f1}, \theta_{f2}$ ).

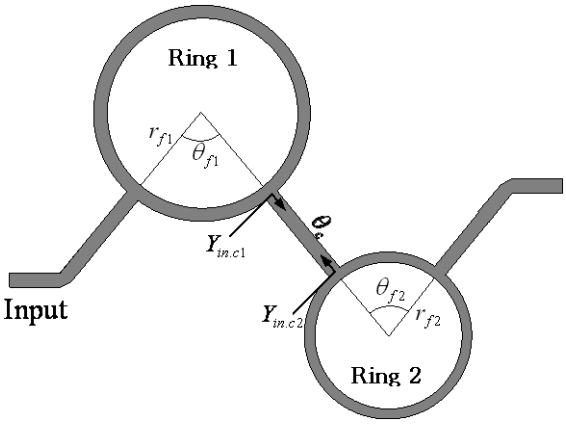



Fig 1. Configuration of the Ring Resonator Fed by Two Orthogonal Feed Lines

The conventional ring resonator of orthogonal feeding has bandstop, so extract shunt connecting $\lambda_g/4$ short-stub as shown in figure 2. Then, input admittance($Y_{IN}$) is given by

$$Y_{IN} = Y_{IN1} + Y_0 \left[ \frac{Y_{IN2} + jY_0 \tan\theta_c}{Y_0 + jY_{IN2} \tan\theta_c} \right] \tag{1}$$

Where $Y_{IN1}$ is $jY_0 \tan\theta_1$, $Y_{IN2}$ is $jY_0 \tan\theta_2$, $Y_0$ is $\frac{1}{Z_0}$. $Y_0$ is characteristic admittance of transmission, $\theta_1$ and $\theta_2$ is physical length of short-stub. If length of transmission lines is zero, input admittance($Y_{IN}$) is given by

$$Y_{IN} = Y_{IN1} + Y_{IN2} \tag{2}$$

The characteristic of two short-stub response was represented at 1st·2nd resonance as shown in figure 3. When series resonance occurs, input admittance of imaginary is zero. Because this characteristic, isolation of cascaded ring resonator is decrease in figure 2. However if length of transmission line $\lambda_g/4$, input admittance($Y_{IN.c1}, Y_{IN.c2}$) seen looking toward transmission line is given by

$$Y_{IN.c1} = Y_{IN1} + \frac{Y_0^2}{Y_{IN2}} \tag{3}$$

$$Y_{IN.c2} = Y_{IN2} + \frac{Y_0^2}{Y_{IN1}} \tag{4}$$

Thereby each parallel resonance is existed and series resonance is rejected, it can be achieved high isolation using transmission line $\lambda_g/4$.

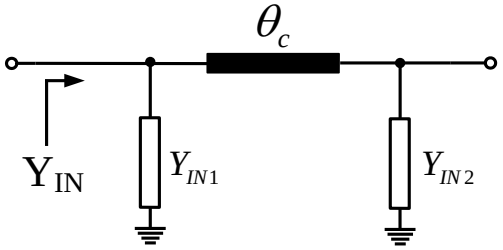



Fig 2. Equivalent Circuit of Cascaded Dual-mode Ring Resonator

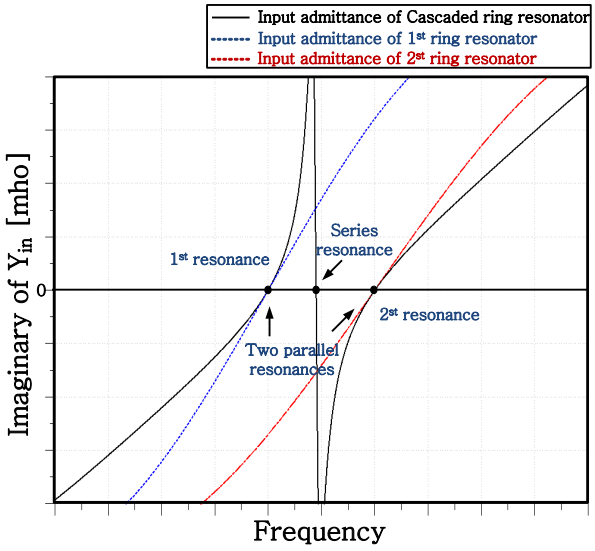
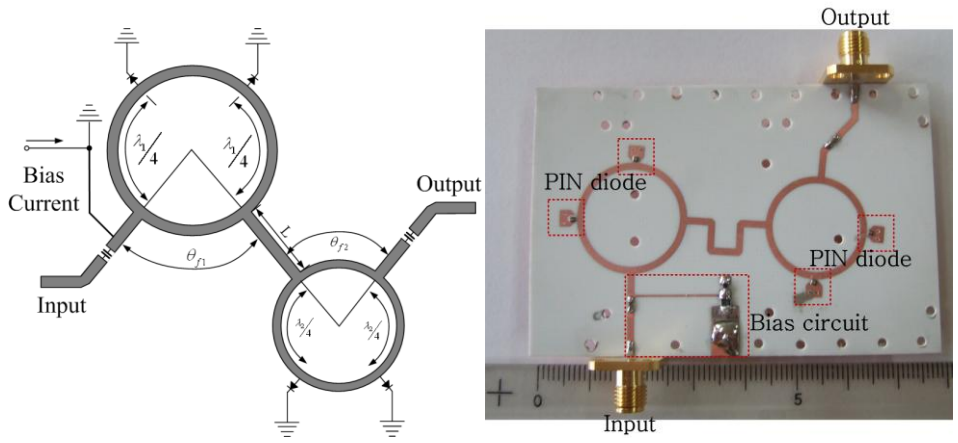



Fig 3. Input Admittance( $Y_{IN}$ ) of Ring Resonator

## 3. Switch design, Fabrication and Result

Fig 3. shows the structure of the proposed bandstop RF switch, which consist of cascaded dual-mode ring resonator and four PIN diodes. The dual-mode ring resonator is directly fed for the sharp bandstop transmission characteristic in order for adjustable bandwidth.[8-10] Such characteristic of the dual-mode ring resonator are much more suitable for RF/microwave switches than other microstrip resonator. Four wire-bonded PIN diodes are mounted in shunt after quarter-wavelength transmission lines resonator frequency of the ring electrical length of the radius of the ring resonator, the resonant frequency is shifted down or up according to the bias condition, while the resistance of the PIN diode is concerned only with insertion loss.

A bandstop RF switch based on cascaded dual-mode ring resonator was design and fabricated on a RO4003 substrate() using a Metelics PIN diode MPN 7380. As switch specifications, a center frequency of 2.595 GHz and bandwidth of 190 MHz was selected for WiMax application, and maximum isolation of 70 dB, minimum insertion loss of 0.8 dB were selected. Under these conditions, the mean radius of 1st and 2nd ring resonator and feeding angle were chosen to each 9.78, 8.84 mm and 88°, 91.6°. Transmission line was determined as 17.3 mm at quarter-wavelength of center frequency 2.595 GHz. The layout of the fabricated bandstop RF switch is shown in Fig 4 and the measured greater than 68.3 dB with bandwidth 181 MHz. The on-state insertion loss less than 0.45 dB are exhibits within the operating frequency range.

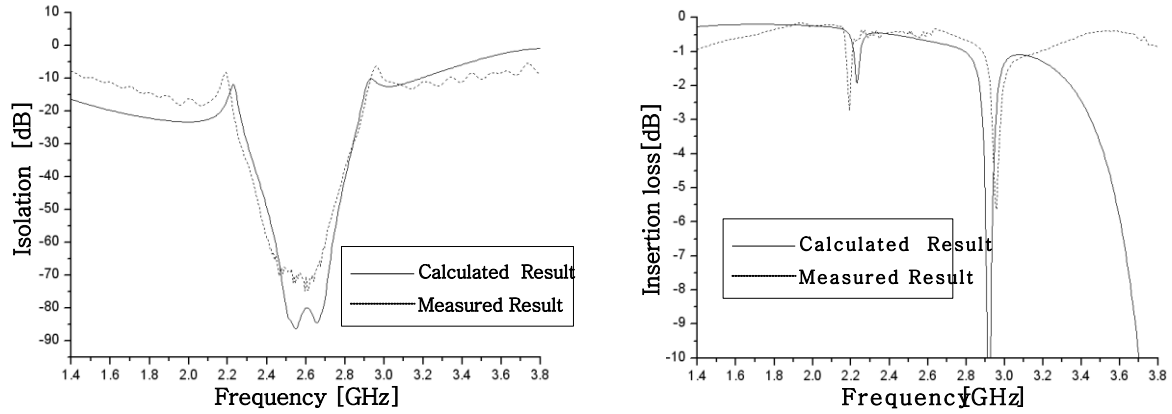



(a) Structure of the RF Switch (b) Fabricated of the RF Switch

Fig 3. Structure and Fabricated of Dual-mode Ring Resonator Switch using $\lambda_g/4$ Transmission Line

## 4. Conclusion

A high performance bandstop RF switch was design utilizing a cascaded dual-mode ring resonator, four PIN diodes and transmission line $\lambda_g/4$. The practical performance of the proposed switch is extracted using input admittance analysis. It exhibits the isolation of 63.5 dB and insertion loss of 0.45 dB within the range of 2.502 ~ 2.683 GHz. The proposed switch was fabricated for WiMax applications, and the results show good agreement with the calculated results. It should be well suited not only WiMax applications but also any other system(Wibro etc…)




(a) Isolation (b) Insertion loss

Fig 4. Structure Simulated Result and Measured Result of RF Switch

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