

# A Study on a Feeding Method to the Multi-band Antenna with a Coupling Phenomenon

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## 1. Introduction

In recent years, a multi-band antenna is needed to integrate various kinds of wireless services [1]. We have proposed a multi-band antenna using several conductive wires with an internal coupling phenomenon [2]. The structure of this antenna is simple. Using a coupling phenomenon between wires [3], the currents of particular modes are excited on the wires to give the multi-band characteristics.

We have manufactured the antenna with wires [4]. It is fed with a semi-rigid coaxial cable. In order to suppress the leak current, a bazooka type balun was introduced at the feed point. However the bazooka type balun works at only one resonant frequency. Therefore, a novel method has been investigated to set multiple feed points on the antenna for multiple frequencies. This method is compatible with practical connections with transmitters and receivers. This paper explains the feeding method for the proposed antenna with and without a reflector.

## 2. Structure of the Primary Proposed Antenna and Feeding Method

Fig.1 shows the structure of a proposed antenna which has three wires each measuring approximately 100mm. The three wires are connected with each other at point P, but are opened at point Q. There are two cranks on #1 wire. The crank lower than the feed point A is closer to #2 wire. The crank higher than the feed point A is closer to #3 wire. It is expected that the coupling phenomenon occurs where the cranks are closest to #2 and #3 wires.

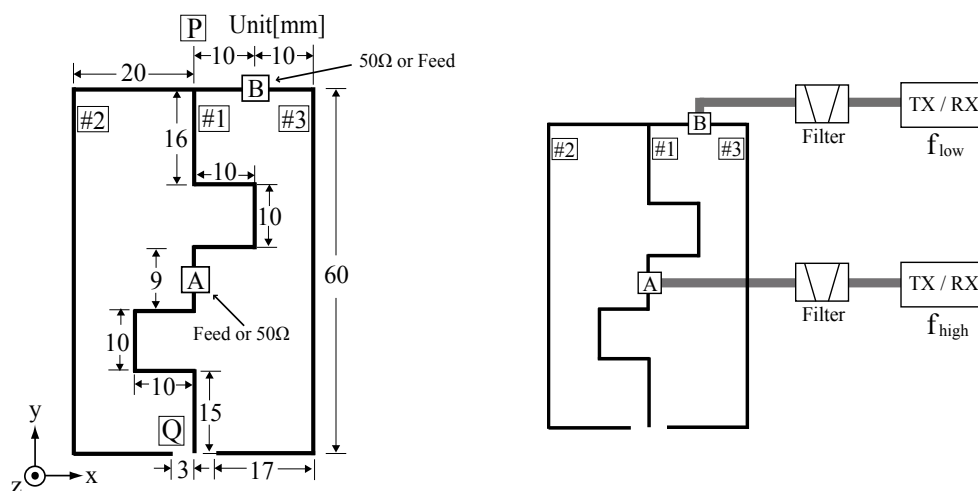


Figure 1: Structure of Proposed Antenna      Figure 2: Example of connection

When the antenna was fed only at the centre point A of #1 wire, the antenna was analyzed using the moment method. It was confirmed that the antenna had two resonant frequencies of 0.77GHz and 2.3GHz [4]. At 0.77GHz, the current was distributed on the #2 and #3 wires. The

current distribution on #2 and #3 wires looked sinusoidal with a half period. At 2.3GHz, the current was distributed on the #1 and #3 wires. The current distribution on the #1 and #3 wires looked sinusoidal with three half periods.

Two feed points were decided by taking into account of the current distribution. The antenna was fed at point A for 2.3GHz and at point B for 0.77GHz, respectively. The feed point B was also adjusted to have the good return loss characteristics. Fig.2 shows an example of connection between the antenna and transmitters or receivers.

In the analysis, when one point was fed, another point was terminated by  $50\Omega$ . The semi-rigid cable and the balun were not taken into account in the analytical model. The solid line in Fig.3(a) shows the return loss characteristic of this antenna when the antenna was fed at point A and  $50\Omega$  is terminated at point B. The solid line in Fig.3(b) shows the return loss characteristic of this antenna when the antenna was fed at point B and  $50\Omega$  is terminated at point A. It is confirmed that this antenna is able to work at two frequencies simultaneously. From the results, the low resonant frequency is 0.81GHz and the high resonant frequency is 2.47GHz.

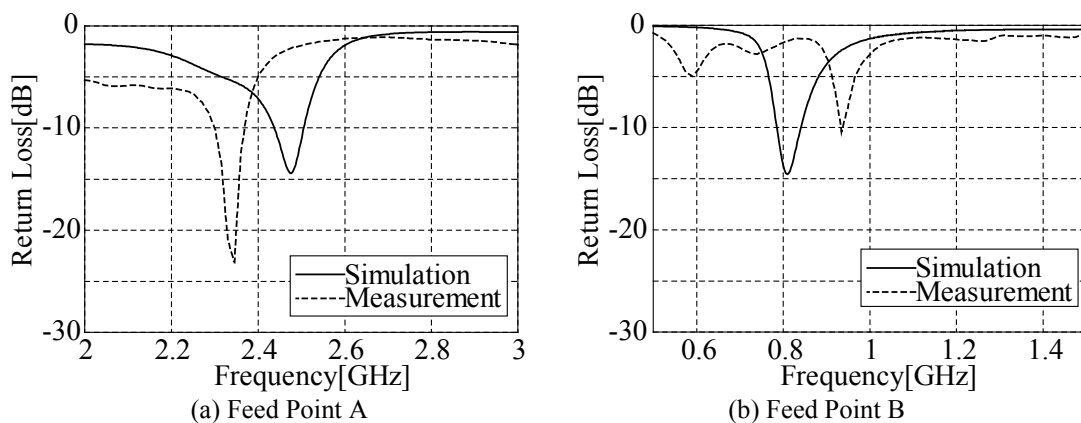


Figure 3: Frequency Characteristics of Return Loss

### 3. Experiment in the Case of Two Frequencies

We have manufactured the antenna according to the simulation results with wires of 1mm diameter. Fig.4 shows the picture of the proposed antenna. As shown in this figure, the bazooka type balun was introduced at the feed point. It is made of a brass cylinder with a diameter of 15mm and a thickness of 1mm. The length is a quarter of a wavelength, 93mm at 0.81GHz and 30mm at 2.47GHz. The dotted lines in Fig.3 show the experimental results. The low and high measured resonant frequencies are similar with the analytical low and high resonant frequencies with 15% and -5% difference. The difference is probably caused by the analytical model not taking the semi-rigid cable and the balun into account.



Figure 4: Picture of the Proposed Antenna (Front View)

#### 4. Characteristics of the Practical Proposed Antenna with a Reflector

An antenna is usually used with a reflector. The proposed antenna with a reflector of 50mm×70mm was analyzed. The reflector is set parallel to the antenna as shown in Fig.5. Fig.6 shows the return loss characteristic of this antenna in the case of  $\Delta z=8\text{mm}$ . It is confirmed that the antenna has three resonant frequencies of 0.78GHz, 1.68GHz and 2.3GHz. It is thought that the coupling phenomenon between the antenna and the reflector generated the new resonant frequency of 1.68GHz.

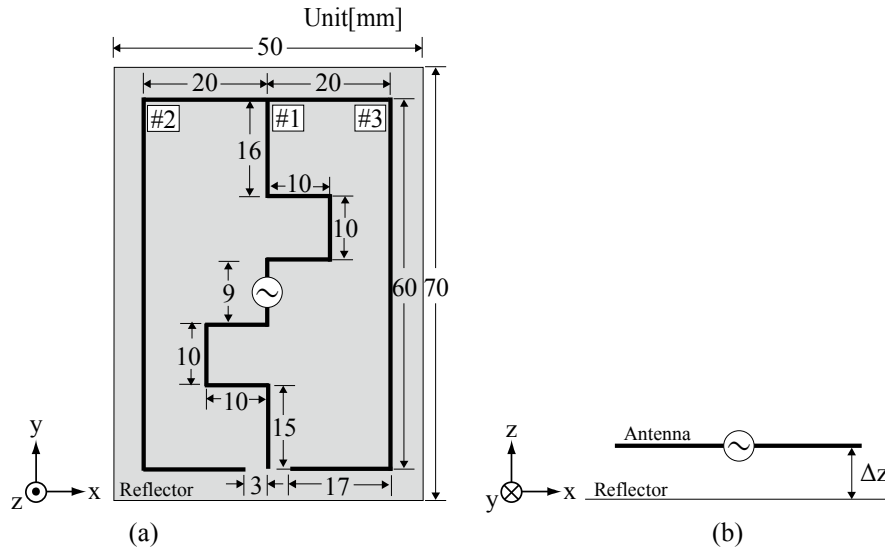


Figure 5: Proposed Antenna with a Reflector

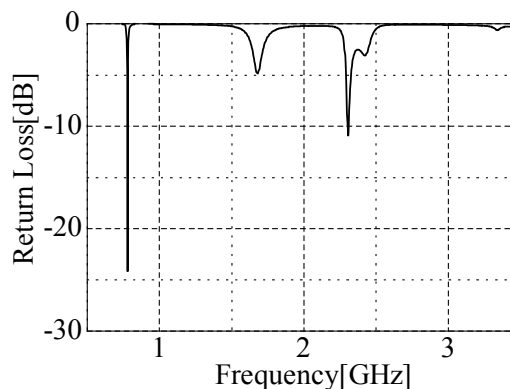


Figure 6: Frequency Characteristics of Return Loss ( $\Delta z=8\text{mm}$ )

#### 5. Three Feeds for Three Frequencies

The three feeds for three frequencies were investigated analytically. Feed points were decided by taking into account of the current distribution on the antenna with a reflector. As shown in Fig.7, the antenna is fed at point A for 1.68 GHz, at point B for 2.3GHz and at point C for 0.78GHz, respectively. The feed points B and C were also adjusted to have the good return loss characteristics. When one point was fed, other points were terminated by 50Ω. Fig.8(a) shows the return loss characteristic of this antenna with a reflector when the antenna is fed at point A and 50Ω is terminated at point B and C. Fig.8(b) and 8(c) show the results in the same way as Fig.8(a). It was satisfied that the return loss at three resonant frequencies is lower than -10dB. It was confirmed that this antenna is able to work at three frequencies simultaneously. From the results, the low resonant frequency is 0.79GHz, the middle resonant frequency is 1.68GHz and the high resonant frequency is 2.3GHz.

