Broadband folded notch antenna with a parasitic notch on a rectangular planar conductor

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Abstract

This paper proposes a new broadband folded notch antenna with a parasitic notch on a rectangular planar conductor. The parasitic notch can provide current distribution on a folded notch antenna similar to current distribution on an axially symmetric quasi-self-complementary antenna, which has an extremely broadband characteristic. In the simulation, it is shown that frequency bandwidth of the folded notch antenna is increased by 1.5 times by the use of the parasitic notch when the parasitic notch is located based on the current distribution on the axially symmetric quasi-self-complementary antenna.

1. INTRODUCTION

A broadband antenna is required for various radio systems such as a multiband mobile phone, and software radio. There are two approaches to realize a broadband antenna. The first method is that an operating frequency bandwidth is controlled by an active element [1]. In this case, equivalent broadband characteristic is realized. The second method is that an operating frequency of an antenna itself is broadband. This paper focuses on the second method.

An axially symmetric self-complementary antenna, which is described with SCA in this paper, is well known to have an extremely broadband impedance characteristic [2]. SCA has a constant input impedance, independently of the source frequency and shape of the structure. However, the constant input impedance of the SCA is 60 $\pi\Omega$, which does not match the conventional 50 Ω radio component. This is a disadvantage of a self-complementary antenna.

On the other hand, a folded notch antenna, which is described with FNA in this paper, can match a 50 Ω radio component. The shape of the FNA is similar to that of an axially symmetric quasi-self-complementary antenna, which is described QSCA in this paper. However, the frequency bandwidth of the FNA is narrower than that of the axially symmetric QSCA. This is a disadvantage of the FNA.

The current distribution on an antenna determines the antenna characteristics such as input impedance, radiation pattern, and gain. The authors paid attention to similarity of structure of the FNA and QSCA and assumed that if the current distribution of the FNA were controlled to resemble that of the QSCA in broadband, frequency bandwidth of the folded notch antenna would become wide. In the work reported in this paper, in order to adjust the current distribution of the FNA, a parasitic notch is employed.

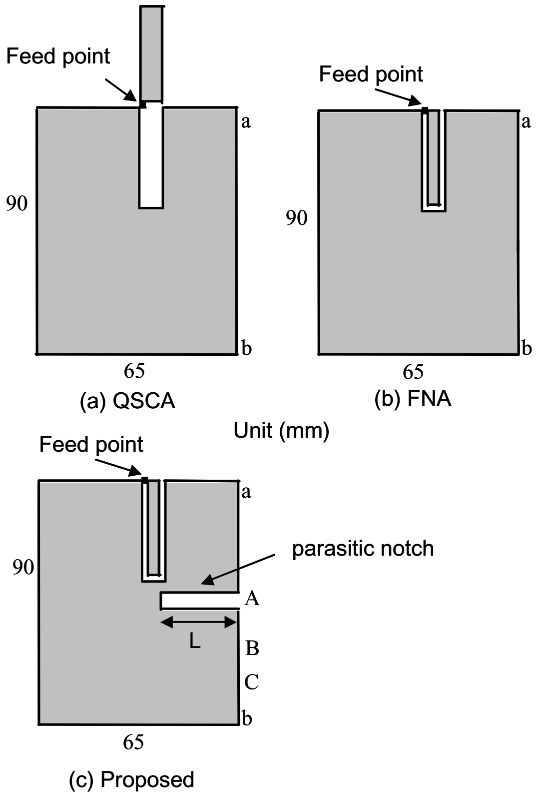


Fig. 1 Antenna Structures.

Current distribution on the FNA and QSCA are determined by simulation. The position of the parasitic notch on the FNA, which controls the current distribution, is determined using the calculated current distribution of the QSCA.

Simulation results show that the parasitic notch at an appropriate position can realize the current distribution similar to that of the QSCA. Also, the bandwidth of the FNA is increased by 1.5 times by the use of the parasitic notch.

2. ANTENNA STRUCTURES

Figure 1(a) shows the configuration of the axially symmetric quasi-self-complementary antenna (QSCA). It is

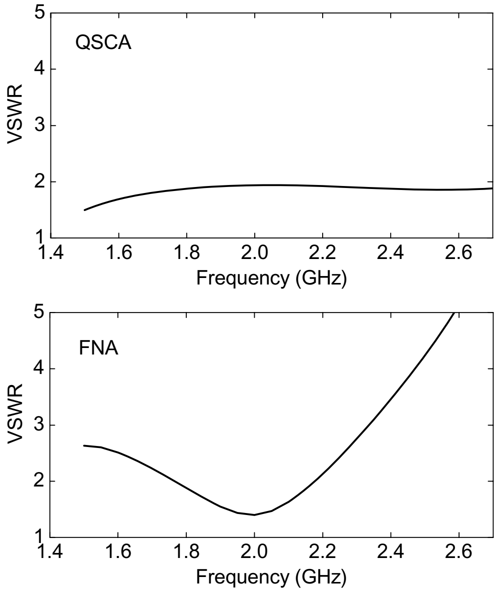


Fig. 2 Frequency responce of VSWR.

composed of a larger planar conductor and a complementary smaller planar conductor. Usually, the axially symmetric SCA includes the 60 $\pi\Omega$ resistance to avoid the truncation effect. In this paper, the 60 $\pi\Omega$ resistance is removed to improve the radiation efficiency [3]. Strictly speaking, the structure of Fig. 1(a) is not self-complementary.

Figure 1(b) shows the configuration of the folded notch antenna (FNA), which is a modified configuration of QSCA shown in Fig. 1(a). The larger planar conductor of the FNA and that of the QSCA are the same. Unlike the configuration of the QSCA, the smaller planar conductor of the FNA rotates on a symmetric axis by 180 degree. Also, the width of the folded notch antenna's smaller conductor is thinner than that of the smaller conductor of QSCA. The input impedance of FNA is adjusted by the width of the folded notch and the distance between two notches in the same way as a folded dipole antenna.

Figure 1(c) shows the proposed broadband FNA with a parasitic notch. The parasitic notch is installed to control the current distribution on the larger planar conductor of the FNA as described below. The parasitic notch is rectangular shape and has length L. The parasitic notch is located along the line a-b.

3. Simulation Results

Current distribution on these antennas are calculated by the NEC2 (Numerical Electromagnetic Code-2) simulation tool, which uses the moment method [3]. Antenna characteristics are determined by the calculated current distribution. In the NEC2 simulation, both the larger planar conductor and the smaller planar conductor are modeled by a rectangular wire-grid.

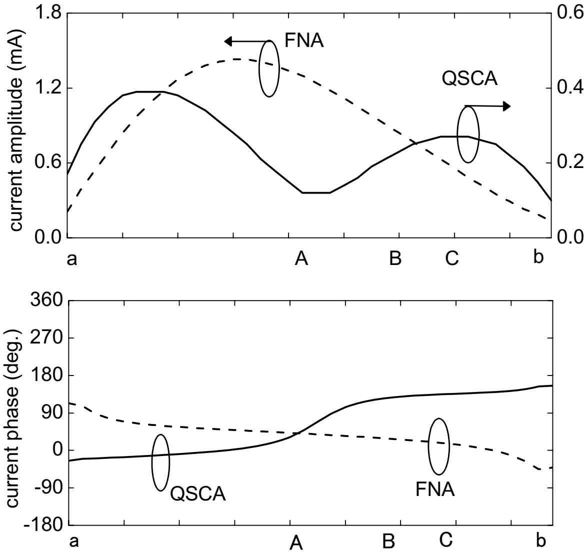


Fig. 3 Current distribution on line a-b.

Figure 2 shows the frequency responses of VSWR for QSCA and FNA, respectively. Note that the normalized resistance for QSCA and FNA are 60 $\pi\Omega$ and 50 Ω, respectively. The frequency bandwidth of the FNA is about 20 % where the frequency bandwidth is calculated on condition that VSWR is 2 or less. When the length of the folded notch is about half-wavelength, VSWR is the minimum value.

On the other hand, the frequency bandwidth of the QSCA is wider than that of the FNA. Although the QSCA does not include 60 $\pi\Omega$ resistance, input impedance of the QSCA is approximately 60 $\pi\Omega$.

Current distribution is shown in order to reveal the difference between the QSCA and the FNA. Figure 3 shows the current distribution on line a-b as shown in Fig. 1, where the frequency is center frequency of the bandwidth of FNA. The line a-b is the portion, at which the difference in current distribution is the greatest. At point A, current distribution of the FNA is markedly different from that of the QSCA. It is cleared that the current amplitude is small and current phase changes greatly at point A on line a-b for the QSCA.

The current distribution on an antenna determines the antenna characteristics such as input impedance, radiation pattern, and gain. The authors paid attention to similarity of structure of the FNA and QSCA and assumed that if current distribution of the FNA were controlled to resemble that of the QSCA, frequency bandwidth of the FNA would become wide.

In order to adjust the current distribution of the FNA, a parasitic notch is installed in the present work as shown in Fig. 1(c). The parasitic notch is located along the line a-b and has length L. Clearly, the current amplitude is expected to be small at point A. Also, the current phase is expected to

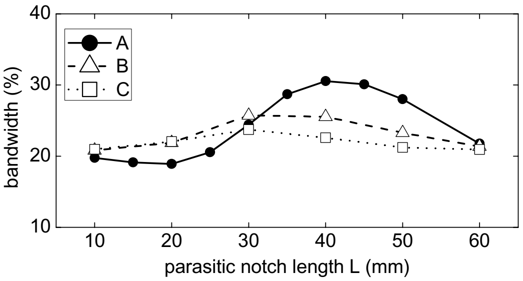


Fig. 4 Frequency bandwidth versus parasitic notch length L.

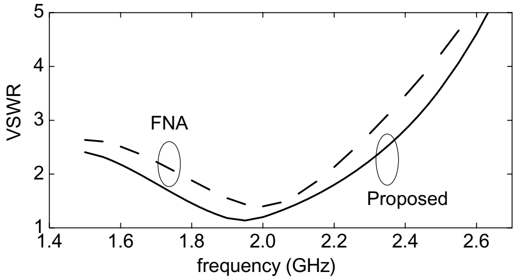


Fig. 5 Frequency response of VSWR.

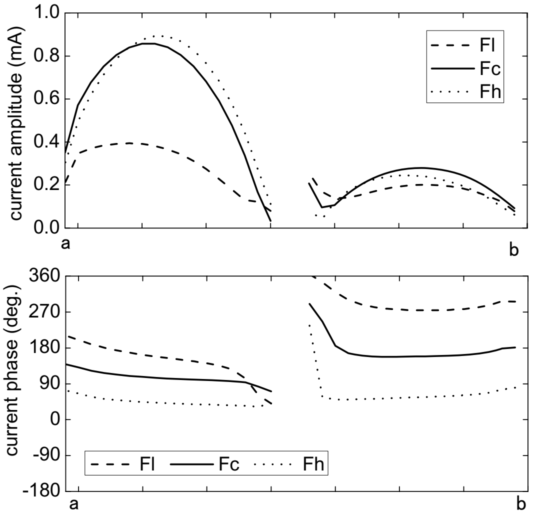
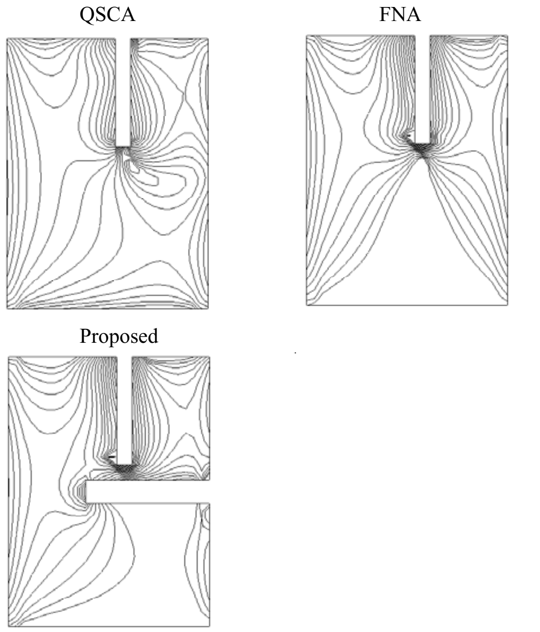


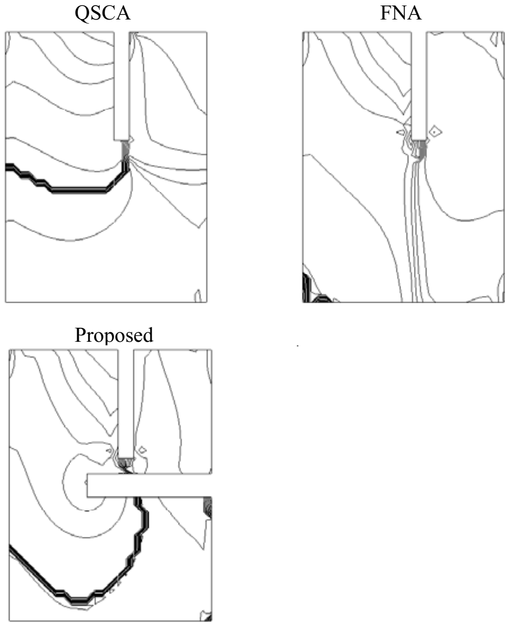
Fig. 6 Current distribution on line a-b of the proposed antenna.

change greatly at point A because of the long path along the parasitic notch.

In order to confirm the authors' assumption, the relationship between the frequency bandwidth and the parasitic notch position is investigated. Figure 4 shows the frequency bandwidth versus the parasitic notch length L, where the parasitic notch is located at point A, B, and C, respectively. Frequency bandwidth is calculated on condition that VSWR is 2 or less.



(a) Amplitude (Contour line interval is 2 dB. Range is from 0 dB to –40 dB)



(b) Phase (Contour line interval is 30 deg.)

Fig. 7 Current distribution on larger conductor.

The bandwidth of the FNA is increased by the parasitic notch. It is important that the maximum frequency bandwidth can be obtained when the parasitic notch is located at A and has length 40 mm. The maximum bandwidth of the FNA is 1.5 times that of the FNA. Although the frequency bandwidth of the proposed antenna is narrower than that of the QSCA, the proposed antenna can match the 50 Ω radio component. As the result, it is confirmed that the parasitic notch is effective for broadband.

Figure 5 shows the frequency responses of VSWR for the FNA and the proposed FNA with the parasitic notch for L=40 mm at point A. The frequency bandwidth of the proposed antenna is about 30 % and the center frequency is almost the same as that of the FNA.

Finally, current distribution is discussed in order to confirm whether the current distribution of the FNA resembles that of the QSCA. Figure 6 shows the current distribution on line a-b of the proposed antenna, where Fl, Fc, and Fh are the frequency of the minimum, the center, and the maximum in the proposed antenna frequency band, respectively. The current amplitude is small and phase changes greatly at point A for both frequencies. The current distribution of the proposed antenna is similar to that of the QSCA.

Also, Figure 7 shows the current distribution on the larger conductor, where the longitudinal current amplitude and current phase are selected. Range of the current amplitude is from 0 dB to –40 dB and the contour line interval is 2 dB. Contour line interval of the current phase is 30 degrees. It is obvious that the parasitic notch controls the current distribution on the larger conductor adequately. As a result, it is confirmed that the authors' assumption is valid for the FNA as shown in Fig 1.

4. CONCLUSION

A new broadband FNA with a parasitic notch on a rectangular conductor was proposed. The authors paid attention to similarity of structure of the FNA and QSCA and assumed that if current distribution of the FNA were controlled to resemble that of the QSCA, frequency bandwidth of the FNA would become wide. In order to control the current distribution, the parasitic notch was proposed. The parasitic notch adjusted the current distribution on the larger conductor in order to resemble the current distribution on QSCA. The simulation results showed that frequency bandwidth of the proposed antenna was 1.5 times the bandwidth of the original FNA when the parasitic notch is located based on the current distribution on the QSCA.

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