Design of a multi-band coupled fed printed dipole antenna as an array element for direction finding systems

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***Abstract* - This article proposes the design of a coupled fed printed dipole antenna for multi-band arrays. The antenna consists of the printed dipole and feeder to obtain the multi-band operation. To confirm the DF capability of the proposed antenna, the pattern of the 4×4 arrays is observed by varying the steering angle.**

***Index Terms* — Coupled feed, array, Printed dipole, Broad beam pattern, Multi-band.**

1. Introduction

Direction finding (DF) systems are often used in the military to detect enemy locations by their radio-frequency communications. Recently, they are also used in a variety of non-military applications, such as detecting un-authorized transmitters, finding shadow zones of various wireless services, and ground-penetrating radars [1]. The characteristic of individual elements in array is the key factor for DF performance because the DF system is implemented by mounting an antenna array that uses the amplitude and phase difference of the induced current at each port [2]. Several types of antennas have been reported for use in DF system, including a Vivaldi [3], a patch antenna [4], a quasi-Yagi antenna [5], multi-loop antennas [6], and slot antennas [7, 8]. However, most of previous researches are focused on bandwidth improvement and impedance matching optimization, while the radiation pattern of antennas such as the broad beam-width for DF systems has not been fully studied yet [4].

In this paper, we propose the design of the multi-band printed dipole antenna with broad beam-width for a wide beam scan angle in DF performance. The proposed antenna structure consists of the radiating printed dipole and feeder that is located on the opposite side of the dipole. The printed dipole is then electromagnetically coupled with the feeder to improve multi-band characteristics. To confirm the DF capability of the proposed antenna, the pattern of the array is observed by varying the steering angle.

2. Printed dipole antenna geometry

Fig. 1 shows the geometry of the multi-band printed dipole antenna structure. The proposed antenna consists of a printed dipole and a feeder that is located on the opposite side of the dipole. The stepped-width arm of the printed dipole is electromagnetically coupled with the feeder to obtain multi-band and broad beam-width characteristics. The length and width of the dipole (L and W_6) are designed considering the operating frequency. The dipole and feeder are printed on both sides of the FR4 substrate with a thickness of D. The design parameters are listed in Table I.

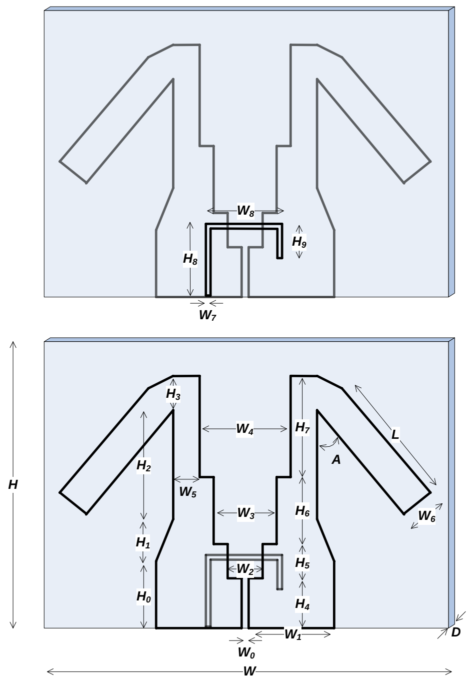


Fig. 1. Geometry of the multi-band dipole antenna.

TABLE I
Parameters of the proposed antenna (mm)

Parameter	Size	Parameter	Size	Parameter	Size
W	*150*	W_3	*14*	H_2	*29.6*
H	*82*	W_4	*16*	H_3	*10*
D	*4*	W_5	*8*	H_4	*3*
L	*40.4*	W_6	*10*	H_5	*25*
A	*40˚*	W_7	*1.5*	H_6	*19*
W_0	*2*	W_8	*20*	H_7	*30*
W_1	*24*	H_0	*20.4*	H_8	*20*
W_2	*10*	H_1	*12*	H_9	*10*

Fig. 2 presents the reflection coefficient and the bore-sight gain as a function of frequency. The blue and red lines indicate the gain and reflection coefficient, respectively. The reflection coefficients are –8.8 dB and –11.1 dB at 1.2 GHz and 2.4 GHz. The bore-sight gains are 5.32 dBi and 6.28 dBi at operating frequencies, respectively.

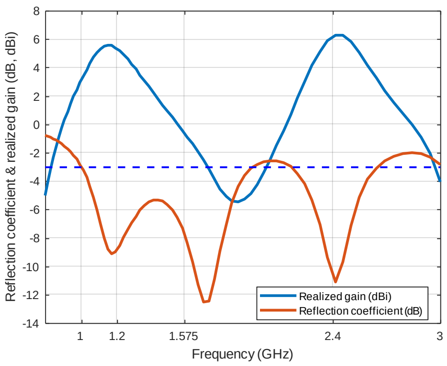


Fig. 2. Reflection coefficient and realized gain of the multi-band antenna.

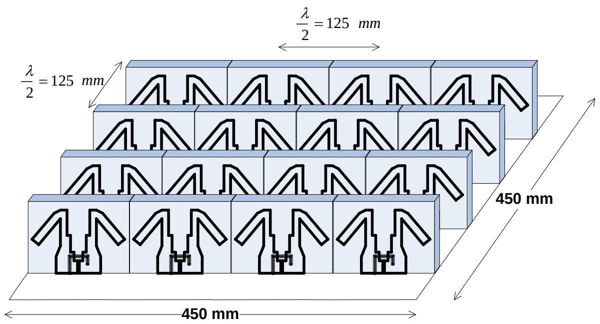
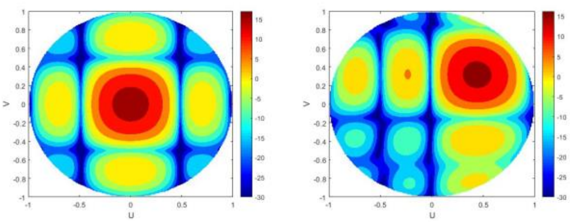


Fig. 3. Geometry of the 4 × 4 antenna array.

Fig. 3 represents the 16-element array using the proposed printed diploes with a element spacing of 125 mm (about $\lambda_0/2$ at 1.2 GHz). The array is mounted on the ground platform of 450 mm × 450 mm.

Fig. 4(a) and (b) present the simulated radiation patterns, when the steering angles are 0° and 30° at 1.2 GHz. The results demonstrate that the proposed antenna is suitable for the single element of the array in DF systems.



(a) $\theta = 0°$, $\phi = 0°$ (b) $\theta = 30°$, $\phi = 30°$.

Fig. 4. Radiation pattern of the 4 × 4 array.

3. Conclusion

We have investigated the design of the multi-band printed dipole antenna with broad beam-width characteristics for a wide beam scan angle in DF systems. The proposed antenna was composed of the radiating printed dipole and feeder, and the dipole was electromagnetically coupled with the feeder for multi-band operation. The reflection coefficients were –8.8 dB and –11.1 dB at 1.2 GHz and 2.4 GHz, and the bore-sight gains were 5.32 dBi and 6.28 dBi, respectively. To confirm the DF capability of the proposed antenna, the pattern of the 4×4 array was observed by varying the steering angle from 0° to 30°. The results demonstrated that the proposed antenna is suitable for the single element of the array in DF systems.

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