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Design and Analysis of CPW Monopole Antenna for Wireless Applications

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Abstract

In this paper, a Coplanar Waveguide (CPW) Monopole Antenna is presented. The proposed antenna operate in 2 different frequency band which make is suitable for different type of Wireless applications such as GSM, Bluetooth, WLAN etc. The antenna design has been analyzing using Sampling – Biorthogonal Time – Domain (SBTD) method. This biorthonormal system has exact interpolation properties and demonstrates superiority over the FDTD in terms ofmemory and speed. For CPW antenna return loss is compare with the traditional Finite-Difference Time - Domain (FDTD) and results are provided.

Keywords:Coplanar Waveguide (CPW), GSM, WLAN, SBTD, FDTD,Return loss, Multiband Antenna.

Introduction

Recently there has been increasing demand of microwave and mobile communication systems, with multiple applications gaining attention to improve the performance of the antenna. Most of the wireless communication systems need a circular polarized antenna to establish a communication link between a satellite (or base station) and mobile device.Among the well-known multiband antenna prototypes, the planar and coplanar monopole antennas of various configurations have become popular because they provide attractive antenna characteristics, namely: low profile, light weight, low cost, versatile configuration for exciting dual or multiresonance modes, and exhibiting wide impedance bandwidth with desirable radiation characteristics. However, the difficulty in designing such antennas is challenging when the size of the antenna needs to be reduced and the number of operating [1].

Usually, multiband antenna design involves many geometry or material parameters. These parameters may be discrete, and often include constrains in allowable values. Optimizing such antennas to closely approximate desired multiresonant performance is similar to searching the global solution from a multidimensional solution space. The particle swarm optimization (PSO), based on the simulation of a simplified sociological behavior associated with swarm such as bees, bird flocking, and fish schooling, is a new optimization algorithm first proposed by Kennedy and Eberhart in 1995 for solving multidimensional discontinuous problems. This technique is simpler than the Genetic

Algorithm (GA) and has been successfully applied to a variety of fields. Especially, the PSO, used in conjunction with the numerical electromagnetic solver, is found to be a revolutionary new approach to antenna design and optimization [2]. Typically, dual-frequency operations have been obtained by multilayer stacked patches and little attention has been paid to single-layer microstrip antennas. The demand for directional antennas with high gain and wideband radiation characteristics for different wireless applications has increased in the last decade [3] – [4].

A cavity-model based simulation tool, along with a genetic optimization algorithm, was presented in [5] for the design of dual-band microstrip antennas. This used multiple slots in the patch, or multiple shorting strips between the patch and the ground plane. The optimization of the positions of the slots and shorting strips was then performed via a genetic optimization algorithm to achieve acceptable antenna operation over the desired frequency bands [4].

The antenna has been analyzed using Sampling Biorthogonal Time-Domain (SBTD)

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method [6]. The positive sampling basis and its biorthogonal dual testing functions are constructed, employing the Daubechies scaling functions D2. Owing to the exact sampling property of the basis functions and their biorthogonal testing functions, the expansion and testing procedures are both rigorous for the (SBTD) method. Recently, the Battle–Lemarie based Multiresolution Time-Domain (MRTD) technique has been successfully applied [1]–[3] to a variety of microwave problems and has demonstrated unparalleled properties. In addition to significant savings in time and in memory by one and two orders of magnitude, respectively, the most important advantage of this new technique is its capability to provide space and time adaptive meshing [8] without the problems encountered by the conventional finite-difference time-domain (FDTD) technique [7] –[9].

SBTD Algorithm

For SBTD scheme the following basis expression is used

$$Sm(x) = S\left(\frac{x}{\Delta x} - m\right) \quad (1)$$

To construct the Daubechies based biorthogonal sampling basis we use the following expression in for a positive sampling function

$$S(x) = \frac{2v}{v-1}\sum_{n=0}^{+\infty}\left(\frac{1+v}{1-v}\right) \emptyset(x-n+1) \quad (2)$$

Where

$\emptyset(x)$is the Daubechies scaling function

S(x) is the Sampling function

V is equal to $^{-1}/_{\sqrt{3}}$

If $\emptyset(1) = \frac{v-1}{2v}$ and $\emptyset(2) = \frac{v+1}{2v}$then equation (2) is written as

$$S(x) = \frac{1}{\emptyset(1)}\sum_{n=0}^{+\infty}\left(\frac{\emptyset(2)}{\emptyset(1)}\right) \emptyset(x-n+1) \quad (3)$$

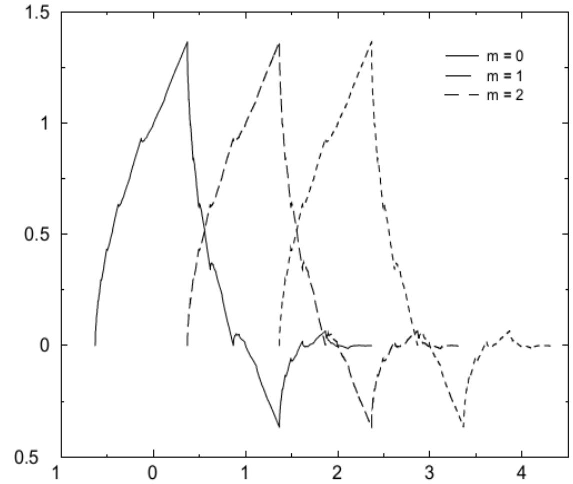

Fig.1 Daubechies shifted scaling functions (N=2) for m=0, 1, 2.

The shifted version of sampling function S(x) is defined as

$$Sm(x) = S(x-m) (4)$$

The following exact interpolating property holds for the above-defined sampling function Sm(x)

$$Sm(x) = \Delta m, k \quad (5)$$

Sampling function Sm(x) is not orthogonal with respect to shift

$$\int_{-\infty}^{+\infty} Sm(x)Sn(x)dx \neq \Delta m, n \quad (6)$$

Therefore biorthogonal testing function Qn(x) is introduced in a such a way that

$$Qn(x) = \sum_p \emptyset(x-p)\emptyset(n-p) \quad (7)$$

So Sm(x) and Qn(x) become orthogonal to each other with respect to shift

$$\int_{-\infty}^{+\infty} Qn(x)Sm(x)dx = \Delta n. m \quad (8)$$

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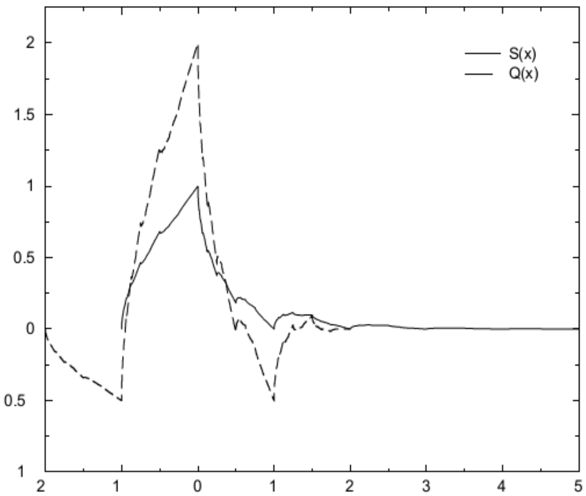

Fig.2 Sampling functionS(x) and biorthogonal functionQ(x).

Due to rapid decay of the sampling function S(x) and finite support of the testing function Q(x), the number of the nonzero coefficients {ai} is small, as in the case of Wavelet-Galerkin Time-Domain (WGTD) technique with the shifted Daubechies basis. There are six updating equations or boundary condition used in SBTD methods which are achieved using Maxwell equations [7] – [9]. Some of the equation is given below

$$1. {}_{k+1/2}H^{x}_{l,m+1/2,n+1/2} = {}_{k-1/2}H^{x}_{l,m+1/2,n+1/2} + \Delta t/\mu_{l,m+1/2,n+1/2} \left[1/\Delta z \sum^{2}_{i=-3ai.k} E^{y}_{l,m+1/2,n+1/2} - 1/\Delta y \sum^{2}_{i=-3ai.k} E^{y}_{l,m+1/2,n+1/2}\right] \quad (9)$$

$$2. {}_{k+1/2}H^{y}_{l+1/2,m,n+1/2} = {}_{k-1/2}H^{y}_{l+1/2,m,n+1/2} + \Delta t/\mu_{l+1/2,m,n+1/2} \left[1/\Delta x \sum^{2}_{i=-3ai.k} E^{z}_{l+1/2,m,n+1/2} - 1/\Delta z \sum^{2}_{i=-3ai.k} E^{z}_{l+1/2,m,n+1/2}\right] \quad (10)$$

$$3. {}_{k+1/2}H^{z}_{l+1/2,m+1/2,n} = {}_{k-1/2}H^{z}_{l+1/2,m+1/2,n} + \Delta t/\mu_{l+1/2,m+1/2,n} \left[1/\Delta y \sum^{2}_{i=-3ai.k} E^{x}_{l+1/2,m+1/2,n} - 1/\Delta x \sum^{2}_{i=-3ai.k} E^{y}_{l+1+i,m+1/2,n}\right] \quad (11)$$

Design Specifications

The design of the CPW monopole antenna is given in Fig. 3.

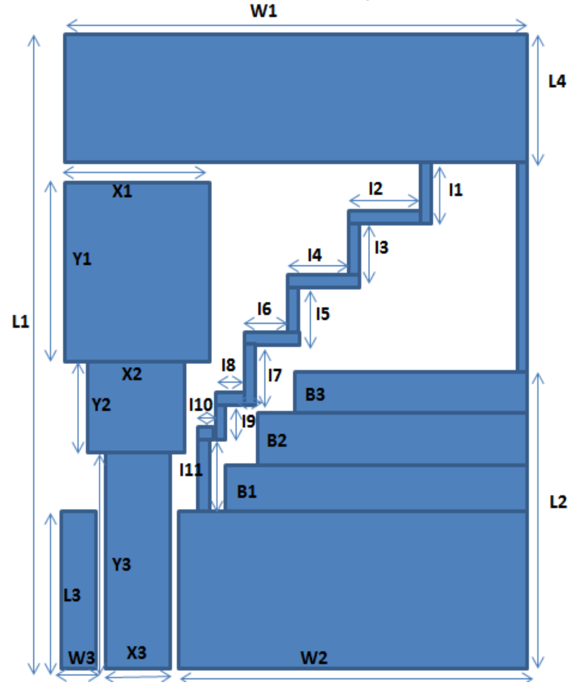

Fig.3 Design of the Proposed CPW Antenna. The antenna dimensions are calculated using PSO Algorithm [2].

Table 1 Parameter of the Proposed Antenna

Parameter	Size in mm	Parameter	Size in mm
L1	24.0	B2	1.4
L2	8.0	B3	1.2
L3	4.50	I1	2.2
L4	4.30	I2	1.85
W1	18.0	I3	1.95
W2	12.50	I4	1.7
W3	1.50	I5	1.8
X1	6.0	I6	1.55
X2	3.70	I7	1.65
X3	2.60	I8	1.50
Y1	6.80	I9	1.50
Y2	2.45	I10	0.5
Y3	6.10	I11	2.70
B1	1.7	Strip width	0.5

In PSO algorithm resembling the social behavior of a swarm of bees to search the location with the most flowers in afield, the optimization procedure of PSO is based on a population of particles that fly in the solution space with velocity dynamically adjusted according to its own flying experience and the flying experience of the best among the swarm.

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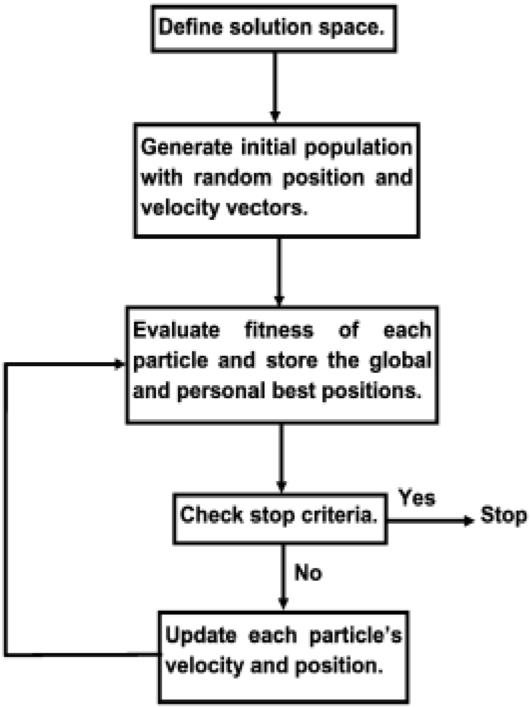

Fig. 4 Flowchart of PSO Algorithm.

Result and Discussion

The return loss of antenna has been analyzed. For the SBTD method mesh size 40x60x10 = 24000 cells is used. Simulation result is present in the Fig. 5.

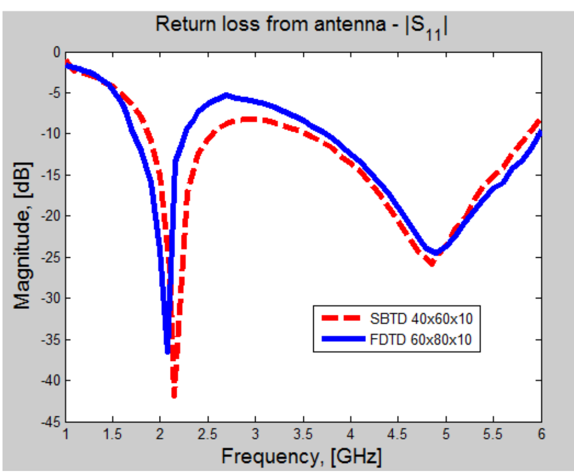

Fig. 5 Return loss of the CPW monopole antenna.

For this design Matlab tool has been used. Here in SBTD method cell size is 24000 cells and in FDTD method 60x80x12 = 57600 cells are used, but still SBTD method gives better performance for small mesh size. In fig. 5 SBTD method gives factor 10 and 952.5/543.8 = 1.75 of the computer memory and computational time saving respectively.

In fig. 6 Radiation patterns has been presented. The radiation characteristic of the antenna is stable within the operating bands, and the cross-polarization radiation patterns are relatively small. The radiation patterns are omnidirectional in nature in H- plane.

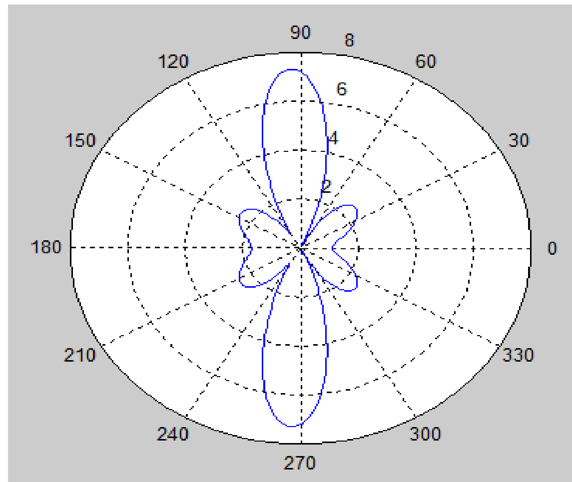

Fig. 6 Radiation pattern s of the CPW monopole antenna.

Conclusion

In this paper, a CPW-fed planar monopole antenna, which is small in size and covering different frequency, has been presented. The proposed antenna has several advantages such as small size, excellent radiation characteristics, and circular polarization in the WLAN operating band. The newly implemented SBTD technique demonstrated better efficiency in terms of accuracy, computational time and computer memory than the traditional FDTD and previously developed MRTD technique.

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