U-Slot 패치를 이용한 광대역 안테나의 설계에 관한 연구

論 文
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A Study on the Design of Wideband Antenn as using U-Slot Patches

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Abstract - Microstrip antennas generally have a lot of advantages that are thin profile, lightweight, low cost, and conformability to a shaped surface application with integrated circuitry. In addition to military applications, they have become attractive candidates in a variety of commercial applications such as mobile satellite communications, the direct broadcast system (DBS), global positioning system (GPS), and remote sensing. Recently, many of the researches have been achieved for improving the impedance bandwidth of microstrip antennas. The basic form of the microstrip antenna, consisting of a conducting patch printed on a grounded substrate, has an impedance bandwidth of 1~2%. For improvement of narrow bandwidth of microstrip patch, we were designed U-slot microstrip patch antenna in this paper. This antenna had wide bandwidth for all personal communication services (PCS) and IMT-2000. For the design of U-slot microstrip patch antenna using a finite difference time domain(FDTD) method. This numerical method could get the frequency property of U-slot patch antenna and the electromagnetic fields of slots.

Key Words : Direct Broadcast System, Global Positioning System, Personal Communication Services, Finite Difference Time Domain, Photonics Band Gap

1. Introduction

According as late the 1990 information technology develops, carrying along terminal market for individual popularized.

Carrying along communication for individual is falling by the third generation's IMT-2000 which carrying along communication market for individual supports multimedia of user's TV audition according to desire, movie appreciation, internet search and so on and high quality obscene sounds and use all the world equal frequency band existent voice and 2 generation of vulgarity data communication putting first.

Necessity of available antenna is risen existent service (PCS and cellular) and together IMT-2000 in this period of transition.

IMT-2000 business is gone vigorously in present domestic, cellular businessman dual band's antenna integration base stationtransceiver system antenna or way to administer that PCS businessman acts existent frequency band and new IMT-2000 frequency towide band's antenna examine.

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Usually, microstrip patch antenna is hard to embody broadband frequency characteristic that satisfy PCS important duty and IMT-2000 important duty at the same time because bandwidth is very small and narrow.

Epitaxy structure that connect ground connection pin in existent broadband microstrip patch antenna to supplement shortcoming as long as is like this, or use coupling with slot of the round side and patch page, or have deformed structure of ground connection part.

Also, microstrip patch antenna etc.. of structure that use photonics band gap(PBG) or

defected ground structure(DGS) are studied abuzz[1] .

Designed usable broadband antenna PCS (1.75GHz~1.87GHz) and IMT-2000 (1.92GHz~2.17GHz) using U-slot patch antenna in this paper.

U-slot antenna can improve narrow frequency important duty problem of patch antenna by performer backfire by duplex resonance by structure that arrange U shape of a character slot on patch side of antenna [5-7].

Digital simulation that use numerical method requires dioxide for space and time sacred ground compulsorily, is permit systems analysis in sacred ground during time because memory and speed problem that limited FDTD's application by rapid development of modern digital computer are solved much.

Because using finite difference time domain(FDTD) to design U-slot patch antenna, observed electric wavespecial

quality in slot of antenna patch, and got design Parameter of U-slot patch antenna.

Also, applied algorithm parallel Tuesday to improve the design speed [8].

2. Finite difference time domain

FDTD of area electromagnetic field problem can apply easily in the free construction which analyze Maxwell's equation that is satisfied time and space by most actual and effective analysis method about laying eggs problem of electromagnetic waves and absorption in fortune sleeves quality or consists of homogeneity and rain homogeneity dielectric substance and magnetic substance and conductor etc. during proposed time because do [4].

2,1 Basis equation

Because simplified perfectly matched layer(PML) that is proposed by D.M. Sullivan compares existent Berenger's perfection conformity to PML more, the calculation amount and use memory increase comparatively, but modelling and PML formalization are simple in case is damage or laying eggs whipping.

Therefore, there is dielectric substance and applied Sullivan's FDTD law in this paper that see because structure is serviceable to apply than Berenger's PML in case of complicated patch antenna or filter [2-3].

Faction that PML transmits in interior by absorption whipping that make to the outermost shell of theborder to absorb electric wave that progress gradually according to each layer should not be reflected.

That is, in case there is material that is A, B, number of reflected image of when transmit by B in A is same with way (1), and in case characteristic impedance of two whipping is equal, reflection does not occur.

$$\Gamma=\frac{\eta_A-\eta_B}{\eta_A+\eta_B} \quad \left(\eta=\sqrt{\frac{\mu}{\varepsilon}}\right) \tag{1}$$

therefore, condition of PML whipping is same with way (2).

$$\eta_0=\eta_m=\sqrt{\frac{\mu^*_{F_m}}{\varepsilon^*_{F_m}}}=1 \tag{2}$$

Here normalization with done Maxwell equation D_z is way (3) as following be

$$\frac{\partial D_z}{\partial t}=\frac{1}{\sqrt{\varepsilon_0\mu_0}}\left(\frac{\partial H_y}{\partial y}-\frac{\partial H_x}{\partial z}\right) \tag{3}$$

Is same with way (4) if solve D_z to apply PML to three-dimensional space.

$$j\omega\cdot\left(1+\frac{\sigma_x(x)}{j\omega\varepsilon_0}\right)\left(1+\frac{\sigma_y(y)}{j\omega\varepsilon_0}\right)\left(1+\frac{\sigma_z(z)}{j\omega\varepsilon_0}\right)^{-1}Dz$$
$$=c_0\cdot\left(\frac{\partial H_y}{\partial x}-\frac{\partial H_x}{\partial y}\right) \tag{4}$$

If arrange with way (5)

$$j\omega\cdot\left(1+\frac{\sigma_x(x)}{j\omega\varepsilon_0}\right)\left(1+\frac{\sigma_y(y)}{j\omega\varepsilon_0}\right)Dz = c_0\left(1+\frac{\sigma_z(z)}{j\omega\varepsilon_0}\right)\cdot$$
$$\left(\frac{\partial H_y}{\partial x}-\frac{\partial H_x}{\partial y}\right) = c_0\cdot Curl\,h+c_0\cdot\frac{\sigma_z(z)}{\varepsilon_0}\frac{1}{j\omega}Curl\,h \tag{5}$$

Here, if $I_{D_z}=\frac{1}{j\omega}Curl\,h$

$$j\omega\cdot\left(1+\frac{\sigma_x(x)}{j\omega\varepsilon_0}\right)\left(1+\frac{\sigma_y(y)}{j\omega\varepsilon_0}\right)Dz=c_0\left(Curl\,h+\frac{\sigma_z(z)}{\varepsilon_0}I_{D_z}\right) \tag{6}$$

If readjust

$$D_z^{n+1/2}(i,j,k+1/2)$$
$$=gi3(i)\cdot gj3(j)\cdot D_z^{n-1/2}(i,j,k+1/2)$$
$$+gi2(i)\cdot gj2(j)\cdot\frac{1}{2}\cdot(Curl\,h+$$
$$gk1(k)\cdot I^n_{D_z}(i,j,k+1/2))$$

$$Curl\,h=[H_y^n(i+1/2,j,k+1/2)$$
$$-H_y^n(i-1/2,j,k+1/2)$$
$$-H_x^n(i,j+1/2,k+1/2)+H_x^n(i,j-1/2,k+1/2)]$$
$$I^n_{D_z}(i,j,k+1/2)=I^{n-1}_{D_z}(i,j,k+1/2)+Curl\,h \tag{7}$$

Here,

$$gi1(i)=xn,\ gj1(j)=xn,\ gk1(k)=xn,\ 0\le xn\le 0.333$$
$$gi2(i)=\left(\frac{1}{1+xn}\right),\ gj2(j)=\left(\frac{1}{1+xn}\right)$$
$$gk2(k)=\left(\frac{1}{1+xn}\right),\ gi3(i)=\left(\frac{1-xn}{1+xn}\right)$$
$$gj3(j)=\left(\frac{1-xn}{1+xn}\right),\ gk3(k)=\left(\frac{1-xn}{1+xn}\right) \tag{8}$$

it is (8).

D_x to as if concern and arrange D_x , D_y, H_x, H_y, H_z to treat do can.

Also, is same with dispersion space Δt way (9)

$$\Delta t=\frac{\Delta d}{2c_0} \tag{9}$$

2.2 Application of FDTD law

When analyzed U-slot patch antenna and inputed Gausian pulse using FDTD method net waveform using fast fourier transmit(FFT) S11 save .

Also, applied parallel algorithm to improve the analysis speed.

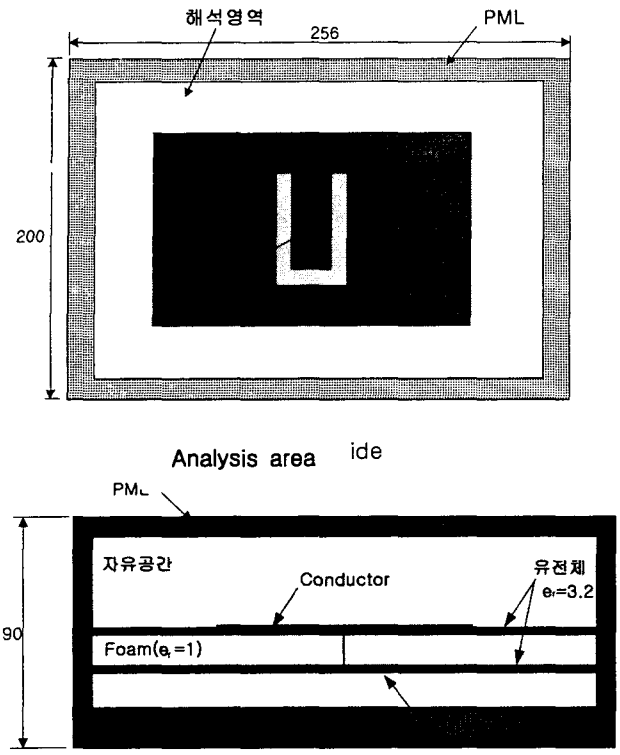
Fig. 1 To analyze silver U-slot patch antenna(a), show boundary condition that do modelling with (b).

Surface of microphone loss trip conductor applied $E_t=0$ supposing by perfection conductor and outer wall side of antenna applied PML.

Matrix size that use to apply FDTD law executed analysis in third dimension right angle coordinate system being 90×200×256(mm).

Also, absorption border condition number of layers 8 EA PML' s apply.

This time, dispersion space is dx = dy = dz = 0.5(mm) and dispersion time is dt = 0.33e-13(s).



(b) side

Fig. 1 Designed U-slot tablet public peace hoop or FDTD boundary condition

FDTD law is very useful because can apply conveniently in various rescue, but require much times fairly.

Therefore, various algorithm is applied for speed improvement.

Applied algorithm parallel anger for speed improvement at FDTD law application in this paper, and IBM SP-2 super computer in super computer center has all 32 nodes in MIMD type.

Program that is applied in this dissertation did parallel anger so that may act in 10 processors and saw speed improvement effect more than about 9.5 times.

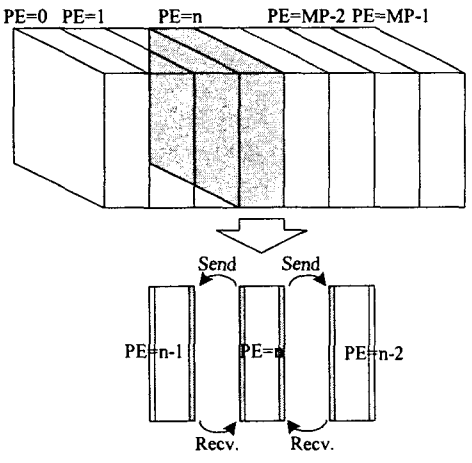


Fig. 2 parallel anger of processor

Fig. 2 is displaying method parallel anger of processor.

Must divide memory shared to apply techniques to FDTD parallel anger that use n EA processor by area of a n EA and each processor communicates the outermost shell value of each area to processor that adjoin after calculate each allocated area.

3. Design and manufacture

3.1 Design

U-slot antenna is by structure that derive duplex resonance making U shape of a character's slot to center feeder distribution center surroundings in antenna do four corners supremacy with figure 3.

Slot and street of distance (W_s) slot between slot must save distance (B) between (L_s) U-slot and patch, position (F) design parameter of input point in important design parameter of U-slot patch antenna to do the first resonance frequency (f1) the second resonance frequency (f2) to resonate in use wide-band to design U-slot patch antenna.

If achieve simulation using FDTD method sequentially about each design parameter, get same result coming Fig. 4.

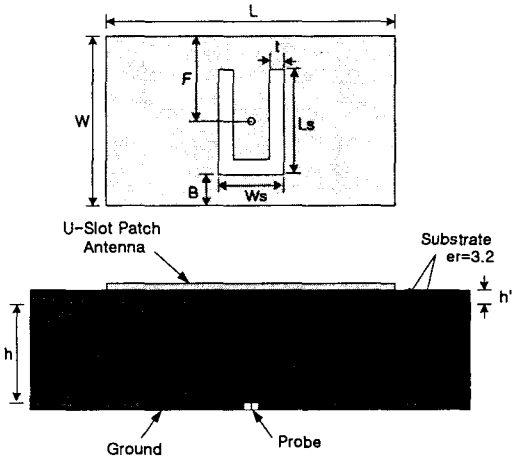
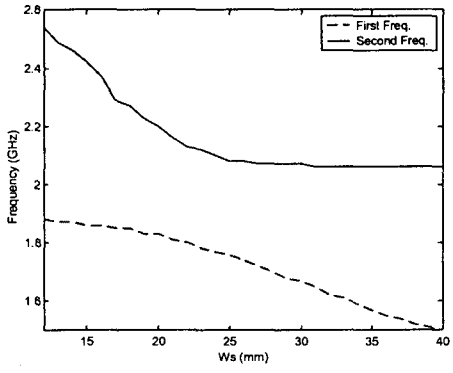
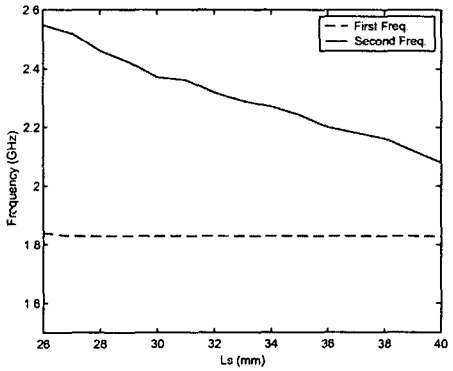


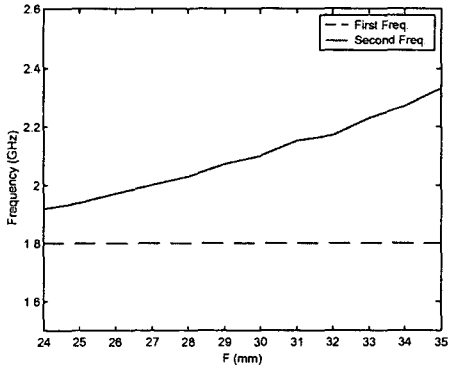
Fig. 3 U-slot patch Antenna 1



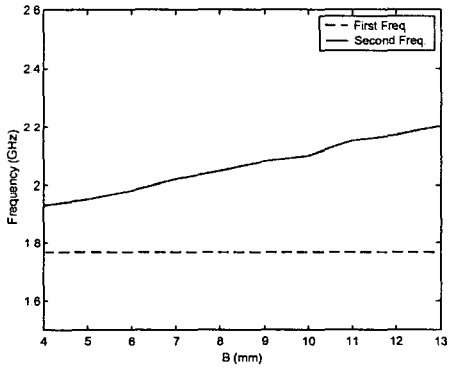
(a) Distance between slot (Ws)



(b) Street tooth of slot (Ls)



(c) Position of input point (F)



(d) Distance of patch and U-slot interval (B)

Fig. 4 Change of design parameter

Fig. 4 (a) The first the second resonance frequency decrease, and also reduces continuously the first resonance frequency from (W_s) 25mm neighborhood according as increase (W_s) like course, but can know that the second resonance frequency is no change almost.

Fig, 4 (b) While the first resonance frequency is seldom change of resonance frequency by (L_s) change together coming the second resonance frequency change serious .

Fig. 4 (c) the first resonance frequency according to F is no change almost but the second resonance frequency can confirm that resonance frequency rises according as F grows.

Fig. 4 (d) with Fig. 4 (c) relationship F analogously according as B increases the first resonance frequency almost change have while, but the second resonance frequency can know that rise.

3.2 Analysis and results of measurements

Fig. 5 is displaying designed U-slot patch antenna, and simulation result and d appeared to each Fig. 6 (a), Fig. 6 (b).

Fig. 5 Manufactured U-slot patch antenna

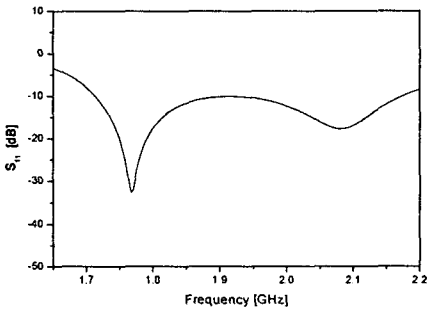
Fig. 6 (a) satisfies to bandwidth from below 10 dB to frequency 1.72GHz~2.17GHz being reflection loss that save to simulation.

Fig. 6 (b) is as result that measure manufactured antenna by HP8753 network analyzer.

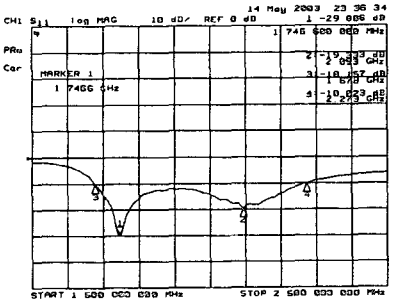
When see measured result, have proxy of 1.678GHz~2.273GHz in reflection loss department 10 dB low.

This satisfies PCS important duty (1.75GHz~1.87GHz) and IMT-2000 important duty (1.92GHz~2.17GHz) at the same time.

Fig. 7 It is electromagnetic field distribution chart that do simulation because using silver FDTD.



(a) Simulation result



(b) When measure

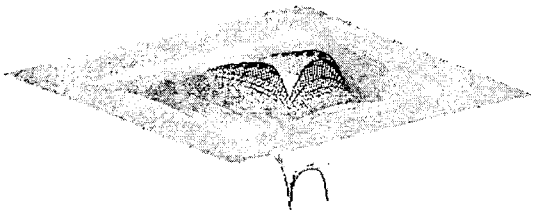
Fig. 6 Reflection loss

By probe at patch central sine wave that is transmit out of patch when did sudden change see can .

If see U-slot of antenna and dry field of patch, slot part and patch part can know always that false echo is opposite.

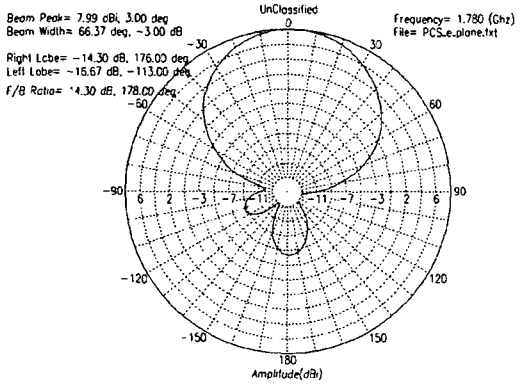
Can presume that duplex resonance happens by such U-slot's effect.

(a) $t = 500\Delta t$

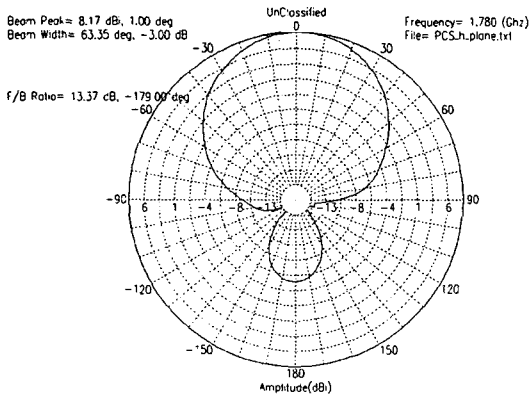


(b) $t = 800\Delta t$

Fig. 7 Electromagnetic fields distribution in patch slot



(a) E_plane



(b) H_plane

Fig. 8 Radiation pattern

Fig. 8 Is displaying E-plane of silver 1.78GHz and H-plane's radiation pattern.

4. Conclusion

So that can use PCS and IMT-2000 integration base station transceiver system in this paper, design and manufactured microstrip patch antenna that use U-slot that have broadband special quality.

Arrange U-slot on patch side to improve narrow bandwidth of microstrip patch antenna, and manufacture is easy and designed firmly by applying dielectric substance board, term of work, structure of dielectric substance board.

U-slot microstrip patch antenna special quality change by change of design para meta of length of slot that is design para meta of antenna, range of slot, distance between slot, position of input point, slot and distance between patch etc. because do simulation through FDTD that apply PML tendency grasp, and this by standard suitable antenna design and result and result that manufacture that manufactured, and do simulation 1, 2 cars resonance frequency displayed 17.6 dB - in 32 dB, 2.09GHz - in each 1.77GHz and measured result showed that agree almost by 19.3 dB - in 29.8 dB, 2.093GHz - in 1.746GHz, but bandwidth showed simulation value and some difference.

Antenna that is studied in this paper is expected to be utilized to antenna for PCS and IMT-2000 service in building shade area preferentially, and is expected to be profitable manufacturing drug and economical expense cotton on establishment space that two service is available to one antenna in case patch antenna that use U-slot is applied.

Hereafter, is considered that is subject to study forward to use to triple band antenna that include this antenna to radio LAN frequency band.

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