5. H. Nam, H. Lee, and Y. Lim, A design and fabrication of bandpass filter using miniaturized microstrip square SIR, Elect Electron Technol Conf Dig (2001), 395–398.
6. J.R. Crute and L.E. Davis, A compact microstrip interdigital stepped impedance bandpass filter with enhanced stop band, Microwave Opt Technol Lett 34 (2002), 336–340.
7. M.-H. Weng, H.-W. Wu, and Y.-K. Su, Compact and low loss dual-band bandpass filter using pseudo-interdigital stepped impedance resonators for WLANs, IEEE Microwave Wireless Compon Lett 17 (2007), 187–189.
8. J. Zhang, J.-Z.B. Cui, and X. Wsun, Compact and harmonic suppression open-loop resonator bandpass filter with tri-section SIR, Prog Electromagn Res 69 (2007), 93–100.
9. X. Wang, P. Liu, and Y. Li, New compact configuration of a stepped impedance ceramic bandpass filter, Microwave Opt Technol Lett 41 (2004), 146–149.
10. Y.W. Kong and S.T. Chew, A miniaturized end-coupled filter using stepped-impedance resonators, Microwave Opt Technol Lett 46 (2005), 97–99.
11. H. Zhang and K.J. Chen, Miniaturized coplanar waveguide bandpass filters using multisection stepped-impedance resonators, IEEE Trans Microwave Theory Tech 54 (2006), 1090–1095.
12. D. Packiaraj, M. Ramesh, and A.T. Kalghatgi, Design of a tri-section folded SIR filter, IEEE Microwave Wireless Compon Lett 16 (2006), 317–319.
13. G.L. Matthael, L. Young, and E.M. Jones, Microwave filters, impedance-matching network, and coupling structures, Artech House, Norwood, MA, 1980.
14. J.-S. Hong and M.J. Lancaster, Microstrip filter for RF/microwave applications, Wiley, 2001.

AN ELECTROMAGNETICALLY COUPLED DUAL-BAND DUAL-POLARIZED MICROSTRIP ANTENNA FOR WLAN APPLICATIONS

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ABSTRACT: *A new design of a dual-band dual-polarized electromagnetically coupled slot loaded square patch antenna, covering the WLAN 5.2 GHz and 5.8 GHz bands, achieving bandwidth enhancement by using tapered slot structure, is presented here. The proposed antenna covers 5.09–5.47 GHz and 5.7–5.88 GHz bands. Details of the antenna design along with experimental and simulated results are presented and discussed.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1867–1870, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23502

Key words: *dual-band dual-polarized microstrip antenna; WLAN antennas; tapered slot microstrip antennas*

1. INTRODUCTION

Because of compactness, microstrip radiators are popular in communication electromagnetics. Many techniques are used for obtaining dual-band operation in microstrip antennas. A variety of dual-band microstrip antennas are available in literature. Two typical designs of compact dual-band dual-polarized microstrip antennas are presented in [1] and [2], in which dual-band dual polarizations are achieved by introducing two orthogonal resonant lengths along the patch by etching slots. Another typical design by which frequency tuning is achieved by varying the shorting wall width is presented in [3].But the disadvantage of such designs is their low bandwidth when designed for special applications. Gao and Sambell in [4] presents a broadband dual-polarized antenna. It uses two orthogonal feeds which results in complexities in transmitter design. An antenna which covers all the three WLAN application bands is presented in [5]. It uses the principle of tapering in the monopole antenna geometry for achieving bandwidth enhancement.

In this article, we are presenting a dual-band tapered slot square patch antenna. Because the 2.4-GHz WLAN band has a higher interference from microwave ovens and cordless phones, the current trend is to use the 5.2/5.8 GHz bands. The proposed antenna covers both the above bands.

2. ANTENNA DESIGN

The Proposed design consists of a square microstrip patch of side $L = 36$ mm, fabricated on an FR4 epoxy substrate of dielectric constant, $\varepsilon_r = 4.4$ and height, $h = 1.6$ mm (see Fig. 1). A major central square slot tilted by 45° along its axis having dimension $L_1 = 23$ mm is fabricated initially for achieving tapered slot structure. Ansoft High Frequency Structure Simulator (HFSS) is used to optimize the dimensions and positions of the slot. For obtaining proper return loss characteristics, a rectangular slot tilted by 45° is etched parallel to the lower left edge of the major slot. The dimensions of the minor slot are selected to be 14 mm by 3 mm. The antenna is electromagnetically coupled using a 50 Ω transmission line fabricated on the same substrate and the feed point is optimized through simulation. The top view, side view, and the photograph of the fabricated antenna are shown in Figures 1(a), 1(b), and 2, respectively.

3. RESULTS AND DISCUSSION

The experimental and simulated return loss characteristics, using Agilent PNA Series Network Analyzer and HFSS, of the proposed

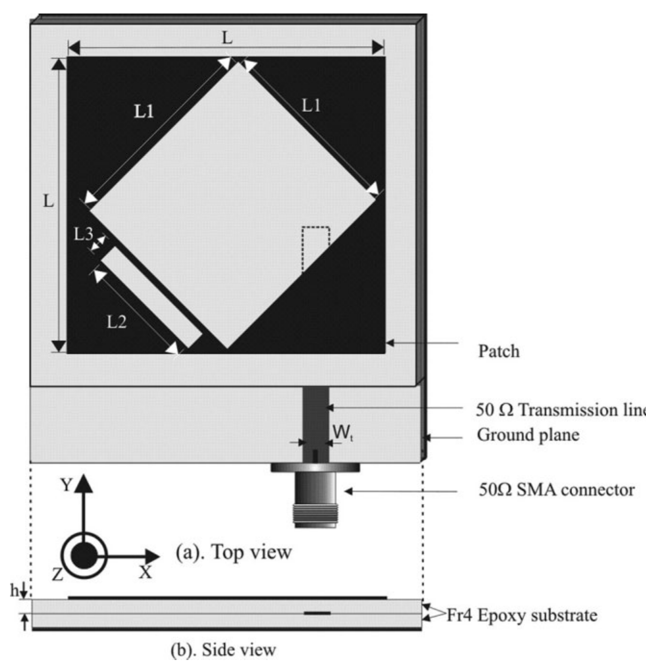

Figure 1 Antenna Geometry

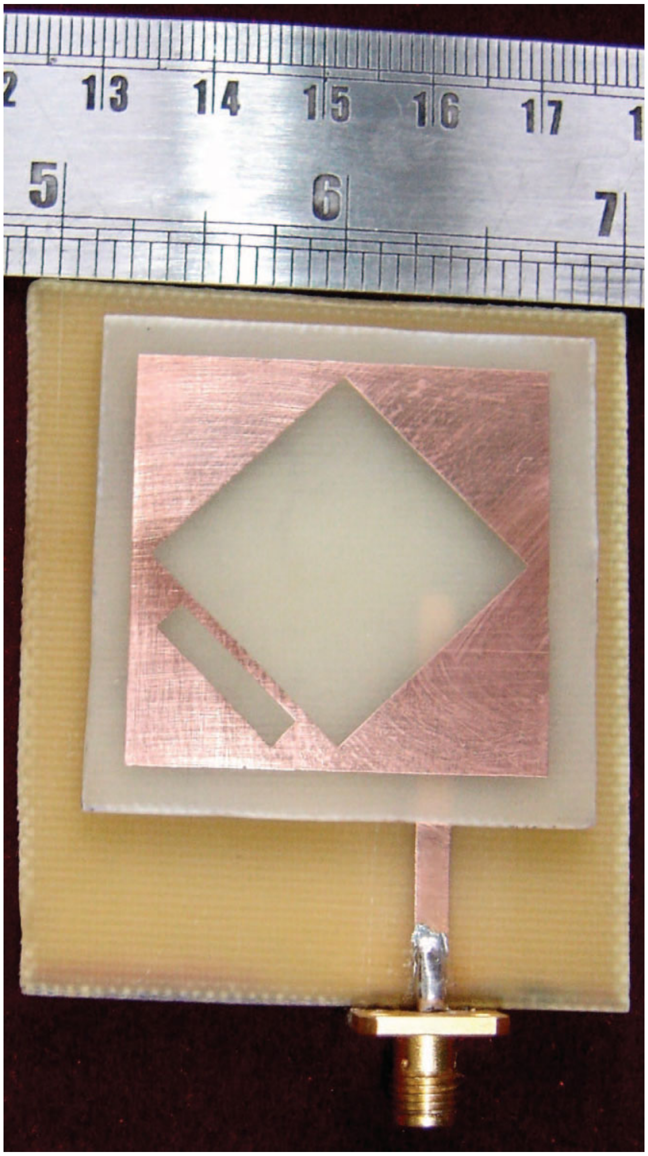

Figure 2 Photograph of the proposed antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

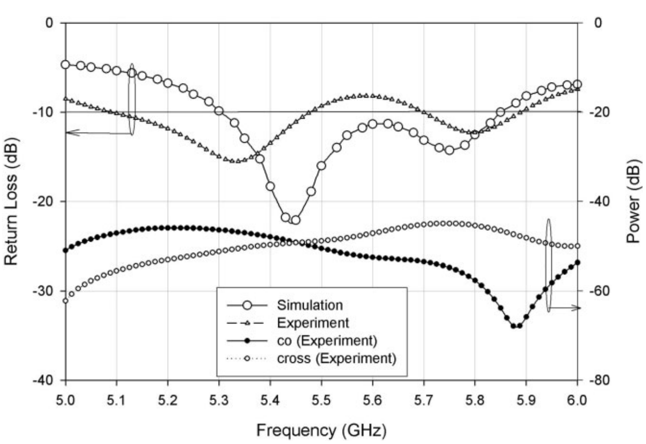

Figure 3 Measured return loss, co and cross powers with L = 36 mm, L_1 = 23 mm, L_2 = 23 mm, and L_3 = 3 mm, ε_r = 4.4 mm, h = 1.6 mm, and Wt = 3 mm

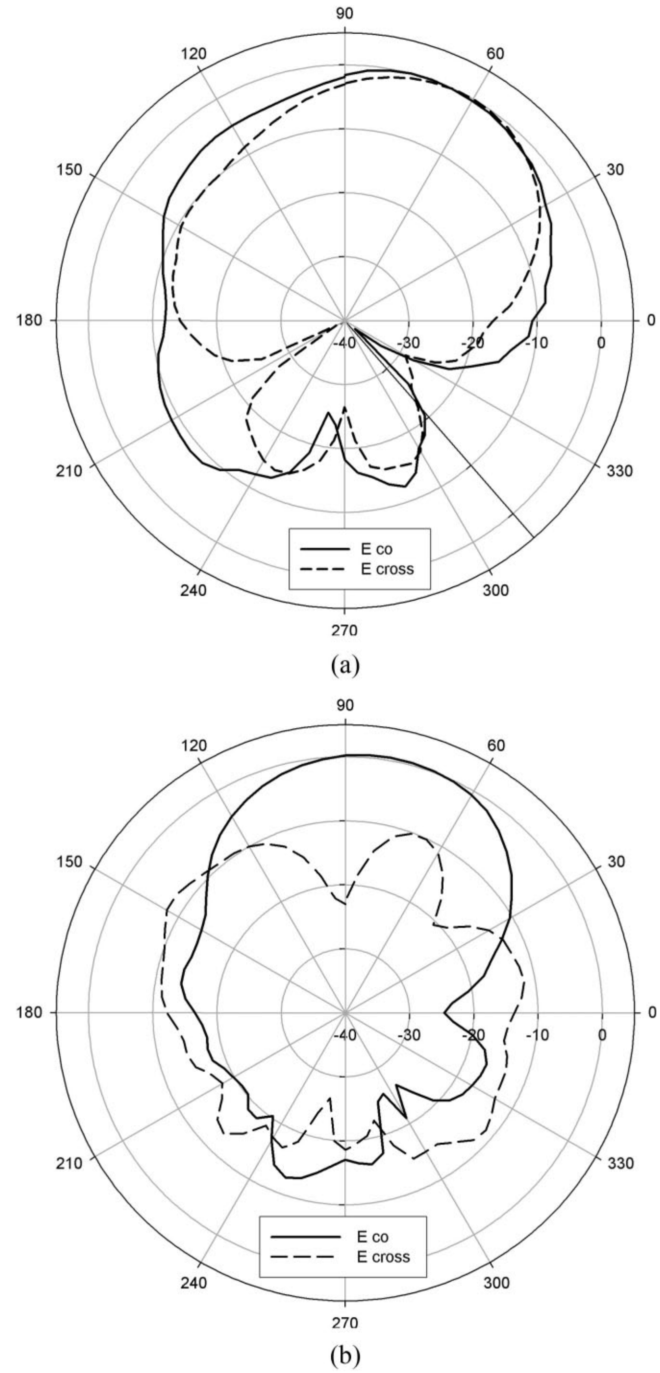

Figure 4 (a) Measured radiation patterns of the antenna at f = 5.3 GHz. (b) Measured radiation patterns of the antenna at f = 5.8 GHz

design are shown in Figure 3. A good matching below −10 dB over the first 5.09–5.47 GHz band and in the 5.69–5.88 GHz band is observed. It covers the WLAN 5.2 GHz and 5.8 GHz bands with bandwidth of 7.32% and 3.28%, respectively. A wide band standard horn antenna is used to measure the cross polar received power levels in both bands (see Fig. 3). The vector current density of the antenna at both the center frequencies is shown in Figure 5. It is observed that the vector surface current paths corresponding to the second band is making an angle of 45° degree with the axis of the square patch [Fig. 5(b)]. The second band has a better cross polar isolation. There are two distinct surface current paths for the first band as shown in Figure 5(b). The first band has a lesser cross

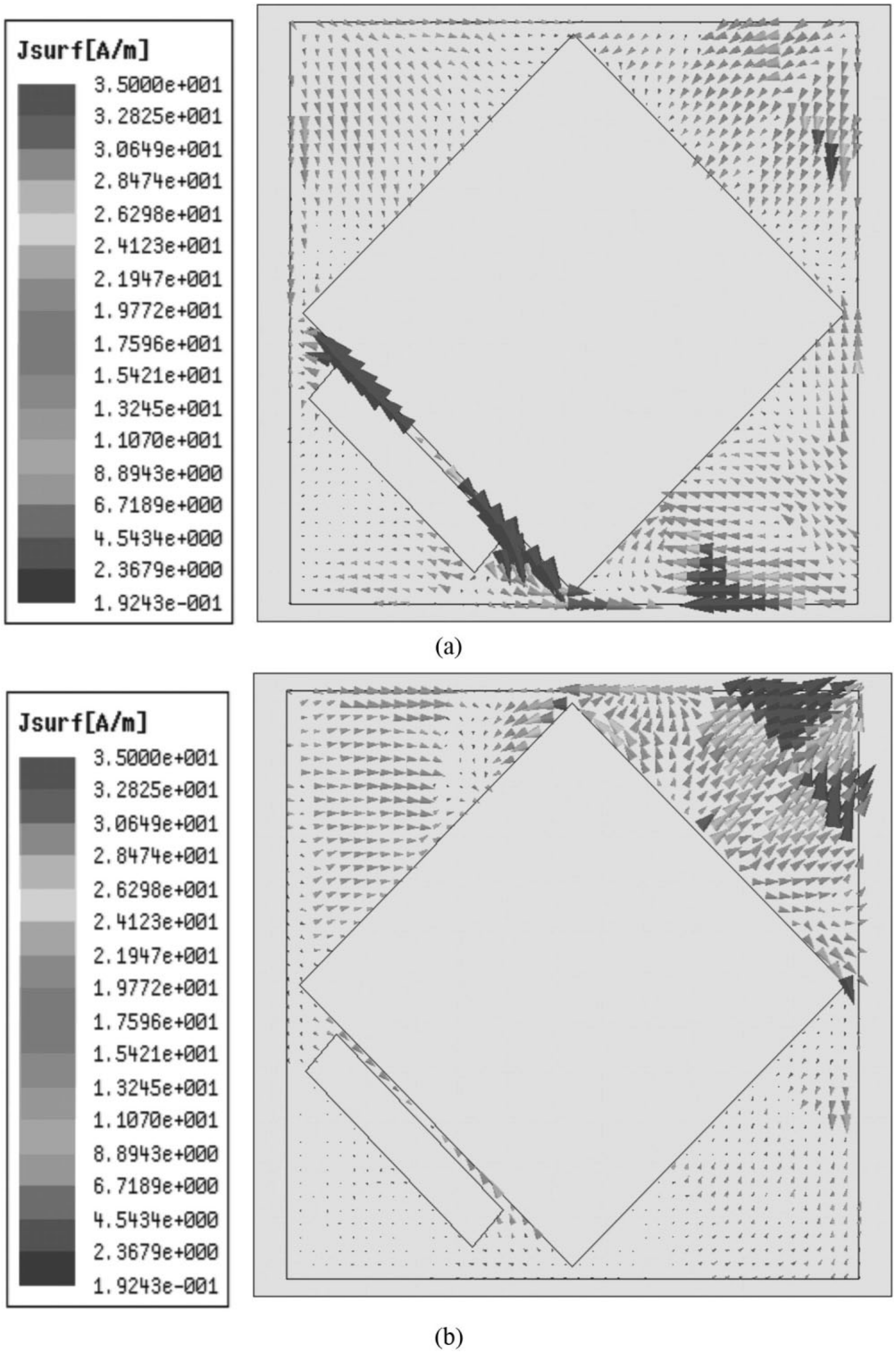

Figure 5 (A) Simulated surface current distribution of the proposed antenna at $f = 5.3$ GHz. (b) Simulated surface current distribution of the proposed antenna at 5.8 GHz

polar isolation shown in Figure 3. The radiation patterns of the antenna is shown in Figure 4. It is evident that the first band is elliptically polarized and the second is linearly polarized. From the polarization pattern measurement, the axial ratio is found to be 3.73 at 5.2 GHz.

4. CONCLUSION

A tilted slotted microstrip antenna incorporating dual-band dual polarization is proposed. The antenna is operating in the WLAN 5.2 GHz/5.8 GHz bands having bandwidth of 7.32% and 3.28%, respectively, in the first and second bands. The peak gain of the antenna is found to be 3 dBi for the first band and 4 dBi for the second band.

REFERENCES

1. G.S. Binoy, C.K. Aanandan, P. Mohanan, and K. Vasudevan, Compact dual-frequency dual-polarised slotted microstrip patch antenna, Microwave Opt Technol Lett 29 (2001), 60–62.

2. Manju Paulson, Sona O.Kundukulam, C.K. Aanandan, and P. Mohanan, A new compact dual-band dual-Polarized microstrip antenna, Microwave Opt Technol Lett 29 (2001), 315–317.
3. S.-H. Chen, J.-S. Row, and C.-Y.-D. Sim, Single-feed Square-ring patch-antenna with dual-frequency operation, Microwave Opt Technol Lett 49 (2007), 991–994.
4. S. Gao and A. Sambell, Broad band dual-polarised proximity coupled circular path antenna, Microwave Opt Technol Lett 47 (2005), 298–302.
5. R. Zaker, Ch. Ghobadi, and J. Nourinia, A modified microstrip-fed two step tapered Monopole antenna for UWB and WLAN applications, Prog Electromagn Res, PIER 77 (2007), 137–148.

EXACT DESIGN OF EVANESCENT-WAVE AMPLIFICATION USING BILAYER PERIODIC CIRCUIT STRUCTURES

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ABSTRACT: *An efficient method is presented to design the evanescent wave amplification exactly by cascading two layers of periodic series-shunt capacitors and inductors, which simulate a bilayer of magnetic and electric plasmas. Based on the presented method, equivalent lumped parameters of circuit structures are retrieved, from which the evanescent-wave amplification (EWA) is obtained at a designed frequency. Full-wave simulations show that the relative offset of the EWA frequency is less than 0.1%. The structure has been fabricated and measured, and the measurement results have good agreements with the simulation results. The proposed method can be used to design other periodic circuit structures, and the exact design of EWA can be used in the fabrication of novel components.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1870–1873, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23501

Key words: *evanescent wave amplification; periodic series-shunt capacitors; periodic series-shunt inductors; equivalent lumped parameters*

1. INTRODUCTION

Evanescent wave amplification (EWA) is one of the most important properties of metamaterials, which can lead to super-resolution imaging [1, 2]. Several theoretical analysis have been reported and EWA can be obtained by cascading two layers of double positive and double negative media or electric and magnetic plamas [1, 3-5]. The relevant experiments have also been studied and the amplification of evanescent waves has been created through surface plasmon between two layers [5-7]. However, most of experiments cannot be exactly designed at a required frequency, which makes it difficult to further design novel components based on the EWA property. For example, in the EWA design in Ref [5]., the required frequency is at 0.5 GHz, while the full-wave simulation and measurement results are at 0.45 GHz, which have a relative error of 10%. Such larger relative error is mainly caused by the parasitical parameters of metallic vias and microstrip line used for the weld of lumped capacitors and inductors.

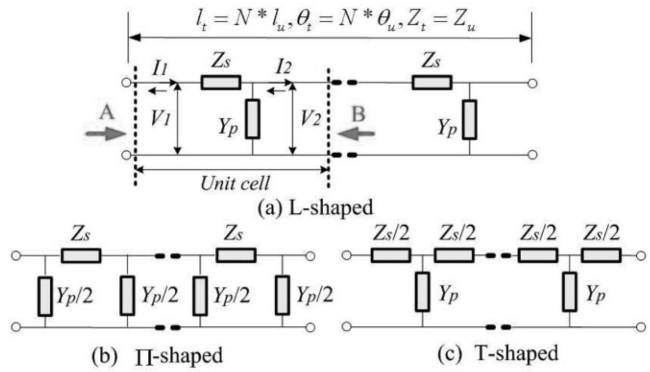

Figure 1 Three types of general periodical circuit models with L-shaped, II-shaped, and T-shaped

To exactly design EWA at a required frequency, we have to retrieve the parasitical parameters of the whole structure. Ref. [8] presented a fitting procedure to obtain the frequency-dependent models of periodic structures from scattering (S) parameters. The theory of general transmission line (TL) is also a powerful analysis tool for the effective lumped-parameter retrieval of periodic structures [9, 10]. By using the general TL theory, not only the effective permittivity and permeability but also the equivalent inductance, capacitance, and resistance are extracted simultaneously from the S-parameters of the unit cell, which is more direct and exact than the fitting procedure. However, asymmetric (L-shaped) circuit models have been used in the existing general TL theory, which will lead to the inconsistent characteristic impedance of the same unit cell if observed from different sides. Moreover, no change of the lumped parameters at a fixed frequency point has been assumed, which results in unpractical frequency-dependent lumped values in the frequency band far away from the fixed frequency point.

In this article, we provide a rigorous analysis on the characteristic impedance of general II- and T-shaped symmetrical circuit models. Effective lumped circuit parameters are extracted from the S-parameters of the whole structure, which contain the coupling among all unit cells. The retrieved parameters are more exact than those from the conventional retrieval methods based on single unit cell. No change of lumped parameters is assumed in a narrow frequency band instead of at a frequency point, and the values of components are solved at several frequencies in the narrow band. Using such a method, complicated circuit models can be retrieved directly using practical frequency-dependent lumped values. We use the proposed method to design a EWA experiment at a given frequency of 0.5 GHz. Full-wave simulations show that the final EWA frequency is 0.49947 GHz, which has a relative error less than 0.1%. The structure is fabricated and measured, and measurement results have good agreements with simulation results.

2. AN IMPROVED RETRIEVAL METHOD

We choose three types of general periodic circuit models, L-shaped, II-shaped, and T-shaped, for analysis, as shown in Figure 1. The length of unit cell is l_u, which can be arbitrarily large. Obviously, the L-shaped structure is asymmetric and others are symmetric. First we consider the L-shaped structure. On the basis of Bloch theorem [11], we obtain two groups of telegraph equations under conditions A (wave propagating from left to right) and B (wave propagating from right to left, see Figure 1(a)) as