stages for wireless mobile devices to provide a preliminary design guide for IC placement, which can reduce the design cycles of the entire product.

6. CONCLUSION

In this article, a placement optimization procedure for practical ICs has been presented to enhance RFI performance in mobile devices. The concept of a PCF and PTF were introduced to characterize the RFI source radiation and the near-field coupling between the sources and the victim antennas. By combining the PCF and the PTF with a signal power specification for the victim antennas, a spatial near-field specification for ICs has been derived for placement optimization of ICs in mobile devices to achieve RFI reduction. The spatial near-field specification can be applied not only for optimized IC placement but also for RFI evaluation of ICs with a specific position. Both applications can be applied in the initial design stages of wireless mobile devices to reduce the entire design cycle by providing the optimal layout for the IC integration and the qualified integrated circuit selection from a RFI standpoint.

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DESIGN AND REALIZATION OF A NOVEL NONPLANAR DUAL-POLARIZED LOG-PERIODIC DIPOLE ARRAY FOR 1–13 GHz

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ABSTRACT: *A feasible and low cost approach to implement a nonplanar dual-polarized log-periodic dipole array antenna using printed circuit board (PCB) technology is proposed. The proposed antenna utilizes a very short transition from a coaxial cable to a balanced twin-lead transmission line to realize an ultrawide bandwidth balun, and has two distinct scaling factor values for high and low frequency elements. A prototype of the antenna operating over the frequency range of 1–13 GHz was designed, fabricated, and tested. An average gain of 7 dBi is obtained. Measured VSWR, cross-polarization and front-to-back ratio are better than 2.6, −16 dB, and 22 dB, respectively.* © 2016 Wiley Periodicals, Inc. Microwave Opt Technol Lett 58:37–39, 2016; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.29488

Key words: *dual-polarized log-periodic dipole array; reflector feeds; balanced twin-lead transmission line; ultrawide bandwidth balun; square kilometer array; Allan telescope array*

1. INTRODUCTION

The log-periodic dipole array (LPDA) antenna has been widely studied and used in wideband telecommunication applications as well as antenna measurement, electromagnetic compatibility (EMC) testing, and reflector feeds because of its end-fire radiation pattern, constant and adjustable beam width, low cross-polarization, and constant input impedance over multioctave bandwidth [1–3]. After introduction of printed LPDAs [4], several schemes have been proposed to simplify feeding mechanism, reduce fabrication cost, and provide integration with planar circuits at microwave and millimeter-wave frequencies [5,6]. Despite many advantages of printed LPDAs, nonplanar LPDAs are more suitable as feed antennas as they can provide full-polarization operation with an axially symmetric radiation pattern, as it is needed for optimum illumination of reflector antennas. As a result, nonplanar LPDA antennas have been proposed as reflector feeds for the next generation of astronomy telescopes such as square kilometer array and Allan telescope array (ATA) [7–9]. For instance the proposed nonplanar LPDA

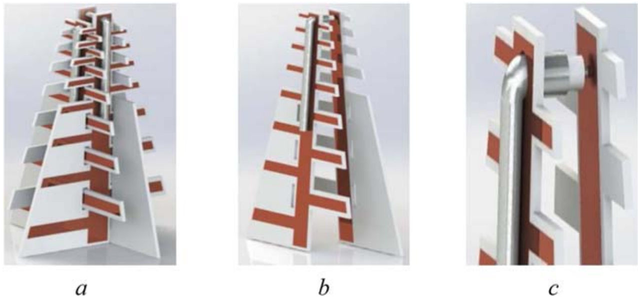

Figure 1 A sample designed schematic of the proposed XLPDA antenna. (a) The general configuration, (b) Only one of the arrays, and (c) Zoomed in view of the feeding point. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

for the mid frequency range of ATA exhibits good performance [8,9] but it suffers from a high fabrication cost and significant back lobes. Besides, the fabrication method does not provide enough accuracy for realization of dipole elements at Ku and Ka bands.

Here, we present a design for a nonplanar dual-polarized LPDA (XLPDA) antenna which utilizes Printed Circuit Technology (PCB) to obtain a low cost fabrication method and higher frequency operation than previous nonplanar LPDA antennas. The antenna has been designed, optimized, and fabricated demonstrating acceptable characteristics.

2. ANTENNA CONFIGURATION

A schematic configuration of the designed XLPDA antenna is shown in Figure 1(a). This antenna consists of two LPDAs which are placed orthogonal to each other to provide the dual-polarization operation, as well as the feeding mechanism of the two arrays. As depicted in Figure 1(b), each LPDA is comprised of two almost identical double sided printed boards forming the dipole elements and the wave-guiding strips. The bottom and top layers are electrically connected using a large number of via holes, to effectively form a block of conducting material.

Having the strips on the bottom layer of the boards plays a twofold role; first, it reduces dielectric losses by confining the waveguide field in the air instead of FR-4 boards (which are used for their mechanical strength and support in addition to their low cost). Second, having four of these strips is necessary for impedance matching of the formed balanced guiding structure to feeding coaxial cables. This impedance matching is also essential for having no tilt in the patterns of the two LPDAs in both *E*- and *H*-planes, that is, exciting the right mode of the antenna.

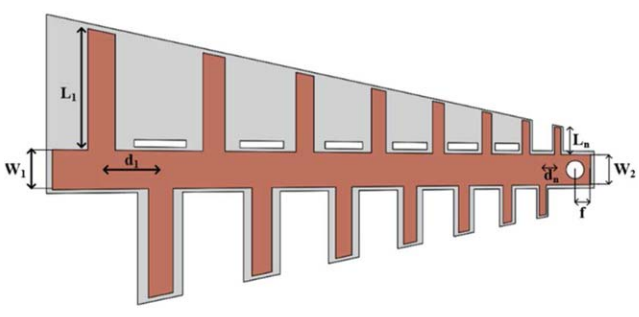

Figure 2 Top layer of substrate. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

TABLE 1 Parameters of 1–13 GHz XLPDA

Parameters	Value	Parameters	Value
σ	0.116	τ_2	0.9
τ_1	0.84	N_2	11
N_1	14	W_1	8 mm
L_1	87 mm	W_2	2.5 mm
d_1	40.3 mm	f	1.3 mm

A close up of feeding portion for one of the LPDAs is shown in Figure 1(c). The outer conductor of the coaxial cable is laid on one of the strip lines and its inner conductor is connected to the opposite strip line near the shortest element of the array. This feeding mechanism realizes a balun which operates over an ultrawide bandwidth. It is worth noting, here, that proper implementation of this feed portion is very critical for acceptable performance of the antenna. In addition, as it is obvious from the dual polarized operation of the antenna, and can be seen in Figure 1(a), two feeding coaxial cables are needed and two baluns must be realized.

Top layer of the substrate for a 15-element LPDA is shown in Figure 2. Removing the substrate between the low frequency dipole elements at the right side of the antenna and slots at the left side, provides a sturdy mechanical design for intertwining two adjacent orthogonal LPDAs.

3. ANTENNA DESIGN

For proof of concept, a prototype of the antenna with an input impedance of 50 Ω was designed to operate in the frequency range of 1–13 GHz. Based on conventional LPDA antenna design formulae, scaling, and spacing constants τ and σ were initially chosen as 0.84 and 0.12 to achieve an average gain of 7 dBi [10]. The length and number of dipoles as well as the distance between consecutive dipoles can be easily calculated using τ, σ, upper and lower edge of the operating frequency band [10].

Primary simulations of the proposed antenna demonstrated that large values of τ should be used to realize a good impedance matching at higher frequencies of the operating band. However, good impedance matching was achieved for both small and large scaling constant values at lower frequencies. The antenna length is directly proportional to τ and considerably increases with a small increase in the value of τ. To reduce the

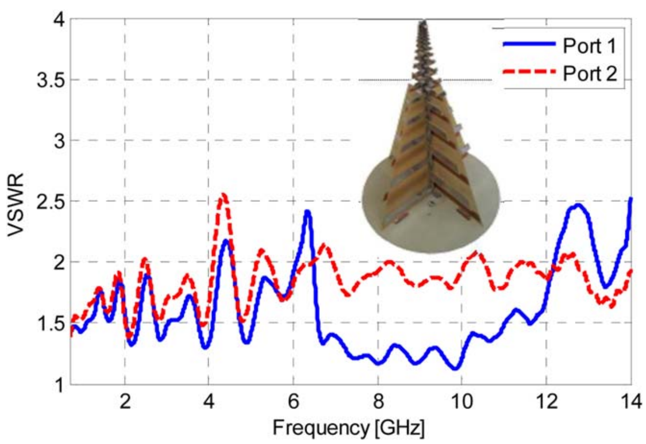

Figure 3 Measured VSWR of the two ports of the fabricated XLPDA. The inset shows a photograph of the antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

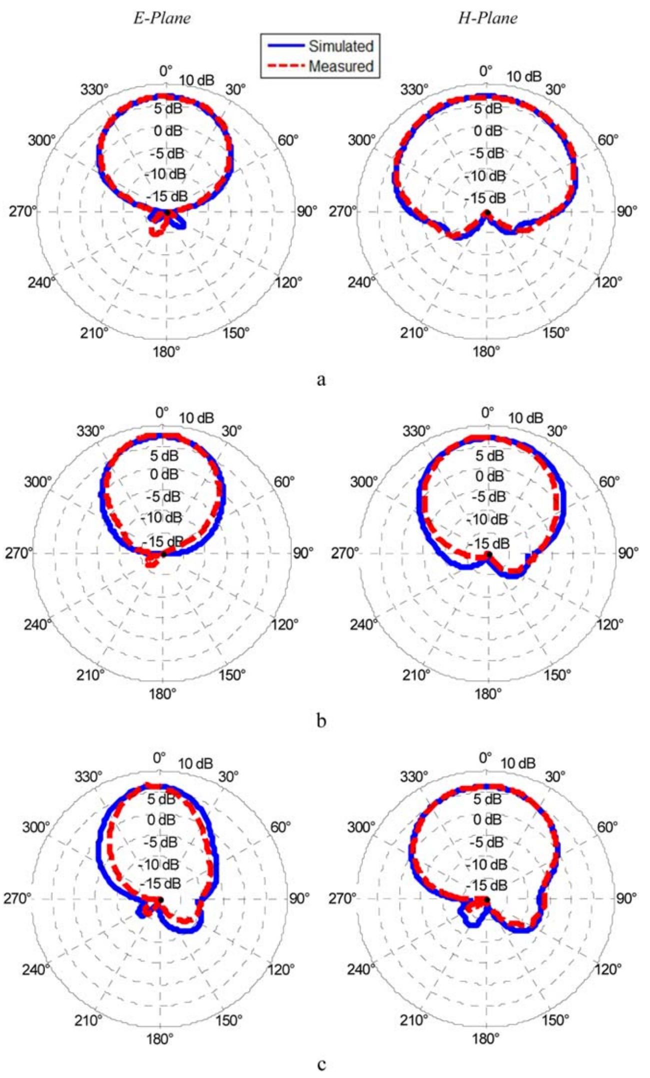

Figure 4 Measured and simulated co-polarized radiation patterns. (a) 1 GHz, (b) 10 GHz, and (c) 13 GHz. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

size of the antenna and obtain a good VSWR over the entire band, two distinct scaling constants τ_1 and τ_2 ($\tau_2 > \tau_1$) were used for low and high frequency parts of the antenna, respectively. With this design, the antenna gain is slightly higher at high frequencies. This deviation of conventional LPDA design (having two different scaling constants for low and high frequency ranges) enables an acceptable impedance matching and nearly constant gain over a wide bandwidth, while limiting the length of the antenna to a reasonable size. Other design parameters are shown in Figure 2, and optimized values are listed in Table 1. In this table, N_1 and N_2 denote the number of dipoles scaled with τ_1 and τ_2, respectively.

4. SIMULATION AND MEASUREMENT RESULTS

The designed antenna has been fabricated on a FR-4 substrate with 0.8 mm thickness. Figure 3 shows the measured VSWR of the two ports with a photograph of the fabricated antenna shown as inset. It can be seen that the VSWR is less than 2.6:1.0 over the frequency range of 1–14 GHz.

Measured and simulated copolarized radiation patterns are presented in Figure 4 where a good agreement is observed. An average gain of 7 dBi is achieved, and the front-to-back ratio and cross-polarization level are better than 22 dB and −16 dB, respectively. This high cross-polarization is mainly because of the electromagnetic coupling between adjacent orthogonal LPDAs, and the fact that the feeding lines of the two antennas completely overlap spatially. This means that any fabrication imperfection can result in coupling between the two orthogonal modes of the feeding lines and increasing the cross-polarization ratio.

5. CONCLUSION

A new approach for implementing a nonplanar dual-polarized LPDA antenna is presented, and a prototype for the frequency range of 1–13 GHz has been designed, fabricated, and tested successfully. By introducing two scaling factor τ_1 and τ_2, a good VSWR was obtained, while maintaining a reasonable length for the total structure. Measured data demonstrates a cross-polarization and front-to-back ratio of better than −16 dB and 22 dB, respectively and an average gain of 7 dBi. Good performance over a wideband frequency range alongside a reliable, simple, and low cost fabrication process makes this antenna a suitable candidate for various wideband communication applications.

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FRACTAL DIPOLE ANTENNA FOR UWB APPLICATIONS

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ABSTRACT: *A double-printed elliptical slot inscribed, rectangular fractal dipole antenna for ultrawideband (UWB) applications is*