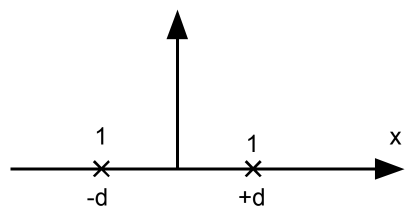
TD ANTENNES
Réseaux

I Réseau de réseaux

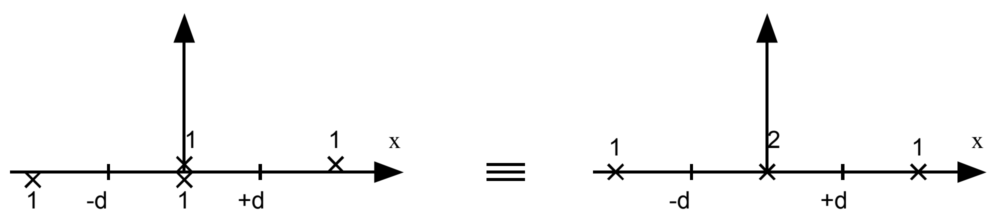
1°) Une source isotrope placée à l'origine des axes émet $\vec{E}_0(\vec{r})$. La même source est translatée en $x = +d$. Donner l'expression du champ rayonné.

2°) On dispose deux sources identiques obtenues par translation de l'antenne précédente, en $x = +d$ et en $x = -d$. Donner l'expression du champ rayonné, et du facteur de réseau $f_1(\vec{u})$.



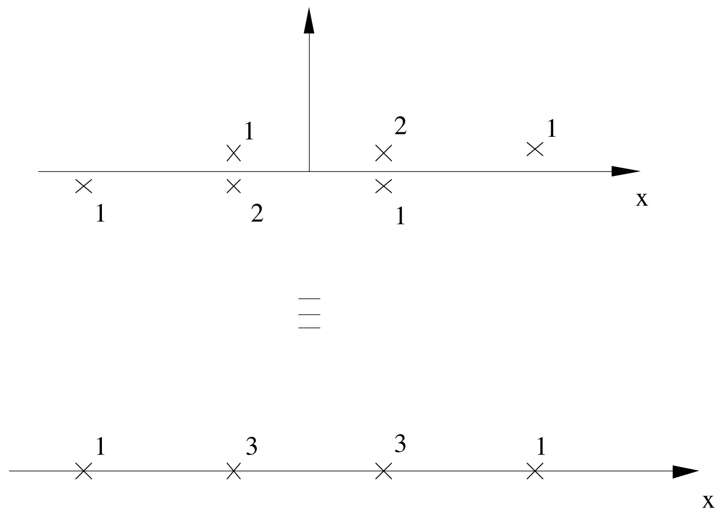
3°)

a) On étudie maintenant le rayonnement de deux antennes du type 2°), l'une obtenue par translation de $+d$, et l'autre par translation de $-d$:



Donner l'expression du facteur de réseau.

b) On répète l'opération précédente. Quelle est l'expression du nouveau facteur de réseau ?



4°) On étudie les diagrammes de rayonnement dans un plan contenant l'alignement.

a) Tracer les allures de $f_1(u_X), f_2(u_X), f_3(u_X)$ sur la même figure.

b) Comment est modifié le lobe principal, lorsque le nombre d'éléments augmente ?

c) Comment choisir d pour avoir un seul maximum dans le domaine visible ?

5°) Soit un réseau constitué de n éléments. Tous les éléments sont en phase, mais l'amplitude de l'élément *i* (*i* variant de 0 à *n*-1) est donnée par C_n^i.
Déterminer l'expression de l'angle d'ouverture à 3 dB du lobe principal.

II Etude d'un « Wide-Band printed Double-Sided Dipole Array »

Se reporter à l'article joint, tiré de « IEEE Transactions on Antennas and Propagation », February 2004

On étudie le réseau représenté en figure 2 (page 629). Il s'agit d'un réseau à deux dimensions de 8 éléments par 4. On utilise les notations de l'article où Ox représente l'axe horizontal (8 éléments) et Oy représente l'axe vertical (4 éléments)

1°) L'antenne élémentaire du réseau est constituée de 2 « pavés » gravés sur des faces différentes du substrat d'épaisseur 0.254 mm. Ces deux « pavés » sont alimentés en opposition de phase à l'aide du balun représenté en figure 3.

a) L’antenne élémentaire se comporte-t-elle plutôt comme un dipôle demi-onde, ou plutôt comme une antenne imprimée classique de type « patch » ?

b) Quelle est le plan de polarisation (du champ E) ?

2°) On étudie le diagramme de rayonnement de la figure 6 (page 630), obtenu à la fréquence f = 10 GHz

Retrouver par le calcul la position des deux premiers zéros

3°) La figure 7 représente le gain réel (mesuré) du réseau en fonction de la fréquence, ainsi que le « gain idéal » calculé.

a) Retrouver par le calcul la valeur du « gain idéal » à f = 10 GHz

b) Trouver sur la courbe la valeur du gain réel du réseau à f = 10 GHz.
En déduire la valeur du gain d’une antenne élémentaire à la même fréquence.

4°) En examinant la figure 2, on note la présence d’un plan métallique à 5.77 mm de l’antenne.

a) Quelle est son influence ? (avec / sans)

b) Comment cette distance de 5.77 mm a-t-elle été choisie ?

are observed when the array spacing is larger. Smaller maximum antenna gain, about 5.5 dBi for $W = 85$ mm and 4.7 dBi for $W = 110$ mm, than that (about 6.1 dBi) for $W = 96$ mm studied in Fig. 3 was measured. The obtained results suggest that the array spacing has great effects on the performance of the proposed antenna, and should be considered in practical applications. The corresponding measured data are also given in Table II for easy comparison.

IV. Conclusion

The omnidirectional planar dipole array antenna has been proposed and successfully implemented. The constructed prototypes for operation in the 2.4 GHz band for WLAN operation have been experimentally studied. Within the 2.4 GHz band, the proposed antenna shows good impedance matching (better than 1.5:1 VSWR), and the measured antenna gain reaches about 5.0–6.1 dBi. Good omnidirectional radiation with small variations (less than 2 dBi) in the azimuthal plane has also been obtained. The proposed antenna is suitable for applications in a WLAN access point.

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A Wide-Band Printed Double-Sided Dipole Array

B. G. Duffley, G. A. Morin, M. Mikavica, and Y. M. M. Antar

***Abstract*—A 32-element wide-band printed dipole array is analyzed and successfully implemented. The elements used are double-sided printed dipoles fed with a balanced twin-lead transmission line. A wide-band balun and a launcher system for the array were designed and implemented. Excellent correlation between simulated and measured radiation patterns was observed and good overall performance with a bandwidth in excess of an octave was obtained.**

***Index Terms*—Dipole arrays, planar arrays.**

I. Introduction

Modern communication requirements continue to push for more bandwidth capabilities of antenna systems. At the same time, the antenna must satisfy the technical requirements for high performance,

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B. G. Duffley and Y. M. M. Antar are with the Department of Electrical and Computer Engineering, Royal Military College, Kingston, ON K7K 7B4, Canada.

G. A. Morin is with Defence Research and Development Canada, Ottawa, ON K1A 0Z4, Canada.

M. Mikavica is with the Department of Electrical Engineering, University of Belgrade, 11120 Belgrade, Yugoslavia.

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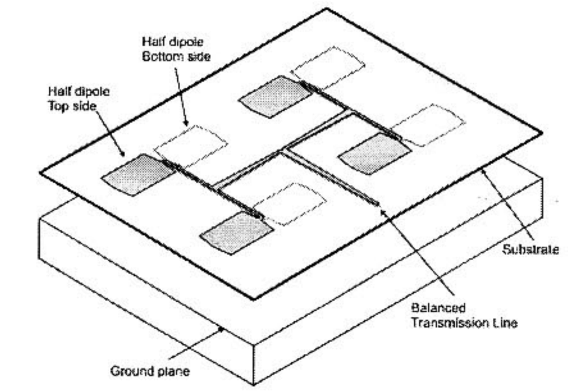

Fig. 1. Array of four printed-dipole elements.

being lightweight and low profile as well as the need to meet the additional economic constraints of low cost, simplicity, and reliability. Printed microstrip architectures have been widely investigated and are attractive for their conformability, small size, and cost effectiveness. While their bandwidth capabilities have been pushed to upwards of 30%, this may still be not adequate for some future system demands. An architecture that looks promising for providing other attractive features is the double-sided printed dipole. The configuration for a four-element array as shown in Fig. 1 consists of a dipole with each arm printed on opposite sides of the substrate, fed by a balanced transmission line. The substrate used is very thin; hence, the dipole arms are only slightly out of phase, resulting in insignificant effect on the radiation pattern. The dipole is spaced approximately one quarter wavelength above the ground plane so that the dipole image is in-phase in the boresight direction.

Originally developed by Wilkinson in 1974 [1], more recent research has dealt with bandwidth improvements and impedance optimization of the printed dipole [2]–[4]. Most recent work has focused on optimizing the impedance characteristics of the element by reshaping the dipole configuration, e.g., implementing flared or bow tie in which the dipole arms are gradually spread. Recently Mikavica *et al.* [5] proposed the use of wide rectangular dipoles based on the analogy with cylindrical dipole antennas having more uniform input impedance when made thicker. The rectangular dipole has achieved one octave bandwidth compared to 33% attained by the normal bow tie configuration. Such good performance could be promising for array applications and is worthy of further investigation. While configurations using arrays of this type of structure were described in the literature, no detailed analysis or comprehensive measurements were provided.

In this paper, we report results from an investigation on a novel 32-element wide-band double-sided printed dipole array. The array was analyzed, fabricated, and successfully optimized for improved performance. Various parts of the array architecture that affect the performance such as the launcher system and a wide-band balun and array height over the ground plane have been investigated. Excellent correlation between simulated and measured radiation patterns has been obtained.

II. Antenna Configuration

The design consisted of a 32-element array of wide-band printed dipoles as shown in Fig. 2 and Table I. Essentially each dipole can be considered as center-fed by a balanced transmission line. As the conductors of the transmission line are on opposite sides of the substrate, so too is each dipole arm. The printed array was etched onto a 7×7 in^2,

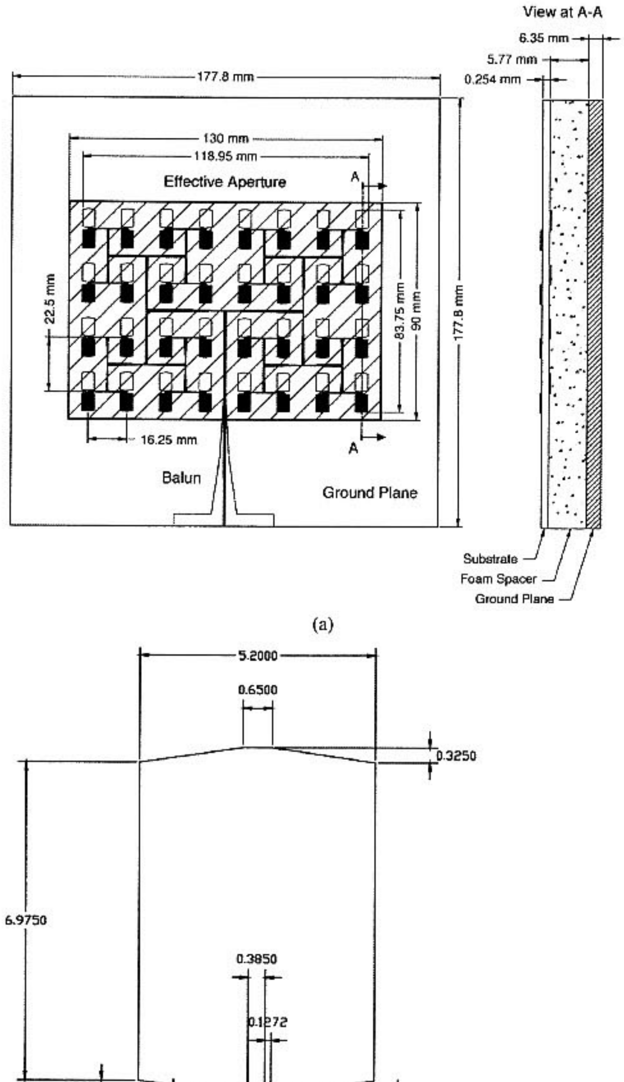

Fig. 2. (a) Configuration of the wide-band printed-dipole array. (b) Dimensions of one side of the dipole and feed.

TABLE I
DIMENSIONS OF THE WIDE-BAND ARRAY

Parameter	Dimension (mm)	Parameter	Dimension (mm)
Dipole Length	16.25	Element Colinear (y)-Spacing	22.50
Dipole Width	5.20	Element Broadside (x)-Spacing	16.26
Array Length (x)	118.92	Aperture Length (x)	130
Array Width (y)	83.74	Aperture Width (y)	90
Height Over Ground	5.77		

0.254-mm-thick piece of Arlon, Cu Clad 217 substrate. It was then positioned 5.77 mm above a 1/4-in-thick aluminum ground plane using a

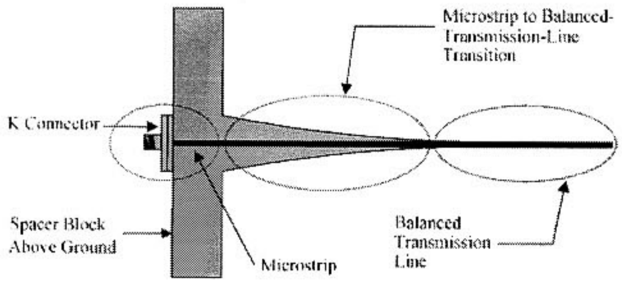

Fig. 3. Wide-band balun (top view).

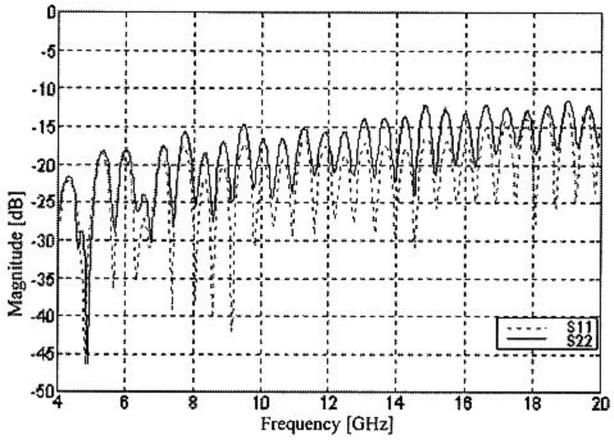

Fig. 4. Double balun S11 and S22.

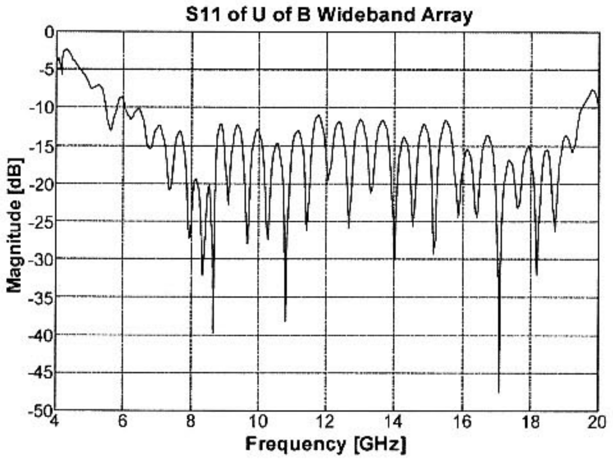

Fig. 5. S11 of the wide-band array.

Rohacell 31 HF foam spacer, which was milled to the required dimension. This $1/4\lambda$ height was selected based on the desired performance at 13 GHz. The $1/4\lambda$ height over ground is a function of the highest frequency of operation. All components were held in place by the use of a square plexiglass ring.

For interfacing the antenna to a 50-Ω coaxial cable, a 40-GHz launcher with a K-connector was used. To provide a transition between the connector and the balanced transmission line, a wide-band balun, as shown in Fig. 3, was designed and optimized. It connects the coaxial connector to the shown microstrip line with gradual transition into the balanced twin line. Information on the principle of operation of similar baluns can be found in [6]. In order to characterize the wide-band

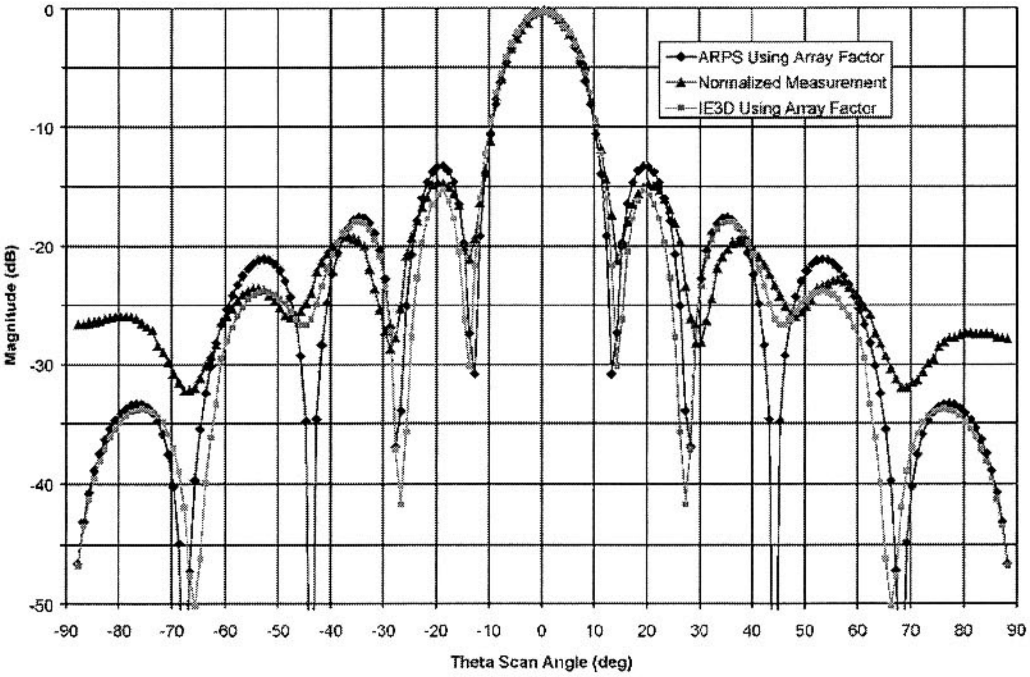

Fig. 6. Comparison of simulated (ARPS/IE3D) versus measured H-plane radiation.

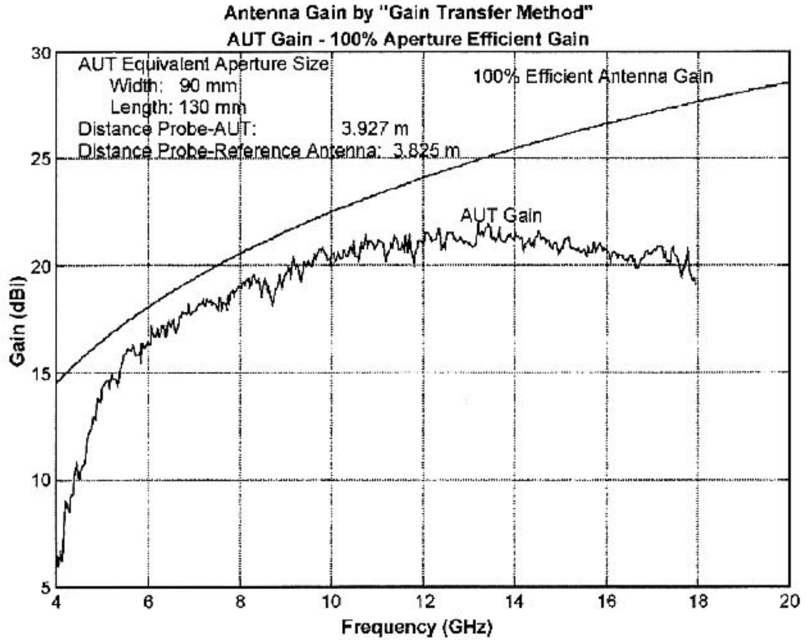

Fig. 7. Gain of wide-band array compared to 100% aperture efficient antenna of same aperture size.

balun, return loss measurements for two baluns back-to-back were performed and found better than 15 dB over a wide range (4–15 GHz), as can be seen in Fig. 4.

A unique aspect of the double-sided printed dipole is the use of the balanced twin line feed network. Since the transmission line utilizes both sides of the same substrate that each arm of the printed dipole resides upon, the architecture exploits all of the well-known advantages of the planar microstrip system [7]. The surface wave losses can be exceptionally low due to the fact that the substrate can be very thin (0.01λ).

III. Results

The measured array return loss as seen in Fig. 5 is less than 10 dB over the 6–18 GHz bandwidth. The ripple was attributed to internal reflections between the dipole and the launcher. Radiation measurements were performed and showed that side lobes remained below -12 dB from 4 to 18 GHz in the H-plane and 6–14 GHz in the E-plane. The difference in the patterns of the two planes is due to the fact that the array is rectangular and has only four elements in the E-plane. In addition, the spacing of the elements is 22.5 mm in the E-plane and 16.26 mm in the H-plane. Shown in Fig. 6 are the measured and simulated radiation patterns at 10 GHz. The simulated patterns are produced using IE3D and ARPS. The good correlation between measured and simulated results is noticed. It is also noticed that both ARPS and IE3D produced patterns very similar to the measured data even though they calculate their pattern based on the single element pattern and the array factor without taking coupling effects in the simulation. This indicates that at this frequency mutual coupling may not be a serious concern. The larger differences observed near the horizon could be attributed to the finite physical size of the ground plane; the simulation assumes an infinite ground plane. The finite ground plane and edge effects may also account for the slight variation in the null and sidelobe locations.

Gain measurements were performed on the array at different frequencies, as shown in Fig. 7. Gain at boresight is found to track the theoretical maximum within 3 dB from 6 to 12 GHz with larger differences at higher frequencies. The bandwidth over which the efficiency is found to be over 50% and extends from 4.9 to 11.2 GHz.

In conclusion, the double-sided wide-band printed dipole element and its implementation within a 32-element array has been successfully demonstrated. Generally, good performance including very wide-band operation has been obtained. Very good agreement between the simulation and measurements has been obtained, thus providing confidence in the concept and the array design procedure implemented here. Further investigation toward optimization of various array parameters such as elements and their spacing, feed network, ground plane height, etc., could lead to improved performance.

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Proximity-Coupled Microstrip Reflectarray

The Nan Chang and Yu Chen Wei

***Abstract*—In this paper, a microstrip reflectarray on a two-layer substrate is presented. The delay lines were proximity-coupled to corners of patches. Compared with delay lines in a single-layer reflectarray, the delay lines used here play two important roles: phase delay and impedance match. As it is a two-layer structure, we can get more design flexibilities. For linear polarized waves, -3 dB gain bandwidth can be achieved to 22%. Antenna patterns with -15 dB side-lobe and -30 dB cross-polarization level can also be obtained. It is demonstrated that simple design formula used in a single-layer reflectarray can also be used for the present case.**

***Index Terms*—Microstrip, reflectarray.**

I. INTRODUCTION

The reflectarray antenna was extensively studied as it has a flat, rather than a curved, reflecting surface. This feature makes it a good candidate to replace the parabolic reflector. Several variations of the microstrip reflectarray have been studied. Among them, the most common are variable stub-length method [1]–[3], variable patch size method [4]–[6], and variable rotation angle method [7], [8]. However, one common disadvantage of all reflectarrays is their narrow bandwidth [6]–[10]. This narrow bandwidth limitation in reflectarrays is principally attributed to two factors: 1) the narrow bandwidth of the elements and 2) the differential spatial phase delays due to an extended path length between the feed and the reflectarray [11]. The large size reflectarrays are the most restricted by the second factor. For moderate size reflectarrays, the first factor is of the most concern. The phase variations in a microsrip reflectarray by the variable patch size method were analyzed in [9]. Since the phase distribution on the surface of a reflectarray with patches of different sizes changes with frequency, reflectarrays are limited to very narrow-band applications. In [9], a multiplayer printed reflectarray based on patches of different sizes was proposed to increase the bandwidth, and the largest bandwidth that could be realized is 16.7%. In [10], 7.2% gain bandwidth was reported for an X-band varying stub-length reflectarray built on a single-layer substrate.

In this paper, we concentrate on variable stub-length reflectarrays built on a two-layer substrate. Using different dielectric layers for both radiating elements and delay lines, we provide more flexibility for impedance match. At the same time, the patch-ground plane spacing can be increased to obtain greater bandwidth. The feeding technique is not new in microstrip antennas but it is applied to the design of printed reflectarrays. We will show that 22% gain bandwidth can be achieved in this paper. For the radiating elements, they can be of any shape. Here, they are realized by corner-feed coupling, as shown in Fig. 1, between diamond-shaped patches and delay lines. The reason is that the circular polarized wave can easily be generated through this way for future study as well. However, we only deal with linear polarization in this paper.

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T. N. Chang is with the Graduate Institute of Communication Engineering, Taipei, Taiwan, R.O.C. (e-mail: tnchang@ttu.edu.tw).

Y. C. Wei was with Tatung University, Taipei, Taiwan, R.O.C. He is now with Liteon Company, Taipei, Taiwan, R.O.C.

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