# A Reflectarray Using Log-Periodic Dipole Array Element

Keisuke Konno and Qiang Chen

Department of Communications Engineering, Graduate School of Engineering, Tohoku University

***Abstract*—This paper presents a study of reflectarray using a log-periodic dipole array (LPDA) element. Wideband scattering performance of the LPDA element is demonstrated numerically. A five elements linear reflectarray is designed and fabricated. Scattering performance of the fabricated reflectarray was measured in order to show its wideband scattering performance experimentally.**

***Index Terms*—Reflectarray, log-periodic dipole array element, wideband**

## I. Introduction

A planar reflectarray is generally composed of a primary source and non-identical printed microstrip elements [1]. Non-identical printed microstrip elements are designed in order to scatter incident field from the primary source to desired direction. It is well known that the planar reflectarray is low-profile, lightweight, and easy to fabricate. On the other hand, narrow bandwidth is well known as one of the major disadvantages of the planar reflectarray.

The bandwidth of the planar reflectarray is limited by following two factors [2]. The first one is inherently narrow bandwidth of planar microstrip elements. Multi-layered reflectarrays have been proposed in order to overcome the inherently narrow bandwidth of the planar reflectarray element [3]-[5]. The other one is differential spatial phase delay. A conformal reflectarray can be applicable in order to reduce the differential spatial phase delay.

On the other hand, recent advancement of an additive manufacturing technology enables to fabricate a 3D reflectarray element. For example, 3D printed dielectric reflectarray elements are introduced to a reflectarray working in THz band [6]. A dielectric resonator reflectarray working in mm-wave band has been designed and fabricated using a fused deposition modeling 3D printing technology [7]. According to previous studies, tradeoff between bandwidth and size of an antenna has been clarified [8]-[10]. Therefore, reflectarrays with 3D printed element is expected to be wideband rather than conventional planar microstrip reflectarrays.

In this paper, wideband scattering performance of a reflectarray with a log-periodic dipole array (LPDA) element is demonstrated [11]-[13]. The LPDA element is designed using method of moments (MoM) [14]. A reflectarray with the LPDA element is designed and fabricated using a 3D printing technology. Scattering performance of the fabricated reflectarray is demonstrated via measurement results.

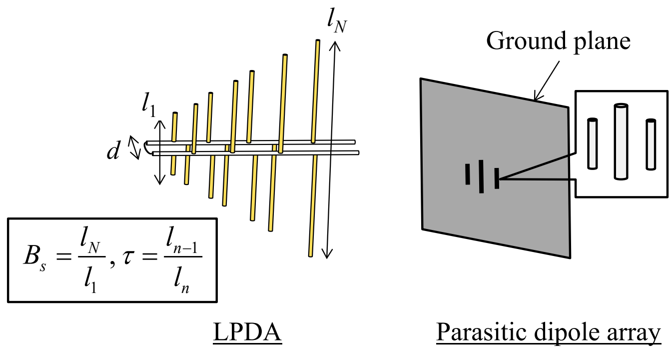


Fig.1. Geometry of LPDA element and parasitic dipole array.

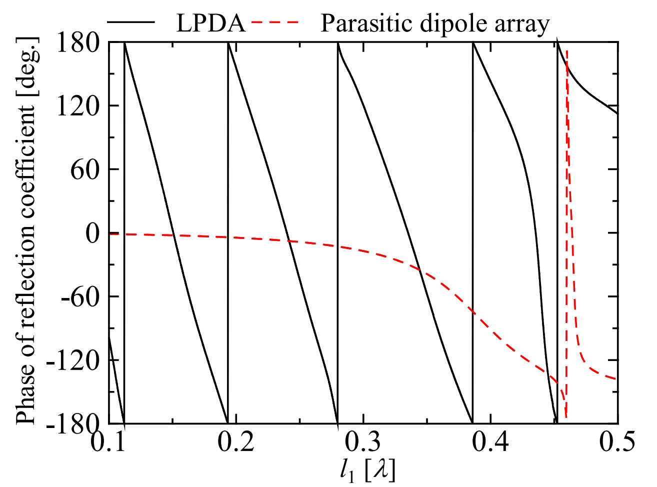


Fig. 2. Reflection coefficient of LPDA and parasitic dipole element. Structure parameters of the LPDA are τ=0.85, *d*=4 mm, structure bandwidth *B*=3, radius of wire is 0.45 mm.

## II. Design of LPDA Element

Geometry of a LPDA element is shown in Fig. 1. $N$ is the number of dipole elements, $l_n$ indicates the length the of $n$th dipole element, and $d$ is spacing between a two-wire parallel transmission line. According to its self-complementary nature, a LPDA element working in a specific frequency band is readily available when a couple of structural parameters are given. In recent years, it has been clarified that the LPDA also works as a wideband scatterer and interested readers can refer to [11]-[13] in order to know how to design the LPDA element as a scatterer.

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Phase of reflection coefficient of the LPDA element is shown in Fig. 2. As a reference, phase of reflection coefficient of a parasitic dipole element is also shown [15]. All dimensions of the parasitic dipole elements except for length of main dipole (=$l_1$) are optimized in advance in order to maximize its phase variation and omitted here. Both of these elements are illuminated by plane wave of normal incidence and scattering field to ($\theta_s$, $\phi_s$)=(20$^o$, 90$^o$) is obtained using the MoM. It is found that the phase of reflection coefficient of the LPDA element varies linearly while that of the parasitic dipole element is strongly non-linear. The linearity of the phase variation results in wideband scattering performance of the LPDA element. In addition, phase of reflection coefficient of the LPDA element varies over 1440 deg. Such large phase variation indicates that the LPDA works as a reflectarray element.

## III. Performance of Reflectarray

A five elements linear reflectarray with the LPDA elements is designed and its scattering performance is demonstrated. Fig.3 shows a geometry of the reflectarray. Dimensions of each reflectarray element were obtained from the reflection coefficient. Mainbeam of the scattering field of the designed reflectarray is directed to ($\theta_s$, $\phi_s$)=(20$^o$, 90$^o$). The designed reflectarray was fabricated using a 3D printing technology. The fabricated reflectarray was coated ink made by copper. Bistatic radar cross section (BRCS) of the fabricated reflectarray was measured in a radio anechoic chamber and the measurement system is shown in Fig. 4. Double-ridged waveguide horn antennas (Schwarzbeck BBHA9120D) were used as transmitting/receiving antennas.

The simulated and measured BRCS of the designed 5×1 reflectarray with the LPDA elements are shown in Fig. 5 and Fig. 6, respectively. It is found that the main beam of the fabricated reflectarray is directed to ($\theta_s$, $\phi_s$)=(20$^o$, 90$^o$) over wideband except for small beam tilt. The beam tilt comes from the effect of mutual coupling between reflectarray elements which were neglected during numerical simulation of the reflection coefficient. According to the limitation of our measurement system, distance between transmitting/receiving antennas and the reflectarray was not long enough to keep far field criterion. As a result, the maximum measured BRCS level was larger than simulated one. Although the measured BRCS level was affected by the near field, the wideband scattering performance of the reflectarray with the LPDA element has been demonstrated.

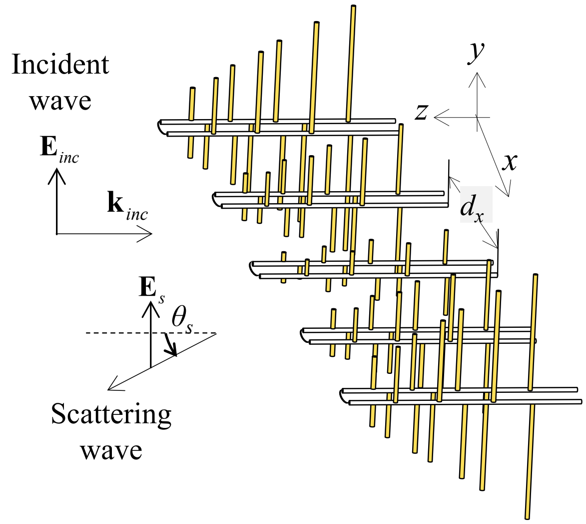


Fig.3. An example of reflectarray.

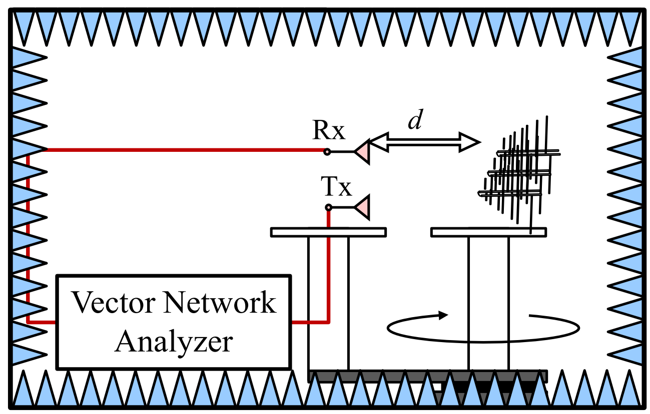


Fig.4. Measurement systems.

## IV. Conclusion

In this paper, scattering performance of a reflectarray with LPDA elements has been demonstrated. Reflection coefficient of the LPDA element was obtained and its linearity has been shown. A five elements linear reflectarray was designed and fabricated using a 3D printing technology. Scattering performance of the fabricated reflectarray was measured. Except for the effect of mutual coupling between reflectarray elements and the effect of near field, it can be concluded that the performance of the reflectarray with the LPDA elements has been demonstrated well.

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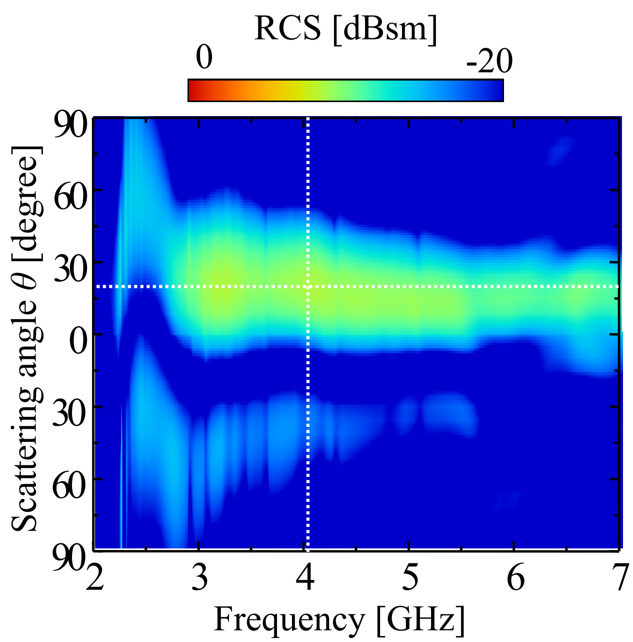


Fig. 5. Simulated BRCS of the designed reflectarray

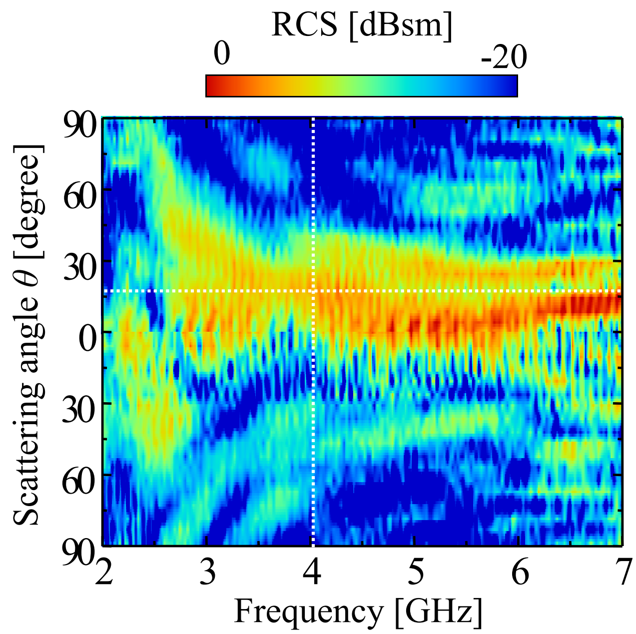


Fig. 6. Measured BRCS of the fabricated reflectarray