Experimental Investigation of Elimination Blindness Propagation Channel Using Reflectarray

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***Abstract*—A 42×44-element reflectarray using interdigital gap loading structure element is used as a passive reflector for elimination blindness propagation channel. The proposed reflectarray is designed with a 58-degree scattering angle and fabricated to experimentally investigate the performance and effectiveness in improvement of the receiving signal noise ratio (SNR) and channel quality. It was found that the received power level were improved by more than 12 dB for cumulative distribution function (CDF) at 1% as compared to those without the reflectarray in the none-line-of-sight (NLOS) environment.**

I. Introduction

Blocking of radio waves from base stations of cellular mobile communications by high and dense buildings in urban areas is a serious problem, particularly in narrow streets, because it very much weakens the signal level and greatly affects the quality of communications decrease the channel capacity for a multi-input multioutput (MIMO) system. Generally, in cases where a direct microwave path cannot be established (i.e., None-Line-of-Sight, NLOS) between two points, it is possible to reconstruct a path by using a reflectarray [1–3]. Compared with the general solution by using RF boosters for blindness elimination, the electric devices with active conponents and power supplies are not needed.

In our previous [2], a reflectarray element using the interdigital gap loading structure is proposed. The performance of the element was validated by the simulated results and the measurement results in anechoic chamber. In this paper, we design a 42×44-element reflectarray using element similar with that in [2]. Outdoor experiments were performed in typical wireless scenarios to investigate the performance and effectiveness in improvement of the receiving signal noise ratio (SNR) and channel quality.

II. Design of Reflectarray With Interdigital Gap Loading Structure

A 42×44-element reflectarray operating at Ku-band (11 GHz) with a scattering angle of 58° for normal incidence is designed. The geometry of the designed reflectarray is shown in Fig. 1. The reflectarray element has a similar structure with that in [2]. As discussion in the previous work [2], this element has features of lager reflection phase range and equal total element size, which are prominent characters for large aperture reflectarray design taking account for sufficiency reflection phase range, phase delay and mutual coupling.

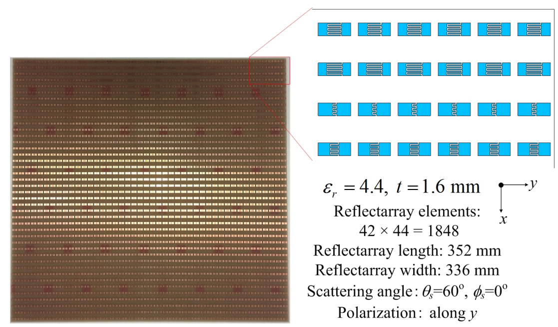

Fig. 1. Geometry of 42×44-element reflectarray using ingerdigital gap loading element.

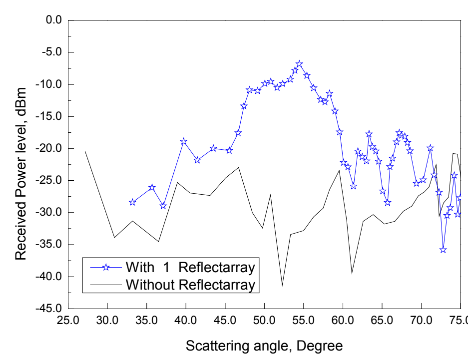

Fig. 2. Measured received power level with/without 42×44-element reflectarray at 11 GHz.

III. Scattering Pattern Measurement for 42×44-Element Reflectarray

To validate the basic characteristics of the 42×44-element reflectarray, an experiment was carried out to get the scattering pattern. For the frequency licence limitation in Japan, all of the outdoor experiments were performed using the 11

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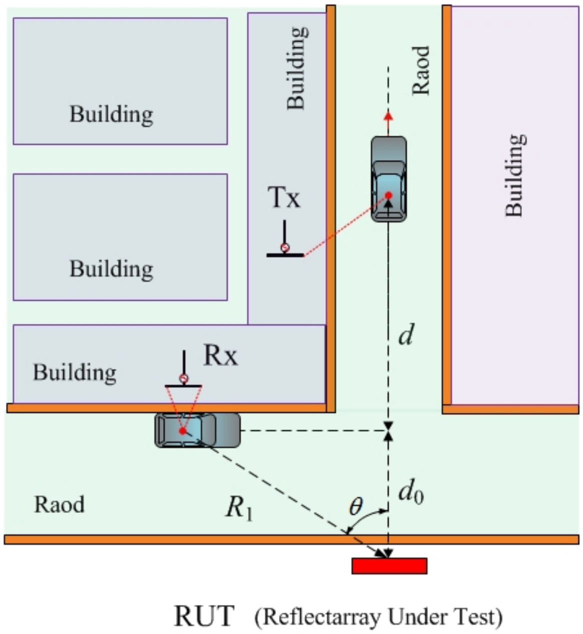
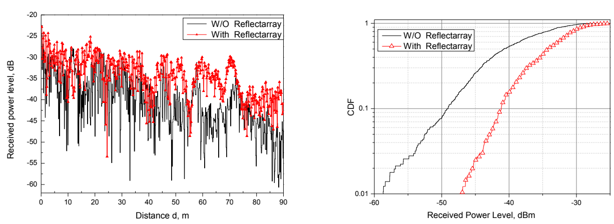


Fig. 3. Schematic of the blindness elimination measuremnet. (R_1 = 30 *m*, d_0 = 15.5 *m*)



(a)

(b)

Fig. 4. Measured results(a) Received power level along the road, *d* from 0 to 90 *m*. (b) CDF of the received power with/without three reflectarray

GHz reflectarray antenna tested at Ishigaki-jima. To meet the far field condition, the distance between the center of the receiving antenna and that of RUT is selected as more than 8.0 m. The measured scattering pattern results is shown in Fig. 2, including received power level with one reflectarray and without reflectarray. As can be seen clearly , the mainbeam scattering angle of the RUT is around 55 °, which agrees well with the design result.

IV. Cumulative Distribution Function for NLOS Environment

Another outdoor experiments was performed using three connected 42×44-element reflectarray antennas in typical NLOS wireless scenarios. The schematic of the blindness elimination measuremnet is depicted in Fig. 3. It is obvious that there is a NLOS path between the receiving car and transmitting car. The receiving and transmitting antennas in this measurement are selected as omnidirectional (horizonal plane) antennas taking account to multi-path effect in the real wireless environment. The receiving car parked on one side of the horizonal road in front of a building and the received power level values are read and saved by a computer program. The RUT is installed on the other side of the road. The transmitting car was moving along another road beside the building(*d*: from 0 to 90 *m*). As shown in Fig. 3, the direction from the receiving antenna to the RUT is about 58 /degree to the surface of RUT. For the RUT has a scattering angle around 55 to 58 °, the meanbeam of the reflectarray can sufficiently cover the road in which the transmitting car was moving.

A total of 1860 experimental results were obtained along the road (*d*, from 0 to 90 *m*) and the results were expressed in the form of received power level and cumulative distribution function (CDF). As can be seen clearly in Fig. 4, the received power level degrades when the distance *d* changed form 0 to 90 *m* as the transmitting car is moving far away form the RUT. And, by using the reflectarray, most of the received power level along the road is larger than that of without reflectarray. Compared with the case of without reflectarray, the CDF at 1% is improved more than 12 dB when the reflectarray is installed, which is especially effective for improving weak signal propagation environment.

V. Conclusion

Reflectarray using interdigital structure is designed and experimental investigated for elimination blindness propagation channel. The experimental results shows that the normal-incident EM waves can be reradiated to a more than 55° angle and the blindness in NLOS environment can be sufficiently eliminated. More than 12 dB CDF at 1% is improved compared with that without reflectarray. Furthermore, the reflectarray can also be used to increase the multipatch richness for MIMO communication.

Acknowledgement

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