1B4-4

Complex Radiation Pattern Measurement Using a Optical-fibre Cable Applicable to a Handset Adaptive Array

#Satoru Amari[1], Atsushi Yamamoto[1], Hiroshi Iwai[1], Yoshio Koyanagi[2] and Koichi Ogawa[1]
[1]Network Development Center, Matsushita Electric Industrial Co., Ltd.
1006, Kadoma, Osaka, 571-8501 Japan
E-mail: amari.satoru@jp.panasonic.com
[2]Communication System Development Center, Panasonic Mobile Communications Co., Ltd.
5-3, Yokosuka, Kanagawa, 239-0847 Japan

1. Introduction

Recently, several studies have been made of adaptive array and MIMO antennas for mobile handsets [1]-[3]. In order to evaluate array performances, it is necessary to accurately measure complex radiation patterns since the array is controlled using not only the amplitude but also the phase of the receiving signal at each element. One can measure the complex radiation pattern by connecting a signal cable to a handset array [4]. With regard to mobile handsets, however, the metallic cable might have a great influence on the radiation pattern. Thus, measurements have been reported for a complex radiation pattern, using a fibre optic cable [5], [6]. However, there are few reports of measurements conducted using an optical cable to investigate a handset array.

This paper presents a complex radiation pattern measurement using an optical-fibre cable, applicable at 2 GHz to a handset adaptive array comprising two elements. The handset array consists of a monopole and a planar inverted-F antenna (PIFA). In the first step of our investigation, the measurements of the complex radiation patterns from the handset array were carried out employing a fibre optic cable. A phase calibration was made to permit an accurate measurement of the phase of each element. In the second step, we investigated the interference reduction characteristics of the handset adaptive array using measured complex radiation patterns. In order to verify the measurement with the fibre optic cable, a calculation was performed using the Method of Moments (MoM). The success of the optical measurement method in estimating the interference reduction characteristics of the handset adaptive array was confirmed by both measurements and calculations.

2. Optical-fibre measurement method

Figure 1 shows the fibre optic method of measurement. A network analyzer was used both as a transmitter and a receiver. The laser diode module (LD) converted the RF signal into an optical signal. The photo diode module (PD) extracted the RF signal from the optical signal, modulated by the RF signal. The dimensions of the PD, including the battery power source, were 20 mm (L) × 17 mm (W) × 15mm (H). This small structure enabled us to install the PD in the handset. The LD and PD operated from DC to 2.5GHz.

3. Complex radiation pattern of the handset antennas

3.1 Handset array

Figure 2(a) illustrates the handset array. The metal rectangular parallelepiped was used to represent the body of the handset. In Fig. 2(a), a quarter-wavelength monopole was mounted on top of the metal case and a PIFA was attached on the side plate, adjacent to the upper plate. The dimensions of the antennas gave a resonant frequency of nearly 2 GHz. The feed-point of the PIFA was located such that a good VSWR condition of less than 2 was obtained at 2 GHz. Figure 2(b) depicts the setup of the handset for the fibre optic measurement method. As shown in Fig. 2(b), the handset was inclined at angle of 60 degrees from the vertical.

ISBN: 978-4-88552-223-9 C3055©IEICE

3.2 Method of phase calibration

Figure 3 shows the connection of the PD to the antenna inside the handset. This shows the matching circuit for the PD, the coaxial cable and the matching circuit for the antenna, between the PD and the antenna. To obtain only the phase of the antenna, it is necessary to remove the redundant phases resulting from these circuits and cable. A copy of the handset was made in order to calibrate the phase of the antenna. The copy handset antennas were replaced by SMA connectors, so as to measure the phase directly between the matching circuits of the PD and the antenna.

3.3 Measured complex radiation patterns

Figures 4 and 5 show the amplitude and the phase distributions for the θ-component of the radiation patterns, in the xy-plane, from the handset array. Figure 6 shows the phase difference between the monopole and the PIFA. For comparison purposes, the data measured by using the coaxial cable and the results calculated from the MoM are also shown in the figures. Figs. 4, 5 and 6 indicate that the data measured using the fibre optic measurement method are in good agreement with the calculated results. However, it is found that the measurement using the coaxial cable differs markedly from the calculation, particularly in the amplitude and the phase of the PIFA. This fact indicates that the coaxial cable has a significant influence on the complex radiation patterns.

4. Interference reduction characteristics of the handset adaptive array

To verify the fibre optic measurement method, we investigated the interference reduction characteristics for the handset adaptive array using the minimum mean square error (MMSE) algorithm. Figure 7 shows the amplitude distribution of the θ-component of the radiation pattern of the adaptive array in the xy-plane, when the desired and interference signals impinge upon the handset in the directions of 120 or 180 degrees. In the calculation, the input SNR was set at 20 dB and input SIR was 0 dB. In this paper, we define the input SNR as an SNR at a receiver when an isotropic antenna is used as the receiving element, permitting the performance of antennas used in the adaptive array to be included in the simulation results.

As can be seen in Fig. 7, a deep null is observed in the direction of the interference, in the case of the fibre optic measurement method. Furthermore, the peak of the radiation pattern was obtained in the direction of the desired signal. With regard to the coaxial cable measurement method, the null and peak were obtained in the direction of desired and interference signals in the same manner as the measurement using the optical fiber. The output SNR and output SIR are listed in Table 1. It can be seen from Table 1 that the agreement between the measurements and calculation is very good. However, comparison of the data measured using the coaxial cable and the calculated results indicate that there are large discrepancies in the radiation patterns from the array. Table 2 gives the optimal weights of each method. The weights obtained by the coaxial cable measurement method diverge more from the calculation than those of the fibre optic measurement method. We conclude from this fact that the fibre optic measurement method is applicable to the evaluation of the handset adaptive array, whereas the measurement using the metal cable has a large error in the radiation pattern.

5. Conclusion

We examined interference reduction characteristics at 2 GHz of a handset adaptive array comprising a monopole and a PIFA, using a fibre optic measurement method. From the measurements obtained, the applicability of the fibre optic measurement method to the evaluation has been successfully proved.

References

[1] K. Ogawa, A. Yamamoto, and J. Takada, "Multipath Performance of Handset Adaptive Array Antennas in the Vicinity of a Human Operator," IEEE Trans. Antennas Propagate. AP-53, No. 8, pp. 2422-2436, Aug. 2005.

[2] Y. Koyanagi, A. Yamamoto, and K. Ogawa, "Experimental study of the performance of handset adaptive array antennas in the Vicinity of a Human Operator," Antennas and Propagation Society International Symposium, vol.1B, pp. 323-326, July 2005.

[3] K. Ogawa, H. Iwai, A. Yamamoto, and J. Takada, "Channel Capacity of a Handset MIMO Antenna Influenced by the Effects of 3D Angular Spectrum, Polarization, and Operator,"

Antennas and Propagation Society International Symposium, pp. 153-156, July 2006.

[4] T. A. Laitinen, J. Ollikainen, C. Icheln, and P. Vainikainen, “Rapid Spherical 3-D Field Measurement System for Mobile Terminal Antennas,” IMTC2003, Instrumentation and Measurement Technology Conference, Vail, CO, USA, pp. 968-972, May 2003.

[5] M. L. VanBlaricum, “Photonic systems for antenna applications,” IEEE Antennas Propagation Magazine, vol.36, no.5, pp. 30-38, Oct. 1994.

[6] T. Fukasawa, K. Shimomura, and M. Ohtsuka, “Accurate measurement method using fiber optics for an antenna on a portable telephone,” Wireless Communication Technology, 2003. IEEE Topical Conference, pp. 138-139, Oct. 2003.

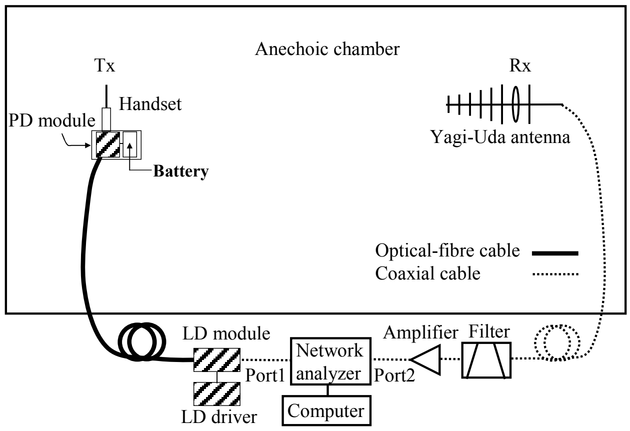
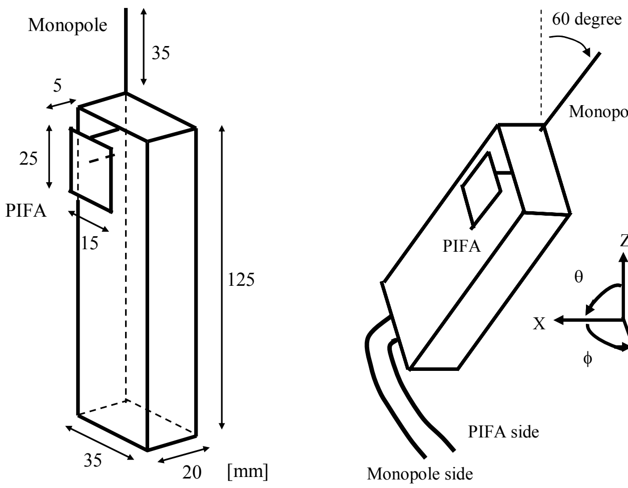


Figure1: Fibre optic measurement



(a) Handset array (b) Handset orientation

Figure 2: Handset antennas

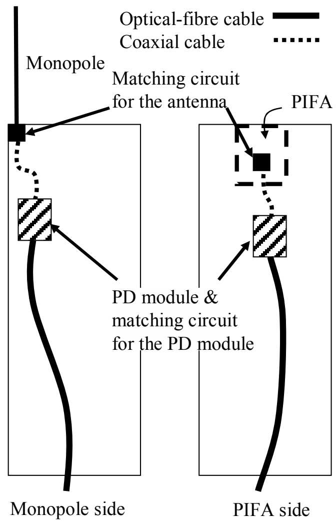
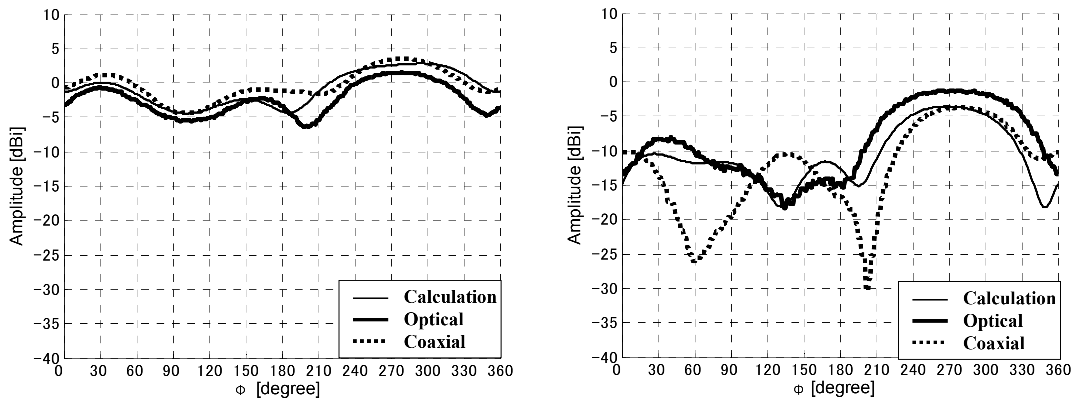
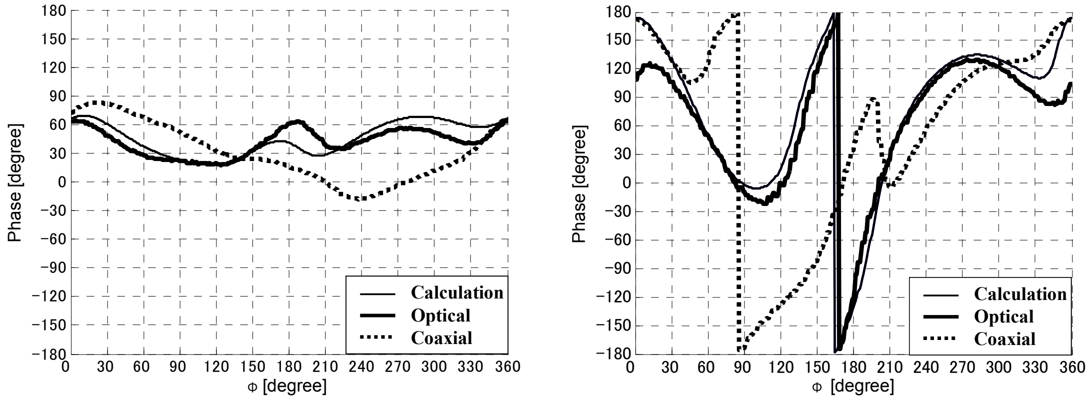


Figure 3: Handset internals



(a) Monopole (b) PIFA

Figure 4: Amplitude distributions from the handset



(a) Monopole (b) PIFA

Figure 5: Phase distributions of the handset

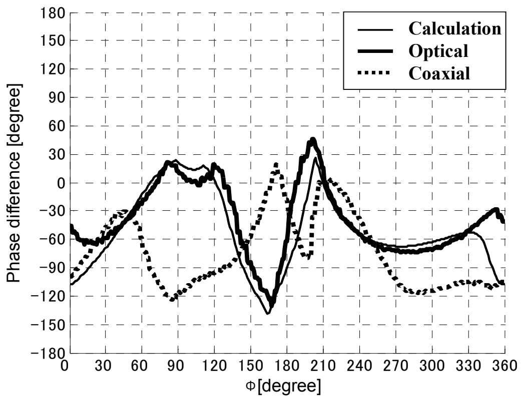


Figure 6: Phase difference between a monopole and a PIFA

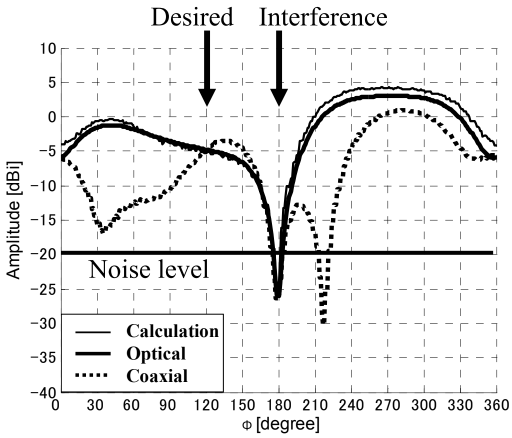


Figure 7: Amplitude distribution after MMSE control

Table 1: The output SNR and output SINR of each system [dB]

	SNR	SINR
Calculation	15.2	12.2
Fibre Optic measurement	14.8	11.8
Coaxial cable measurement	15.1	12.1

Table 2: The optimal weights of each system

	Monopole	PIFA
Calculation	1.1+j0.3	2.4+j1.1
Fibre Optic measurement	1.0+j0.3	3.1+j0.5
Coaxial cable measurement	0.5+j0.3	-2.1+j2.1