Design School of Reception Antennas on Digital Terrestrial Television for High School Students by Using WIPL-D

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Abstract: Three day design school of the reception antenna on the digital terrestrial broadcasting for high school students has been held by using the electromagnetic simulator WIPL-D. This school is the first trial of the education based on the electromagnetic simulator. The students designed the reception antennas composed of wire or planar conductor in the frequencies from 470 MHz to 518 MHz. The students could understand the antenna characteristics by seeing the animation of current and electromagnetic field distribution on the display of PC.

Keywords: Education, reception antenna, and WIPL-D

1. Introduction

With the development of the computers, many kind of electromagnetic simulators based on the Method of Moment, the Finite Difference Time Domain method, the Finite Element Method, the Transmission Line Matrix Method and so on are used for the analysis of antennas, microwave circuits and optical circuits. Technical Group on Microwave Simulator Technology in IEICE Japan has summarized the numerical analysis method on the antennas, the microwave circuit and the optical circuit and so on [1], [2]. The members of this group has also proposed the benchmarks of microstrip antennas and discussed the numerical results by the electromagnetic simulators [3], [4].

Due to the development of the animation tools in the electromagnetic simulators, recently, the user can see the near field distribution or current distribution on the antenna in addition to the input impedance characteristics and the far field radiation characteristics, and understand the antenna characteristics intuitively. Therefore the electromagnetic simulators are useful in the education of electromagnetic wave theory and the antenna engineering for the university students.

The digital terrestrial broadcasting in Japan was started in the frequencies from 470 MHz to 710 MHz on December 2003 [5]. For the reception of the conventional analog terrestrial broadcasting, directional antennas with high gain and narrow beam width, such as the Yagi-Uda antenna, are used in order to suppress the ghost image due to the echo. On the other hand, a small antenna with low gain is sufficient for the reception of the digital terrestrial broadcasting in the urban area.

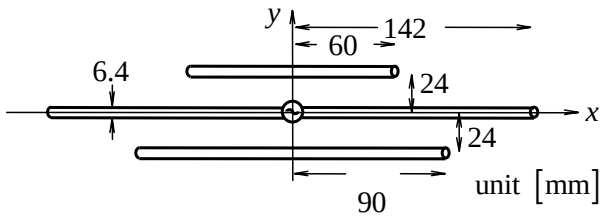
The author has organized three day design school of the reception antenna on the digital terrestrial broadcasting by using the electromagnetic simulator WIPL-D for high school students [6]. The frequency band of the digital terrestrial broadcasting in Nagasaki is from 470 MHz to 518 MHz. Six students of the technical high school participated in this school. On the morning of first day, students studied on the fundamental electromagnetic wave theory and antenna theory, then they studied the relation between the current and radiation field of the dipole antenna. After that, they studied how to manipulate WIPL-D, and practiced making the input file of WIPL-D. On the second day, the students designed the geometry of the antenna. On the third

day, all students fabricate their antennas. Finally, the input impedance of these antennas are measured and connected to the TV receiver.

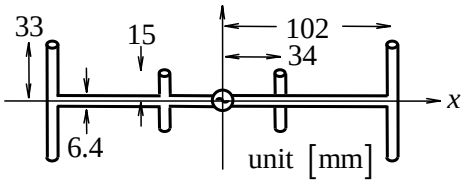
In this paper, this design school is introduced and it is shown that WIPL-D is very useful tool for the education of student.

2. Structure of Antennas

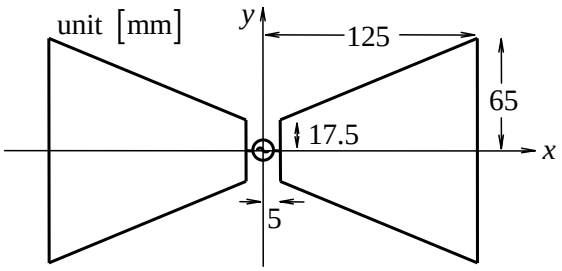
Figure 1 show the structure of the reception antennas designed by the students. In the numerical analysis by WIPL-D, antennas are excited by the delta-function generators and the thickness of conductor is assumed to be infinitely thin. Antenna #1 and #2 are composed of wire and the other antennas are planar antennas. The radius of antenna wire is 3.2 mm and the thickness of copper plate is 0.1 mm. The geometries of all antennas are designed by each student without any suggestion from the instructor. The students designed their antenna by seeing the input impedance characteristics, the far field radiation pattern and the animation of current distribution.



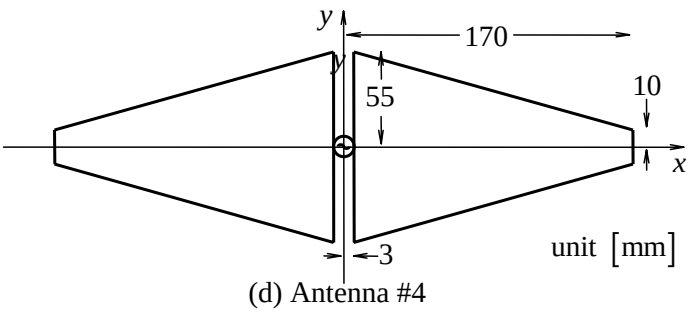
(a) Antenna #1



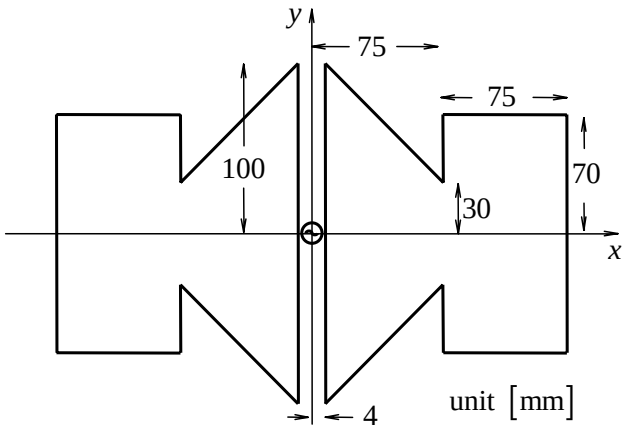
(b) Antenna #2



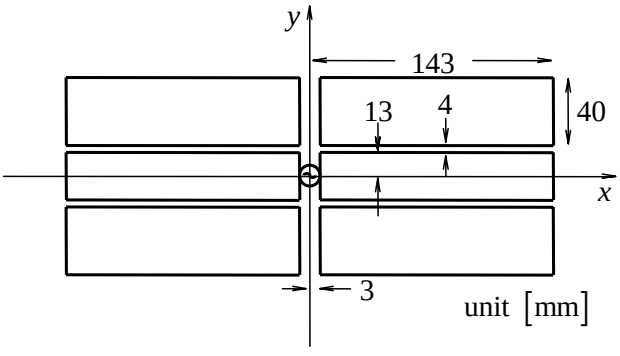
(c) Antenna #3



(d) Antenna #4

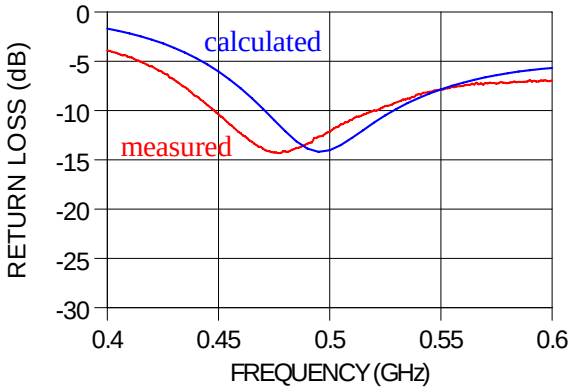


(e) Antenna #5

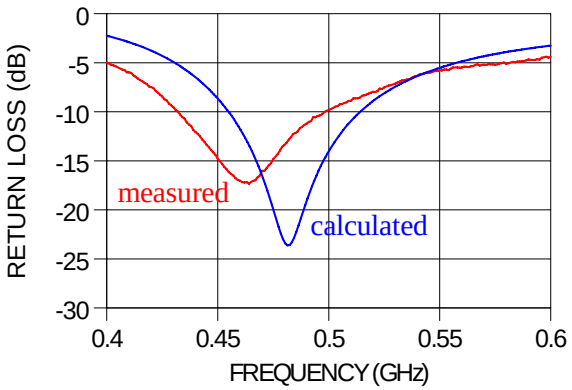


(f) Antenna #6

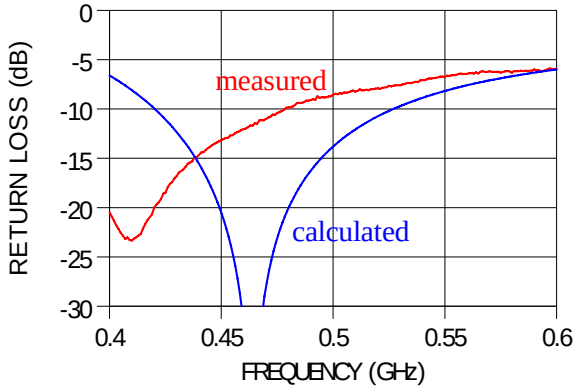
Fig. 1. Structure of receiving antennas designed by high school students.



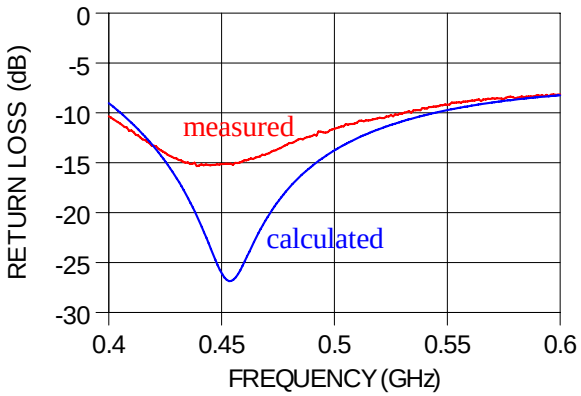
(a) Antenna #1



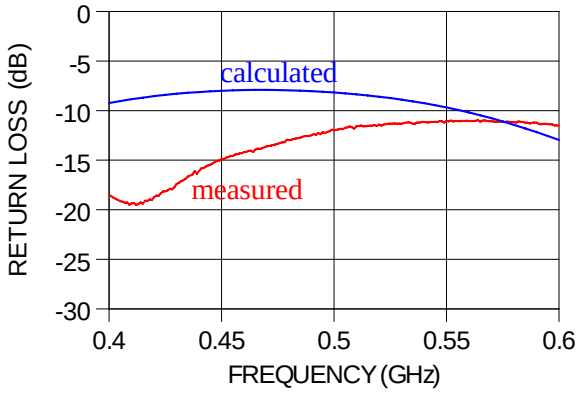
(b) Antenna #2



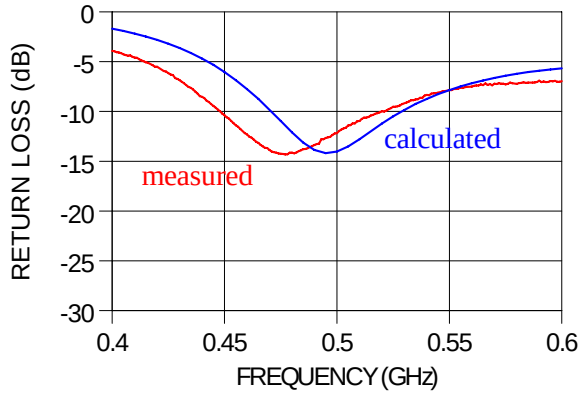
(c) Antenna #3



(d) Antenna #4



(e) Antenna #5

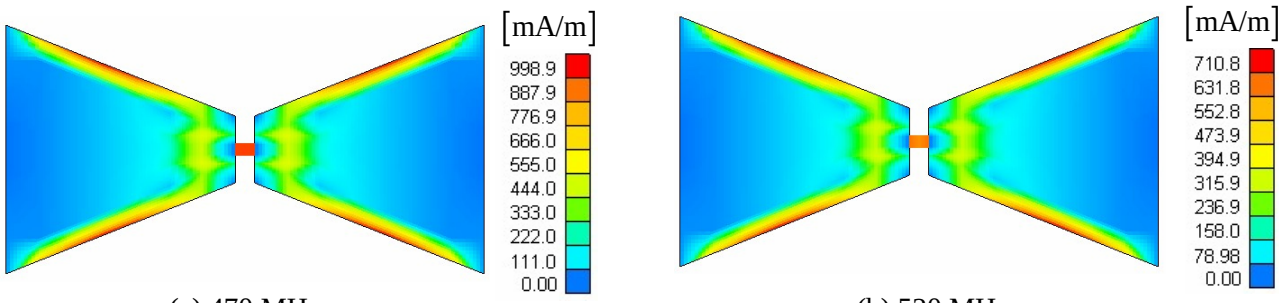


(f) Antenna #6

Fig. 2. Return loss characteristics of antennas.

3. Results and Discussion

Figure 2 shows the calculated and measured return loss characteristics of antennas. In the fabricated antennas, the coaxial cable of the characteristic impedance 75 Ω is connected to the feed point of antenna without using the balun. In the measurement of return loss of antenna, the mismatch loss between the coaxial cable and the network analyzer with the characteristic impedance 50 Ω is not compensated. Therefore, the difference of calculated and measured return loss may occur. Figure 3 shows the current distribution of the antenna #3. The similar distribution is obtained in the frequency from 470 MHz to 520 MHz. Figure 4 shows



(a) 470 MHz (b) 520 MHz

Fig. 3. Current distribution on Antenna #3.

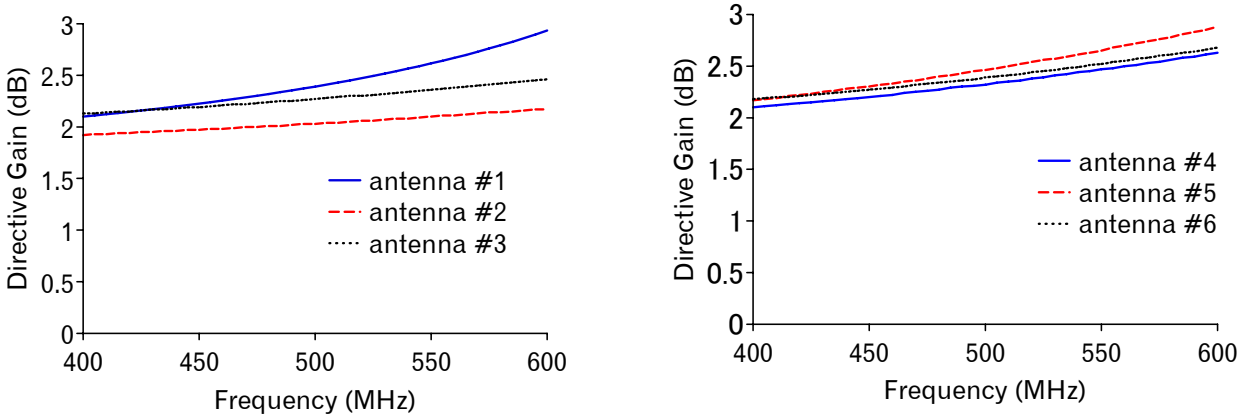


Fig. 4. Directive gains of antennas.

the calculated directive gains of these antennas. The directive gain of all antennas except for the antenna #2 is from 2 dB to 3dB.

4. Conclusion

Three day design school of the reception antenna on the digital terrestrial broadcasting by using WIPL-D for high school students has been held as the first trial of the education based on the electromagnetic simulator. The antenna characteristics are not necessarily good, because these antennas are designed by the amateurs. The students could understand the antenna characteristics by seeing the animation of current and electromagnetic field distribution on the display of PC. All antennas are connected to TV receiver in the room and confirmed by seeing the pictures.

References

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