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The convergence property of the method of Moment for Dipole antenna using new segmentation.

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1. Introduction

In recent years, mobile communication equipment including smartphones are widely used. In these equipment, an antenna is important devices to communicate with base stations. In order to develop high-performance antenna, numerical analysis is important. The Method of Moment[1] (MoM) is one of the antenna analysis methods. In the MoM analysis, currents of the antenna are divided by segments. The MoM gives us a beneficial result in antenna analysis for dipole antenna. However, calculated input impedance of the antenna by MoM does not converge by increment segments. In order to improve convergence property by segmentation method in Galerkin-Moment method using piecewise sine function as expansion function. New segmentation methods had been proposed[2,3]. In ref.[3], a new segmentation which uses root of Chebyshev polynomial. In this segmentation method, division point to make segment is defined by using root of Chebyshev polynomial has been proposed. The result shows good convergence in half-wave dipole antenna analysis. In this study, the segmentation method is applied to several antenna lengths and several length of feeding gap. Moreover, the reason of improvement is discussed.

2. Method of Moment

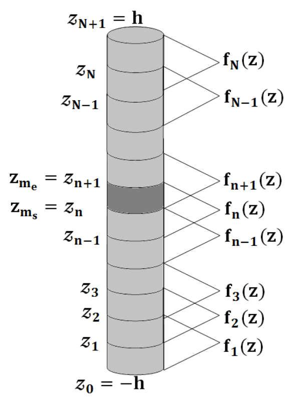

Figure 1: analysis model

In this section, the Method of Moment is explained briefly. In this paper, a dipole antenna with radius r, length 2h, and feeding gap size d is analyzed. As shown in figure 1, the antenna is divided by N segments, in order to analysis by MoM. Current on the surface of the antenna is approximated by expression (1) as

$$\mathbf{J}(\mathbf{r}') \approx \sum_{n=1}^{N} \mathbf{J}_n \quad , \quad \mathbf{J}_n = I_n \mathbf{f}_n(\mathbf{r}') \qquad (1)$$

where $\mathbf{J}_n$ is current on segment n, I_n is coefficient to be determined. I_n is called as expansion coefficient. $\mathbf{f}_n$ is function. Using scattering electric field equation as

$$\mathbf{E}^{\mathbf{scat}}(\mathbf{r}) = -j\omega\mu_0 \int_S \overline{\overline{G_0}}(r, r') \cdot \mathbf{J}(\mathbf{r'})\, dS' \qquad (2)$$

matrix equation can be obtained. The matrix equation can be expressed as

$$\overline{\overline{Z}}\mathbf{I} = \mathbf{V} \qquad (3)$$

Expansion coefficient I_n are obtained by solving matrix equation, and current density $\mathbf{J}(\mathbf{r'})$ can be derived by substituting the expansion coefficient into expression (1). Moreover, M_f functions of expansion are assigned to the feeding part, a voltage vector is represented by equation (4), where $\Delta h_m = z_m - z_{m-1}$.

$$V_m = \begin{cases} \dfrac{V_0}{k_0 d}\dfrac{1-\cos k_0 \Delta h_{m_s+1}}{\sin k_0 \Delta h_{m_s+1}} & m = m_s \\ \dfrac{V_0}{k_0 d}\left\{\dfrac{1-\cos k_0 \Delta h_m}{\sin k_0 \Delta h_m} + \dfrac{1-\cos k_0 \Delta h_{m+1}}{\sin k_0 \Delta h_{m+1}}\right\} & m_s < m < m_e \\ \dfrac{V_0}{k_0 d}\dfrac{1-\cos k_0 \Delta h_{m_e}}{\sin k_0 \Delta h_{m_e}} & m = m_e \\ 0 & else \end{cases} \qquad (4)$$

Finally, input impedance of the antenna is obtained by the following expression.

$$Z_{in} = \frac{V_0^2}{\sum_{m=m_s}^{m_e} V_m I_m} \qquad (5)$$

3. Segmentation using root of Chebyshev polynomial

Figure 2 shows the segmentation in the MoM analysis. z_n is a location in z-direction to define segmented current $\mathbf{J_n}$. In the conventional the MoM analysis an equal segmentation length (Fig.1) is used. In this case z_n is defined as.

$$z_n = \frac{n}{N+1} h \qquad (6)$$

However, the convergency for increasingt number of segmentations is not good by using this segmentation[3]. The segmentation by using root of chebyshev polynomial had been proposed. In this paper, this segmentation will be used to improve convergency for several length dipole antennas. In ref.[3], segmentation using root of Chebyshev polynomial for improving analysis accuracy and convergence. The dividing point of each segmentation is defined by the following equation.

$$z_n = \cos\frac{2n-1}{2N} h \qquad (7)$$

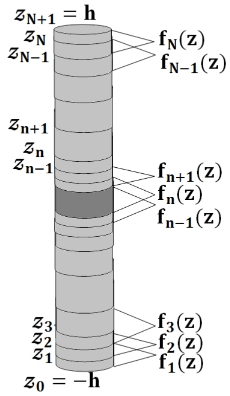

Figure 2: The segmentation using root of Chebyshev polynomial

4. Analysis result

4.1 The convergence in antenna of varied lengths

This study examined the effectiveness of the segmentation using root of Chebyshev polynomial by use of quarter-wavelength dipole antenna, one-wavelength dipole antenna, and 3/2 wavelength dipole antenna. Figure 3 ~5 show the analysis results. In these figures horizontal axis is number of divisions vertical axis is reactance or resistance. From this analysis results, the segmentation using root of Chebyshev polynomial provides shows good convergence for every antenna.

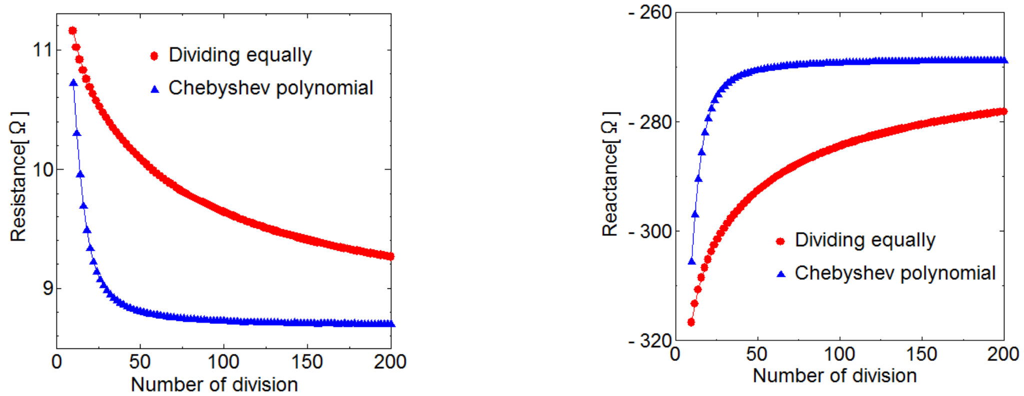

Figure 3: The convergence of input impedance to the number of division
(quarter-wavelength dipole antenna $L = 0.25$ $a = 2.5\times10^{-3}$)

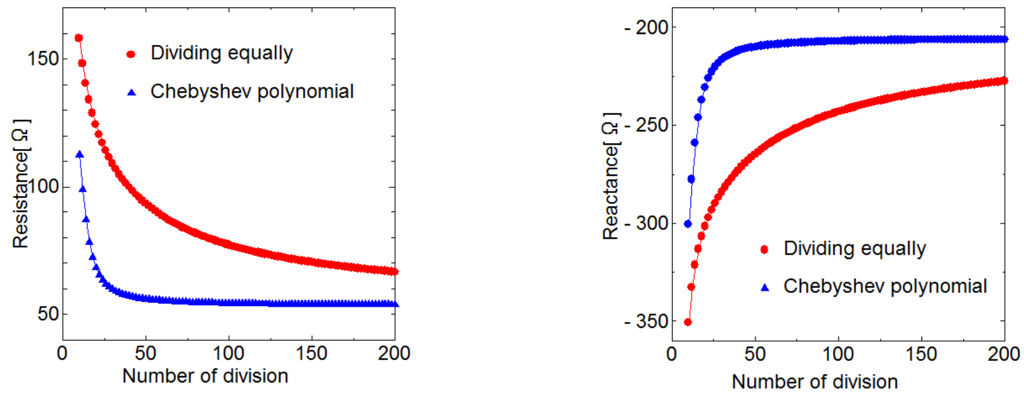

Figure 4: The convergence of input impedance to the number of division
(full-wavelength dipole antenna, $L = 1$ $a = 10\times10^{-3}$)

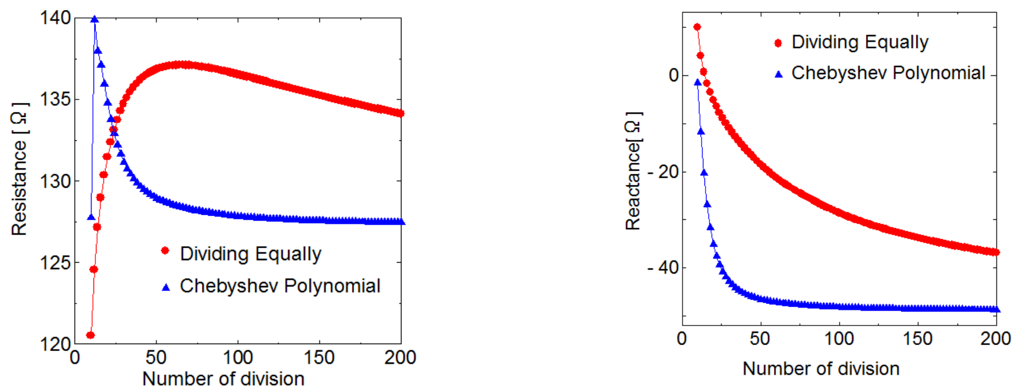

Figure 5: The convergence of input impedance to the number of division
(3/2 wavelength dipole antenna, $L = 1.5$ $a = 15\times10^{-3}$)

4.2 The convergence in antenna of varied gaps of feed

Next, this study examined the effectiveness of the segmentation using root of Chebyshev polynomial in analysis of Dipole antenna of varied gap distance of feed. Figure 6 shows convergence of input impedance in each feeding gap. Figure 6 shows units convergence of input impedance to converged value. In this analysis the division number is changing as 46, 66, and 86 by each segmentation. The converged value was set to a result of 200 segments divided case by using root of Chebyshev polynomial. From Figure 6, the segmentation using root of Chebyshev polynomial provides good convergence any feeding gap.

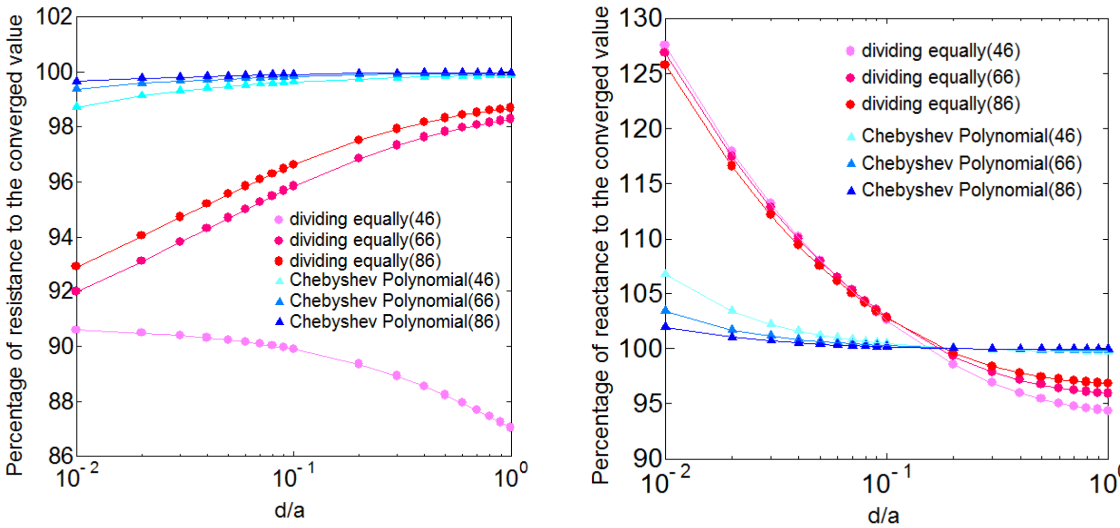

Figure 6: The convergence of input impedance to the number of division (half-wavelength dipole antenna, $L = 0.5 \quad a = 5\times10^{-3}$)

6. Conclusion

From analysis results, the segmentation using root of Chebyshev polynomial is indicated good convergence to the equal segmentation any length and feeding gap. The improvement of convergence is thought that due to that the segmentation using the Chebyshev polynomial concentrates the dividing points in the edges of antenna where the variation of electric field is rapidly.

References

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