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Peak Search Algorithm for Frequency Analysis

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1. Introduction

In the peak search of the frequency characteristics, it is difficult to find the peak for large scale circuits. If we carry out frequency analysis as changing the frequency, we have to increase the frequency gradually. However, if the changing step is large, we may miss the peaks. Also there is no guarantee that the peak values exist at the frequencies.

In this article, we propose an algorithm to find the peak of the frequency characteristics by combining the frequency analysis of SPICE with the cubic spline interpolation and the Newton method.

2. Peak search algorithm

The peak value of linear reactance circuits is considered to be decided by the character of $|Z|$ or $|Y|$ which is the impedance/admittance matrix of the given circuits. Therefore, we consider that it is enough to examine a specific node to find the peak. In our algorithm, we carry out frequency analysis of SPICE and obtain the frequency characteristics $f(\omega)$ for a specific node. The peaks correspond to the frequency satisfying $f'(\omega) = 0$. In order to calculate $f'(\omega)$ from the discrete data of $f(\omega)$ obtained from SPICE, the following numerical differentiation is used.

$$f'(\omega) = \frac{f(\omega + \Delta) - f(\omega)}{\Delta} \tag{1}$$

where Δ is a small variation of frequency ω.

In order to interpolate the discrete data of $f'(\omega)$, we use the cubic spline approximation method. Using the four successive points of $f'(\omega)$, the coefficients a_0, a_1, a_2, a_3 of the cubic spline function

$$f'(\omega) = a_0 + a_1\omega + a_2\omega^2 + a_3\omega^3 \tag{2}$$

can be determined.

Next, in order to solve the equation $f'(\omega) = 0$, we use the Newton method.

$$\omega_{i+1} = \omega_i - f'(\omega_i)/f''(\omega_i) \tag{3}$$

If we decide a convergence radius θ with a suitable value and $|\omega_{i+1} - \omega_i| < \theta$ is satisfied, we consider ω_{i+1} to be a solution.

3. Simulation result

We consider the RLC ladder circuit as shown in Fig. 1. Figures 2(a) and (b) show the frequency characteristics for the cases that the numbers of the ladder are 3 and 5, respectively, obtained by using the AC analysis of SPICE.

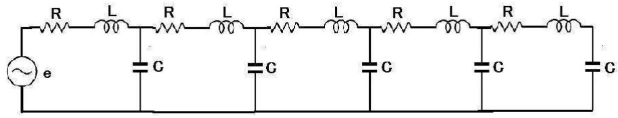
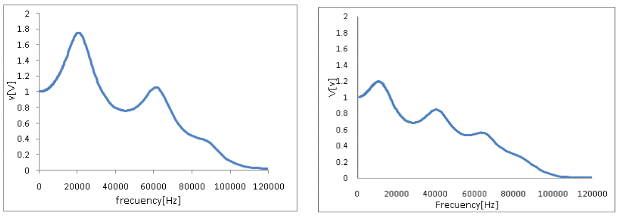


Figure 1: Example circuit. $R = 1$ [kΩ], $C = 1$ [nF], $L = 10$ [mH], $e = E\cos\omega t$ [V], $E = 1$ [V].



(a) (b)

Figure 2: Frequency characteristics of the circuit in Fig. 1. (a) Ladder is 3. (b) Ladder is 5.

The peak values obtained from the discrete data of the curves in Fig. 2 are summarized in Table 1. By comparing the calculated peak values with the frequency characteristics curves, we can say that our proposed algorithm works well for the circuit.

Table 1 Calculated peak values.

# of ladder	peak 1	peak 2	peak 3
3	19.83	59.43	—
5	10.47	39.67	62.77

4. Conclusions

In this study, we have proposed an algorithm calculating the peak values of the frequency characteristics curves obtained by the AC analysis of SPICE. The discrete data were interpolated by using the cubic spline function and the frequency giving the peak was calculated by the Newton method.

The proposed algorithm will be applied to nonlinear large scale circuits if accurate frequency characteristics can be obtained. Hence, we will combine the proposed algorithm with the previously proposed Sine-Cosine circuits to obtain accurate frequency characteristics.

References

[1] A.Ushida and M.Tanaka, "Computer Simulation of Electronic Circuits," Corona Publishing Co. Ltd., 2002.