Simulation Analysis of a ±180° Phase Shifter Circuit Model

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***Abstract*—In this paper, a ±180° phase shifter circuit model is proposed, consisting of two transmission lines and an LC tank as a unit cell. Four-unit cells are cascaded to form the phase shifter circuit model. Using the Keysight ADS simulation tool, the circuit model exhibits excellent S-parameter performance and a tunable ±180° phase response. Three parameters, including the number of unit cells, electrical length, and capacitance value, are analyzed to examine their effects on the resonance frequency, bandwidth, phase response, and S-parameter symmetry.**

***Keywords*—phase shifter; LC tank; phase response**

I. Introduction

Satellite communication is an important communication technology and a key indicator of a country's technological capability. Therefore, many countries are actively developing satellite communication technologies, particularly focusing on low-Earth-orbit (LEO) satellite systems. LEO satellites typically operate at an altitude of about 500 km above Earth and travel at speeds of approximately 30,000 km/h. Consequently, phased-array antennas with beam steering capability are required at the receiver to track these high-speed moving satellites. The key component of beam steering is a phase shifter with a linear and continuously tunable phase response [1]. This type of phase shifter was previously proposed in [2]. In this paper, a complementary analysis of the circuit model is presented. Three parameters, the number of unit cells, electrical length, and capacitance value are investigated to evaluate their effects on the resonance frequency, bandwidth, phase response, and S-parameter symmetry.

II. Circuit Model

Fig. 1 illustrates the circuit model of the phase shifter with n unit cells. Each unit cell consists of two 50 Ω identical transmission lines with electrical length βl and an LC tank formed by an inductor in parallel with a capacitor. The LC tanks of each unit cell are identical, meaning that $L_1 = L_2 = \cdots = L_n$ and $C_1 = C_2 = \cdots = C_n$.

In the following analysis, the circuit model is simulated using the Keysight ADS tool. The operating frequency (f_0) for one unit cell is set to 28 GHz with a half power bandwidth (*HPBW*) of 1 GHz. Then, from (1) and (2), the required resonant inductance and capacitance are calculated as

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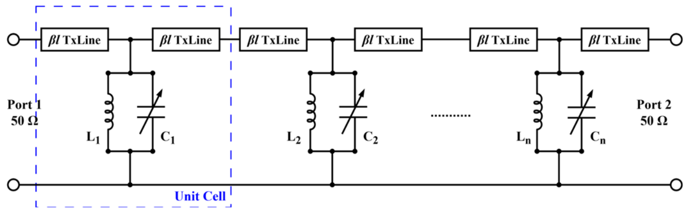

Fig. 1 Circuit model of the phase shifter with n unit cells.

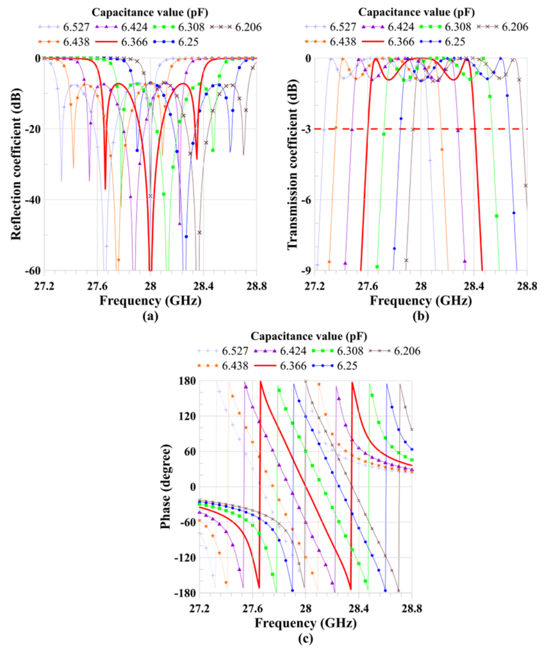

Fig. 2 Effect of capacitance for four-unit cells: (a) reflection coefficient, (b) transmission coefficient, and (c) phase response.

III. Conclusion

A ±180° phase shifter circuit model is proposed, which exhibits excellent S-parameter performance and a tunable ±180° phase response. Three parameters were analyzed to guide how to correct asymmetry and tune the phase shift in practice.

References

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