Transmission Efficiency Analysis for T-section Impedance Matching Circuit with Lossy Circuit Elements

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1. Introduction

Impedance matching networks are used extensively in wireless communications and wireless power transfer (WPT) system[1]. The most commonly used lumped parameter circuits are the L-section, T-section, and Π-section matching circuit. However, most of impedance matching circuits have been designed by using inductors and capacitors without taking their ohmic losses (Q-factor) into account. In this research, an exact approach to design T-section impedance matching circuit with consideration of elements ohmic losses will be confirmed .

2. Formulation of Impedance Conjugate Matching Condition

As we known, The circuit can achieve maximum power transmission when the input impedance (Z_{in}) including matching circuit and load as shown on Fig.1 is equivalent to the complex conjugate of the source impedance (Z_s^*).

$$Z_{in} = Z_s^* \quad (1)$$

The Q-factor is used to defined the ohmic loss of reactance and susceptance as:

$$Q_X = |X_1|/R_1 = |X_2|/R_2 \text{ and } Q_B = |B|/G \quad (2)$$

And compared with L-section impedance matching circuit, T-section circuit has an additional variable X_2 as shown in Fig.1. So we need one more design parameter which is the loaded quality factor Q_n.

$$Q_n = |X_2 + X_l|/R_l \quad (3)$$

To solve equation set of (1), (2) and (3), the values of X_1, X_2 and B can be readily obtained easily. And we choose the negative values that represent capacitance.

3. Results and Conclusion

the design parameters are setted as $Q_X = Q_B = 100$, $Q_n = 10$. As shown in Fig.2, the value of X_1, B decreased along with the increase of Q and X_2 increased. And the efficiencies increased as shown in Fig.3. It is approved that the consideration of ohmic loss in circuit elements is important for exactly designing impedance matching networks when Q_X , Q_B are small values. Furthermore, the transmission efficiency will be 100% without considering the circuit elements ohmic loss at matched frequency but it will significantly decrease when the elements have their ohmic losses.

[1] Q.Yuan, S.Suzuki, and Q.Chen, “Design Method of Lossy Impedance Matching Circuit”, IEICE Tech. Rep., vol.116, No.218, AP2016-106, pp.97-100, Sept.2016.

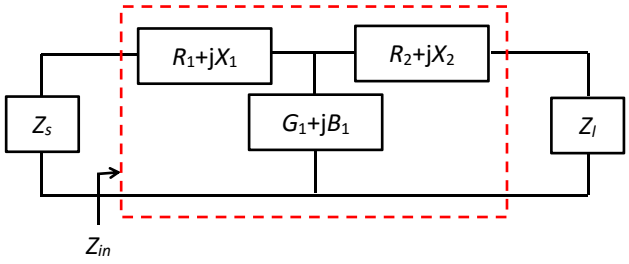

Fig.1 T-section impedance matching circuit

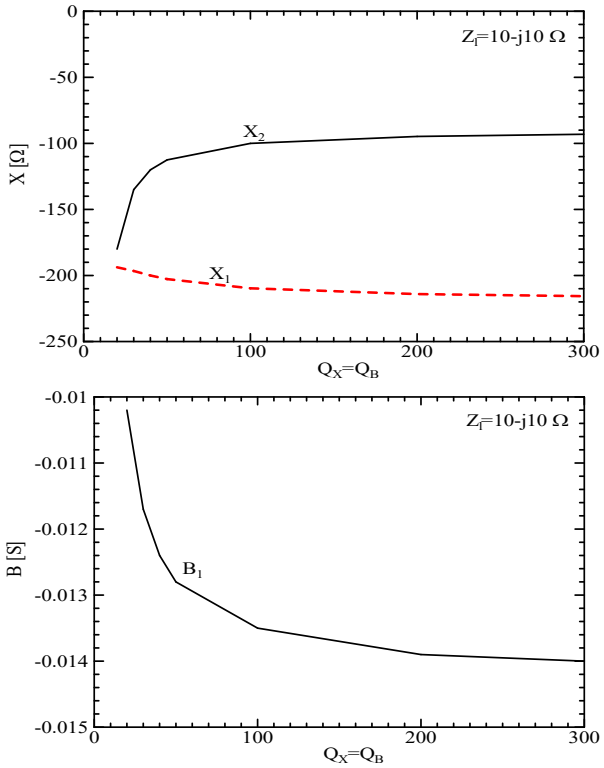

Fig.2 The value of X_1, X_2 and B

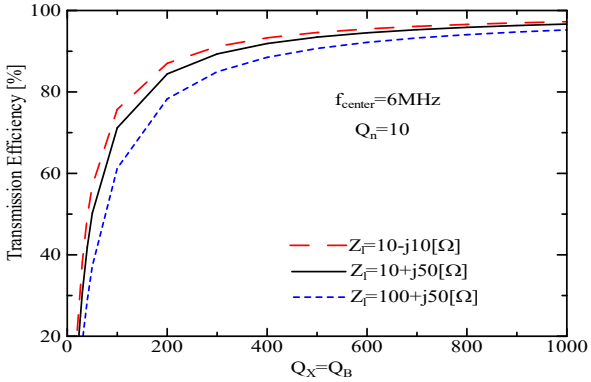

Fig.3 Transmission Efficiency versus Q-factor