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Application of Parametric Equivalent Circuit in Wireless Communication System

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ABSTRACT. *This article introduces the application of three-parameter equivalent circuit models of transistors in various circuits of wireless communication systems. It mainly introduces the equivalent circuit of mixed πparameter, h parameter and Y parameter. Based on the three parameters, the transistor model is established. According to the circuit model, the parameters of the amplifier are obtained. The circuit model constructed by the parametric equivalent circuit is simple and convenient to calculate. It provides a good analysis basis for the analysis of the circuits at various levels in the wireless communication system and provides convenient conditions for the study of signal transmission and processing in the wireless communication system.*

KEYWORDS: *Mixed π parameter; H parameter; Y parameter; Circuit model*

1. Introduction

A wireless communication system is a system that uses electromagnetic waves as a carrier to transmit information through free space. The wireless communication system is divided into two parts, transmitting and receiving. Therefore, the core part of the communication system is the transmitting device and the receiving equipment. The components of the transmitting device and the receiving device in different wireless communication systems are not exactly the same, but their basic structures are similar. The basic circuits and principles of the device are the same and follow the same rules.

The basic circuits in the wireless communication system are divided into three stages which are low frequency, intermediate frequency and radio frequency, according to frequency division. The IF and RF circuits are high-frequency circuits. The basic circuits include high-frequency oscillators, amplifiers, mixers, and modulation and demodulation circuits. The low-frequency circuit includes a low-frequency amplifier and a low-frequency power amplifier. Because the components used in high-frequency circuits are basically the same as the components used in low-frequency circuits, but the high-frequency characteristics presented in high-frequency circuits have a great impact on the circuit, so transistors should be used in wireless communication systems. The parameter equivalent circuit analyzes the circuit, and certain parameters of the transistor cannot be ignored in the circuit analysis

2. Π-Parameter Equivalent Circuit

The π parameter equivalent circuit is the physical parameter model. The π parameter equivalent circuit is determined by the physical process inside the transistor. This equivalent circuit considers the junction capacitance effect due to the high working frequency, and the lead inductance and carrier transit time between the poles cannot be ignored. It can be seen that the π parameter equivalent circuit can only be applied to low-frequency circuits of wireless communication systems. The transistor equivalent π parameter equivalent circuit is shown in Figure 1.

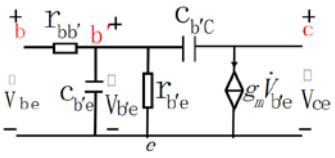

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Figure.1 Transistor Mixed Π Parameter Equivalent Circuit

In the figure, rbb' is the body resistance of the base region, which is a given parameter of the transistor; rb'e is the emitter junction resistance, and transconductance Cb'c is the collector junction capacitance, which is a given parameter of the transistor. As seen in the formula $,C_{b'e} = \frac{g_m}{2\pi f_T}$, the emitter junction capacitance Cb'e, f_T is the characteristic frequency of the transistor. The parameters given by the transistor are different according to the model of the transistor. The current source is a controlled current source, which represents the controlling effect of the base-emitter voltage of the transistor on the collector current. In the wireless communication system, the small-signal model established by the π parameter is used to analyze and calculate the frequency characteristics of the low-frequency baseband circuit. It provides theoretical analysis basis for signal transmission, signal filtering, anti-interference and other aspects of communication system.

3. H-Parameter Equivalent Circuit

By using the characteristic curve of transistor transfer, the circuit model of output circuit and input circuit of transistor is simulated. Under the linear condition, the transistor is regarded as a linear two-port network. By using the characteristic equation of output circuit and input circuit of transistor, the circuit model is defined by the method of total differential, and the h-parameter equivalent circuit is established.

The input circuit of transistor is simulated by the dynamic input resistance rbe on the characteristic curve. The dynamic input resistance rbe is obtained by selecting the working current and working voltage near the static operating point Q. In this way, the transistor output characteristic curve can be approximately regarded as a current source controlled by the base current, so the output circuit of the transistor can be simulated with an approximate current source. [1] In this way, the small signal model of the transistor is formed, and the full differential circuit is formed, thereby determining the H-parameter equivalent circuit. The H-parameter equivalent circuit of the transistor is shown in Figure 2.

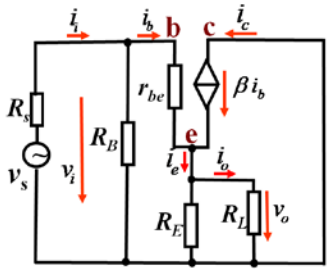

Figure.2 H-Parameter Equivalent Circuit

In wireless communication systems, H-parameter equivalent circuits are used to theoretically analyze low-frequency baseband circuits. It can be used to analyze and calculate the voltage gain, power gain, circuit characteristics, and frequency characteristics of the low-frequency amplifier circuit. It also can provide high gain and stable output signals for signal transmission.

4. Y Parameter Equivalent Circuit

Considering the transistor as an active four port network, the matrix equations of output and input voltage and current are listed, and the four port network model of the transistor is obtained. Since the transistor is a current-controlled component, both the input and output have current, so it is more convenient to use a Y-parameter equivalent circuit. In the medium and high frequency amplifiers of wireless communication systems, the Y-parameter equivalent circuit model of the transistor is often used to analyze the circuit. Its advantage is that the resulting expression has universal significance and is widely used. The analysis circuit is more convenient.[2] If we choose input current and output current as parameters and input voltage and output voltage as independent variables, we can list the matrix equations, as shown in formula (1).

$$\begin{cases} I_1 = y_{ie}V_1 + y_{re}V_2 \\ I_2 = y_{fe}V_1 + y_{oe}V_2 \end{cases} \quad \textit{(Formula 1)}$$

The y-parameter model is determined according to the circuit connection relationship and the matrix equation,

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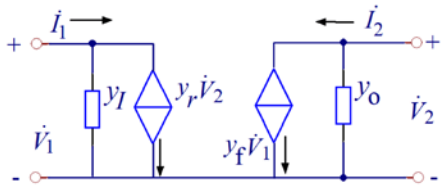
as shown in Figure 3.[3] The Y parameter belongs to the transistor's own parameters, which is only related to the characteristics of the transistor, and has nothing to do with the connection form of the external circuit. The y



parameter is used to make the operation more convenient and quick. The parallel operation of the admittance is directly added, making the calculation process more convenient and simple .

Figure.3 Transistor y Parameter Equivalent Circuit

It can be seen that the use of the Y-parameter equivalent circuit to analyze the circuit has a clear physical meaning and it is more convenient to calculate the circuit parameters. At the same time, a way to improve the voltage gain and power gain of the amplifier circuit is obtained. In the wireless communication system, the medium and high frequency amplifier uses Y parameter to analyze the circuit [4].

5. Conclusion

In summary, the same transistor can be represented by different equivalent circuits in different occasions. In wireless communication system, different parameter equivalent circuits can be selected to analyze and calculate the circuit parameters and performance according to the working frequency and the role of the circuit in wireless communication system.[5] And the parameters of various parameters equivalent circuits of the same transistor can be converted to each other. Although the conversion formula is complicated, we can choose the appropriate parameter equivalent circuit to analyze the circuit according to the operating frequency of the circuit in the wireless communication system. It can be seen that the parameter equivalent circuit is widely used in wireless communication systems, and it also plays a pivotal role.

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