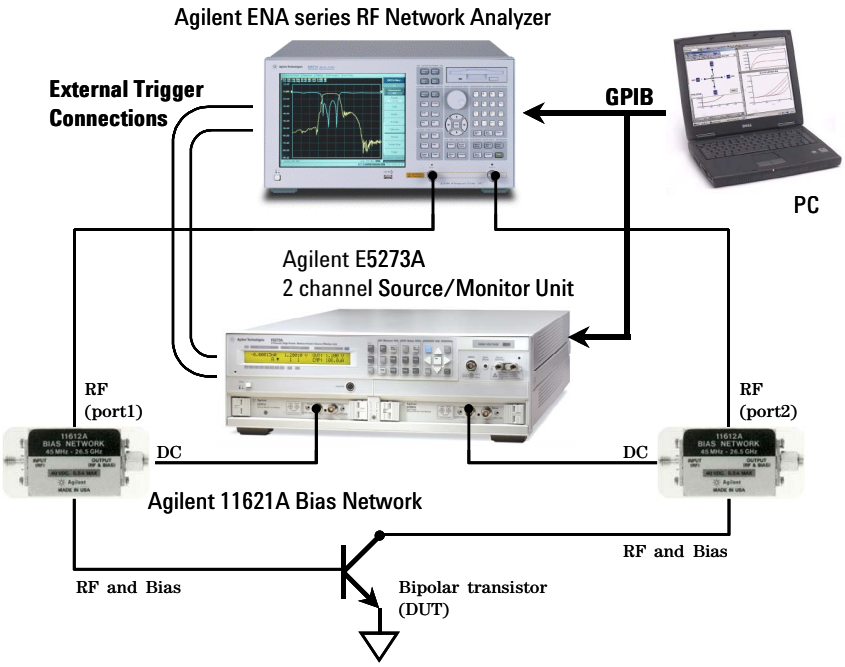
High Speed f_T versus Ic Characterization of Bipolar Transistors Using Agilent E5270A and ENA series RF Network Analyzer

Application Note E5270-2



Overview

This application note shows you how to perform high-speed f_T versus Ic characterization of bipolar transistors using the Agilent E5270 Series of Parametric Measurement Solutions. The enhanced trigger functions of the E5270 Series enable you to perform a frequency sweep using the Agilent E5070B ENA Series RF Network Analyzer for each bias output step. As a result, you can execute complex measurements with the ENA such as f_T versus Ic very quickly.

System Configuration

A bipolar transistor (DUT) is connected to the RF ports of the ENA and to the DC output terminals of E5273A through 11612A bias networks.

A computer controls the E5273A 2ch DC source/monitor and E5071B network analyzer through GPIB. In addition, the external trigger input and output of the E5273A are connected to the handler interface of the ENA as follows:

E5273A Trigger Output

⇔ E5071B External Input

E5273A Trigger Input

⇔ E5071B Port A0

The E5273A acts as the trigger master.

S-Parameter Measurements and Cut-Off Frequency, fT, Calculation

The E5273A supplies bias voltages to a bipolar transistor, and the ENA measures S-parameters. H-parameters are calculated from the measured S-parameters, and the absolute value of H21 is plotted versus frequency. The Figure 2 shows typical |H21| characteristics. From the H21-frequency characteristics, the cut-off frequency f_T is calculated. In order to calculate the f_T, the absolute value of H21 at 1 GHz is calculated, and a line is drawn there with a –6 dB/octave slope. The intercept point of this line with the X-axis is the f_T. In the example just shown, the f_T is 14.8 GHz.

f_T versus Ic Characteristics

S-parameters are measured at particular bias conditions. To find a maximum cut-off frequency f_T_max, it is necessary to change the bias conditions. For example, base current (Ib) is swept while measuring the collector current (Ic). At each step of the Ib sweep, S-parameters are

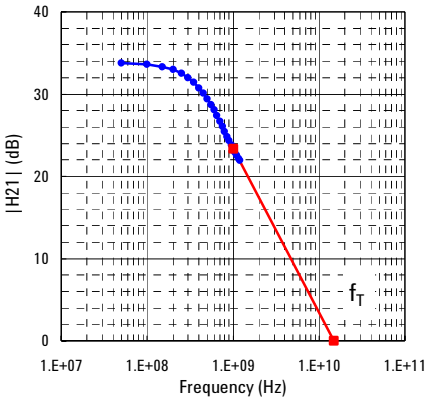


Figure 1. Typical |H21| characteristics

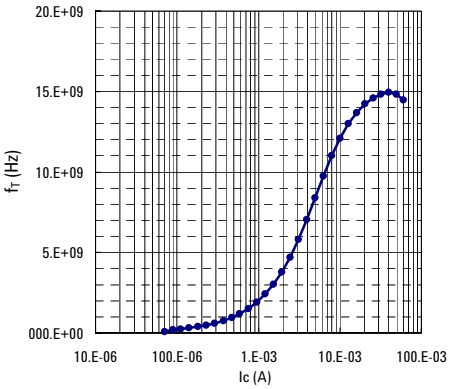


Figure 2. f_T versus Ic Curve

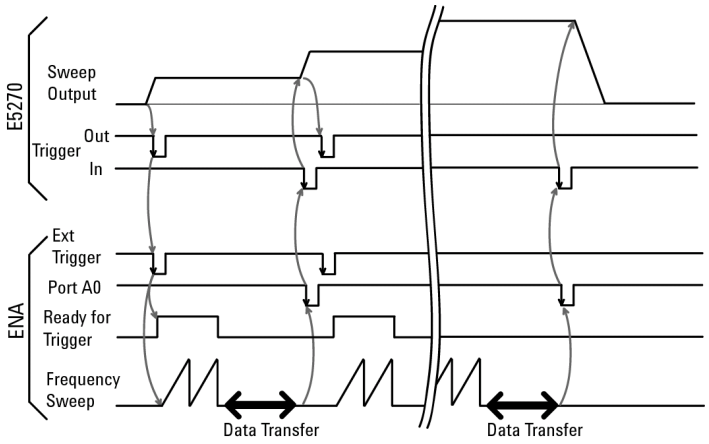


Figure 3. Handshake between E5270A and ENA Network Analyzer

measured to calculate the cut-off frequency, f_T. Then an f_T versus Ic curve is drawn (similar to the graph shown in Figure 1), and the maximum cut-off frequency, f_T_max, is extracted from this curve. In the example shown in Figure 2, the f_T_max is 14.9 GHz at a collector current of 40 mA.

Handshake between the ENA and E5270A through External Triggers

A computer controls both the ENA and E5270A through GPIB. Additionally, the ENA and E5270A perform handshaking with each other using the external trigger.

Figure 3 shows a handshake between the ENA and the E5270A. After outputting a step of bias voltage, the E5270A sends a trigger signal to the ENA to notify it that it is ready for the frequency sweep. After receiving a trigger signal, the ENA starts a frequency sweep to measure S parameters. After completing the data transfer, the ENA sends a trigger signal to the E5270A. The E5270A then outputs the next step voltage. This cycle continues until the last step voltage.

Conclusion

By using trigger functions of ENA and E5270A, you can perform high-speed f_T versus Ic characterization, and retrieve the maximum f_T parameter effectively.

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