

# Hints, Tips and Solutions

Mustafa Taner, Applications and Support Engineer

**Q. How can I obtain Fmax, Gmax, Upg and K factor plots from s-parameter measurements.**

A. Typically, *UTMOST III* s-parameter module is used to measure the FT versus IC (collector current) characteristic of bipolar transistors. The FT\_CE routine can also be utilized to extract important parameters such as Fmax, Gmax, Upg and K factor. These parameters provide a clear indication of the performance of the device as an amplifier.

Brief description of these parameters as follows:

**GMAX** (Maximum Available Gain):

GMAX is the forward power gain when the input and output are simultaneously conjugately matched. GMAX is only defined for an unconditionally stable device. ( $K > 1$ ).

**FMAX** : The frequency where GMAX gain is equal to 1.

**K** (Stability Factor):

K is a measure of oscillatory tendency. For  $K < 1$  the device is potentially unstable and can oscillate by the application of some combination of passive load and source admittances. For  $K > 1$  the device is unconditionally stable. K plays an important role in amplifier design.

**UPG** (Unilateral Power Gain):

UPG is defined as the forward power gain in a feedback amplifier whose reverse gain has been adjusted to zero by a loss less reciprocal feedback network.

The relations between the measured s-parameters and K, GMAX and UPG are given as:

$$D = s_{11} \times s_{22} - s_{12} \times s_{21}$$

$$K = (1 + |D|^2 - |s_{11}|^2 - |s_{22}|^2) / (2 \times |s_{12}| \times |s_{21}|)$$

$$GMAX = |s_{21} / s_{12}| \times (K - \sqrt{K^2 - 1})$$

The FT\_CE routine is set as default to measure four s-parameters (s11, s12, s21 and s22) and display the h21 vs frequency. The Ft is defined as the frequency point where  $|H_{21}|$  is equal to 1. The user can view the GMAX, UPG and K factor plots and extract Fmax from the GMAX versus frequency plots. In order to view the GMAX and K factor plots the the Fit Variable”Gmax=1, Upg=2” should be set to 1. (Figure 1). Same variable should be set to 2 to view UPG versus frequency and K factor plot. If set to 0 (default) the H21 versus frequency plots will be displayed and FT will be extracted for each DC bias point. The Fmax will be extracted from the GMAX vs. freq. (Figure 2) or UPG vs. freq. plots (Figure 3).

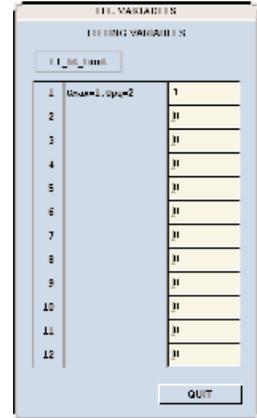


Figure 1. Fit Variables screen of the FT\_CE routine.

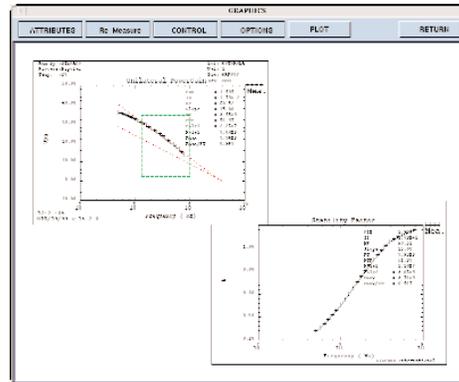


Figure 2. GMAX vs Frequency and K Factor plots.

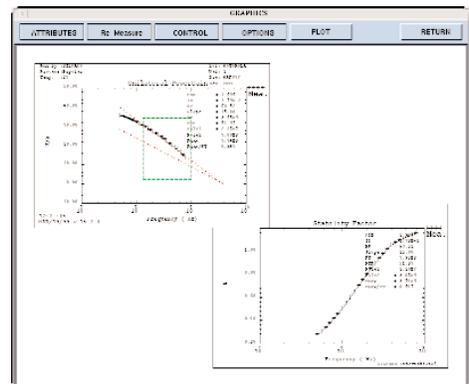


Figure 3. UPG vs. Frequency and K Factor plots.

**Call for Questions**

If you have hints, tips, solutions or questions to contribute, please contact our Applications and Support Department  
 Phone: (408) 567-1000 Fax: (408) 496-6080  
 e-mail: [support@silvaco.com](mailto:support@silvaco.com)

**Hints, Tips and Solutions Archive**

Check our our Web Page to see more details of this example plus an archive of previous Hints, Tips, and Solutions  
[www.silvaco.com](http://www.silvaco.com)