

Description of Parameter Calculator

To use this calculator, you will need to download the free "Mathplayer" program from the Mathematica website at <http://www.wolfram.com/products/player/>

This calculator provides graphs of a variety of important transistor parameters (as a function of relevant SPICE parameters with the exception of Ptf, plus the DC operating point) along with an actual number for a particular operating point. This number is shown in the title of the graph. All of the relevant SPICE parameters are adjustable by slider controls and/or by directly typing in the value. This calculator is pre-loaded with the SPICE parameters for an NE851M03 transistor.

The operating point is set by the slider controls I_c and V_{ce} . The value for a particular parameter at a particular operating point is given in the Title of the graph. For example, if the plot is of f_t , then the title will contain the f_t of the device when operated at a collector current value of I_c and a voltage collector to emitter of V_{ce} . The plot itself will be f_t plotted against I_c at an operating voltage of V_{ce} .

You will observe that certain parameters develop an imaginary component for certain values of I_c and V_{ce} . This is because more voltage is dropped across internal resistors of R_c and R_{eb} than is available and the device is effectively in saturation.

There are two parameters, I_{cminP} and I_{cmaxP} that are used to set the minimum and maximum values of collector current on the graph. This is useful for zeroing in on a particular value of collector current.

The button labeled Plot type has two modes; LogLog and LogLinear. For some of the graphs, this selection will change the graph from a LogLog Plot to a LogLinear Plot. When used in conjunction with I_{cminP} and I_{cmaxP} , the graph can be narrowed to a range and the values can be easily read.

The slider labeled R_e sets the value of an external resistor in the emitter (such as would be done to control the gain of an actual amplifier). It is used to determine the value of C_e .

Individual graphs are selected by a drop down menu labeled *plot*. Available graphs include:

- 1) f_t plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

f_t is the Transition Frequency and is the frequency at which the transistor current gain becomes unity.

- 2) T_t plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

$T_t = \frac{1}{2\pi f_t}$ It is a commonly used parameter in high frequency design.

- 3) C_{jc} plotted against Voltage Collector to Emitter (V_{ce}) with I_c adjustable through the use of a slider control (or by directly typing in the desired value). Normally this parameter is calculated as a function of V_{bc} (voltage base to collector), but V_{bc} is not always easily determined. This calculator allows you to enter V_{ce} and it calculates V_{bc} by subtracting V_{be} (Voltage base to emitter) from V_{ce} .

C_{jc} is the junction capacitance between the base and collector when the junction is reverse biased. It is a parameter that is frequently the determining limitation for bandwidth. This calculator assumes that there is no resistance in the collector and therefore no voltage gain to create a Miller effect multiplier.

- 4) V_{be} (Voltage Base to Emitter) plotted against collector current (I_c).
- 5) C_{β} plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value). This is the capacitance between the base and emitter for the high frequency linear model.

$$C_{\beta} = g_m T_t \text{ Where } g_m = \frac{I_c}{V_t}$$

V_t is the thermal voltage and is equal to 26 mv at room temperature.

- 6) V_{bc} (Voltage Collector to Base) plotted against Voltage Collector to Emitter (V_{ce}) with I_c adjustable through the use of a slider control (or by directly typing in the desired value).
- 7) C_{bt} plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

C_{bt} is the series combination of C_{β} with C_{eb} . C_{eb} is the capacitance reflected into the base because of the emitter bulk resistance (called R_e in SPICE, but what I have renamed as R_{eb} because of confusion with externally added emitter resistors and with the Mathematica function Re for Real. C_{bt} is one step closer to determining the input capacitance to an amplifier.

$$C_{eb} = \frac{T_t}{R_{eb}}; C_{bt} = \frac{T_t}{R_{eb} + \frac{1}{g_m}}$$

- 8) C_e plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

For a difference amplifier, the gain is set by an emitter resistance (R_e). In order to eliminate negative elements in the base and in fact to create as pure a capacitor in the base as possible, R_e is paralleled with a capacitor of value C_e . The required value of C_e is $C_e = \frac{T_t}{R_e}$. When C_e is equal to this value, it reflects a value of C_e in series with C_{bt} into the base.

- 9) C_{in} plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

$$C_{in} \text{ is the series combination of } C_e \text{ and } C_{bt}. \text{ It is equal to } C_{in} = \frac{T_t}{R_{eb} + \frac{1}{g_m} + R_e}$$

10) C_t plotted against collector current (I_c) with V_{ce} adjustable through the use of a slider control (or by directly typing in the desired value).

C_t is the total capacitance seen in the base. It is the sum of C_{in} and C_{bc} .