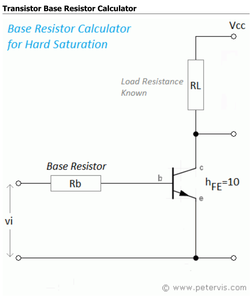
Transistor Base Resistor Calculator



Consider a *base resistor* that controls the amount of current entering the base junction of a *bipolar junction transistor* (BJT) to cause it to conduct in the saturation region. This resistor determines the amount of saturation current $I_{b(sat)}$ flowing into the base junction, and that controls the amount of saturation current $I_{c(sat)}$ flowing through the collector and emitter junctions. For hard saturation, engineers usually use a DC current gain h_{FE} value of 10.

An NPN transistor requires a positive voltage at the base junction to switch ***ON*** and control a load (RL) such as a low-voltage relay with a known resistance value. In these types of switching applications, we require it to behave as a switch and conduct fully in the *saturation* region. A proper value of base resistance is therefore required for conduction in this region, and this value is different for different input switching voltages. There are two calculators in this multi-page section of the article, where the first one is for when the load resistance is known, whilst the second, is for when the load current is known.

Calculator 1: Compute Rb When Load Resistance is known

In order to use this calculator, you will need to know the input switching voltage (Vi), supply voltage Vcc, and the load resistance RL.

h_{FE}
100

RL (Ω)
100

Vcc (V)
5

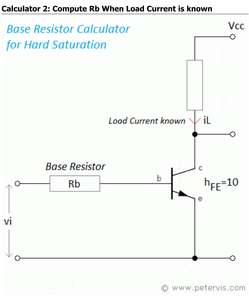
Vi (V)
5

Rb (Ω)
10000

Calculate Rb

Use the Standard_Resistor_Values chart to find the nearest standard resistor value. This chart will show you the colour code. For switching applications, a ¼-watt resistor with 5-% tolerance usually works fine.

Calculator 2: Compute Rb When Load Current is known



In order to use this calculator, you will need to know the input switching voltage (Vi), supply voltage Vcc, and the load current iL.

h_{FE}
10

iL (A)
0.000

Vcc (V)
5

Vi (V)
5

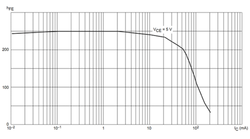
Rb (Ω)

Calculate Rb

Use the Standard_Resistor_Values chart to find the nearest standard resistor value. This chart will show you the colour code. For switching applications, a ¼-watt resistor with 5-% tolerance usually works fine.

hFE and Collector Current Theory

In transistor literature, there are two different types of gain parameters with the same three letters. Small case "h_{fe}" represents the *small-signal current gain* or AC gain, and we do not use this parameter when using the transistor as a switch. The parameter "h_{FE}" represents the *DC gain*, and this is the parameter to consider. When selecting the h_{FE} value for transistor switching purposes we always choose the minimum rating as the worst case because we want the transistor to conduct in the saturation region. For hard saturation, engineers usually choose a value of 10.



Remember that a bipolar transistor is a *current amplifier*, because a small amount of current "Ib" through the base controls a larger amount of current "Ic" flowing through its collector. How large this current flow is depends upon a gain factor known as "h_{FE}", also sometimes called the DC current gain, and beta. Hence, the current flowing through the collector is proportional to the base current multiplied by gain, as shown by the formula below.

$$\mathbf{Ic = Ib \times h_{FE}}$$

The h_{FE} parameter is not a constant though, because a transistor may have many ratings for different collector currents Ic. Students often find it difficult to visualise the relationship between h_{FE} and collector current. The graph above shows h_{FE} on the y-axis and collector current on the x-axis for a general-purpose transistor. As you can see, when the collector current increases, h_{FE} decreases.

When to use NPN and PNP Transistors

It is important to note that when the switching voltage to the base junction is positive, it is customary, to use an NPN transistor. However, when the switching voltage is 0-V or negative, then PNP transistor is utilised to switch the load. Usually, a general-purpose transistor such as the PN2222 has maximum collector rating (Ic) of 600-mA DC. If your load requires more current, then it is common sense to consider transistors with a larger Ic rating. Engineers tend to use *Darlington* transistors in cases where greater currents are required to drive larger loads such as relays and motors.

NPN Transistor	Maximum Collector Current Ic
PN2222	600-mA DC
2N2222	800-mA DC
MPSA13/MPSA14	500-mA DC
2N3904/2N3903	200-mA DC

This Article Continues...

Transistor_Base_Resistor_Calculator
Transistor_Base_Resistor_and_Hard_Saturation
Transistor_Hard_Saturation_as_Rule_of_Thumb
Transistor_as_a_Switch
Standard_Resistor_Values

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