Maximum Transistor Rating

- Limitations specified in the datasheet
- Maximum rating are given for: V_{CE}, I_C, P_D, …

Example:

Power Dissipation maximum ratings

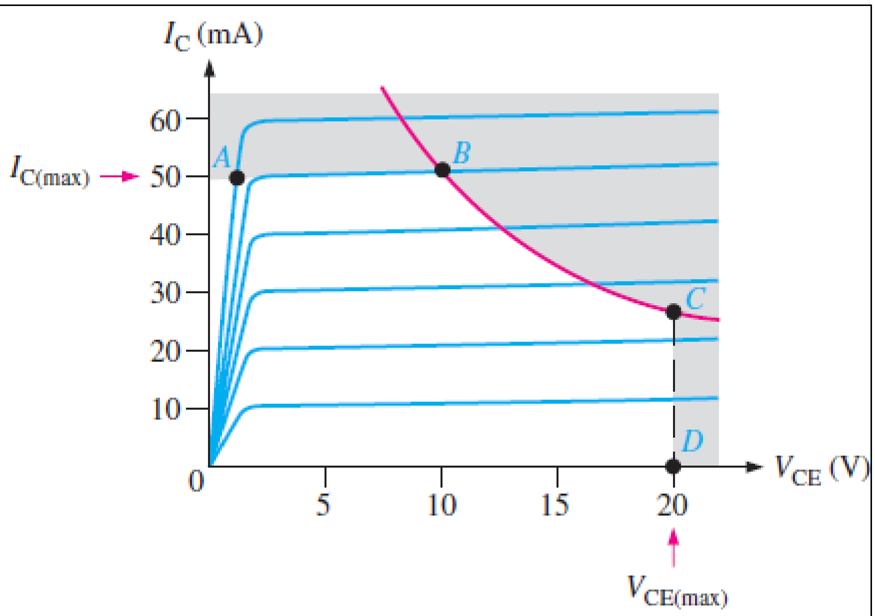
$$P_{D\,(max)} = I_C \times V_{CE}$$

- For a given transistor, assume

$$P_{D(max)} = 500\text{ mW}$$
$$V_{CE(max)} = 20\text{ V}$$
$$I_{C(max)} = 50\text{ mA}.$$

- Let us take the following values:

$P_{D(max)}$	V_{CE}	I_C
500 mW	5 V	100 mA
500 mW	10 V	50 mA
500 mW	15 V	33 mA
500 mW	20 V	25 mA



- From these values, the maximum power dissipation curve can be plotted on the collector characteristic curves, as shown. (red)
- The curve shows that this particular transistor cannot be operated in the shaded portion of the graph.

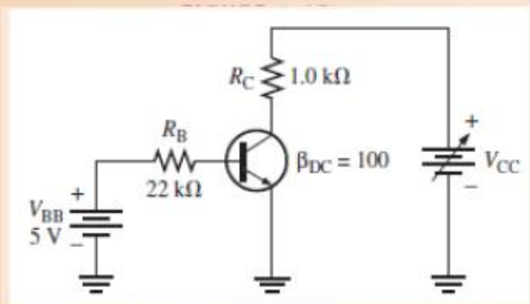
EXAMPLE 4–5 A certain transistor is to be operated with $V_{CE} = 6$ V. If its maximum power rating is 250 mW, what is the most collector current that it can handle?

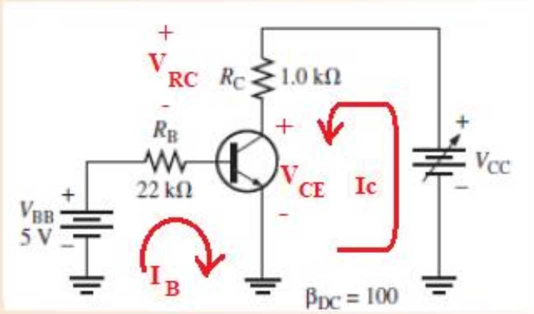
Solution

$$I_C = \frac{P_{D(max)}}{V_{CE}} = \frac{250\text{ mW}}{6\text{ V}} = \mathbf{41.7\text{ mA}}$$

This is the maximum current for this particular value of V_{CE}. The transistor can handle more collector current if V_{CE} is reduced, as long as $P_{D(max)}$ and $I_{C(max)}$ are not exceeded.

EXAMPLE 4–6 The transistor in Figure 4–19 has the following maximum ratings: $P_{D(max)} = 800$ mW, $V_{CE(max)} = 15$ V, and $I_{C(max)} = 100$ mA. Determine the maximum value to which V_{CC} can be adjusted without exceeding a rating. Which rating would be exceeded first?





Solution First, find I_B so that you can determine I_C.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5\text{ V} - 0.7\text{ V}}{22\text{ k}\Omega} = 195\ \mu\text{A}$$

$$I_C = \beta_{DC} I_B = (100)(195\ \mu\text{A}) = 19.5\text{ mA}$$

I_C is much less than $I_{C(max)}$ and ideally will not change with V_{CC}. It is determined only by I_B and β_{DC}.

The voltage drop across R_C is

$$V_{R_C} = I_C R_C = (19.5\text{ mA})(1.0\text{ k}\Omega) = 19.5\text{ V}$$

So,

$$V_{CC(max)} = V_{CE(max)} + (V_{R_C} = 15\text{ V} + 19.5\text{ V} = \mathbf{34.5\text{ V}}$$

V_{CC} can be increased to 34.5 V, under the existing conditions, before $V_{CE(max)}$ is exceeded. However, at this point it is not known whether or not $P_{D(max)}$ has been exceeded.

$$P_D = V_{CE(max)} I_C = (15\text{ V})(19.5\text{ mA}) = 293\text{ mW}$$

Since $P_{D(max)}$ is 800 mW, it is *not* exceeded when $V_{CC} = 34.5$ V. So, $V_{CE(max)} = 15$ V is the limiting rating in this case. If the base current is removed causing the transistor to turn off, **$V_{CE(max)}$ will be exceeded first** because the entire supply voltage, V_{CC}, will be dropped across the transistor.

Derating $P_{D\ (max)}$

- **P_D(max)** is usually specified at **25°C**. For higher temperatures, P_D(max) is **less**.
- Datasheets often give **derating factors** for determining P_D(max) at any temperature above 25°C.

EXAMPLE 4–7 A certain transistor has a $P_{D(max)}$ of 1 W at 25°C. The derating factor is 5 mW/°C. What is the $P_{D(max)}$ at a temperature of 70°C?

Solution The change (reduction) in $P_{D(max)}$ is

$$\Delta P_{D(max)} = (5\text{ mW/°C})(70°\text{C} - 25°\text{C}) = (5\text{ mW/°C})(45°\text{C}) = 225\text{ mW}$$

Therefore, the $P_{D(max)}$ at 70°C is

$$1\text{ W} - 225\text{ mW} = \mathbf{775\text{ mW}}$$

Note: an example of a BJT Datasheet is given in Page 189.