Example 5.3 Calculate the saturation voltage of a bipolar transistor biased with a base current of 1 mA and a collector current of 10 mA. Use $\alpha_R$ = 0.993 and $\alpha_F$ = 0.2.

Solution The saturation voltage equals:

$$V_{CE,sat} = V_t \ln\left\{\frac{1+\frac{I_C}{I_B}(1-\alpha_R)}{\alpha_R\left[1-\frac{I_C}{I_B}\frac{(1-\alpha_F)}{\alpha_F}\right]}\right\} = 0.1\,\text{V}$$