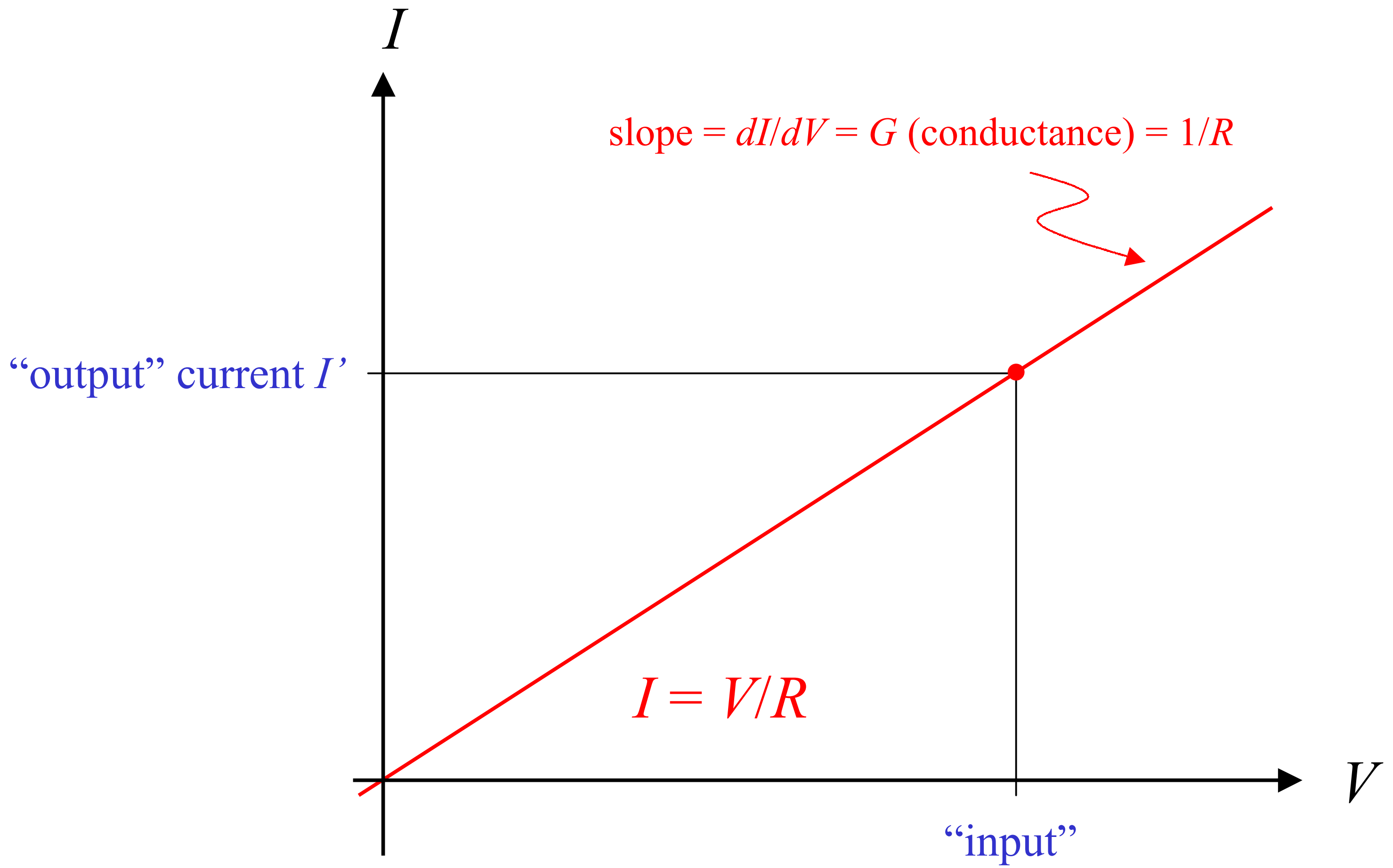
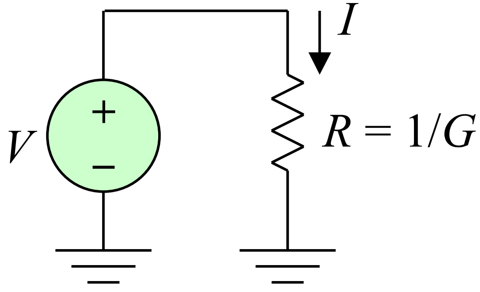
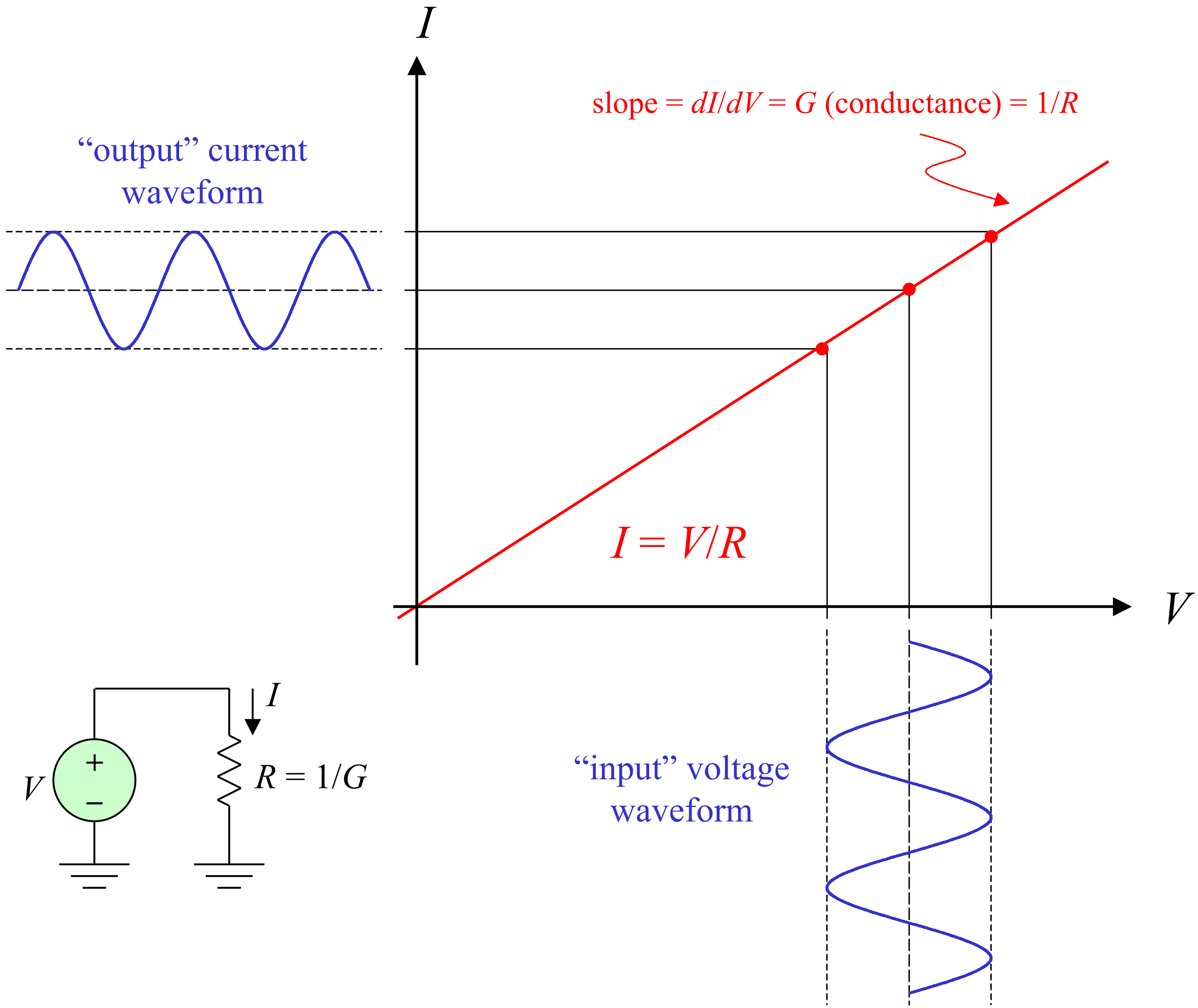
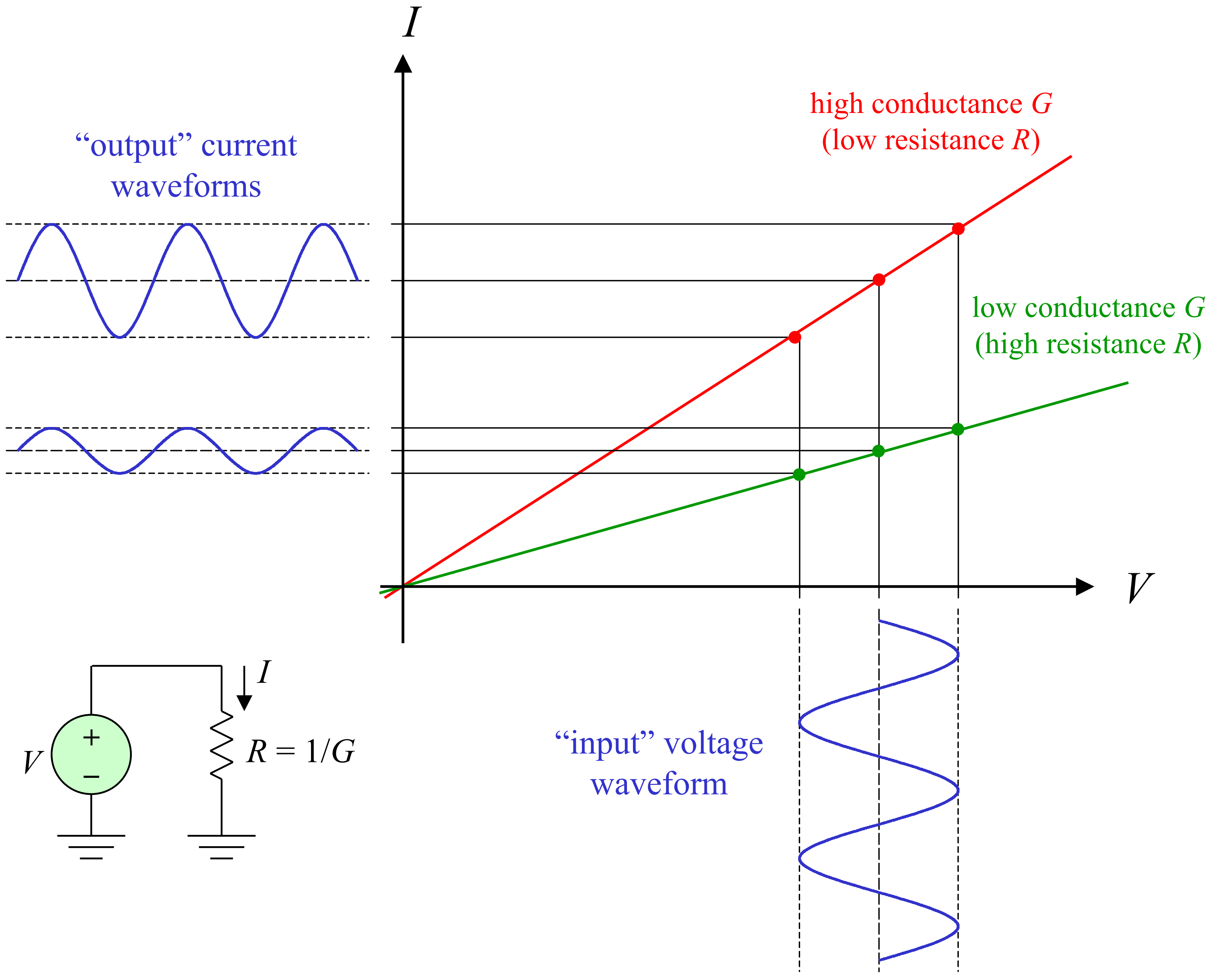
Small-Signal Concepts

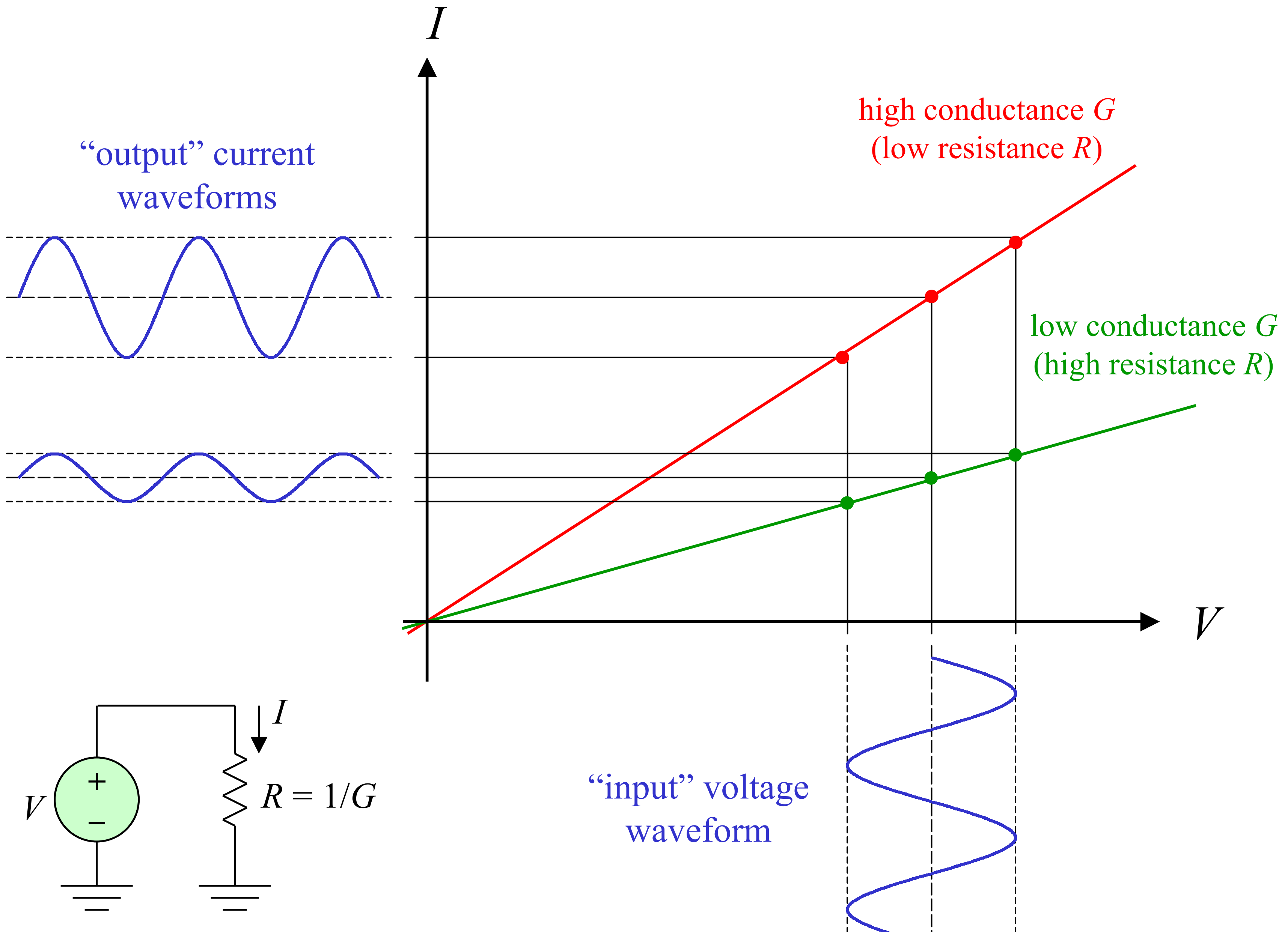
ECE 3110


I
slope = dI/dV = G (conductance) = 1/R
"output" current I'
I = V/R
V
"input"
voltage V'

I
V
+
–
R = 1/G

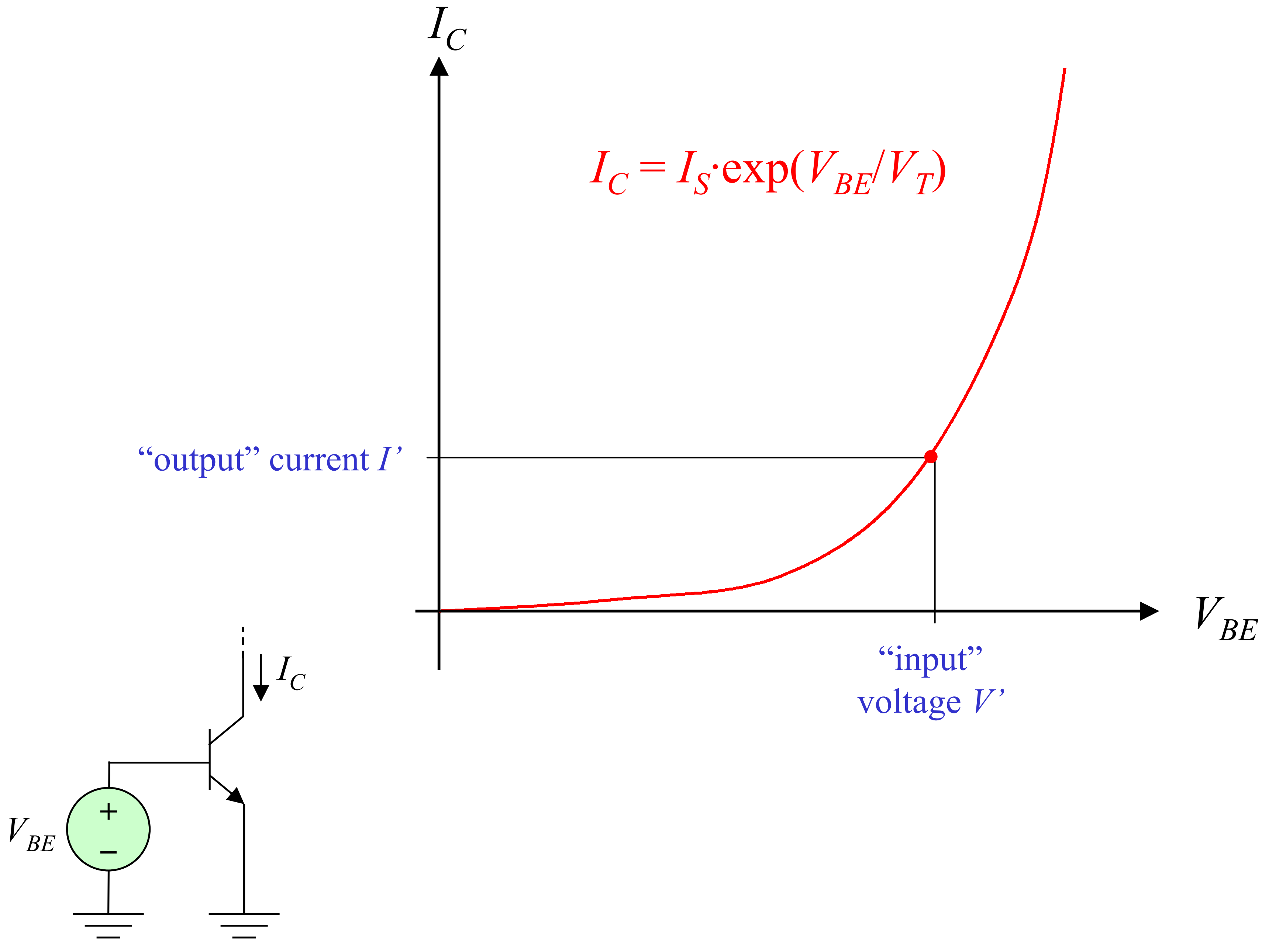


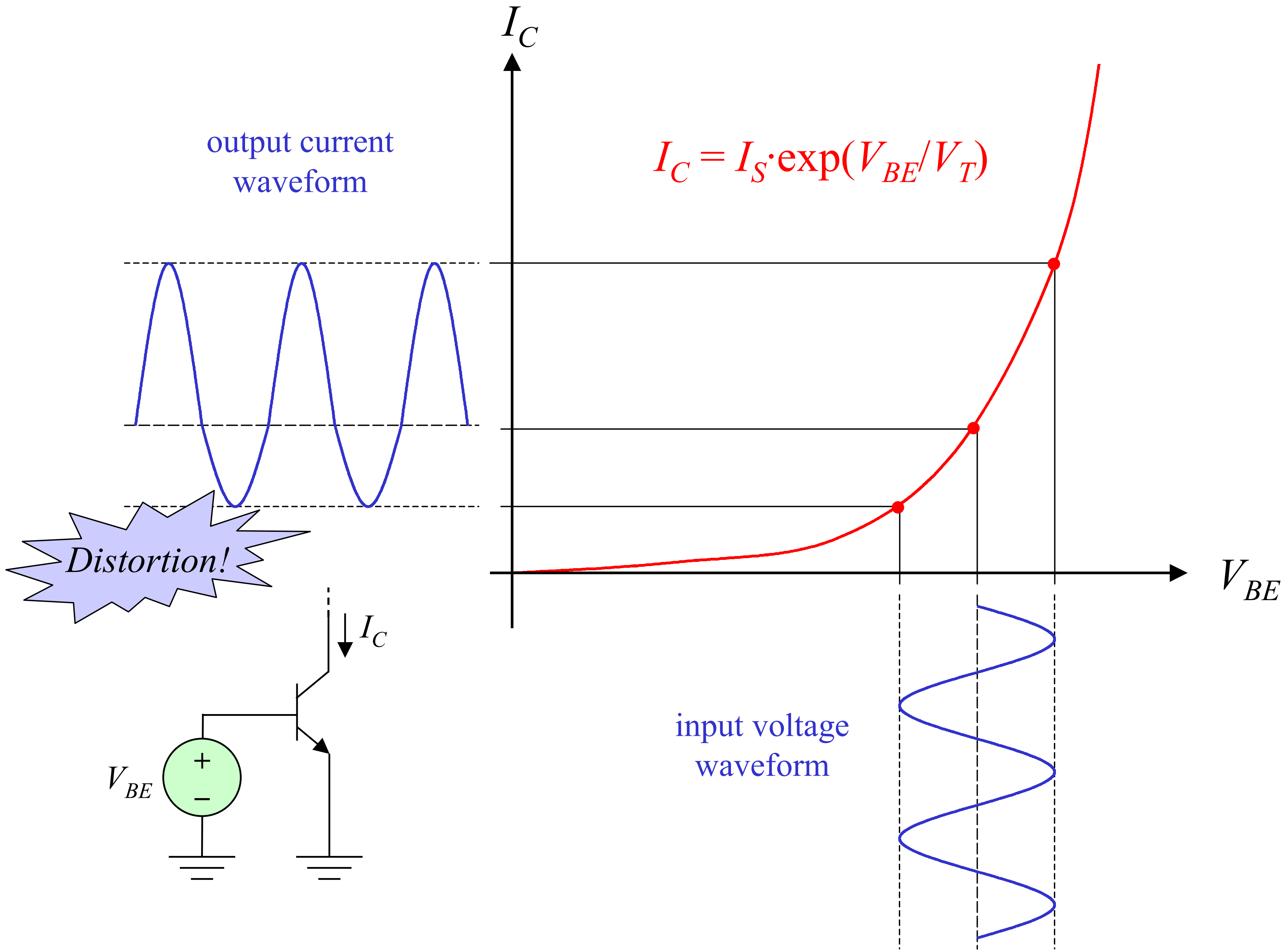
I
slope = dI/dV = G (conductance) = 1/R
“output” current
waveform
I = V/R
V
I
V
+
–
R = 1/G
“input” voltage
waveform


I
high conductance G
(low resistance R)
"output" current
waveforms
low conductance G
(high resistance R)
V
I
V
+
−
R = 1/G
"input" voltage
waveform

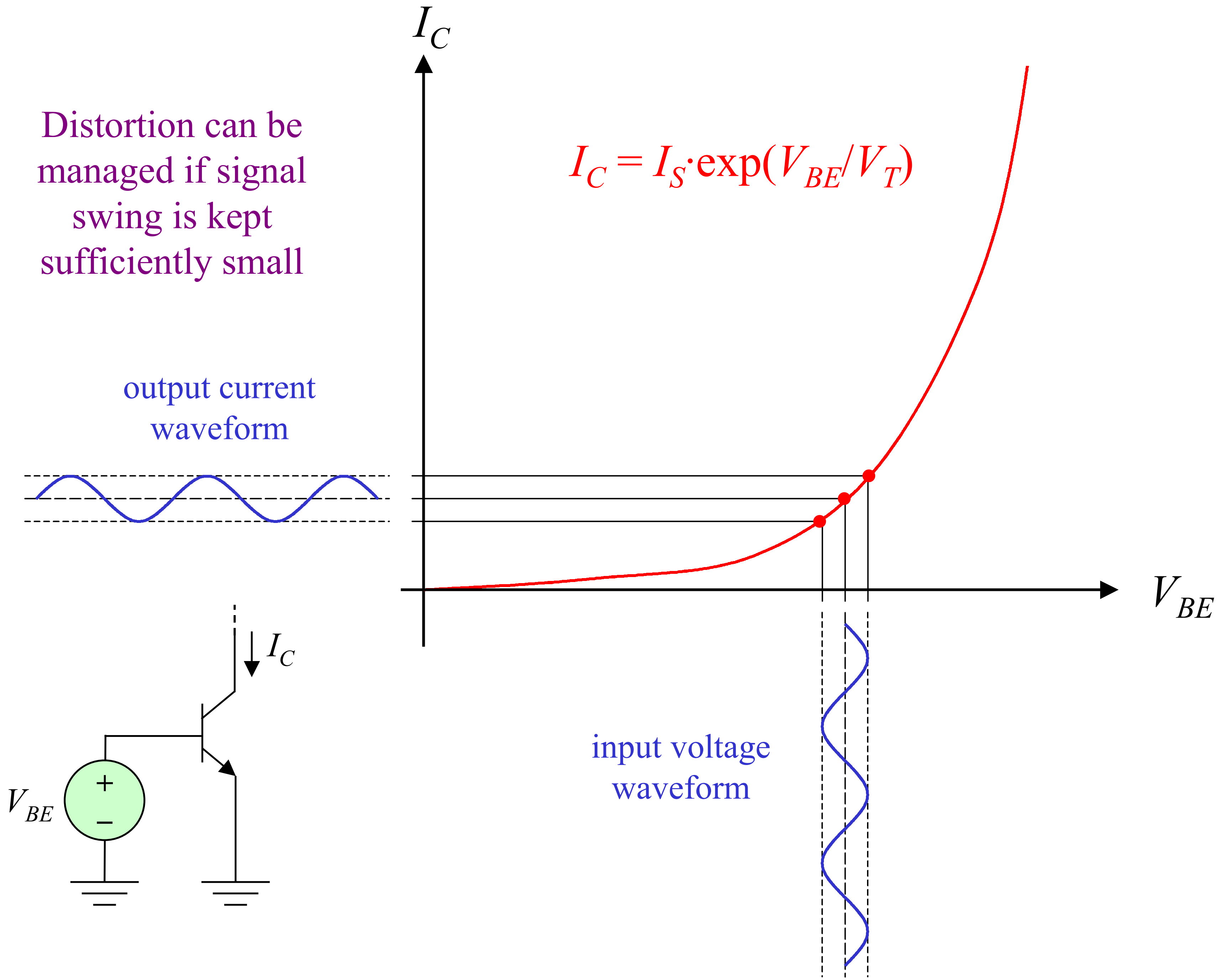


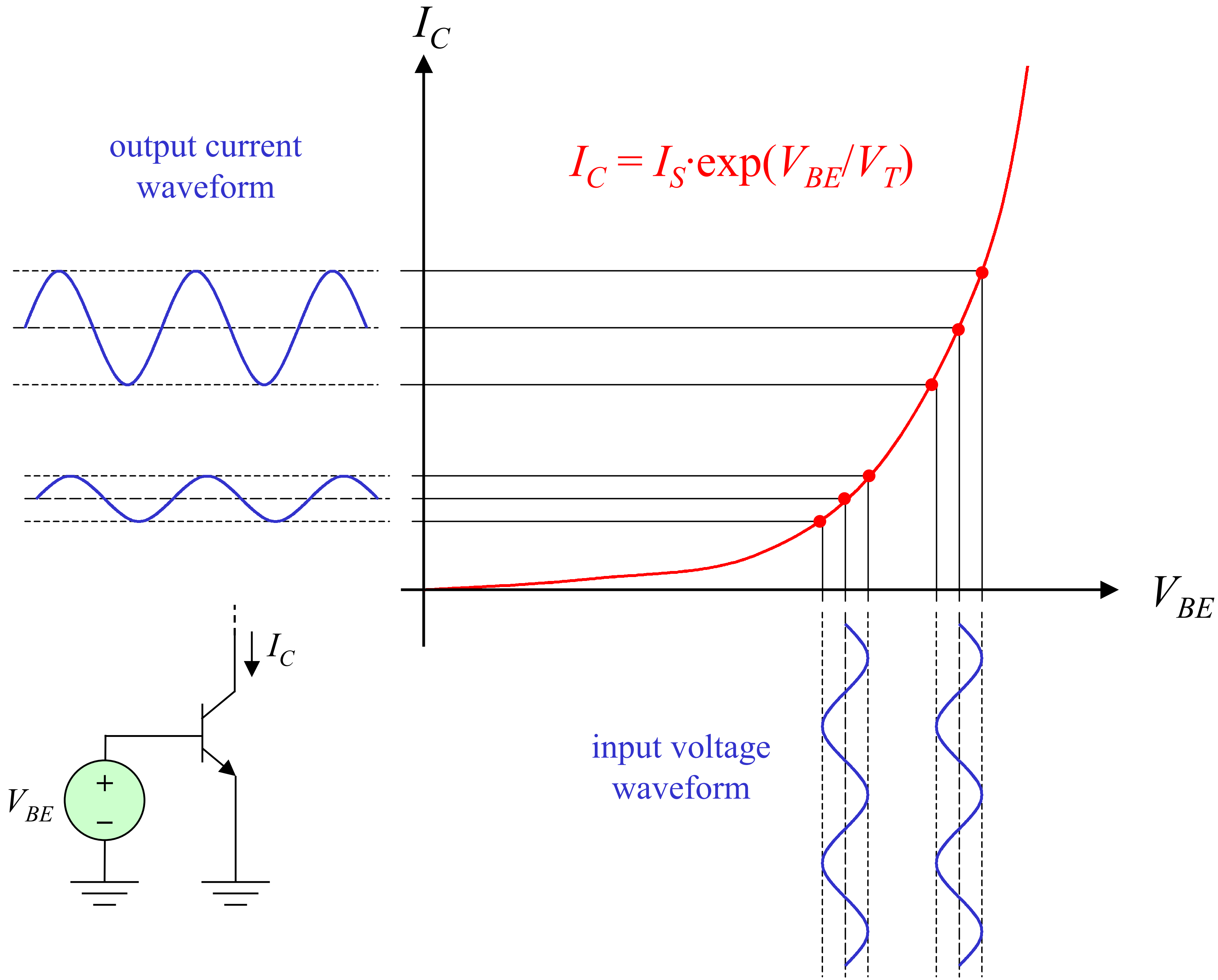
What if we replace the linear resistor with a nonlinear device like a transistor?


I_C
$I_C = I_S \cdot \exp(V_{BE}/V_T)$
“output” current I'
V_{BE}
“input”
voltage V'
I_C
V_{BE}
+
−

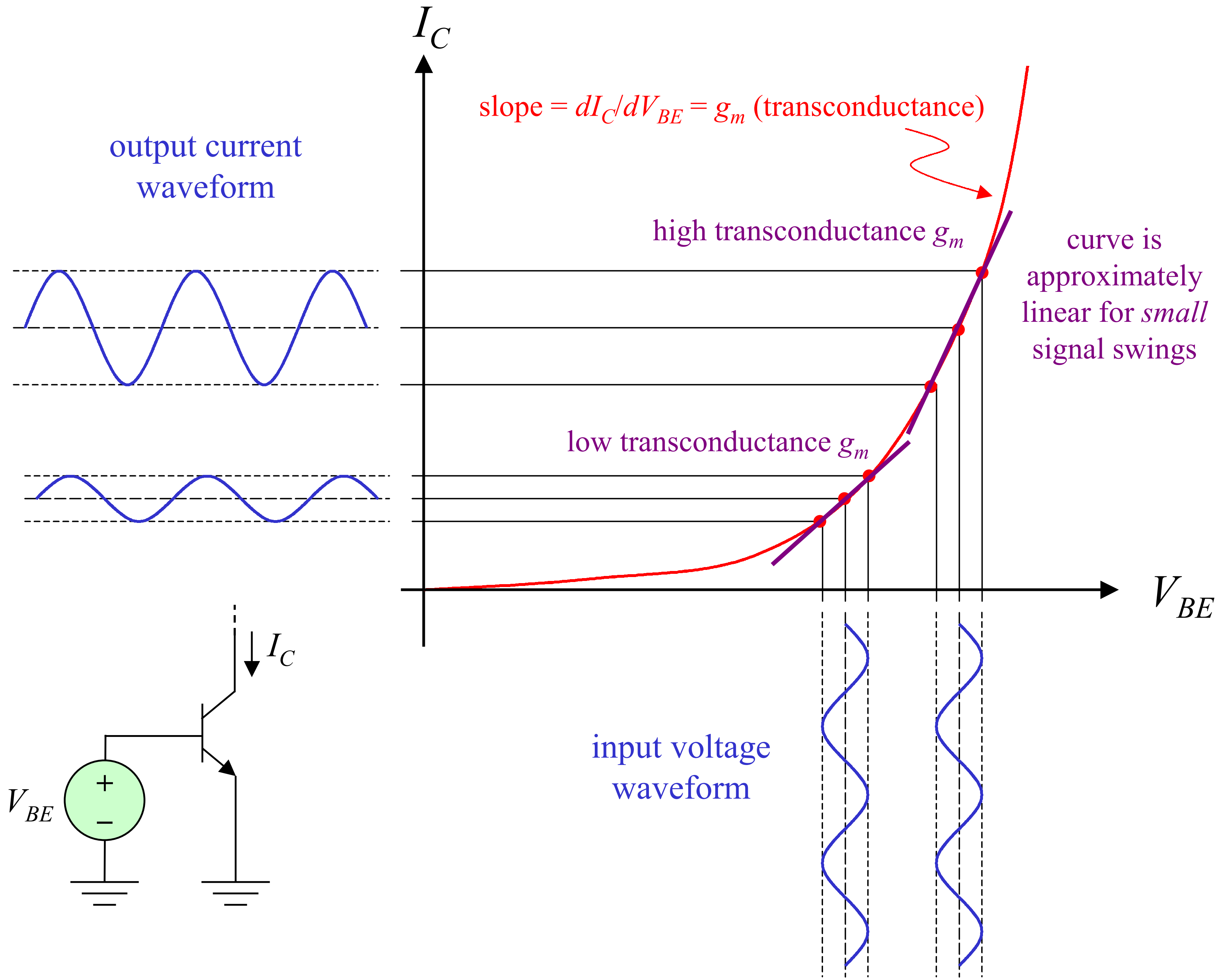


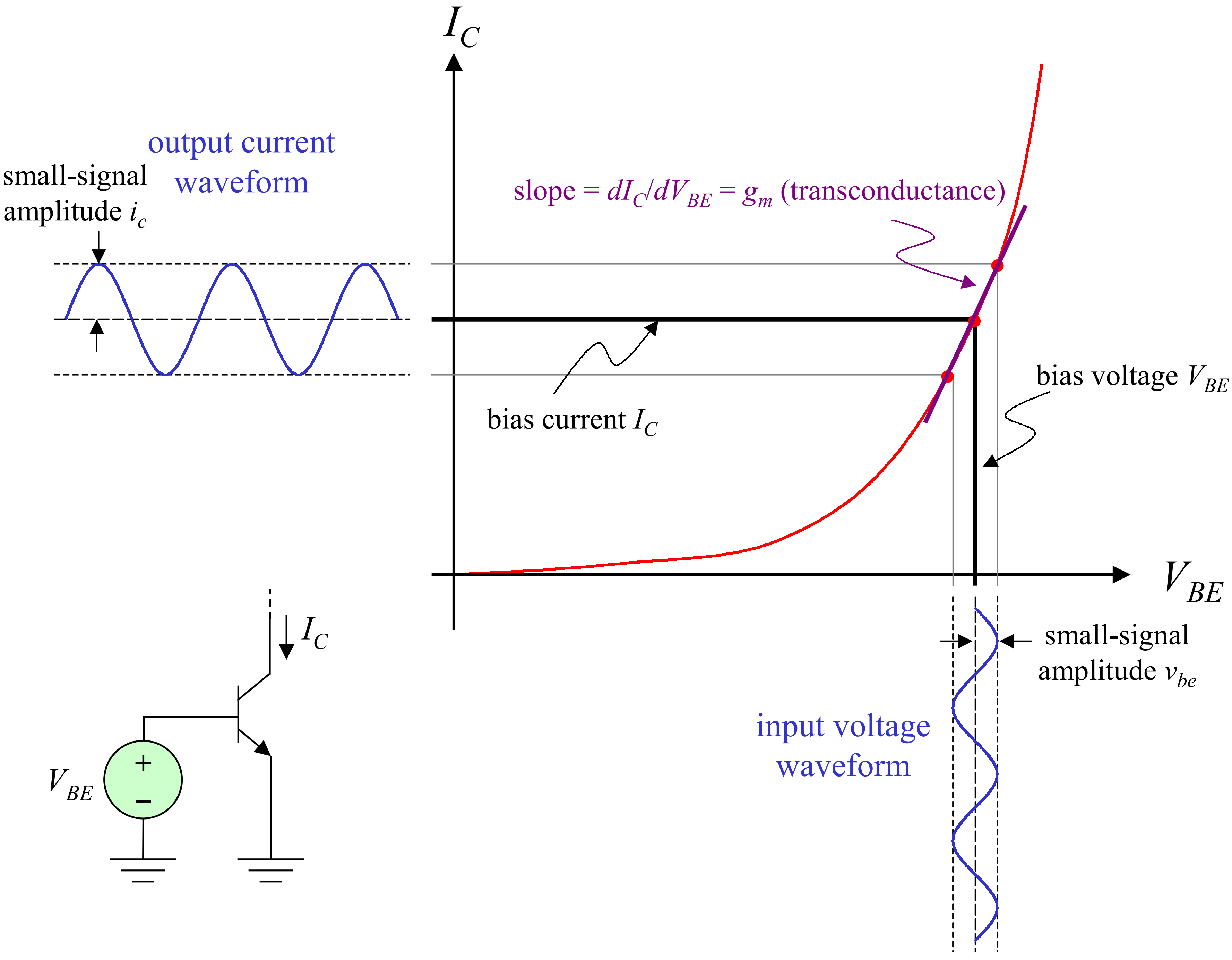
I_C
output current
waveform
$I_C = I_S \cdot \exp(V_{BE}/V_T)$
Distortion!
V_{BE}
I_C
V_{BE}
+
–
input voltage
waveform


Distortion can be managed if signal swing is kept sufficiently small
I_C
$I_C = I_S \cdot \exp(V_{BE}/V_T)$
output current waveform
V_{BE}
I_C
V_{BE}
+
–
input voltage waveform

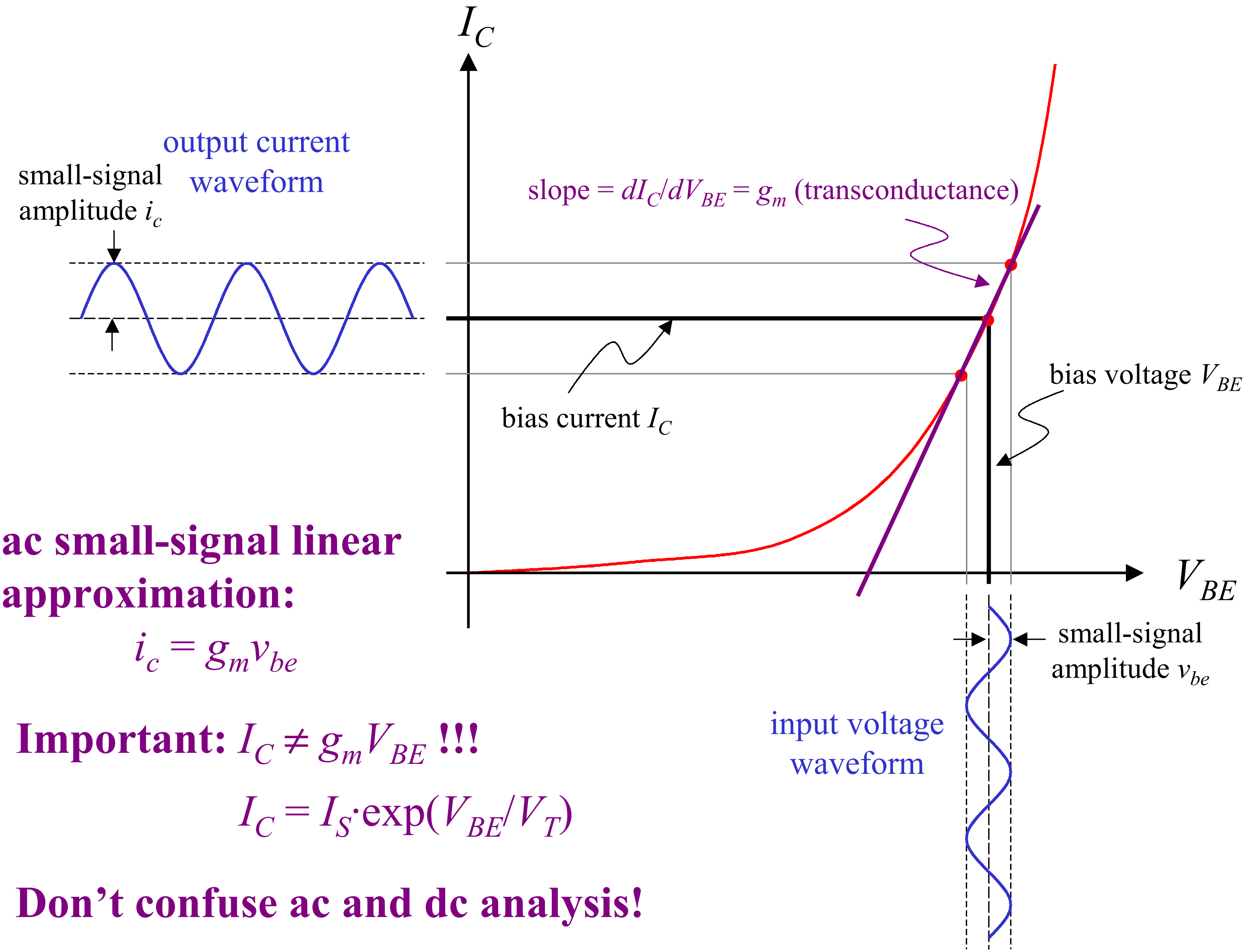


I_C
output current
waveform
$I_C = I_S \cdot \exp(V_{BE}/V_T)$
V_{BE}
I_C
V_{BE}
+
−
input voltage
waveform


I_C
slope = $dI_C/dV_{BE} = g_m$ (transconductance)
output current waveform
high transconductance g_m
curve is approximately linear for *small* signal swings
low transconductance g_m
V_{BE}
I_C
+
–
V_{BE}
input voltage waveform



I_C
output current
waveform
small-signal
amplitude i_c
slope = $dI_C/dV_{BE} = g_m$ (transconductance)
bias voltage V_{BE}
bias current I_C
V_{BE}
I_C
V_{BE}
+
–
small-signal
amplitude v_{be}
input voltage
waveform



ac small-signal linear approximation:

$$i_c = g_m v_{be}$$

Important: $I_C \neq g_m V_{BE}$ **!!!**

$$I_C = I_S \cdot \exp(V_{BE}/V_T)$$

Don't confuse ac and dc analysis!