Application to non-linear loads

Thevenin

\[ i = \frac{V_T - V}{R_T} \]

\[ i' = -\frac{1}{R_T} V + \frac{V_T}{R_T} \]

\[ V = 0 \]

\[ i = \frac{V_T}{R_T} \]

\[ i_c = \frac{V_T}{R_T} \]

\[ V_c = V_T \]

\[ V = 0 \]

\[ i = 0 \]

\[ V_c = V_T \]

\[ i = -\frac{1}{R_T} V + \frac{V_T}{R_T} \]

set of all possible outputs.

called a load line but really is a source line

Q-point (operating point)

Example 3-18

\[ V_T = V_c = \frac{100}{100 + 100} \cdot 5 = 2.5V \]

\[ R_T = 100 \parallel 100 = 50 \]

\[ i_N = i_c = \frac{V_T}{R_T} = \frac{2.5}{50} \]

\[ = 50 \text{mA} \]

If you know the diode will operate at 1.7 volts:

\[ P_D = V_i = (1.7)(0.018) = 30.6 \text{mW} \]
3.5 Maximum signal transfer

Consider the power being delivered to the load.

At the interface

\[ V = \frac{R_L}{R_L + R_T} V_T \]

\[ I = \frac{V_T}{R_L + R_T} \]

\[ P = V I = \frac{R_L V_T}{R_L + R_T} \cdot \frac{V_T}{R_L + R_T} = \frac{R_L V_T^2}{(R_L + R_T)^2} \]

When do we get maximum power to the load, i.e., the value of \( R_L \)

\[ \frac{\partial P}{\partial R_L} = \frac{V_T^2}{(R_L + R_T)^2} + \frac{R_L V_T^2 (-2)}{(R_L + R_T)^3} = 0. \]

\[ \frac{(R_L + R_T) - 2R_L \cdot V_T^2}{(R_L + R_T)^3} = 0 \]

\[ R_L + R_T - 2R_L = 0 \]

\[ R_T - R_L = 0 \]
Example 3-19

Given measurements find max output.

\[
\begin{align*}
4 &= \frac{5V}{50 + R_T} \\
200 + 4R_T &= 50V_T \\
\frac{200 + 4R_T}{50} &= \frac{375 + 5R_T}{75} \\
(200)(75) + (75)(4)R_T &= (375)(50) + (50)(5R_T) \\
(75)(4)R_T - (50)(5)R_T &= (375)(50) - (200)(75) \\
300R_T - 250R_T &= 18750 - 15000 \\
50R_T &= 3750 \\
R_T &= 75 \Omega \\
4 &= \frac{50}{50 + 75} \\
\frac{(125)(4)}{50} &= V_T = 10.
\end{align*}
\]

Max voltage out = \( V_{\text{DC}} = 10 \text{ volts} \)

Max current out = \( I_{\text{DC}} = \frac{10V}{75\Omega} = 133 \text{ mA} \)

Max power out occurs at \( R_L = 75\Omega \),

@ \( R_L = 75\Omega \)

\[
\begin{align*}
V_{\text{OUT}} &= \frac{75}{75 + 75} \times 10 = 5 \text{ volts} \\
P_{\text{OUT}} &= \frac{(V_{\text{OUT}})^2}{R_L} = \frac{(5)^2}{75} = \frac{25}{75} = 333 \text{ mW}.
\end{align*}
\]
At this point resistors are the only elements we can use to design interface circuits.

Examples of interface circuits.
These are often called two-port circuits.
Design Example 3-23

Design the two-port interface circuit so the load "sees" a Thévenin resistance of 50Ω between terminals (C) and (D), while simultaneously the source "sees" a load resistance of 300Ω between (A) and (B).

**Design**: We can try different interface circuits.

**Series**

\[ R_T = 300\Omega \quad \text{OK} \]

\[ R_T = 550 \gg 50 \quad \text{NOT OK} \]

**Parallel**

\[ R_T \ll 50 \quad \text{NOT OK} \]

\[ R_T = 60 \parallel 300 = 50 \quad \text{OK} \]

**Try two resistor circuits**

Want source to see larger resistance than 50Ω so this requires a series R.

**Design**

\[ R_1 + \frac{50 R_2}{R_2 + 50} = 300 \]

Non-linear equations with solutions \( R_1 = 273.9 \) and \( R_2 = 54.8 \)Ω.