Day 4

Impedance
Homework

56
Chapter 1. Resistors

The resistance to ground in this circuit is given by taking resistors $R$ and $R + R_e$ in parallel, with the result in series with a resistor $R$. Equating these two results, we have

$$R + R_e = R + R(R + R_e)^2.$$  \hspace{1cm} (1.123)

Simplifying this and defining $R = R_e/R$, we can write this equation as

$$R^2 + R = 0.$$  \hspace{1cm} (1.124)

This equation has one positive root, namely

$$R = 5 + \frac{1}{2},$$  \hspace{1cm} (1.125)

which is called the inverse golden mean. Thus,

$$R_e = 5 + \frac{1}{2} R,$$  \hspace{1cm} (1.126)

or the total resistance to ground from the point $V$ is given by the golden mean times $R$, or

$$R + R_e = 5 + \frac{1}{2} R,$$  \hspace{1cm} (1.127)

Problem 1.12

Consider the circuit below, with 3 cascaded voltage dividers (not all the same).

(a) Compute $V_{out}$.

(b) Compute the current in each one of the resistors in the circuit, assuming no load connected to $V_{out}$.

Solution 1.12

(a) Replacing the first divider by the Thévenin equivalent, we obtain the following equivalent circuit:

7. Find the Thévenin equivalent of the circuit shown below. Note that the arrow indicates a current source, which is just a device that provides the constant current indicated. [Ex. 1.38, H&H]
Question 1

Find the amplitude of the transfer function for this circuit and find the high and low frequency limits.
Bode Plot

Log-Log plot of Amplitude vs. Frequency

This is a Low-pass filter

Because the integrator “passes” low frequencies without attenuation, and “rolls off” high frequencies, it is called a low-pass filter.

2.3.6 Example Problem: Alternate Scaling

What is the scaling of $-3 \text{ dB/octave}$, expressed in $\text{dB/decade}$?

Solution. This is still a scaling of $-3 \text{ dB}$. A decade is a factor of 10, which means a factor of 10 reduction in amplitude, or $20 \log_{10} (1/10) = -20 \text{ dB}$, so $-20 \text{ dB/decade}$.

2.3.7 Example Problem: High-Pass Filter

Consider the differentiator from Section 2.2.2.

In doing this problem you should see why this is also called a high-pass filter.

(a) Compute $\tilde{T}(\omega)$. (b) Compute $\tilde{T}(\epsilon)$. (c) Work out the low- and high-frequency asymptotics of $\tilde{T}(\omega)$. (d) Find $f_{3 \text{ dB}}$.

Solution. (a) Using the voltage-divider formula again,

$$\tilde{T}(\omega) = \frac{\tilde{V}_{\text{out}}}{\tilde{V}_{\text{in}}} = \frac{R}{R + \omega C} = \frac{1}{1 + \omega RC}.$$  

(2.48)
Question 2

Find the input and output impedance of this circuit
Inductors
Question

What would this do?

Use your *qualitative* understanding of impedance...
Ringing
Resistors

Size generally correlated to power capability
Colors specify nominal resistance
Resistor Fun

What resistance is this?
Resistor Fun

What resistance is this?

Green
5

Blue
6

Orange
3
Resistor Fun

What resistance is this?

Green 5
Blue 6
Orange 3

\[ R = 56 \times 10^3 = 56 \, \text{k}\Omega \]

(5% accuracy)
Resistor Fun

How about these?
Resistor Fun

How about these?

Yellow 4
Purple 7
Brown 1

\[ R = 47 \times 10^1 = 470 \ \Omega \]
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