PreLab 7: Transient Response of a 2nd Order Circuit

ECEN 214 - 517
TA: Saad Muaddi
Due Date: October 28, 2020

A. Design a Sallen-Key circuit as shown in Figure 7.1. Choose component values so that the circuit produces a critically damped response (Q = 1/2) and a resonant radian frequency of ωo = 2000π rad/sec (fo = 1kHz). Be sure to choose component values that are available to you in your lab kit. You will not be able to exactly achieve the design goals with the restrictions of the component values, but you should try to get as close as possible with what you have. Repeat your design for each of the following cases:

a. Q = 0.25 (slightly overdamped)

b. Q = 0.1 (overdamped)

c. Q = 1 (slightly underdamped)

d. Q = 2.5 (under damped).

$R_1, C_1 \qquad f_c = \frac{1}{2\pi\sqrt{R_1C_1R_2C_2}}$

$\frac{V_{out}(s)}{V_{in}(s)} = \frac{(2\pi f_c)^2}{s^2 + 2\zeta(2\pi f_c)s + (2\pi f_c)^2}$

$Q = \frac{1}{2\zeta} \qquad \frac{C_2}{a} \leq \zeta^2 \qquad \frac{C_1}{a} \geq 4Q^2$

$f_c = 1000 \qquad Q = 0.5$

$\frac{V_{out}}{V_{in}} = \frac{39062.500}{s^2 + 12500\,s + 39062500}$

$(2\pi f_c)^2 = \frac{1}{R_1C_1R_2C_2}$ ① $\rightarrow 2\zeta(2\pi f_c) = \frac{1}{R_2C_1} + \frac{1}{R_1C_1}$ ②

solve ① & ②

$R_1 = 16k\Omega$
$R_2 = 16k\Omega$
$C_1 = 0.01\mu F$
$C_2 = 0.01\mu F$
$f_c = 994.718Hz$

$\frac{V_{out}(s)}{V_{in}(s)} = \frac{1}{R_1R_2C_1C_2} \Big/ s^2 + s\left(\frac{1}{R_2C_1} + \frac{R}{C_1C_2}\right) + \frac{1}{R_1R_2C_2}$

a) $Q = 0.25$ - slightly overdamped

$R_1 = 13k\Omega$
$R_2 = 5.6k\Omega$
$C_1 = 0.01\mu F$
$C_2 = 0.033\mu F$
$f_c = 1026.827Hz$

$Q_s = \frac{41628041.62}{s^2 + 25549.455 + 41628041.62}$

b) $Q = 0.1$ - overdamped

$R_1 = 47k\Omega$
$R_2 = 24k\Omega$
$C_1 = 0.001\mu F$
$C_2 = 0.02\mu F$
$f_c = 1010.39Hz$

$Q_s = \frac{40296582}{s^2 + 82543.26 + 40296582}$

c) $Q = 1$ - slightly underdamped

$R_1 = 47k\Omega$
$R_2 = 24k\Omega$
$C_1 = 0.01\mu F$
$C_2 = 0.0022\mu F$

d) Q = 2.5 - underdamped

$R_1 = 13k\Omega$

$R_2 = 5.6k\Omega$

$C_1 = 0.1\mu F$

$C_2 = 0.0033\mu F$

Table of values

	R1	R2	C1	C2
0.25	13	5.6	0.01	0.033
0.1	47	24	0.001	0.02
1	47	24	0.01	0.0022
2.5	13	5.6	0.1	0.0033