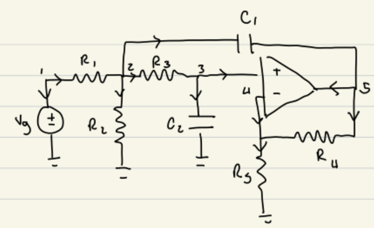


1. ① $i_{v_g} + i_{R_1} = 0$ $\quad i_{R_1} = v_1/R_1$ $\quad i_{vg} = ?$

② $-i_{R_1} + i_{R_2} + i_{R_3} + i_{c_1} = 0$ $\quad i_{R_2} = v_2/R_2$ $\quad i_{c_1} = (v_2 - v_5)\, j\omega C_1$

③ $-i_{R_3} + i_{c_2} = 0$ $\quad i_{R_3} = (v_2 - v_3)/R_3$ $\quad i_{c_2} = v_3\, j\omega C_2$

④ $-i_{R_4} + i_{R_5} = 0$ $\quad i_{R_4} = (v_5 - v_4)/R_4$ $\quad i_x = ?$

⑤ $-i_{c_1} + i_{R_4} + i_x = 0$ $\quad i_{R_5} = v_4/R_5$

① $v_1 = -v_g$

② $-v_1/R_1 + v_2/R_2 + v_2 - v_3/R_3 + (v_2 - v_5)\, j\omega C_1 = 0$

$v_1\left(-\frac{1}{R_1}\right) + v_2\left(\frac{1}{R_2} + \frac{1}{R_3} + j\omega C\right) + v_3\left(-\frac{1}{R_3}\right) + v_5(-j\omega C) = 0$

③ $v_3 - v_2/R_3 + v_3\, j\omega C_2 = 0$

$v_2\left(-\frac{1}{R_3}\right) + v_3\left(\frac{1}{R_3} + j\omega C\right) = 0$

④ $v_4 - v_5/R_4 + v_4/R_5 = 0$

$v_4\left(\frac{1}{R_4} + \frac{1}{R_5}\right) + v_5\left(-\frac{1}{R_4}\right) = 0$

⑤ $v_3 = v_4$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & -C_1 & 0 & 0 & C_1 \\ 0 & 0 & -C_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \dot v_1 \\ \dot v_2 \\ \dot v_3 \\ \dot v_4 \\ \dot v_5 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ -1/R_1 & 1/R_2 + 1/R_3 & -1/R_3 & 0 & 0 \\ 0 & -1/R_3 & 1/R_3 & 0 & 0 \\ 0 & 0 & 0 & 1/R_4 + 1/R_5 & -1/R_4 \\ 0 & 0 & 1 & -1 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix} + \begin{bmatrix} -v_g(t) \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

5. $\beta t_k = 0$

$t_1 = \frac{\pi}{\beta}$ $\quad$ p.o. $= e^{-\alpha\pi/\beta}$

$v_o(t) = 1 - e^{-\alpha t}\cos\beta t - \left(\frac{\alpha}{\beta}\right)e^{-\alpha t}\sin\beta t$

$v_o'(t) = -e^{-\alpha t}(-\sin\beta t)\beta + \cos\beta t(\alpha e^{-\alpha t}) - \left(\frac{\alpha}{\beta}\right)\left[e^{-\alpha t}(\cos\beta t)\beta + \sin\beta t(-\alpha e^{-\alpha t})\right]$

$0 = \beta e^{-\alpha t}\sin\beta t + \alpha e^{-\alpha t}\cos\beta t - \alpha e^{-\alpha t}\cos\beta t + \frac{\alpha^2}{\beta}e^{-\alpha t}\sin\beta t$

$0 = \beta e^{-\alpha t}\sin\beta t + \frac{\alpha^2}{\beta}e^{-\alpha t}\sin\beta t$

$0 = \sin\beta t_1$

$t_1 = \frac{\pi}{\beta}$

p.o. $= v_o(t_1) - 1 = v_o\left(\frac{\pi}{\beta}\right) - 1 = e^{-\alpha\pi/\beta}$

p.o. $= 1 - e^{-\alpha(\pi/\beta)}\cos\pi - \cancel{\frac{\alpha}{\beta}e^{-\alpha(\pi/\beta)}\sin\pi}_{\,0} - 1$

p.o. $= -e^{-\alpha\pi/\beta}(-1)$

p.o. $= e^{-\alpha\pi/\beta}$

6. $R_1 = R_2 = R_4 = R_5 = 1\,k\Omega$ $\quad \alpha = \frac{a}{2} = 10K$

$1\,k\Omega = \frac{2}{a}10^7$ $\quad \beta = \sqrt{b - \left(\frac{a}{2}\right)^2}$ $\quad \beta^2 = b - \left(\frac{a}{2}\right)^2$

$\beta^2 = b - \alpha^2$

$a = 20K$ $\quad b = \beta^2 + \alpha^2$

$R_3 = \frac{2\alpha}{\beta^2 + \alpha^2}10^7$ $\quad$ p.o. $= e^{-\alpha\pi/\beta}$

$0.09 = e^{-10000\pi/\beta}$ $\quad R_3 = \frac{20000}{13000^2 + 10000^2}10^7$

$C_1 = C_2 = 0.1\,\mu F$ $\quad -2.41 = \frac{-10000\pi}{\beta}$

$R_3 = \frac{a}{b}10^7$ $\quad \beta = 13035.65$ $\quad R_3 = 740.938\,\Omega$

4. $H(s) = \dfrac{V_o(s)}{V_g(s)} = \dfrac{b}{s^2 + as + b}$

$v_o(t) = 1 - e^{-\alpha} \cos \beta t - \left(\dfrac{\alpha}{\beta}\right) e^{-\alpha t} \sin \beta t$

$\alpha = \dfrac{a}{2}$ $\quad \beta = \sqrt{b - \left(\frac{a}{2}\right)^2} \quad \to \quad \beta^2 = b - \left(\frac{a}{2}\right)^2$

$a = 2\alpha$ $\quad \beta^2 = b - \dfrac{4\alpha^2}{4} \quad \to \quad b = \alpha^2 + \beta^2$

$R_4 = R_5 = 1\,k\Omega$ $\quad C_1 = C_2 = 0.1\,nF$

$R_1 = R_2 = \dfrac{2}{a} 10^7$

$R_3 = \dfrac{a}{b} 10^7$

$H(s) \cdot V_g(s) = V_o(s)$ $\quad V_o(s) = \dfrac{1}{s}\left[\dfrac{b}{s^2 + as + b}\right]$

$V_g(s) = \dfrac{1}{s}$ $\quad V_o(s) = \dfrac{\alpha^2 + \beta^2}{s\left[s^2 + 2\alpha s + \alpha^2 + \beta^2\right]} = \dfrac{\alpha^2 + \beta^2}{s\left[(s+\alpha)^2 + \beta^2\right]}$

$= \dfrac{A}{s} + \dfrac{Bs + C}{(s+\alpha)^2 + \beta^2}$

$A: \dfrac{\alpha^2 + \beta^2}{\alpha^2 + \beta^2} = 1$

$Bs^2 + Cs + s^2 + 2\alpha s + \alpha^2 + \beta^2 = \alpha^2 + \beta^2$

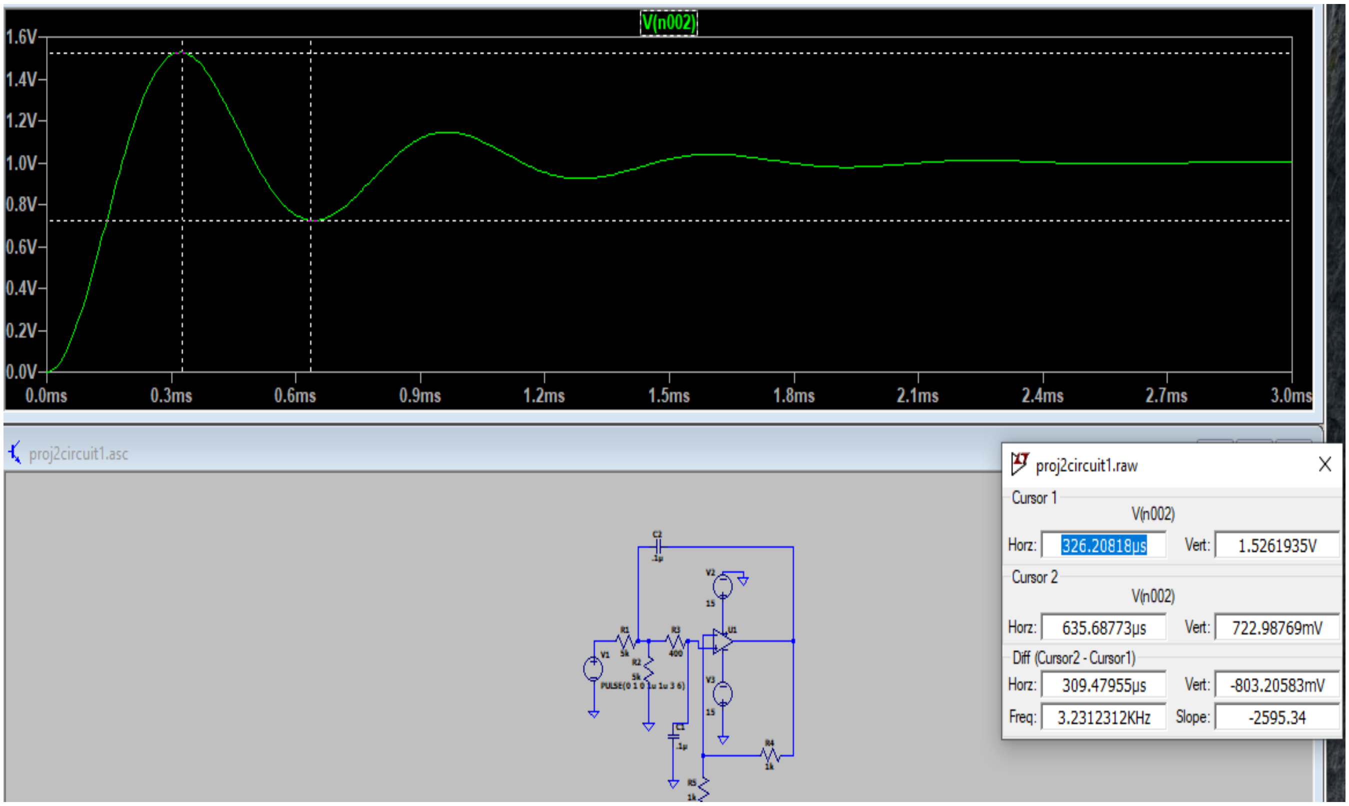
$s^2(B+1) = 0$ $\quad s(C + 2\alpha) = 0$

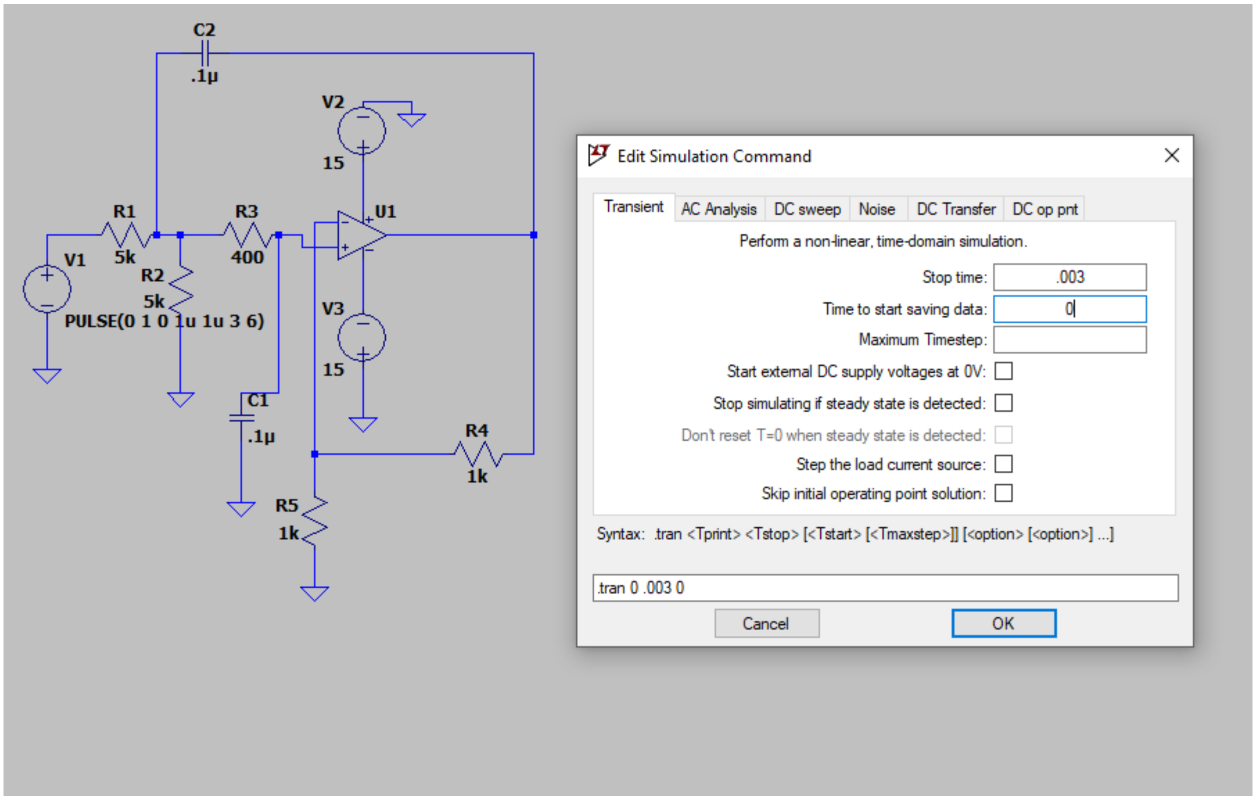
$B = -1$ $\quad C = -2\alpha$

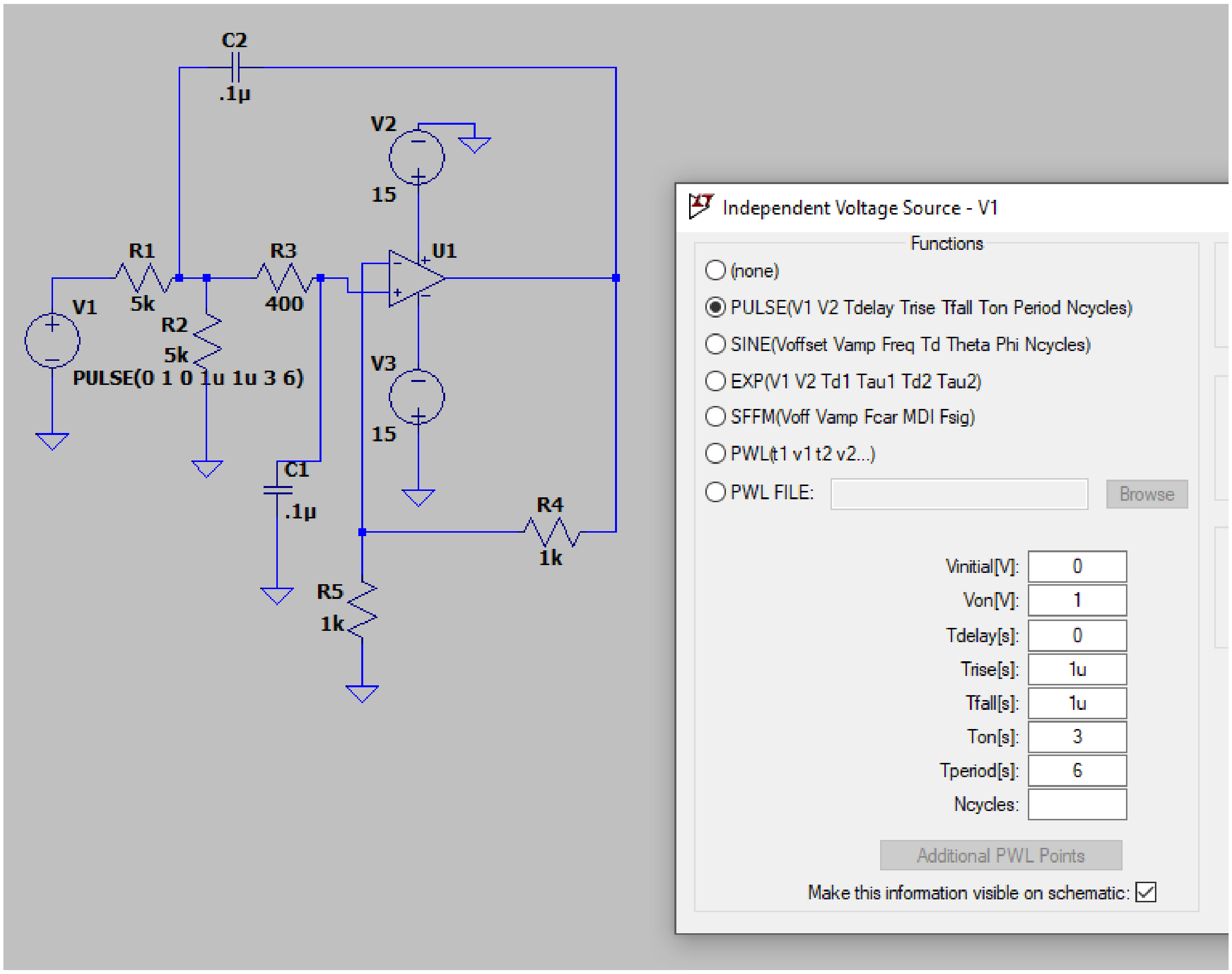
$= \dfrac{1}{s} - \dfrac{(s + 2\alpha)}{(s+\alpha)^2 + \beta^2} = \dfrac{1}{s} - \dfrac{(s+\alpha) + \alpha}{(s+\alpha)^2 + \beta^2} = \dfrac{1}{s} - \dfrac{(s+\alpha)}{(s+\alpha)^2 + \beta^2} + \dfrac{\alpha}{(s+\alpha)^2 + \beta^2}$

$= 1 - e^{-\alpha t} \cos \beta t - \left(\dfrac{\alpha}{\beta}\right) e^{-\alpha t} \sin \beta t$

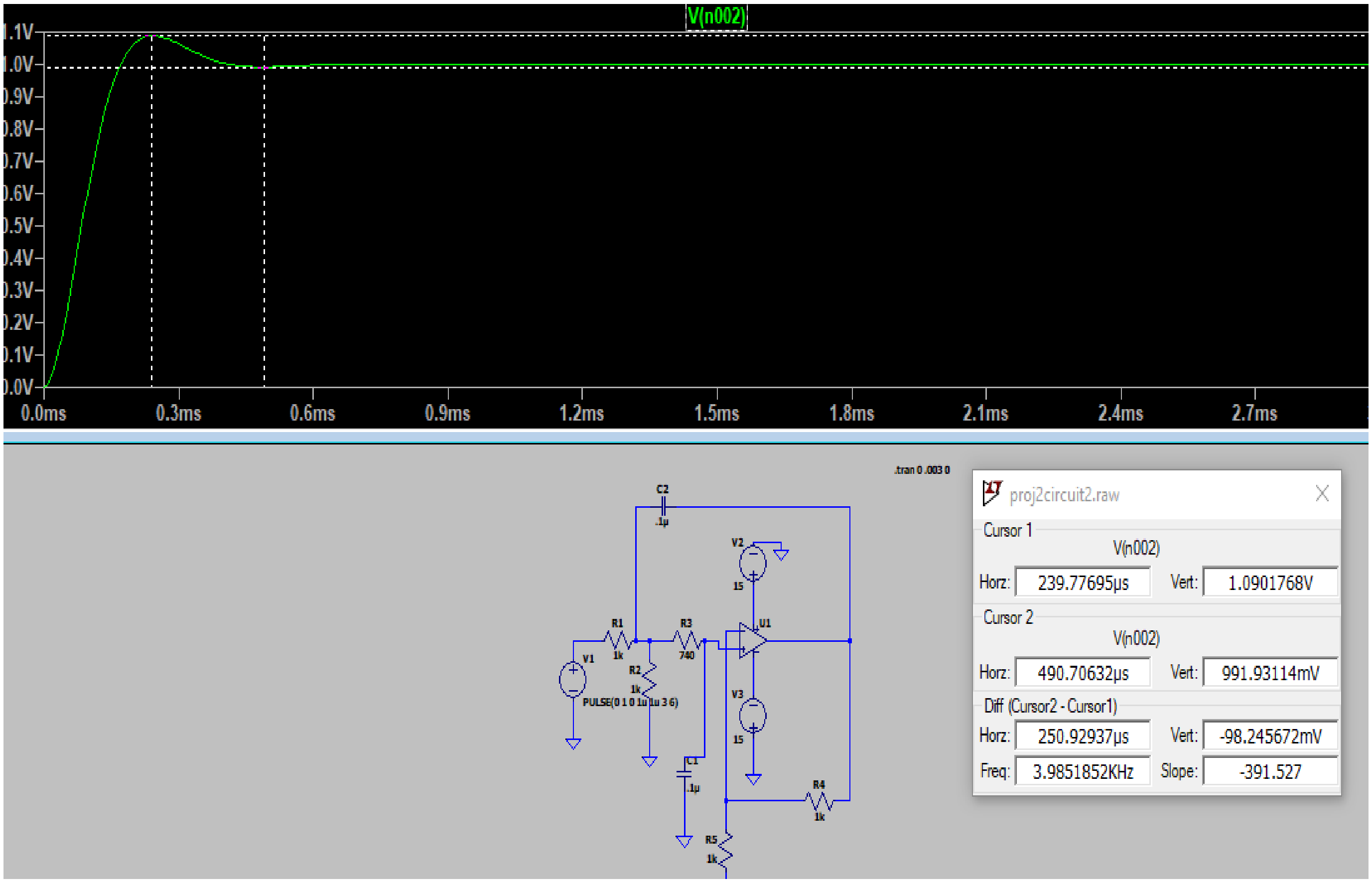
Circuit 1:

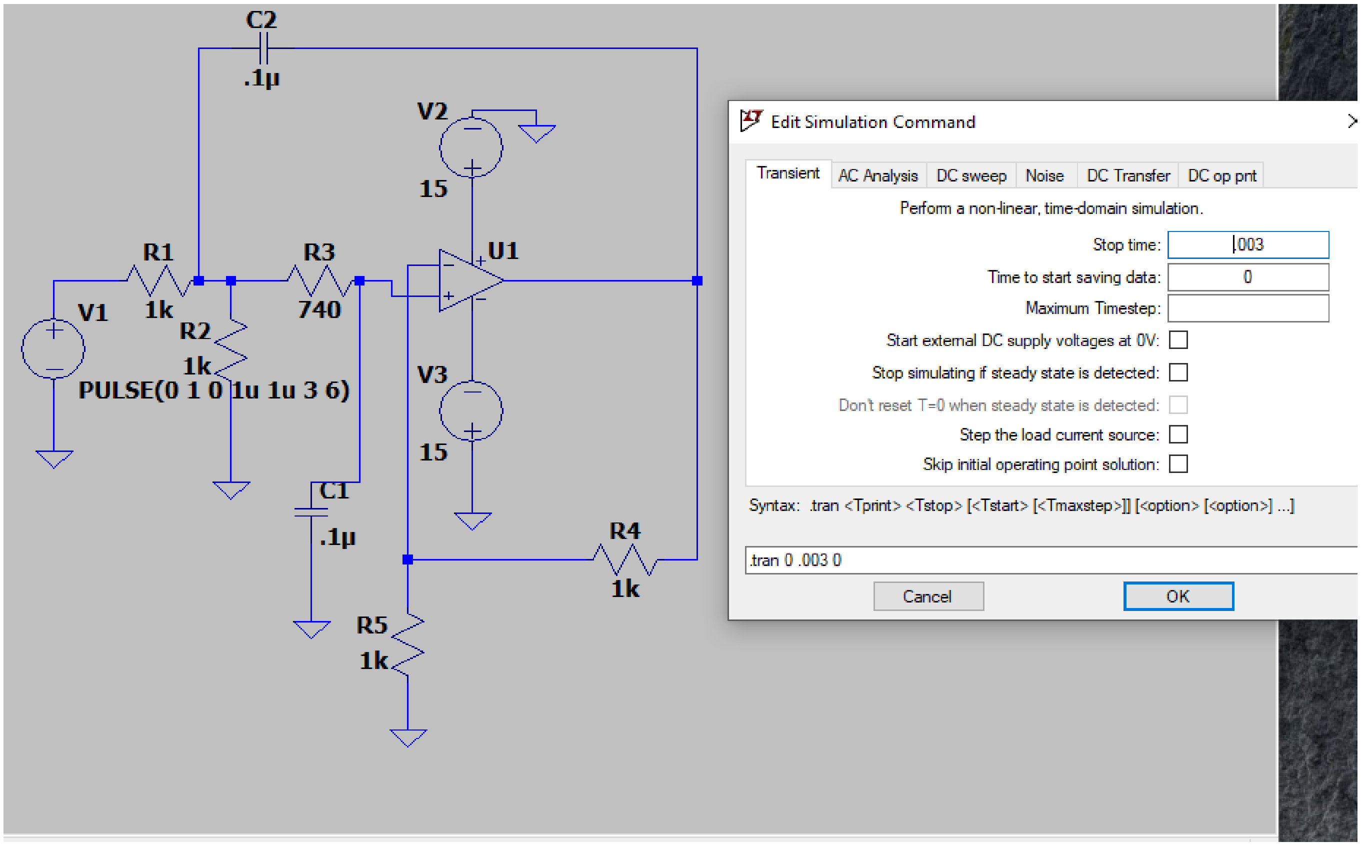

V(n002)
1.6V
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
0.0ms
0.3ms
0.6ms
0.9ms
1.2ms
1.5ms
1.8ms
2.1ms
2.4ms
2.7ms
3.0ms
proj2circuit1.asc
proj2circuit1.raw
Cursor 1
V(n002)
Horz: 326.20818µs
Vert: 1.5261935V
Cursor 2
V(n002)
Horz: 635.68773µs
Vert: 722.98769mV
Diff (Cursor2 - Cursor1)
Horz: 309.47955µs
Vert: -803.20583mV
Freq: 3.2312312KHz
Slope: -2595.34

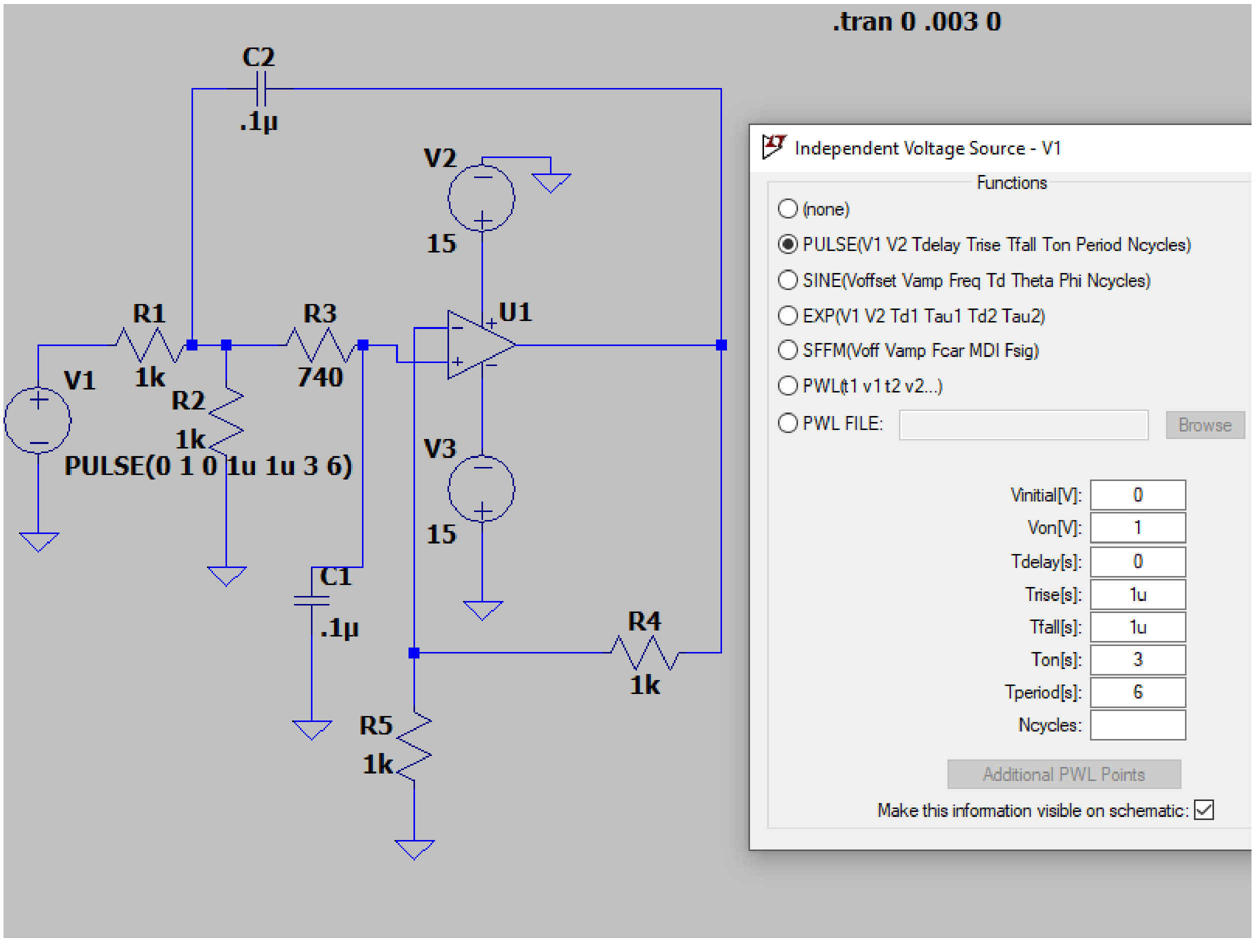

C2
.1μ
V2
15
R1
R3
U1
V1
5k
400
R2
5k
PULSE(0 1 0 1u 1u 3 6)
V3
15
C1
.1μ
R4
1k
R5
1k
Edit Simulation Command
Transient
AC Analysis
DC sweep
Noise
DC Transfer
DC op pnt
Perform a non-linear, time-domain simulation.
Stop time: .003
Time to start saving data: 0
Maximum Timestep:
Start external DC supply voltages at 0V:
Stop simulating if steady state is detected:
Don't reset T=0 when steady state is detected:
Step the load current source:
Skip initial operating point solution:
Syntax: .tran <Tprint> <Tstop> [<Tstart> [<Tmaxstep>]] [<option> [<option>] ...]
.tran 0 .003 0
Cancel
OK


C2
.1µ
V2
15
R1
R3
U1
V1
5k
400
R2
5k
PULSE(0 1 0 1u 1u 3 6)
V3
15
C1
.1µ
R4
1k
R5
1k
Independent Voltage Source - V1
Functions
(none)
PULSE(V1 V2 Tdelay Trise Tfall Ton Period Ncycles)
SINE(Voffset Vamp Freq Td Theta Phi Ncycles)
EXP(V1 V2 Td1 Tau1 Td2 Tau2)
SFFM(Voff Vamp Fcar MDI Fsig)
PWL(t1 v1 t2 v2...)
PWL FILE:
Browse
Vinitial[V]: 0
Von[V]: 1
Tdelay[s]: 0
Trise[s]: 1u
Tfall[s]: 1u
Ton[s]: 3
Tperiod[s]: 6
Ncycles:
Additional PWL Points
Make this information visible on schematic:

Circuit 2:


V(n002)
1.1V
1.0V
0.9V
0.8V
0.7V
0.6V
0.5V
0.4V
0.3V
0.2V
0.1V
0.0V
0.0ms
0.3ms
0.6ms
0.9ms
1.2ms
1.5ms
1.8ms
2.1ms
2.4ms
2.7ms
.tran 0 .003 0
C2
.1µ
V2
15
R1
1k
R3
740
U1
V1
R2
1k
PULSE(0 1 0 1u 1u 3 6)
V3
15
C1
.1µ
R4
1k
R5
1k
proj2circuit2.raw
Cursor 1
V(n002)
Horz: 239.77695µs
Vert: 1.0901768V
Cursor 2
V(n002)
Horz: 490.70632µs
Vert: 991.93114mV
Diff (Cursor2 - Cursor1)
Horz: 250.92937µs
Vert: -98.245672mV
Freq: 3.9851852KHz
Slope: -391.527


C2
.1µ
V2
15
R1
R3
U1
V1
1k
740
R2
1k
PULSE(0 1 0 1u 1u 3 6)
V3
15
C1
.1µ
R4
1k
R5
1k
Edit Simulation Command
Transient
AC Analysis
DC sweep
Noise
DC Transfer
DC op pnt
Perform a non-linear, time-domain simulation.
Stop time:
.003
Time to start saving data:
0
Maximum Timestep:
Start external DC supply voltages at 0V:
Stop simulating if steady state is detected:
Don't reset T=0 when steady state is detected:
Step the load current source:
Skip initial operating point solution:
Syntax: .tran <Tprint> <Tstop> [<Tstart> [<Tmaxstep>]] [<option> [<option>] ...]
.tran 0 .003 0
Cancel
OK


.tran 0 .003 0
C2
.1µ
V2
15
R1
R3
U1
V1
1k
R2
740
1k
PULSE(0 1 0 1u 1u 3 6)
V3
15
C1
.1µ
R4
1k
R5
1k
Independent Voltage Source - V1
Functions
(none)
PULSE(V1 V2 Tdelay Trise Tfall Ton Period Ncycles)
SINE(Voffset Vamp Freq Td Theta Phi Ncycles)
EXP(V1 V2 Td1 Tau1 Td2 Tau2)
SFFM(Voff Vamp Fcar MDI Fsig)
PWL(t1 v1 t2 v2...)
PWL FILE:
Browse
Vinitial[V]: 0
Von[V]: 1
Tdelay[s]: 0
Trise[s]: 1u
Tfall[s]: 1u
Ton[s]: 3
Tperiod[s]: 6
Ncycles:
Additional PWL Points
Make this information visible on schematic: