ECE 2300 Applied Circuits Lab Practical Part 2

Spring 2025

You've been given a job as a design engineer. Congratulations! Using the skills you've built, your goal is to design a circuit to meet the specifications for the "practical" problem below.

You can **only use components found in your lab kit** for your final design. When designing, you can calculate the "ideal" component and then approximate it using your lab kit or you can design your components starting from this limitation.

You are welcome to work in groups of up to 3 people on this assignment. If you work in a group, you should turn in a single submission. You are also welcome to work individually if you prefer.

1 Practical 2: Stairstep Generator

1.1 Specifications

For the second practical, you must design a circuit that produces the output in Fig. 1. You can use any of the components in your lab kit. You cannot use the AD2 wavegen.

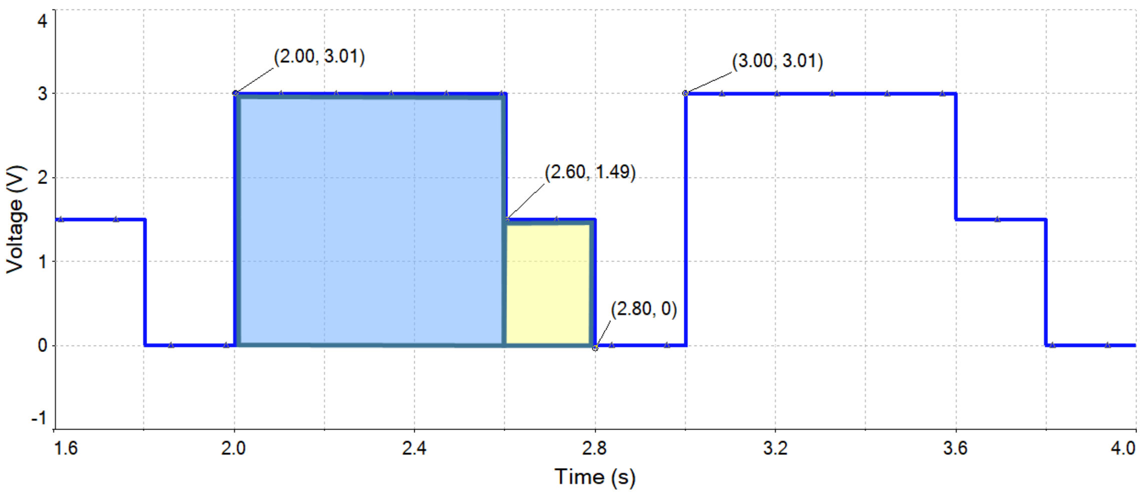


Figure 1: Stairstep waveform. Here, each block of the x-axis is 0.2s. The waveform is at 3V for 0.6s, 1.5V for 0.2s, and 0V for 0.2s and then repeats this pattern. The start-up condition for time $t = 0$ is arbitrary and not important.

1.2 Deliverables

You must build your design both in Multisim and physically on your breadboard. In your submission, include:

1. A brief summary (one page or less) stepping through how your circuit works and how you designed your circuit, including calculations. If there are any discrepancies between your real and simulated circuits, note down what they are, and why you think they may be happening.

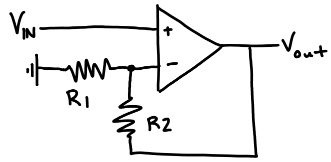
2. A screenshot of your final Multisim schematic and an annotated transient analysis of the simulated output.

3. A picture of your breadboarded circuit and the output in waveforms.

4. A short description of the contribution of each group member.

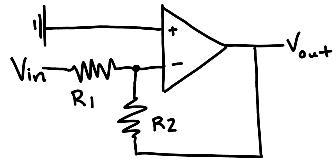
For both of the graphs, include proper annotations to show that your circuit meets the proper specifications.

NON-INVERTING OPAMP



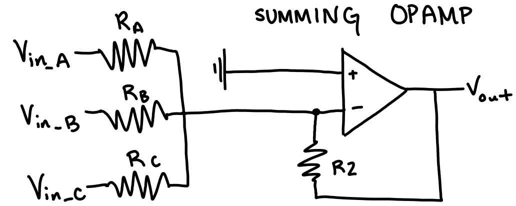
$$V_{OUT} = V_{IN}\left(1 + \frac{R_2}{R_1}\right)$$

INVERTING OPAMP



$$V_{OUT} = -V_{IN}\left(\frac{R_2}{R_1}\right)$$

SUMMING OPAMP



$$V_{OUT} = -\left(\frac{R_2}{R_A}V_A + \frac{R_2}{R_B}V_B + \frac{R_2}{R_C}V_C\right)$$

OR

$$R_A = R_B = \cdots = R_{in} \rightarrow \quad V_{OUT} = -\frac{R_2}{R_{in}}\left(V_A + V_B + V_C\right)$$

VOLTAGE DIVIDER $(5v \rightarrow 3v)$

$$3v = 5v\,\frac{R_2}{R_2+R_1}$$

$$\frac{3v}{5v} = \frac{R_2}{R_2+R_1}$$

$$\frac{3}{5} = \frac{3\Omega}{3\Omega+2\Omega}$$

$$\downarrow$$

$$\frac{3}{5} = \frac{1.5k\Omega}{1.5k\Omega+1k\Omega} \checkmark$$

$R_1 = 1k\Omega$
$R_2 = 1.5k\Omega$

SUMMING OPAMP

$$V_{OUT} = -\frac{R_2}{R_{in}}\left(V_A + V_B\right)$$

$$3v = -\frac{R_2}{R_{in}}\left(5v + 5v\right)$$

$$\frac{3v}{10v} = \frac{-R_2}{R_{in}}$$

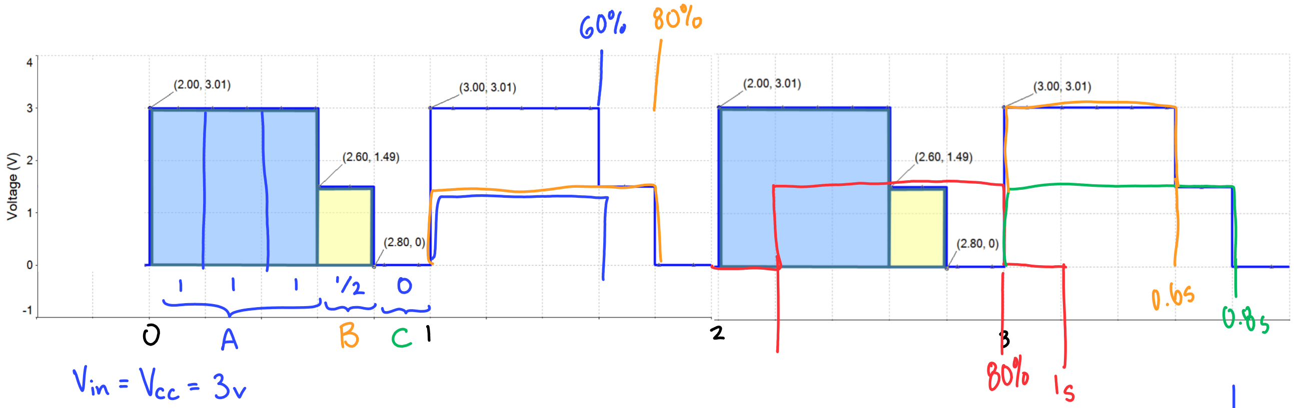
$$\Downarrow$$

$$R_2 = 0.3R_{in}$$

$$\Downarrow$$

$$R_2 = 11.7k = \underbrace{3(3.9k)}_{\text{in series}}$$

$$R_{in} = 39k$$



$V_{in} = V_{CC} = 3v$

$V_{EE} = -3v$

A

$V_{OUT} = V_{in}$

$V_{CC} = -V_{EE} = 3v$

B

$V_{OUT} = \frac{1}{2} V_{in}$

$\frac{1}{2} V_{EE} = 1.5v$

C

$V_{OUT} = 0$

$V_{OUT} = V_{CC} + V_{EE}$

Duty Cycle (60%)

$$D = \frac{T_{on}}{T_{total}} = \frac{R_A + R_B}{R_A + 2R_B} = 0.60$$

↓ MATLAB

$R_A = \cancel{3300\,\Omega}$ 2700

$R_B = \cancel{6800}\,\Omega$ 5600

Duty Cycle (80%)

$$D = \frac{T_{on}}{T_{total}} = \frac{R_A + R_B}{R_A + 2R_B} = 0.80$$

↓ MATLAB

$R_A = \cancel{10k\Omega}$ 8200

$R_B = \cancel{3300}\,\Omega$ 2700

$$T_{total} = 0.693(R_A + 2R_B)C_{60}$$

$$1s = 0.693(R_A + 2R_B)10\,\mu F$$

$$R_A + 2R_B = \frac{1s}{0.693 \cdot 100\,\mu F}$$

↓ MATLAB

68000Ω
4700Ω
+ Ω
72700Ω

FIND C_{60}

$$T_{total} = 1s$$

$$T_{total} = 0.693(R_A + 2R_B)C_{60}$$

$$T_{total} = 0.693(3.3k\Omega + 2 \cdot 6.8k\Omega)C_{60}$$

$$C_{60} = \frac{1s}{0.693(16.9k\Omega)}$$

$$C_{60} = 85.4\,\mu F \approx 100\,\mu F$$

$$C_{60} = \underline{\underline{100\,\mu F}}$$

FIND C_{80}

$$T_{total} = 1s$$

$$T_{total} = 0.693(R_A + 2R_B)C_{80}$$

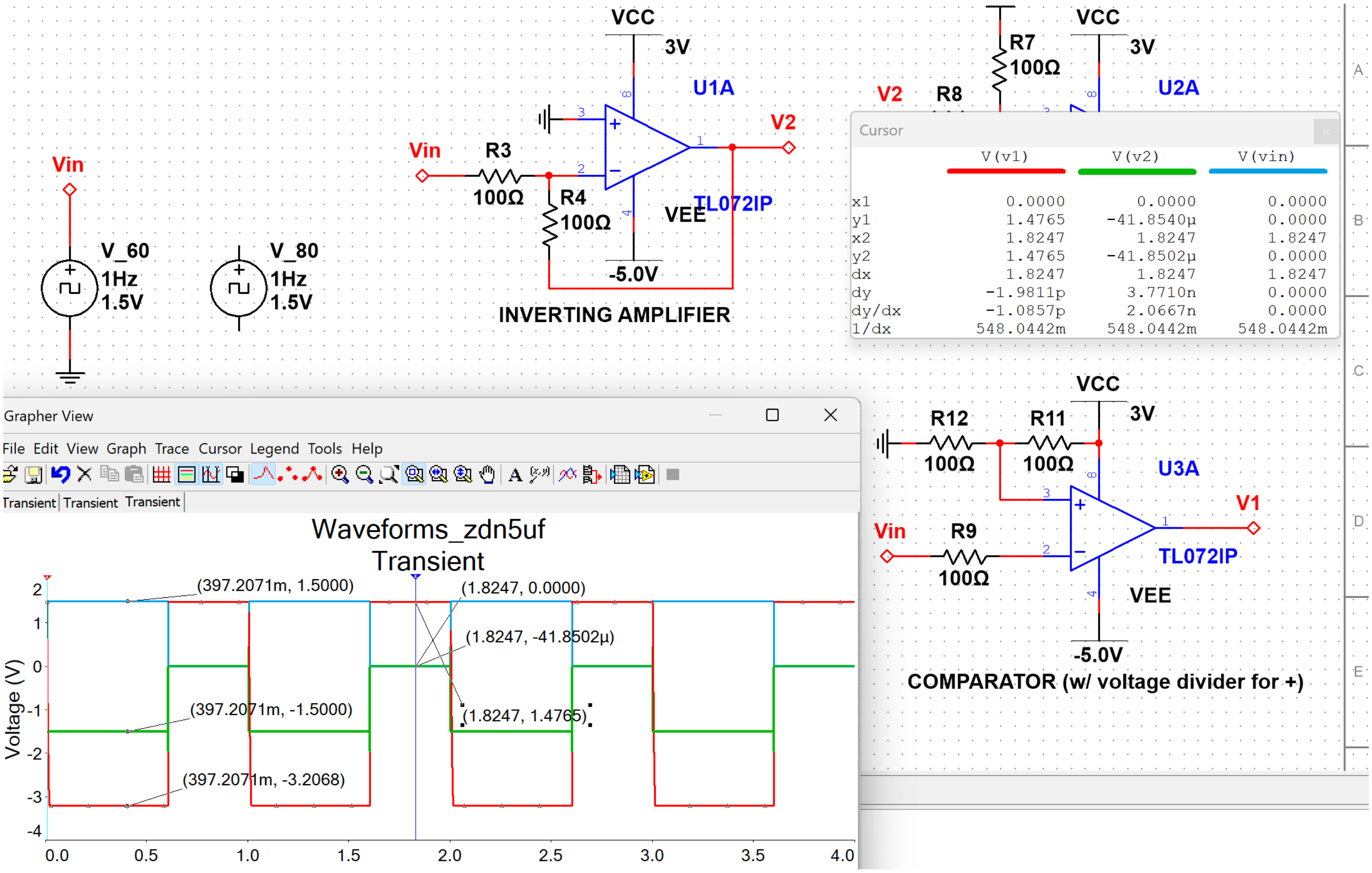
$$T_{total} = 0.693(10k\Omega + 2 \cdot 3.3k\Omega)C_{80}$$

$$C_{80} = \frac{1s}{0.693(16.6k\Omega)}$$

$$C_{80} = 86.9\,\mu F \approx 100\,\mu F$$

$$C_{80} = \underline{\underline{100\,\mu F}}$$

Q: What's the difference in output between comparator (V1) and inverting amplifier (V2)?
Vin = input current = 1.5v



One Shot Charging Cycle

$t_c = 1.1\,RC$

$0.2_s = 1.1\,RC$

$R_{ONE} = \dfrac{0.2s}{1.1\,C}$ $\qquad$ $\dfrac{0.6s}{1.1\,C}$ $\qquad$ $\dfrac{0.8s}{1.1\,C}$

$R_{ONE} = \dfrac{0.2s}{(1.1)(10\mu F)}$ $\qquad$ $\dfrac{0.6s}{(1.1)(10\mu F)}$ $\qquad$ $\dfrac{0.8s}{(1.1)(10\mu F)}$

$R_{ONE} = 18181$ $\qquad$ 54545Ω $\qquad$ 72727Ω

MATLAB $\downarrow$ $\qquad$ MATLAB $\downarrow$

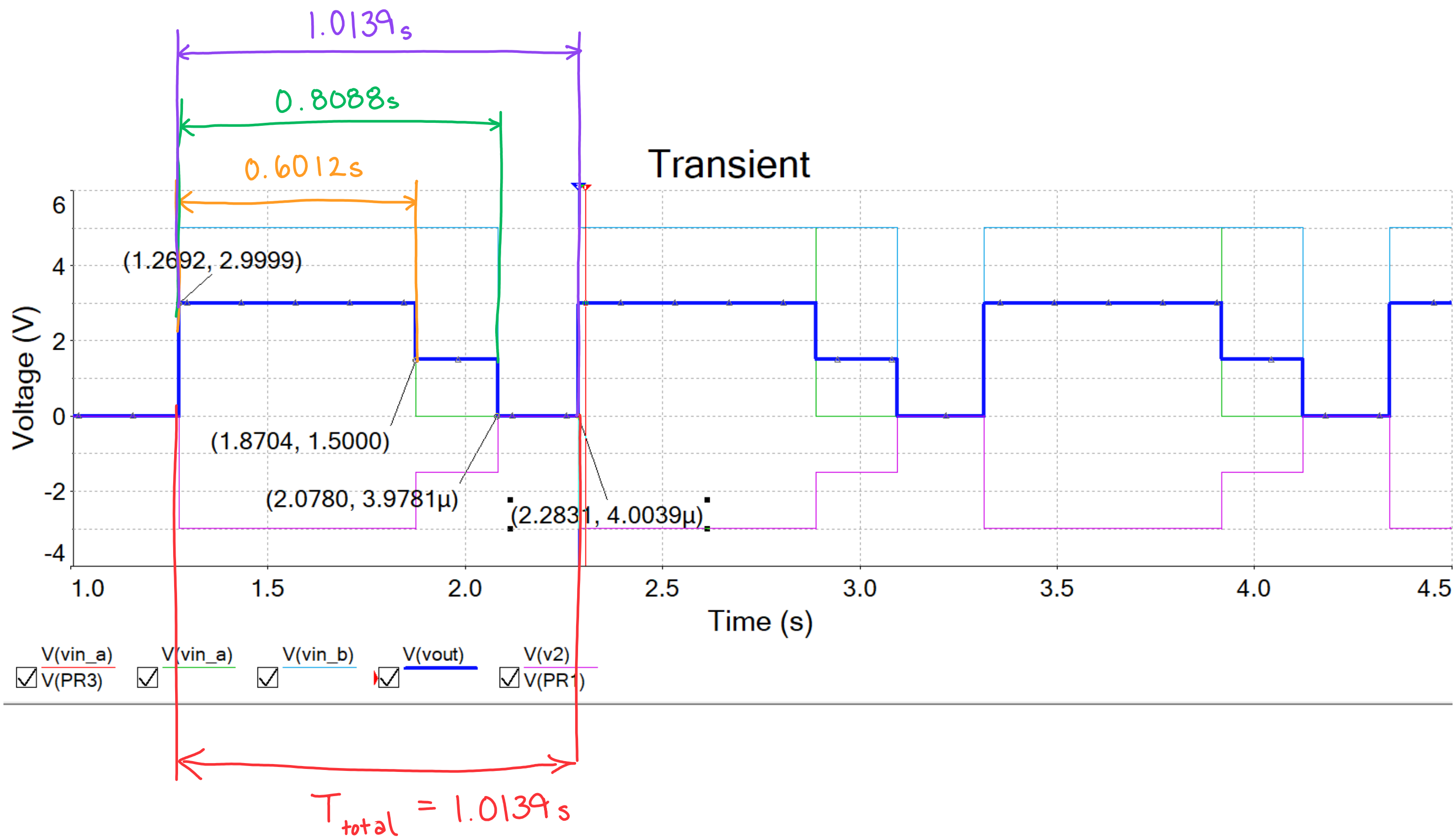
$0.62 = 56363$

47k
47k
4.7k

$0.84 = 76363$

68k
8.2k

$$\begin{array}{r} 27000\Omega \\ 22000\Omega \\ +\ \ 5600\Omega \\ \hline 54600\Omega \end{array} \xleftarrow{OR} \begin{array}{r} 27000\Omega \\ 27000\Omega \\ +\ \ 560\Omega \\ \hline 54560\Omega \end{array} \qquad \begin{array}{r} 68000\Omega \\ 4700\Omega \\ +\ \ 27\Omega \\ \hline 72727\Omega \end{array} \xrightarrow{OR} \begin{array}{r} 68000\Omega \\ 4700\Omega \\ +\ \ \Omega \\ \hline 72700\Omega \end{array}$$

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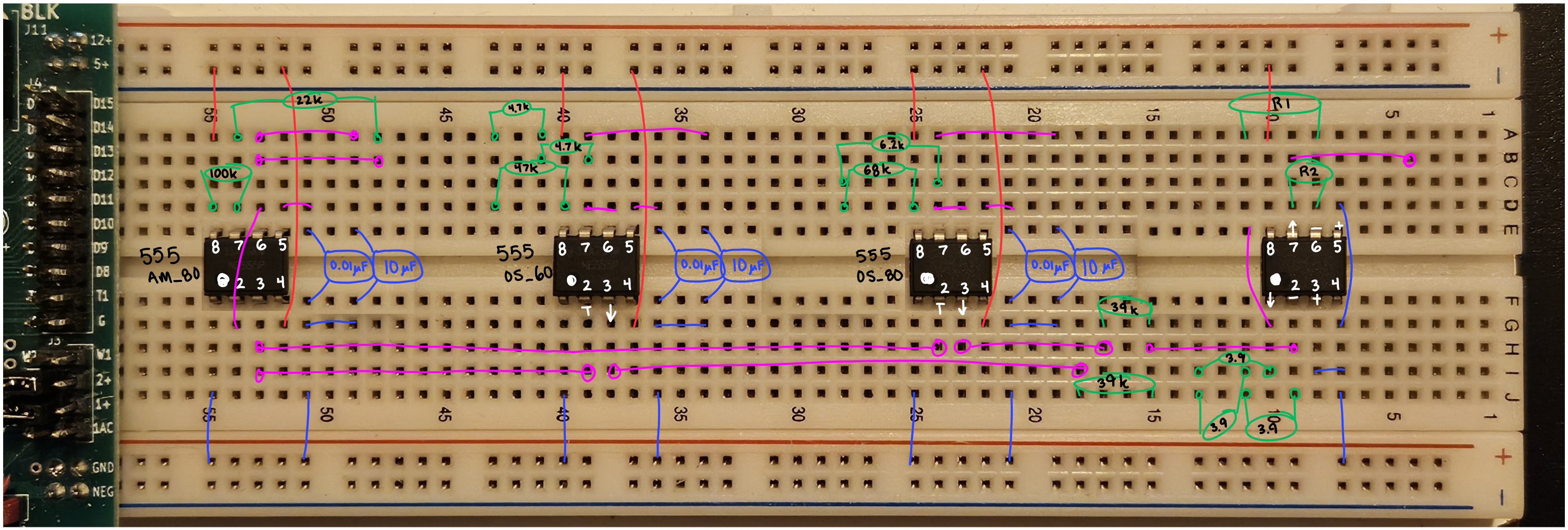
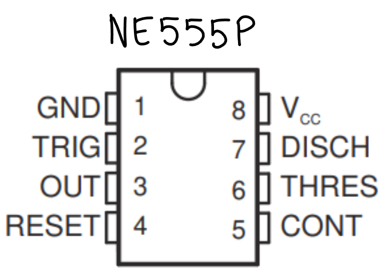
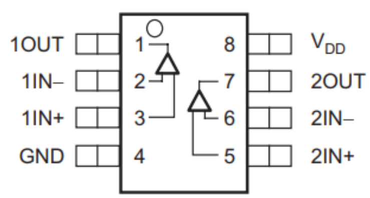
>> find_req_555(80, 0.5)
Found 16 unique solutions for RA, RB to achieve the specified gain in a 555 timer.
```

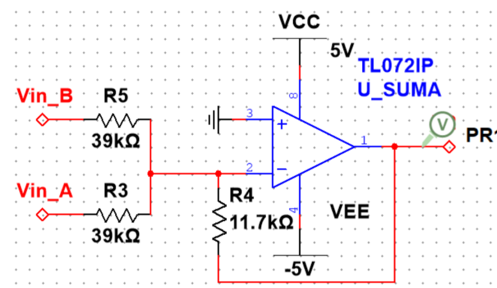
RA	RB	Duty_Cycle	Percent_Error (Duty)	Time	Percent_Error (Time)
8200	68000	0.52843	33.946	0.99931	0.0694
✗ 1e+05	22000	0.84722	5.9028	0.99792	0.208
1.2e+05	12000	0.91667	14.583	0.99792	0.208
6800	68000	0.52381	34.524	0.9896	1.0396



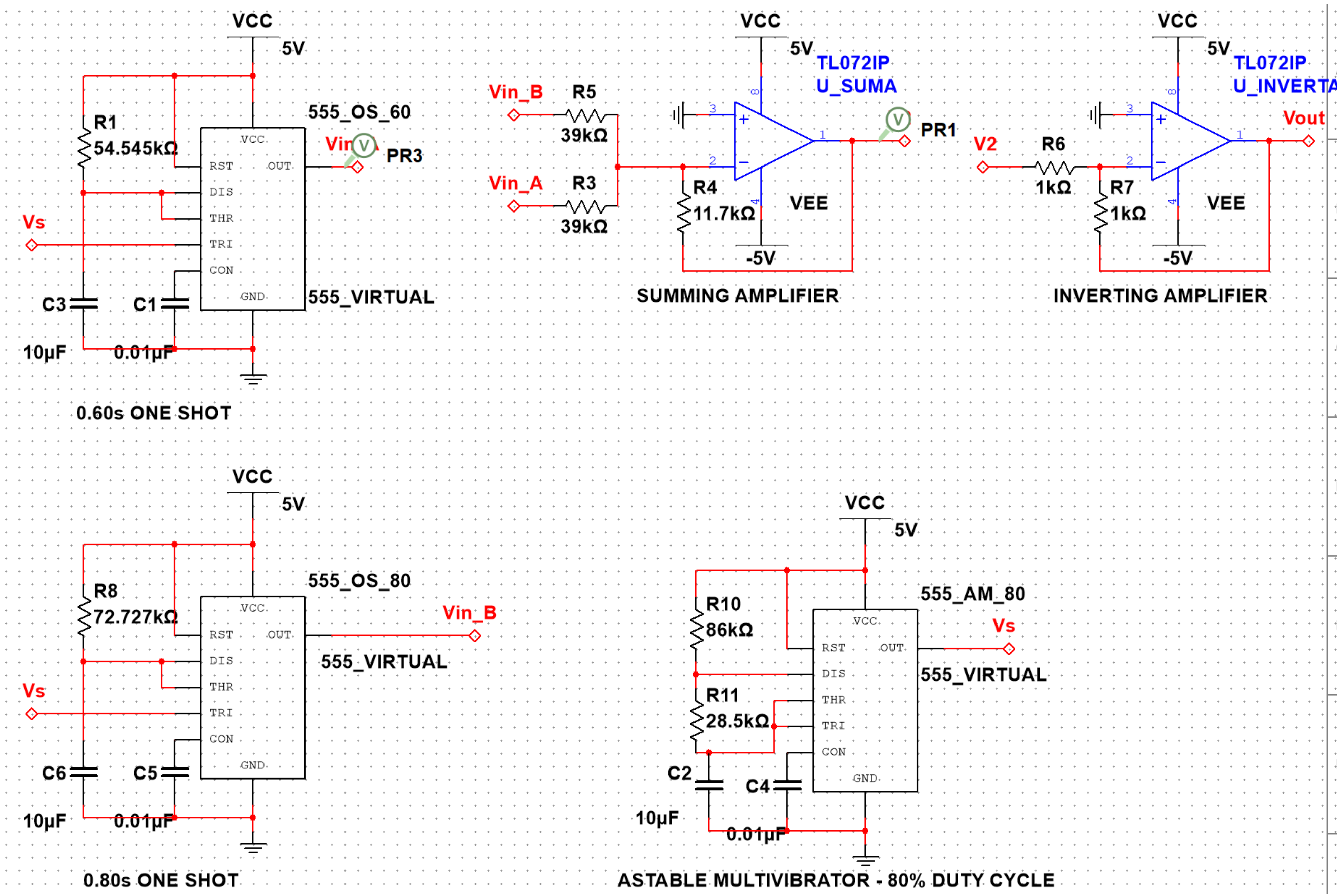


TLV272: D, DGK, and P Packages
8-Pin SOIC, VSSOP, and PDIP
Top View





SUMMING AMPLIFIER


VCC
5V
R1
54.545kΩ
555_OS_60
VCC
RST
OUT
DIS
THR
TRI
CON
GND
Vin_A
PR3
Vs
C3
C1
10µF
0.01µF
555_VIRTUAL
0.60s ONE SHOT
Vin_B
R5
39kΩ
Vin_A
R3
39kΩ
R4
11.7kΩ
VCC
5V
TL072IP
U_SUMA
VEE
-5V
PR1
SUMMING AMPLIFIER
V2
R6
1kΩ
R7
1kΩ
VCC
5V
TL072IP
U_INVERTA
Vout
VEE
-5V
INVERTING AMPLIFIER
VCC
5V
R8
72.727kΩ
555_OS_80
Vin_B
555_VIRTUAL
Vs
C6
C5
10µF
0.01µF
0.80s ONE SHOT
VCC
5V
R10
86kΩ
R11
28.5kΩ
555_AM_80
Vs
555_VIRTUAL
C2
C4
10µF
0.01µF
ASTABLE MULTIVIBRATOR - 80% DUTY CYCLE