

**Union College**  
**ECE 363**  
**QUIZ 4 Fall 2017**  
**Solution**

**NAME:** \_\_\_\_\_

**Note:** See pages 777 to 779 in your text book. Make sure to look at both inverting and non-inverting amplifiers.

**Problem #1: OP-AMP amplifier design with a single power supply.**

Design a non-inverting amplifier using an LM358 op-amp with a gain as close to 15 as you can get, and a single power-supply.  $V_{sat(+)} = V_{CC} - 1 \text{ V}$  and  $V_{sat(-)} = 0 \text{ V}$ . Use a power supply of 15 V and a load of  $R_L = 1 \text{ k}\Omega$ . Sketch the output for  $V_{in} = .010 \cdot \sin(2 \cdot \pi \cdot 1 \text{ kHz} \cdot t)$ . Sketch the maximum undistorted output.

**Calculations:**

**Calculate  $V_{REF}$  and values for  $R_1$  and  $R_2$**

$$V_{REF} = V_{SAT(+)} / 2 = (15-1)/2 = 7 \text{ V}$$

$$V_{REF} = (V_{CC} \cdot R_2) / (R_1 + R_2) \text{ (this is the voltage divider equation)}$$

Choose  $R_2 = 10 \text{ k}$  and  $R_1 = 11 \text{ k}$ .

$$\text{Actual } V_{REF} = 7.14 \text{ V}$$

**Calculate values for  $R_3$  and  $R_4$**

$$A_V = 1 + R_3/R_4$$

Trying some standard values that would give a ratio of 14 I chose  $R_3 = 154 \text{ k}\Omega$  and  $R_4 = 11 \text{ k}\Omega$ .

**Calculate Values for Capacitors**

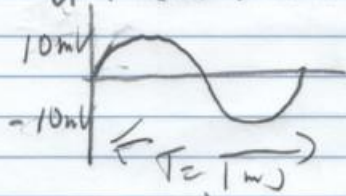
Using the equations on page 799 of the textbook and  $F_C = 10 \text{ Hz}$ . Use next large form standard capacitor value chart.

$$C_1 = 3.3 \text{ uF}$$

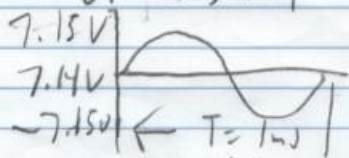
$$C_2 = 12 \text{ uF}$$

$$C_3 = 1.5 \text{ uF}$$

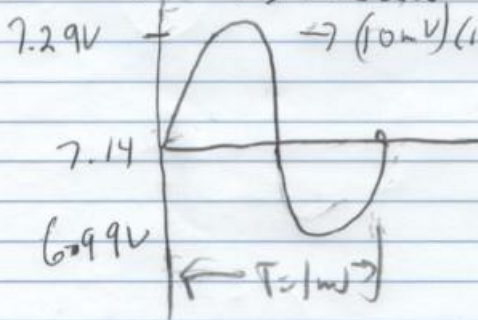
① Sketch inputs + outputs for  $V_{in} = 0.01 \sin(2\pi/1\mu s \cdot t)$   
 $V_{in}$   $V(5)$  on schematic



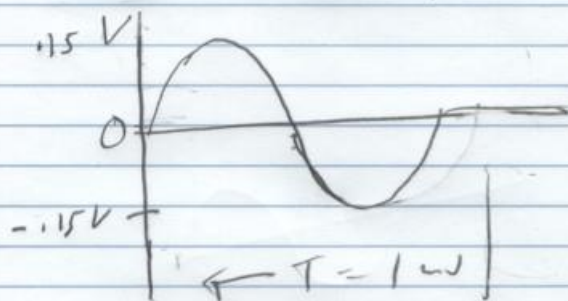
$V_{in} (+)$  of op-amp  $V(2)$  on schematic

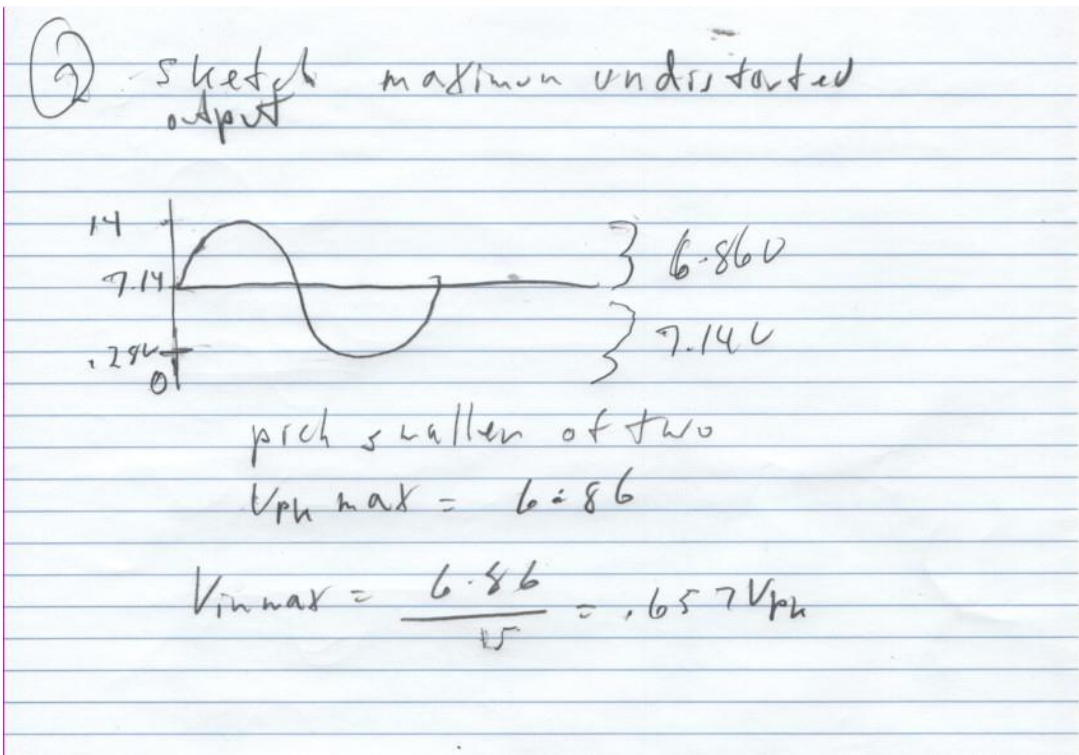


$V_{out}$   $V(1)$  on schematic input and output is



$V_{out}$  after cap





**Simulate circuit**

Note that the  $V_{SAT(+)}$  from the simulation is about  $V_{CC} - 1.35\ V$  not  $V_{CC} - 1\ V$ .

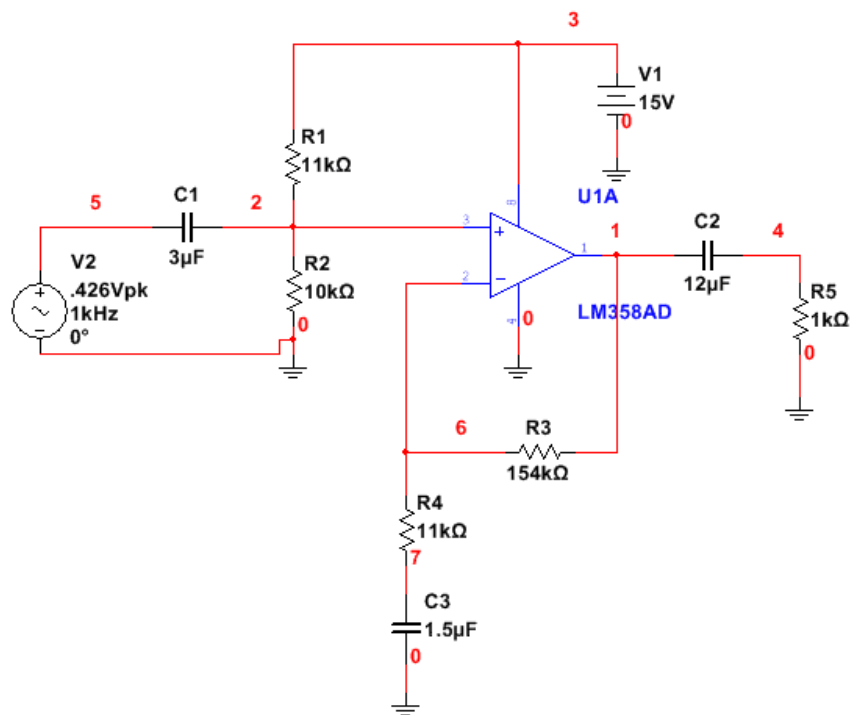


Figure 1 Simulation circuit

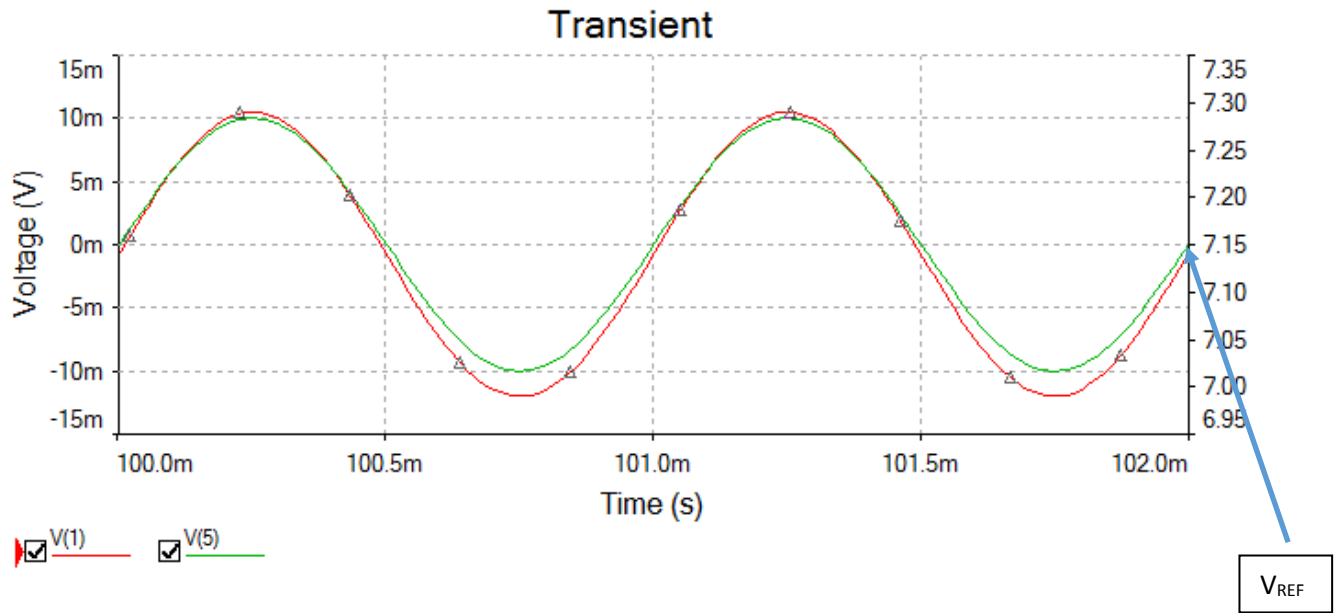


Figure 1 Input 10 mV pk

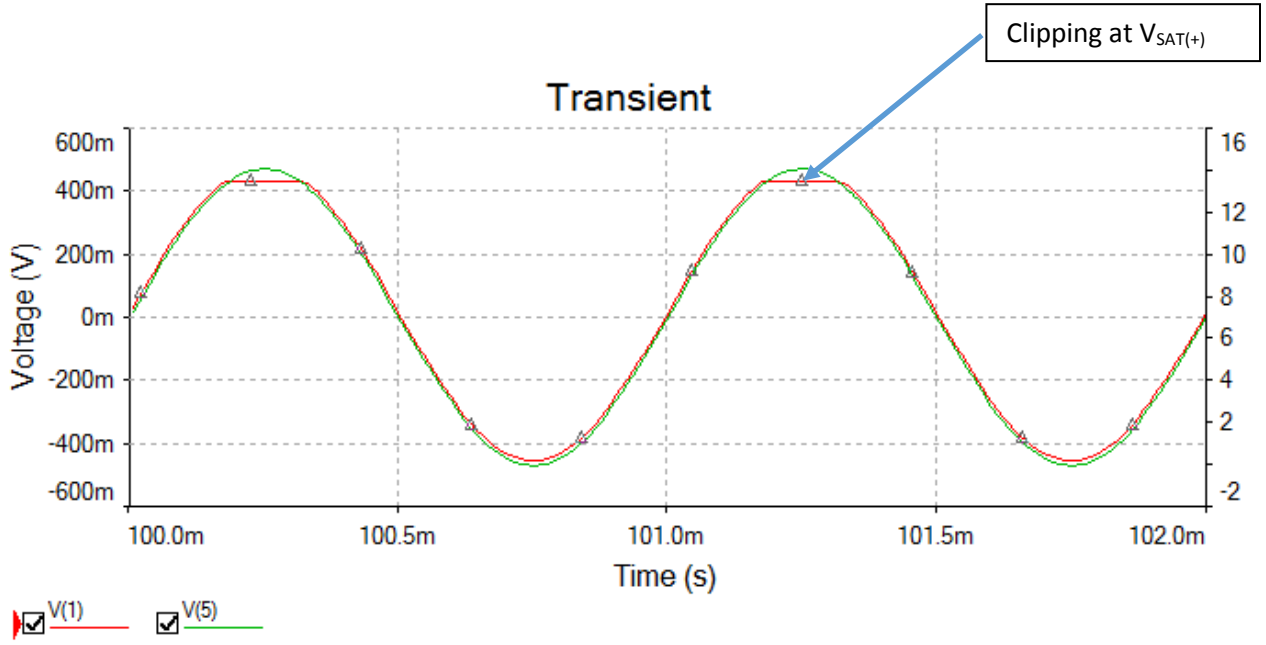


Figure 2 input  $V_{in} = .458$  V pk note clipping

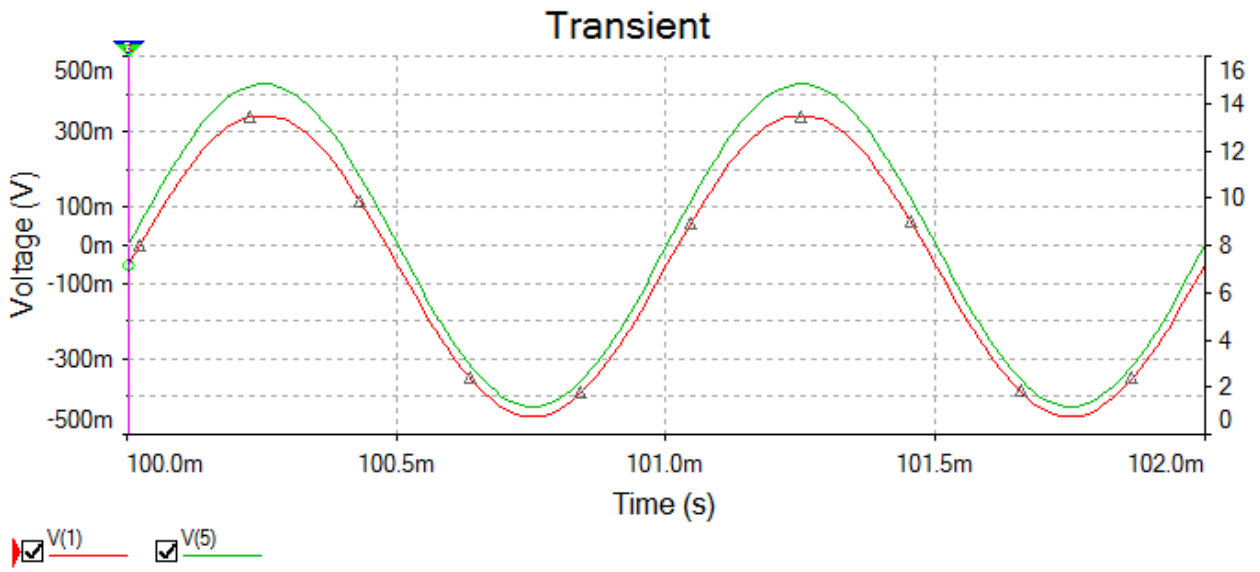


Figure 3  $V_{in} = .426 V_{pk}$  no clipping This is the maximum undistorted output