# TL072

## Application review

Art Kay

12-22-2024

# Simple version of IC5B circuit



**Circuit labels:** R1 56k, R3 10k, Vin 5.5, Vinv, Vout, 5.5V, +11V

**Plot:** Output vs Input voltage (V), annotations 4.51V and 6.49V

**Calculations:**
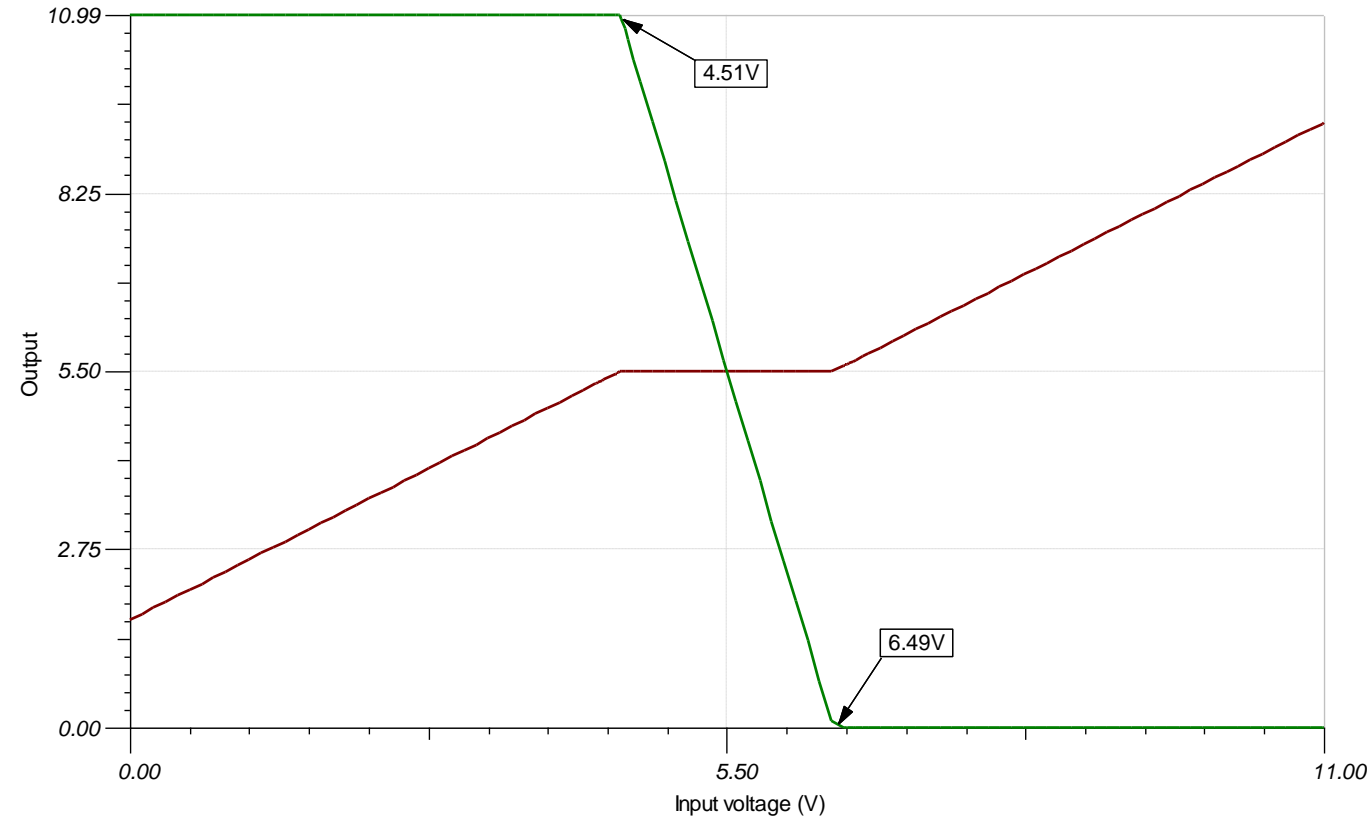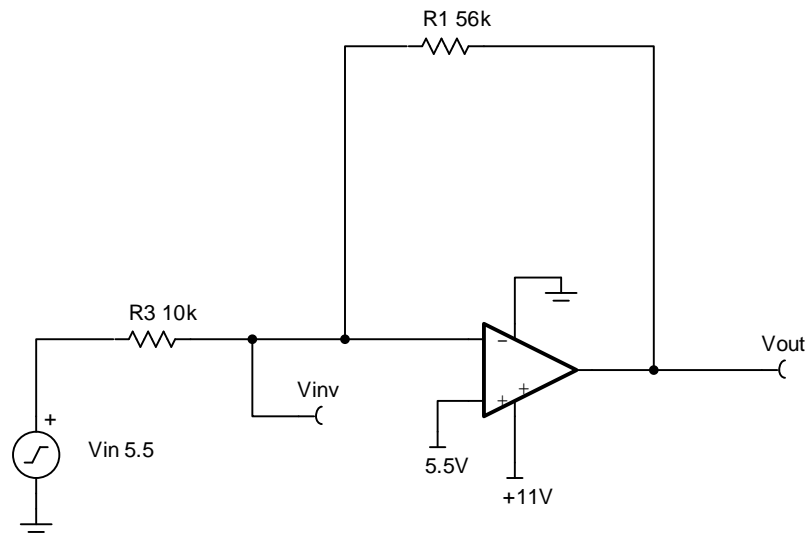
$$Rf := 56 \qquad Rg := 10$$

$$G_{inv} := \frac{-Rf}{Rg} = -5.6$$

$$G_{non} := \frac{Rf}{Rg} + 1 = 6.6$$

$$V_{out} = G_{inv} \cdot V_{in} + (5.5) \cdot G_{non}$$

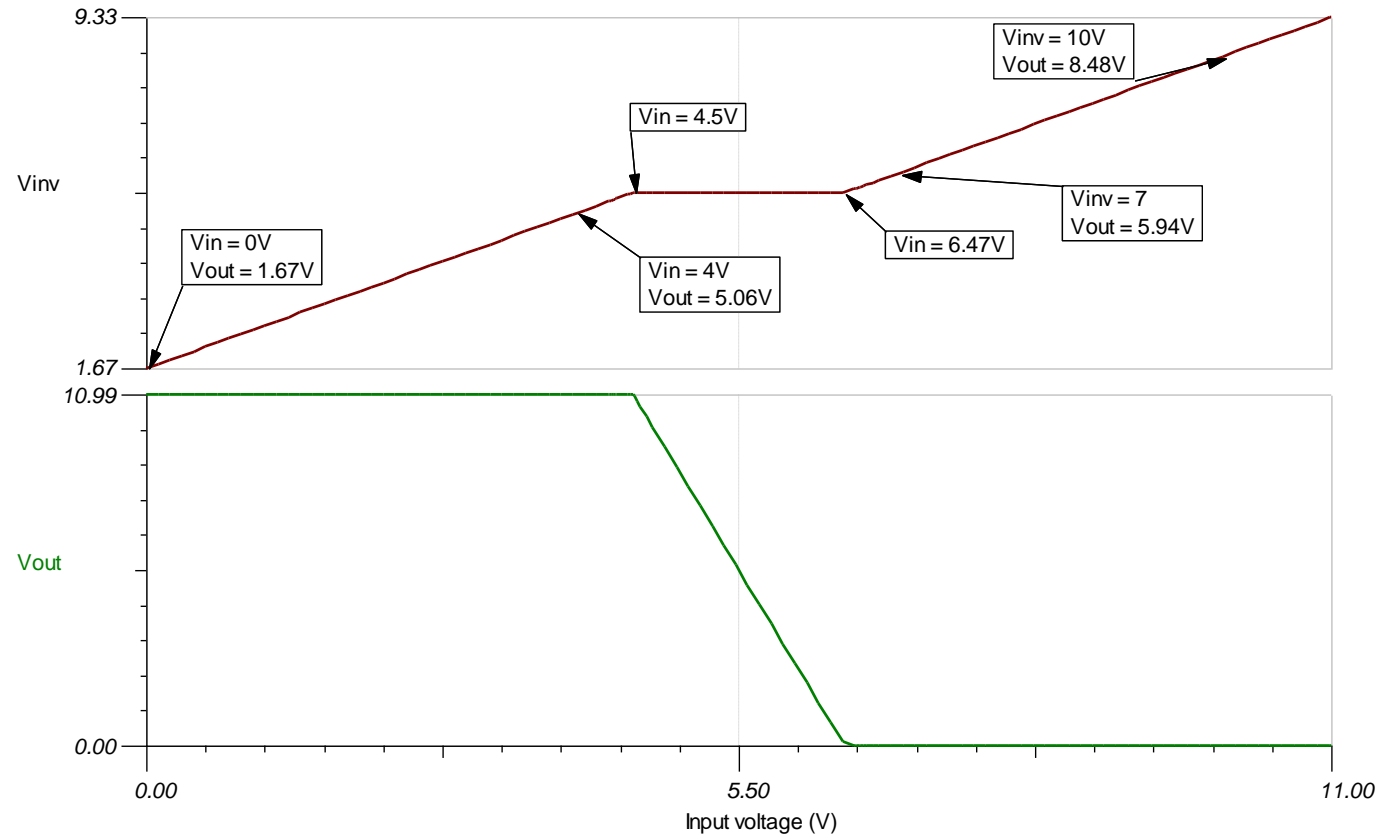$$V_{out} = -5.6 \, V_{in} + 36.3$$

solve for Vout = 0V

$$0 \, V = -5.6 \, V_{in} + 36.3 \xrightarrow{\text{solve}, V_{in}} 6.482142$$

solve for Vout = 11V

$$11 = -5.6 \, V_{in} + 36.3 \xrightarrow{\text{solve}, V_{in}} 4.5178571$$

Here is the circuit without the diodes. Note that the output is only linear for input signals from the range of 4.51V to 6.49V. This is predicted with both simulation and calculation

# Simple version of IC5B circuit (Vinv)



Below 4.5V and above 6.47V the circuit is open loop. To understand Vinv in this case you can just erase the op amp and think of this as a series circuit with two power supplies: Vout and Vin. The equations in these two regions are given to the right.

for inputs below 4.5V

$$V_{inv} = (V_{out} - V_{in}) \cdot \frac{R_3}{R_1 + R_3} + V_{in}$$

for Vin = 0V

$$V_{inv0} := (11 - 0) \cdot \left(\frac{10}{56 + 10}\right) + 0 = 1.667$$

for Vin = 4V

$$V_{inv4} := (11 - 4) \cdot \left(\frac{10}{56 + 10}\right) + 4 = 5.061$$

for inputs above 6.47V

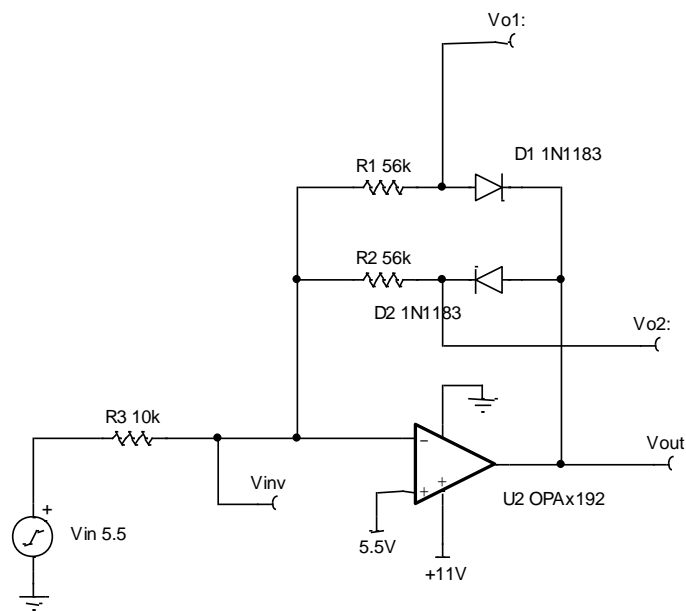$$V_{inv} = (V_{in}) \cdot \frac{R_1}{R_1 + R_3}$$

for Vin = 7V

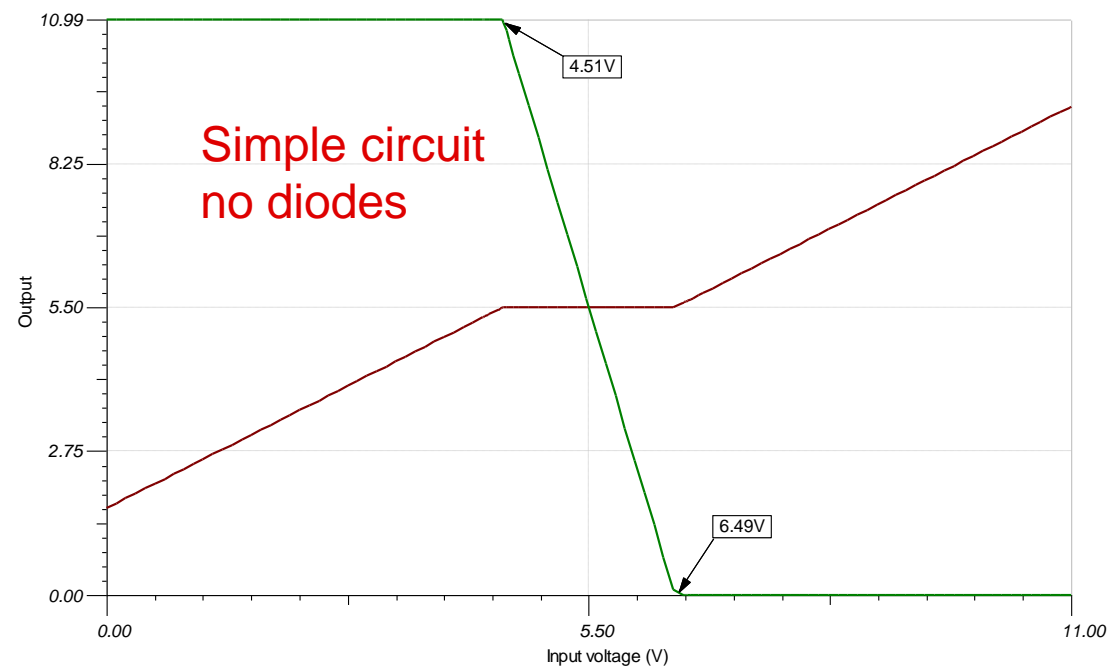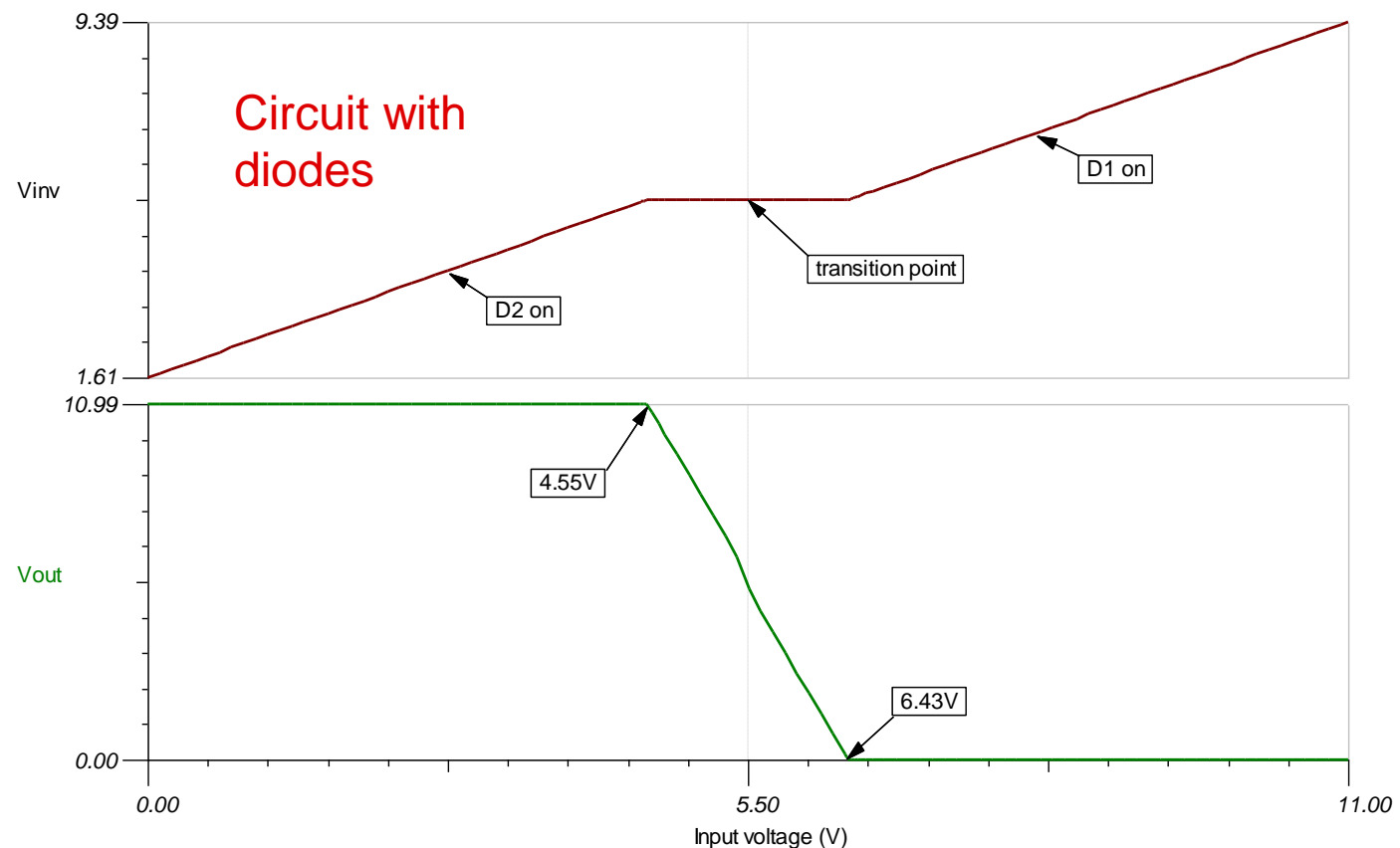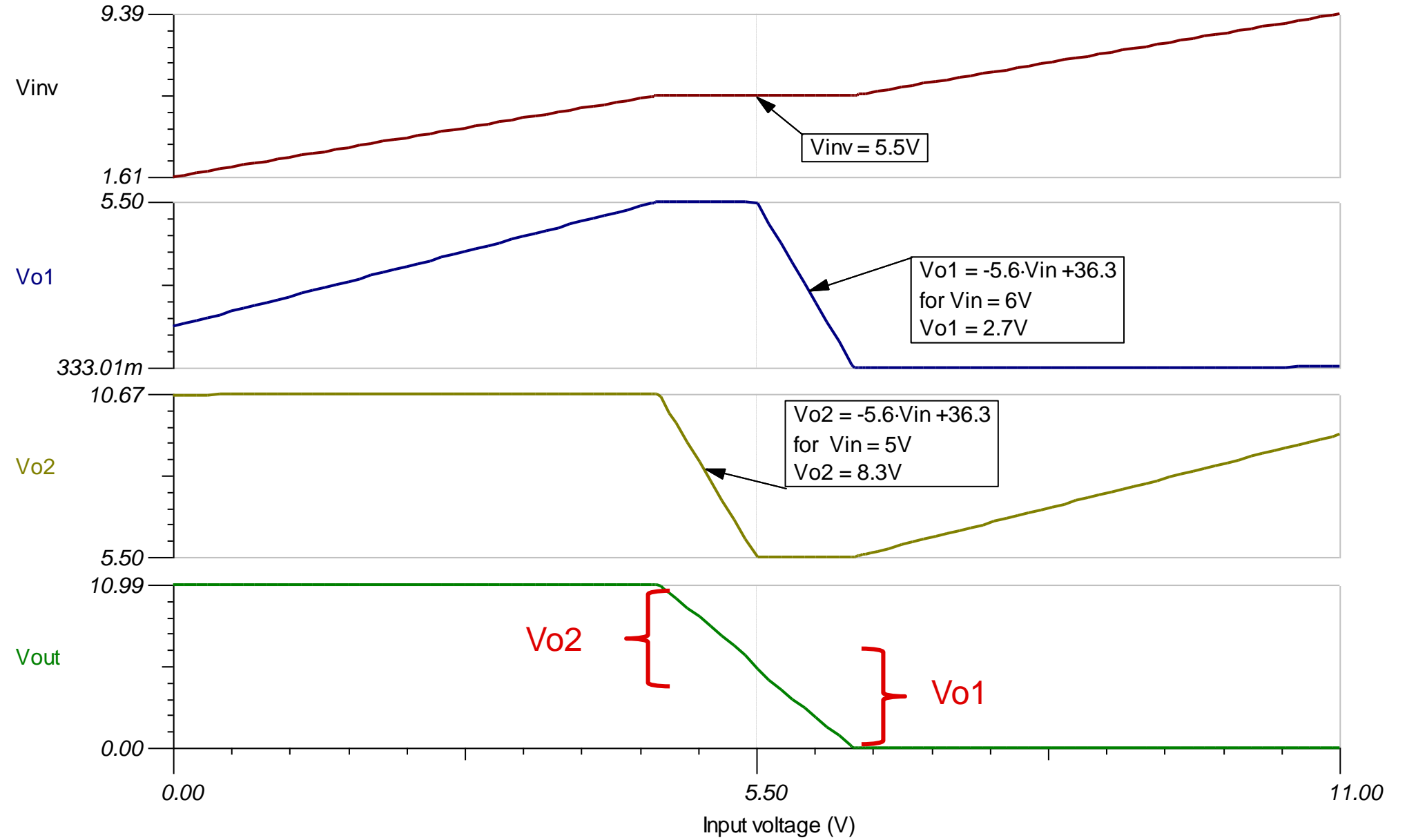$$V_{inv0} := (7) \cdot \left(\frac{56}{56 + 10}\right) = 5.939$$

for Vin = 10V

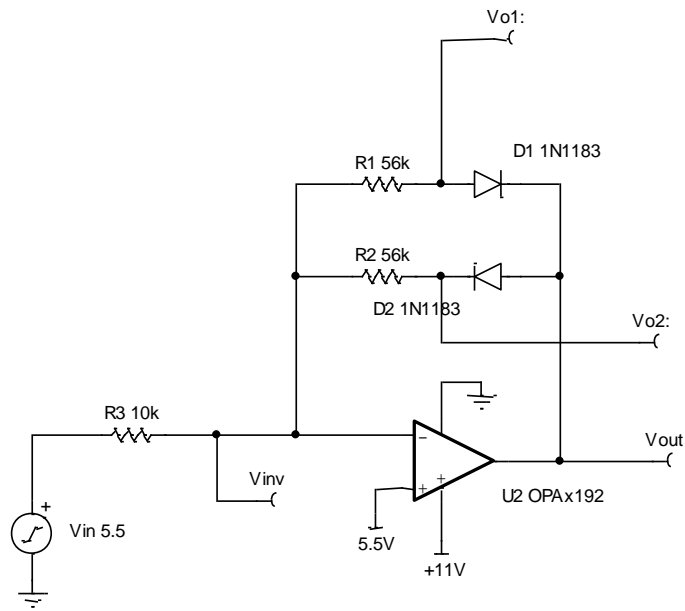$$V_{inv4} := (10) \cdot \left(\frac{56}{56 + 10}\right) = 8.485$$
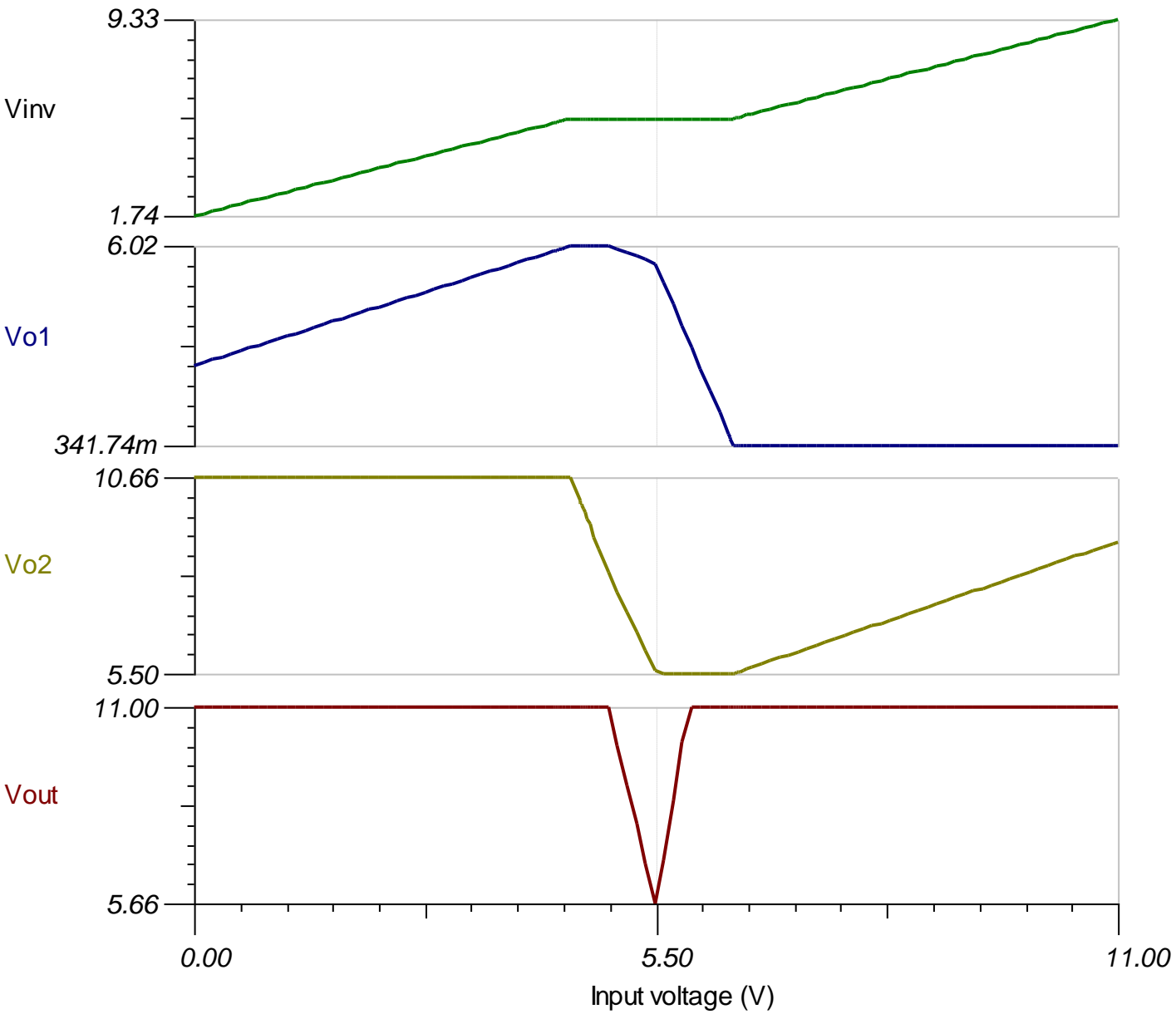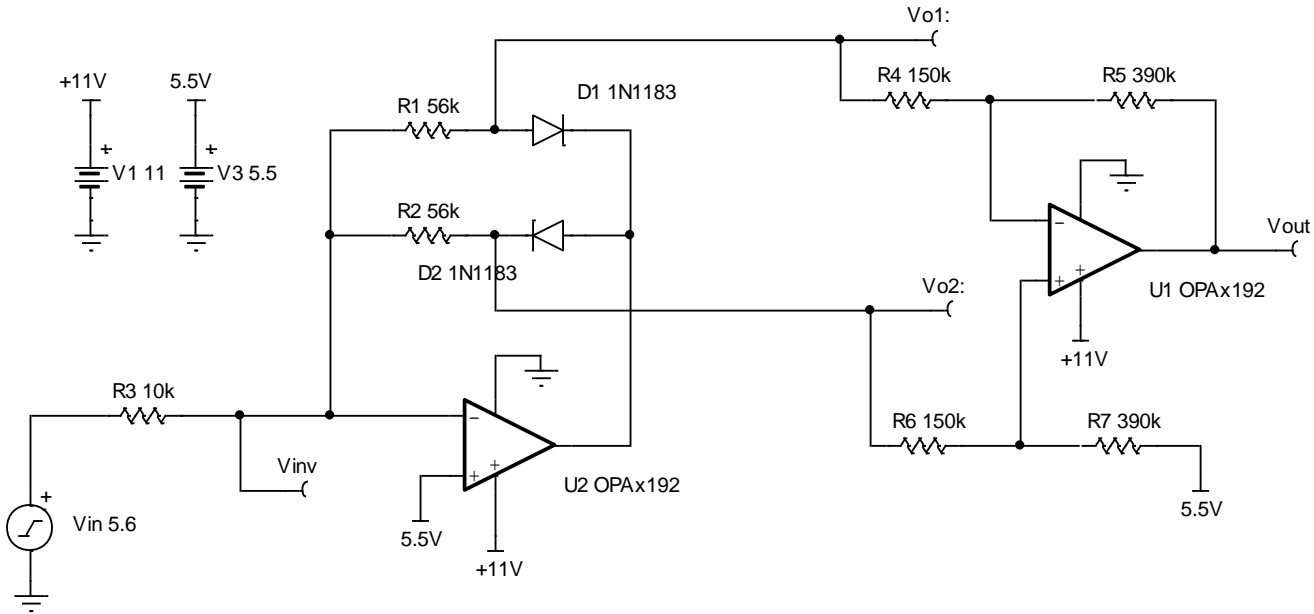
# Circuit IC5B
## (Vout and Vinv only)



Add the diodes back in and look at the output pin.  Notice from the output pin perspective, the two circuits are basically the same.  If you look closely at the circuit with diodes you will see a small non-linearity when the output signal passes through 5.5V.  The non-linearity occurs when switching from one diode to the other diode.  In this circuit either one of the two diodes are always on, but they are never on at the same time.
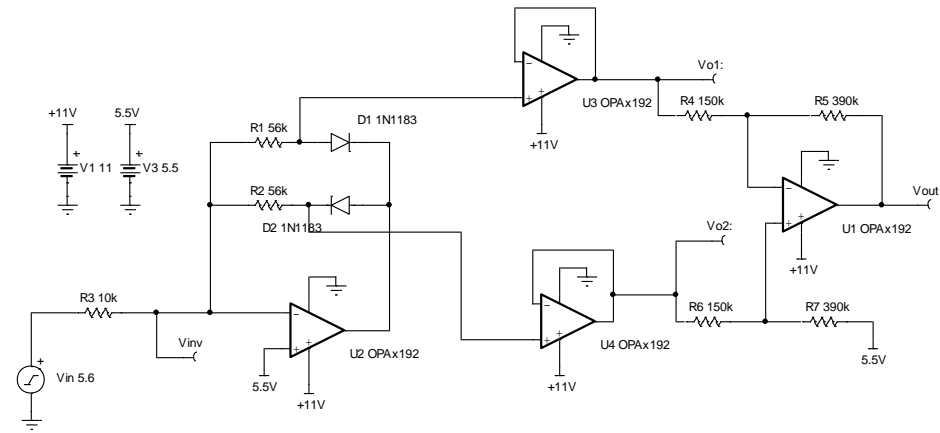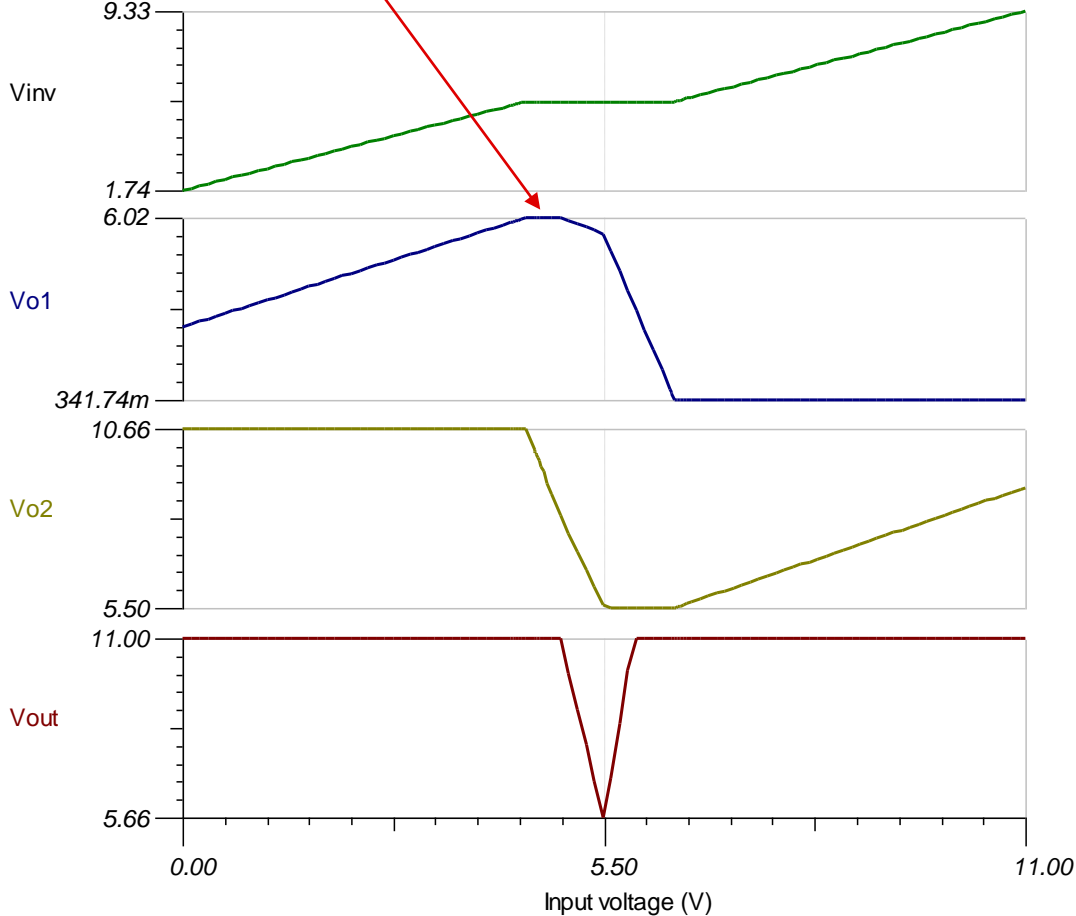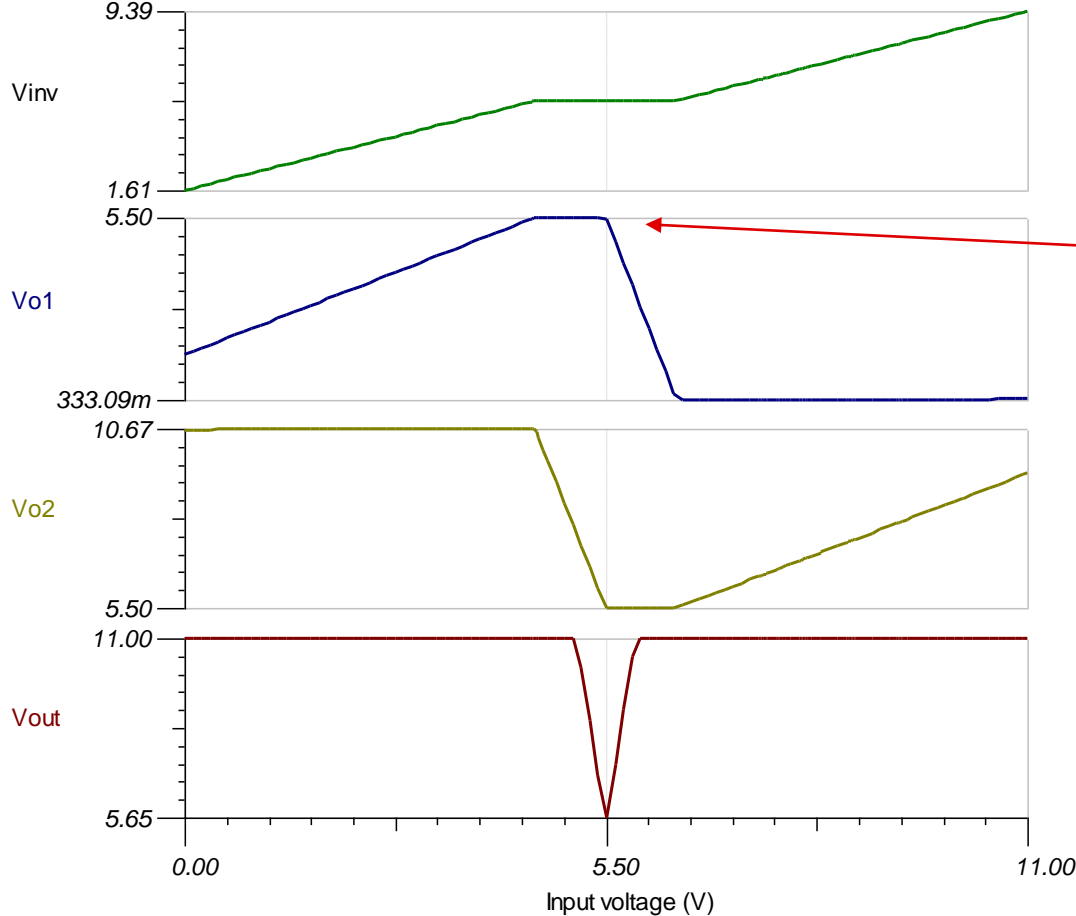
TEXAS INSTRUMENTS

# Circuit IC5B



Vo1:

R1 56k    D1 1N1183

R2 56k    D2 1N1183

D2 1N1183    Vo2:

R3 10k

Vinv    Vout

Vin 5.5    U2 OPAx192

5.5V

+11V

Vinv

Vinv = 5.5V

Vo1

Vo1 = -5.6·Vin +36.3
for Vin = 6V
Vo1 = 2.7V

Vo2

Vo2 = -5.6·Vin +36.3
for  Vin = 5V
Vo2 = 8.3V
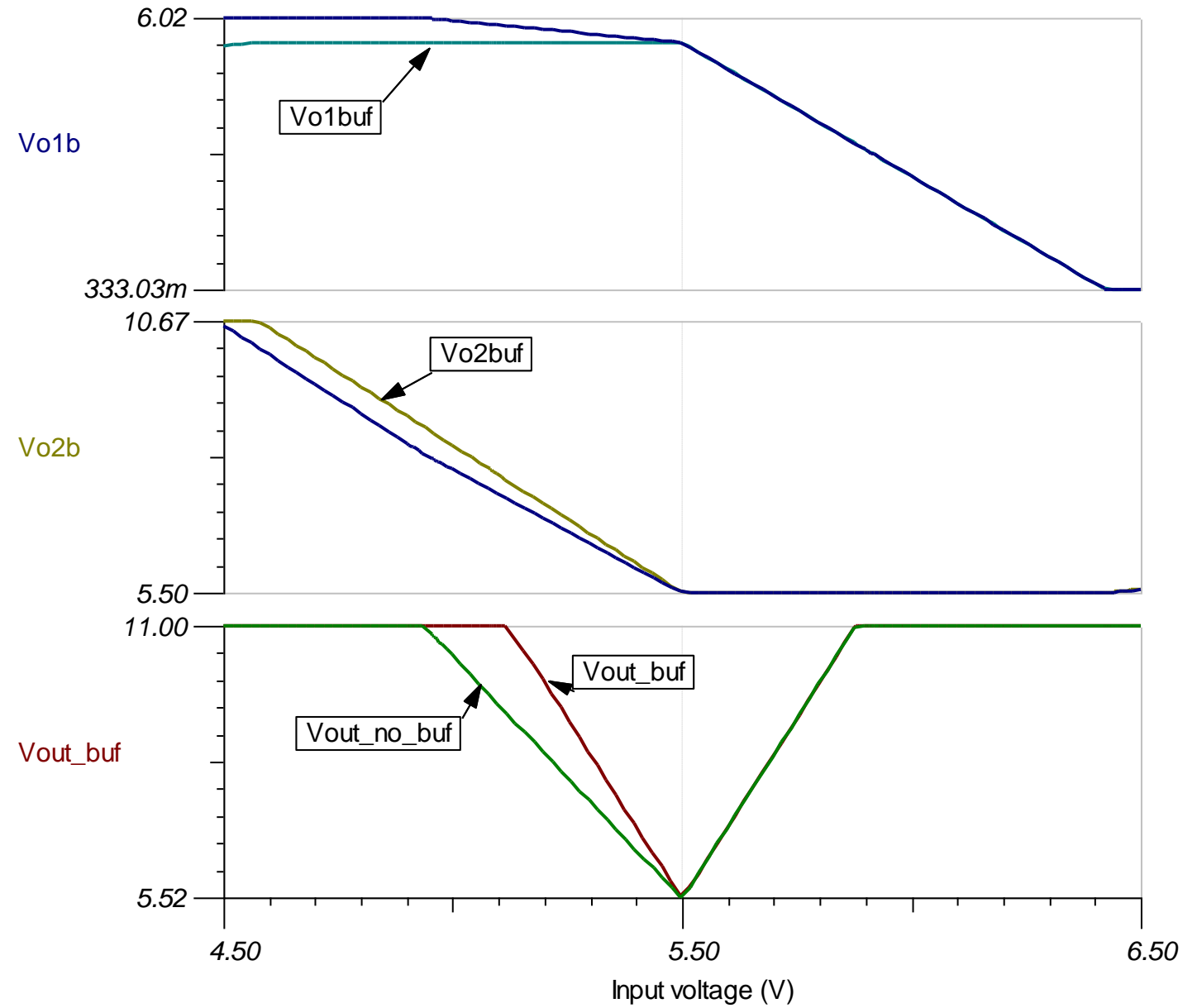
Vout

Vo2

Vo1

Input voltage (V)

# IC6A circuit

# Add buffer

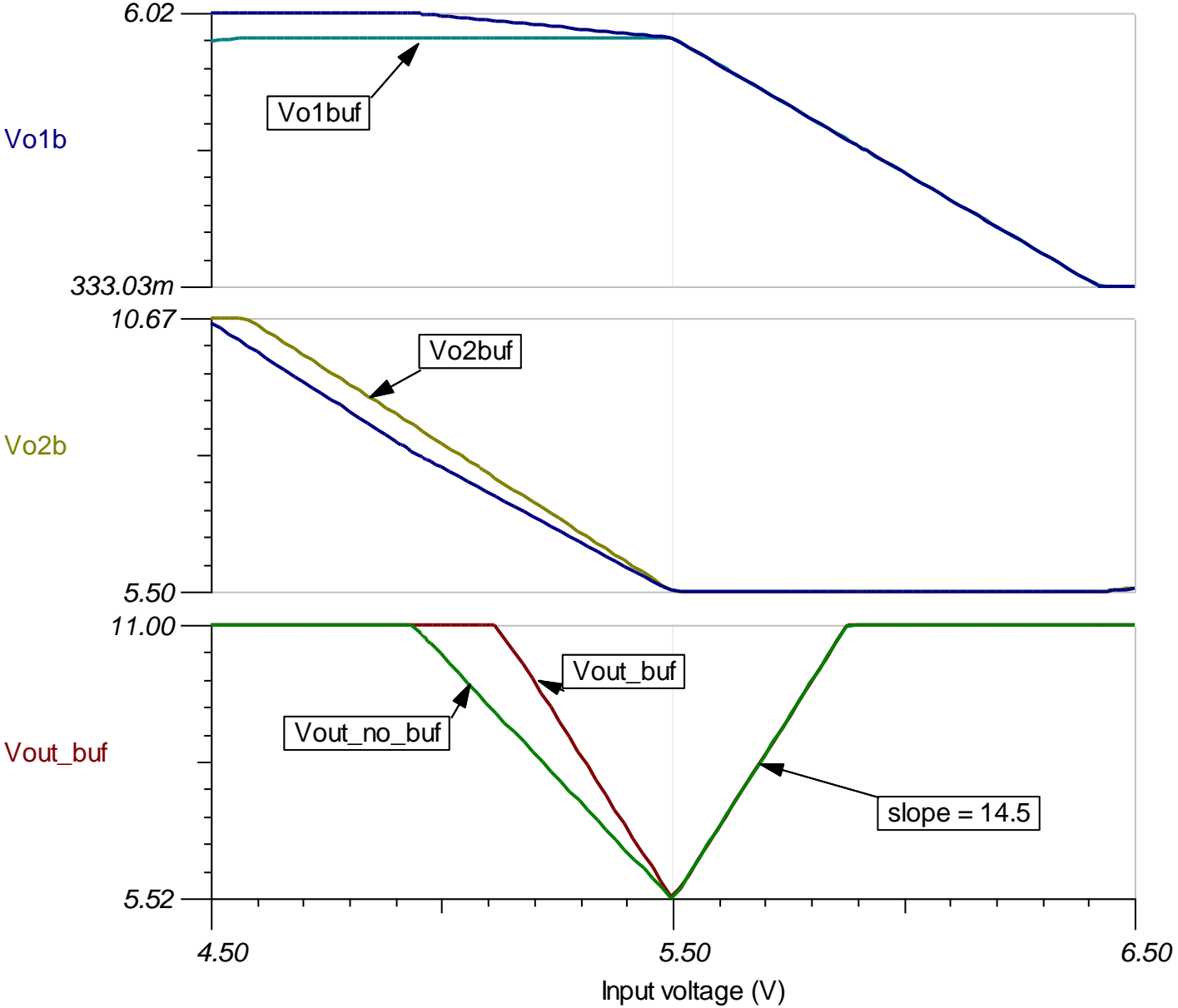# Zoom in on linear range

# Slope when not loaded.



$$\frac{56}{10} \cdot \frac{389}{150} = 14.523$$