INDIAN INSTITUTE OF SCIENCE, BENGALURU

DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING

DESIGN FOR ANALOG CIRCUITS LABORATORY REPORT

ASSIGNMENT 11

PHOTORESISTOR BASED CIRCUITS

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1 Photoresistor Characteristics

1.1 Aim

To obtain the DC operating characteristics of the photoresistor optocoupler circuit.

1.2 Schematic

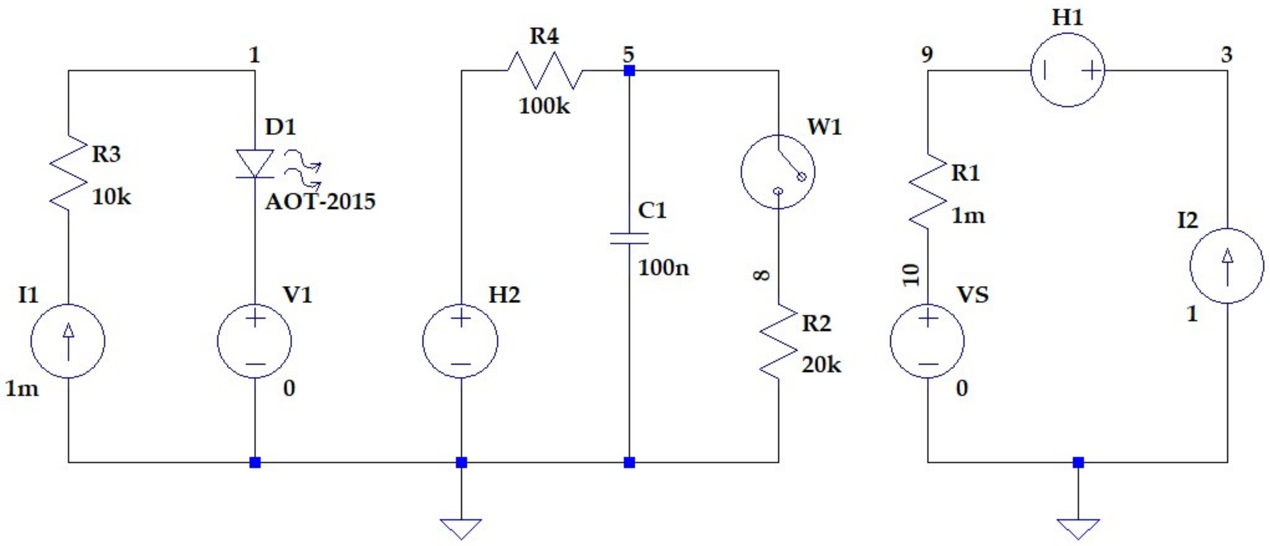

Figure 1: LTSpice schematic of photoresistor optocoupler circuit

1.3 DC operating point simulation

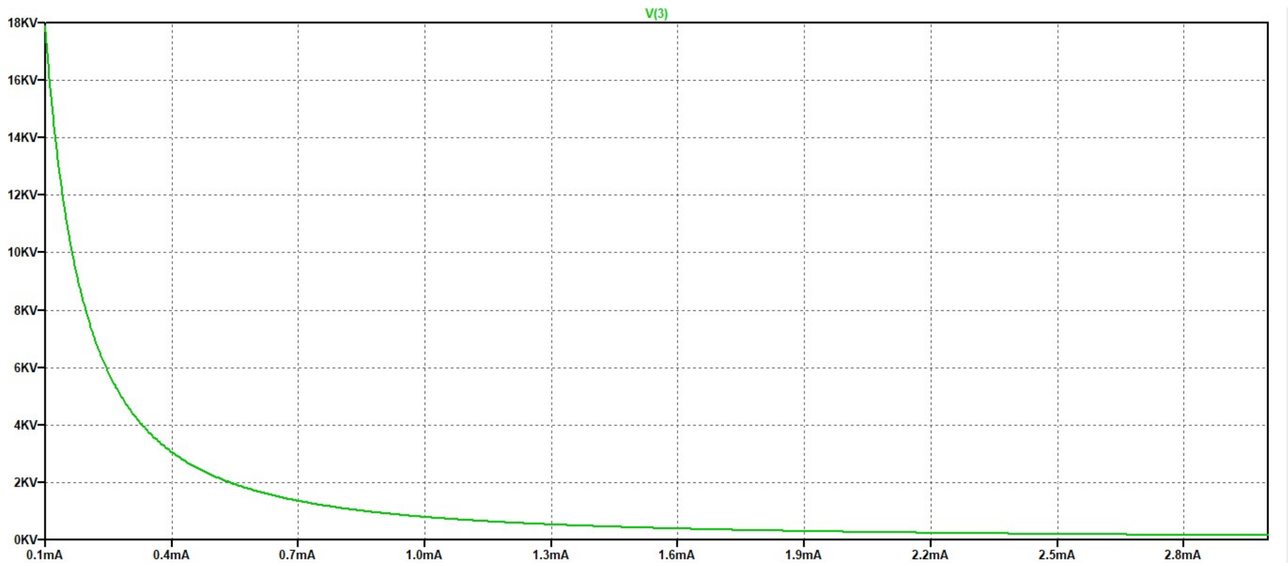

Figure 2: DC operating point simulation of photoresistor optocoupler circuit

The figure 2 above shows the DC operating point simulation results of the photoresistor optocoupler circuit. The circuit behaves like a current controlled resistor, whose value decreases with increase in the control current source value.

2 Voltage Divider

2.1 Aim

To obtain the DC operating point characteristics and transient simulation outputs of voltage divider circuit designed from photoresistor optocouplers.

2.2 Schematic

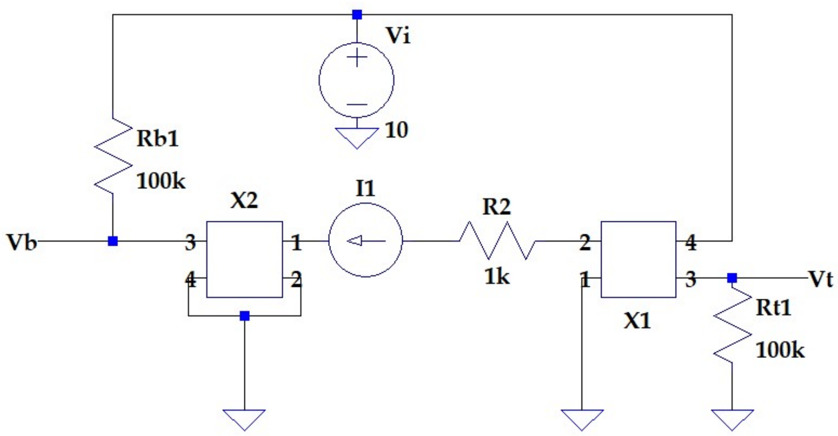

Figure 3: LTSpice schematic of voltage divider

2.3 DC operating point simulation

The figure 4 shows the DC operating point simulation results (outputs of the voltage divider V_t, V_b versus the driving current I1) of the voltage divider circuit. The circuit composes of two voltage dividers with a $100k\Omega$ resistor and a photoresistor each (one with the photoresistor at top and another with the photoresistor at bottom). X1 is the top photoresistor and X2 is the bottom photoresistor, both being driven by same current source I1.

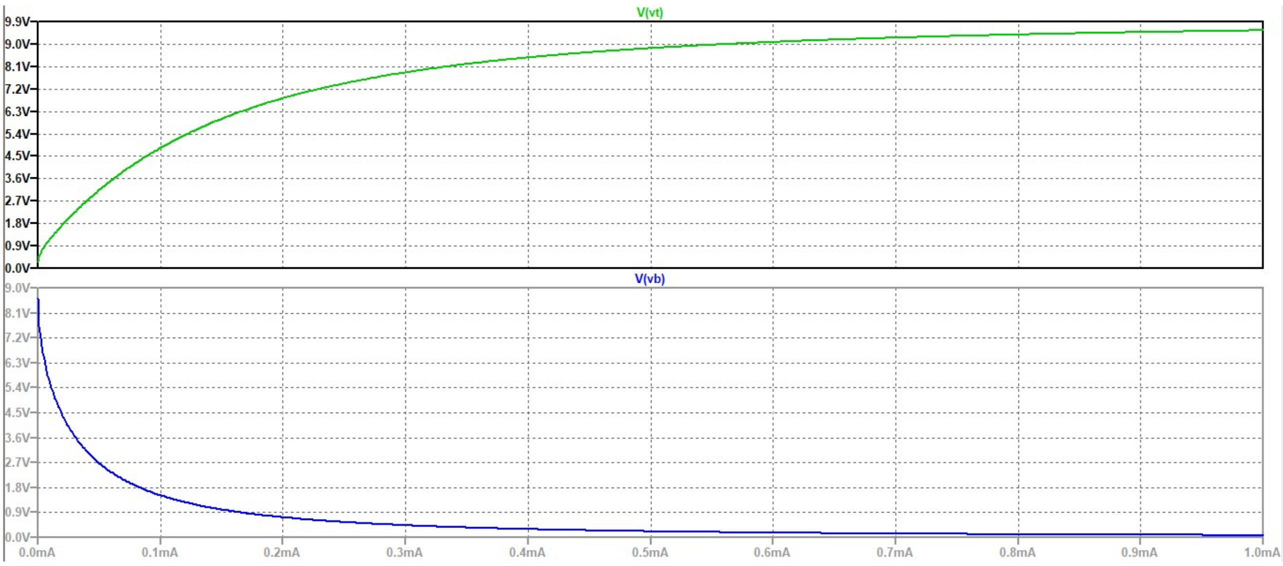

Figure 4: DC operating point simulation of voltage divider

2.4 Transient simulation results

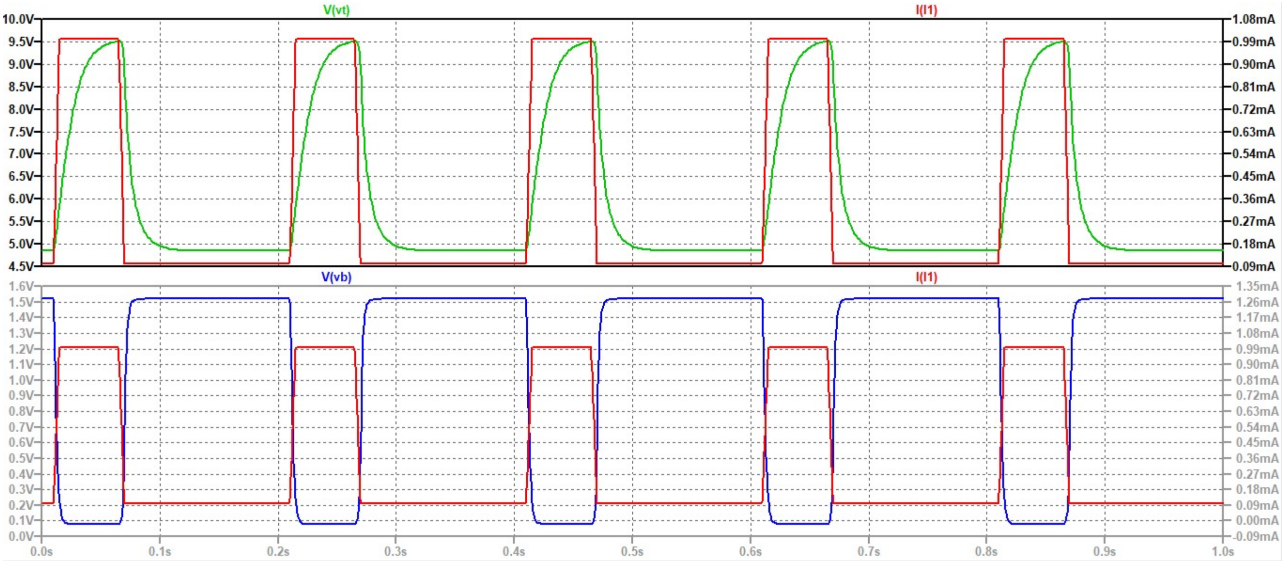

Figure 5: Transient simulation of voltage divider

The figure 5 shows the transient response of the voltage divider with a pulse current input of 200ms period and 25% duty cycle. The lower and upper limits of the current pulse are 0.1 mA and 1 mA respectively.

3 Voltage Controlled Oscillator

3.1 Aim

To perform transient simulation of voltage controlled oscillator circuit designed using photoresistor optocoupler.

3.2 Schematic

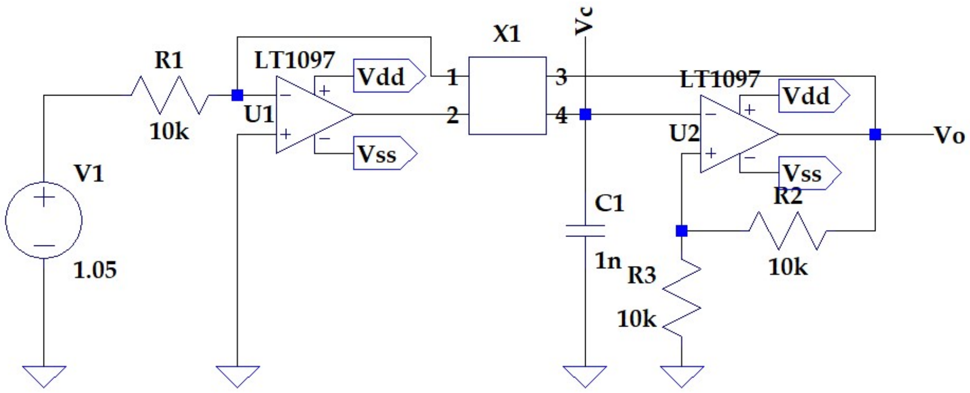

Figure 6: LTSpice schematic of voltage controlled oscillator

3.3 Transient simulation results

Figure 7 shows the transient simulation results of the voltage controlled oscillator. The obtained oscillation frequency is 8.293 kHz. It is to be noted that the value is not the same as the theoretical value, and also the output is not a square wave due to the slew rate limitations of the op-amp.

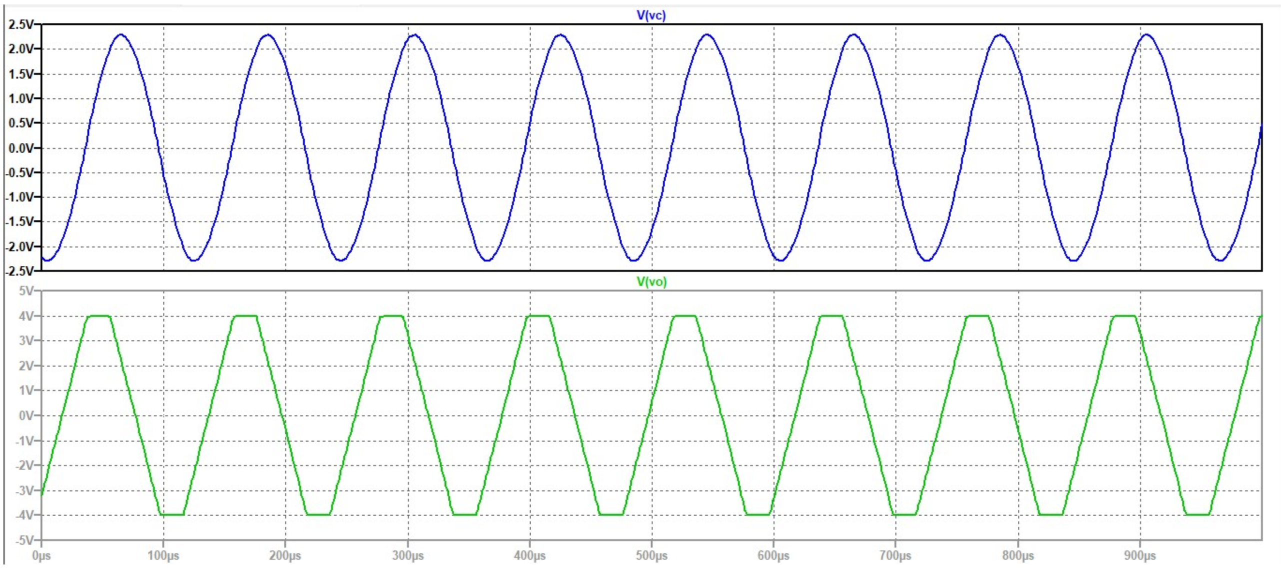

Figure 7: Transient simulation of voltage controlled oscillator

4 Voltage Controlled Amplifier

4.1 Aim

To obtain the closed loop and open loop characteristics of the voltage controlled amplifier circuit designed with photoresistor optocoupler.

4.2 Schematic

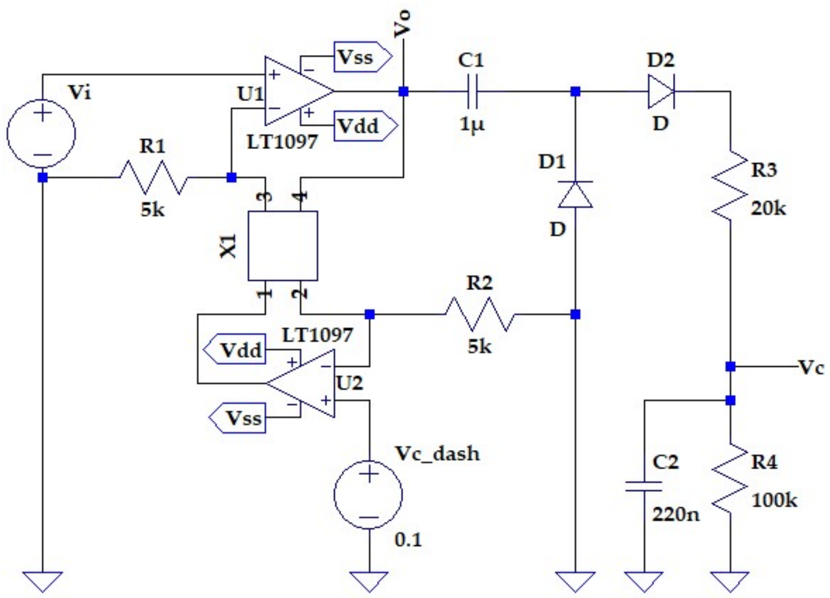

Figure 8: LTSpice schematic of voltage controlled amplifier in open loop

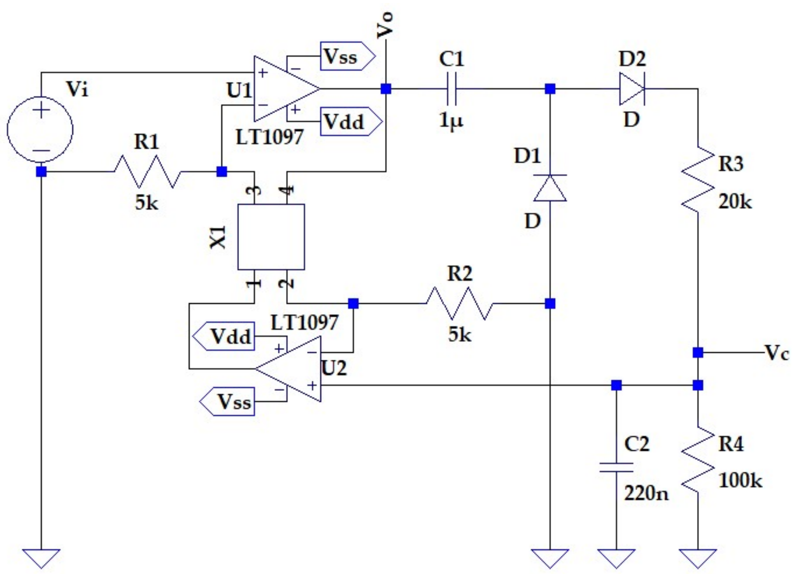

Figure 9: LTSpice schematic of voltage controlled amplifier in closed loop

4.3 Transient simulation - open loop

The figure 8 shows the open loop schematic of the voltage controlled amplifier. The voltage source Vc_dash($V_{c'}$) is used to control the gain of the circuit. The gain of the circuit versus Vc_dash is tabulated below.

$V_{c'}$	V_o	V_c	Gain
0.125	$0.311V$	$20\mu V$	31.09
0.25	$0.174V$	$0.136\mu V$	17.45
0.5	$90.5mV$	$6.47nV$	9.05
1	$45.3mV$	$0.941nV$	4.53
2	$23.8mV$	$0.23nV$	2.38
3	$17.67mV$	$0.123nV$	1.767
4	$15mV$	$87.95pV$	1.5
5	$13.5mV$	$71.5pV$	1.356

The figure 10 below shows the transient simulation results for a 10 mV, 500 Hz sinewave input with $V_{c'} = 0.5V$.

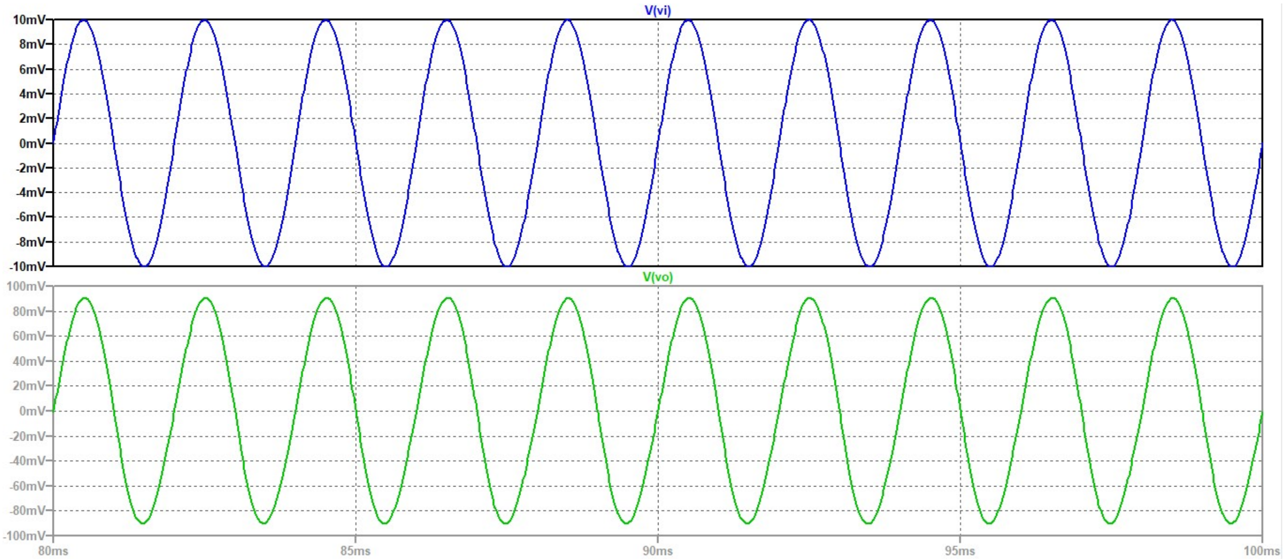

Figure 10: Open loop transient simulation of voltage controlled amplifier with $V_{c'} = 0.5V$

4.4 Transient simulation - closed loop

The figure 8 shows the open loop schematic of the voltage controlled amplifier. The voltage source Vc_dash($V_{c'}$) is used to control the gain of the circuit. The gain of the circuit versus Vc_dash is tabulated below.

$V_i(mV)$	V_o	V_c	gain
100	$0.946V$	$0.191V$	9.46
250	$1.266V$	$0.361V$	5.06
500	$1.642V$	$0.569V$	3.28
1000	$2.224V$	$0.900V$	2.22
2000	$3.212V$	$1.466V$	1.61
4000	$5.066V$	$2.538V$	1.27

The figure 11 shows the closed loop transient simulation waveforms of the voltage controlled amplifier (V_i, V_o, V_c) for 250 mV, 50 Hz sinewave input.

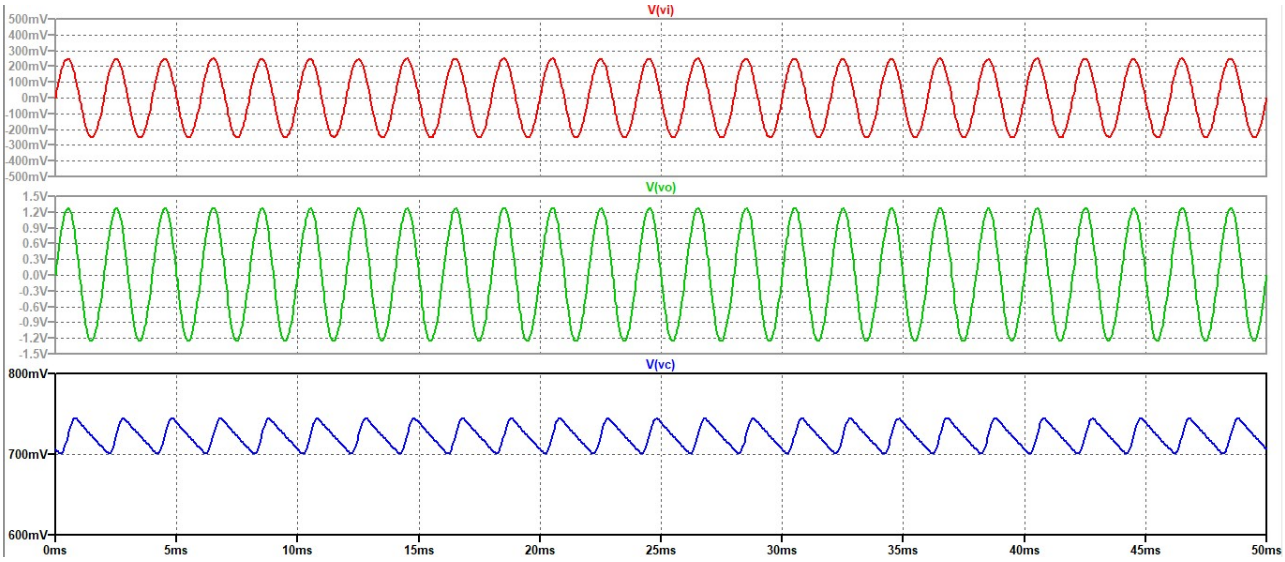

Figure 11: Closed loop transient simulation of voltage controlled amplifier with $V_i = 0.25V$

5 Conclusions

(1). The resistance of a photoresistor falls exponentially with the current through the LED (the intensity of light emitted by the LED). This property can be employed in audio applications and active gain compensated oscillators which require variable resistance.

(2). The voltage controlled oscillator output suffers from the slew rate limitations of the op-amp, causing mismatch in the frequency.

(3). The voltage controlled amplifier open loop gain falls exponentially with the control voltage.

(4). The voltage controlled amplifier in closed loop has a compression ratio given by

$$\frac{gain|_{V_i=0.1V}}{gain|_{V_i=4V}} = \frac{9.46}{1.27} = 7.45$$