How to Design Photodiode Amplifier Circuit

General Purpose Amplifiers

www.ti.com/general-amps

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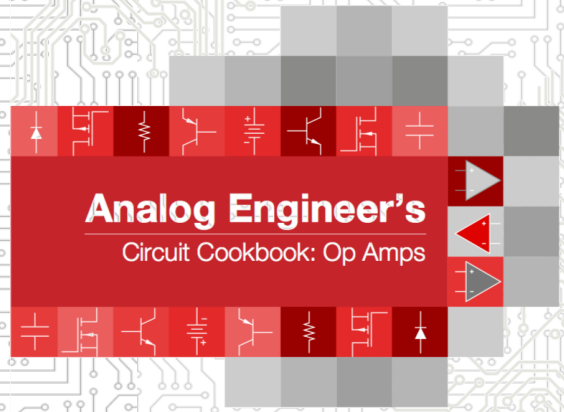
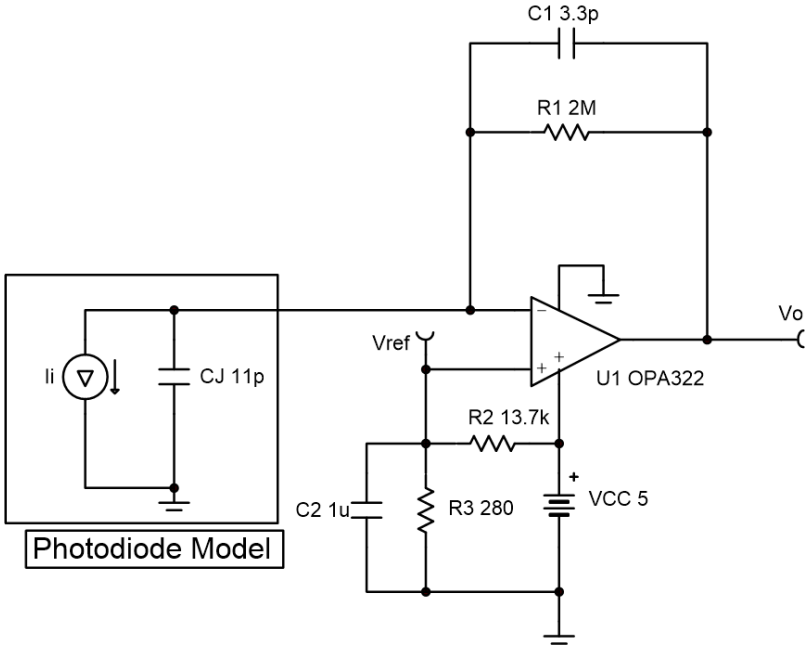


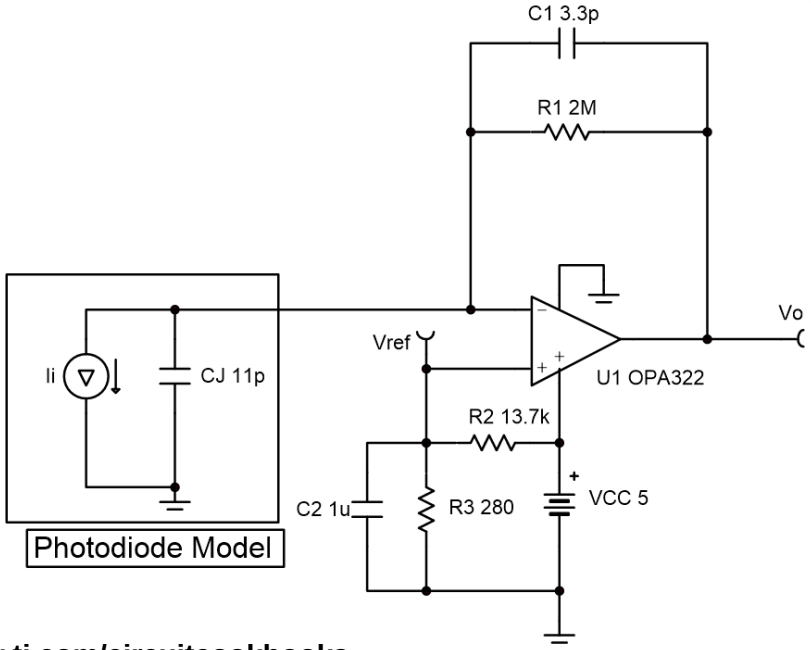
Circuit Description



$$V_o = I_i \times R_1 + V_{cc} \times \left(\frac{R_3}{R_2 + R_3} \right)$$

Design Steps

Input		Output		BW	Supply		
I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
0A	2.4µA	100mV	4.9V	20kHz	5V	0V	0.1V



Current to Voltage

Reference Voltage

$$V_o = I_i \times R_1 + V_{cc} \times \left(\frac{R_3}{R_2 + R_3}\right)$$

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Design Steps

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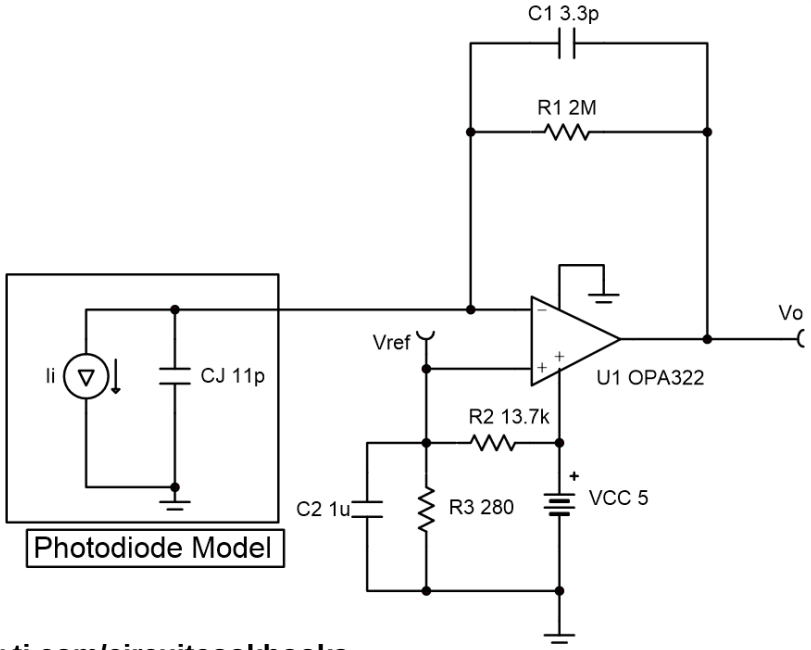

$$R_1 = \frac{V_{oMax} - V_{oMin}}{I_{iMax}}$$

$$R_1 = \frac{4.9V - 0.1V}{2.4\mu A} = 2M\Omega$$

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Design Steps

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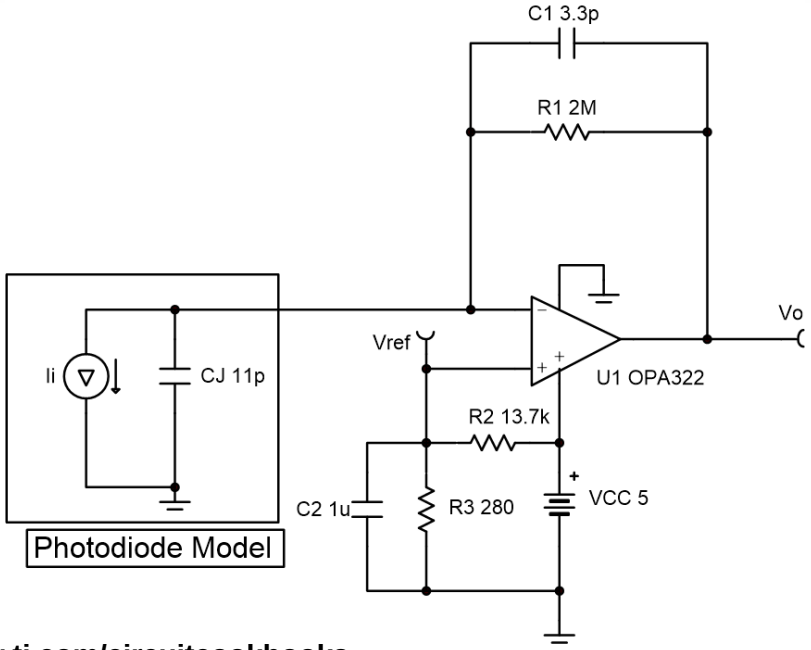

$$C_1 = \frac{1}{2 \times \pi \times R_1 \times f_p}$$

$$C_1 = \frac{1}{2 \times \pi \times 2M\Omega \times 20kHz} = 3.97pF$$

$$C_1 \rightarrow 3.3pF$$

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Design Steps

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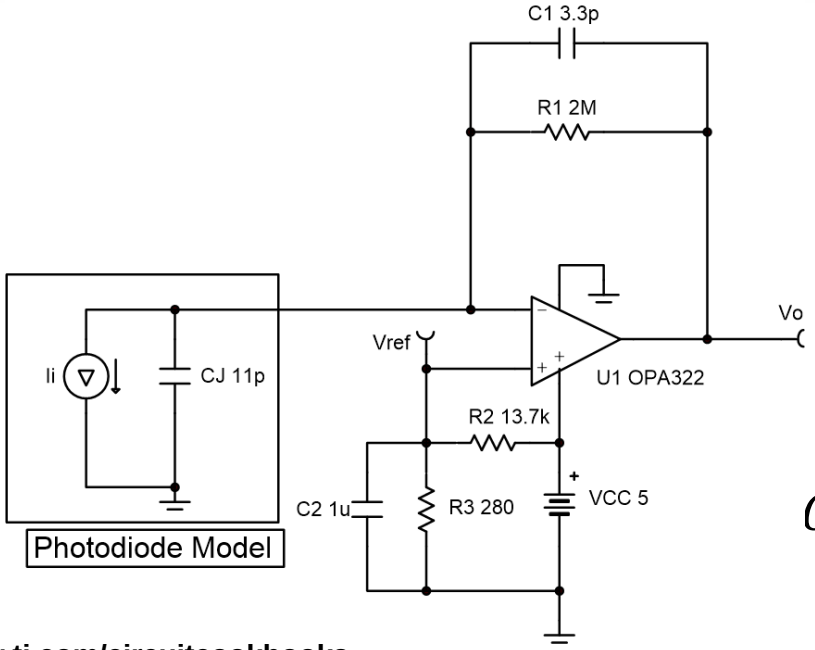

$$GBW > \frac{C_i + C_1}{2 \times \pi \times R_1 \times {C_1}^2}$$

$$C_i = C_j + C_d + C_{cm} = 20pF$$

$$GBW > \frac{20pF + 3.3pF}{2 \times \pi \times 2M\Omega \times 3.3pF^2} > 170kHz$$

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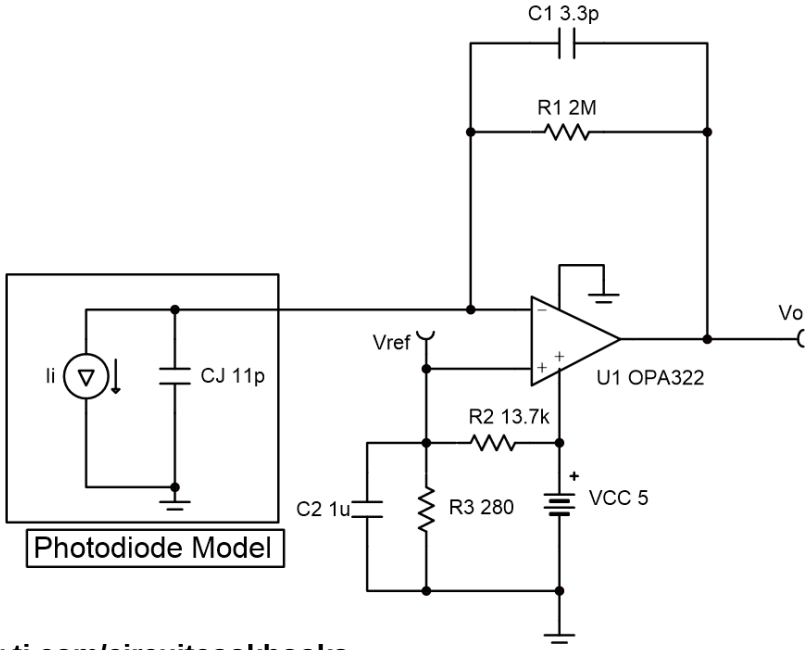
Design Steps

Input		Output		BW	Supply		
I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
0A	2.4µA	100mV	4.9V	20kHz	5V	0V	0.1V



$$R_2 = \frac{V_{cc} - V_{ref}}{V_{ref}} \times R_3$$

$$R_2 = \frac{5V - 0.1V}{0.1V} \times R_3 = 49 \times R_3$$

$$R_2 = 13.7k\Omega$$

$$R_3 = 280\Omega$$

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Design Steps

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I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
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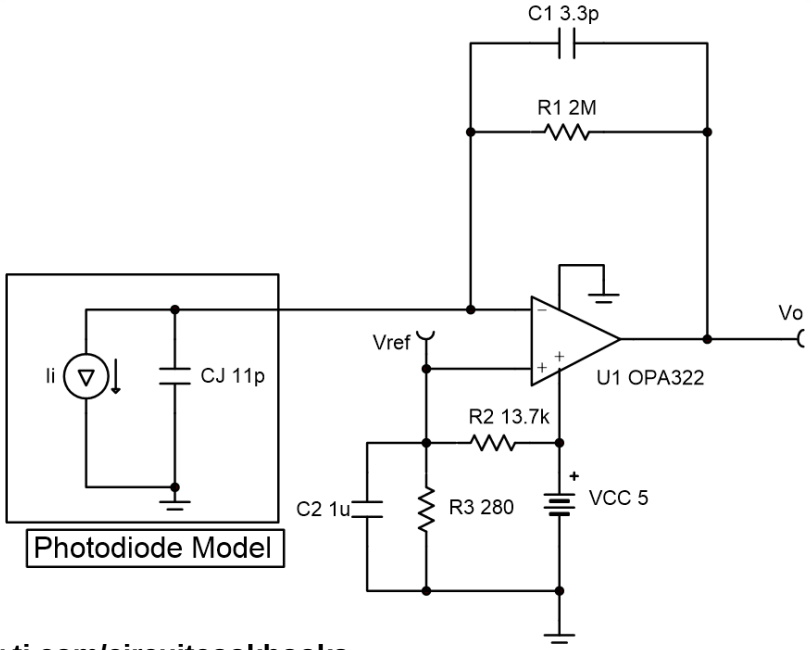

$$f_c = \frac{1}{2 \times \pi \times C_2 \times (R_2 || R_3)}$$

$$f_c = \frac{1}{2 \times \pi \times 1\mu F \times (13.7k\Omega || 280\Omega)}$$

$$f_c = 580Hz$$

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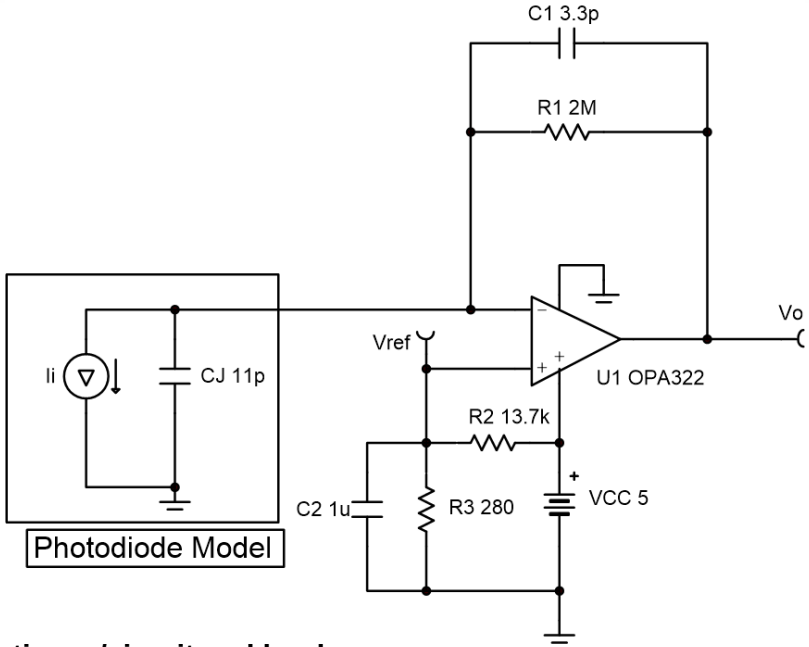
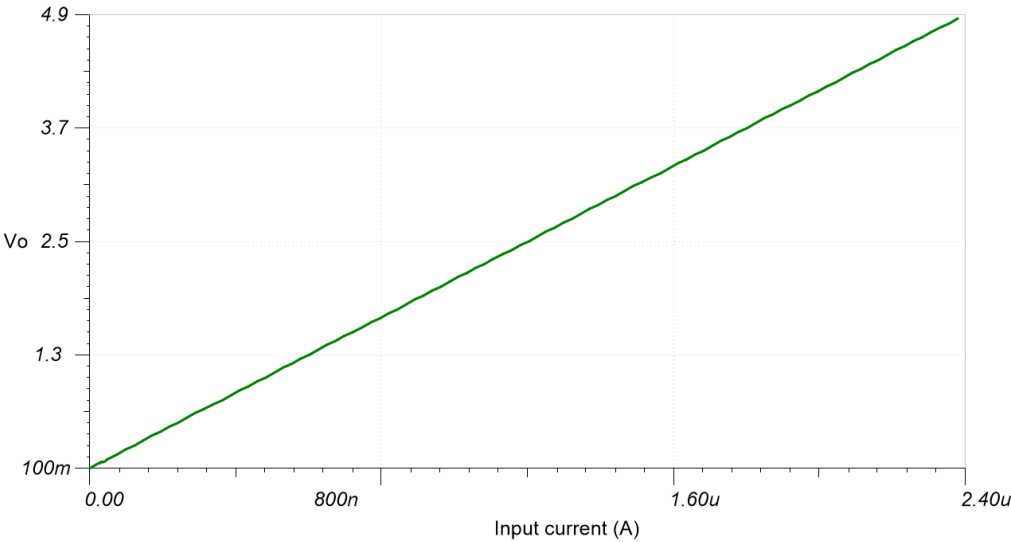
DC Results

Input		Output		BW	Supply		
I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
0A	2.4µA	100mV	4.9V	20kHz	5V	0V	0.1V





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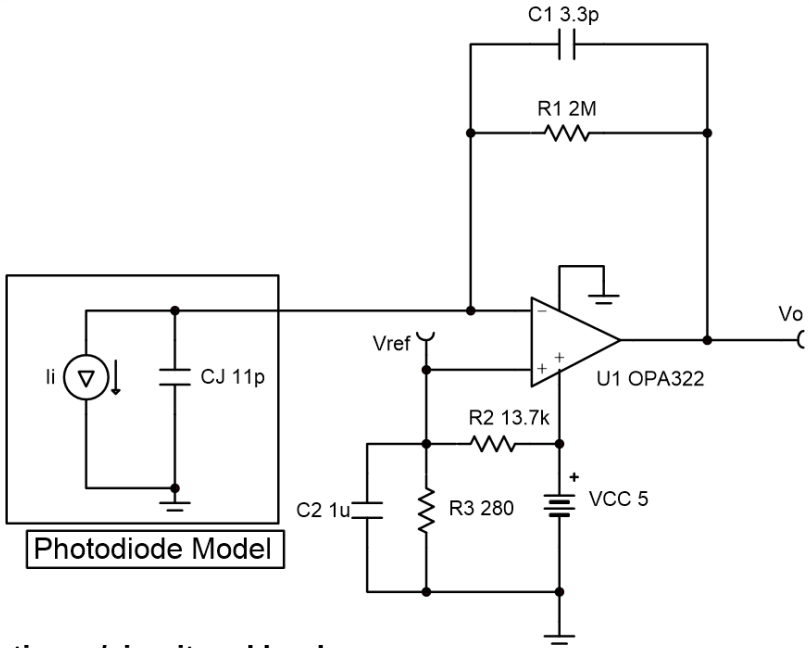
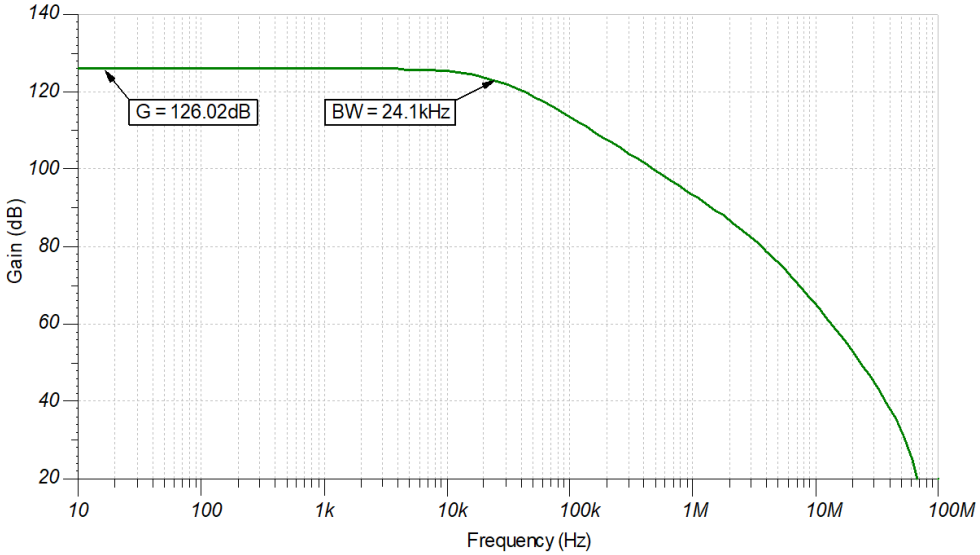
AC Results

Input		Output		BW	Supply		
I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
0A	2.4µA	100mV	4.9V	20kHz	5V	0V	0.1V





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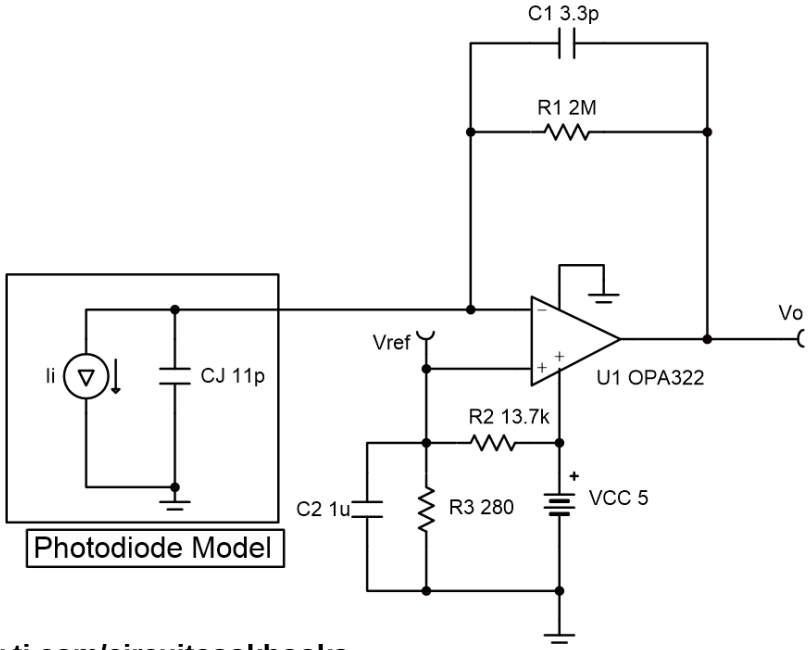
Design Notes

Input		Output		BW	Supply		
I_{iMin}	I_{iMax}	V_{oMin}	V_{oMax}	f_p	V_{cc}	V_{ee}	V_{ref}
0A	2.4µA	100mV	4.9V	20kHz	5V	0V	0.1V



Design Notes:

1. A bias voltage (V_{ref}) prevents the output from saturation at the negative power supply rail when the input current is 0A.
2. Use a JFET or CMOS input op amp with low input bias current to reduce DC errors.
3. Set the output range based on the linear output swing (See op amp A_{ol} specification).

Design Resources

EE Cookbook: Op Amp
www.ti.com/circuitcookbooks
Step-by-step circuit design of common op amp building block circuits.

TI Designs
www.TI.com/tidesigns
Ready-to-use reference designs with
theory, calculations, simulations
schematics, PCB files, bench test results

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