Position-sensitive device

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1 Introduction

2 Position-sensitive detector

[1]

Parameter	Symbol	Values		Unit
		Typical	Maximum	
Dark current	I_d	0.5	10	nA
Interelectrode resistance	R_e	7	15	kΩ
Terminal capacitance	C_t	150	300	pF

Table 1: Important parameters of the S5990 extracted from the datasheet [2].

3 Preamplifier

The photocurrents created by our detector are in the range of microampere where they are vulnerable to noise. Using a preamplifier, we can increase the amplitude of the signal for an improved signal-to-noise ratio. The typical photocurrent preamplifier is based on the transimpedance (current-to-voltage) amplifier design using a voltage-feedback operational amplifier. Converting the current to a voltage signal has the benefit that the voltage signal can be easily visualized with an oscilloscope. Furthermore, the voltage-feedback operational amplifier design appears to be more common than the current-feedback operational amplifier, as manufacturers offer much more choice and they are more prominent in the literature. That said, current feedback operational amplifiers are reported to be a viable solution for high-speed and high-bandwidth applications, see Ref. [3, p. 110] for an overview of the benefits of current feedback amplifiers and Ref. [4, Ch. 9] for a comparison.

3.1 Gain

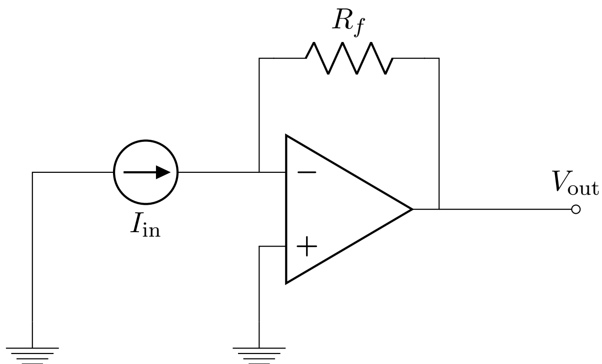
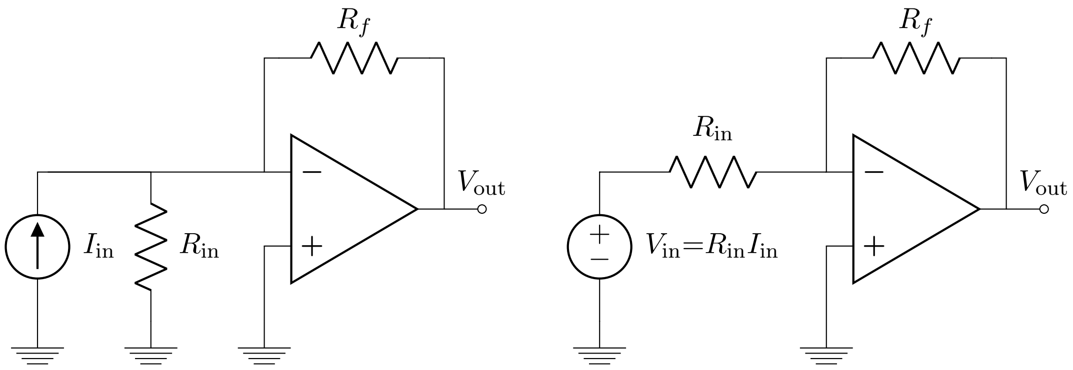


Figure 1: Simple transimpedance amplifier circuit.

$$V_{\mathrm{out}} = R_f I_{\mathrm{in}} \tag{1}$$



(a) Transimpedance amplifier.

(b) Inverting amplifier.

Figure 2: Equivalence between transimpedance and inverting amplifier using source transformation.

3.2 Offset

3.2.1 Input offset voltage

[3, p. 54]

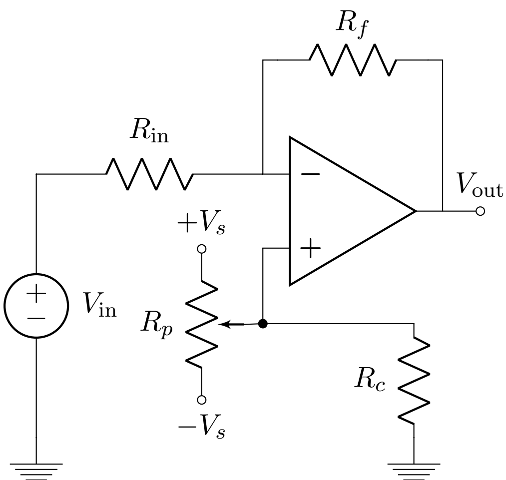
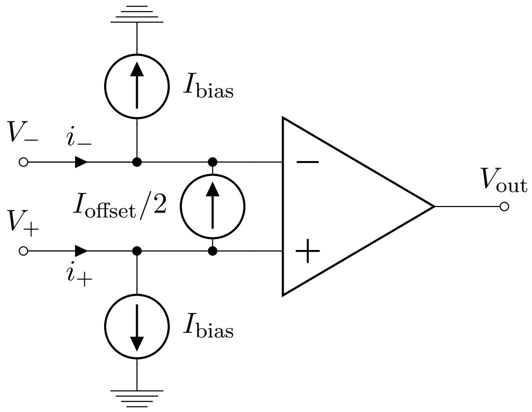
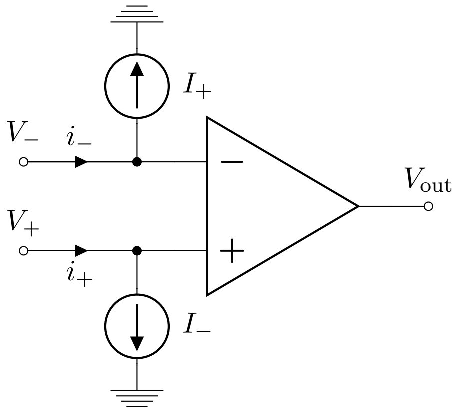


Figure 3: Input current offset compensation.

3.2.2 Input bias current



(a) Equivalent current sources as reported in the datasheet.



(b) Alternative equivalent current sources.

Figure 4: Non-zero input current from the operational amplifier.

$$I_+ = I_{\text{bias}} + \frac{1}{2} I_{\text{offset}} \qquad I_{\text{offset}} = I_+ - I_- \tag{2}$$

$$I_- = I_{\text{bias}} - \frac{1}{2} I_{\text{offset}} \qquad I_{\text{bias}} = \frac{I_+ + I_-}{2} \tag{3}$$

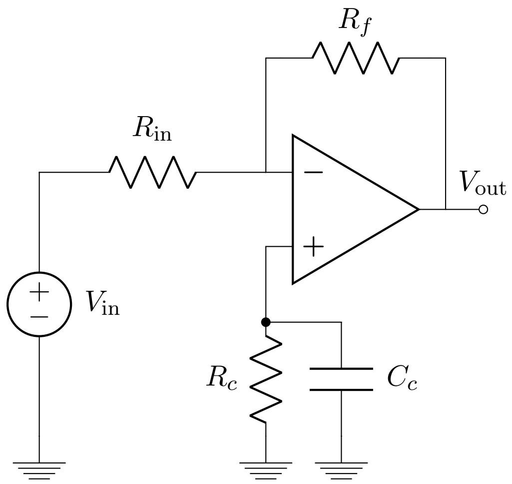


Figure 5: Input current offset compensation.

[3, p. 57] [5, p. 25]

$$R_c = \frac{R_{\text{in}} R_f}{R_{\text{in}} + R_f} \tag{4}$$

3.3 Noise

3.4 Stability

[6, p. 693] [7, p. 183] [4, Ch. 5] [5, Ch. 3]

Glossary

S5990 Hamamatsu two-dimensional PSD. 3

References

[1] Date Noorlag. "Lateral-photoeffect position-sensitive detectors". PhD thesis. Delft University of Technology, 1974.

[2] *S5990 2D PSD*. Hamamatsu. URL: `https://www.hamamatsu.com/resources/pdf/ssd/s5990-01_etc_kpsd1010e.pdf` (visited on 03/03/2019).

[3] Walt Jung. *Op Amp Applications Handbook*. Elsevier, 2005. ISBN: 9780750678445.

[4] Ron Mancini Bruce Carter. *Op Amps for Everyone*. Elsevier, 2002. ISBN: 9780750677011.

[5] Jerald Graeme. *Photodiode Amplifiers. Op Amp Solutions*. McGraw Hill Professional, 1996. ISBN: 9780070242470.

[6] Philip Hobbs. *Building Electro-Optical Systems. Making it all Work*. John Wiley & Sons, 2011. ISBN: 9781118211090.

[7] Art Kay. *Operational Amplifier Noise. Techniques and Tips for Analyzing and Reducing Noise*. Elsevier, 2012. ISBN: 9780750685252.