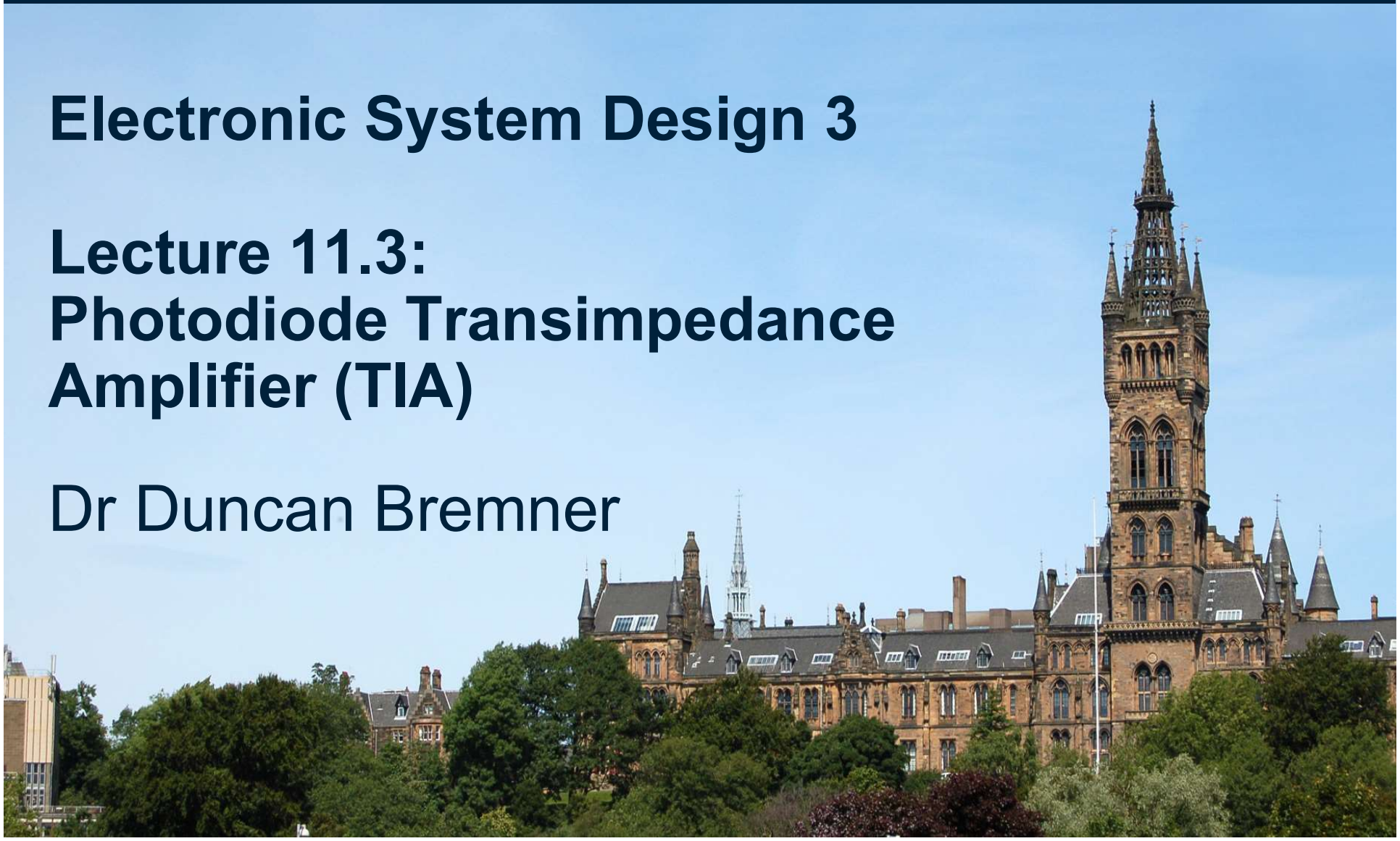
University of Glasgow

Electronic System Design 3

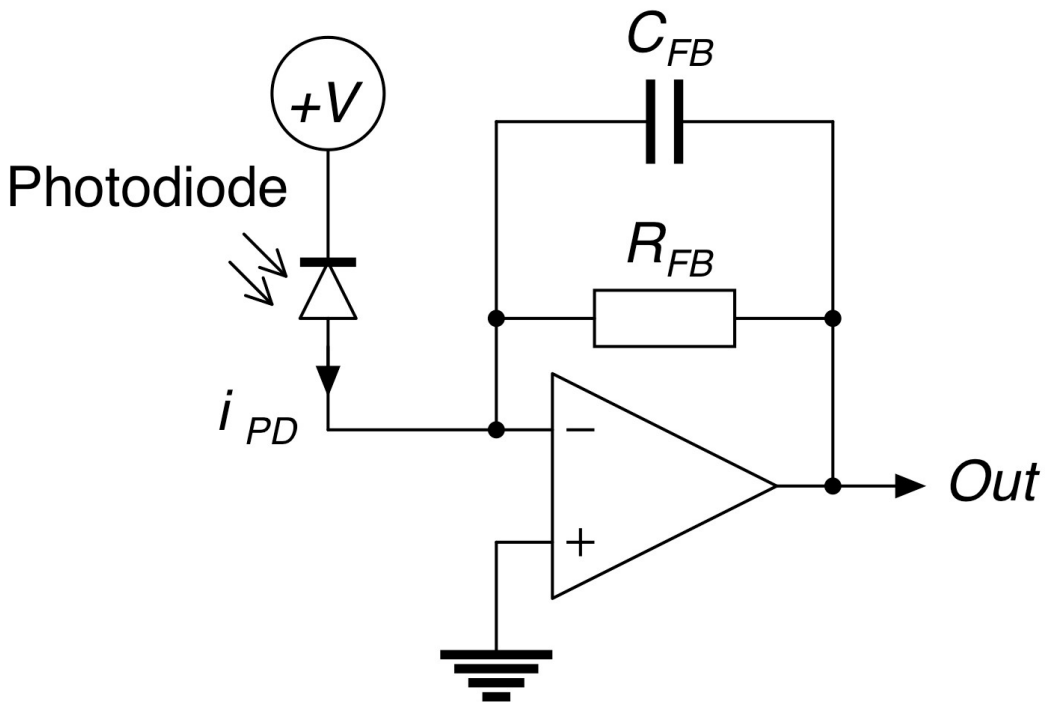
Lecture 11.3: Photodiode Transimpedance Amplifier (TIA)

Dr Duncan Bremner



Design 3

Current amplifier (photodiode amp)



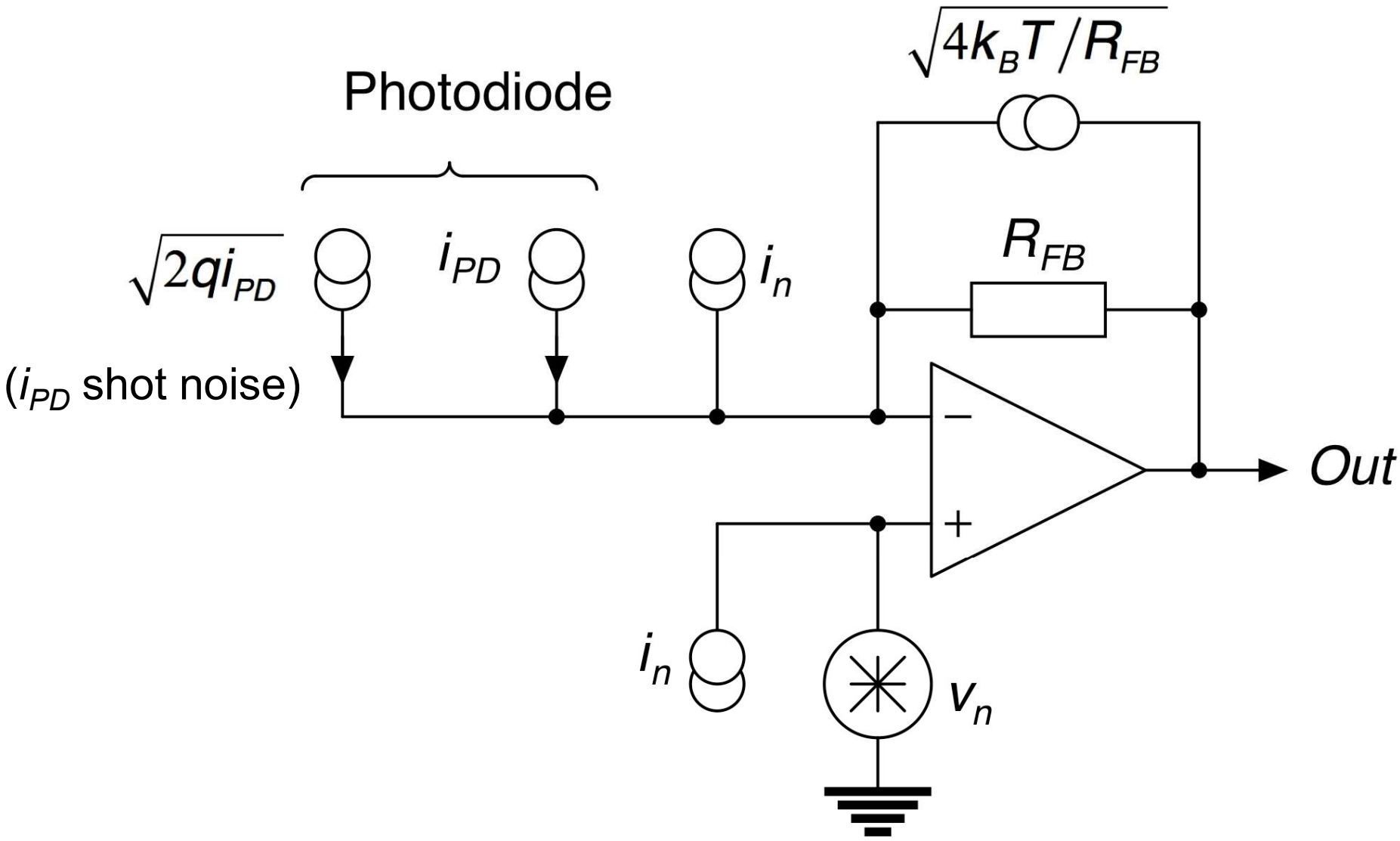
Notes:

- Photodiode is ≈ constant current source
- C_{FB} is **necessary** for stability: use 1pF 👀 (Ignore for this analysis)
- Photodiode has full shot noise

Design 3 (2)

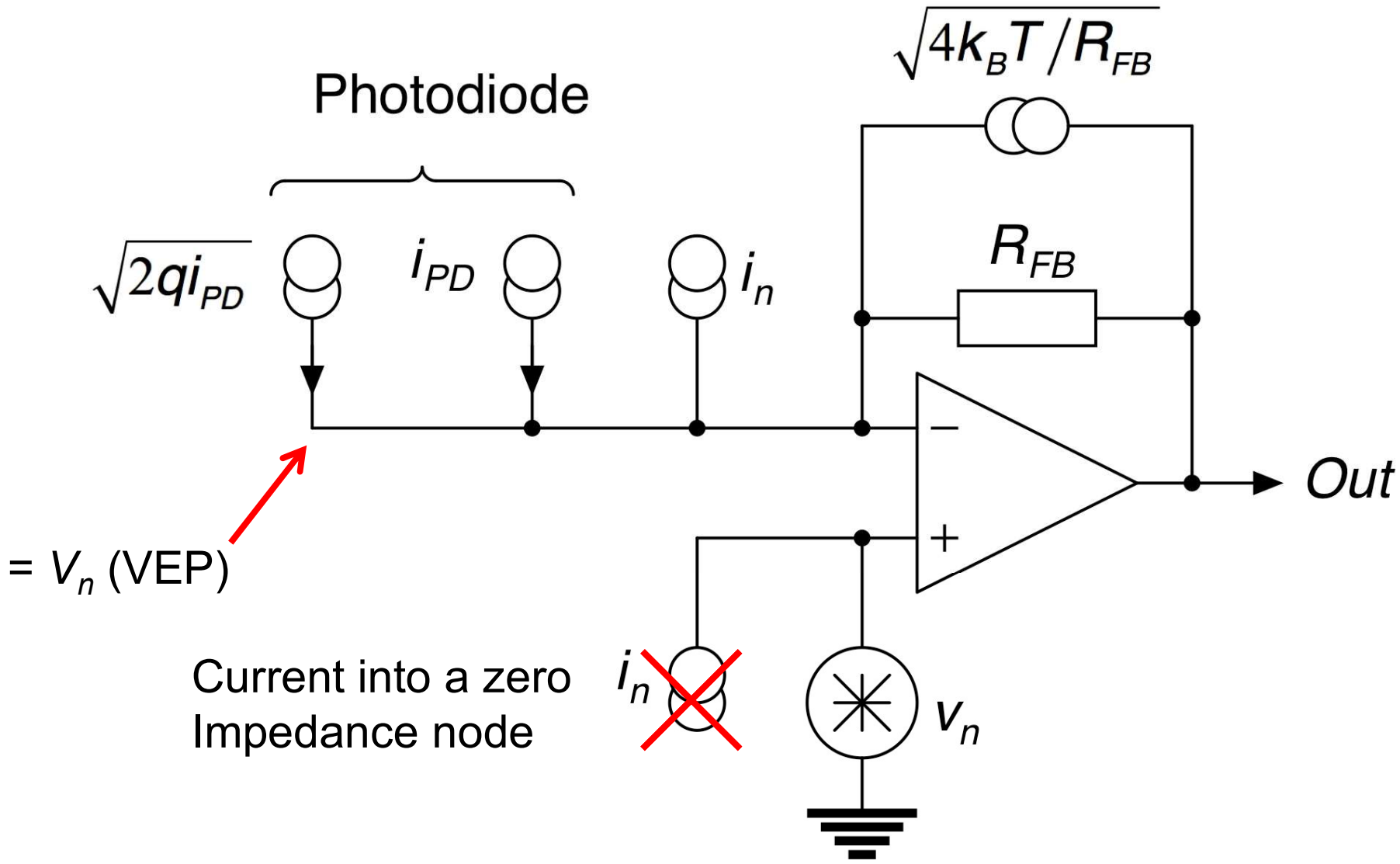
(R_{FB} thermal)

Re-draw to include all noise sources



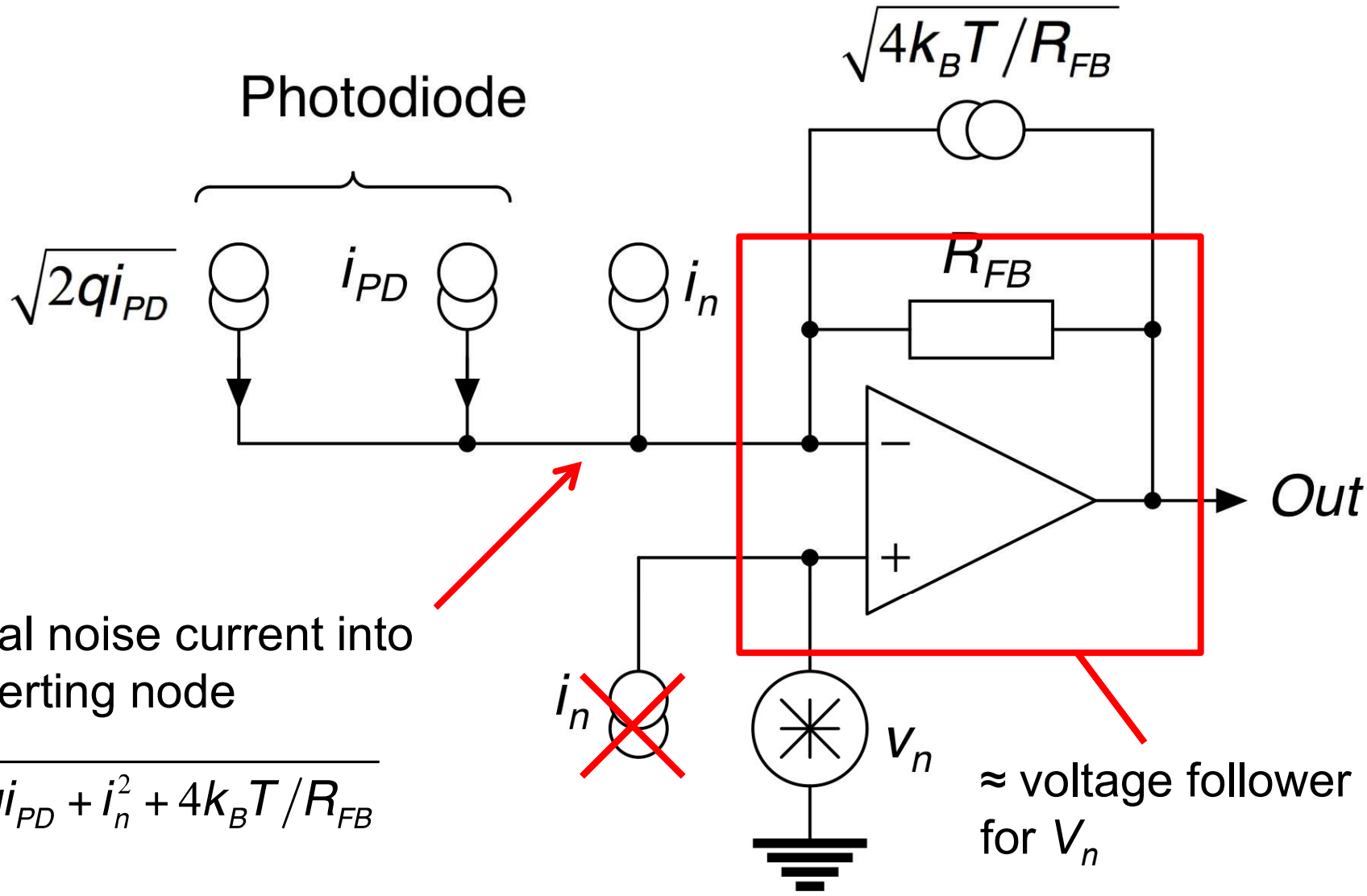
Re-draw to include **all** noise sources

Design 3 (2)



Design 3 (2)

Re-draw to include all noise sources



Design 3 (3)

Hence total noise RTI is total current noise through R_{FB} + v_n / R_{FB}
Added as uncorrelated noise sources:

$$i_n(RTI) = \sqrt{\frac{v_n^2}{R_{FB}^2} + 2qi_{PD} + i_n^2 + \frac{4k_BT}{R_{FB}}}$$

As the shot noise is the fundamental limit for the measurement of photodiode current, for low noise we require that

$$2qi_{PD} >> \frac{v_n^2}{R_{FB}^2} + i_n^2 + \frac{4k_BT}{R_{FB}}$$

Amplifier noise

Resistor noise

Hence $R_{FB} >> \frac{4k_BT}{2qi_{PD}}$

For i_{PD} = 100nA; then R_{FB} >> 510kΩ

Noise Analysis: Summary

Convert detailed circuit to noisy amplifier model

Uncorrelated noise sources add as sum of squares $v_{tot} = \sqrt{v_1^2 + v_2^2 + \cdots v_n^2}$

Largest source will dominate : $\sqrt{2^2 + 1^2} = 2.23$ -> Intuition!

Voltage = noise spectral density $\cdot$ $\sqrt{\text{bandwidth}}$

Noise Figure $= 20 \cdot \log_{10} \frac{v_{ni}}{v_{Th}}$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Thank you
谢谢
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