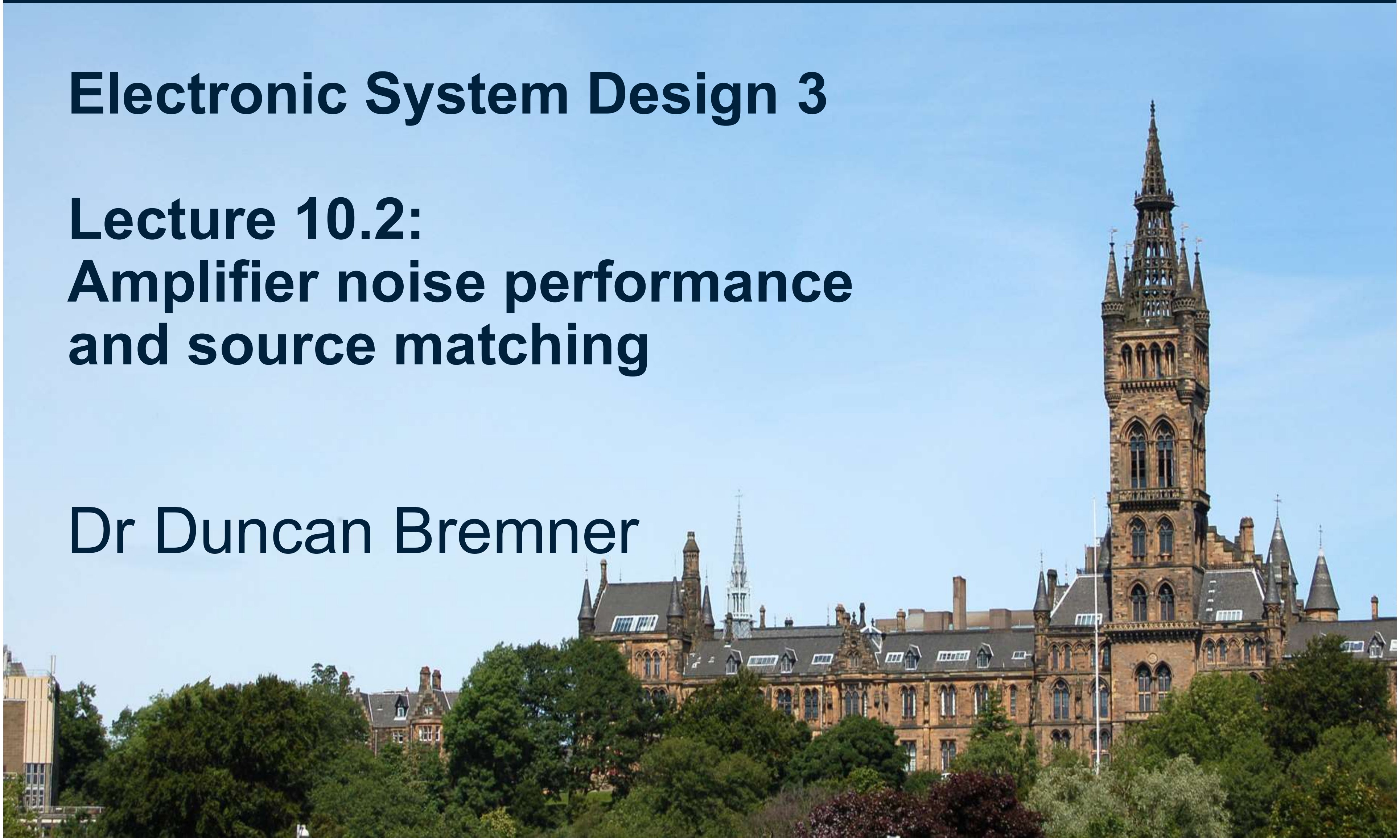
Electronic System Design 3

Lecture 10.2:
Amplifier noise performance and source matching



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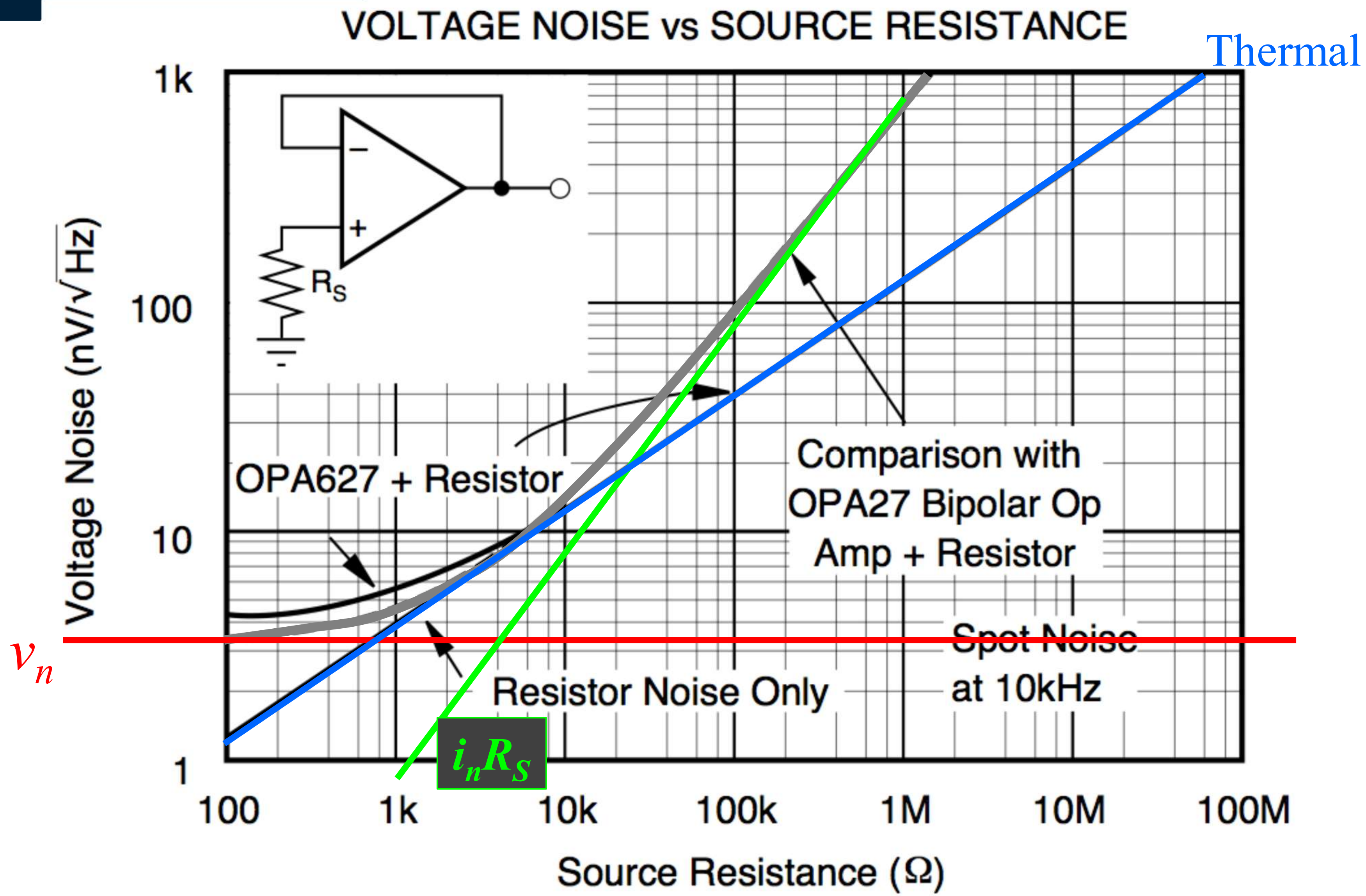
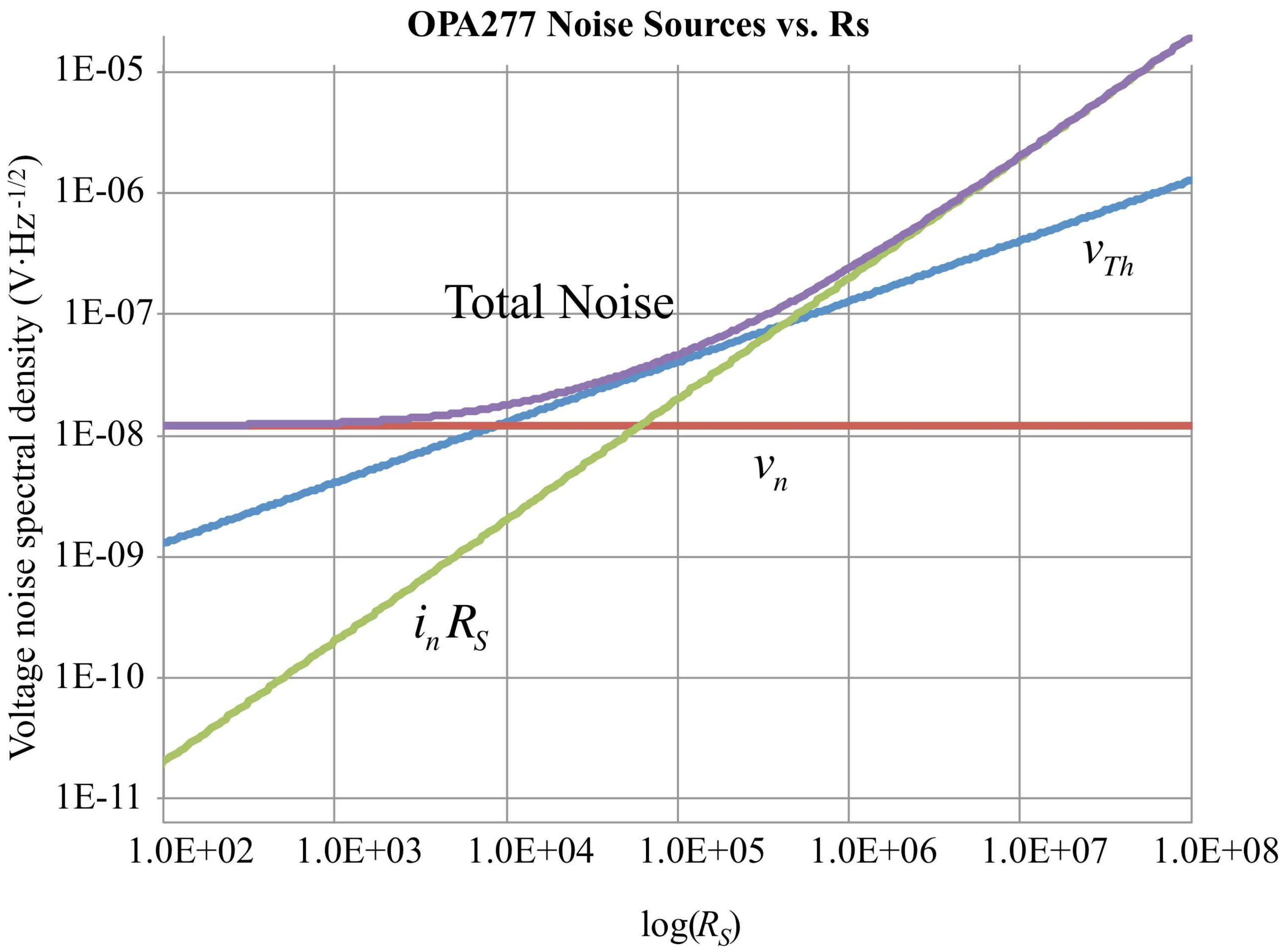
…more real Amplifiers



OPA277 Noise Performance



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Noise Figure

All amplifiers add noise to the thermal noise of the source

$$\sqrt{4k_B T R_S} < \sqrt{4k_B T R_S + i_n^2 R_S^2 + v_n^2} = v_{ni}$$

The "goodness" of the amplifier is how **little** it makes things worse.

$$\text{Define } NF \equiv \frac{v_{ni}}{\sqrt{4k_B T R_S}}$$

Usually expressed in dB

$$NF = 20\log_{10}\left(\frac{v_{ni}}{\sqrt{4k_B T R_S}}\right) dB$$

Always > 0

Noise figure

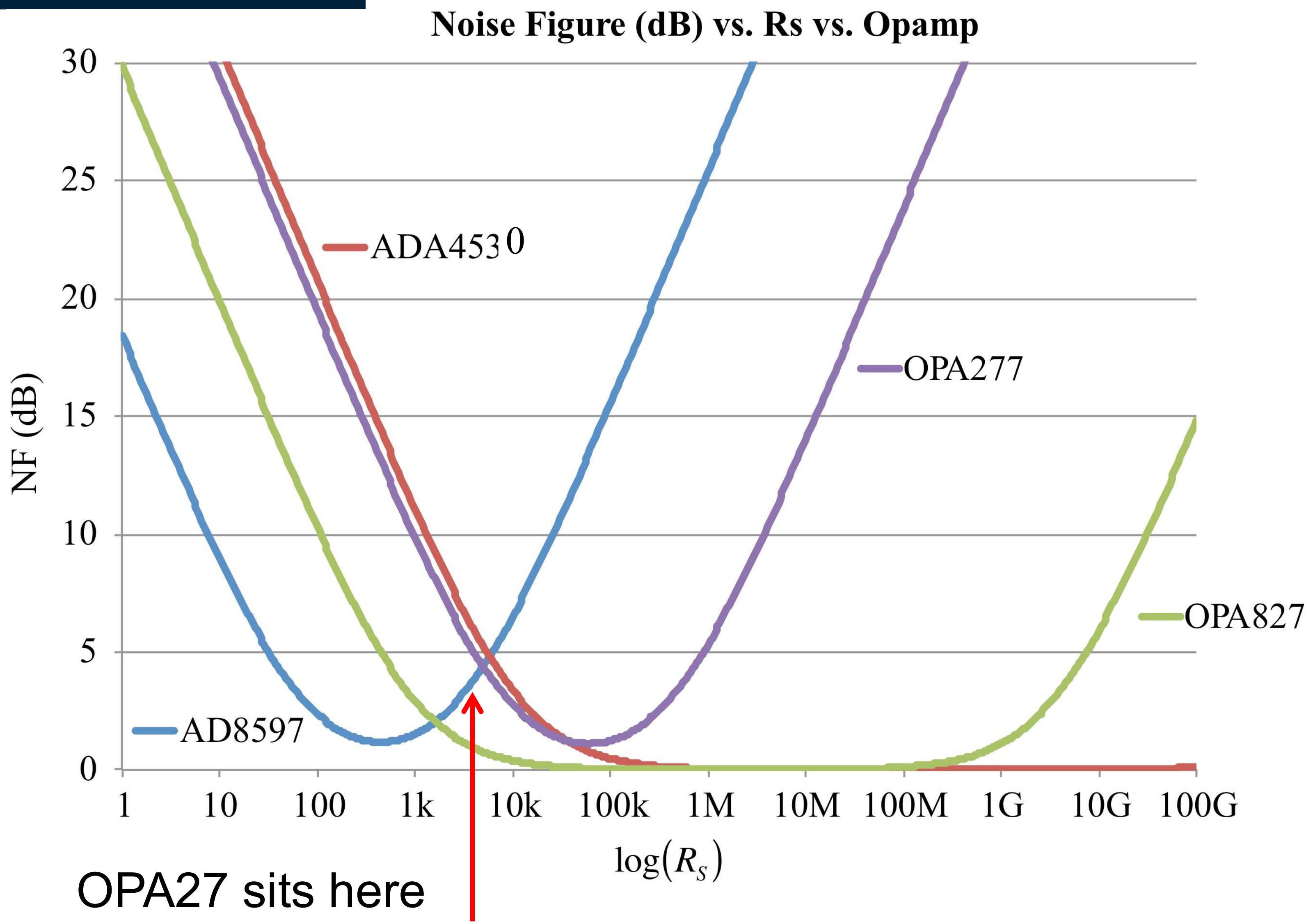
The noise figure depends on the amplifier **and** the source resistance

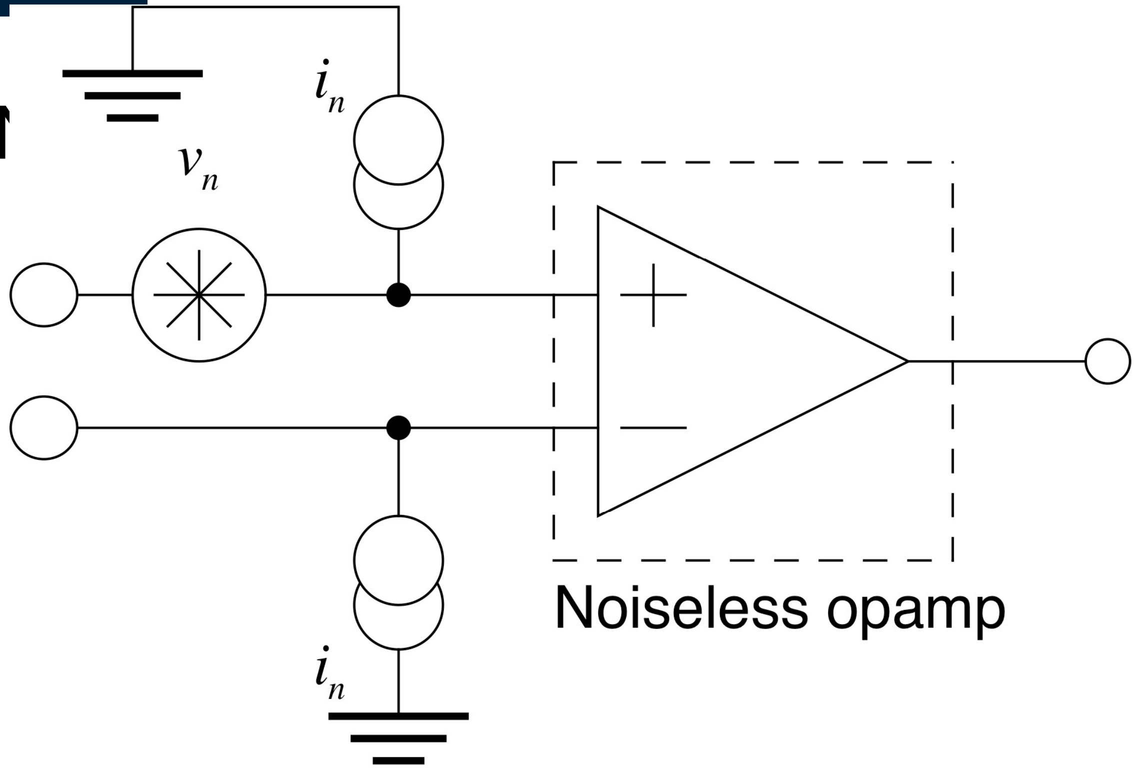
There is **no** "best" opamp, it depends on what it is being used for.

Four excellent opamps:

Opamp	$v_n\,(\mathrm{nV \cdot Hz^{-1/2}})$	$i_n\,(\mathrm{fA \cdot Hz^{-1/2}})$	R_{OPT}
AD8597	1.07	2400	446Ω
ADA4530	14	0.07	200MΩ
OPA827	4	2.2	1.82MΩ
OPA277	12	200	60kΩ

Source Resistor matching





Note that the two i_n sources are uncorrelated: **Add as squares**

Note that the sources go in the same place as bias current and offset voltage

Shot Noise

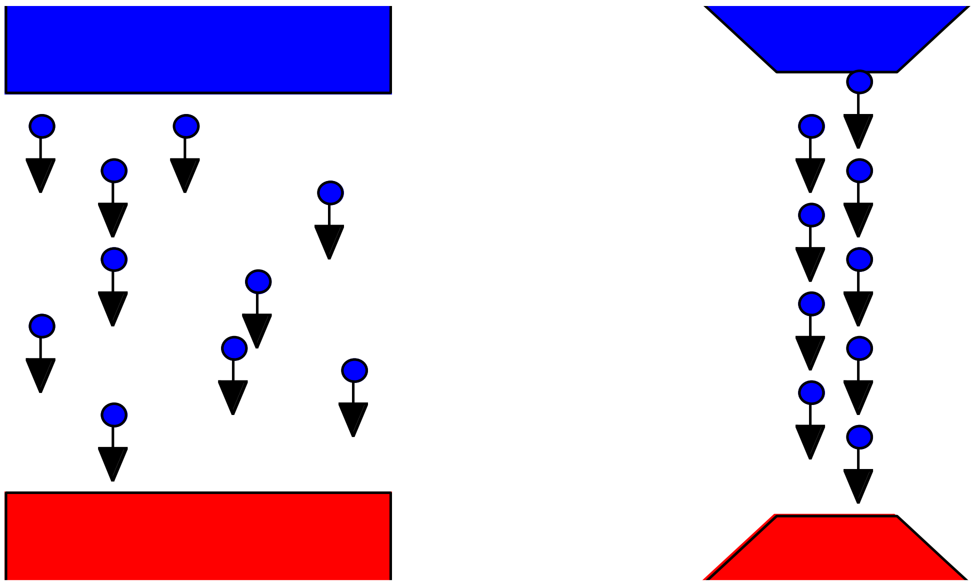
Due to electrons crossing a potential barrier

- Charge is quantized
- Emission is uncorrelated

Photodiode

Base current

Diode current



Metal film resistor

Uncorrelated | Correlated

Shot Noise | No Shot Noise

Shot Noise (2)

$$i_{sh} = \sqrt{2qI_{DC}B}$$

q = electron charge

I_{DC} = DC current flow

B = Bandwidth (Hz)

Shot noise **only occurs** when current is flowing

Shot noise **increases** with current

$$\text{Signal : Noise ratio} = \frac{I_{DC}}{i_{sh}} = \sqrt{\frac{I_{DC}}{2qB}} \text{ improves with } I_{DC}$$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Thank you
谢谢
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