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Electronic System Design 3
Lecture 7.1: Instrumentation Amps and Common Mode Rejection

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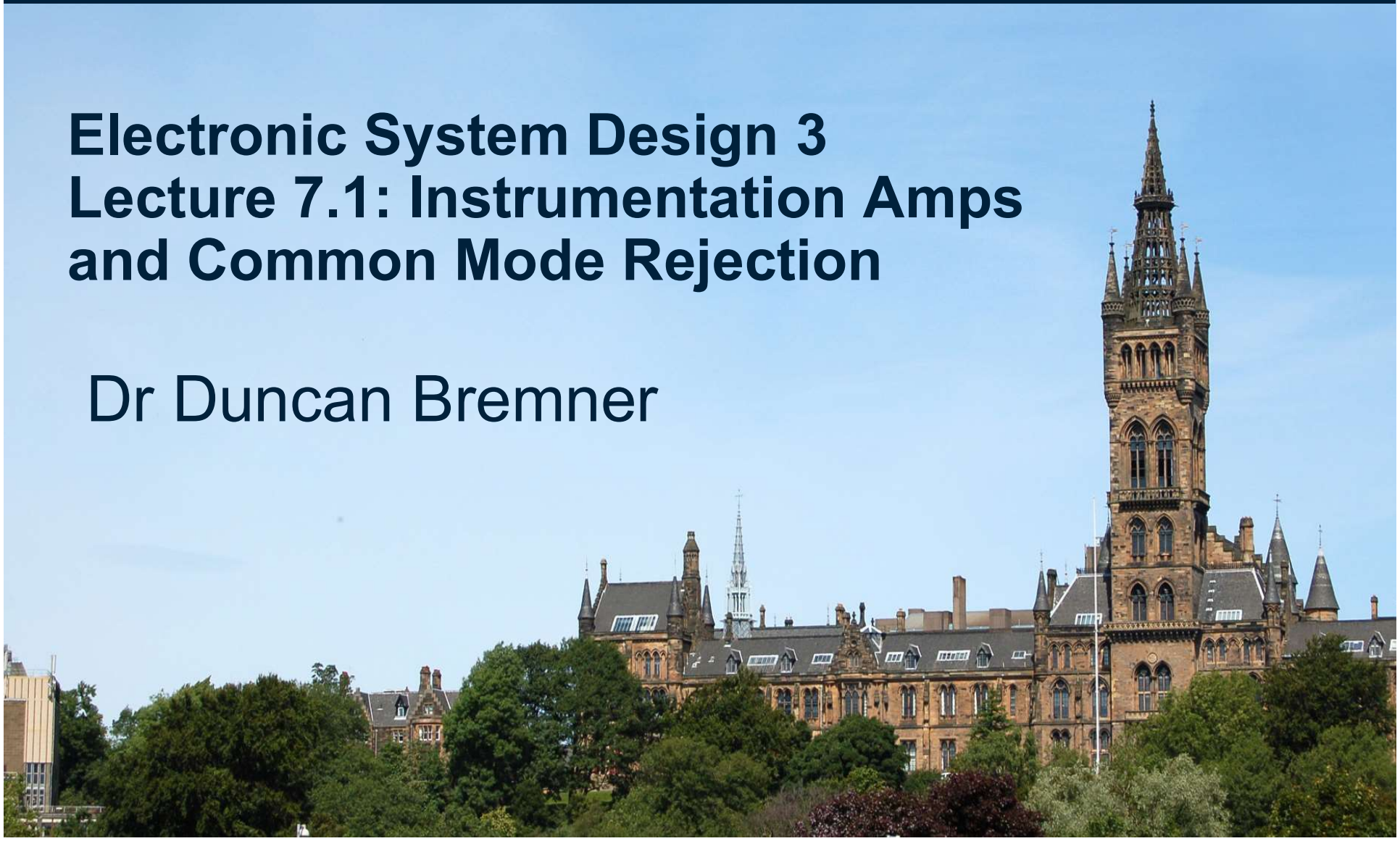


…From previous lecture

Common-Mode Rejection

Problem with previous circuit is that ground is a signal level...

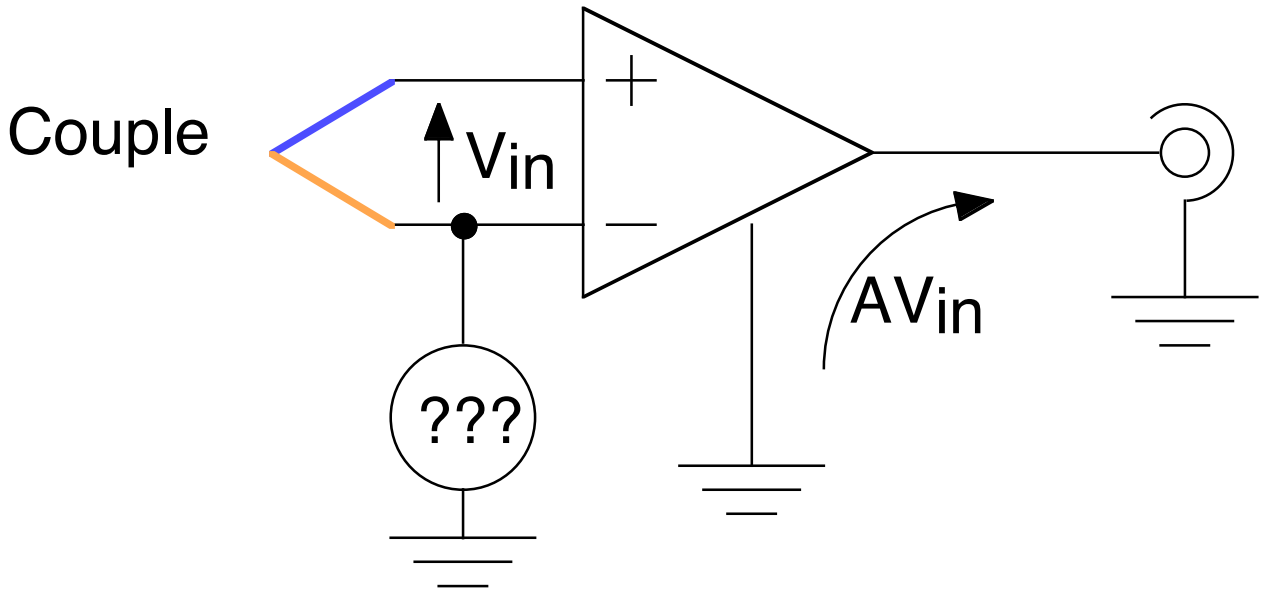
And a sewer for random stray currents

Use PLAN B

Measure the **difference** between the two leads and let them vary with respect to "Ground" however they like

Common-Mode Rejection (2)

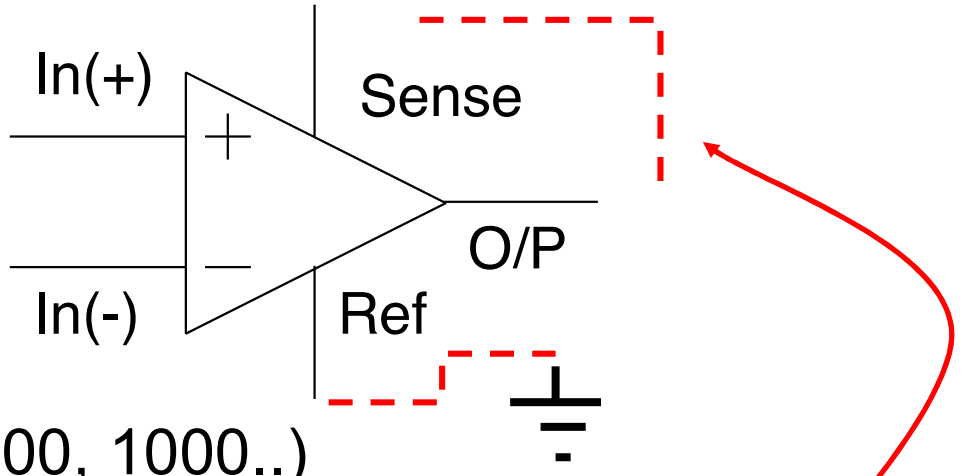
Component “X” = Instrumentation Amplifier



Component X

- Has a big gain (O/P is big, so no more problems)
- Doesn't care what ground potential “???” Is
  = Common-mode rejection
- Produces an output voltage with respect to an explicit third (output ground) input

Perfect Instrumentation Amplifier



- Gain is finite (e.g. 100, 1000..)
- Gain is pure differential (Function of In(+)–In(–) only)
- Gain is ideally ZERO for pure common-mode signals
- "Sense" is feedback connection.
- ‘Ref’ is <u>usually</u> Ground

If "Sense" connected to "O/P”

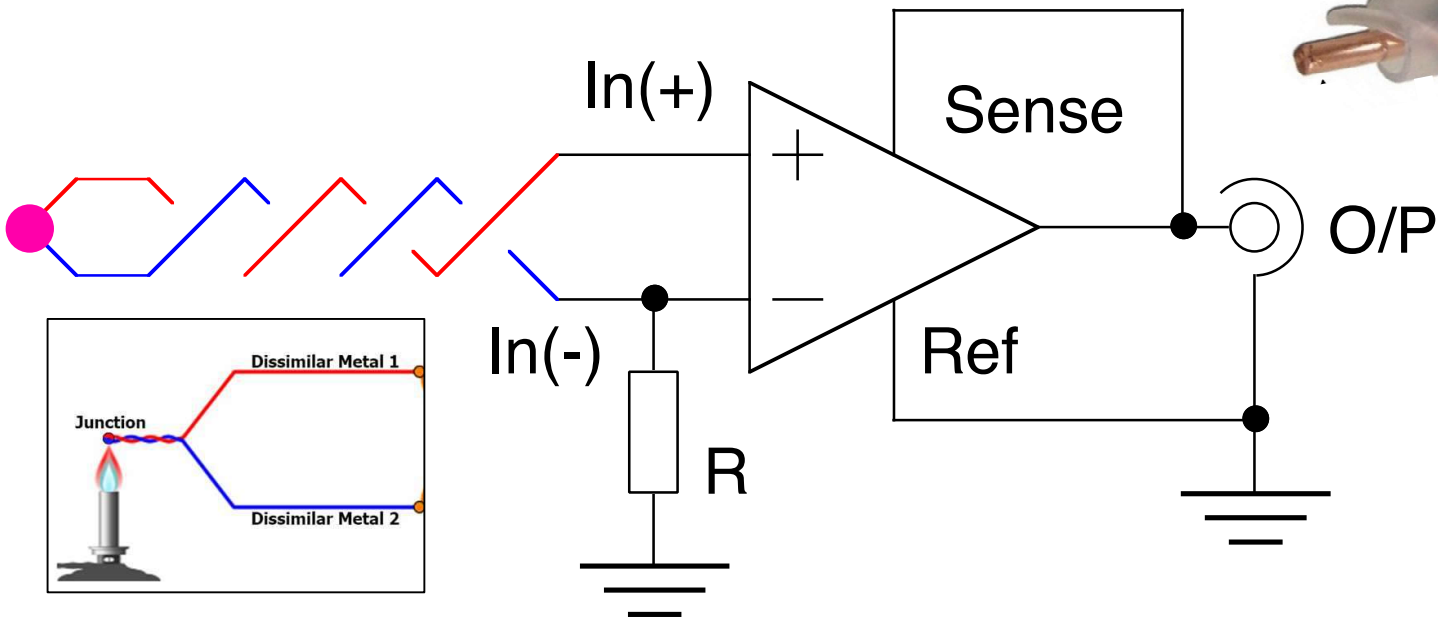
$$(\mathrm{O/P} - \mathrm{Ref}) = A_V(\mathrm{In(+)} - \mathrm{In(-)}) + A_{CM}\left(\frac{\mathrm{In(+)} + \mathrm{In(-)}}{2}\right)$$

Only if ‘Perfect’ Inst Amp; Acm = 0

(Where A_V is the differential voltage gain and A_{CM} is the common-mode voltage gain)

Instrumentation Amplifier (2)

Application



Instrumentation amp (INA) is connected to thermocouple by a twisted pair, to avoid magnetic pickup.

Ref is connected to the ground of the O/P connector

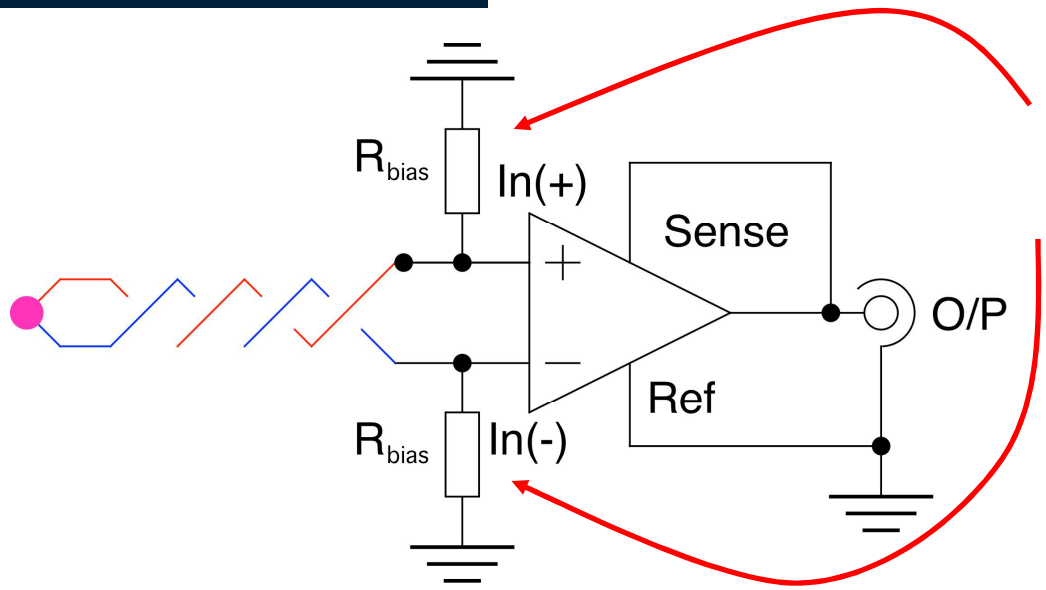
=> Voltage between inner & outer of coaxial cable is O/P

R is a large resistor to bleed away bias current (see later)

Circuit is immune to voltage present on "ground"

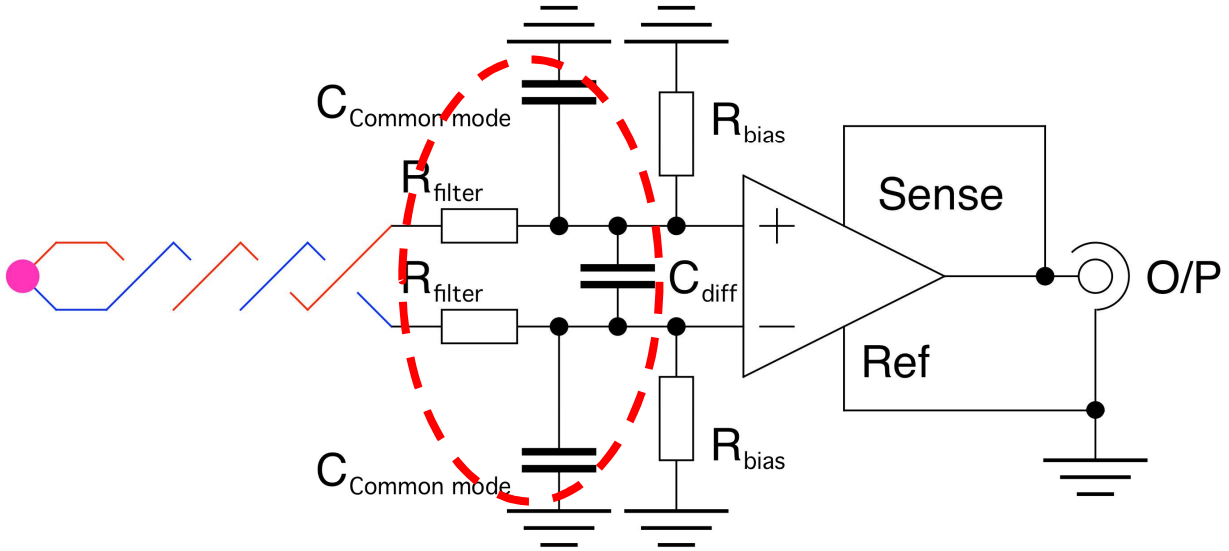
Instrumentation Amplifier (3)

Improved:



Since the name of the game is rejecting the average voltage; symmetry is always a good idea.

Adding a low pass filter (symmetrical) to eliminate radiofrequency interference is a good practical move



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THAT 1510 Microphone Preamp

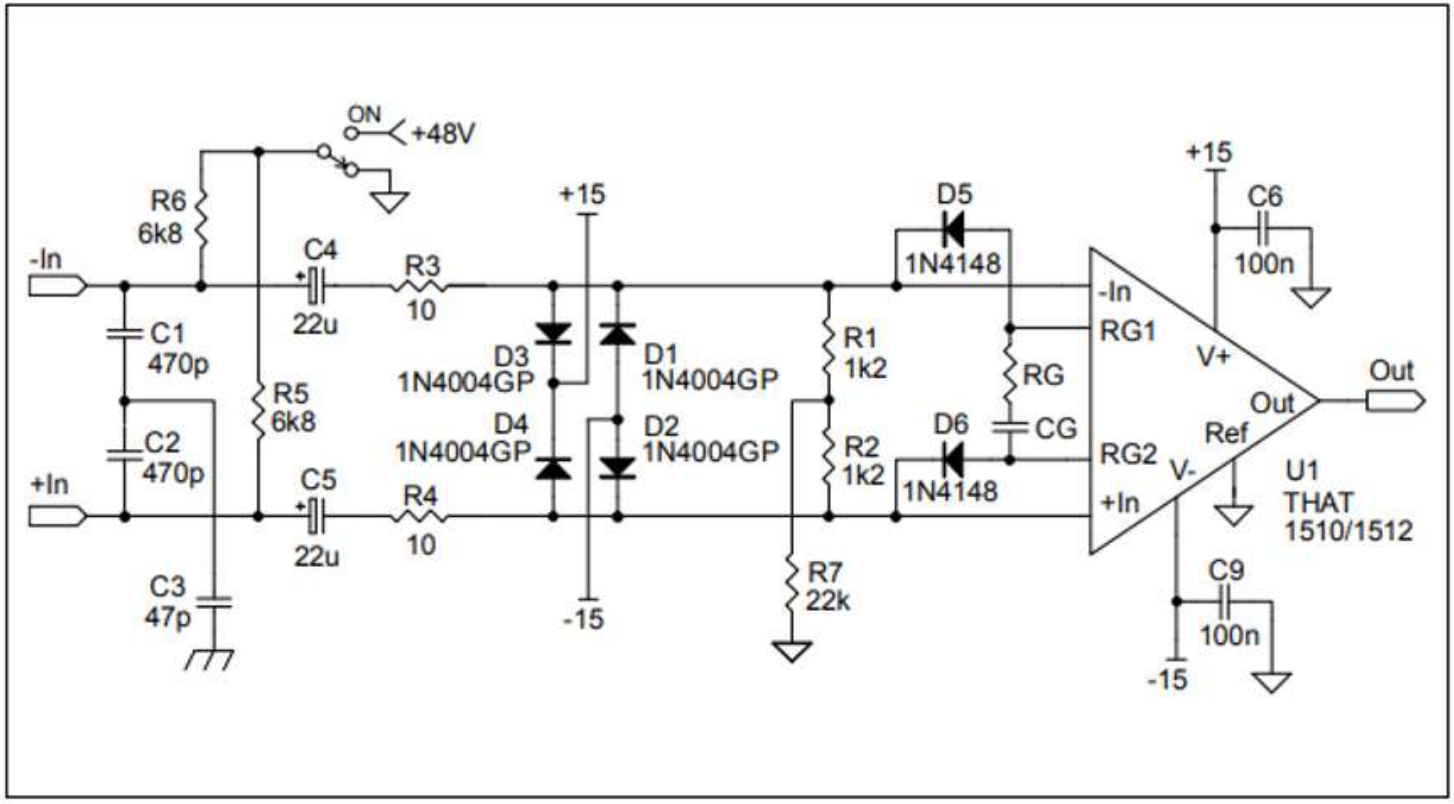
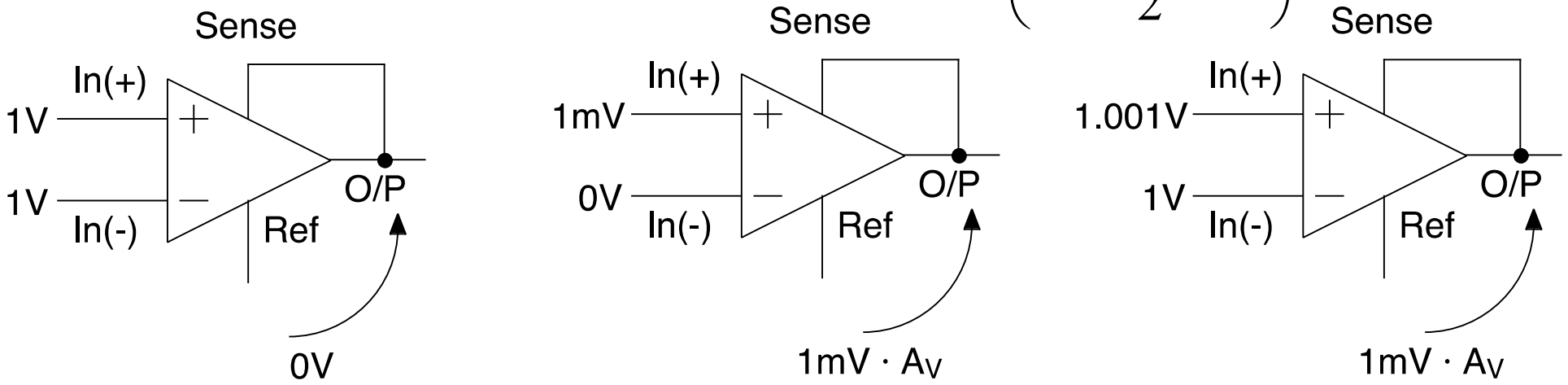


Figure 5. Recommended 1510 / 1512 Circuit with Phantom Power

Common-Mode Rejection Ratio (CMRR)

Perfect instrumentation amplifier
has a "common-mode" gain =0

$$(\text{O/P-Ref}) = A_V(\text{In(+)-In(-)}) = A_V(\text{In(+)-In(-)}) + 0\left(\frac{\text{In(+)}+\text{In(-)}}{2}\right)$$



In practice no instrumentation amp is perfect: A change in the average (common-mode) voltage will give a change in output

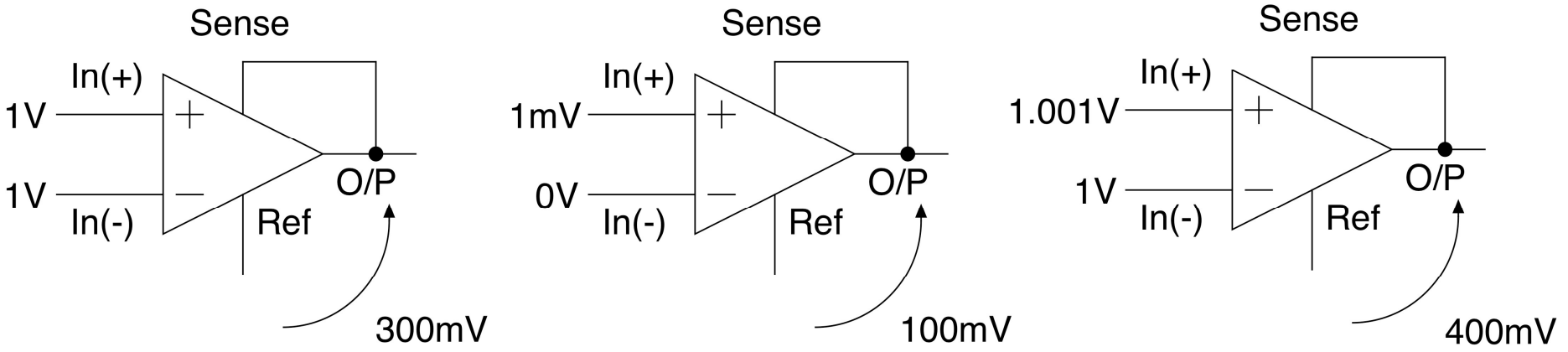
$$(\text{O/P - Ref}) = A_V(\text{In(+)} - \text{In(-)}) + \text{A}_{\text{CM}}\frac{(\text{In(+)} + \text{In(-)})}{2}$$

Normally $A_V >> \text{A}_{\text{CM}}$; $\dfrac{A_V}{\text{A}_{\text{CM}}} = CMRR$

Hambley § 9.2

CMRR(2)

Thus if A_v = 100 and A_{CM} = 0.30 (so CMRR = 333 = 50.4dB):



So an input of 333mV on both inputs gives **Exactly** the same output as 1mV difference between both inputs: With a CMRR of 333 the minimum voltage difference you can detect is 1mV for a common - mode voltage of 300mV.

If the common mode voltage is 1V the minimum detectible differential voltage is 3mV.

Important: minimum detectable signal is assumed when the 'error' signal is the same as the 'real or wanted' signal.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Thank you
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