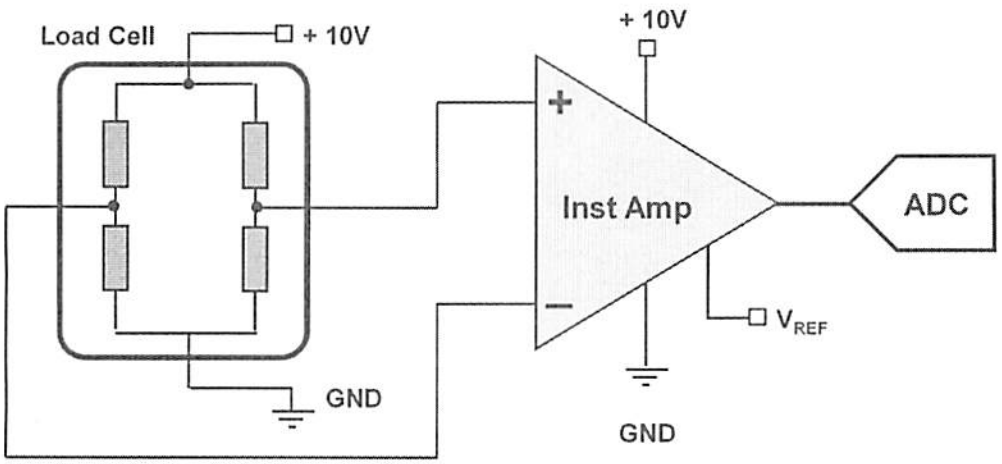
BME/ECE 386 QUIZ (W20) NAME: Solutions

1 problem for 20 pts

Digital Weighing Scale

An application requires a digital weighing scale that can measure up to 100 kg with a sensitivity of 10 g. The only available components are the following:

- Load cell with RO = 2.5 mV/V @ 200 kg and V_S = +10V
- Instrumentation amplifier with A_d = 500 and V_{REF} = 3V
- ADC operating from 0 to +10V with 14 bits
- Measurement noise voltage = 0.2 mV_{RMS}.



a) Does this system satisfy the maximum load specification? Show all work!

+10

b) Does this system satisfy the desired sensitivity? Show all work!

(a) Method #1 ← Either method is fine → METHOD #2

Max V_{Meas} = 10V

$V_{Meas} = V_{Ref} + A_d V_s RO \frac{L}{L_{rated}}$

For L = 100kg

$\rightarrow V_{Meas} = 3 + 500 \cdot 10V \cdot .0025\frac{V}{V} \cdot \frac{100kg}{200kg}$

$= 9.25V < 10V$ ✓ ☺

YES

Max V_{Meas} = 10V

$V_{Meas} = V_{ref} + A_d V_s RO \frac{L}{L_{rated}}$

What L produces V_{Meas} = 10V?

$10 = 3 + 500 \cdot 10V \cdot .0025\frac{V}{V} \cdot \frac{L}{200kg}$

$\rightarrow L = 112kg > 100kg$ ✓ ☺

YES, we can measure 100kg!

(extra sheet for work)

+10 (6)

$$\Delta V_{MIN} = \begin{cases} \Delta V_{ADC} = \dfrac{10-0}{2^{14}-1} = 0.61\,mV \leftarrow \text{Larger} \\ V_N = 0.2\,mV_{rms} \end{cases}$$

↑ This is ΔV_{MIN}!

$$\Delta L_{MIN} = \frac{\Delta V_{MIN}}{\frac{\partial V_{meas}}{\partial L}} = \frac{\Delta V_{MIN}}{A_d \cdot V_s \cdot RO \cdot \frac{1}{L_{rated}}}$$

Either method is fine

Method #1

For $\Delta V_{MIN} = 0.61\,mV$,

$$\Delta L_{MIN} = \frac{0.61\,mV}{500 \times 10V \times 2.5\frac{mV}{V}} \times 200\,kg$$

$$= 9.76 \times 10^{-3}\,kg$$

$$= 9.76\,g < 10\,g \checkmark$$ ☺

OK to be more sensitive than spec

YES

Method #2

For $\Delta L = 10\,g$, what is ΔV_{meas}?

$$\Delta V_{meas} = 500 \times 10V \times 2.5\frac{mV}{V} \times \frac{.010\,kg}{200\,kg}$$

$$= 0.625\,mV > 0.61\,mV$$

we can detect this! ☺

YES