Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$\dfrac{5.0}{1024} = \mathbf{4.88\ mV}$; $\dfrac{3.00}{0.004883} = 614.4$, code **614**; 512×4.88 mV $= \mathbf{2.50\ V}$

2.2

$128 \times \dfrac{3.3}{256} = \mathbf{1.65\ V}$; step **12.9 mV**; $\dfrac{1.00}{0.0129} = 77.6$, code **78**, giving **1.006 V**

2.3

$V = 1365 \times \dfrac{3.3}{4096} = 1.100$ V; $R_T = 10\ \text{k}\Omega \times \dfrac{1.100}{3.3 - 1.100} = 5.0\ \text{k}\Omega$; about **45 °C**

2.4

ideal $6.02 \times 12 + 1.76 = \mathbf{74.0\ dB}$; ENOB $= \dfrac{68 - 1.76}{6.02} = \mathbf{11.0\ bits}$

3.1

$\dfrac{3.3}{4} = \mathbf{0.825\ V/g}$, with $0\,g$ at **1.65 V**

$\dfrac{4g}{4096} = \mathbf{0.98\ mg}$ per LSB

$3000 \times \dfrac{3.3}{4096} = 2.417$ V; $\dfrac{2.417 - 1.65}{0.825} = \mathbf{0.93}\,g$

the 2 mg noise is about 2 LSB, so more bits would only measure noise: 12 bits is enough

3.2

0 to 1.0 V, only **30**% of the range

codes 0 to 1241: $\dfrac{100\ \mu\text{A}}{1241} = \mathbf{0.081\ \mu A}$ per LSB

30 kΩ gives 0 to 3.0 V, and $\dfrac{0.806\ \text{mV}}{30\ \text{k}\Omega} = \mathbf{27\ nA}$ per LSB

$t \geq 13 \times 0.693 \times 30\ \text{k}\Omega \times 10\ \text{pF} = 2.7\ \mu\text{s}$; a short default sample time would read low, so set a longer sample time or buffer the signal with an op amp

3.3

(a) $50 = 5 \times 10$, so the hum aliases to $|50 - 5 \times 10| = 0$ Hz; it appears as a steady offset that no later filter can remove

(b) $R = \dfrac{1}{2\pi \times 1 \times 10 \times 10^{-6}} = \mathbf{16\ k\Omega}$; $|H| = \dfrac{1}{\sqrt{1 + 50^2}} = 0.020$, about $\mathbf{-34\ dB}$

(c) the 10 µF capacitor acts as a reservoir: when the 10 pF hold capacitor connects, charge sharing moves the voltage by only $\dfrac{10\ \text{pF}}{10\ \mu\text{F}} = 10^{-6}$ of it; that is 0.004 LSB, so the reading is correct

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(d) sample at 1 kHz and average 100 samples for each logged value; 100 ms is exactly 5 periods of 50 Hz, so the hum averages to zero