Solutions

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

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

2.1

$\frac{9600}{10} = \mathbf{960}$ bytes/s; $\frac{20}{960} = \mathbf{20.8\ ms}$; at 115 200: $\mathbf{1.74\ ms}$

2.2

one byte: $\frac{8}{4 \times 10^6} = \mathbf{2\ \mu s}$; 16 bits = 4 µs, plus 1 µs: 5 µs per sample; $\mathbf{200\ kS/s}$

2.3

$128 - 16$ reserved = **112**; 9 bytes $\times 9$ bits + start, repeated start and stop $\approx$ 84 bits; $\frac{84}{400 \times 10^3} = \mathbf{0.21\ ms}$

2.4

$\frac{16 \times 10^6}{16 \times 115\,200} = 8.68$, so $D = 9$; $\frac{16 \times 10^6}{144} = 111\,111$ baud, $-\mathbf{3.5}\%$; outside $\pm 2\%$, so bytes will be garbled: **no**

3.1

$12 \times 10 = 120$ bits take 12.5 ms at 9600, longer than 10 ms

at 19 200: 6.25 ms, **63**% of the link

16 bytes: 8.3 ms, **83**% at 19 200; 4.2 ms, **42**% at 38 400

choose 38 400: below about 50% leaves room for retries and for timing error

3.2

$\frac{16}{2 \times 10^6} = 8$ µs, plus 1 µs; 9 µs per sample

largest rate $\frac{1}{9\ \mu s} = \mathbf{111\ kS/s}$

bus use $50 \times 10^3 \times 9\ \mu s = \mathbf{45}\%$; CPU $\frac{50 \times 10^3 \times 300}{84 \times 10^6} = \mathbf{18}\%$

use DMA to collect the samples into a buffer, so the CPU takes one interrupt per block, not per sample

3.3

(a) $5 \times 9 + 3 = 48$ bits, $\frac{48}{400 \times 10^3} = 120$ µs; **12**% of the bus

(b) I2C: **2** wires for all three; SPI: SCLK, MOSI, MISO + 3 CS = **6**

(c) $R_p \le \frac{300\ ns}{0.847 \times 150\ pF} = 2.4\ k\Omega$ and $R_p \ge 967\ \Omega$; choose $\mathbf{2.2\ k\Omega}$

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(d) the display needs $30 \times 1024 \times 9 = 276$ kbit/s, 69% of I2C, and with the sensor's 12% that is too full; put the sensor and EEPROM on I2C and the display alone on SPI (4 more wires)