### Q5. You are required to answer 5 out of the 9 questions below from any of the 3 scenarios. Read the questions carefully. Each question is worth 5 marks. You must show your working following the methods taught in class for estimating signal to noise, processing gain, bit depth and computational complexity.

**Scenario A:**

### BAT DETECTOR

You are tasked to specify the requirements for a DSP for a product that will detect the acoustic ‘ping’ sound made by the American Common Brown Bat. The bat emits a short burst of sound at 100 kHz. The burst typically lasts for about 2 ms. The received signal, captured by an ultrasound sensor, varies between 5 mV and 50 mV: noise is typically 25 mV ‘white’ random noise. The signal is to be sampled at 1 MHz, and a 2 kHz wide 500-coefficient band-pass FIR filter will be applied to enhance the SNR by 33 dB.

1. Which ONE of the following ADC bit-depths is the LOWEST that is adequate to detect this signal?
2. 8-bit ADC
3. 12-bit ADC
4. 16-bit ADC
5. Which ONE of the following arithmetic accumulator bit-depths is the LOWEST that is adequate to implement the filter?
6. 8-bit
7. 16-bit
8. 40-bit
9. Which ONE of the following DSP Multiply/ACcumulate (MAC) speeds is the LOWEST that is adequate to implement the filter?
10. 100 MMAC/s
11. 230 MMAC/s
12. 500 MMAC/s

Scenario B:

### MICROWAVE RANGE DETECTOR

You are tasked to specify the requirements for a DSP for a product that uses microwaves to detect metal objects through walls. The system emits and detects the echo of a broadband pulse whose bandwidth is about equal to its centre frequency of 30 GHz, sampled at 200 GHz for 40 ns. The pulse peak amplitude is about 1 V and there is broadband environmental and electronic noise of about 0.01V. A bandpass FIR filter will be used to enhance the SNR by 60 dB.

.

1. Which of the numbers below is the MINIMUM number of bits required so that the ADC quantization noise is less than the input noise?
2. 4-bit
3. 8-bit
4. 12-bit
5. How many filter coefficients are the MINIMUM to achieve the stated SNR enhancement?
6. 100
7. 1000
8. 10000
9. Assuming you use an Accumulator to hold the FIR filter sum, which of the numbers below is the MINIMUM number of bits required in the Accumulator so that the sum does not overflow or need scaling down?
10. 16-bit
11. 24-bit
12. 32-bit

Scenario C:

### AUDIO TONE MEASUREMENT

You are tasked to specify the requirements for a DSP for a product that will measure the variation in sound pressure level of a 10 kHz tone, to an accuracy of 1%. The tone varies between sound pressure levels of 0.01 Pa and 1 Pa and is measured with a microphone whose sensitivity is 10 mV/Pa and whose bandwidth is from 20 Hz to 20 kHz with white noise level 2.5 mV. The sample rate will be 48 kHz.

1. Which of the Processing Gains quoted below is the LOWEST that is required to meet the specification of the above scenario?
2. 6 dB
3. 30 dB
4. 43 dB
5. Assuming you decide to meet the requirement with a simple FIR band-pass filter which of the filter bandwidths quoted below is the MINIMUM that is required to meet the specification of the above scenario?
6. 800 Hz
7. 8 kHz
8. 16 kHz
9. Which of the numbers below is the MINIMUM number of filter coefficients required to meet the specification?
10. 30
11. 60
12. 120