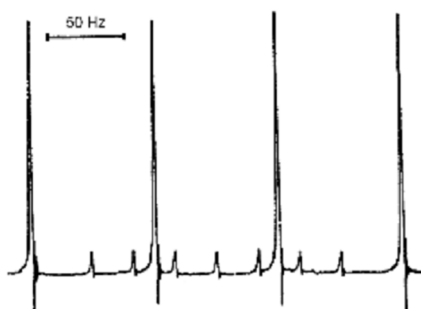


## Workshop 4 - Questions

1. The highest frequency present in an analogue signal is 8 kHz. Choose a sampling rate, an observation time, and a number of samples to:
  - (i) satisfy the Nyquist condition;
  - (ii) achieve  $\leq 0.5$  Hz digital resolution in the Fourier transform.
2. In an NMR experiment, the expected signal offsets span  $\pm 12$  kHz around the carrier frequency. Pick a digitiser dwell time  $\Delta t$  that would avoid signal aliasing and leave a 10% margin on either side of the spectrum.
3. An FID containing peaks at  $-15$  kHz and  $+19$  kHz is sampled at  $f_s = 20$  kHz. Determine the apparent frequencies of both peaks as a result of aliasing. What is the minimum  $f_s$  required to prevent aliasing in this case?
4. If you multiply the FID by  $e^{-kt}$  before the Fourier transform, what convolution kernel have you effectively applied to the spectrum? Explain the impact on peak height and line width.
5. Below is the  $^1\text{H}$  spectrum of the borohydride anion ( $\text{BH}_4^-$ ) in  $\text{D}_2\text{O}$ . Boron has two major isotopes,  $^{11}\text{B}$  (spin  $3/2$ , 80% natural abundance) and  $^{10}\text{B}$  (spin  $3$ , 20% natural abundance).



The spectrum has been acquired on an ancient NMR system, which is why the lines do not appear symmetrical – this may be ignored. Explain why there are 4 intense and 7 weak lines in this spectrum.