

Workshop 2 - Questions

1. A 14.1 Tesla superconducting magnet is put into the persistent mode. The manufacturer quotes a fractional loss of circulating current of 10^{-6} per day.
 - a) Assuming the magnetic field is proportional to the circulating current, estimate the absolute field change after 90 days (in mT) and the corresponding ppm drift.
 - b) If the ^1H Larmor frequency at 14.1 T is 600 MHz, estimate the frequency drift (Hz/day and Hz over 90 days).
2. In the magnet bore the static field B_0 is vertical; probe-generated B_1 RF fields are horizontal.
 - a) Sketch the laboratory axes and indicate the typical orientation of B_0 and B_1 .
 - b) For a nucleus with positive γ , state the direction (clockwise/counter-clockwise) of free precession when viewed from +Z.
3. The RF chain delivers a few kW in the transmit mode and detects nuclear induction signals $< 1 \mu\text{W}$ in the receive mode.
 - a) Take a concrete scenario: $P_{\text{TX}} = 2.0 \text{ kW}$, $P_{\text{FID}} = 1.0 \mu\text{W}$. Compute the power ratio and express it in decibels (dB).
 - b) If the preamplifier's maximum safe input is 10 mW, what minimum isolation (in dB) must the duplexer provide during transmit to prevent damage when a 2.0 kW radiofrequency pulse is sent to the probe?
4. Prove that, in the absence of relaxation, $|\mu|$ is conserved by Bloch equations. Hint: differentiate the squared length of μ with respect to time.
5. Direct Z pulses are typically unavailable in NMR hardware. Propose a sequence of pulses that achieves a Z rotation using a superposition of X and Y rotations, and justify it geometrically.
6. For ^1H nuclei, compute the B_1 amplitude required for a 90-degree pulse of $5 \mu\text{s}$ duration. Would the required B_1 amplitude become smaller or larger if the nucleus is ^{15}N ?
7. A novice user reports very weak FIDs on a properly tuned probe. You observe: large reflected power on the forward/reflected power meters, and very shallow nutation (maxima never reach near unity even at the expected t_{90}).
 - a) Give two instrumental symptoms that indicate poor impedance matching.
 - b) Explain why poor matching wastes transmit power and degrades receive sensitivity.