Exercise Class 4

Exercise 1

Consider an electron subject to a static magnetic field $B_0 = 1\,T$ along $\vec{z}$ and a resonant magnetic field of amplitude $B_1 = 1\,mT$ along $\vec{x}$ coupled to the electron. After calculating the frequency of the resonant field, derive:

a) the pulse envelope amplitude to operate an $\hat{X}$ gate, when the pulse duration is $t_1 = 100\,ns$.
b) the pulse duration to operate an $\hat{X}$ gate, when the pulse envelope amplitude is $\eta = 0.5$.

Exercise 2

Consider an electron subject to a static magnetic field $B_0 = 1\,T$ along $\vec{z}$. A resonant magnetic field with tunable phase of amplitude $B_1 = 1\,mT$ along $\vec{x}$ is coupled to the electron by an on/off switch with no amplitude modulation. Calculate the frequency of the resonant field and draw the pulse schedule to operate the gate $\hat{O} = \hat{H} \cdot \hat{X}$.

Exercise 3

An electron is immersed in a static magnetic field $B = 1\,T$ directed along $\vec{z}$ and coupled to a resonant magnetic field of amplitude $B_1 = 1\,mT$ along $\vec{x}$. Calculate the timing accuracy of a control system to provide a rotation angle accuracy $\Delta\theta = \frac{\pi}{1000}$ along $\vec{x}$.

Exercise 4

Consider a quantum system with natural frequency $\omega_{01} = 2\pi \cdot 5\,GHz$ and anharmonicity $\Delta\omega = 2\pi \cdot 200\,MHz$ where a π-rotation pulse along $\vec{x}$ is operated by ESR. Compare the driving amplitudes η and spectral amplitudes $\mathcal{B}$ of the driving field for the $|1\rangle \rightarrow |2\rangle$ transition for a driving pulse with:

a) rectangular envelope of amplitude η_1 and width $t_1 = 10\,ns$.
b) rectangular envelope of amplitude η_2 and width $t_2 = 100\,ns$.
c) Gaussian envelope of amplitude η_3 with FWHM $\Delta t = 10\,ns$.