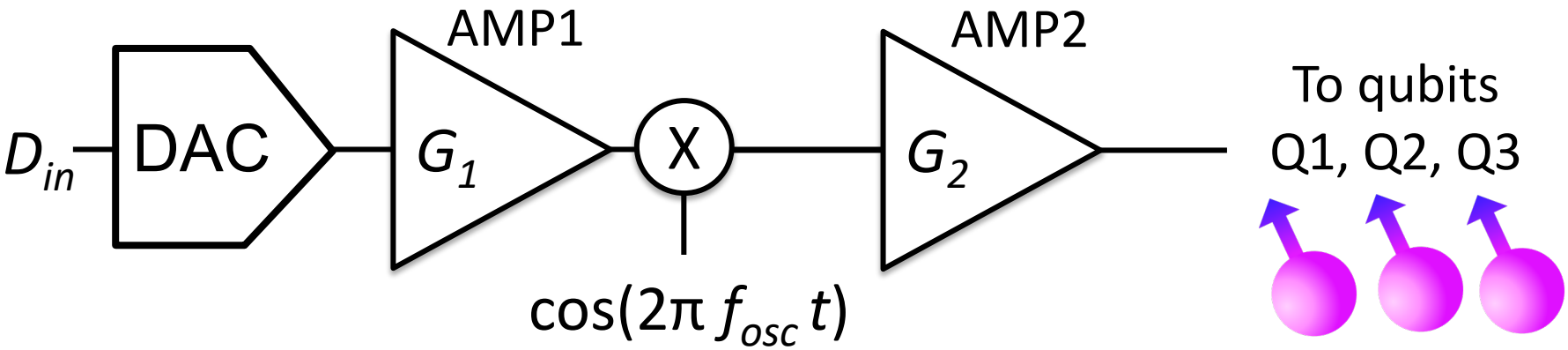
Assignment 5



- 3 qubits (Q1, Q2, Q3)
  - Larmor frequencies: f1=11 GHz, f2=12 GHz, f3=13 GHz
  - Rabi frequency for all qubits: fR = 1 MHz
- G_1=4, G_2=1
- f_{osc} = 10 GHz
- DAC output range= [-0.5 V, +0.5 V]
- For example implementation, see script HW5_example.m

Assignment 5 (1/2)

A. Start from the example in the file HW5_example.m demonstrating a π rotation around the X axis of Q1 for an ideal system, i.e. with a very high sampling rate and a large number of bits.

1. First, we are going to evaluate the effect of quantization, i.e. a limited number of bits in the DAC. While keeping the maximum sample rate fsample=1000e9 (i.e. emulating a continuous-time signal), find the minimum number of bits in the DAC (N) for which a fidelity of 99.9% is achieved for a π-rotation of Q1 and the idle operation on Q2 and Q3.

[1 point]

B. Set the number of bits of the DAC to 10 (N=10). We are going to evaluate the effect of a limited sample rate. Reduce the DAC sample rate (fsample) down to 10 GHz. If we keep the signal at the input of the DAC as in point A, we can observe a large degradation of the fidelity on Q1. Note: for this point, there are no requirements on the fidelity of Q2 and Q3.

1. Change the phase of the signal at the input of the DAC (ph_in) and the gain G1 to bring back the fidelity of Q1 to above 99.9%. **[1 point]**
2. Explain why you had to change the phase. **[2 points]**
3. Explain why you had to change the gain of G1. *Hint: For a full understanding, observe what happens for fsample=10e9, fosc=12e9, f0 = [13e9, 14e9, 15e9].*

[2 points]

Assignment 5 (2/2)

C. Set N=10 and set the other parameters to the initial conditions (fosc=10e9, fsample=1000e9, A=[10e-3 0 0]), i.e. drive a π rotation around the X axis of Q1.

1. Find at least 3 values for fsample (larger than the Nyquist rate) that cause a degradation of the fidelity on Q2 or Q3 with respect to the case in which fsample=1000e9. You may need to change the timestep dt.

[1 point]

2. What are the conditions on fsample to avoid the degradation at point C.1? Which component can be added to the system to relax the requirements on fsample? Where should it be placed?

[2 points]

D. Set fsample=10e9, N=10. If mismatch is added to the DAC elements, what is the maximum variance in the mismatch of the DAC unit elements that keeps the fidelity of Q1, Q2 and Q3 above 99.9%?

[1 point]

Submission of the answers

- Make a **.zip** archive containing
  - A clear, readable **.pdf** with the answers to the questions
  - The corresponding **.m** files
  - spine.m and fidelity.m

- Make a new **.m** file for **every** (sub)question (don't put the code from all assignments in a single file)
- Make sure your code is **readable** and add **comments**

- Name your **.pdf** and **.zip** according to: *lastname_HWx.pdf(zip)* with *lastname* the last name of the student that submits the answers on Brightspace