Assignment 6

- The system comprises 2 target qubits (Q1, Q2)
  - Larmor frequencies: f1=5.1 GHz, f2=4.9 GHz
  - Rabi frequency for all qubits: fR = 1 MHz
- Available basic components:
  - A digital processor with an output rate of 1 GHz that is able to generate the baseband signals to drive the qubits.
  - DACs to convert the digital output signals into the analog domain with a sample rate of 1 GHz and *N* bits.
  - A local oscillator at frequency f_{osc} = 5 GHz is available. The oscillator can generate signals with any phase shift. Multiple signals with different phases (but same frequency f_{osc}) can be generated at the same time.
  - Mixers driven by the local oscillator to upmodulate the baseband signals.
  - Signal adders
  - Amplifiers

Assignment 6 (1/2)

A. Build a system to drive a π-rotation on Q1 while keeping Q2 idle and ensuring a fidelity above 99.9% for both qubits. Minimize the number of bits (N) of the DAC(s). **[3 points]**

B. In the signal gain, you need a factor 1/sinc(fin(1)/fsample). Which component in the system introduces the (inverse) factor sinc(fin(1)/fsample)? What is causing this? **[2 points]**

C. Now we want to obtain a fidelity of 99.99% for Q1 and Q2 for the same operation as in point A. In addition to the above-mentioned components, first-order linear filters are available as well, for which you can choose the bandwidth. For an example on how to implement a filter in Matlab, refer to the file first_order_filter.m on Brightspace. Explain *where* the filter(s) must be added, *why,* and give a range for their *specifications*. You are allowed to modify the baseband signals and the number of bits *N* of the DAC(s) with respect to point A. Minimize *N.* **[2 points]**

Assignment 6 (2/2)

D. Use the same system developed at point B but now allow a fidelity of 99.9% on Q1 and Q2 for the same operation as above. However, the local oscillator cannot be considered ideal anymore: its outputs show amplitude and phase errors.

1. Find the maximum allowed phase mismatch, when assuming no amplitude mismatch.

[1 point]

2. Find the maximum allowed *combined* amplitude and phase mismatch.

[2 point]

Submission of the answers

- Make a **.zip** archive containing
  - A **.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