Pasqal-Use-Case

Release 0.1

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This is the documentation for the exercices regarding the use of a Quantum Machine OPX+ to modulate the amplitude of a laser beam and acquire a signal from a photo-diode.

CHAPTER

ONE

CONTENTS

1.1 2. Writing a QUA program to calibrate your setup

1.1.1 Configuration

A new element is introduced in the setup: an oscilloscope. Its channel 2 is connected to the analog output port number 2 of the OPX controler. A RF signal of frequency 100MHz and duration $9\mu s$ is sent to the oscilloscope. To take into account the raise time for the AOM, the RF pulse has a longer duration of :math`10.12mu s`.

Not written in the config file, the photo-diode is plugged on the first channel of the oscilloscope.

1.1.2 Program

The experiment is repeated for different values of the amplitude sent to the AOM. The amplitude is ramped from 0 to 0.5V with steps of size 0.00025V (2000 steps). The RF pulse is sent to the AOM. 120ns later, the trigger pulse is sent to the port *channel 2* of the oscilloscope, launching the acquisition on *channel 1*. We acquire $10\mu s$ of signal and make the mean of it. When both operations are over, repeat the experiment. We measure intensity function of the voltage.

1.2 3. Measuring with the OPX+

1.2.1 Configuration

The oscilloscope is replaced by the photo-diode. This time, we don't use an output port but an input port of the OPX+. We create a measurement pulse that will only acquire data. We connect to this pulse a post-processing tool `integration` with *integration_weights* $\frac{1}{t_{meas}}$ with t_{meas} the duration of the measurement. Output port 1 of OPX+ is still connected to the AOM.

1.2.2 Program

The program measures the intensity received by the photo-diode for various amplitudes of the RF pulse sent to the AOM. These amplitudes range from 0V to 0.5V with steps 0.00025V. For each amplitude, the experiment starts by sending a RF pulse to the AOM. 120ns later, we start measuring the photo-diode. This measure lasts $10\mu s$. When it is over, the signal is averaged using `integration`: the amplitudes are summed and divided by the acquisition time. The output is saved in the variable *i*.

1.3 4. Post-Processing the acquired data

1.3.1 Theory

The Rabi frequency is proportional to the square root of the Intensity. Let's write this relation as $\Omega = A\sqrt{I}$. Let's assume we know Ω for a RF amplitude V_0, and write this Rabi frequency Ω_0. Using our setup, we measure $I_0 = I(V_0)$, and deduce $A = \frac{\Omega_0}{I_0}$. Therefore we now have $\Omega^2(V) = \frac{\Omega_0^2}{I_0^2}I(V)$. V is obtained from Ω^2 as $V(\Omega) = I^{-1}(\frac{I_0^2}{\Omega_0^2}\Omega^2)$.

1.3.2 Implementation

The core of the problem is about building the inverse function of the intensity I^{-1}, that takes an intensity and outputs a voltage. From the output of the previous simulation, we have two arrays of data associating intensities *i* to voltage *a*. The function looks like a bijection, and it also makes sense to plot the voltage *a* function of the intensity *i*. This disrete *V(I)* set of points can be interpolated using `scipy.interpolate.interp1d()`, building the wanted $V = I^{-1}(I)$ curve. Note that lots of points are necessary in the zones where the I(V) is almost constant (for small amplitudes for example).

To find the RF amplitude associated to a Rabi frequency, you then just have to call the interpolated function just built with parameter $\frac{I_0^2}{\Omega_0^2}\Omega^2(V)$