Lab 2 Midterm Report on the Kinetic Inductance Detector

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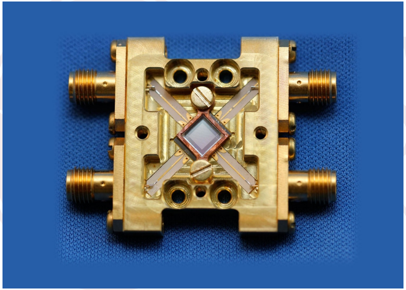
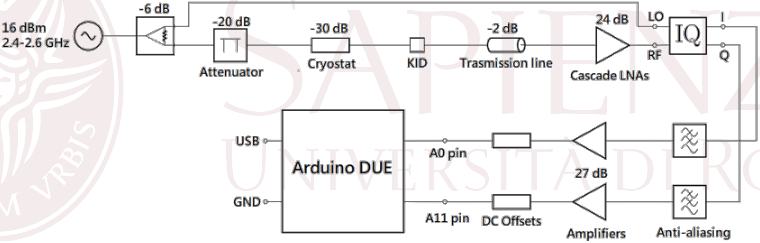
Kid Detector



- Kinetic Inductance Detector
- Used for photon detection in a wide range of frequencies.
- Very sensible to single **photon** interaction via Cooper pairs excitation.
- Works in a **cryogenic** setting, readout via electromagnetic field variation in a **SQUID**.

Our Objective

Develop a **readout system** for the detector using an Arduino Due.
The full read-out chain is comprised of an RF circuit operating at **GHz range** frequencies and an analog amplifying **anti-aliasing** circuit.



The readout works by comparing a reference signal to the signal coming out of the detector. This method is known as **homodyne detection**.

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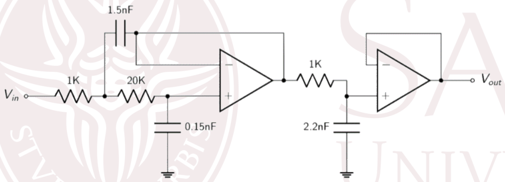
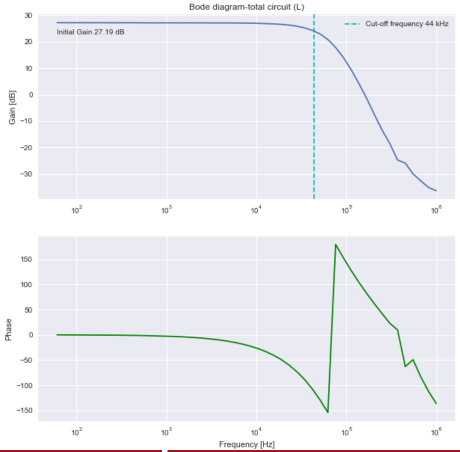
Low Frequency Circuit

The Low-frequency circut serves both as an **Amplifier** and a **Anti-aliasing** filter. It has two identical channels corresponding to the I and Q signal outputted by the RF part of the readout system.
Each channel is equipped with a **3rd order Sallen key filter**, a **27dB non inverting amplifier** and a **summing circuit**.
The whole layout has been soldered on a prototype board and has BNC input.

Low-pass Filter

The low pass filter functions as an **anti-aliasing** measure. The **sampling frequency** of the Arduino Due is about **100kHz** and as such, in order to satisfy the **Nyquist** theorem's condition for the acquisition, the **cutoff** frequency has been set at around **45 kHz**.

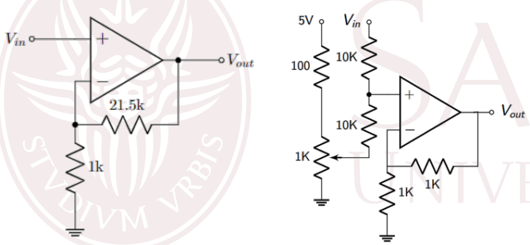




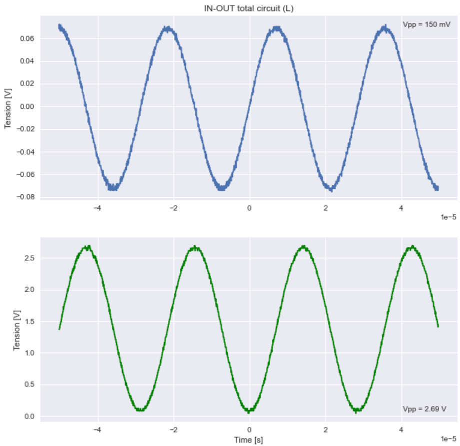
Filter schematic and frequency response analysis of the whole circuit. The filter architecture is a second order **Sallen-Key** filter coupled to an **RC** filter.

Amplificator and Summing Circuit

In order to boost signal strength, an **amplifier** has been built. The total **gain** from amplification is **27 dB**. A **summation circuit** has been built in order to place the signal in a **range** suitable to the **Arduino (0 - 3.3 V)**.



Amplifier and summation schematic.
On the right an example of signal boosting and voltage offsetting.



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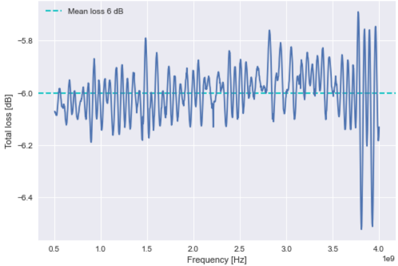
RF Circuit

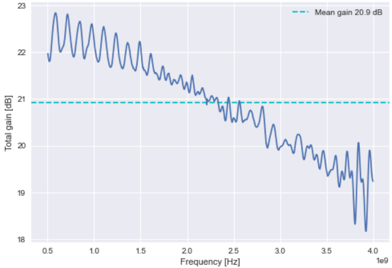
The RF circuit is the part of the DAQ module directly in contact with the experimental apparatus. It's comprised of many different components connected via **SMA cables**. Each component (even the cables) has an **inherent frequency response** that must be factored in when acquiring data.
All of the apparatus works by sending a **reference signal** to the detector and the **mixer** via a **splitter**. The mixer then compares the signal from the KID and the reference one and emits the **output** to the **low-frequency circuit**.
The **KID** has an **inherent attenuation** of **30dB** and its signal must be **amplified** before it enters the mixer.

Splitter and Amplifier

The **splitter** is a component that **splits** a **signal** in two identical channels, each one carrying half the original power. We have determined, using a **Virtual Network Analyzer (VNA)**, an inherent **6 dB attenuation** due to non-ideal behavior. The **amplifier** is used to **boost** the **attuenuated signal** coming from the **cryostat**, we have determined a **gain** of around **21 dB** at the desired range of frequencies.

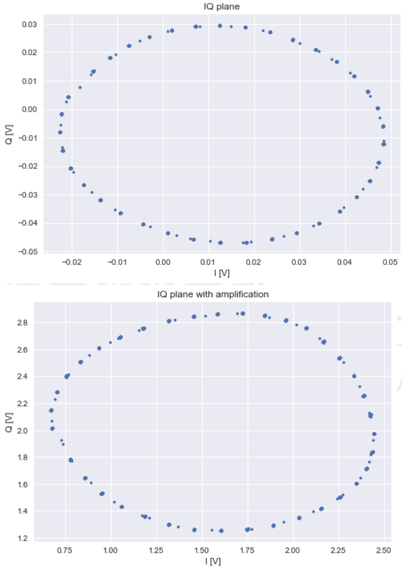
Above on the right, the FRA of one of the splitter outputs. Below on the right, the FRA of the RF amplifier.

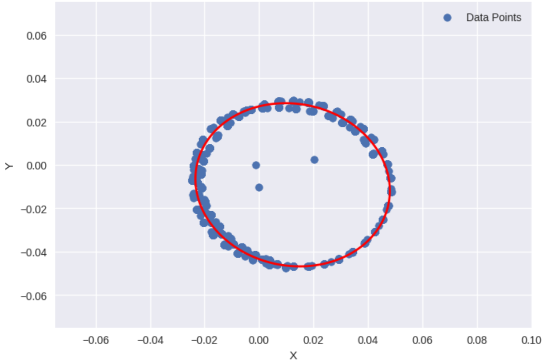




Mixer

The **Mixer** is a **non linear component**, which has an input two signals. The mixer **outputs** a signal that has as amplitude the multiplied amplitudes of the input signals times, respectively, the cos and sin of the phase difference.
It produces **two outputs**, named **I** and **Q** channel.
We have successfully **simulated DAQ** system by substituting the **cryostat** with a **20 dB attenuator** and a **2,5 meter line**.
The **two signals** should have a **90°phase difference** which was observed by measuring and plotting the **I amplitude vs the Q amplitude**.
A data taking using the Arduino has also been performed but will not be shown as we still are trying to reduce noise on this sampling method.
The **data shown** on the next slide has been **acquired** through the use of an **oscilloscope** both at the **output** of the **mixer** and the **output** of the whole **DAQ assembly**.
The **data** taken directly from the **mixer** has then been **fitted** using an **elliptical prior**, showing an **eccentricity of 0.33**.


IQ plane
Q [V]
I [V]
IQ plane with amplification
Q [V]
I [V]


Data Points
Y
X

Thank you for your attention!