Signal analysis on a µMux SQUID

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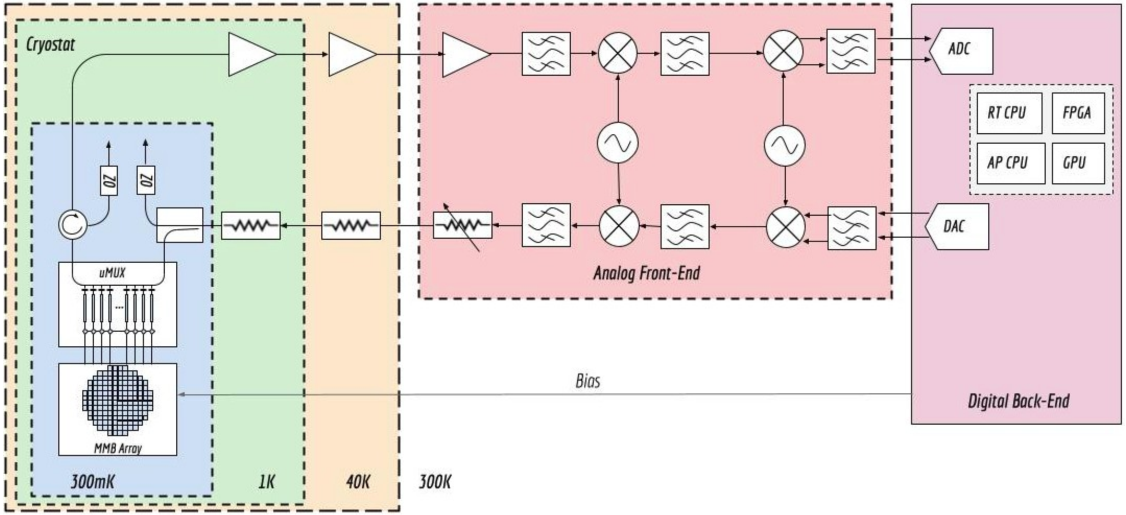
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

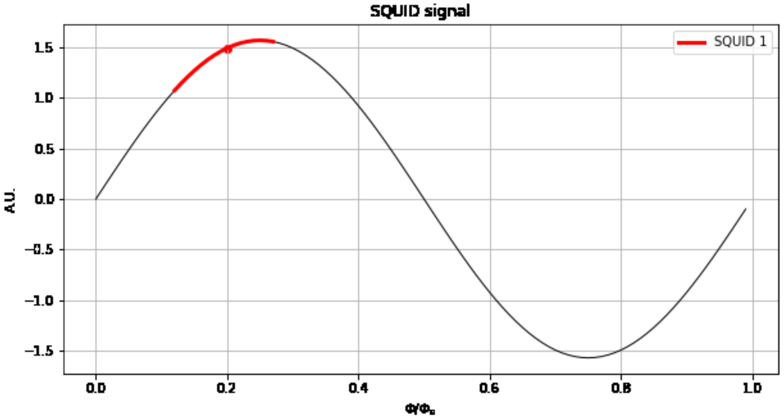
ITeDA

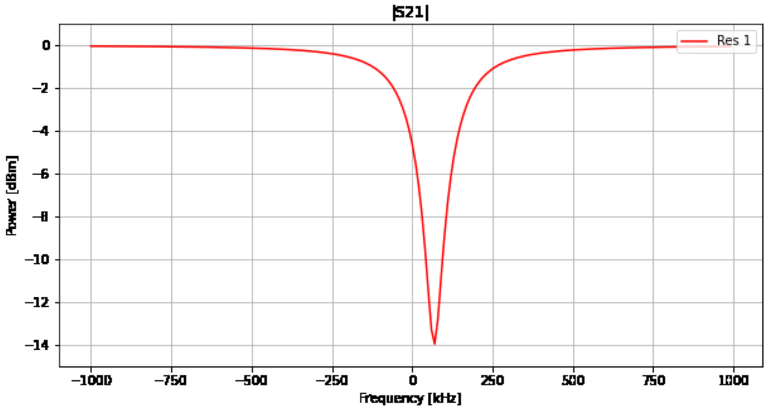
UNSAM UNIVERSIDAD NACIONAL DE SAN MARTÍN

KIT Karlsruher Institut für Technologie

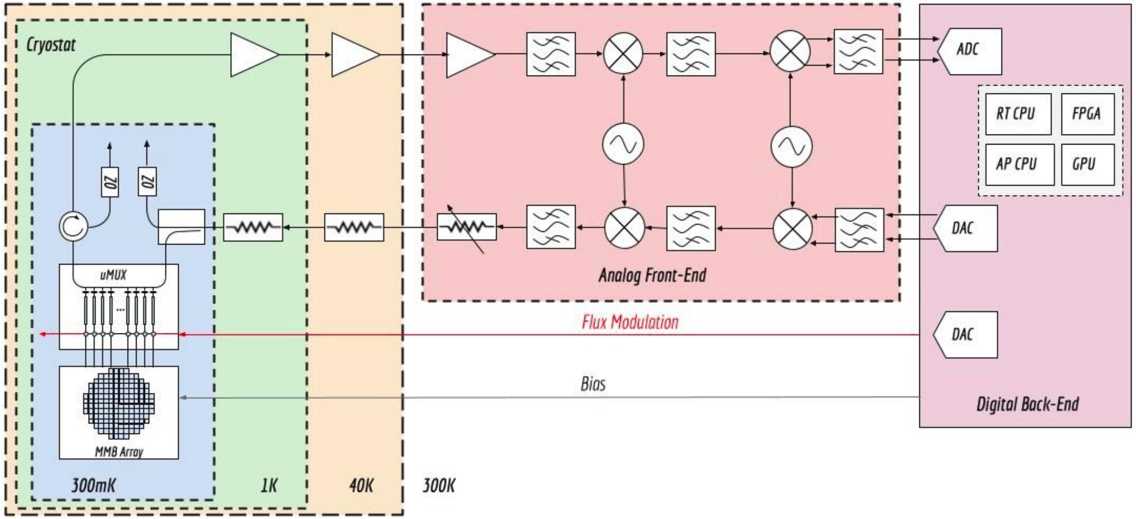
Read-out system

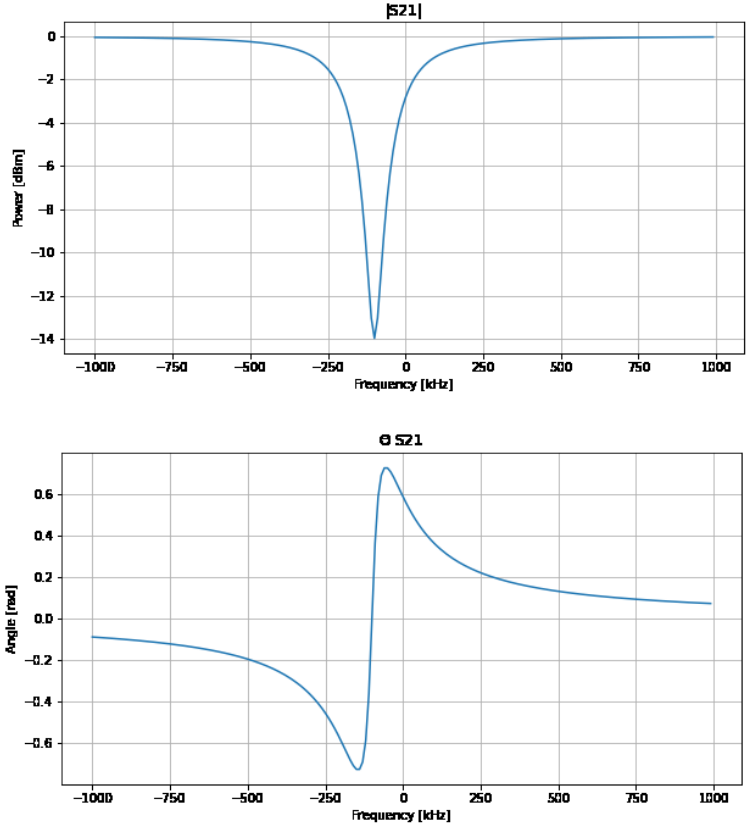




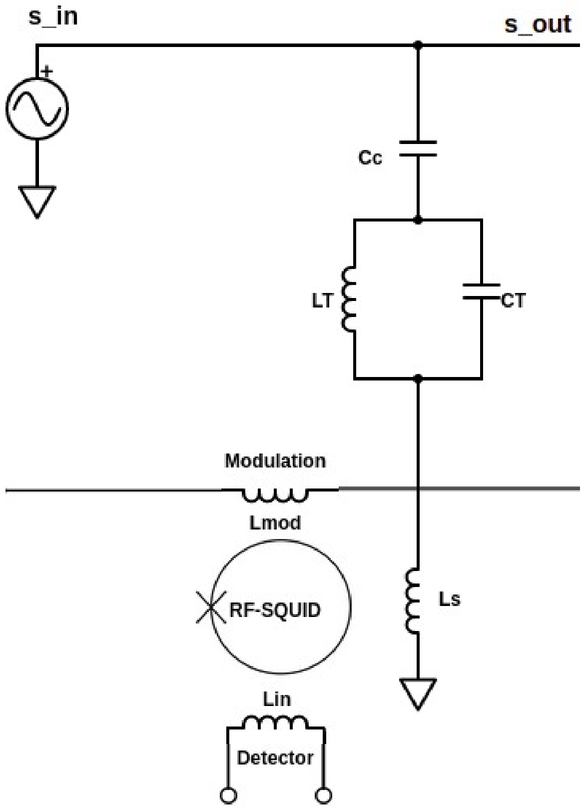


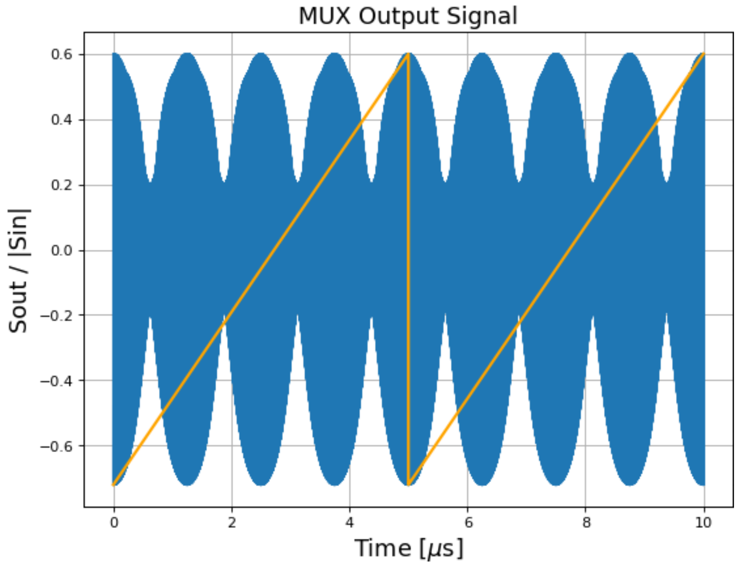
Read-out system





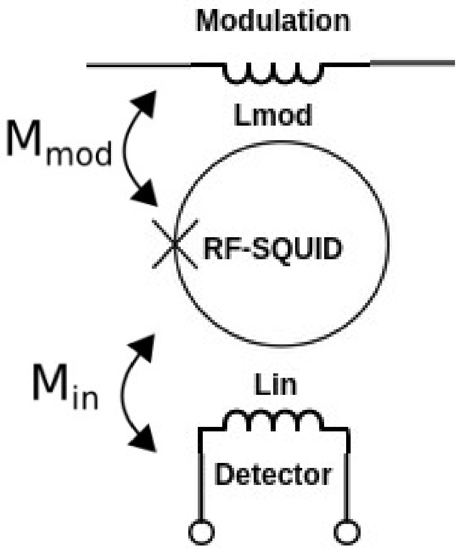
MUX output for a single tone





$$S_{OUT} = |S_{21}| . A_{in} . \cos(w_{in} . t + \varphi S_{21})$$

SQUID modulation

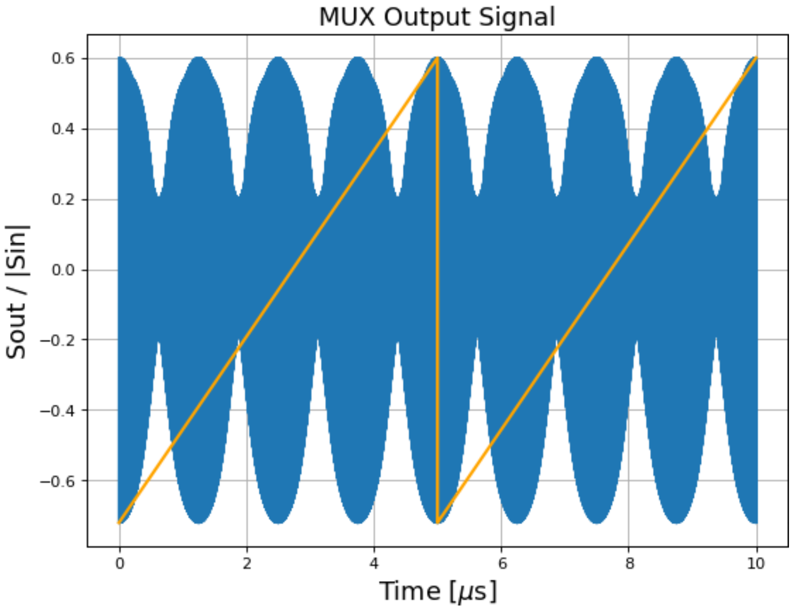


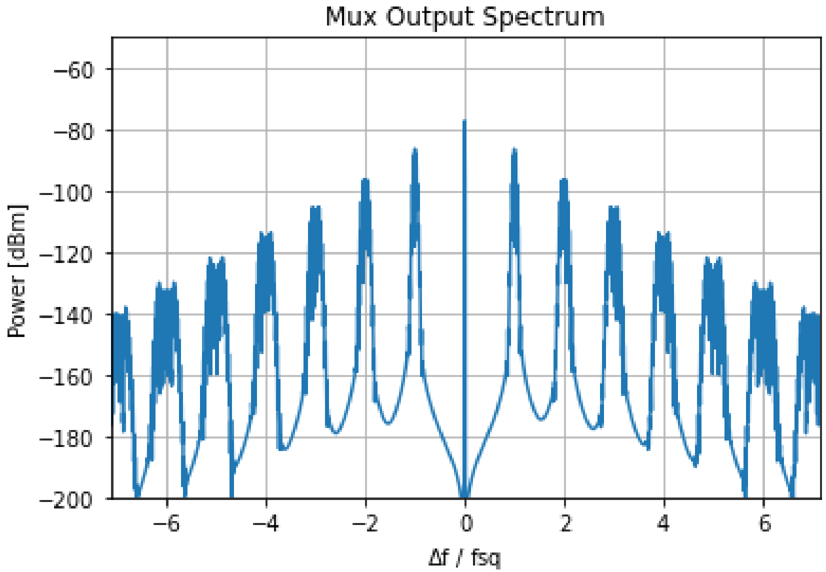
$$I = I_c sin(\frac{2\pi m_{ramp} t}{\Phi_o} + \frac{2\pi \Phi_i}{\Phi_o}), L(t)$$

Systems description

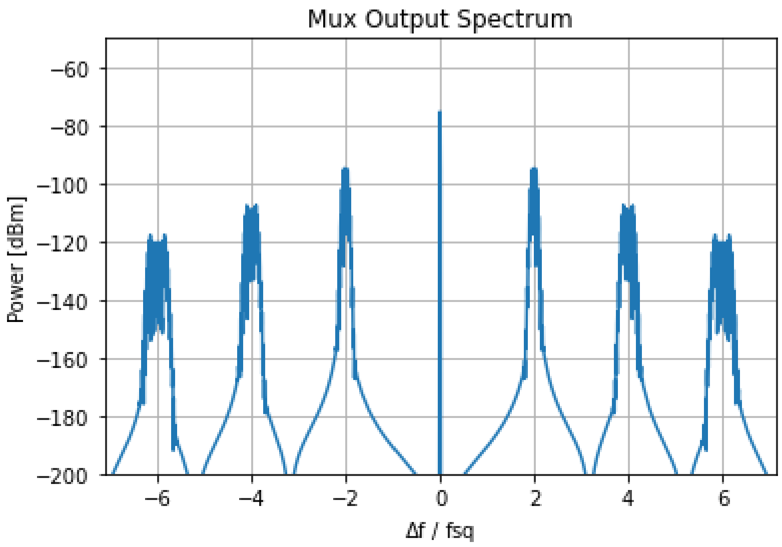
	ECHo	QUBIC
Type	Calorimeter	Bolometer
Detector fmax	1,6MHz	<<100Hz
fsquid	>3,2MHz	>200Hz

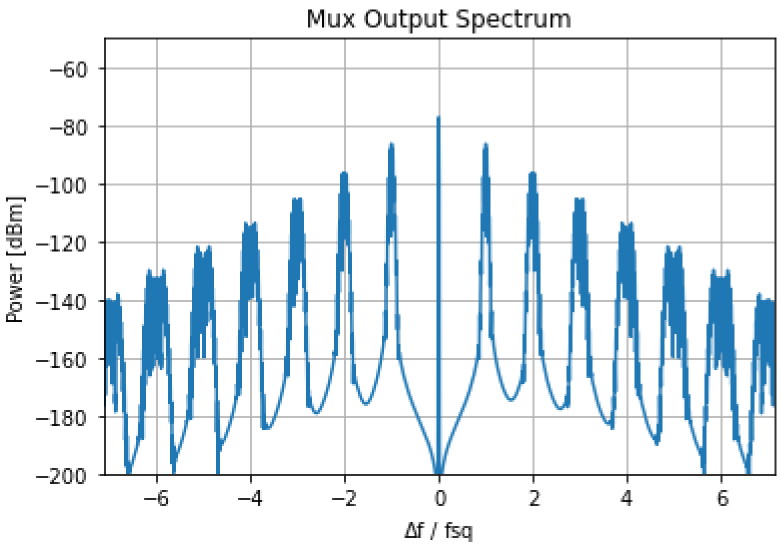
MUX output for a single tone





RF tone modulation bandwidth



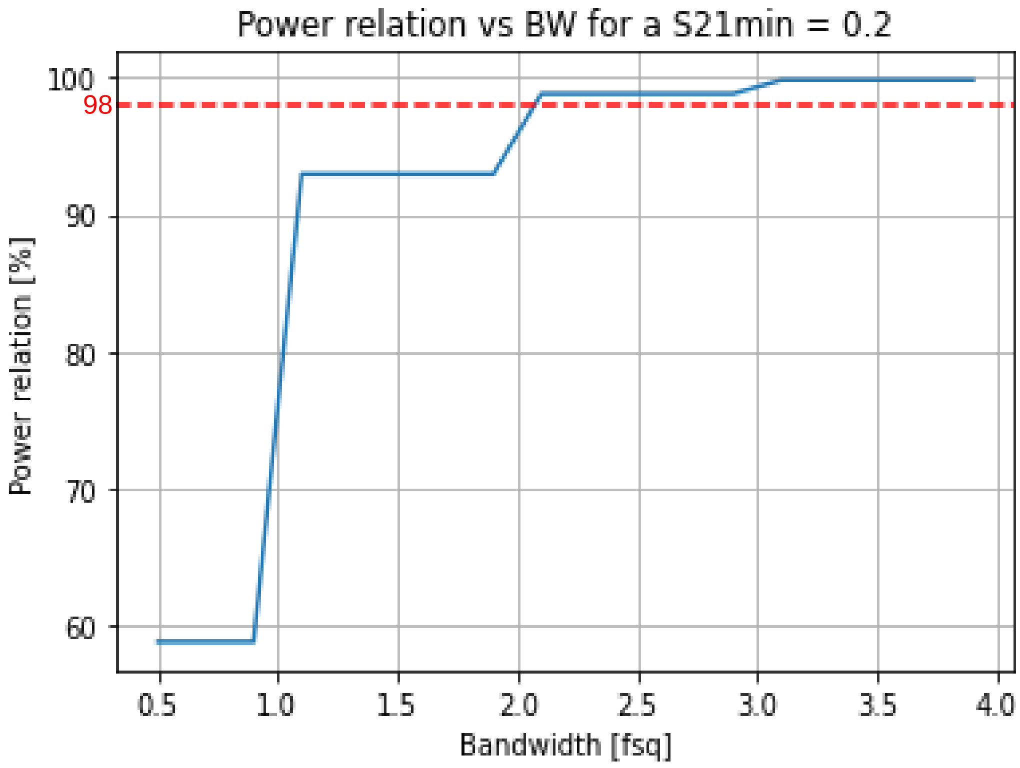


Power without pm: 2.773nW
Power with pm : 2.739nW
Relation : 98.77%

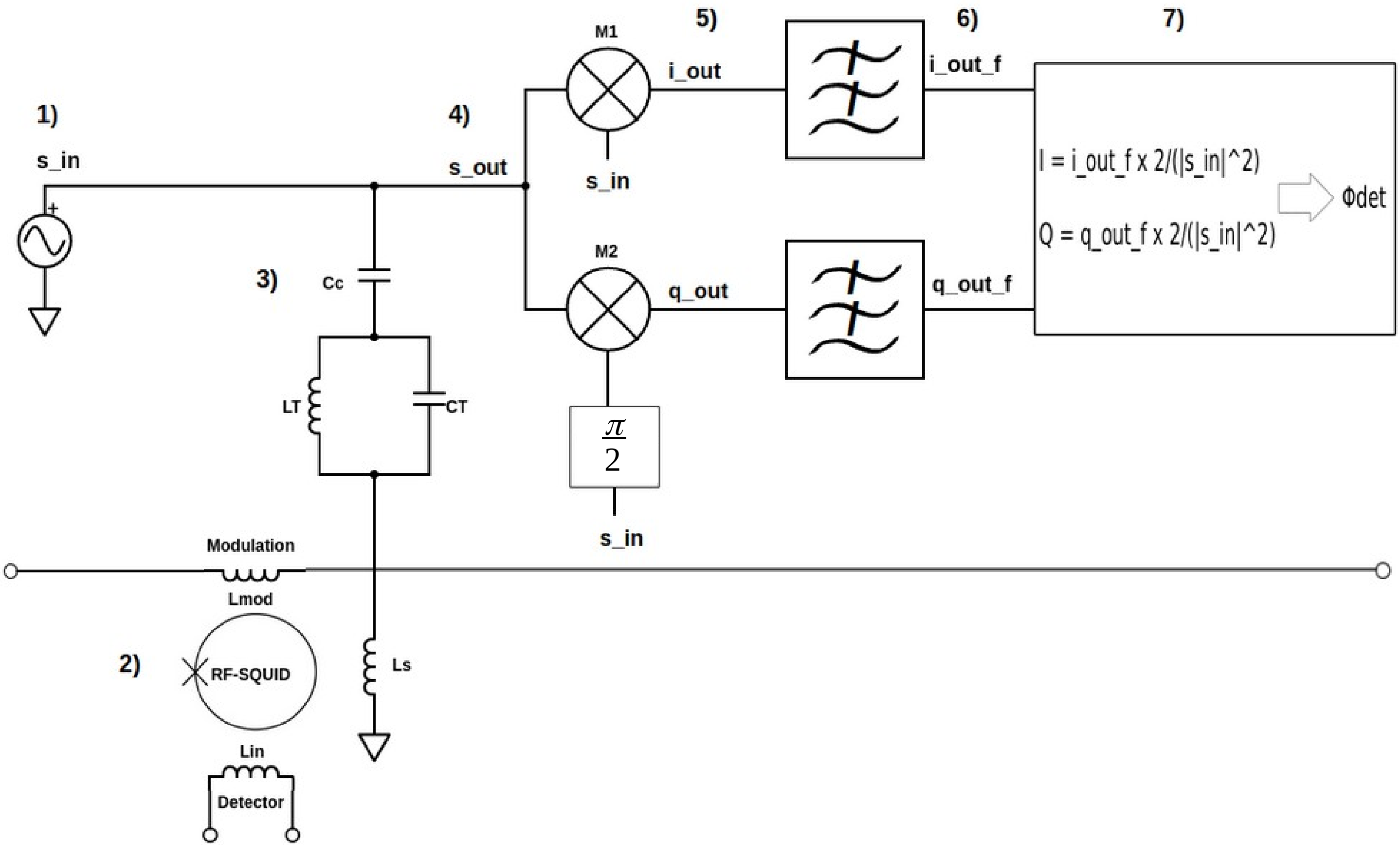
Using BW = 2.fsquid+5.fmax

BW ECHo = 14.4MHz
BW QUBIC = 900Hz

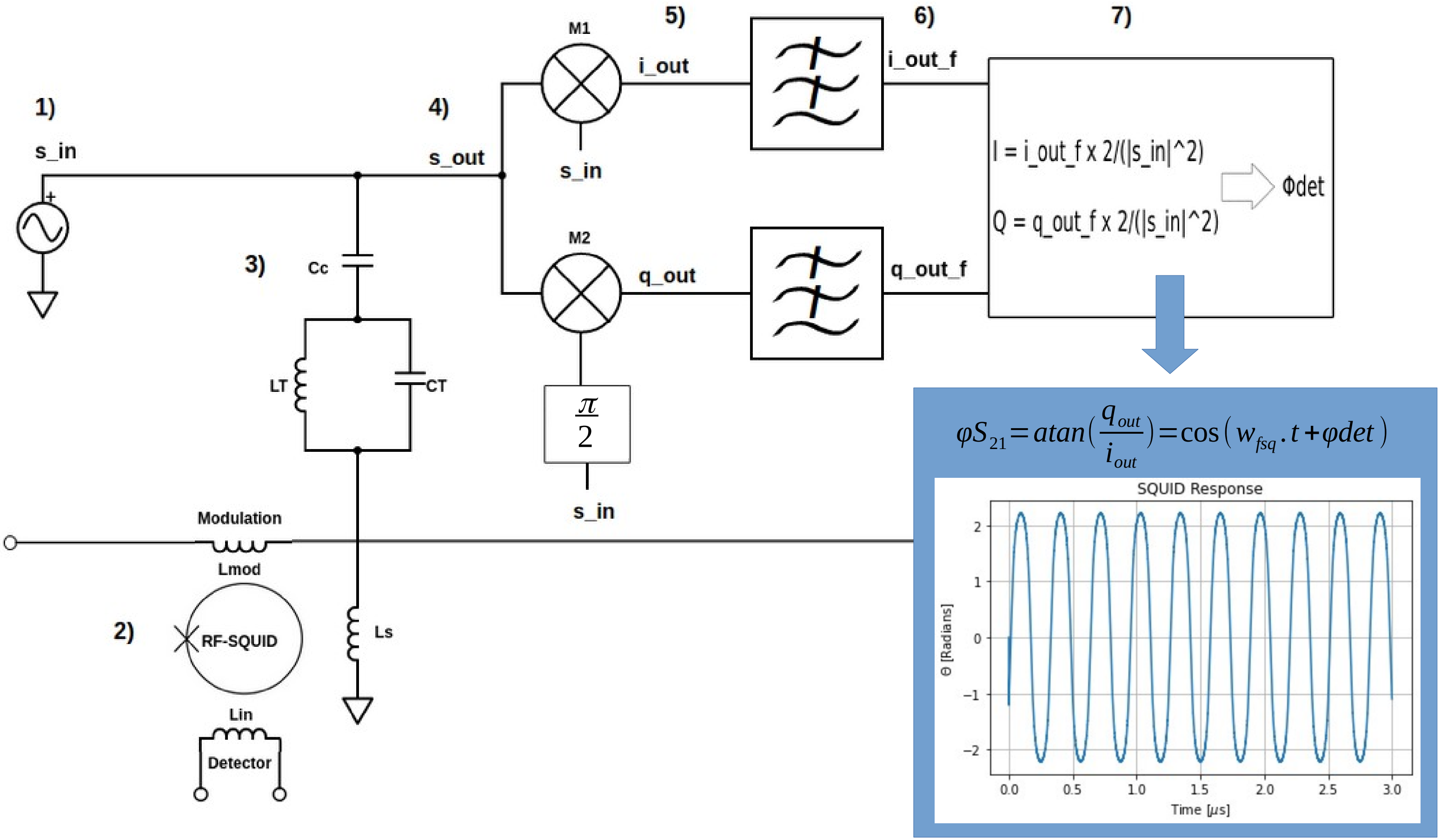
RF tone modulation bandwidth



Demodulation

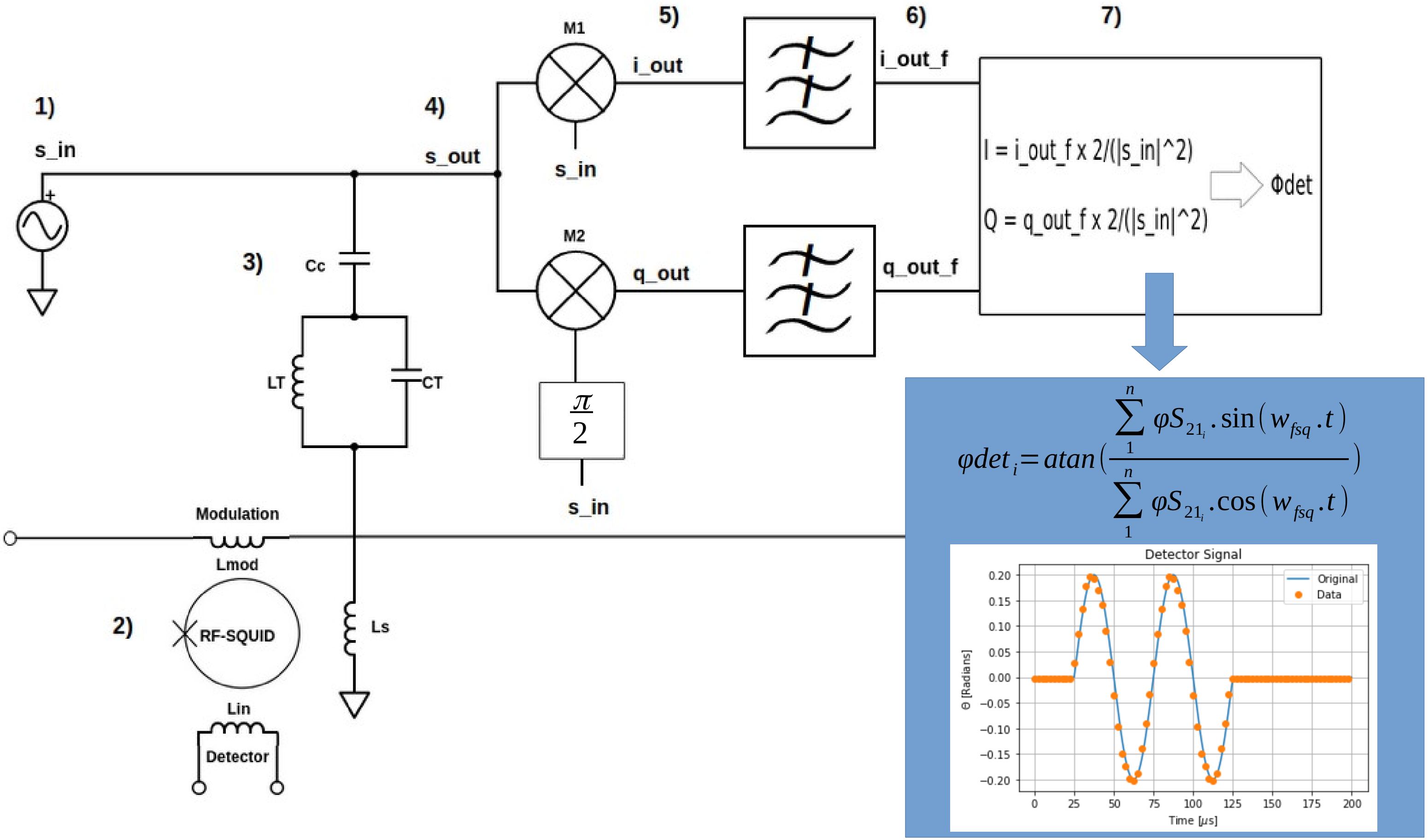


Demodulation



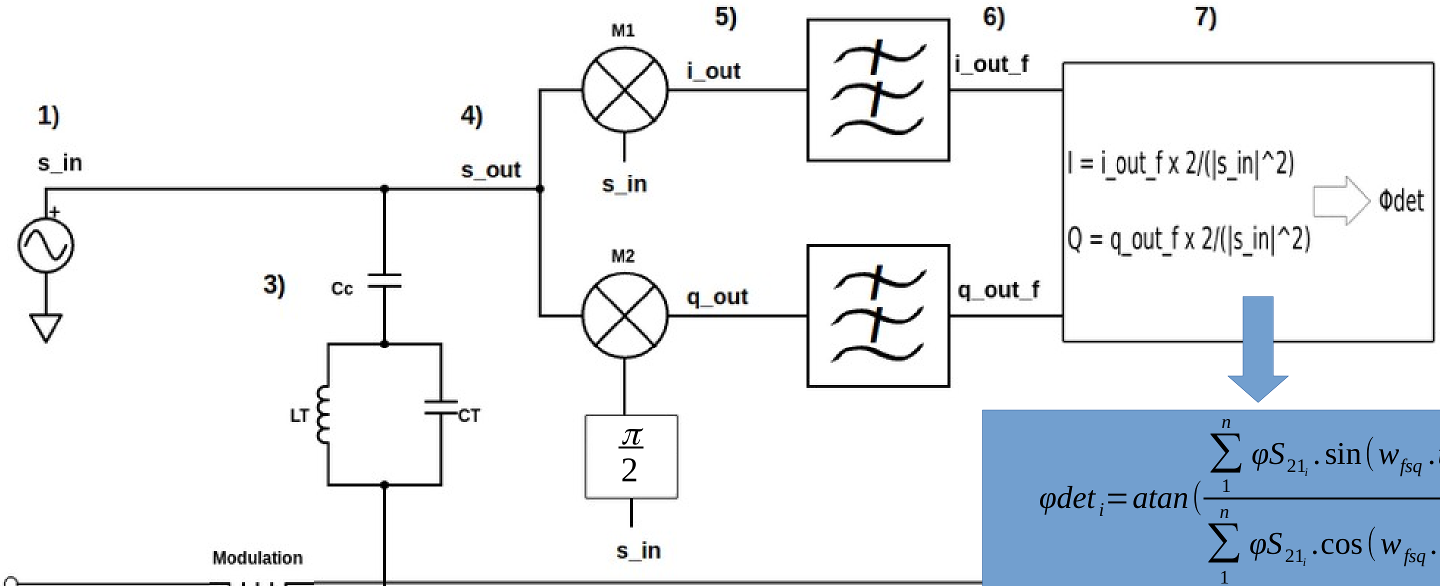
$$\varphi S_{21} = atan\left(\frac{q_{out}}{i_{out}}\right) = \cos\left(w_{fsq}.t + \varphi det\right)$$

Demodulation

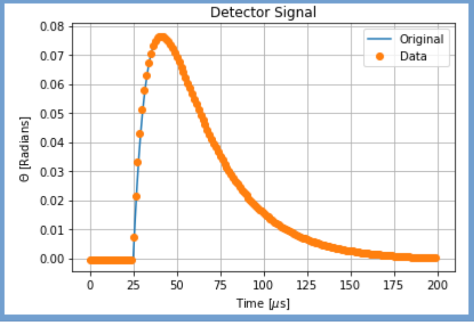


$$\varphi det_i = atan\left(\frac{\sum_{1}^{n} \varphi S_{21_i} . \sin(w_{fsq} . t)}{\sum_{1}^{n} \varphi S_{21_i} . \cos(w_{fsq} . t)}\right)$$

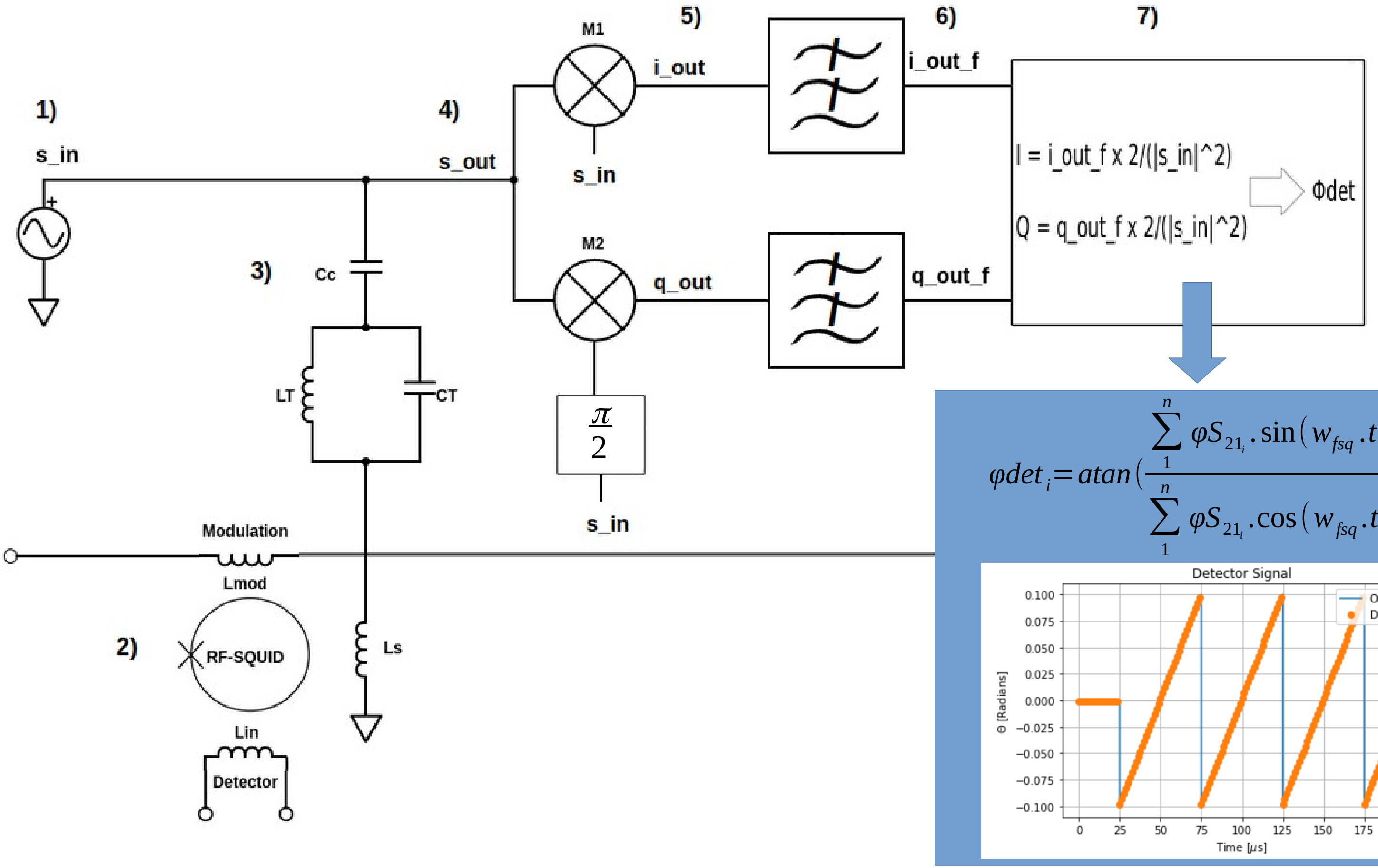
Demodulation



$$\varphi det_i = atan\left(\frac{\sum_1^n \varphi S_{21_i}.\sin(w_{fsq}.t)}{\sum_1^n \varphi S_{21_i}.\cos(w_{fsq}.t)}\right)$$



Demodulation



$$\varphi det_i = atan\left(\frac{\sum_{1}^{n} \varphi S_{21_i} . \sin(w_{fsq} . t)}{\sum_{1}^{n} \varphi S_{21_i} . \cos(w_{fsq} . t)}\right)$$

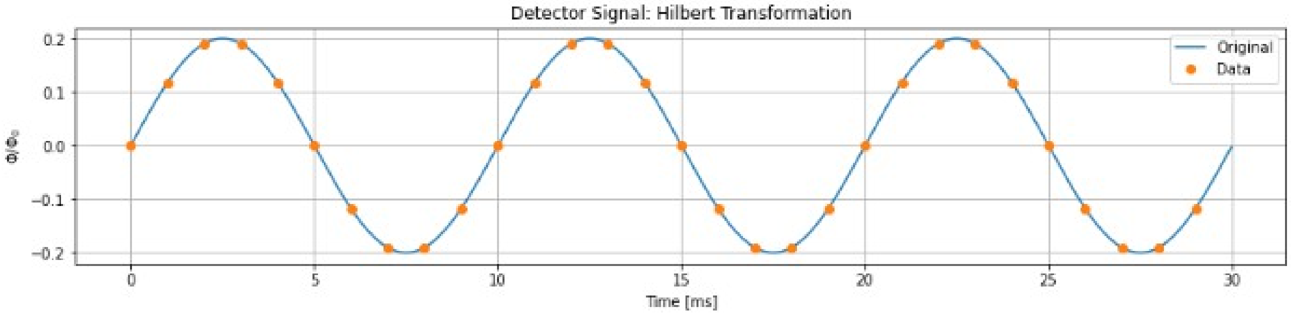
Demodulation

$s = \cos(w_{sq}.t + \varphi S_{21})$ $\hat{s} = -\sin(w_{sq}.t + \varphi S_{21})$

$$f = \cos(w_{sq}.t + \varphi S_{21}) - j.\sin(w_{sq}.t + \varphi S_{21})$$

$$\arctan\left(\frac{-\hat{s}}{s}\right) = w_{sq}.t + \varphi S_{21}$$

$$\varphi S_{21} = \arctan\left(\frac{-\hat{s}}{s}\right) - w_{sq}.t$$



Summary

- The flux ramp modulation technique was shown.
- Mux output signal and all the modulations involved were presented.
- P=f(BW) plot was simulated.
- Demodulated signal was obtained showing two different methods.

Future work

- Analyze the noise of the system
- Obtain a BW criterion related to the signal to be recovered
- Implement the demodulation in a FPGA
- Measurement with detector data

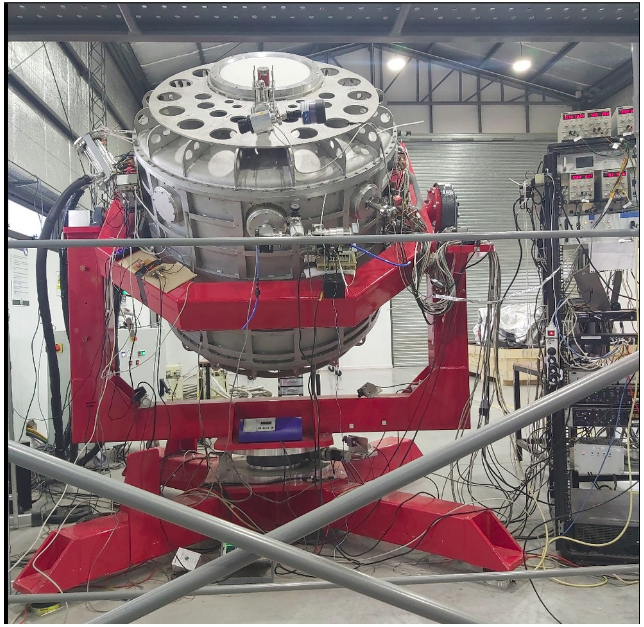
Completed Courses

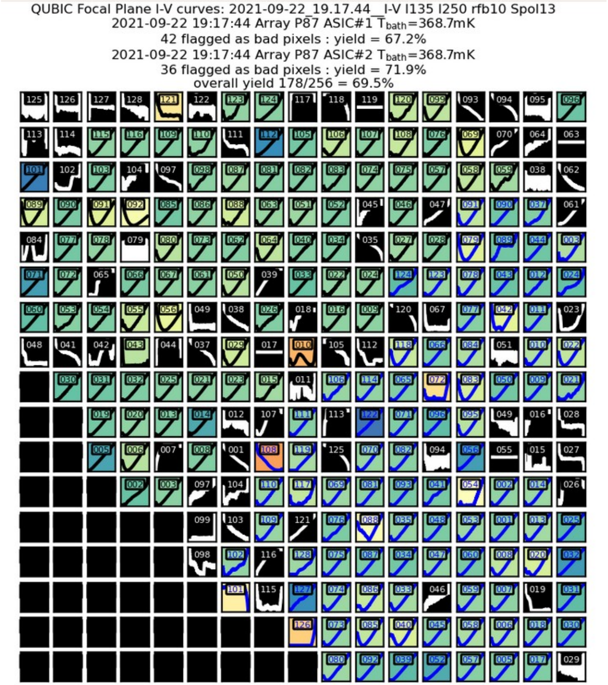
- Elemento de Economía para Tecnólogos, Instituto Sabato, Bs. As. Argentina
- Introducción a Filosofía de la Ciencia, Instituto Sabato, Bs. As. Argentina
- Statistical Data Analysis, Instituto Sabato, Bs. As. Argentina
- Introducción a la Metodología de Elementos Finitos, UNSAM, Bs. As. Argentina
- Deutsch Language, A1.2 and A2.1, UNSAM, Bs. As. Argentina
- Low-Temperature (Superconductive) Detectors, KSETA

Talks

- 8vo Seminario Anual ECyT UNSAM. Bs. As., Argentina

QUBIC




QUBIC Focal Plane I-V curves: 2021-09-22_19.17.44__I-V I135 I250 rfb10 Spol13
2021-09-22 19:17:44 Array P87 ASIC#1 T_{bath}=368.7mK
42 flagged as bad pixels : yield = 67.2%
2021-09-22 19:17:44 Array P87 ASIC#2 T_{bath}=368.7mK
36 flagged as bad pixels : yield = 71.9%
overall yield 178/256 = 69.5%

¡¡Thanks!!

SQUID modulation

SQUID

$$I = I_c sin(\phi)$$
$$L = L_J \cdot sec(\phi)$$
$$\phi = \frac{2\pi\Phi}{\Phi_o} = \frac{2\pi(\Phi_c+\Phi_i)}{\Phi_o}$$

Flux Ramp Modulation

$$I_{ramp} = I \cdot f_{ramp} \cdot t$$

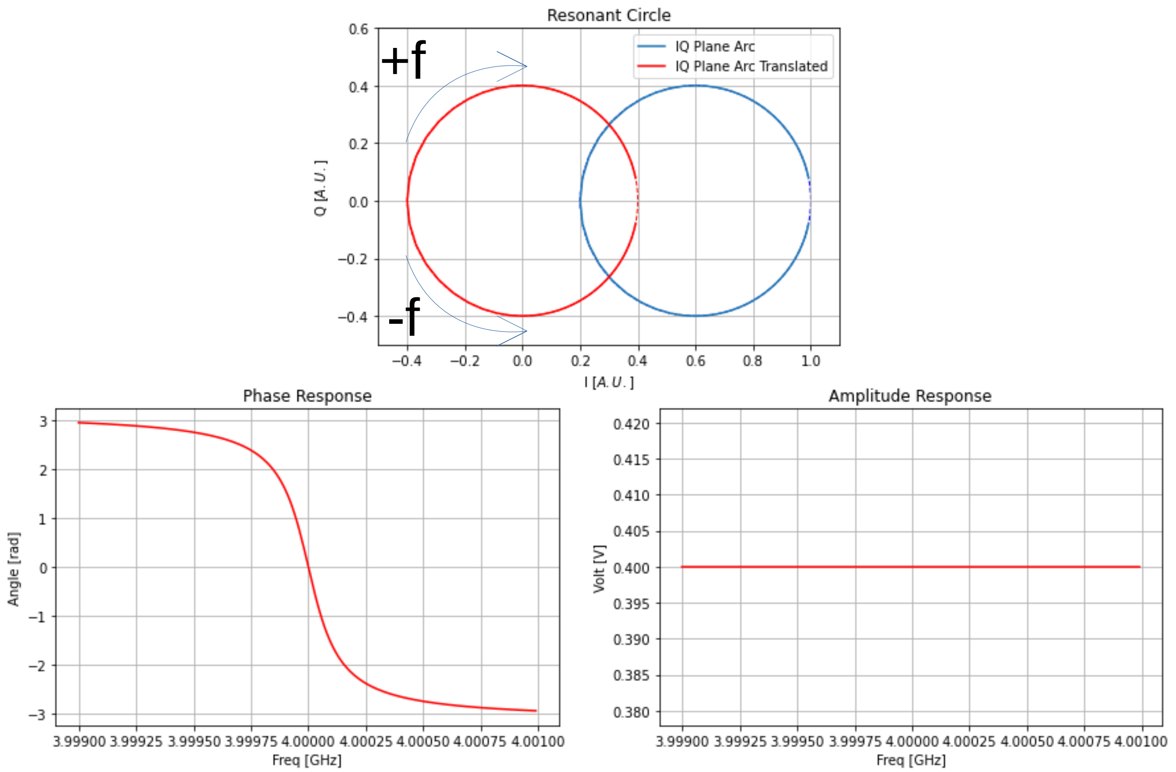
$$\Phi_c = I \cdot M_m \cdot f_{ramp} \cdot t = n_{\Phi_o} \cdot f_{ramp} \cdot t$$

Input Signal

$$\Phi_i = I_i M_i$$

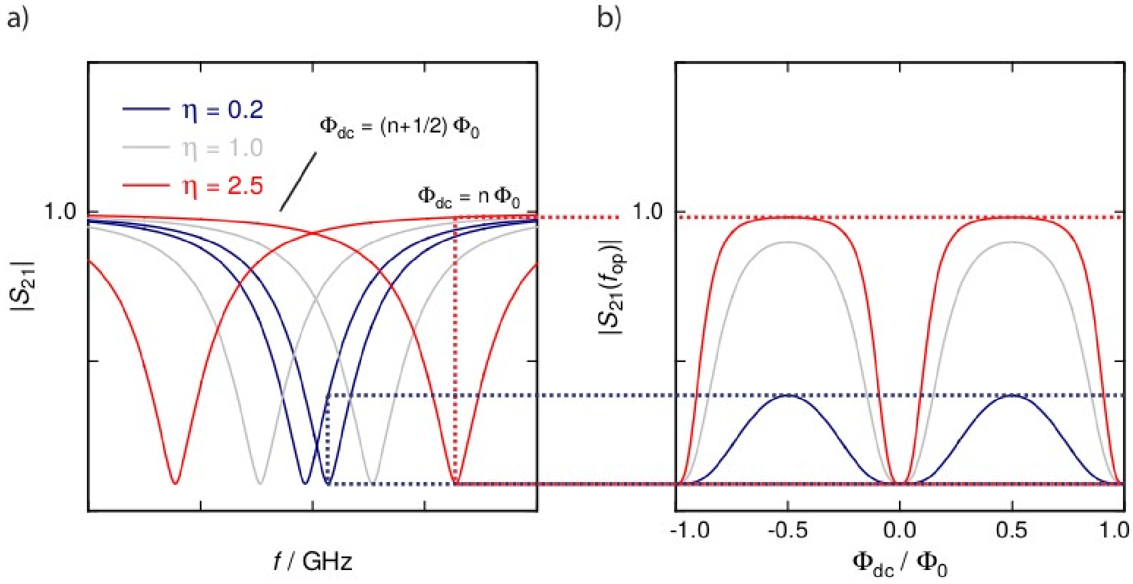
$$I = I_c sin(\frac{2\pi m_{ramp} t}{\Phi_o} + \frac{2\pi\Phi_i}{\Phi_o}), L(t)$$

Resonance circle



$$S_{21} = \frac{S_{21\,min} + 2j.\dfrac{(f - fr(\varphi))}{BWres}}{1 + 2j.\dfrac{(f - fr(\varphi))}{BWres}}$$

Coverage factor



$$f_r = f_0 - \Delta f_r = f_0 - \eta \frac{BW_{res}}{2} \cos(\varphi_{ext})$$

Power vs S21min