NST v02 (2025-04-17)

Created by	Matthew Schulz
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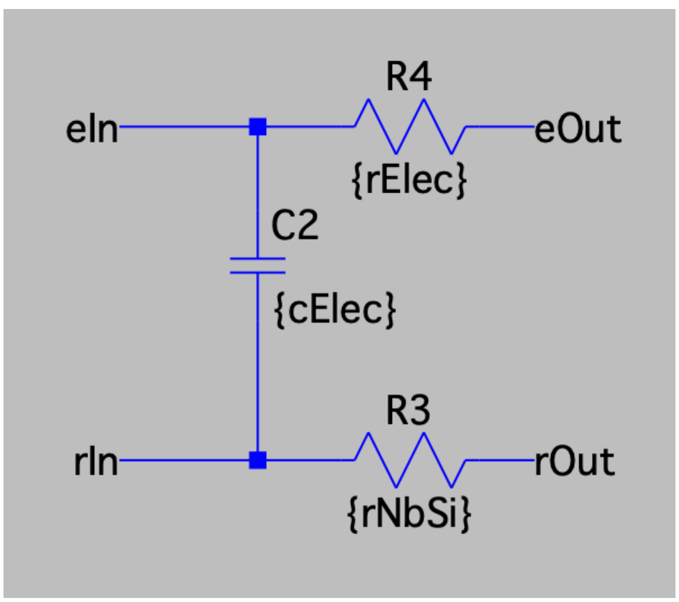
Modeling The 2DEG

In order to accurately model the device, I modeled the per unit length resistance of the 2DEG ($R_{l,2DEG} \approx 1\frac{G\Omega}{m}$) and the NbSi strip ($R_{l,NbSi} \approx 100\frac{k\Omega}{m}$) in addition to the per unit length capacitance of the 2DEG at 10 nm above the metal surface ($C_{l,2DEG} \approx 2.655\frac{\mu F}{m}$).

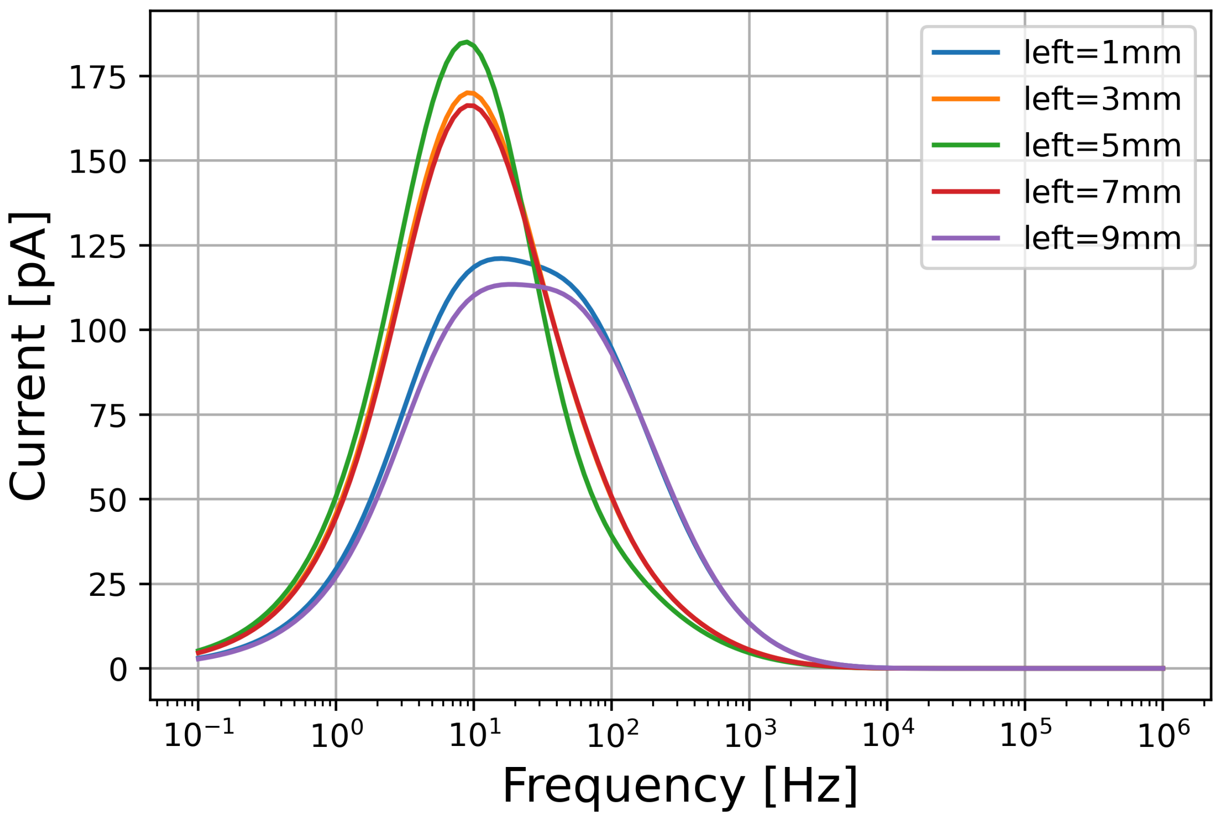


I broke the per unit length resistances and capacitances into 0.1 mm chunks to add some granularity in the model. The resistances in the contacts were all shorted together to simulate the underlying superconducting Nb beneath the contacts. After this, there were 4 different experiments I tried as first passes.

Experiment 1: Lopsided Devices

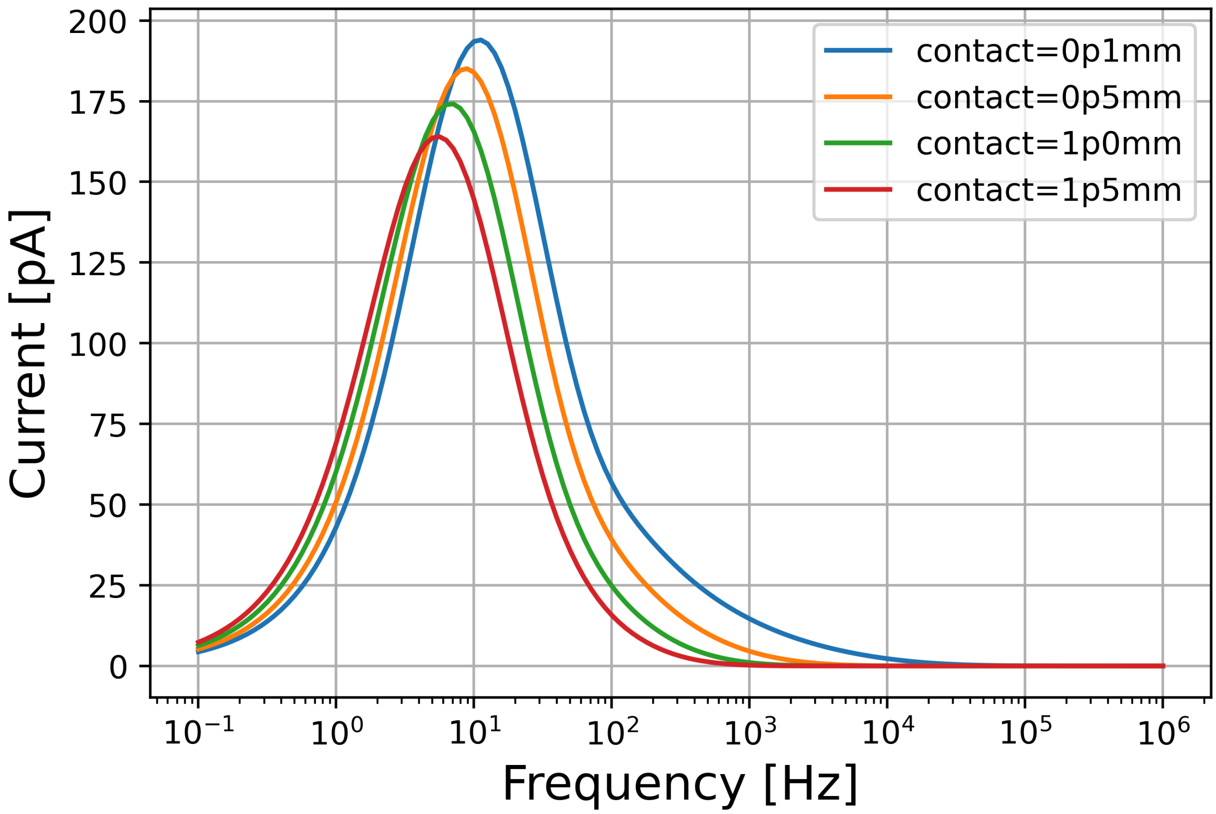
First I tried adding lopsidedness to the device. I tried device circuits where the left NbSi strip (between STI and STM) was {1,3,5,7,9} mm long and the right NbSi strip (between STM and STO) was {9,7,5,3,1} mm long in order to preserve the device length. 1.5 mm contacts were used in measuring this device.

It was found that the best signal was for a symmetric device, while the largest bandwidth was for the most lopsided device.



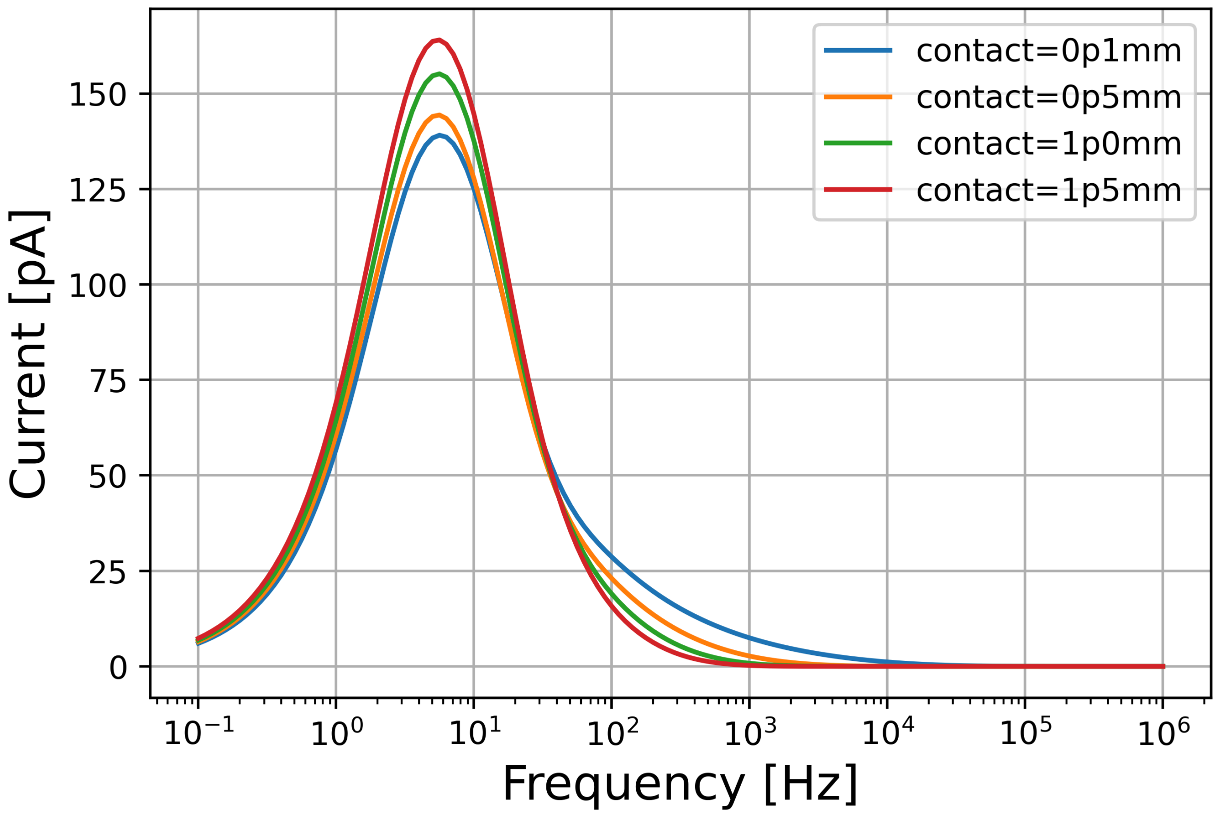
Experiment 2: Changing Contacts, Preserving Strip Length

For this experiment, I changed the length of the contacts while not changing any other lengths in the system. It was found that the smaller contact gave the most signal for the highest frequency range. However, my immediate suspicion upon doing this experiment was that the lack of total device length preservation was an issue; since the entire device acted as a low pass filter, any decrease in length in the contacts would bring a subsequent decrease in the "filtering power", thus boosting the signal.



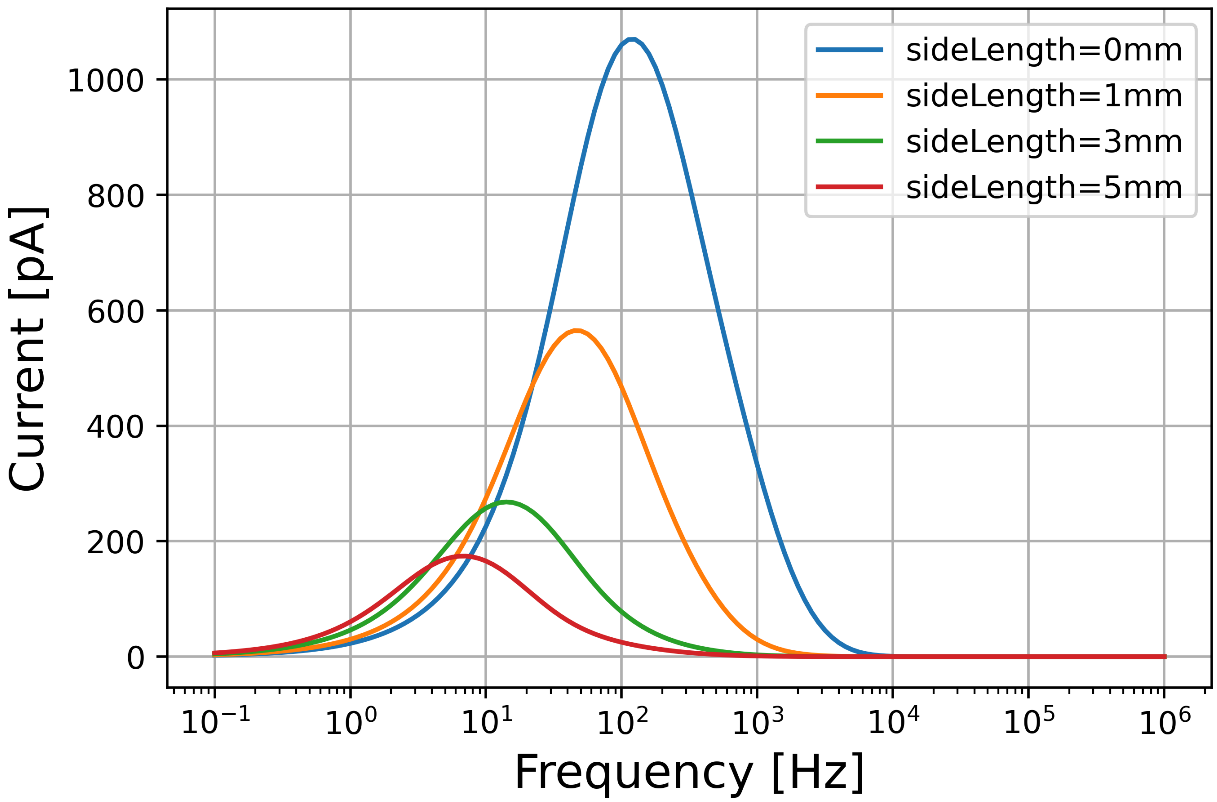
Experiment 3: Changing Contacts, Preserving Total Device Length

Experiment 3 is a version of Experiment 2 where I preserve the total length of the device to 14.5 mm by adding the lost length from the contacts to the NbSi strips in the device. Here it can be seen that the advantage that the smaller contacts had is lost, showing that my suspicions was correct. Intuitively, larger gates feel better because they give more surface area of contact with the electrons.



Experiment 4: Changing Strip Length

The last experiment I decided to do was change the strip length of the NbSi on either side of STM. Note that the 0mm side length is actually 0.1, and is an integer rounding error in printing the legend. Contact lengths were preserved here to 1mm, so the device length did change. However, it's striking the marked increase in signal and peak frequency obtained by making the device smaller. although this would make the dissipation of heat into the helium higher, this may not be all that much of a worry in the long run given the small magnitude of the signal input into the system.


sideLength=0mm
sideLength=1mm
sideLength=3mm
sideLength=5mm
Current [pA]
Frequency [Hz]
0
200
400
600
800
1000
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}