Revisiting the

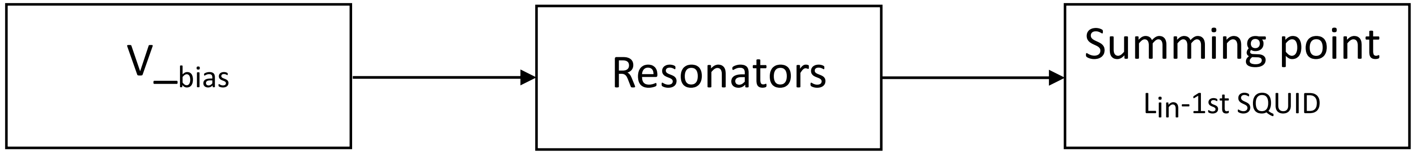
Out of Band Resonances (OBR) of the SAFARI FDM-2-stage SQUID

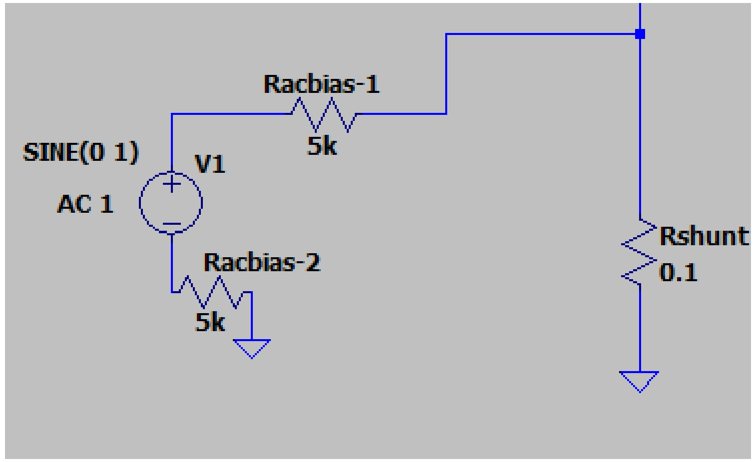
- A SQUID with lower L_{in} shifts away the OBR to the higher frequencies
- The snubber in use still damps down the OBR peak although it can be optimized for the new SQUID
- A nearby OBR could also occur which depends on the Loom-in characteristics. It won't be damped by the snubber at the summing point

Simulation and Modeling using LTspiceXVII

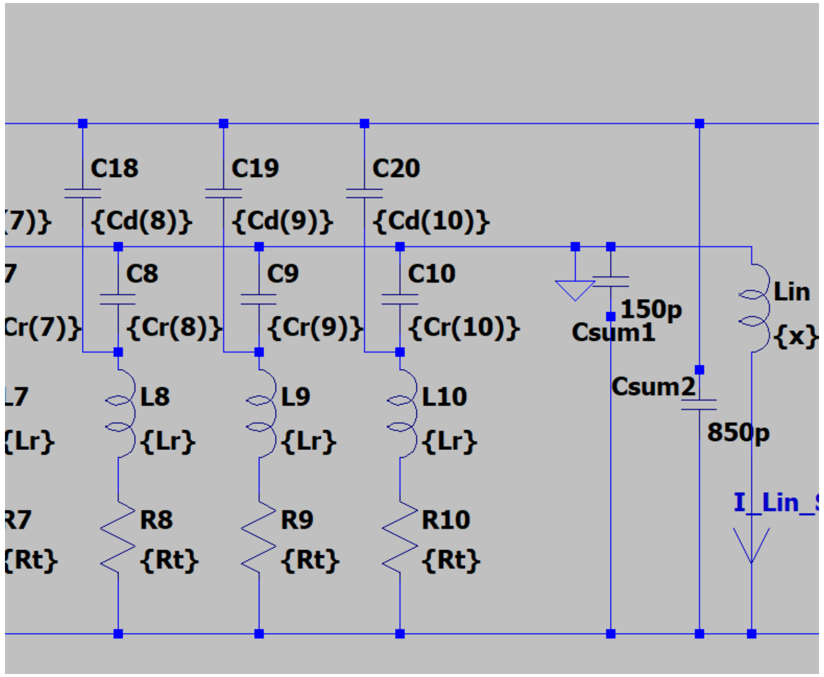
Amin Aminaei, December 2020

Simulation of SAFARI FDM Blocks up to Input of the 1st SQUID



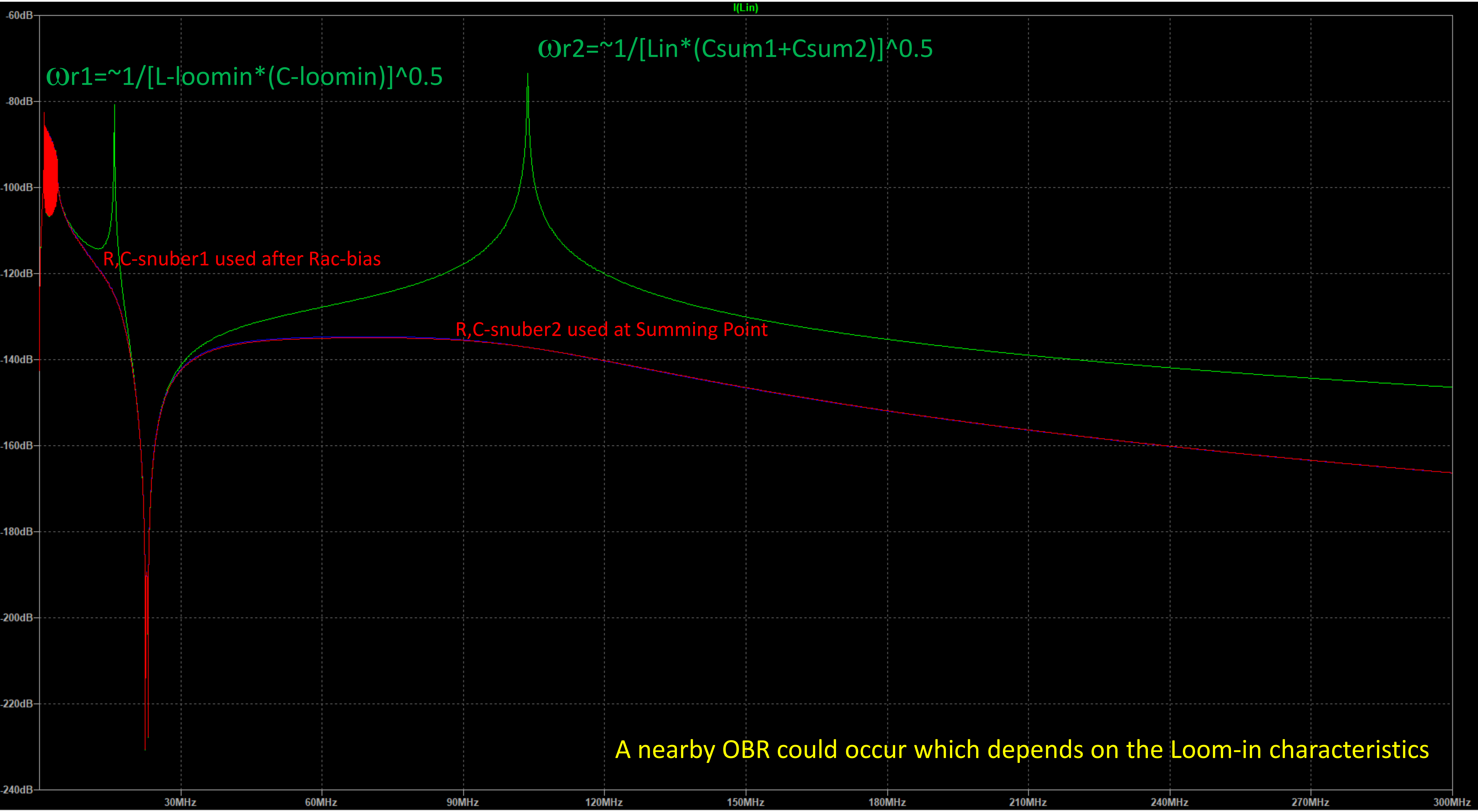


..........176 Pixels(LC's).......



Lin

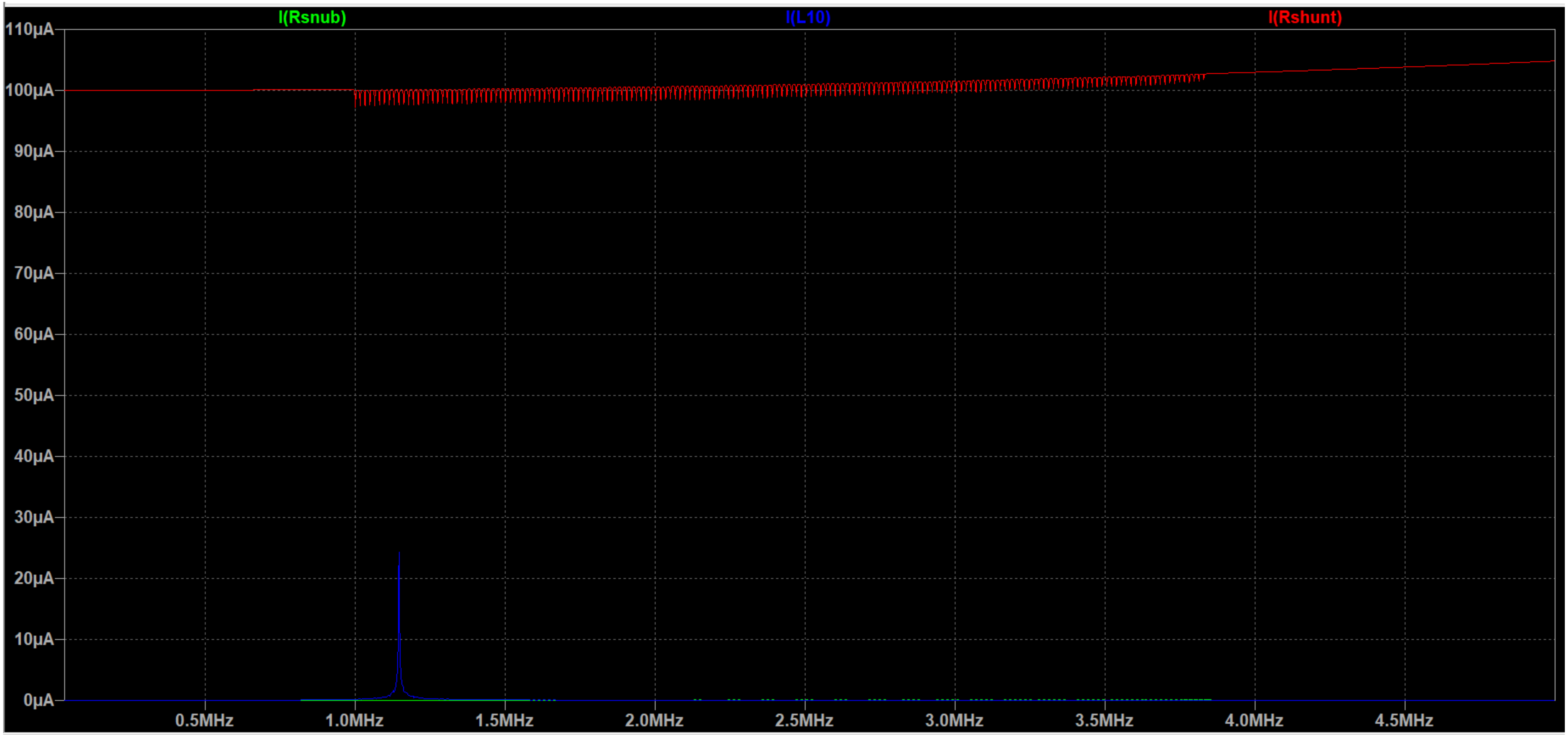
2nH



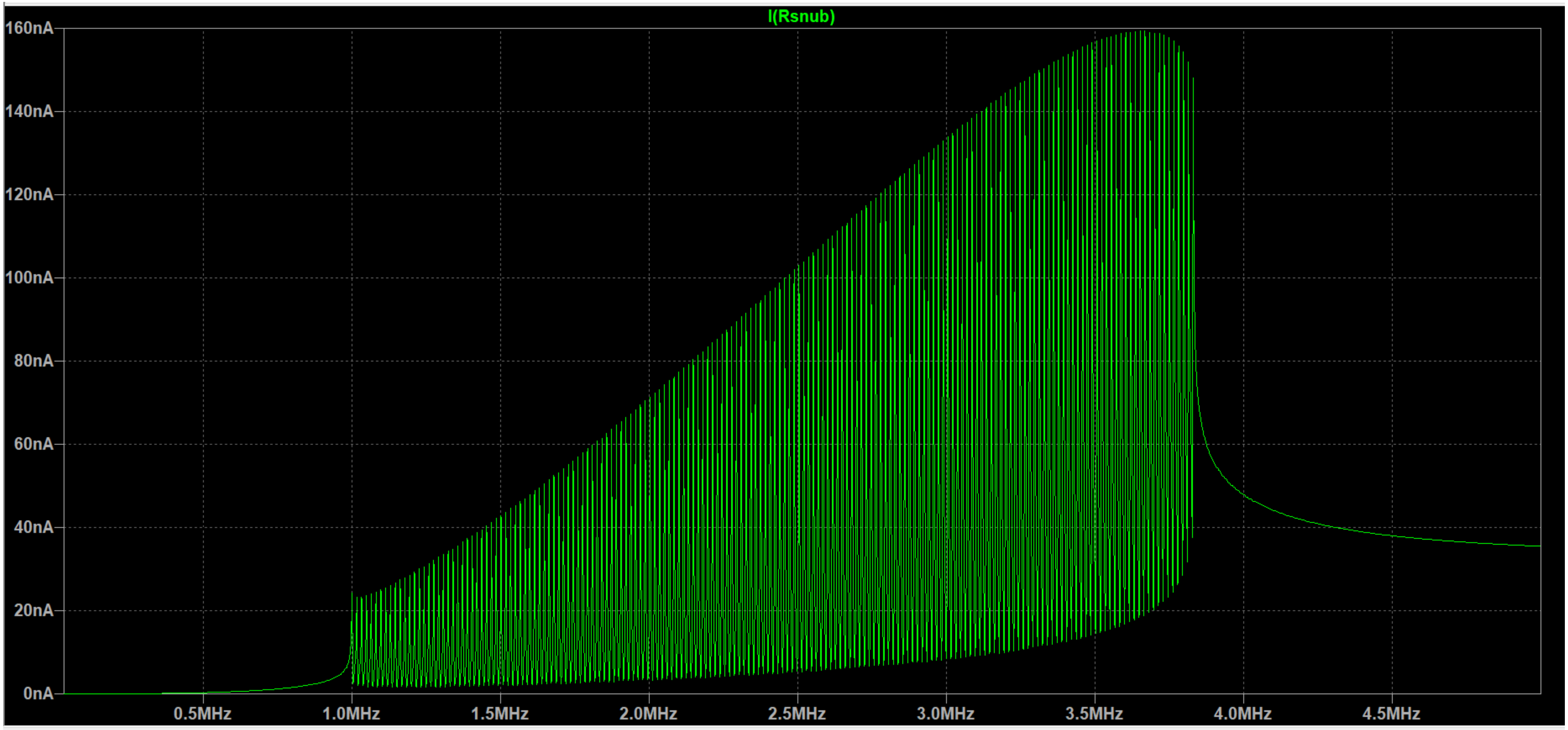
I(Lin)
ωr1=~1/[L-loomin*(C-loomin)]^0.5
ωr2=~1/[Lin*(Csum1+Csum2)]^0.5
R,C-snuber1 used after Rac-bias
R,C-snuber2 used at Summing Point
A nearby OBR could occur which depends on the Loom-in characteristics
-60dB
-80dB
-100dB
-120dB
-140dB
-160dB
-180dB
-200dB
-220dB
-240dB
30MHz
60MHz
90MHz
120MHz
150MHz
180MHz
210MHz
240MHz
270MHz
300MHz

Code (Lin=2nH):

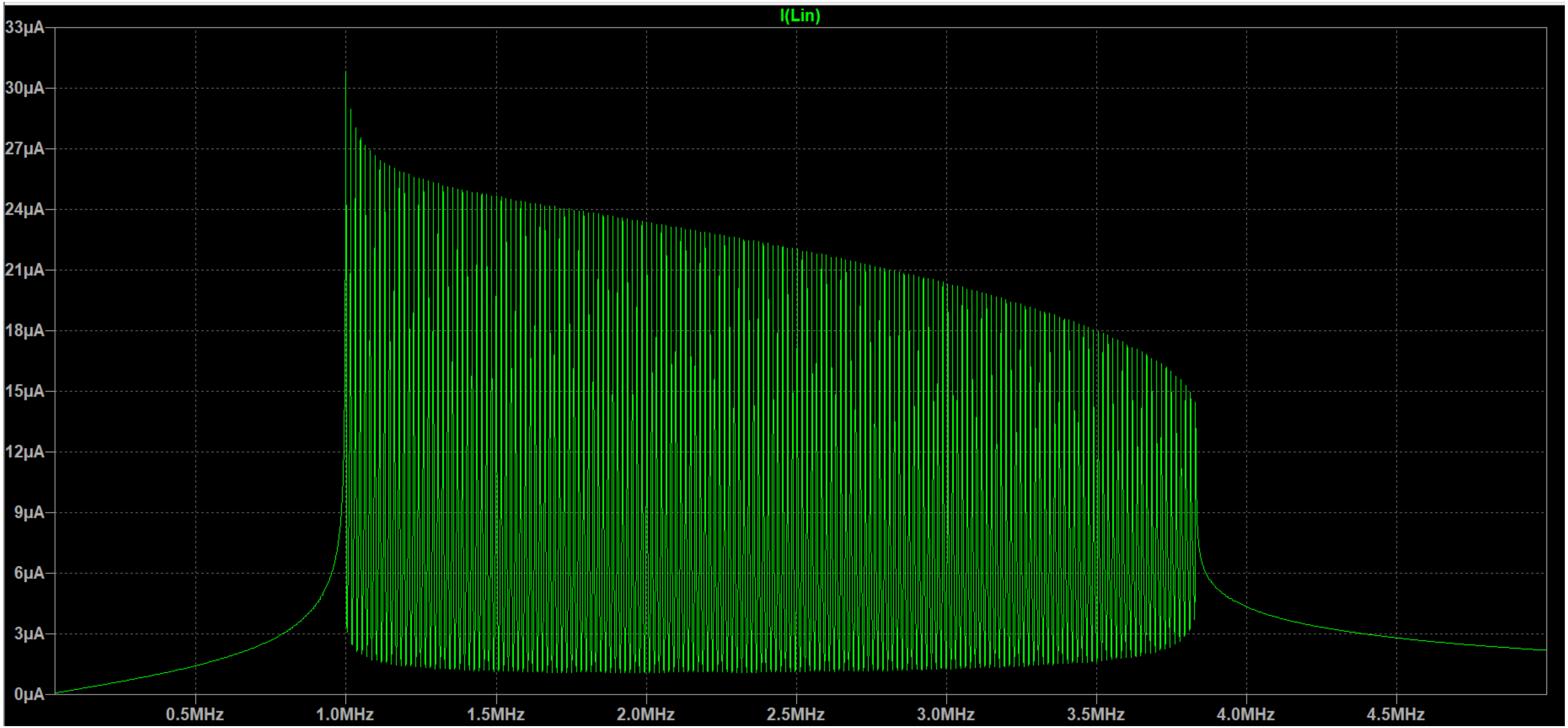
Resonators-176pix-CT-Lin-3.716MHz.asc Resonators-176pix-CT-Lin-3.716MHz.asc



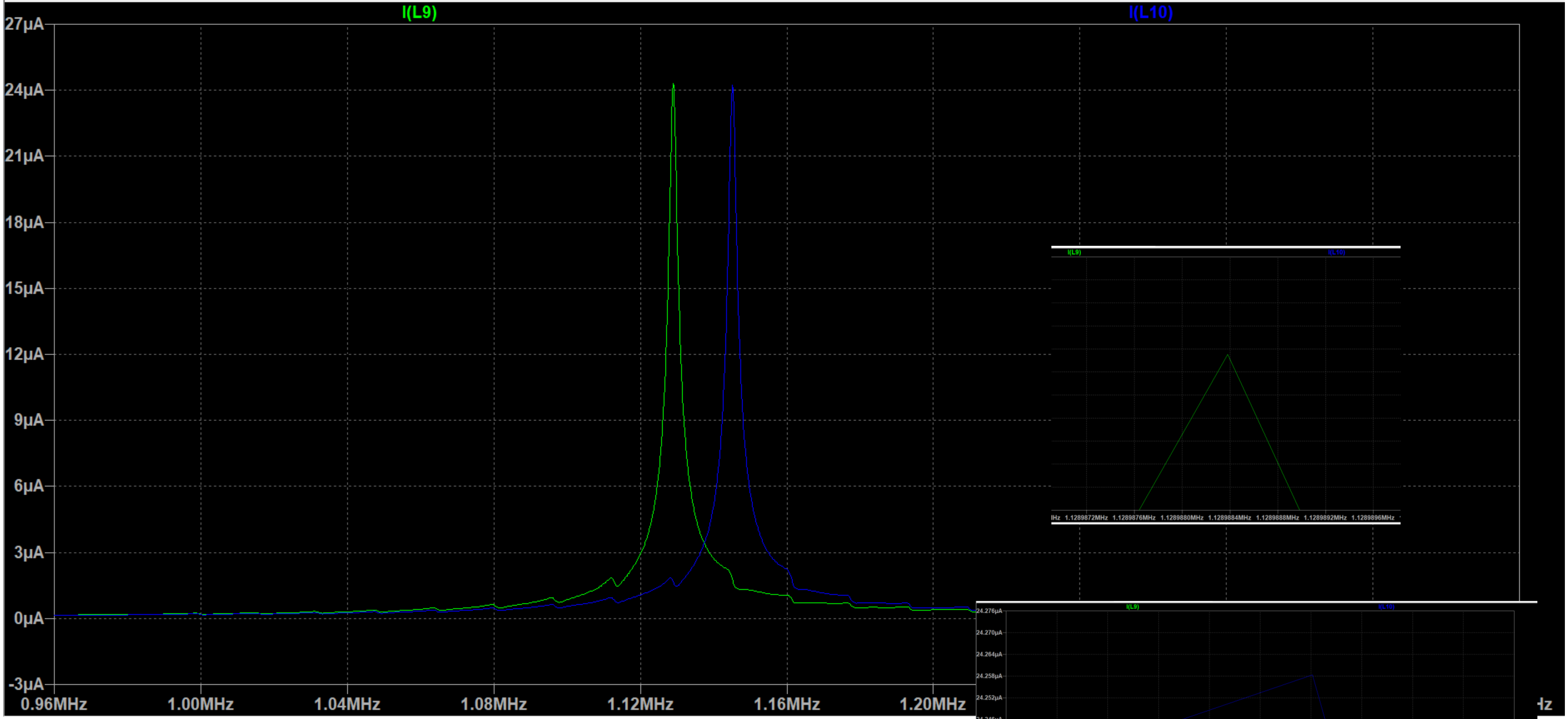
Currents of Rsnub, LC resonator#10 and Rshunt
176 LCs, AC=1V

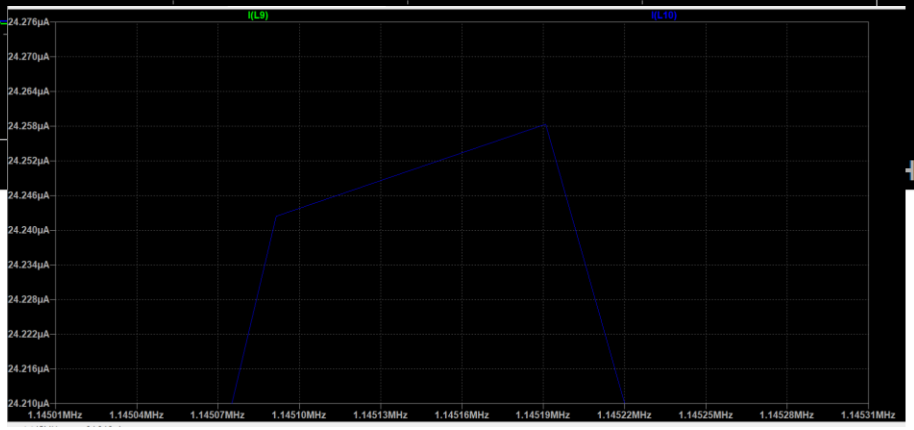


Currents of Rsnub=2.2Ohm, 176 LCs, AC=1V

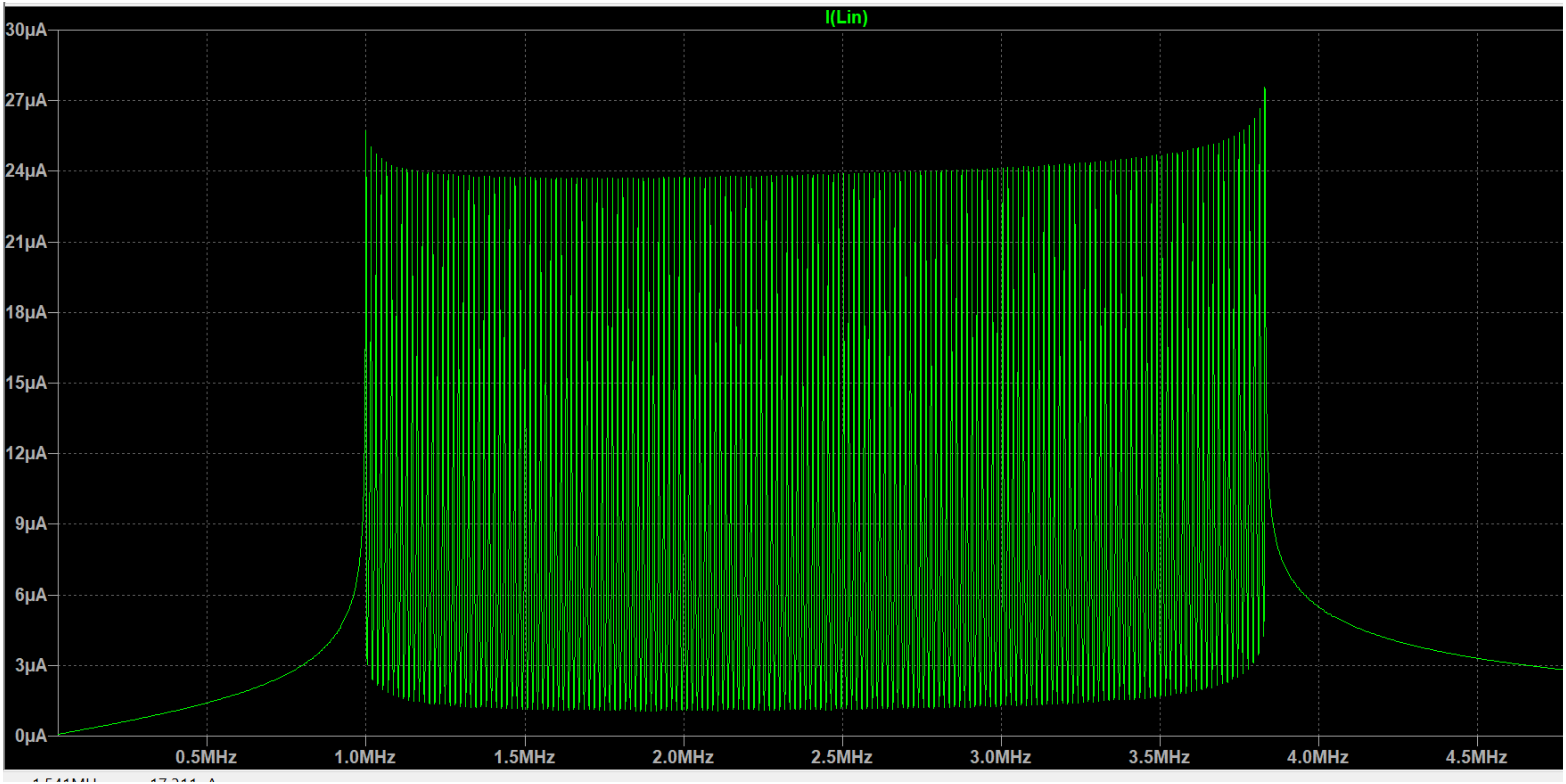


Currents of I(Lin), 176 LCs, AC=1V, Lin=2nH
An illustration of current drop off at the input of SQUID at higher frequencies?

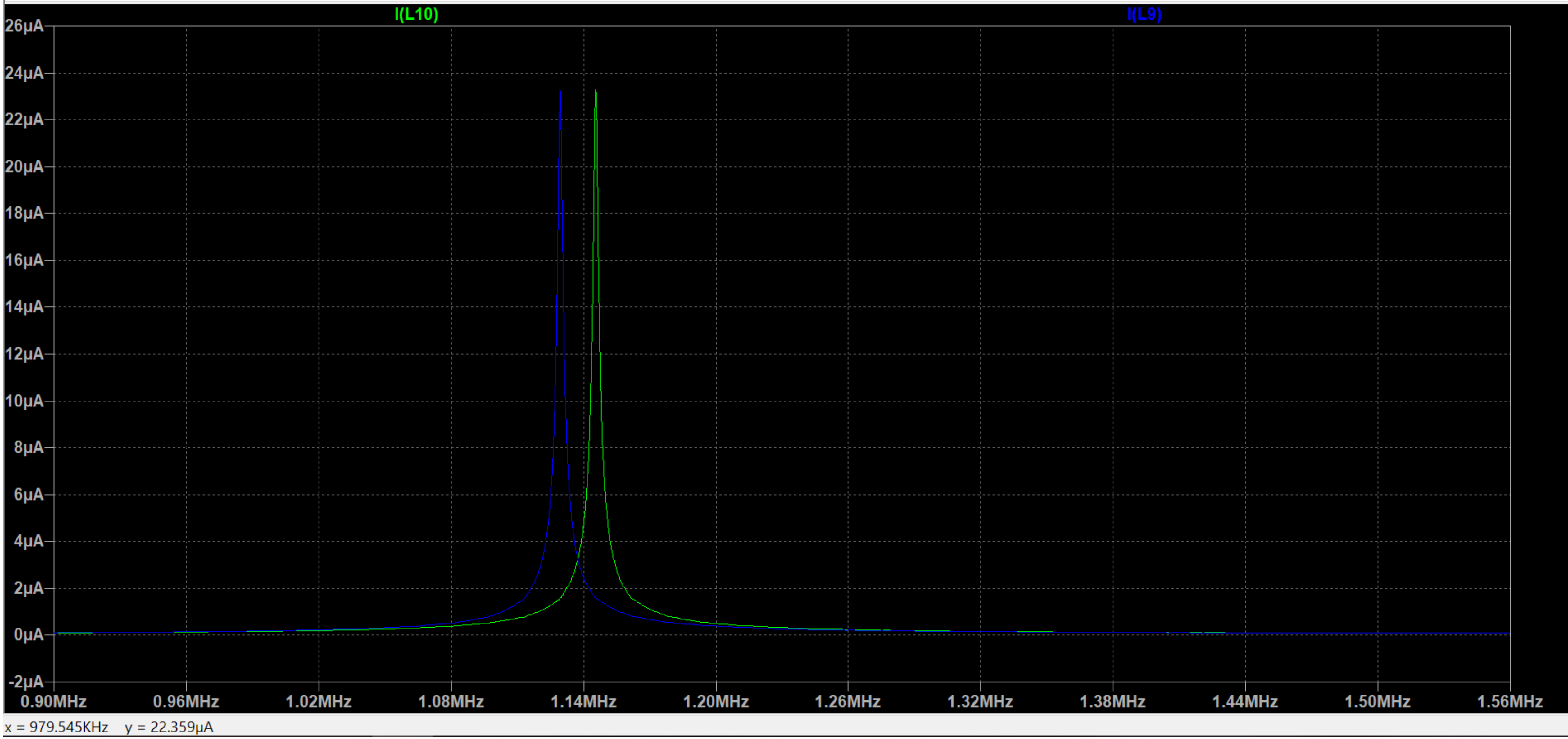




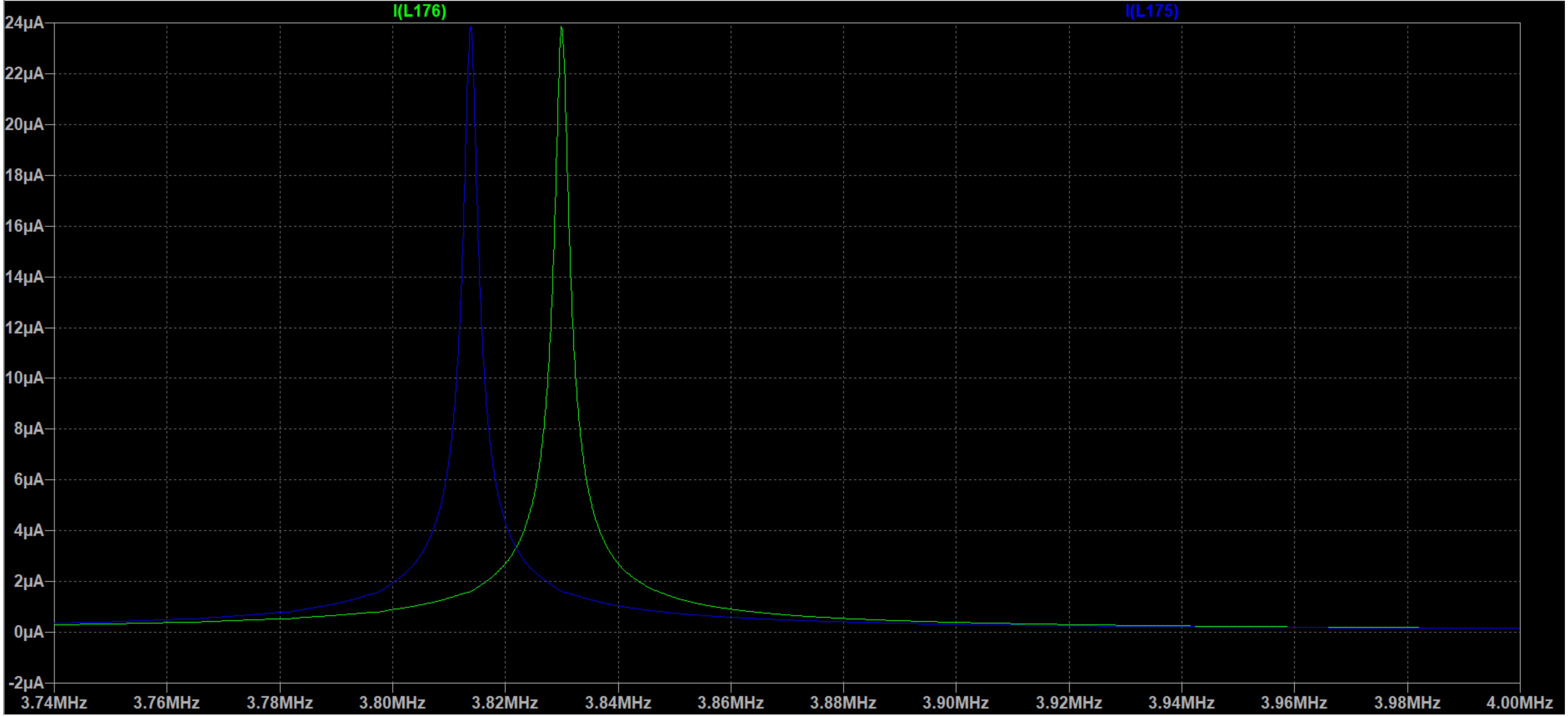
Position of two neighbor LCs with Lin=2nH



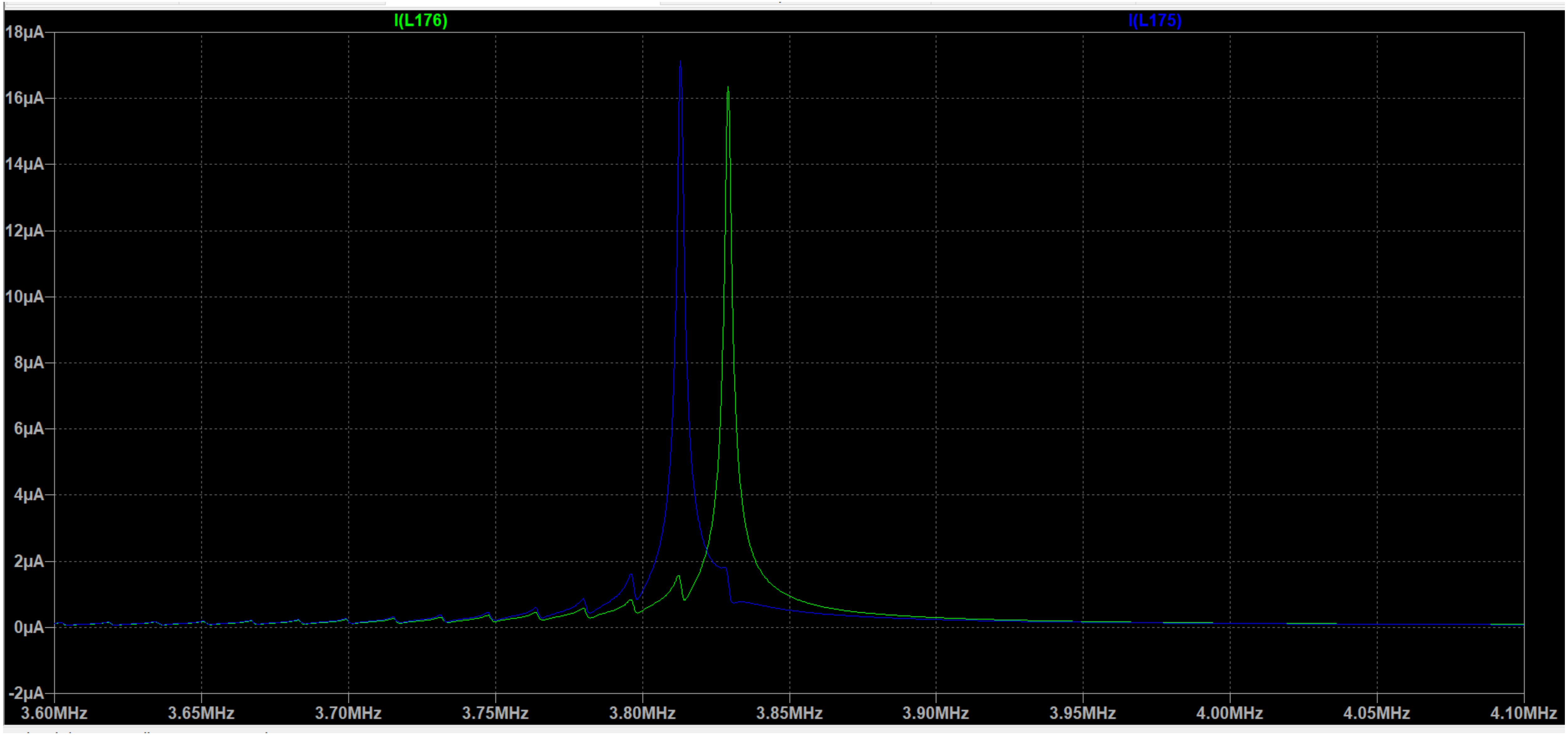
Currents of I(Lin), 176 LCs, AC=1V, Lin ~ 0



Position of two neighbor LCs with Lin~0



Position of two neighbor LCs with Lin~0



Position of two neighbor LCs with Lin=2nH

Summary results

The snubber values in the simulation (and I believe in use in the setup) are R=2.2 Ohm and C=10nf which gives the corner frequency ½.pi.(R.C)=7.23MHz (10Pf would give 7.2GHz!)
(additional info: In the simulation, the first peak of OBR is due to the loom of AC bias around 20MHz and the second peak of OBR is due to the Common inductance and C summing points further away around 100 MHz. Snubber would damp both peaks, see the attached results)
-The current passing through the Snubber resistor is in the order of nA as opposed to uA for the LC resonators and the shunt resistor of 0.1 Ohm. I think this has been briefly addressed by Jan in the meeting of which the current would be dominant in Rshunt since they are in parallel and Rshunt << Rsnubber.
Please see the results in the attached file and let me know if values need to be changed. The AC voltage is 1 volt and Rs is 10 kOhm. Other parameters are Rtes=40mOhm. Lr=3uH, C ratio=9, f=1-3.8MHz, N=176 LCs. You might have measured different values but the order (uA of Rshunt current vs nA of Snubber current should still stand)

-The max. power dissipation of Rsnubber is   (160nA)^2* 2.2=56.3 fW and for Rshunt is ~1nW.

I’ve used the simplified model of resonators up to the input of SQUID to avoid complexity of harness and SQUID and FEE.
I can rerun it for complete model and the number of pixels you used if needed.

Simulation for a) common inductance of 2nH and no common inductance (S.C., in LTSpice a very small value of 0.00001fH to see the current)
Here are the results.
Lc=2nH
Frequency shift: examples of Two neighbour resonators
Fr10=1.14519MHz
Fr9=1.12898MHz
deltaF=16.21kHz
Lc current drops off from some 30uA in 1MHz to 18Ua to 3.8MHz (see the pattern in the attached file)
=================
Lc=0.00001fH (S.C.)
Lc current of common inductance roughly the same in the order of 24uA for all frequencies except edges (max. 27uA) see the pattern
Fr10=1.14558MHz
Fr9=1.12938MHz
deltaF=16.2kHz

Fr10sc-Fr10=~390Hz
Fr9sc-Fr9=~400Hz

Fr175=3.81294MHz   Lcom=2nH   Fr176=3.82914MHz   deltaFr=16.2kHz

Fr175sc=3.81383MHz
Fr176sc=3.83003MHz
deltaFr=16.2kHz   Fr175sc-Fr175=890Hz   highest frequency shift for 176 LC resonators.   Fr176sc-Fr176=890Hz

(1) the power dissipation is higher when having
a higher common inductance.
(2) the power dissipation is higher when with lower TES resistance (lower in transition).
(3) the highest power dissipation comes from shunt resistance which is around 1.05 nW.
(4) the higher the Rac bias, the lower current, so lower power dissipation. Actually now we use 50 kOhm, so should be safe.
(5) the impedance of AC bias loom influence is not significant.
(6) the longer The AC bias loom, the higher power dissipation.
(7) if the loom is very long, will be 3.5 MHz unwanted resonance.

- A cryogenic LNA as a reference performance for in use FEEs.
Some technical info:
Frequency starts at 1 MHz (where FDM begins)and goes up to 3GHz for OBR.
Good noise figure, linearity and gain
Can be used for transfer function study, open loop and BBFB

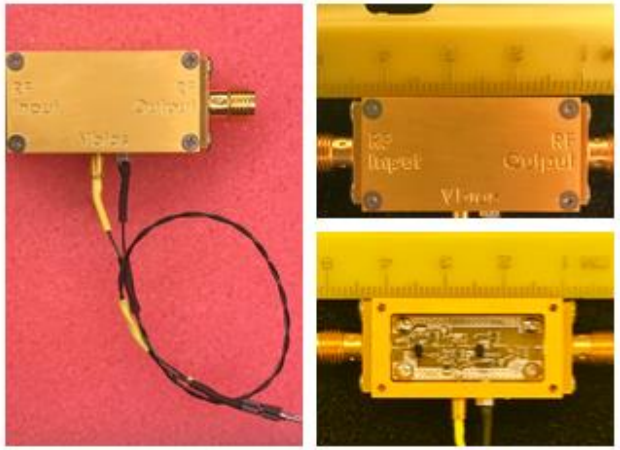
PRODUCT 1:

Product Details	
Part Number	BZ-P0010300-150827-152323
Manufacturer	B&Z Technology
General Parameters	
Type	Low Noise Amplifier
Configuration	Module with Connector
Frequency	1 MHz to 3 GHz
Gain	29 to 30 dB
Gain Flatness	±1.5 dB
Noise Figure	1 to 1.3 dB
P1dB	10 to 20 dBm
P1dB	0.01 to 0.1 W
Input VSWR	2.00:1
Output VSWR	2.00:1
Sub-Category	Octave Amplifier
Supply Voltage	15 V
Current Consumption	95 mA

• Product 2:

1MHz - 2GHz Cryo LNA

$2,500.00



1 Mhz - 2 Ghz Datasheet

Download File

Key Features:

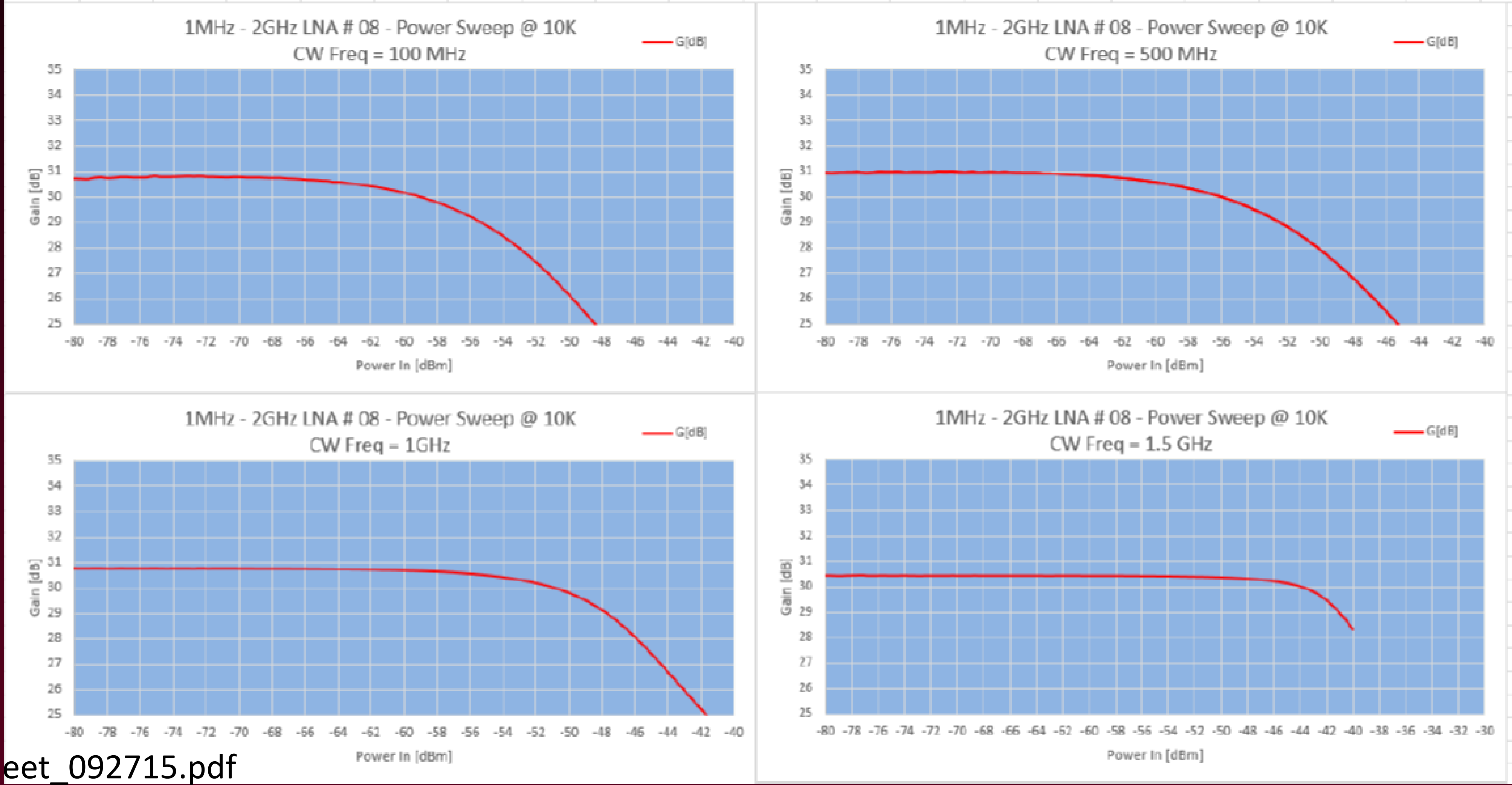
- **Power gain: 30dB**
- **Gain Flatness: < 0.1 dB on the 10-2000MHz band**
- **Noise temperature referenced to the input of LNA : 4-5 Kelvin**
    - **(Noise figure < 0.075 dB)**
- **Input and output Impedance: 50 OHM**
- **Input retun loss: < -10dB**
- **Output retun loss: < -10dB**
- **RF connectors: SMA female for Input and output**
- **Unconditionally stable with any input / output impedance**
- **Input 1dB Compression @ 1GHz: -50dBm**
- **Power consumption: 10mW at 10K**

http://thz.asu.edu/products.html

Linearity Measurements:

1dB Gain Compression Point @ 10K

Power Sweeps @ 10 K



asu_2ghz_cryolna_datasheet_092715.pdf

Linearity Measurements:

1dB Gain Compression Point @ 300K

Power Sweeps @ 300 K