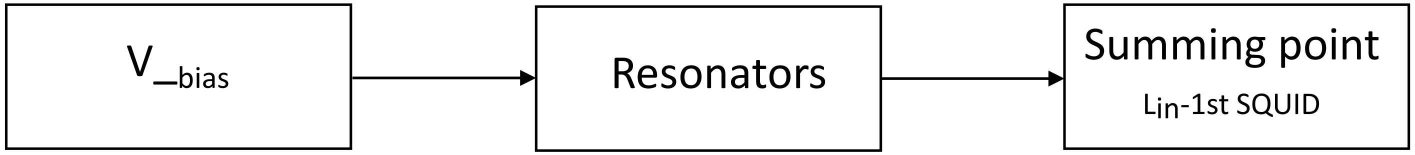
Power Dissipation on SAFARI FDM Model vs R_{TES} and Lin (Input inductance)

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



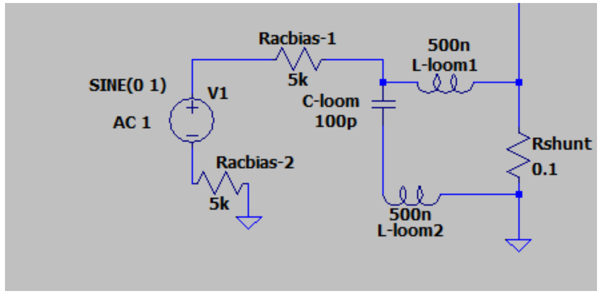
Simulation and Modeling using LTspiceXVII

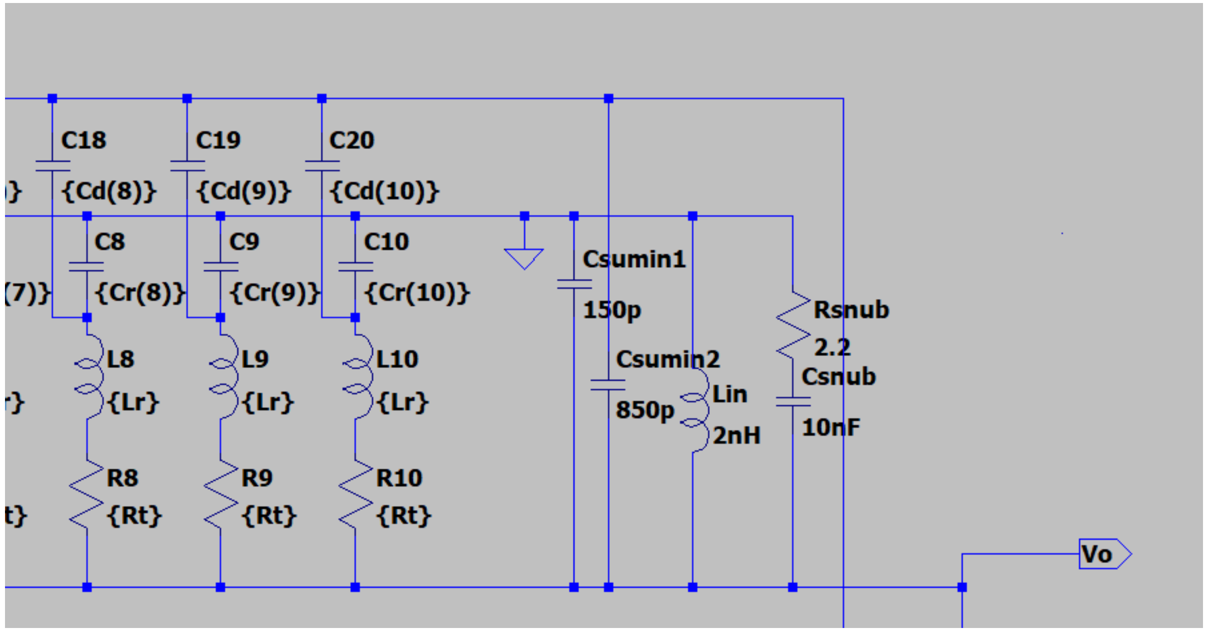
Amin Aminaei, January 2021

- Simulate the power dissipations and current drop with parameters:

1. Voltage 1000 mV, Rfb = 9370 Ohm
2. Rtes=60 & 100 mOhm. Lr=3uH, C ratio=9, f=1MHz-3.8MHz, N=88 LCs
3. With common inductance Lc is 2 nH & 0 nH
4. 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)

	Rtes	Lc
a	60 mOhm	2nH
b	60 mOhm	0
c	100 mOhm	2nH
d	100 mOhm	0

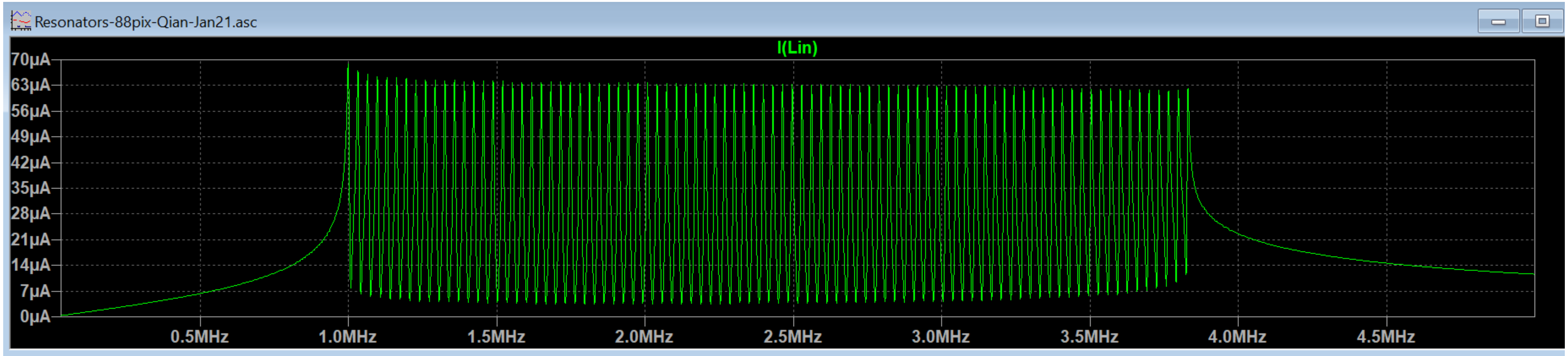


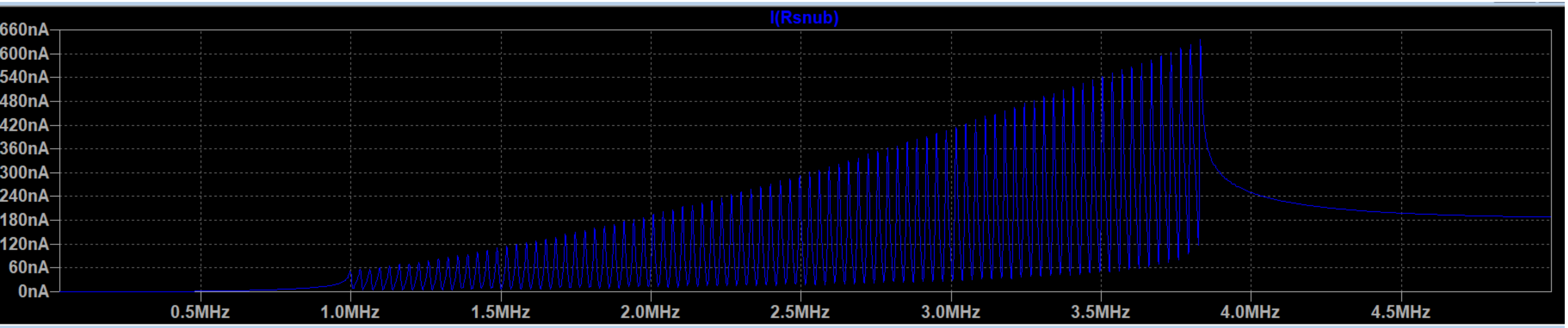


For simplicity, twisted pairs are first modelled with LC lines. Z0=(L/C) ^0.5=70.7Ohm
Transmission line model is presented in slide 12-14.

	Rtes	Lc
a	60 mOhm	2nH

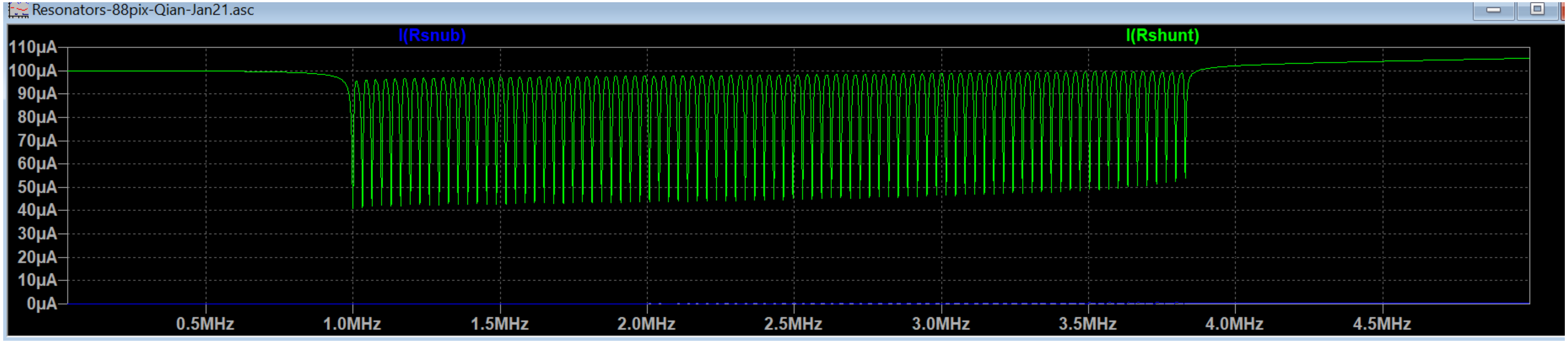
Resonators-88pix-Qian-Jan21.asc





Rsnub=2.2 Ohm

Max. power dissipation: ~2.2* (600e-9)^2=7.9e-13 W

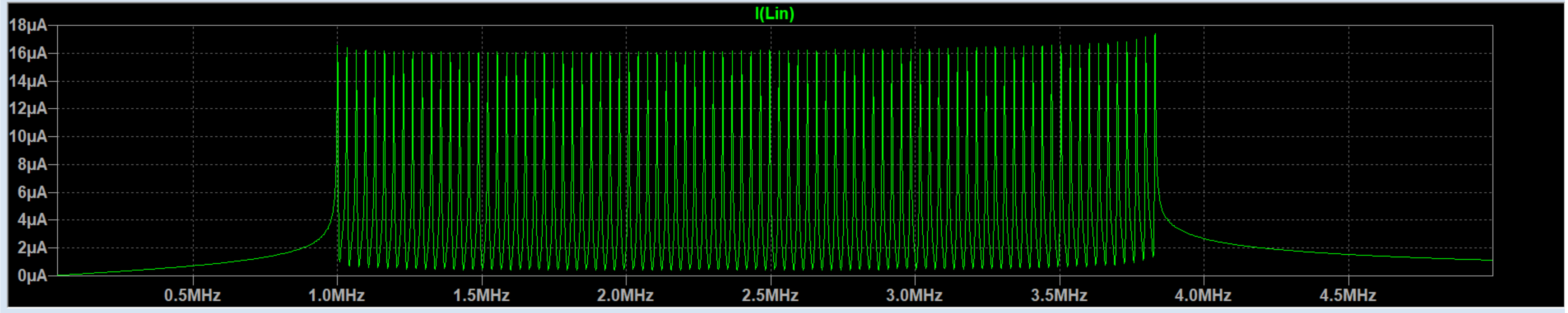


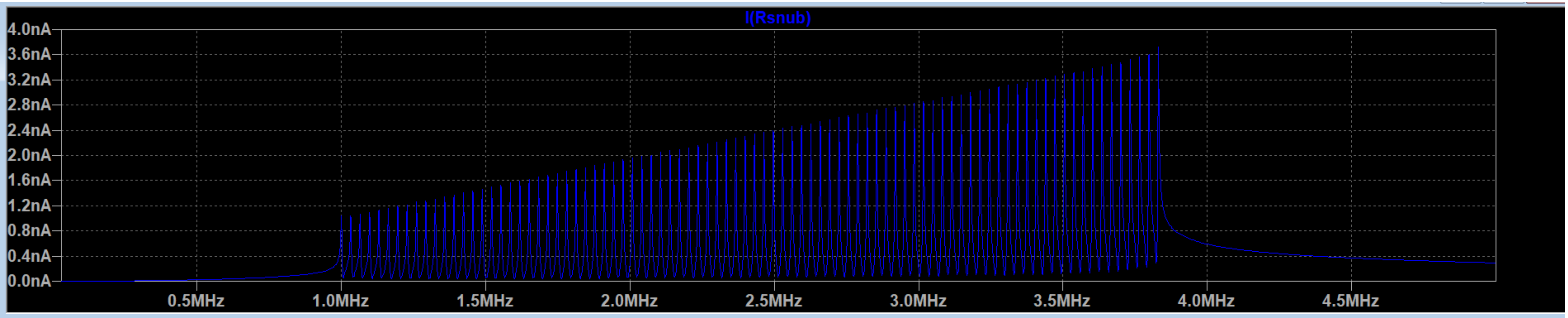
Rshunt=0.1Ohm

Max power dissipation~0.1*(100e-6)^2=1e-9W(1nW)

	Rtes	Lc
b	60 mOhm	0

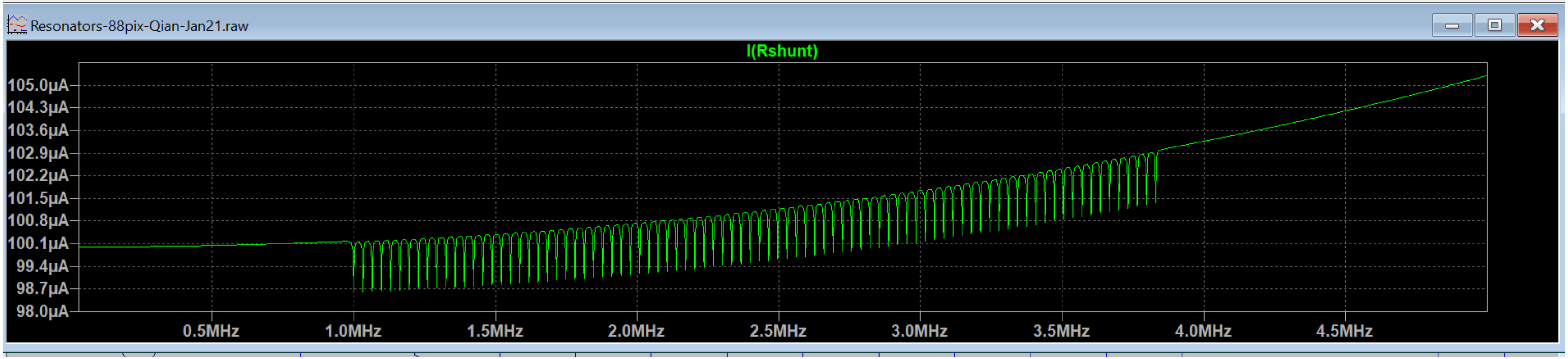
Isc





Rsnub=2.2 Ohm

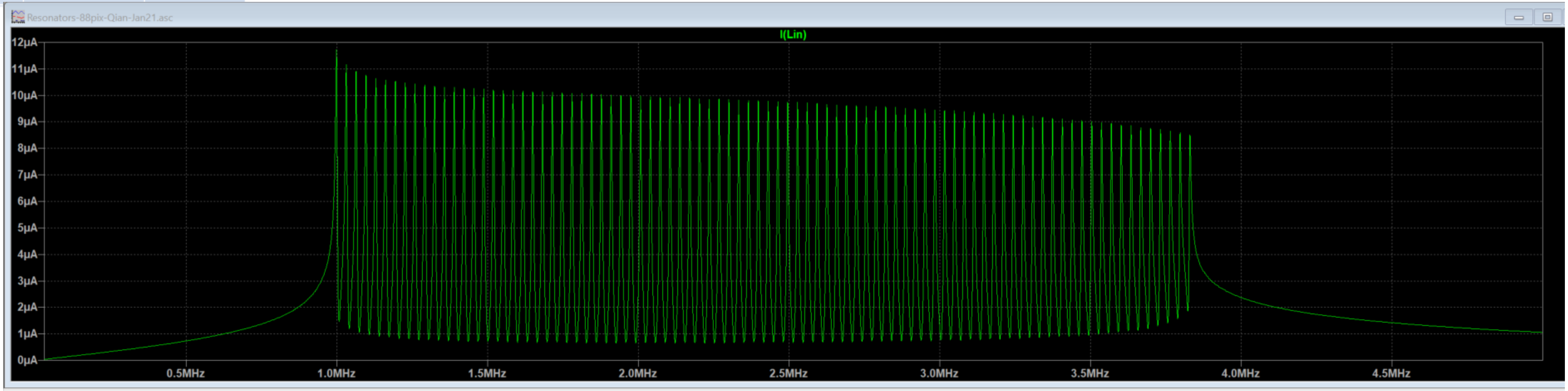
Max. power dissipation: ~2.2* (3.6e-9)^2=2.9e-17W

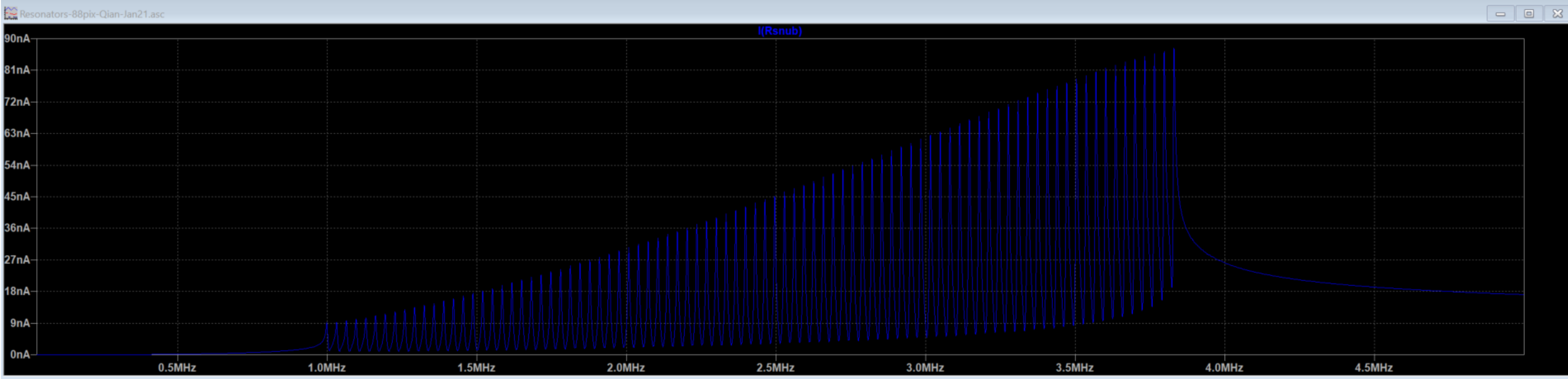


Rshunt=0.1Ohm

Max. power dissipation: ~0.1* (102.9e-6)^2=1.05e-9 W (1.05nW)

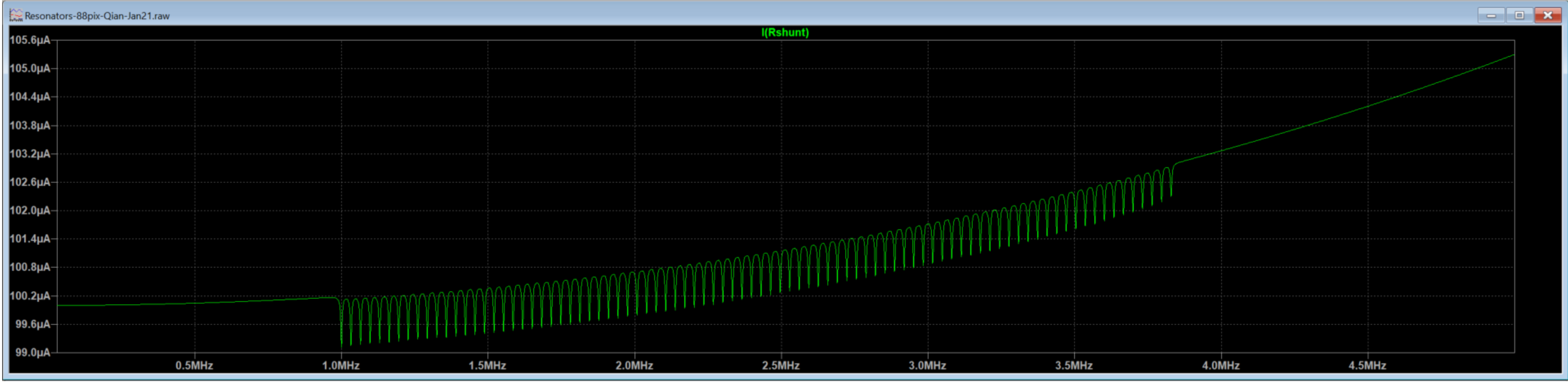
	Rtes	Lc
c	100 mOhm	2nH





Rsnub=2.2 Ohm

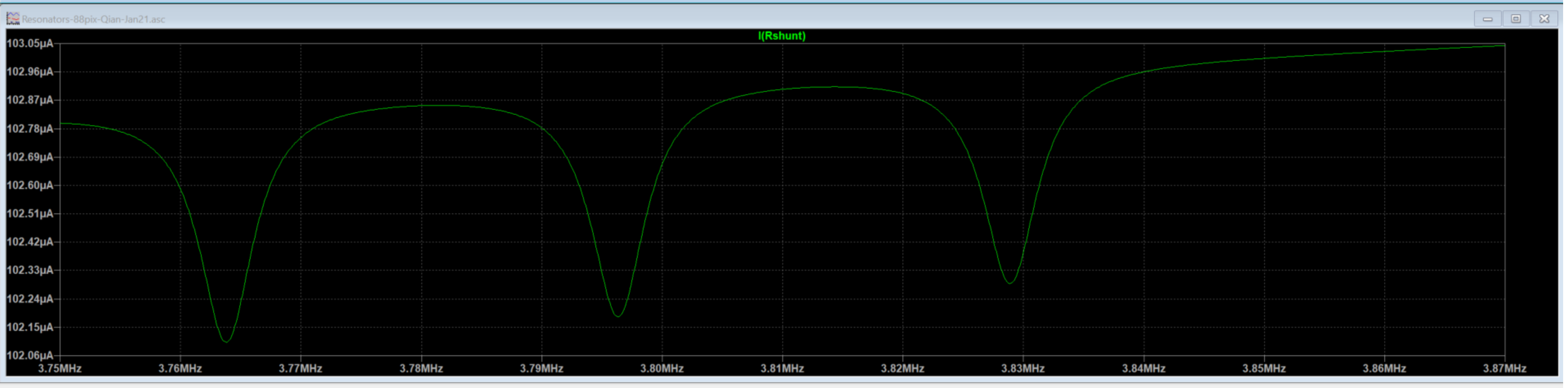
Max. power dissipation: ~2.2* (87e-9)^2=1.67e-14W



Rshunt=0.1Ohm

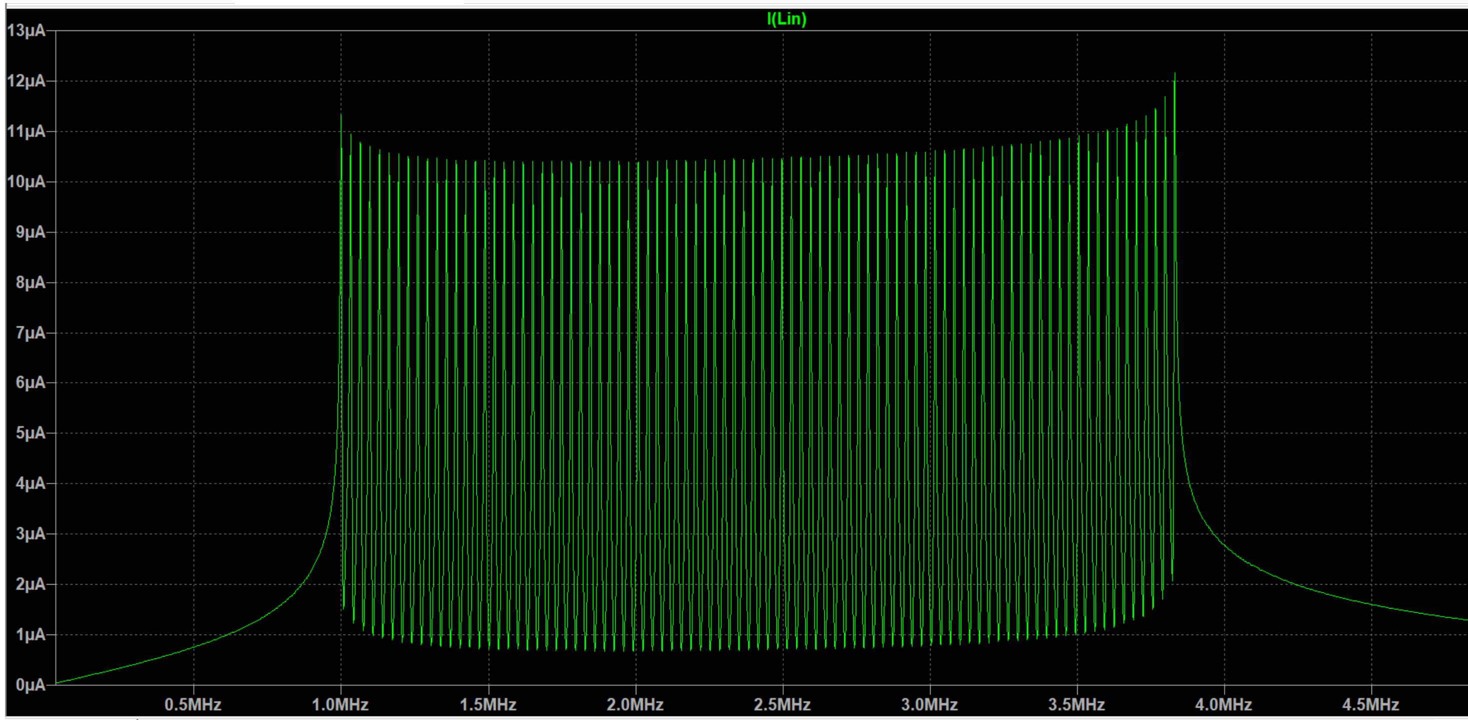
Max. power dissipation: ~0.1* (102.9e-6)^2=1.05e-9 W (1.05nW)

Similar to Rtes=60mOhm but the pattern is changed (cycle of Max and Min)



	Rtes	Lc
d	100 mOhm	0

Resonators-88pix-Qian-Jan21.asc

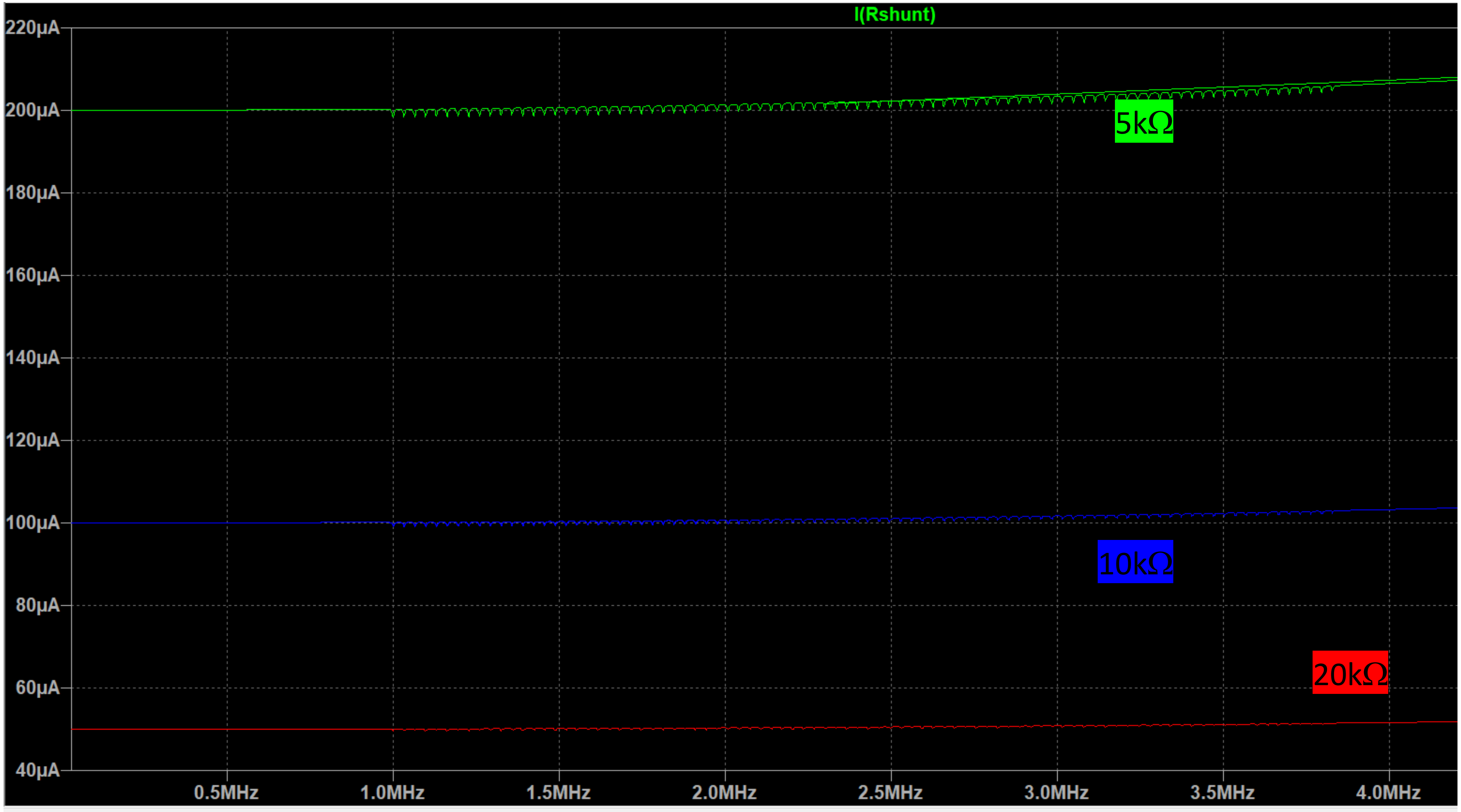


Rsnub=2.2 Ohm

Max. power dissipation: ~2.2* (2.5e-9)^2=1.3e-17 W

Impact of $R_{ac\ bias}$

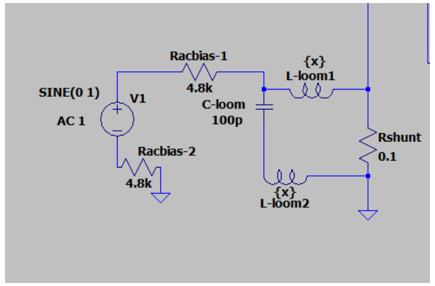
$R_{ac\ bias}$ 5kΩ 10kΩ 20kΩ, Rtes=100m, Rshunt=0.1Ω



Impact of $R_{ac\ bias}$

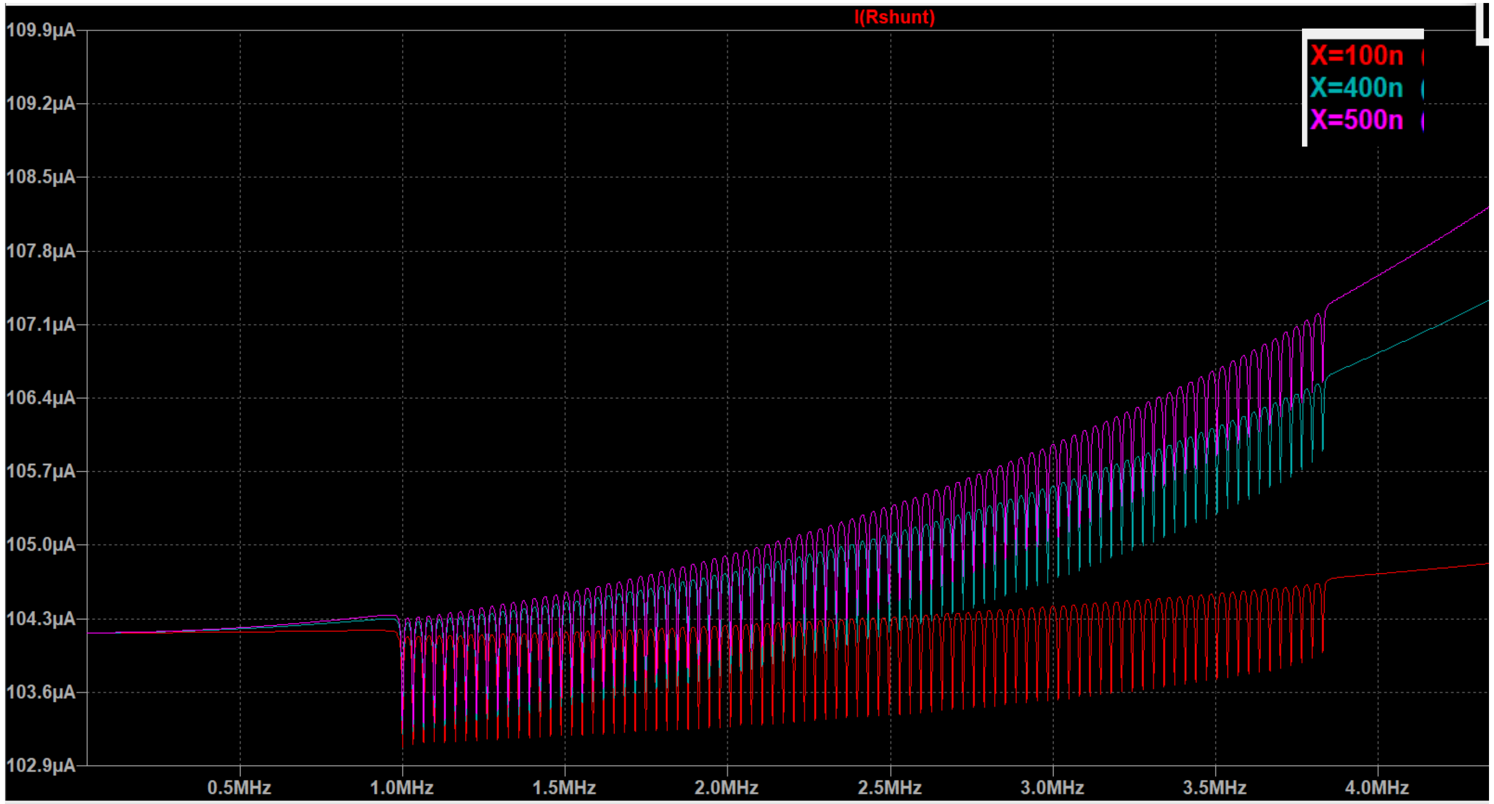
$R_{ac\ bias}$ 5kΩ 10kΩ 20kΩ, Rtes=100m, Rsnub=2.2Ω

Impact of input AC bias loom
a. Characteristic Impedance

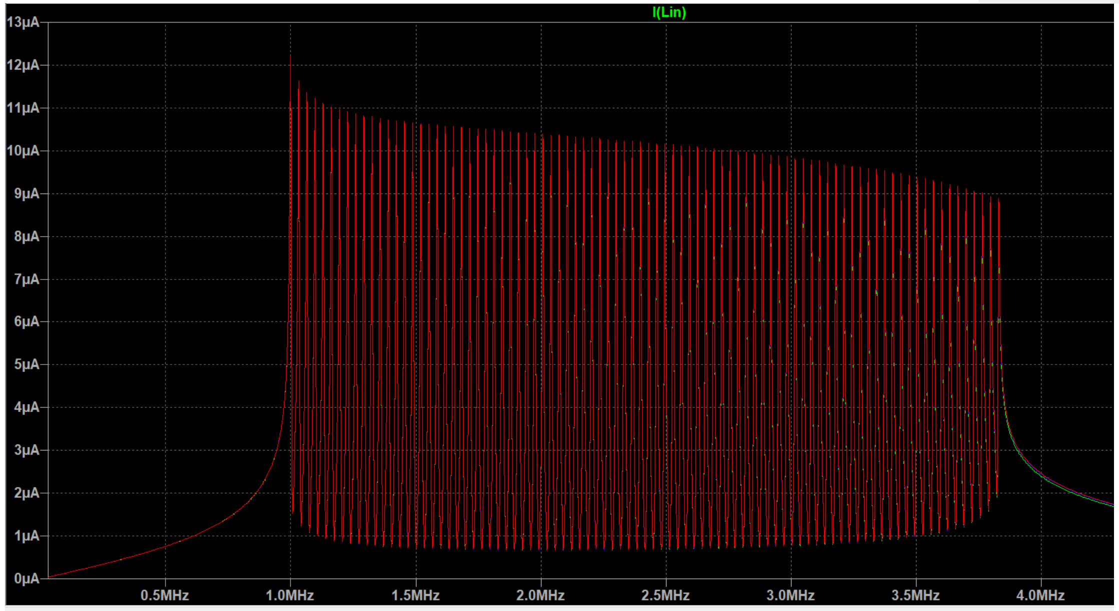


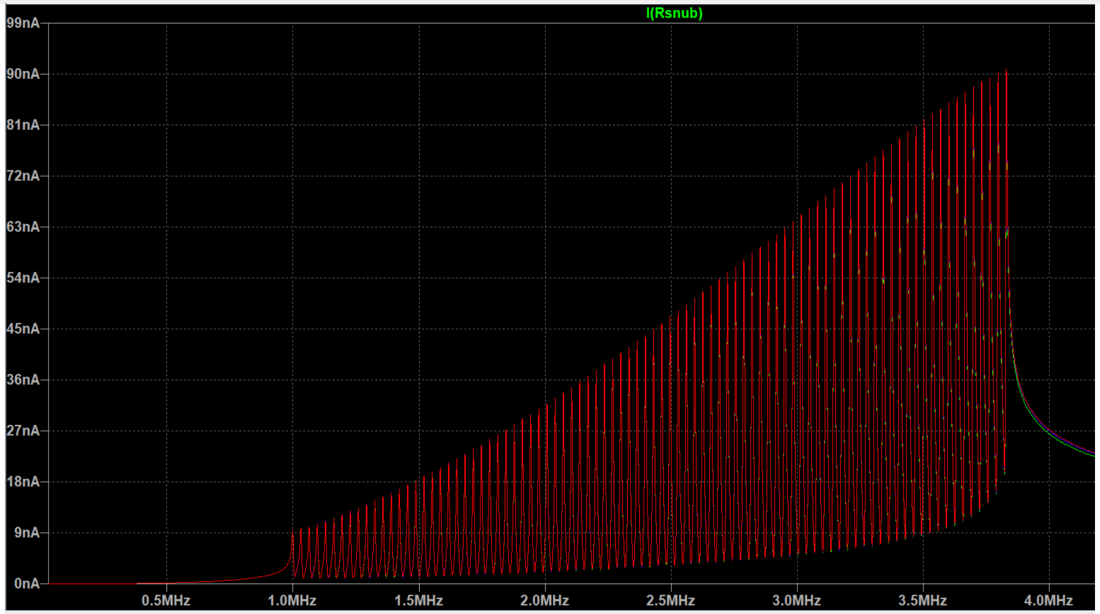
X=500nH 400nH 100nH

Z0= 70 Ω 63 Ω 32 Ω



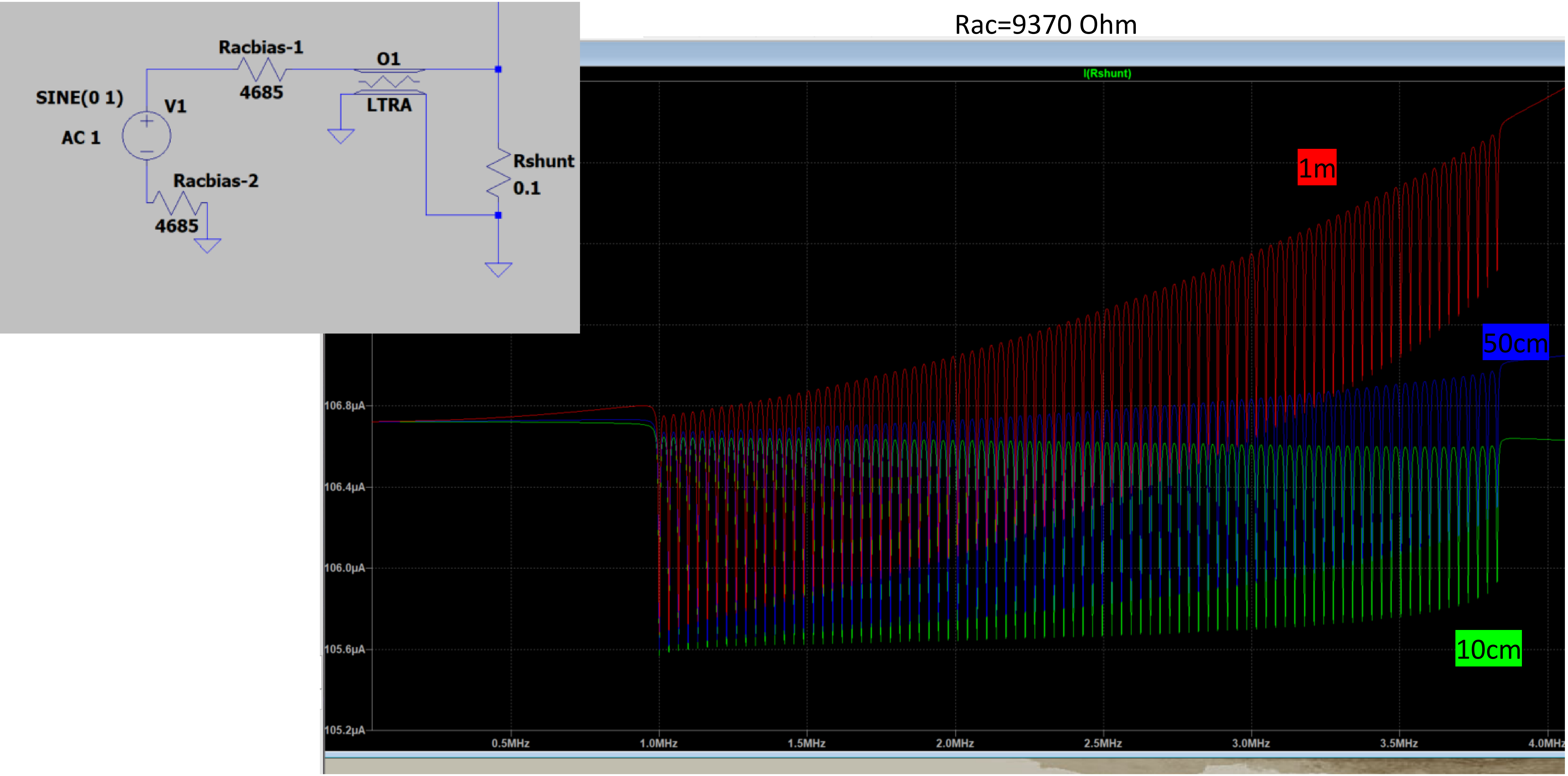
I_{Lin} and $I_{snubber}$ are not affected





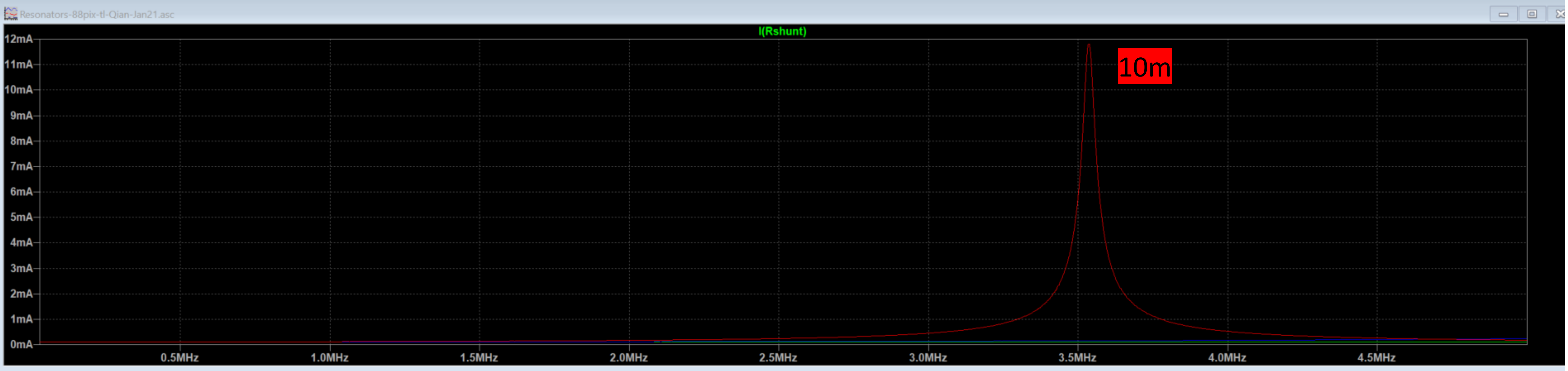
Impact of input AC bias loom
b. length of loom

b1. Short length: (L=500nH, C=100pF, R=G=0)
L= 10cm 50cm 1m
Rtes=100m
Rac=9370 Ohm

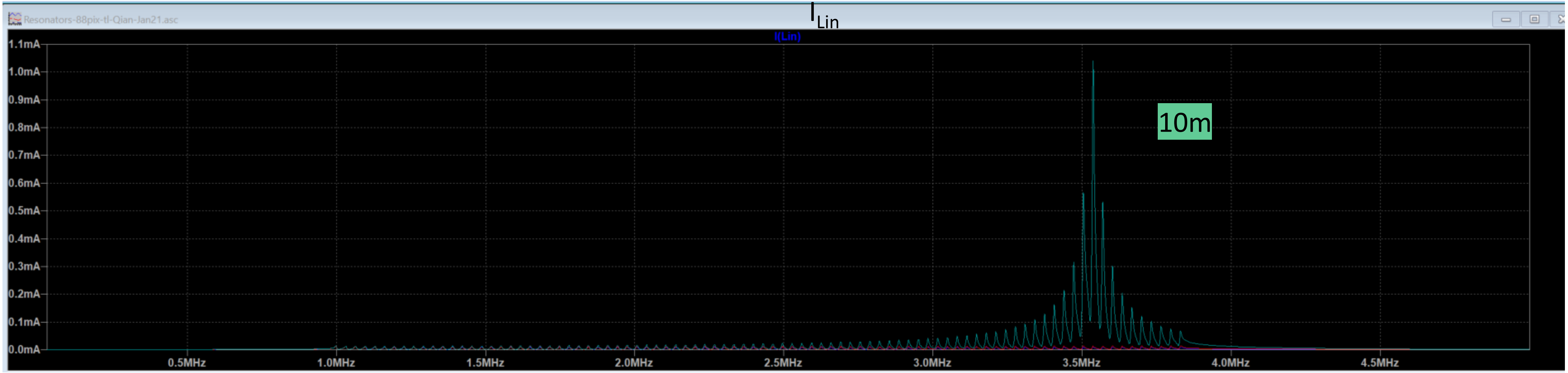


b2. long length: (L=500nH, C=100pF, R=G=0)

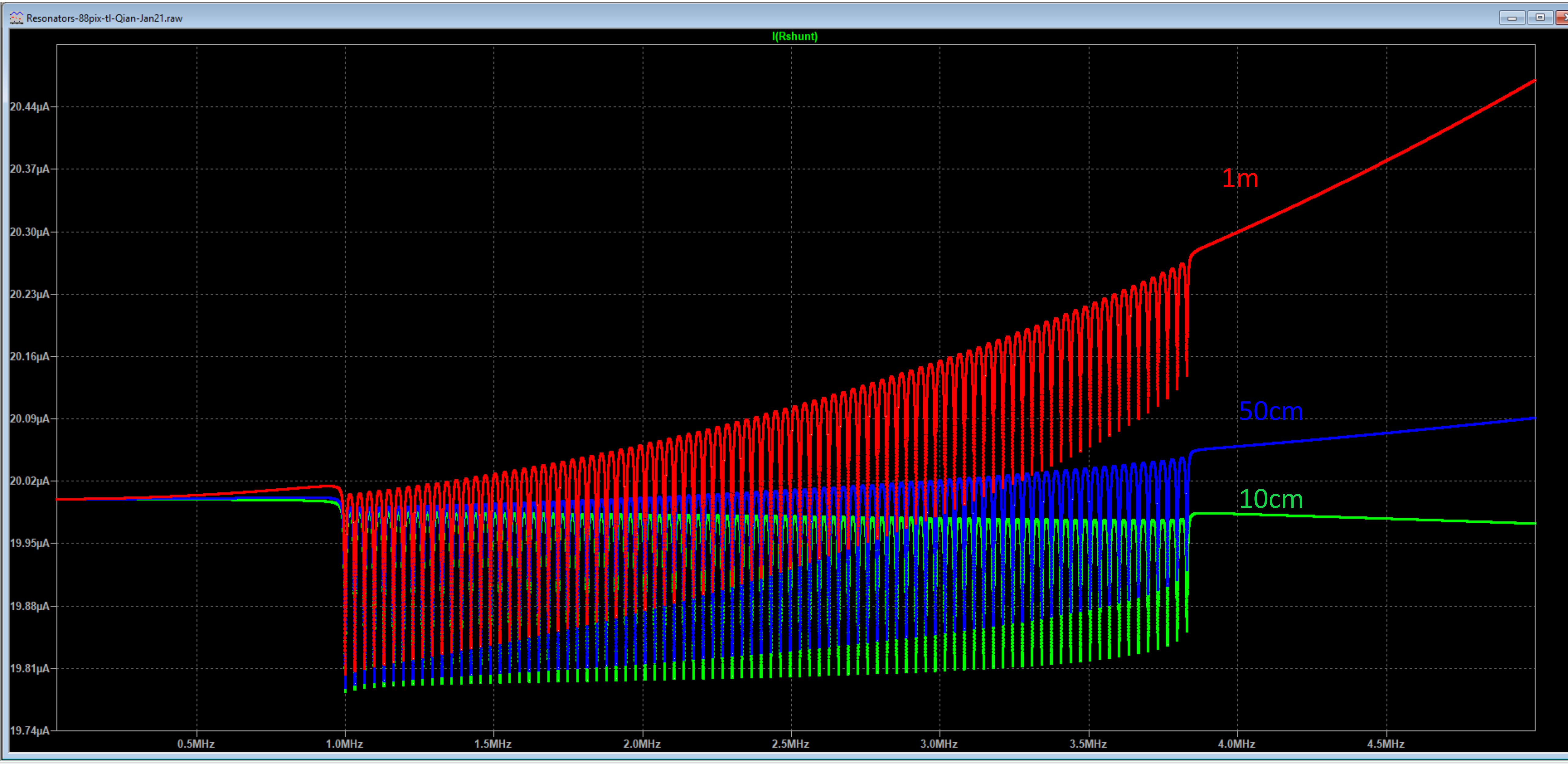
L= 2m 5m 10m with long cable (10m), resonance appear within FDM frequencies (3.5MHz)



I_{Lin}



b1. Input Loom: (L=500nH, C=100pF, R=G=0), Rtes=100m Rac=50kOhm, Length= 10cm 50cm 1m



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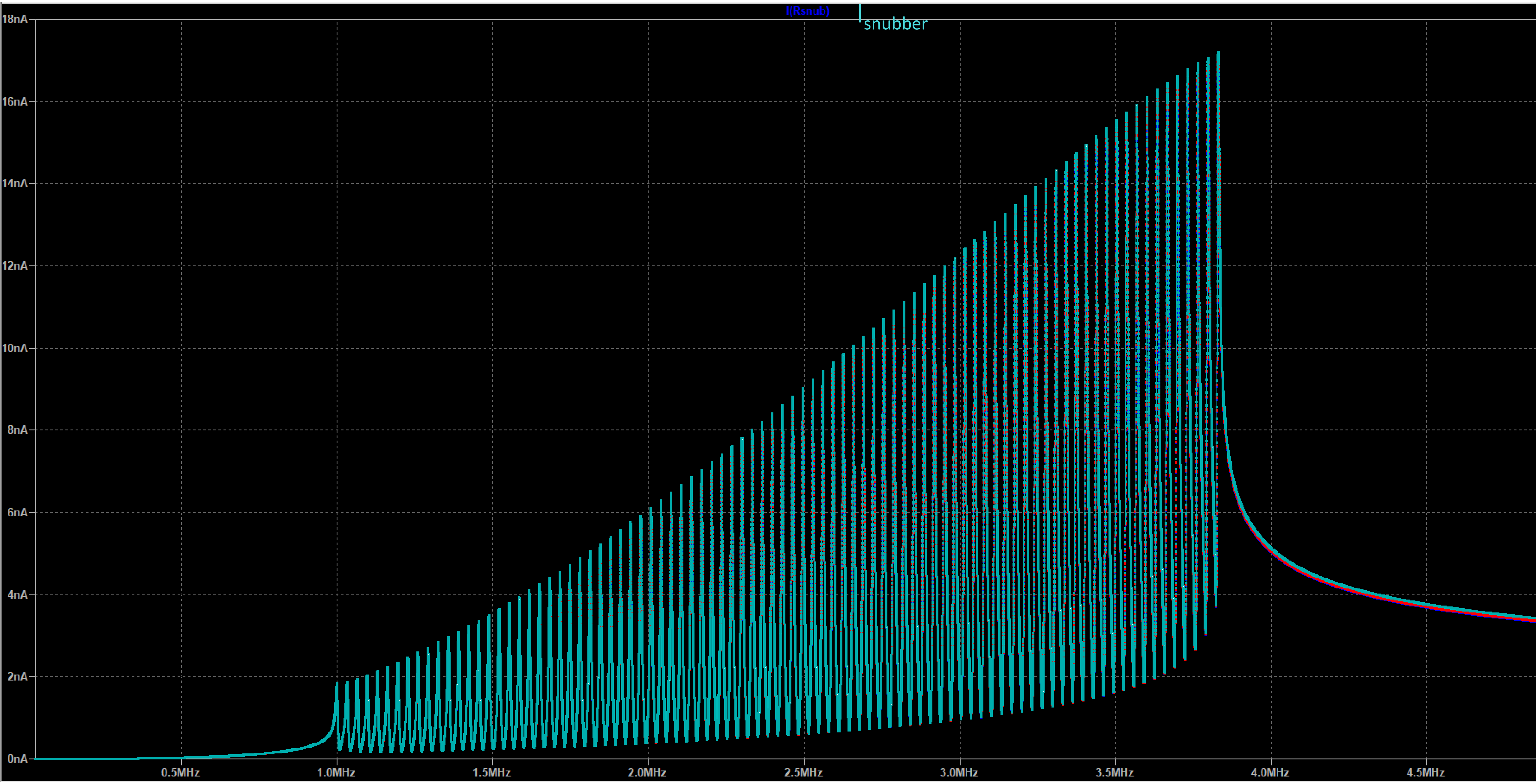

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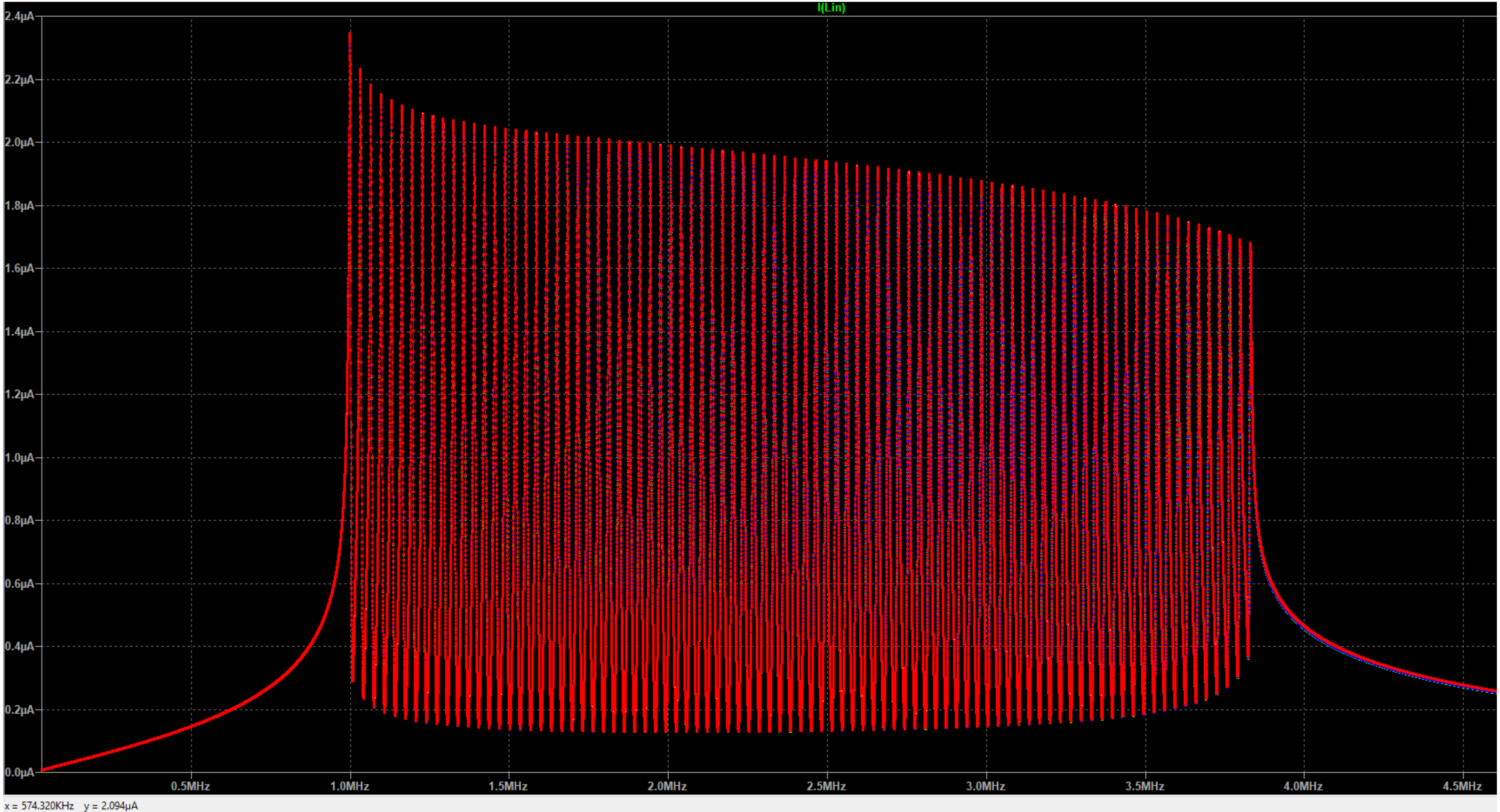

(1) the power dissipation is higher when having a higher common inductance.
(2) the power dissipation is higher when with lower TES resistance (lower in transition).
(3) the highest power dissipation comes from shunt resistance which is around 1.05 nW.
(4) the higher the Rac bias, the lower current, 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.

Thanks Qian!