A Simulation of Twisted Pairs

- Twisted Pair Monel Clad/NbTi 42SWG (in use in the Lab) Superconducting State

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Question 1. The effect of Monel (Copper Nickel alloy) on the resistance of Twisted Pair Monel Clad/NbTi 42SWG

- In the datasheet I have used, Rdc(=85 Ohm) is given. By knowing the cross section the conductivity (assumed to be homogeneous) is calculated.

$$R_{dc} = 2/(\sigma.A) \Rightarrow \sigma = 2.99E6$$

A = Cross section of conductor

$\sigma = Electrical\ Conductivity$

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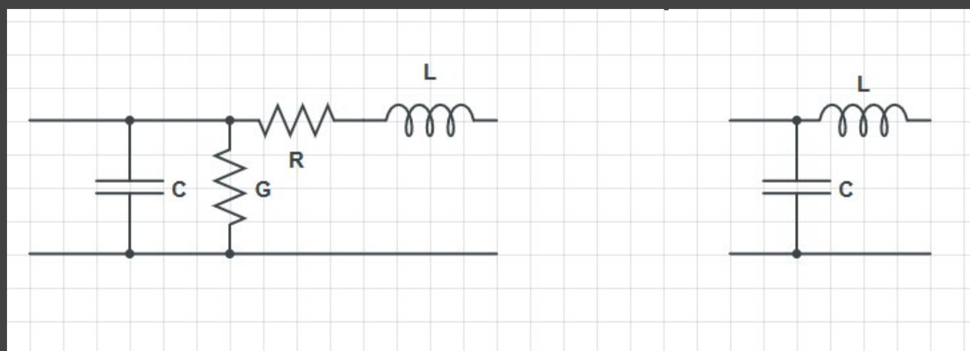
Question 2. Zo of twisted pair vs. Temperature (50 mK, 4K, 300K)

- Resistance changes broadly vs. Temperature
- The critical Temp. is (Tc ~ 11K) for Twisted Pair Monel Clad/NbTi
- Both at mK and 4K, the twisted pair is superconductor
- Frequency dependent part no longer apply when superconductive



- Twisted Pair Monel Clad/NbTi 42SWG
- L= 178nH
- C=175pF
- $Z0_{SC}$ = (L/C) ^0.5 = 32 Ohm

	AWG	Resistance (Ω/m)		
		4.2 K	77 K	305 K
Phosphor bronze	32	3.34	3.45	4.02
	36	8.56	8.83	10.3
Nichrome	32	33.2	33.4	34
Copper	30	0.003	0.04	0.32
	34	0.0076	0.101	0.81
Manganin	30	8.64	9.13	9.69
	32	13.5	14.3	15.1
	36	34.6	36.5	38.8

Lakeshore.com

L, C , Z0 Low/High Frequency, SACAMOS

	L(nH/m)	C(pF/m)	Z0(Ohm/m)
Low Frequency up to 1MHz	278	175	40
High Frequency	178	175	32
SACAMOS	293	63	68

To be verified in the lab

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Code: Nbti42swg-cryo-superc.py

Theory: why results are different

SACAMOS

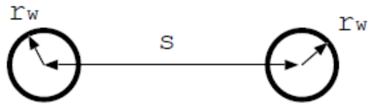


Figure 2.3 Two wire cable

The analytic formulae used to calculate the inductance and capacitance of the two wire transmission line are

$$C = \frac{\pi \epsilon_0}{\ln\left(\frac{s}{2r_w} + \sqrt{\frac{s}{2r_w}^2 - 1}\right)} \tag{2.19}$$

$$L = \frac{\mu_0 \epsilon_0}{C} \tag{2.20}$$

These formulae are used for the calculation of the differential mode inductance and capacitance for twisted pairs.

$R = \mathrm{Re}(Z_{s1} + Z_{s2})$

$L = L_e + (1/\omega)\, \mathrm{Im}(Z_{s1} + Z_{s2})$

$L_e = (\mu_d/4\pi)K$

$G = 4\pi\sigma_d/K$

$C = 4\pi\varepsilon_d/K$

C_model*

C=pi*epsd/K

K=ln((s-r)/r)

*** Transmission Lines and Maxwell's Equations, 2014,** Phil Lucht

SACAMOS: Theory ctd.

3.6.3 Single mode propagation correction

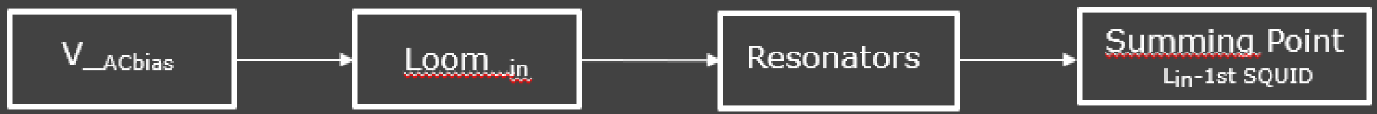
Assume that the frequency dependence of the transmission line parameters takes the form

$$
\begin{aligned}
L(j\omega) &= L_0 + L_{int}(j\omega) \\
R(j\omega) &= R_{dc} + R_{int}(j\omega) \\
C(j\omega) &= C_0 + C_{freq}(j\omega)
\end{aligned}
\tag{3.71}
$$

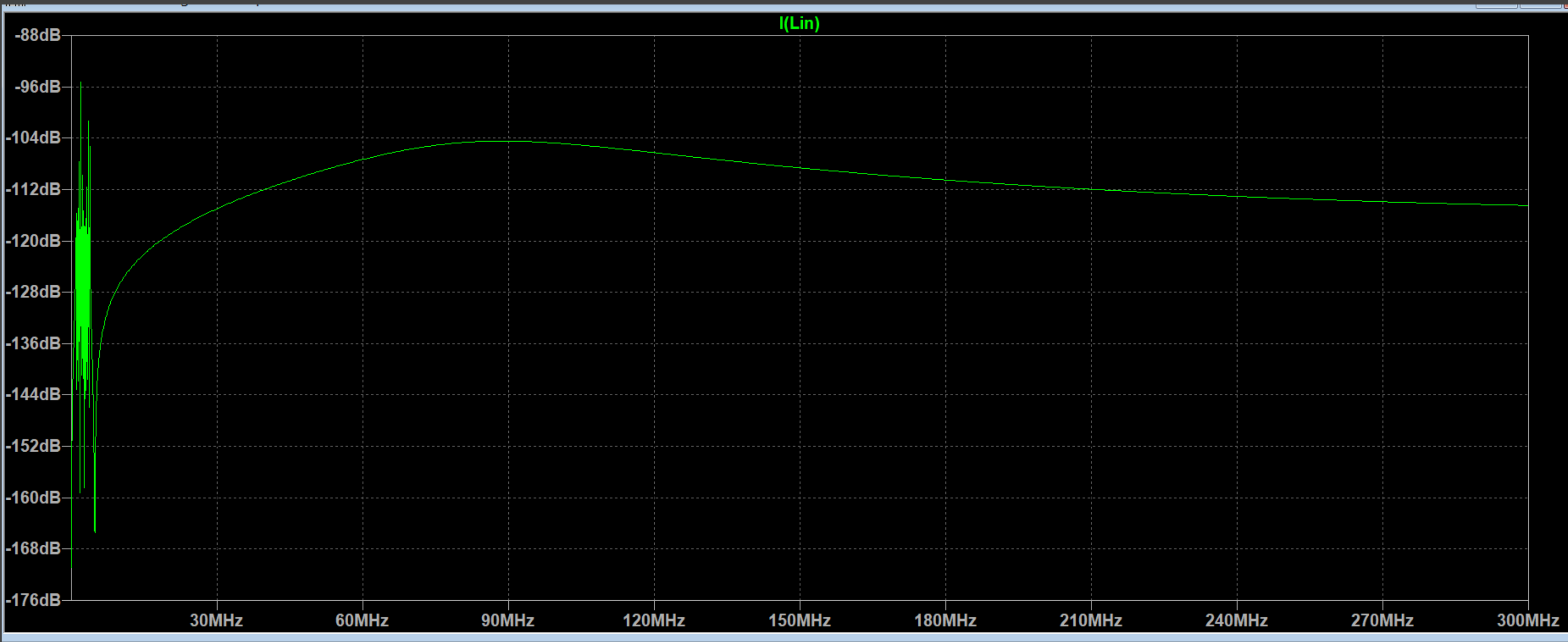
In the light of the models of the frequency dependence of the cable parameters discussed above, we emphasise the following points:

1. The internal inductance, $L_{int}(j\omega)$, decreases with frequency as $\frac{1}{\sqrt{f}}$.
2. The internal resistance, $R_{int}(j\omega)$, is equal to 0Ω at d.c.
3. The internal resistance, $R_{int}(j\omega)$, increases with frequency as $\sqrt{f}$
4. The capacitance, $C(j\omega) \rightarrow C_0$ as $\omega \rightarrow \text{inf}$

LT-Spice model of Input Loom (superconductor)

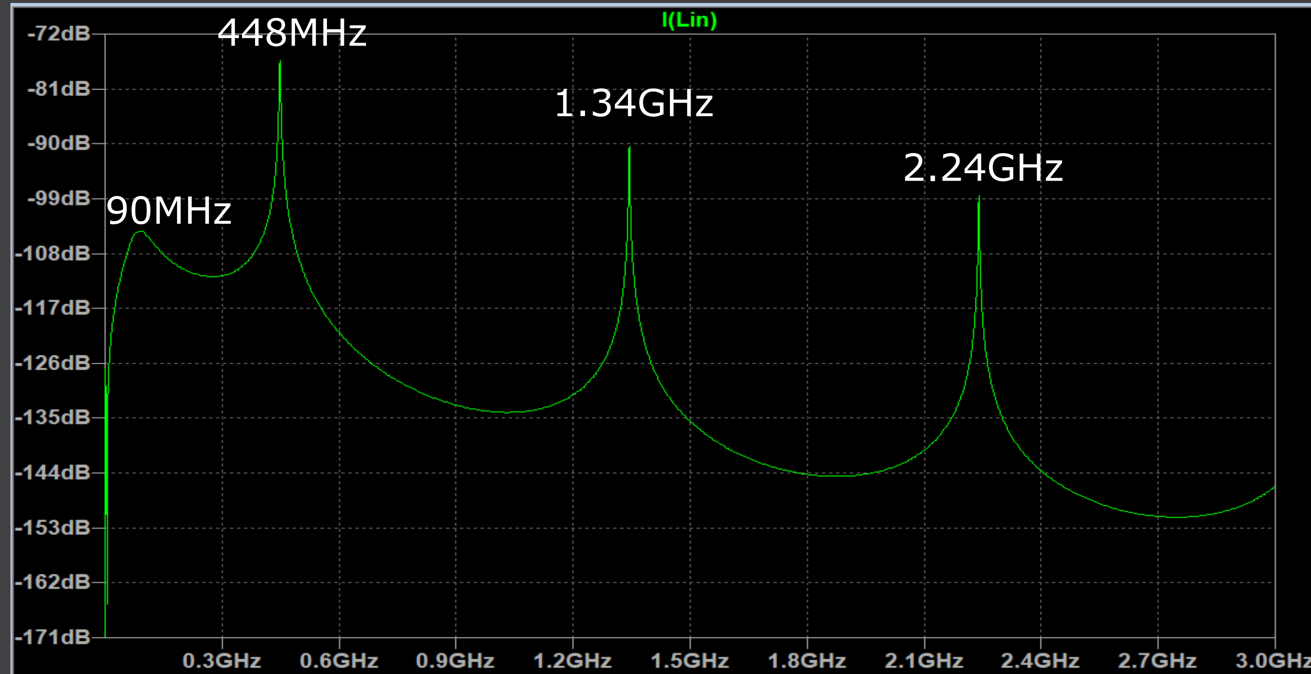


$L_{\_loom}$=10cm, regardless of the Z0 value, OBR is not observed up to 300MHz.



OBR (Loomin=10cm, Up to 3GHz)

My Model



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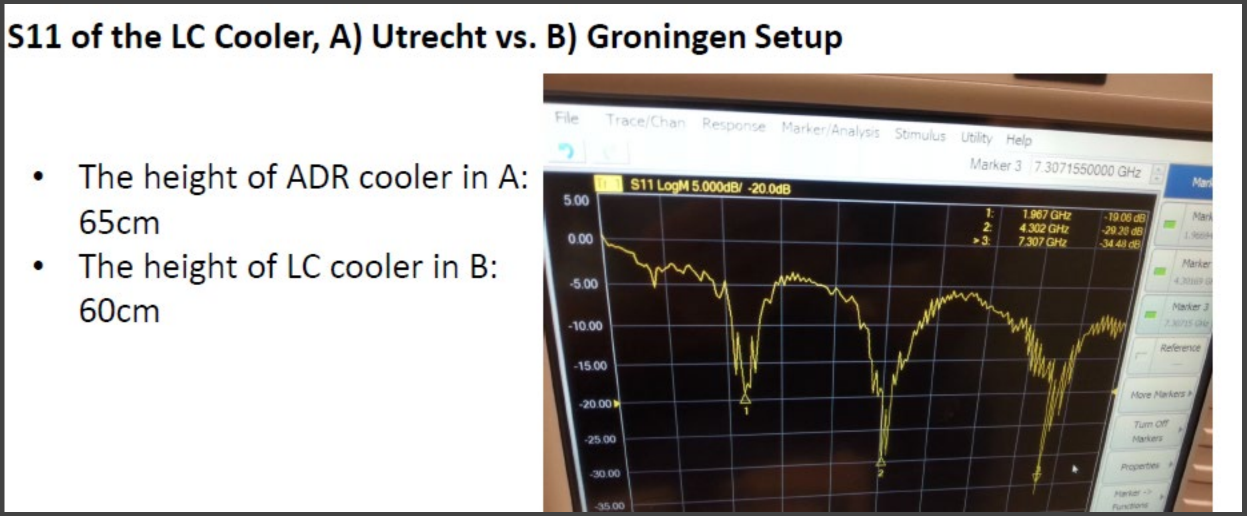
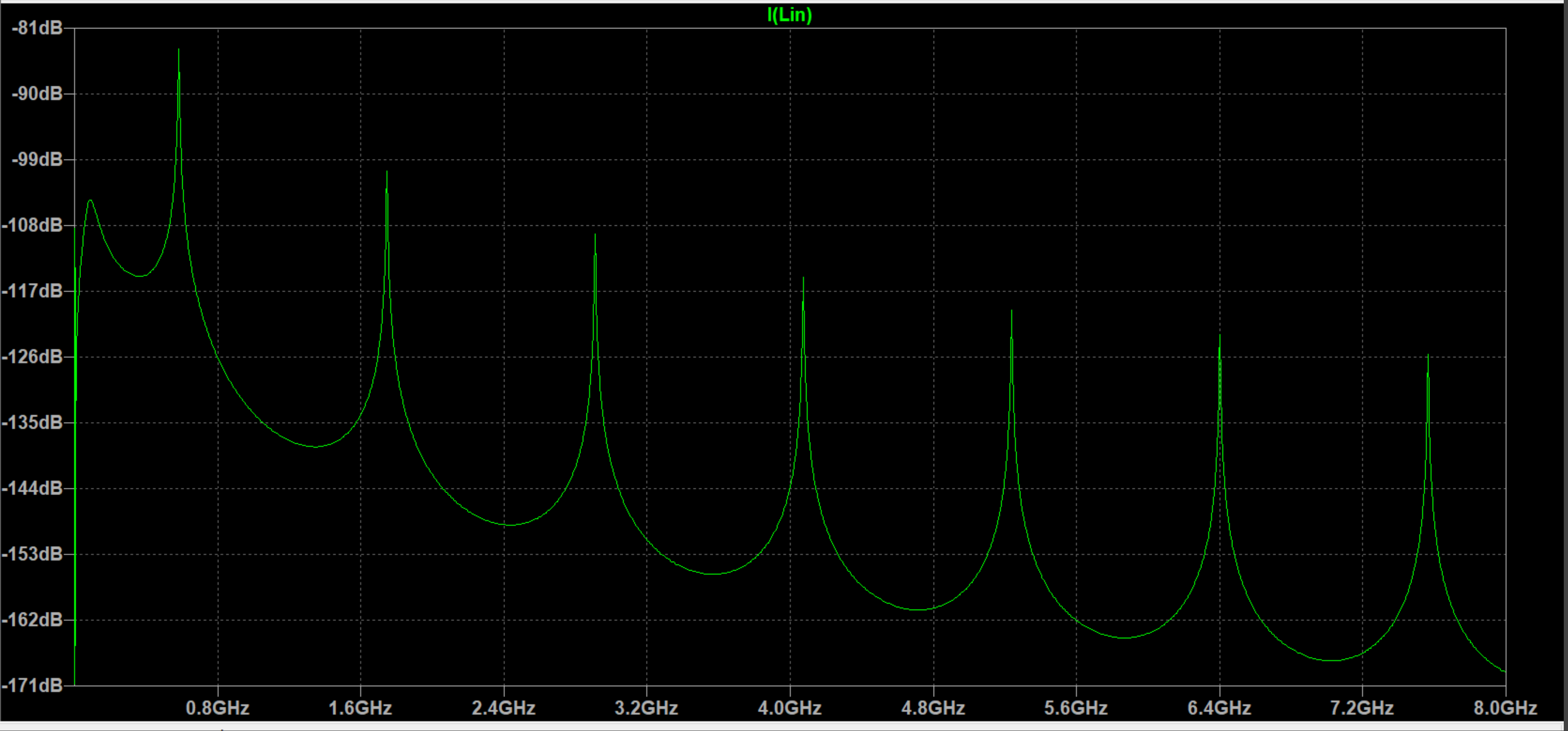
NEXT: Modelling the Loom of the feedback loop

- Backup slides
- Antenna SCAN test



- S11 of the ADR Cooler has been measured at 4K, resonances 1.9 GHz, 4.3GHz and 7.30GHz are similar to the results from the S11 measurement in the Groningen setup (A. Detrain, 2012).   DOESN’T SEEM TO MATCH TO OBR input cable



1.90 GHz 4.30GHz 7.30GHz antenna scan peaks
2.24GHz 4 GHz 7.6 GHz input loom OBR my model
1.74GHz 4.07GHz 7.056GHz input loom OBR SACAMOS

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