Impedance Matching of 640 GHz SIS Mixer in a High IF Band of 11-13 GHz

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http://smiles.tksc.jaxa.jp/~sis

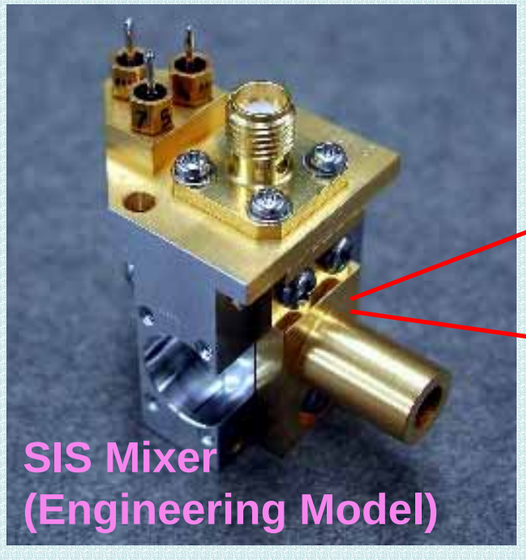
Abstract

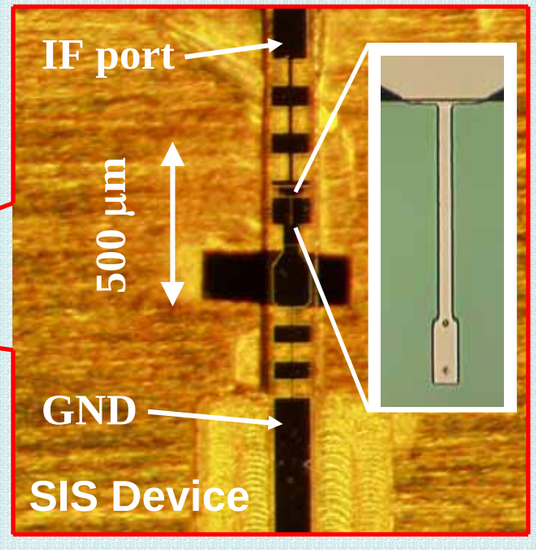
Two 640 GHz SIS mixers are used for SMILES, an atmospheric research mission to be aboard the International Space Station. Those SIS mixers, are operated at a relatively high IF band of 11-13 GHz, which is selected from the scientific reason of the mission. That high IF frequency, however, makes it more difficult to match the SIS device to the subsequent 50 Ω IF line. In addition to an impedance difference in real part, parasitic effects due to bonding wires, RF choke circuit as well as the capacitance of the SIS junctions will play an important role. When the IF matching is poor, the SIS mixer under test often exhibits significant gain ripples in its IF characteristics.

A solution for that is to insert a proper impedance transformer between the SIS mixer device and the IF output port and compensate the undesirable parasitic effects. To experimentally derive the output impedance of the SIS device, we have repeated measurements of the receiver gain with respect to an SIS device combined with several different types of matching transformers. We utilized the set of data with different IF characteristics to determine the SIS mixer parameters by means of a fitting technique. This has worked well and allowed us to establish the SIS mixer model to reproduce the measured data.

With a proper impedance transformer designed based on the above fitting results, we successfully realized a small ripple and better flatness in the gain profiles of the mixer.

640 GHz SIS Mixer for SMILES



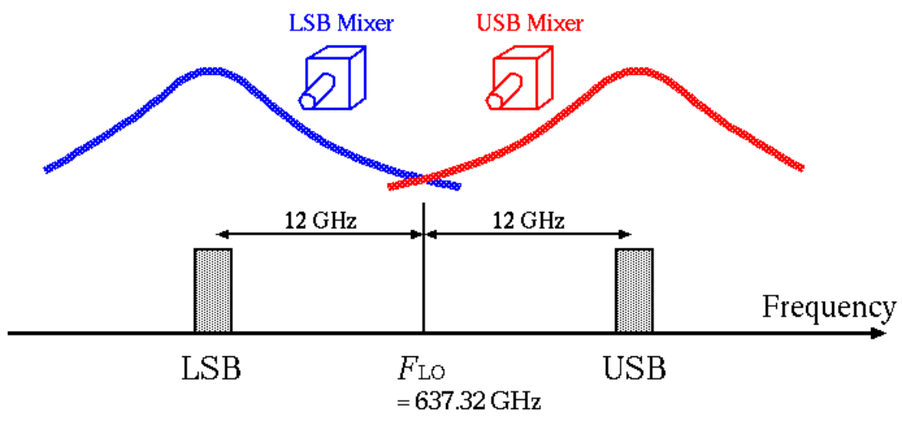


LO : 637.32 GHz
IF : 11-13 GHz

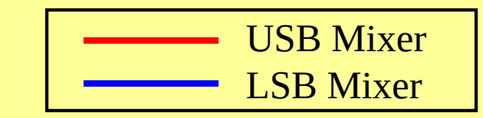
SIS Junction: Nb/AlOx/Nb
Junction Size: ~1 x 1 μm^2
Current Density: 6-7 kA/cm^2
RF Matching: PCTJ

Sideband Separation: Quasioptical separation with FSP

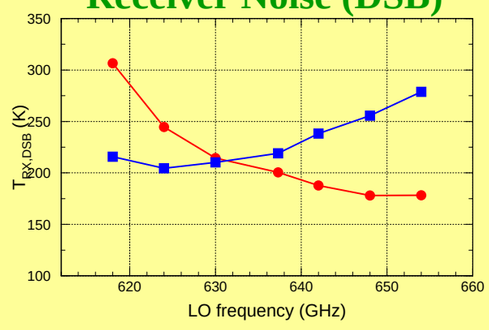
In some cases of high IF system, the frequency separation between upper and lower sideband is not negligible as compared with the RF band-width of an SIS mixer. For SMILES, each mixer is selected to have good performance at each band.



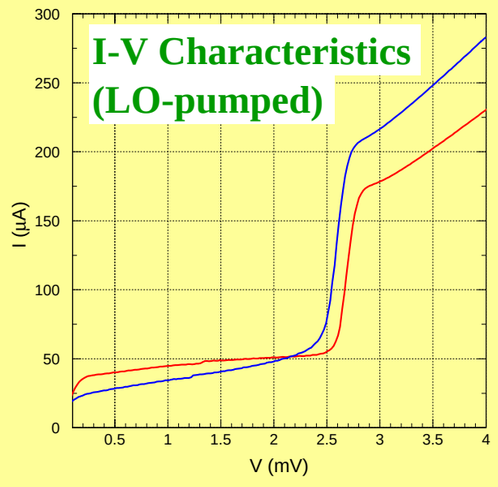
Characteristics of EM Mixer Receiver



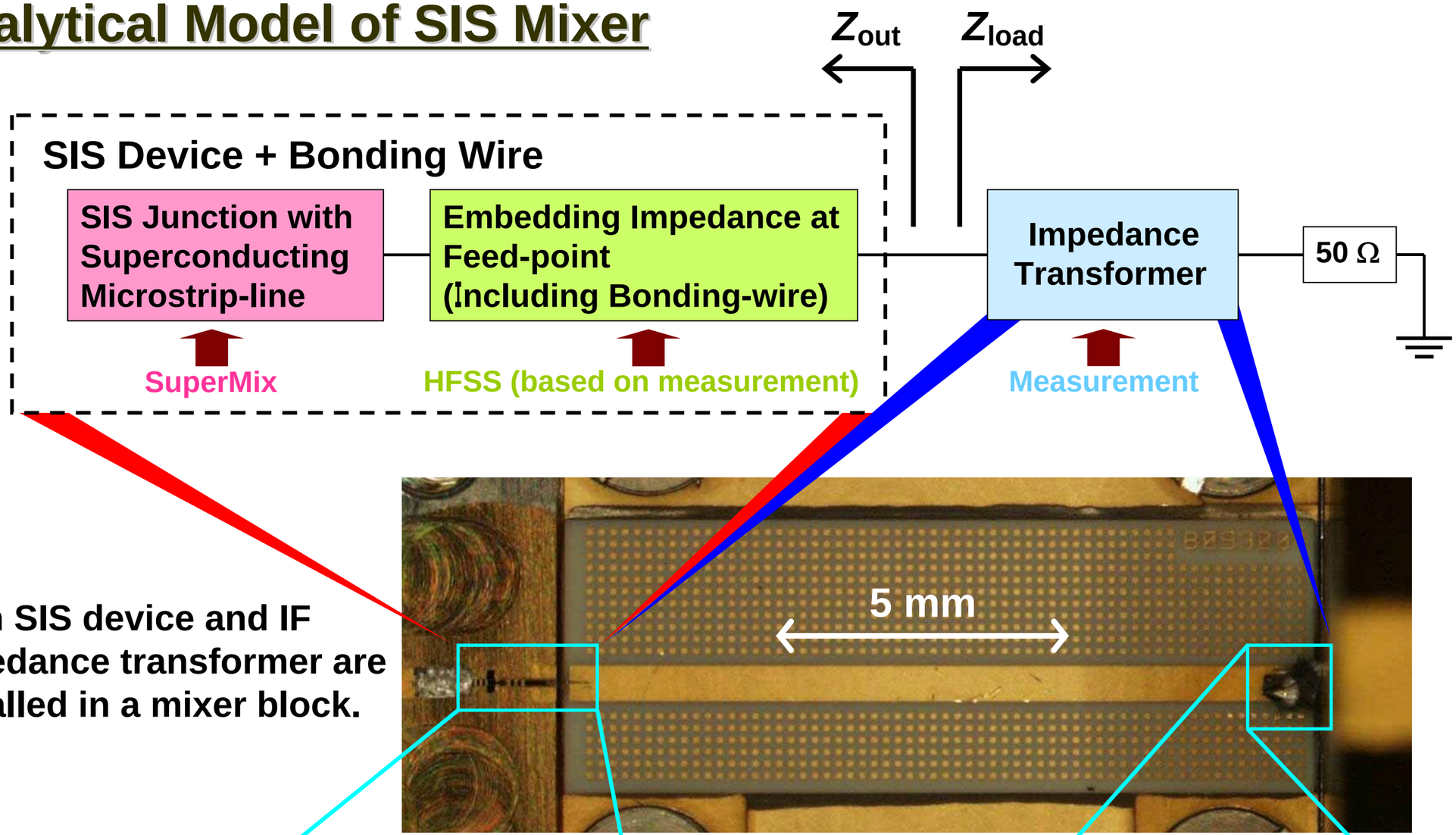
Receiver Noise (DSB)



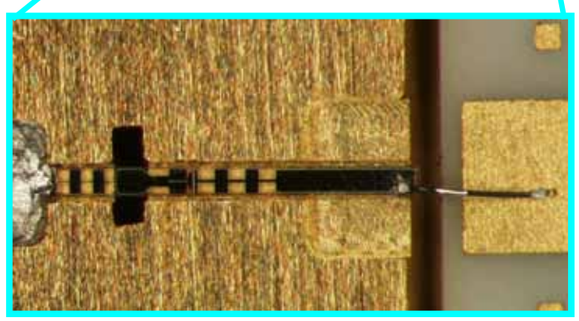
I-V Characteristics (LO-pumped)



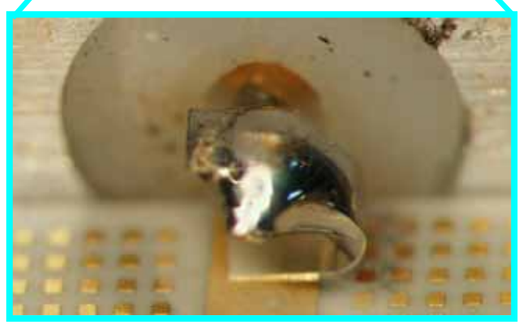
Analytical Model of SIS Mixer



Both SIS device and IF impedance transformer are installed in a mixer block.

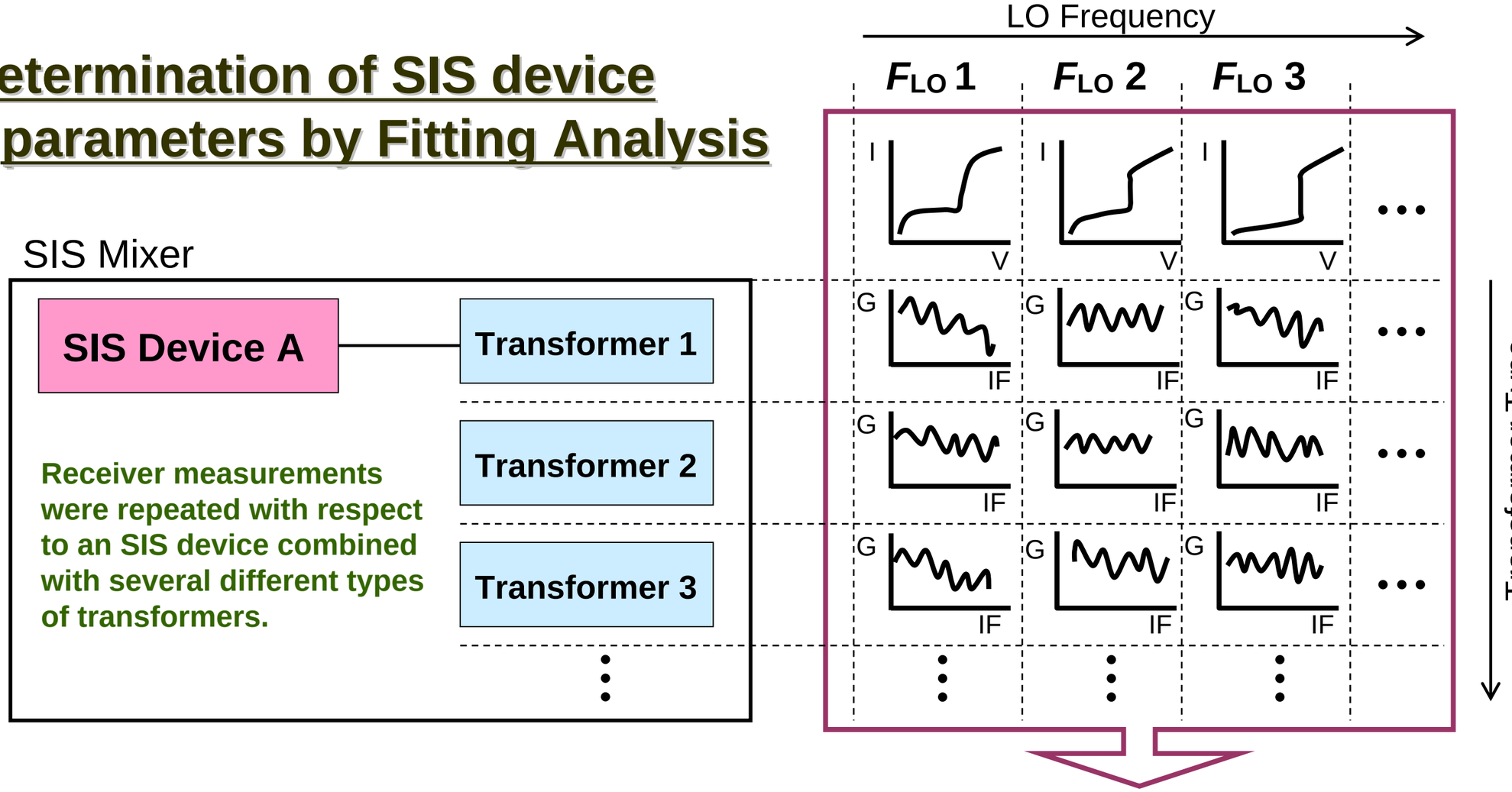


SIS device and bonding wire.



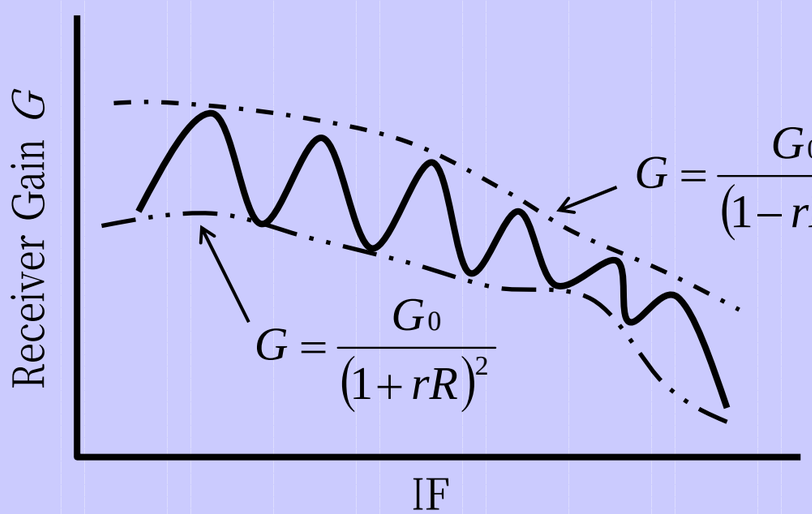
Connection between ribbon wire and SMA connector pin.

Determination of SIS device parameters by Fitting Analysis

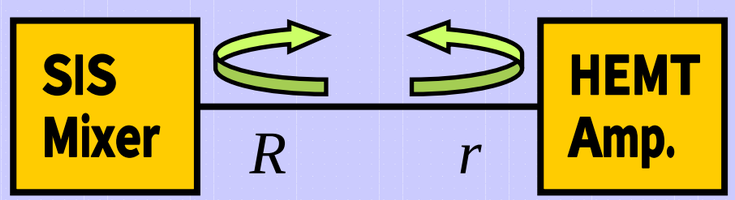


Receiver measurements were repeated with respect to an SIS device combined with several different types of transformers.

Receiver gains and I-V characteristics, measured with different types of transformers and different LO frequencies, were simultaneously fitted to determine SIS device parameters.



$$R = \left| \frac{Z_{load} - Z_{out}^{*}}{Z_{load} + Z_{out}} \right|$$

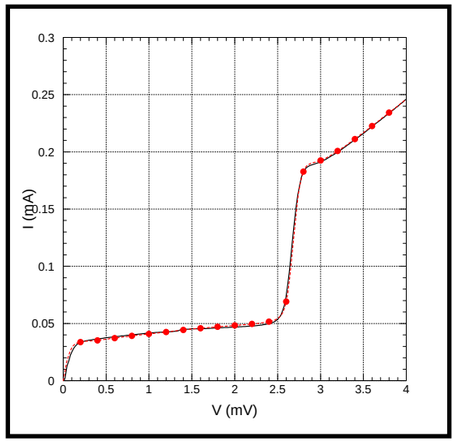


Example of Fitting Result :

Data

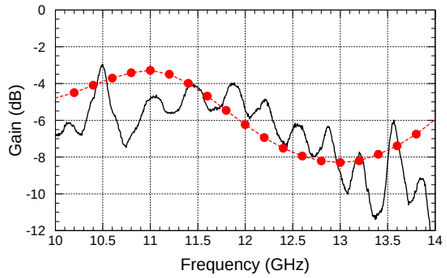
Model

I-V Characteristic

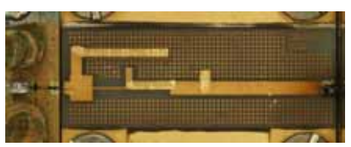


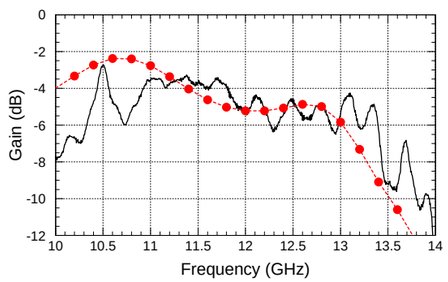
Receiver Gain

50 Ω Thru Line

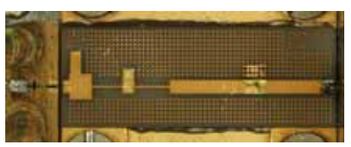


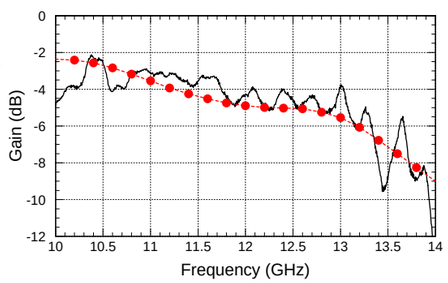
Transformer No. 1-1





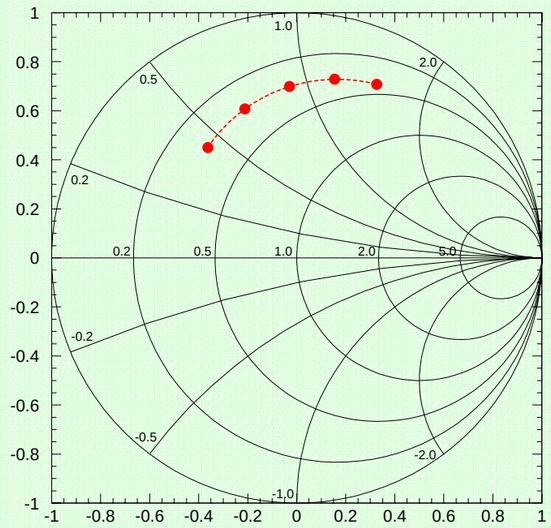
Transformer No. 1-2





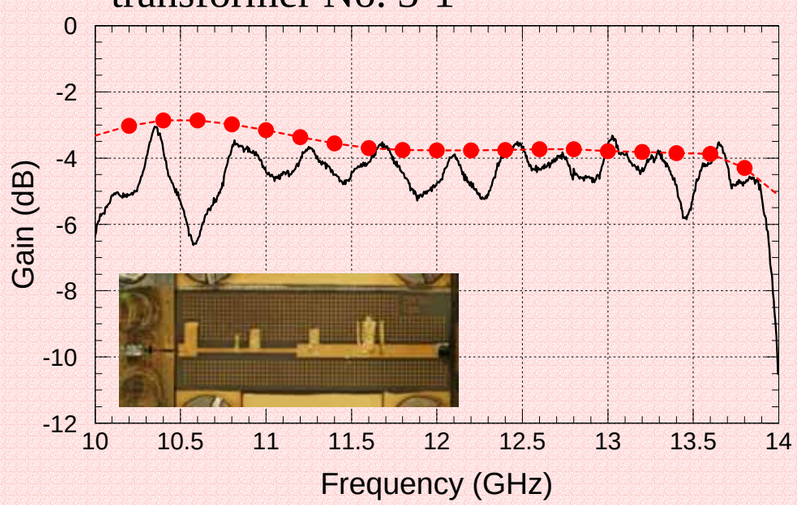
SIS Device A with F_{LO} = 654 GHz

- J_c = 6813 A/cm^2, R_n = 15.9 Ω
- Relatively high dynamic resistance of 550 Ω at bias point



Z_{out} (output impedance of SIS device) in 10-14 GHz$_0$

Receiver gain profile with impedance transformer No. 3-1



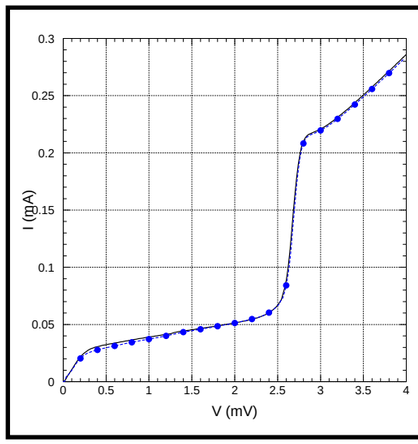
Example of Fitting Result :

SIS Device B with F_{LO} = 618 GHz

- J_c = 5962 A/cm^2, R_n = 13.7 Ω
- Relatively low dynamic resistance of 150 Ω at bias point.

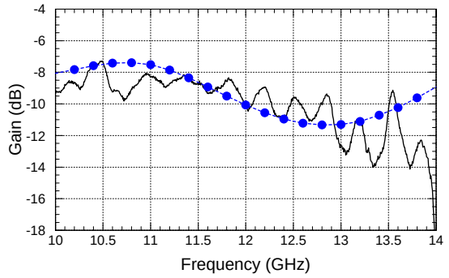
Data
Model

I-V Characteristic

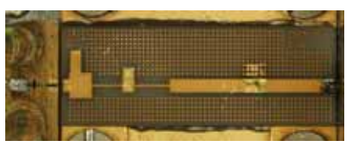


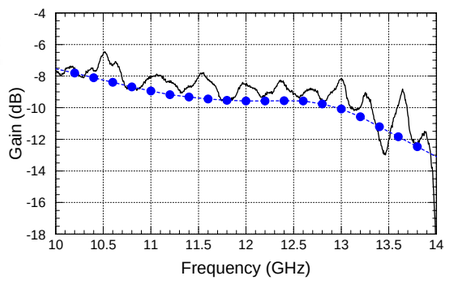
Receiver Gain

50 Ω Thru Line

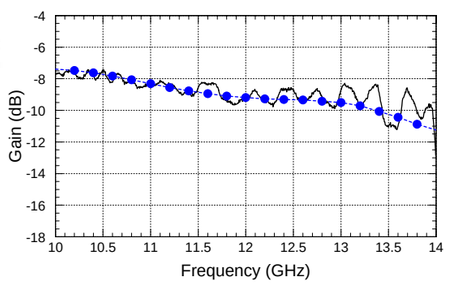


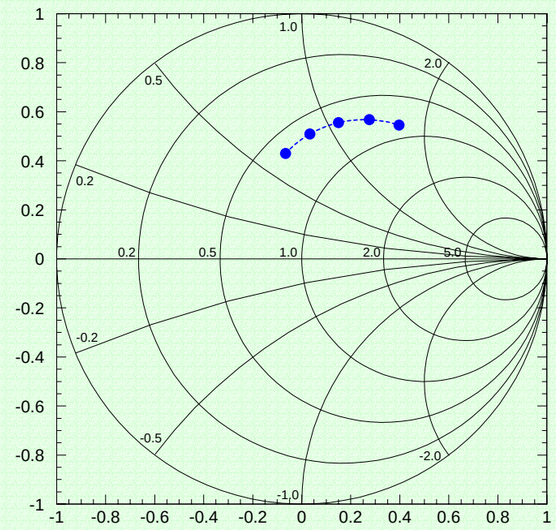
Transformer No. 1-2





Transformer No. 2-2





Z_{out} (output impedance of SIS device) in 10-14 GHz$_0$

Receiver gain profile with impedance transformer No. 3-2