Equivalent Circuits of Some Commercial Spiral Chip Inductors at Microwave Frequencies

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I. Malo, R. Amils

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Change Record

Revision	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
A	2020-14-07	All	First Issue
B	2020-17-11	Sect. 5, 12-18.	Added four ATP inductors more
C	2021-15-09	Sect. 5, 6, 12-14, 22-25, 27.	Added new data for new Piconics quartz coils (h=15 mil) and USuW (h=20 mil).
D	2022-05-16	Sect. 13	Changed equivalent circuit figure and value of Cpar in text which were erroneous

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1. Abstract

Near-ideal inductors are components difficult to implement in practical microwave circuits. One possibility which is often used in MMICs is the spiral planar inductor. This type of component is convenient since it can be efficiently integrated and is quite repeatable. In the case of the MIC type circuits the situation is different, since the size requirements are often too demanding for the standard micostrip etching techniques in soft substrates, making impractical its use. However there are some commercially available spiral chip inductors offered by some manufactures which can be easily used in MICs if connected to the circuit using standard bonding wires. The frequency range in which these inductors can be used depends on many factors, but seldom reaches over 20 GHz, even for the lower inductance and smaller size values. This report presents simple equivalent circuits for some of these inductors obtained by fitting to the S parameters measured with a coplanar probe station. These simple models can be used to represent the components in CAD programs, including their parasitic effects in a limited frequency range. The inductors analyzed were manufactured by Piconics and ATP.

2. Introduction

This report analyzes some types of commercial spiral inductors which can be used in microwave circuits. They were initially considered as an option for the bias circuits of cryogenic wideband amplifiers. In principle spiral inductors could be adequate for covering the inductance range not easily attainable with simple bonding wires (>1 nH). They are far from ideal components and can show multiple self resonances which severely limit the frequency range for which they can be used. The simple equivalent circuit used in this report (figure 1) can only represent the first resonance and should be used with extreme caution at high frequency. However this is generally acceptable, since the spiral inductors are, in general, not useful beyond their self resonance. These components are available in different sizes (height) and with different substrates (alumina, quartz). For our work the height of 10 mils was the most convenient, since it matches that of other passive components in the circuit. It was found that inductors on quartz substrates were more ideal and showed higher resonant frequencies. The parasitics depend on the size, layout and dielectric material used. The results obtained with eight different types are presented in this document. The values of the equivalent circuit components were obtained by comparison with the experimental measurements of the S parameters in a configuration that mimics the typical assembly method used in the amplifiers. The chip inductors were mounted on a copper plate and connected with short bonding wires to coplanar to microstrip transitions (figure 2) on both sides. The measurements were carried out in the 0.250-110 GHz frequency range at ambient temperature using a coplanar probe station.

3. Equipment

- Probe station mod. MPS 150 (Cascade Microtech)
- Coplanar probes mod. ACP 110-A-GSG-125 (Cascade Microtech)
- Vector network analyzer mod. PNA-X 5247 (Keysight)
- Millimeter wave controller mod. N5261A (Keysight)
- Millimeter wave heads mod. N5250CX10 (Keysight)
- Transitions from coplanar to microstrip mod. ProbePoint 0503 (Jmicro)
- Coplanar calibration substrate (ISS) mod. 104-783A (Cascade Microtech)

4. Calibration

The chip inductor measurements were obtained using a standard LRRM calibration performed with the Cascade Microtech ISS calibration substrate (Impedance Standard Substrate, figure 3) using WinCal software. With the standards used this calibration performs reasonably well in all the 250 MHz-110 GHz range sampled. It was verified with an open (probes in air) and with a long matched coplanar line (~27ps) in the ISS substrate. The ISS was used in combination with an absorbing ISS holder (SN 116-334) as recommended by Cascade.

The standard LRMM method yields a calibration referenced to the end of the coplanar probes. As the objective was to measure the inductors, the reference plane had to be shifted to the end of the coplanar-microstrip transitions. This was performed with a built-in feature of the PNA-X which allows de-embedding circuits characterized by their S-parameter files. Appendix I contain some information of the models used to generate the S-parameter files of the transitions. Additional information can be found in a previous Technical Report[1].

5. Equivalent circuit results

The measurements were performed in the complete 250 MHz-110 GHz frequency range accessible to the measurement equipment. However, a good fit with a simple equivalent circuit could only be obtained in a much smaller range. The circuit used is presented in figure 1 and the values of the components for the different inductors are shown in table I. The fit is valid only for frequencies below the limit shown the table (different for each inductor). More details on the results and a comparison of the models and measurements are presented in sections 7 to 14.

In the case of the Piconics components, we also checked the possibility of using the ADS internal spiral inductor model and a 2.5D EM simulation with ADS Momentum. It was found that neither of the two obtained a perfect fit and additional components had to be included to improve the results. In general, these more complex models can predict the existence of more than one resonance, but the results do not coincide exactly with the measurements (see sections 7 to 11).

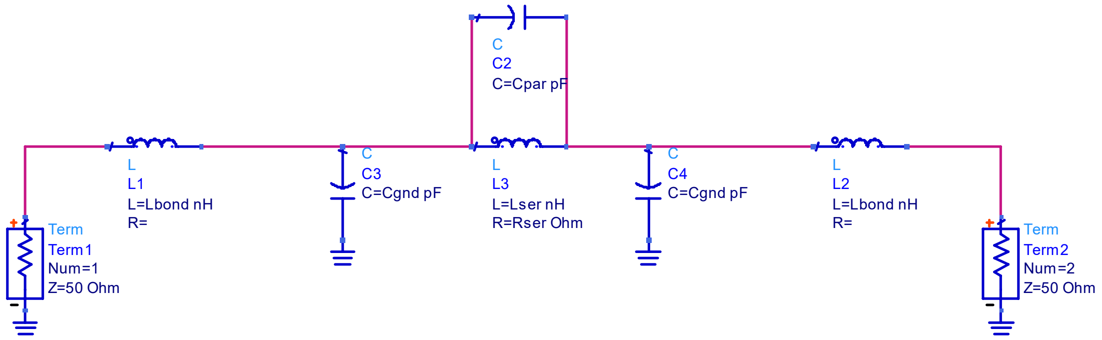


Figure 1: Equivalent circuit used for the inductors, including external bonding wires.

[1] J.D. Gallego, C. Diez González, I. López, I. Malo, "Effect of Source Bonding Wires in HEMT devices", CDT Technical Report 2016-18. http://icts-yebes.oan.es/reports/doc/IT-CDT-2016-18.pdf

TABLE I

Parameters of the equivalent circuit of the spiral inductors measured

Manufacturer	Data Sheet Value (nH)	Material	Size (mil)	Height (mil)	Num. of turns	Equivalent Circuit Elements Lbond (nH)	Cgnd (pF)	Lser (nH)	Rser (Ohm)	Cpar (pF)	Fmax (GHz)	P/N
PICONICS	6.9	Alumina	20x20	15	4.5	0.38	0.045	6.1	3.0	0.024	20	SP4P5-20-ACW
PICONICS	12	Alumina	20x20	10	6.5	0.30	0.055	10.8	3.1	0.013	12	SP6P5-20-ABW
PICONICS	2.1	Quartz	20x20	10	2.0	0.17	0.125	2.3	0.2	0.000	20	SP2P0-20-QBW
PICONICS	6.9	Quartz	20x20	10	4.5	0.19	0.117	6.3	4.3	0.010	20	SP4P5-20-QBW
PICONICS	12	Quartz	20x20	10	6.5	0.22	0.117	9.6	5.0	0.009	20	SP6P5-20-QBW
PICONICS	2.1	Quartz	20x20	15	2.0	0.34	0.019	1.74	0.3	0.010	35	SP2P5-20-QCW
PICONICS	6.9	Quartz	20x20	15	4.5	0.36	0.023	6.2	4.1	0.012	20	SP4P5-20-QCW
PICONICS	12.0	Quartz	20x20	15	6.5	0.26	0.030	10.5	5.0	0.012	20	SP6P5-20-QCW
ATP	2.2	Quartz	22x22	10	2.5	0.19	0.021	1.4	0.6	0.007	40	ATP-I-010-Q-022
ATP	3.5	Quartz	22x22	10	3.0	0.20	0.025	2.5	0.3	0.007	30	ATP-I-010-Q-350
ATP	3.9	Quartz	22x22	10	3.5	0.18	0.027	2.6	1.0	0.008	25	ATP-I-010-Q-390
ATP	7.3	Quartz	25x25	10	4.0	0.19	0.037	5.0	1.4	0.009	20	ATP-I-010-Q-730
ATP	12	Quartz	30x30	10	4.5	0.20	0.048	7.8	1.8	0.008	15	ATP-I-010-Q-120
ATP	28	Quartz	32x32	10	7.5	0.25	0.063	17.0	2.6	0.003	10	ATP-I-010-Q-282
ATP	87.7	Quartz	46x46	10	10.5	0.25	0.101	47.0	6.0	0.055	2	ATP-I-010-Q-877
US uW	2.0	Quartz	27x27	20	2.0	0.13	0.021	1.73	0.8	0.000	35	LX2500Q20-L02-02
US uW	4.0	Quartz	27x27	20	3.0	0.30	0.016	1.94	0.3	0.006	30	LX2500Q20-L03-04
US uW	7.0	Quartz	27x27	20	3.6	0.48	0.018	2.48	0.6	0.010	30	LX2500Q20-L03.6-07
US uW	14.0	Quartz	27x27	20	5.0	0.50	0.024	5.59	5	0.012	20	LX2500Q20-L05-14

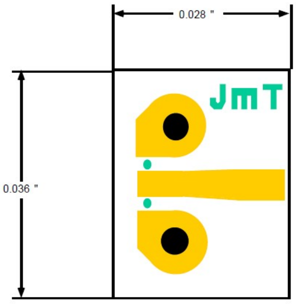


Figure 2: Drawing of Jmicro coplanar to microstrip transition used for the measurements.

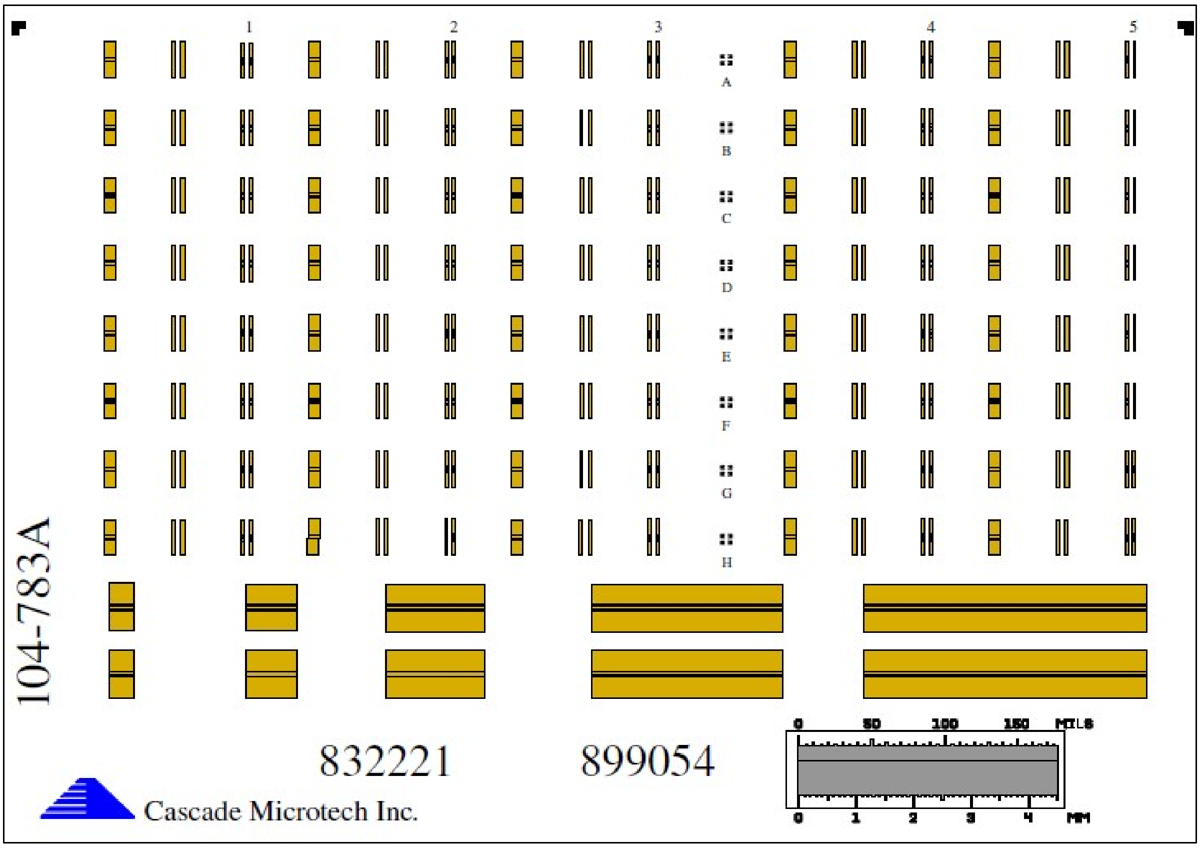
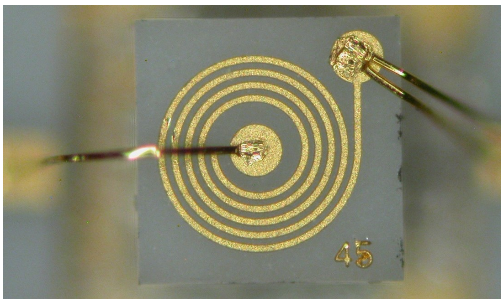
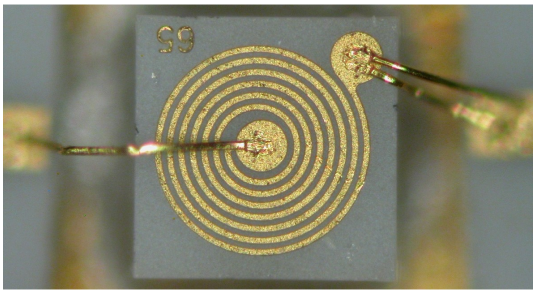


Figure 3: Calibration substrate used for LRRM calibration on the coplanar reference plane in the 0.250-110 GHz frequency range.

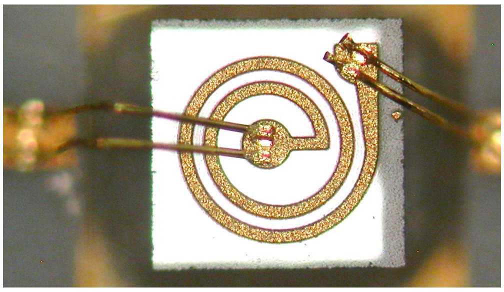
6. Photos



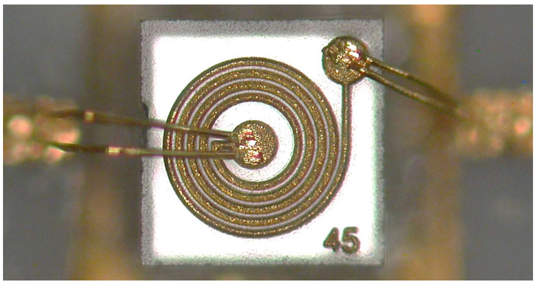
Piconics 6.9 nH 4.5 T 20x20x15 mil alumina



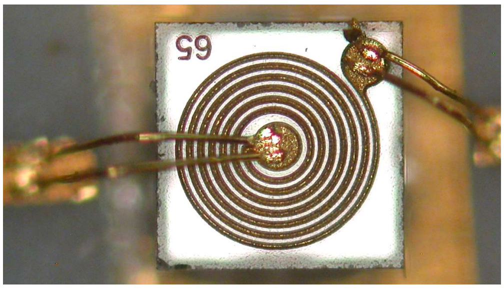
Piconics 12 nH 6.5 T 20x20x10 mil alumina



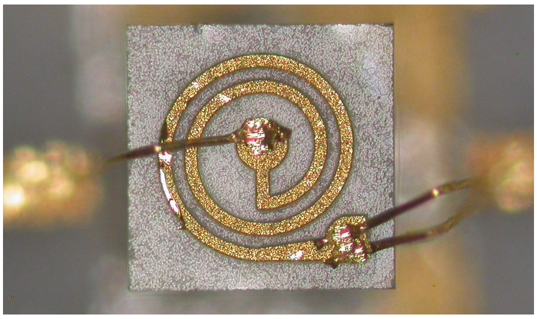
Piconics 2.1 nH 2.0 T 20x20x10 mil quartz



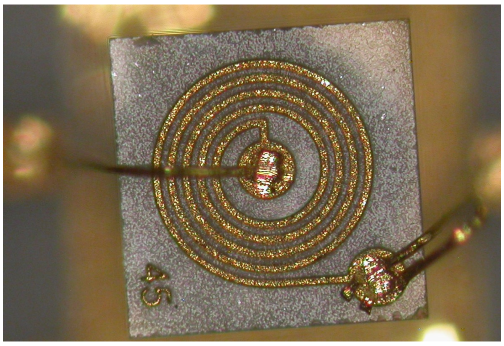
Piconics 6.9 nH 4.5 turns 20x20x10 mil quartz



Piconics 12 nH 6.5 T 20x20x10 mil quartz



Piconics 2.1 nH 2.0 T 20x20x15 mil quartz



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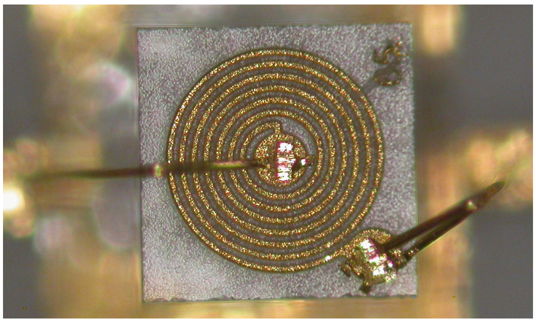
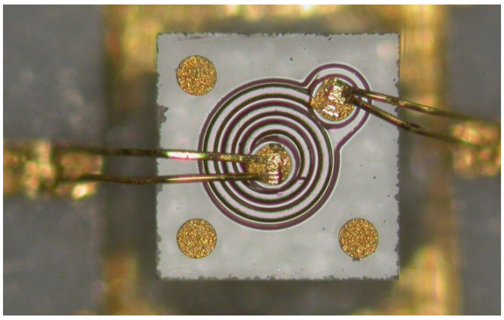
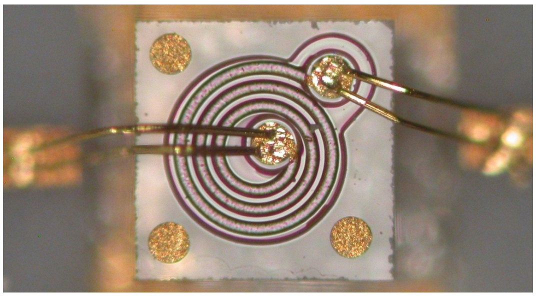


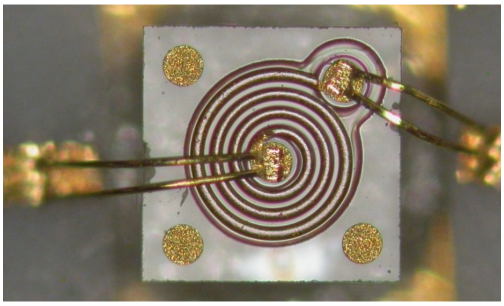
Piconics 12 nH 6.5 T 20x20x15 mil quartz



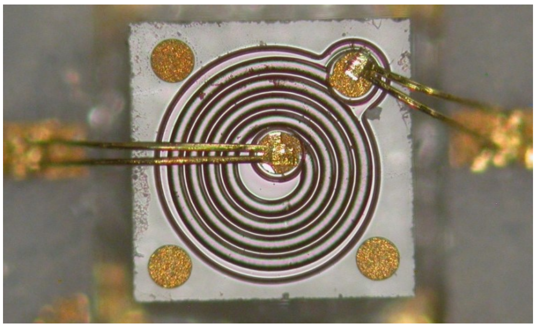
ATP 2.2 nH 2.5 T 22x22x10 mil quartz



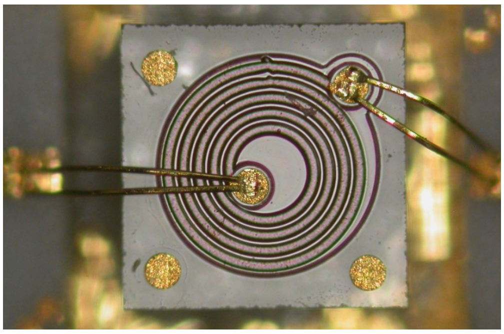
ATP 3.5 nH 3 T 22x22x10 mil quartz



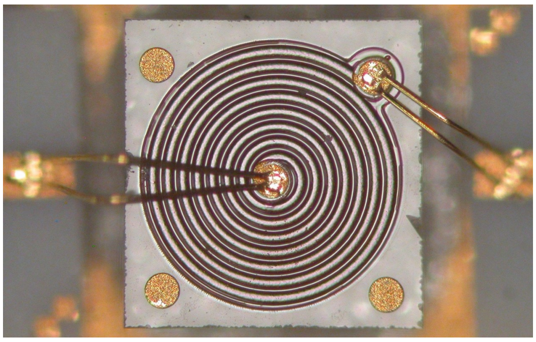
ATP 3.9 nH 3.5 T 22x22x10 mil quartz



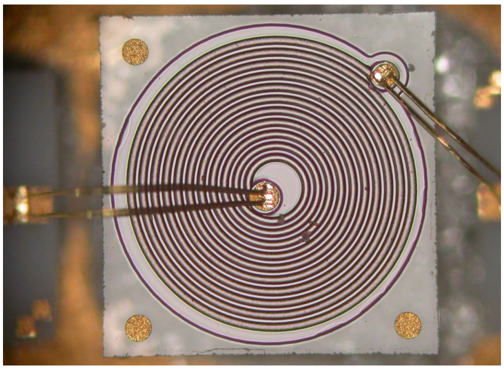
ATP 7.3 nH 4 T 25x25x10 mil quartz



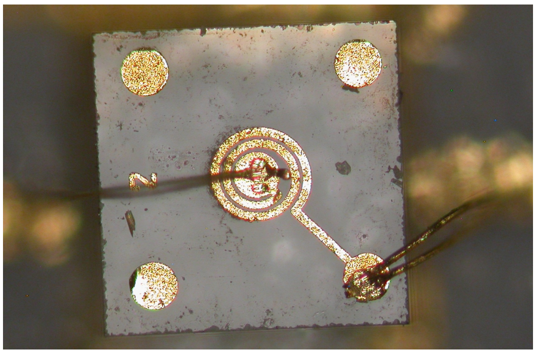
ATP 12 nH 4.5 T 30x30x10 mil quartz



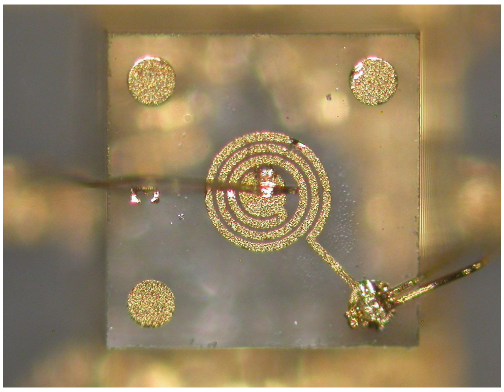
ATP 28 nH 7.5 T 22x22x10 mil quartz



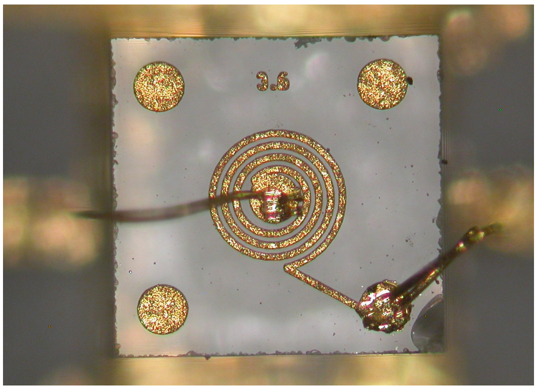
ATP 87.7 nH 10.5 T 46x46x10 mil quartz



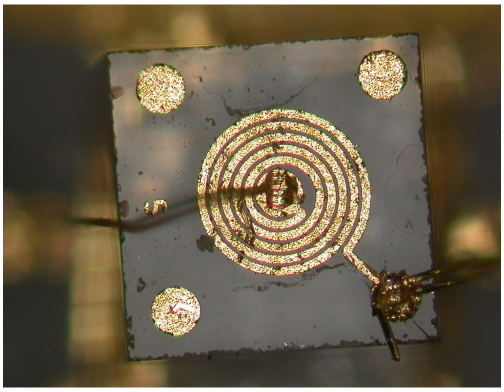
US uW 2.0 nH 2 T 27x27x20 mil quartz



US uW 4.0 nH 3 T 27x27x20 mil quartz

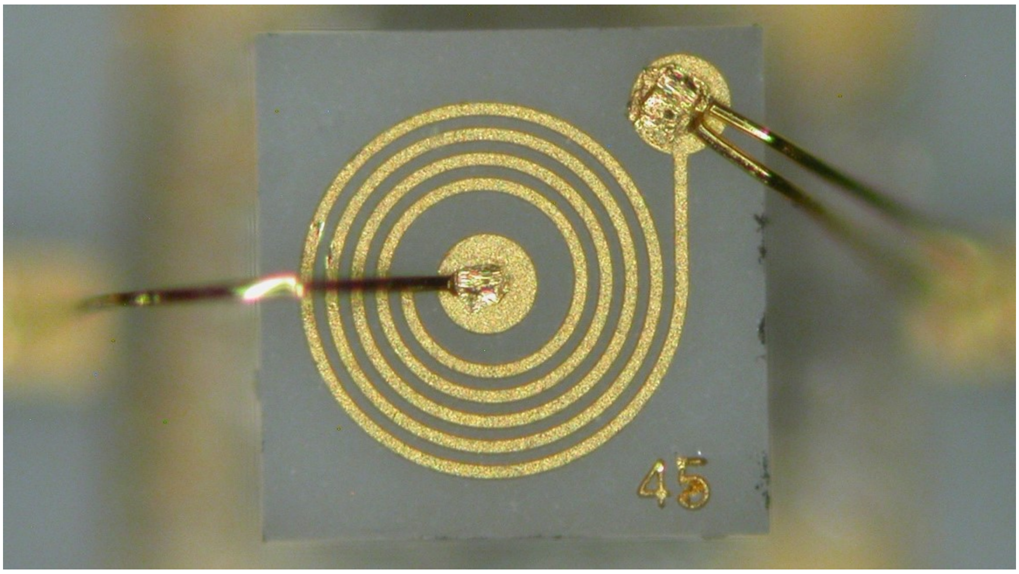


US uW 7.0 nH 3.6 T 27x27x20 mil quartz



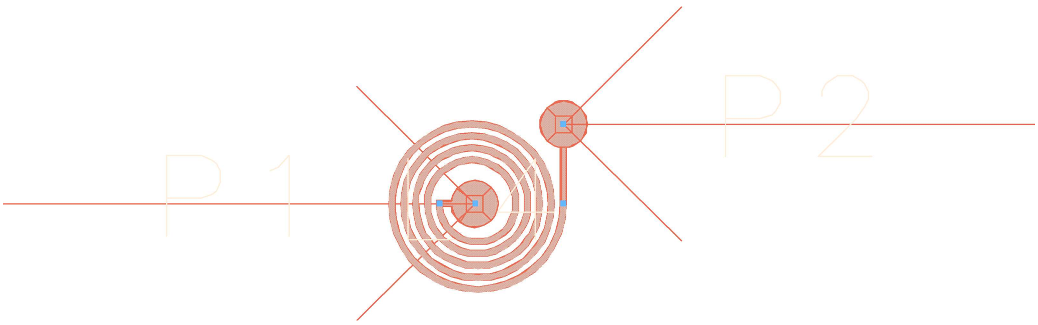
US uW 14.0 nH 5 T 27x27x20 mil quartz

7. Piconics alumina inductor 6.9 nH 4.5 turns 20x20x15 mil chip



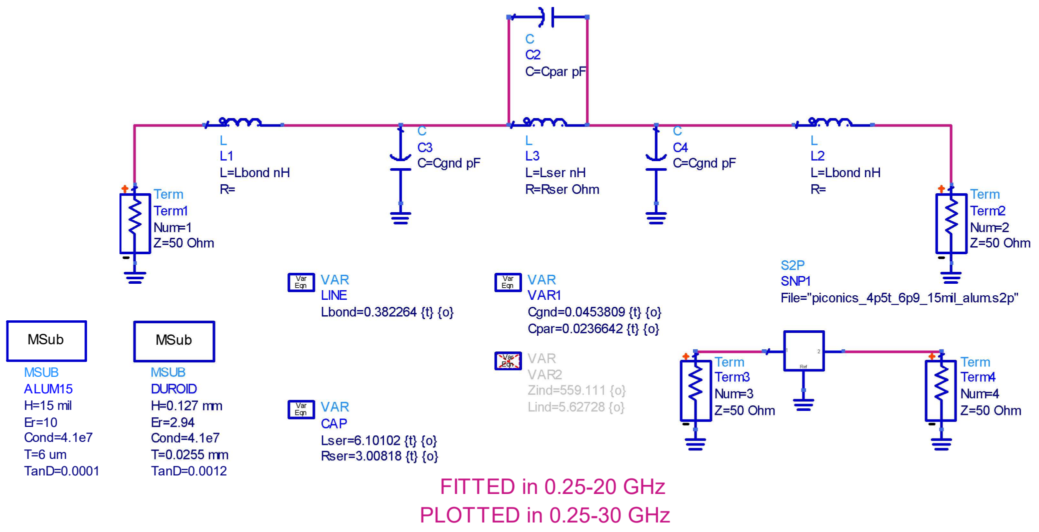
PICONICS model SP4P5-20-ACW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.15 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.381 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.500 mm
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm; sep: ~0.040 mm
Reference planes at the end of Jmicro substrate



SIMPLE L-C MODEL

Good up to ≈20 GHz
Does not predict resonance in S21 at ≈ 24 GHz

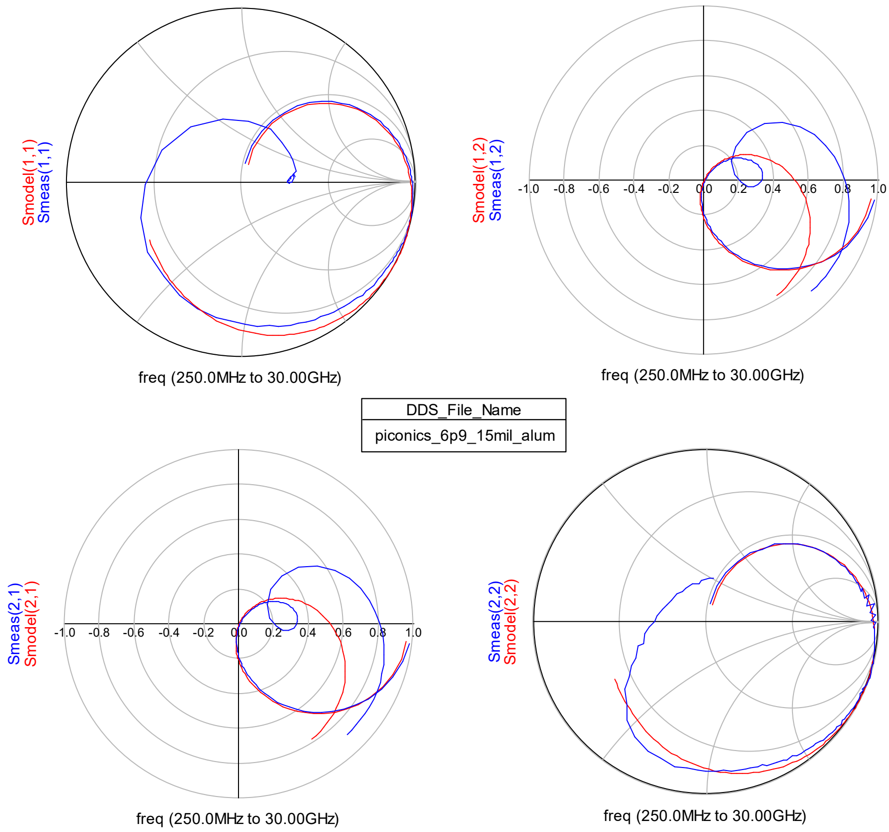


Inductor:
Lser=6.1 nH
Rser=3.0 Ohm

Input-output capacitor:
Cpar=0.024 pF

Capacitors to GND:
Cgnd=0.045 pF

Bond wires:
Lbond=0.38 nH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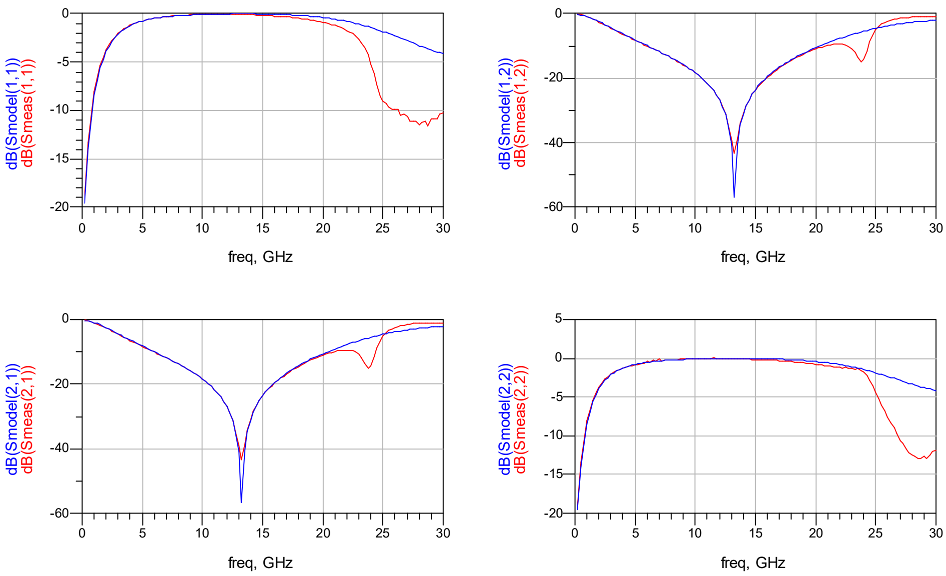
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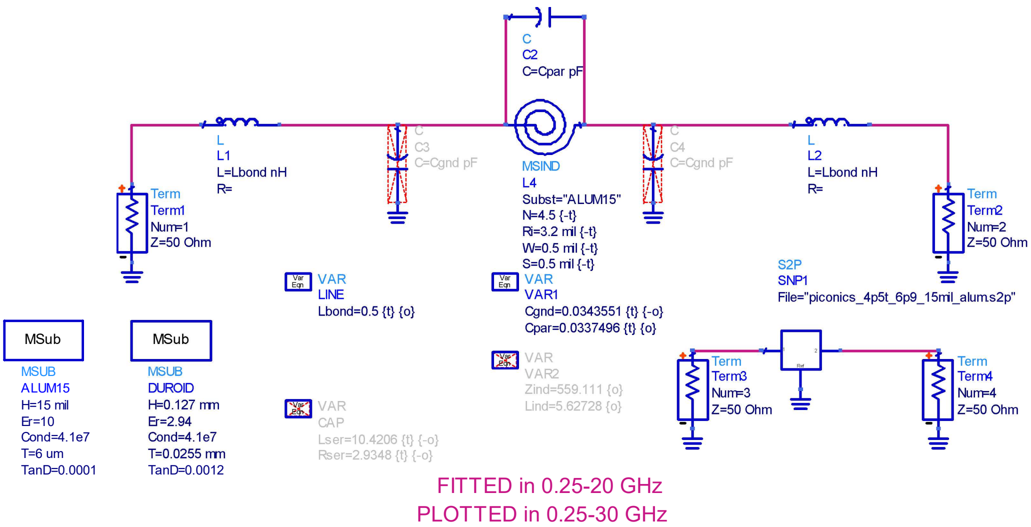
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

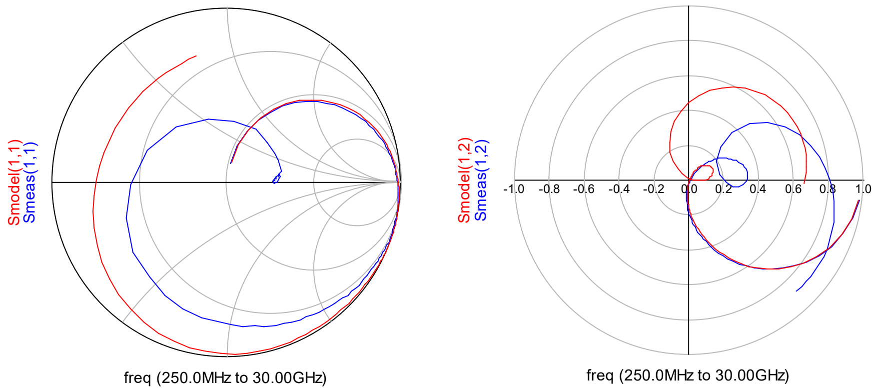
ADS INTERNAL MODEL

Good up to ≈20 GHz
A capacitor from input to output is needed to model S21 adequately
(Probably due to coupling of input-output bond wires)



Input-output capacitor:
Cpar=0.034 pF

Bond wires:
Lbond=0.50 nH



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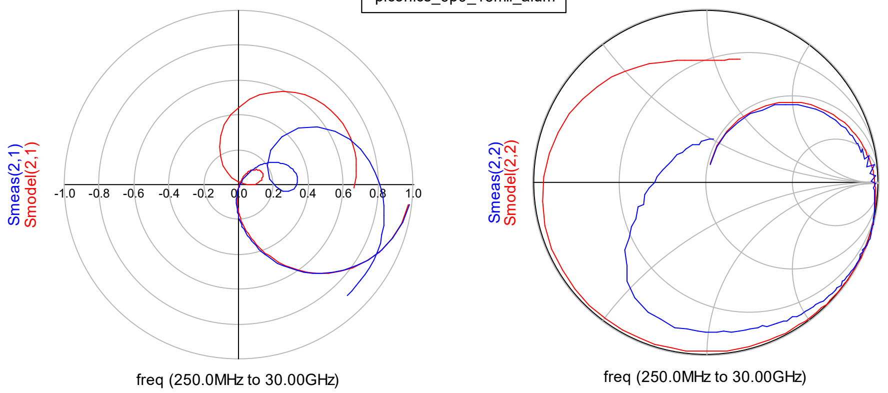
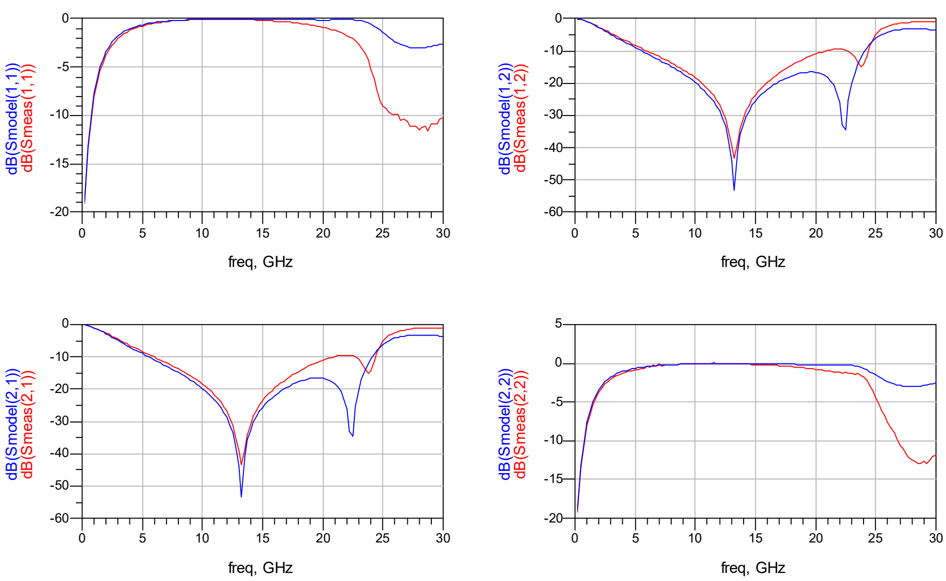
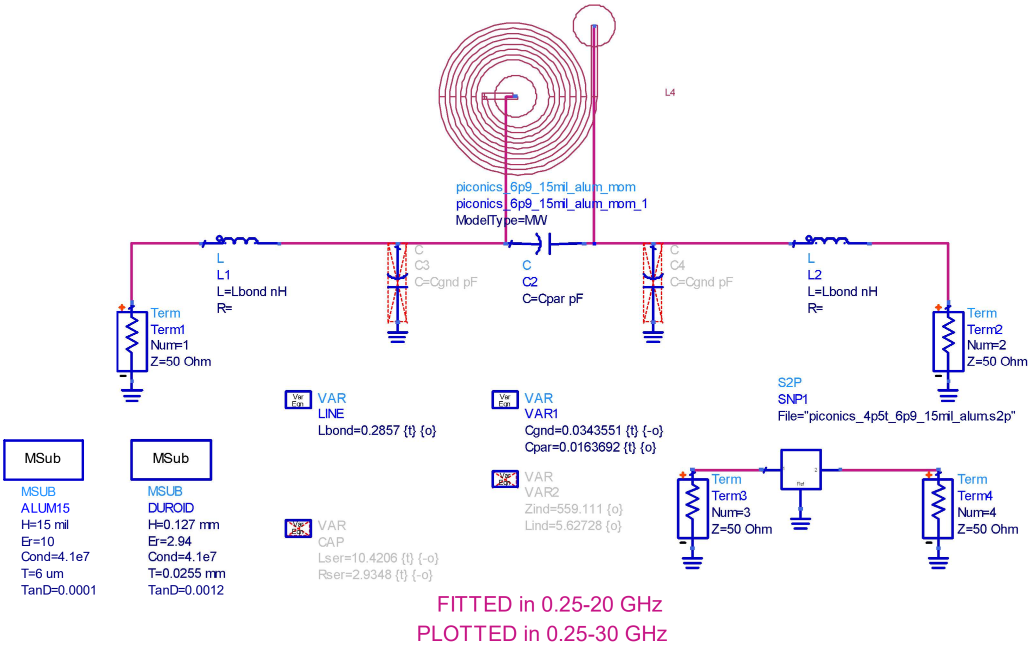




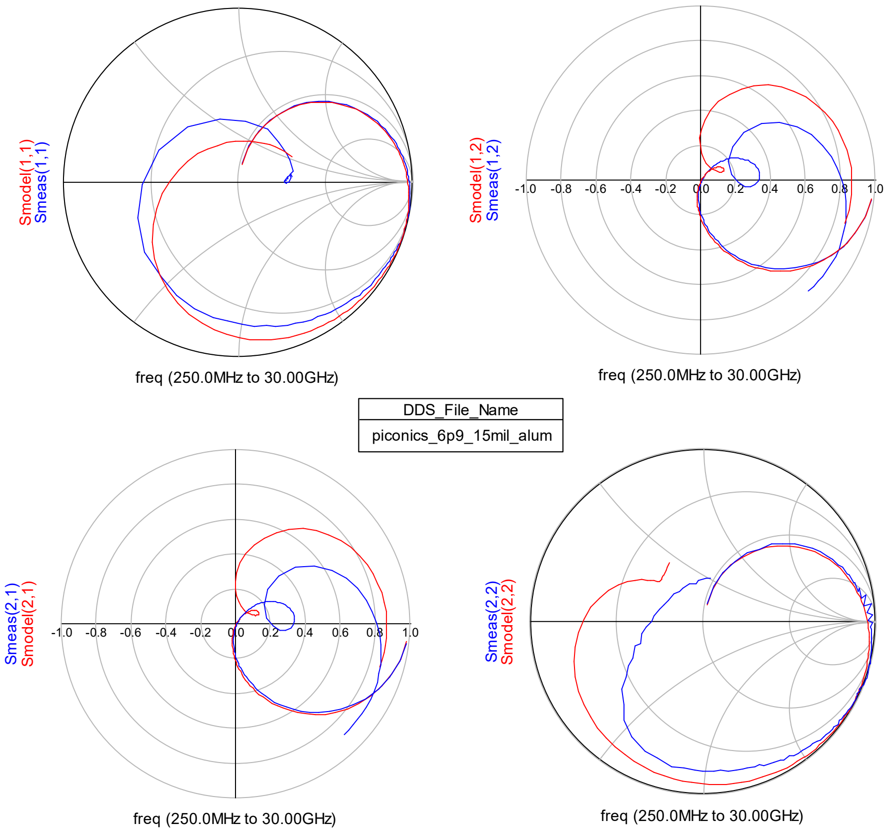
MOMENTUM MODEL

Good up to ≈20 GHz
A capacitor from input to output is needed to model S21 adequately
(Probably due to coupling of input-output bond wires)



Input-output capacitor:
Cpar=0.016 pF

Bond wires:
Lbond=0.29 nH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Smeas(2,1)
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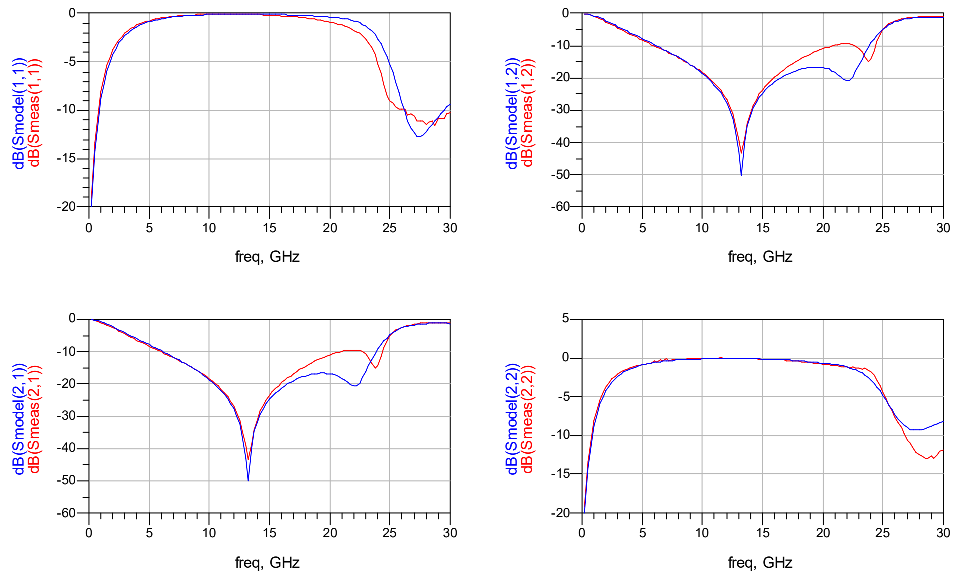
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)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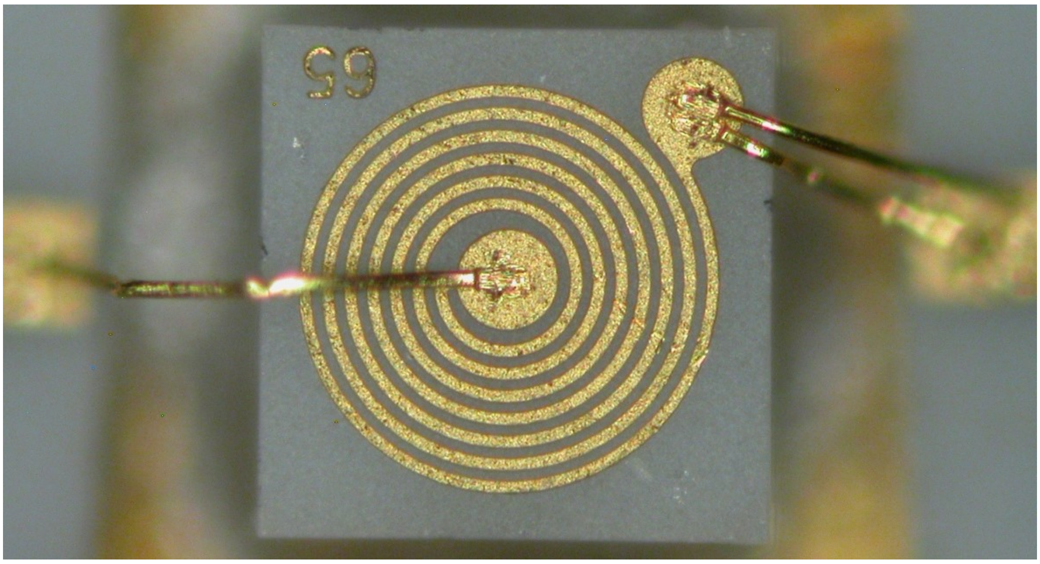
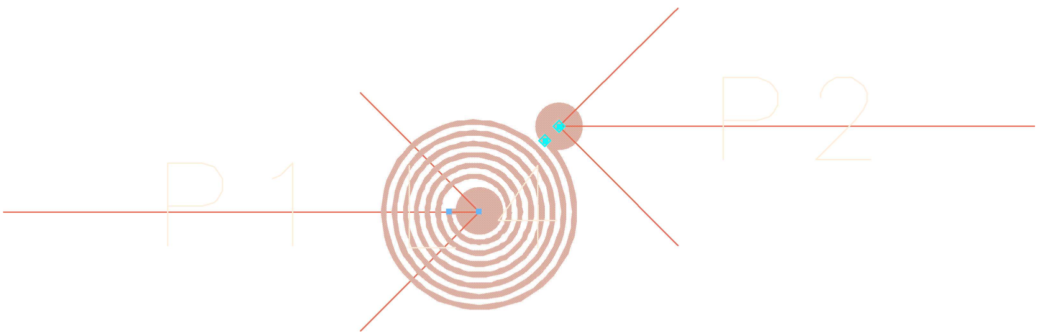
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

8. Piconics alumina inductor 12 nH 6.5 turns 20x20x10 mil chip



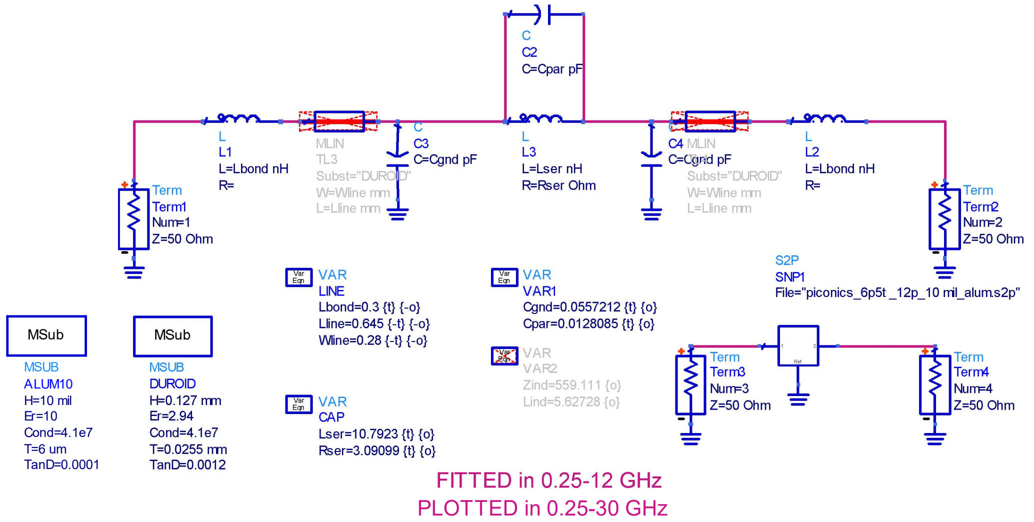
PICONICS model SP6P5-20-ABW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.15 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.500 mm
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm; sep: ~0.040 mm
Reference planes at the end of Jmicro substrate



SIMPLE L-C MODEL

Good up to ≈12 GHz

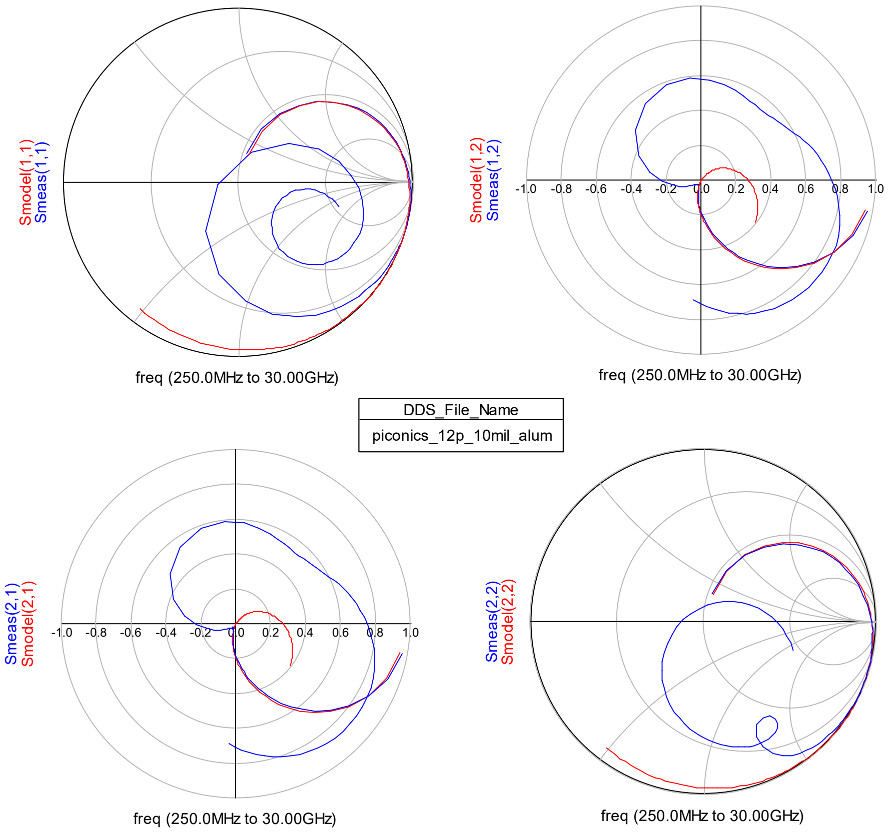


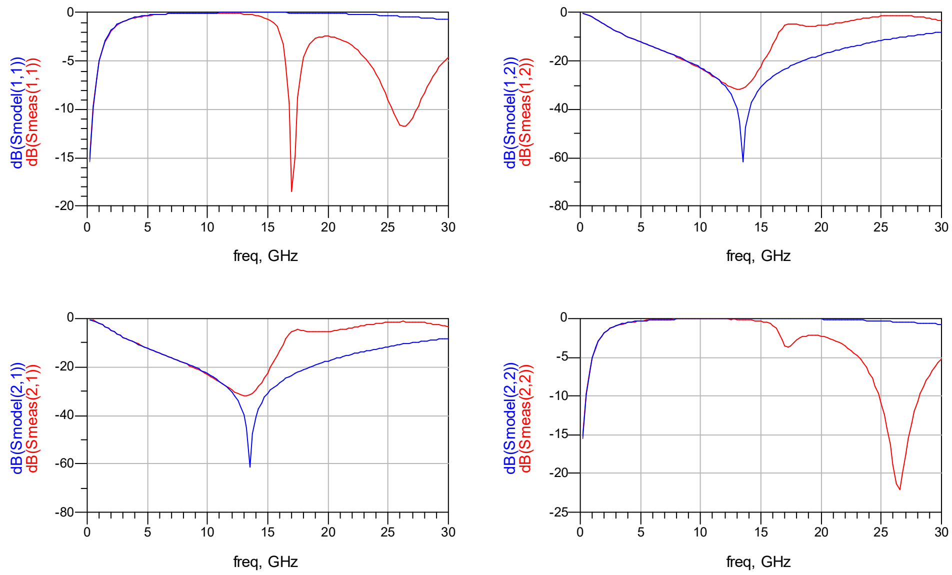
Inductor:
Lser=10.8 nH
Rser=3.1 Ohm

Input-output capacitor:
Cpar=0.013 pF

Capacitors to GND:
Cgnd=0.055 pF

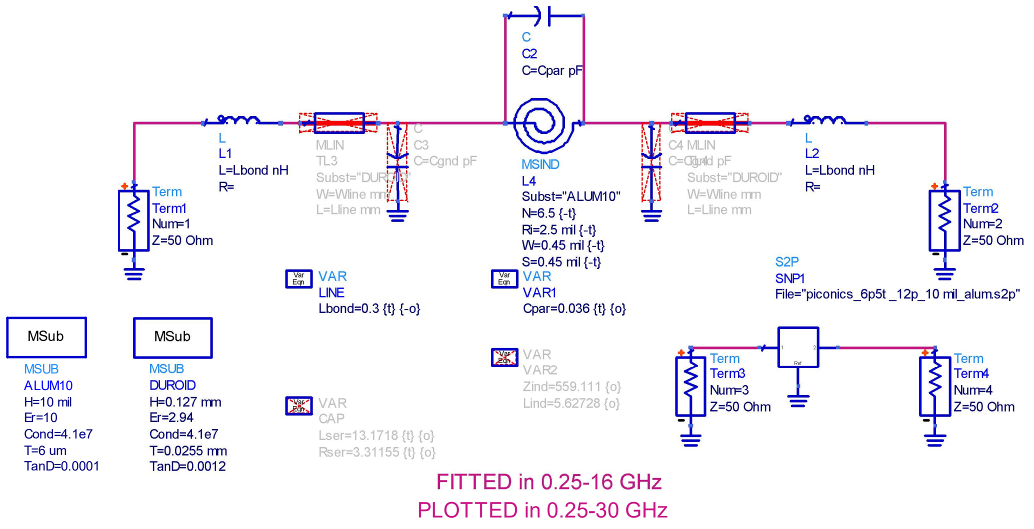
Bond wires:
Lbond=0.30 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_10mil_alum
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

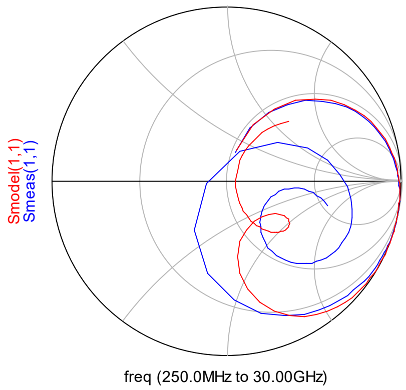
ADS INTERNAL MODEL

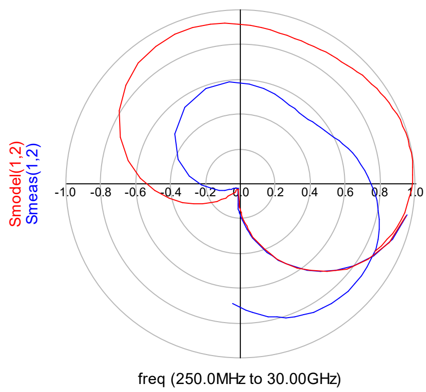
Good up to ≈16 GHz
A capacitor from input to output is needed to model S21 adequately
(Probably due to coupling of input-output bond wires)



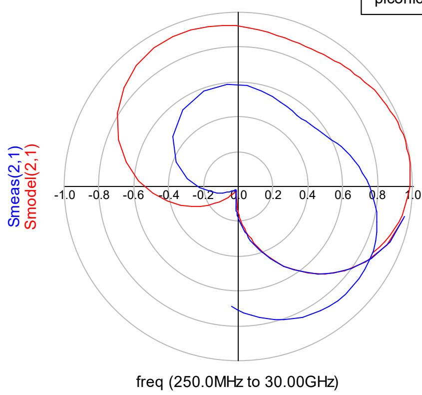
Input-output capacitor:
Cpar=0.036 pF

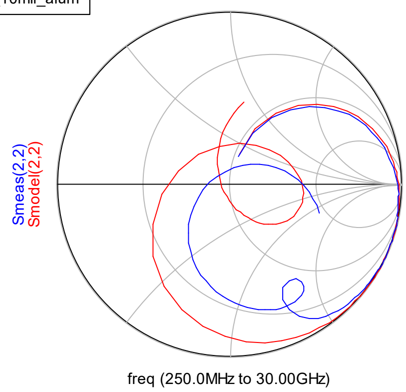
Bond wires:
Lbond=0.30 nH

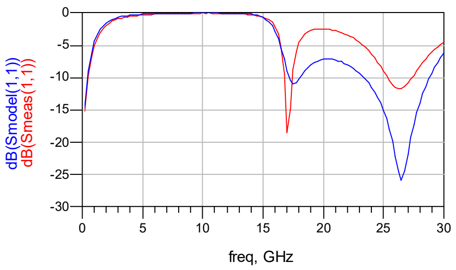


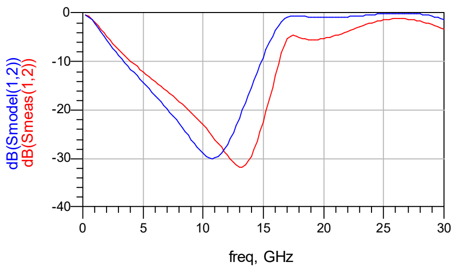


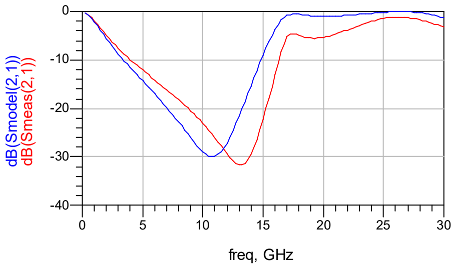
DDS_File_Name
piconics_12p_10mil_alum

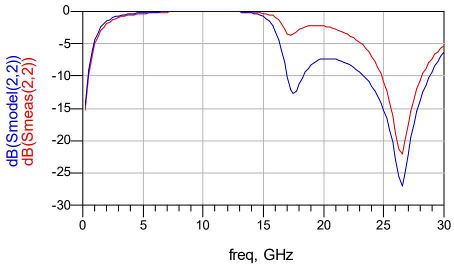






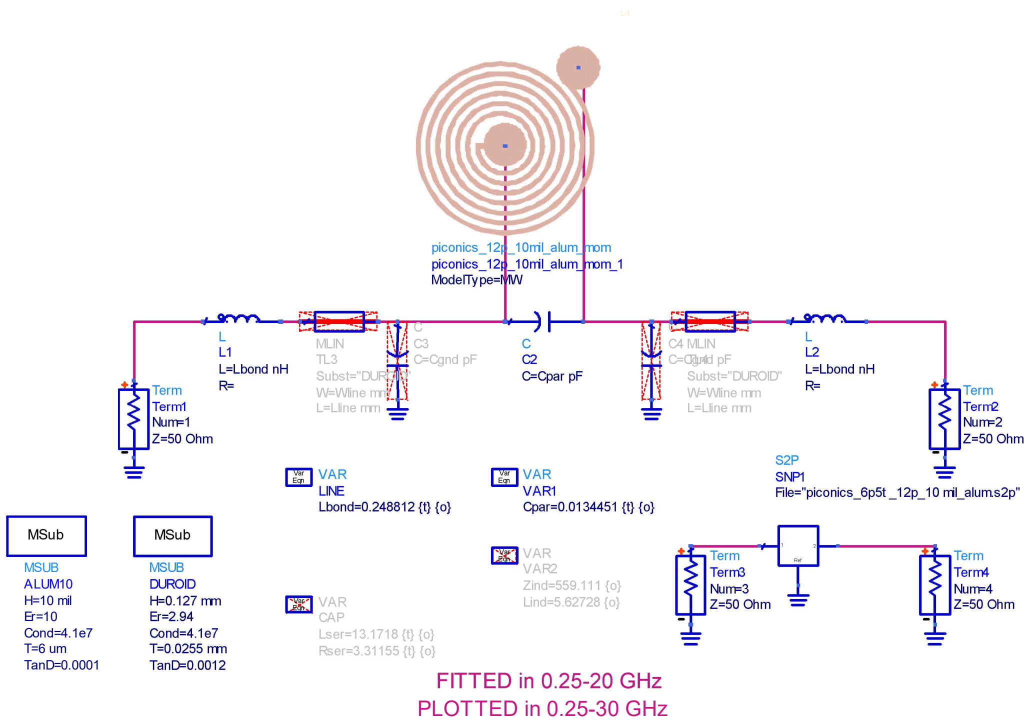






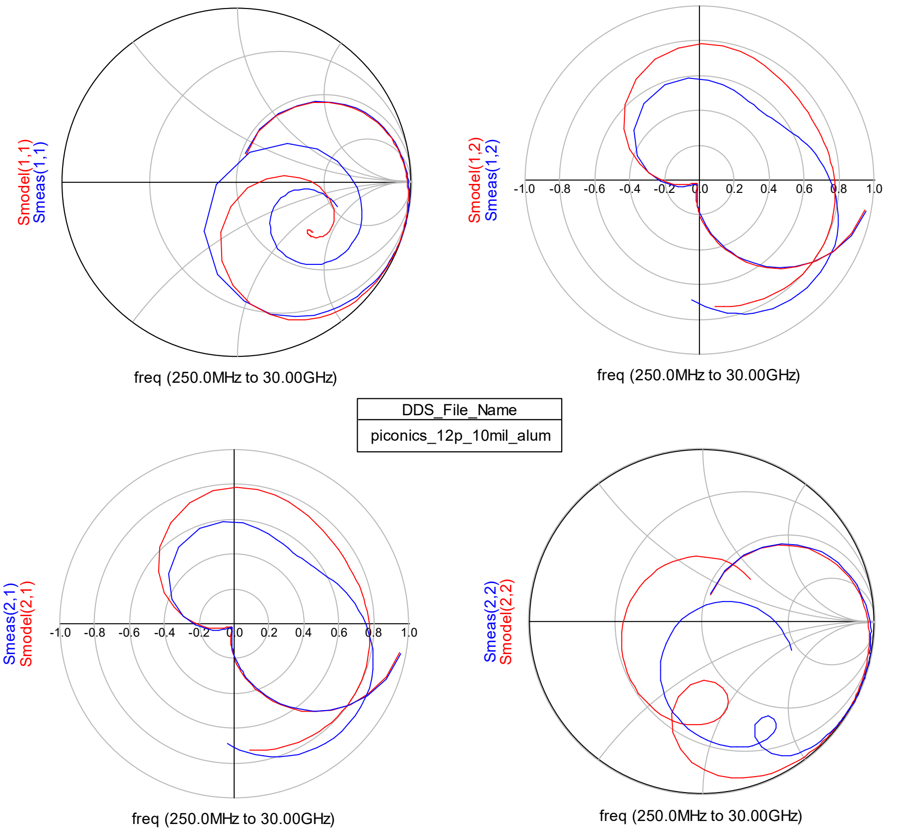
MOMENTUM MODEL

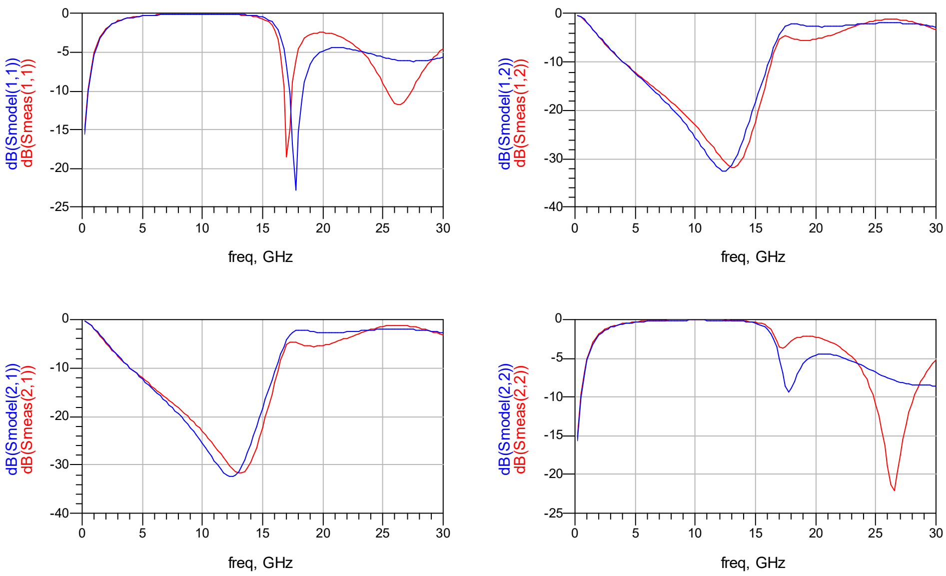
Good up to ≈20 GHz
A capacitor from input to output is needed to model S21 adequately
(Probably due to coupling of input-output bond wires)



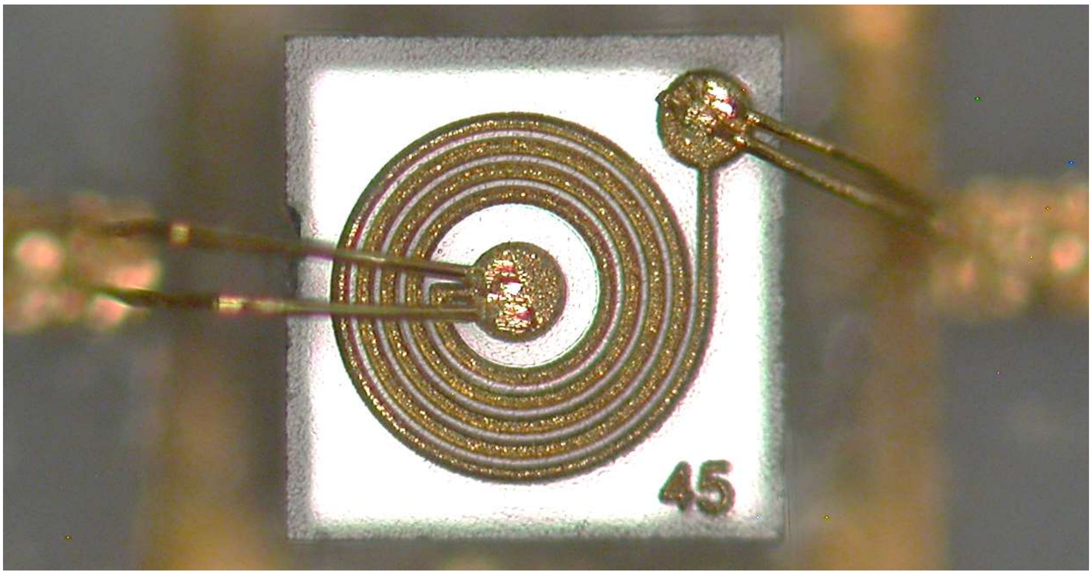
Input-output capacitor:
Cpar=0.013 pF

Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_10mil_alum
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)

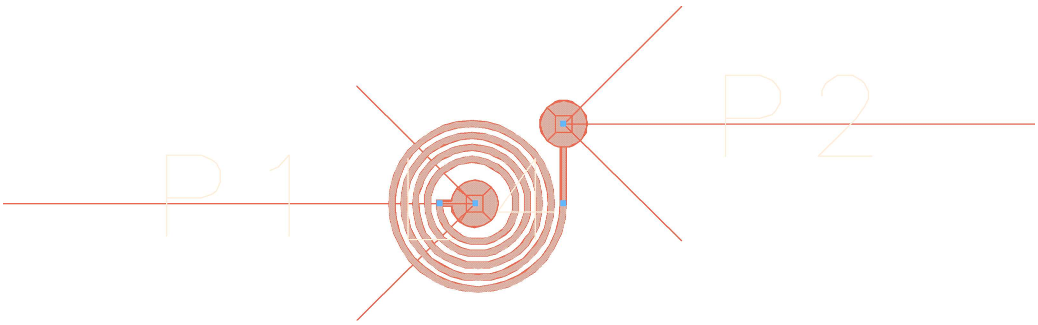

dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

9. Piconics quartz inductor 6.9 nH 4.5 turns 20x20x10 mil chip



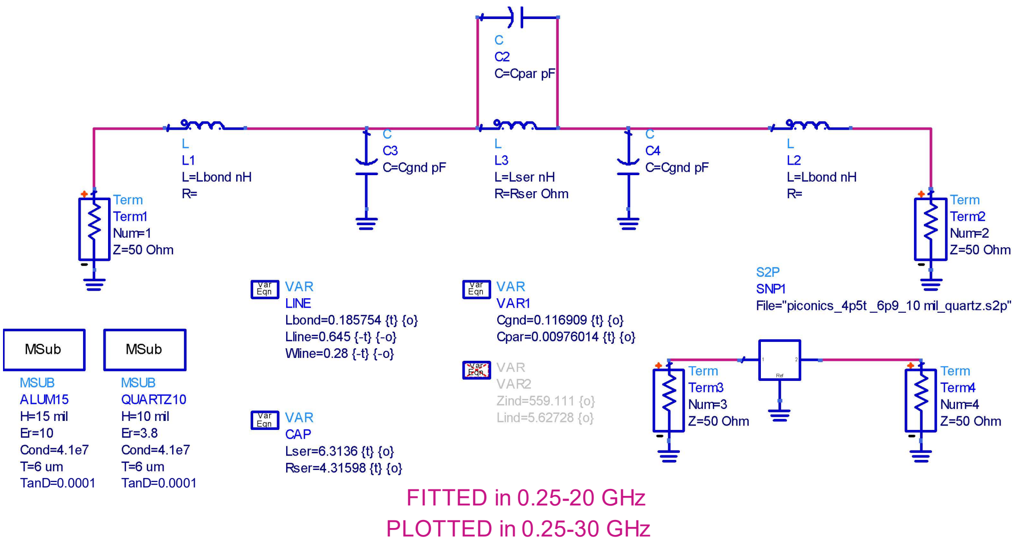
PICONICS model SP4P5-20-QBW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.440 mm; sep: ~40-60 um; height over chip: ~60 um
Bond wire 2: dia: 17 um; horizontal distance: 0.300 mm; sep: ~35 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate



SIMPLE L-C MODEL

Good up to ≈30 GHz
Relatively good prediction

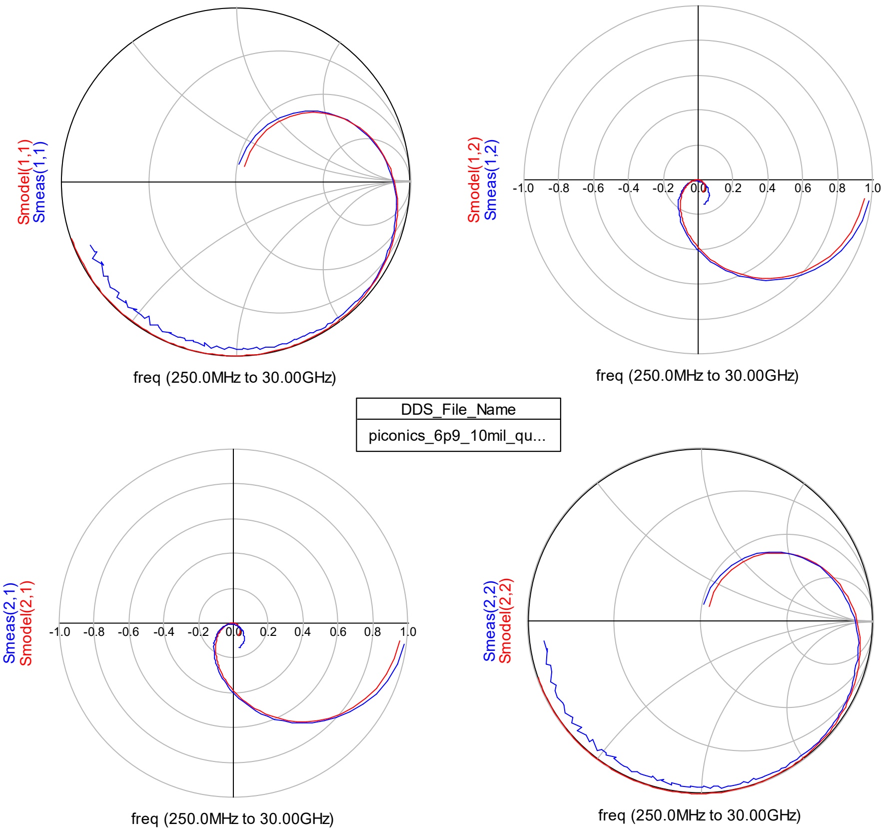


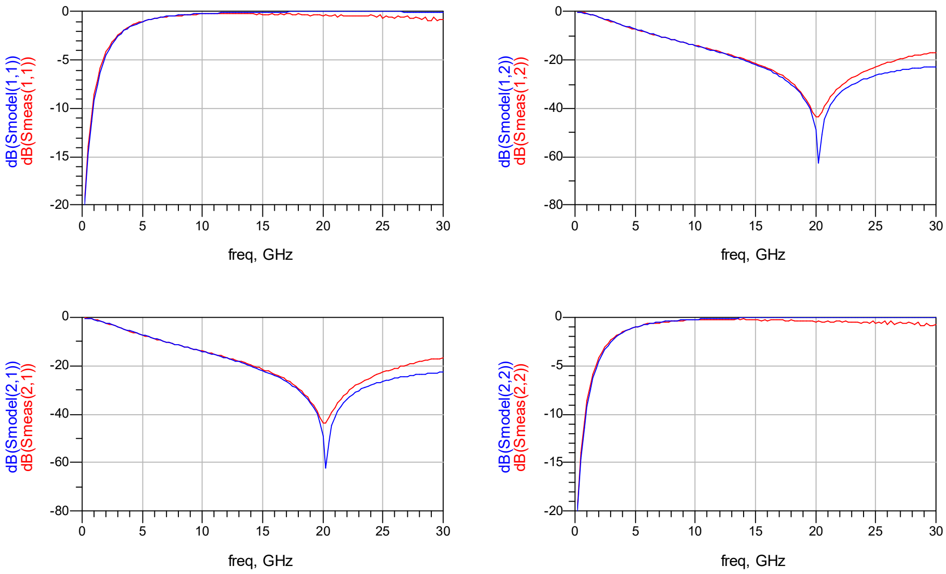
Inductor:
Lser=6.3 nH
Rser=4.3 Ohm

Input-output capacitor:
Cpar=0.010 pF

Capacitors to GND:
Cgnd=0.117 pF

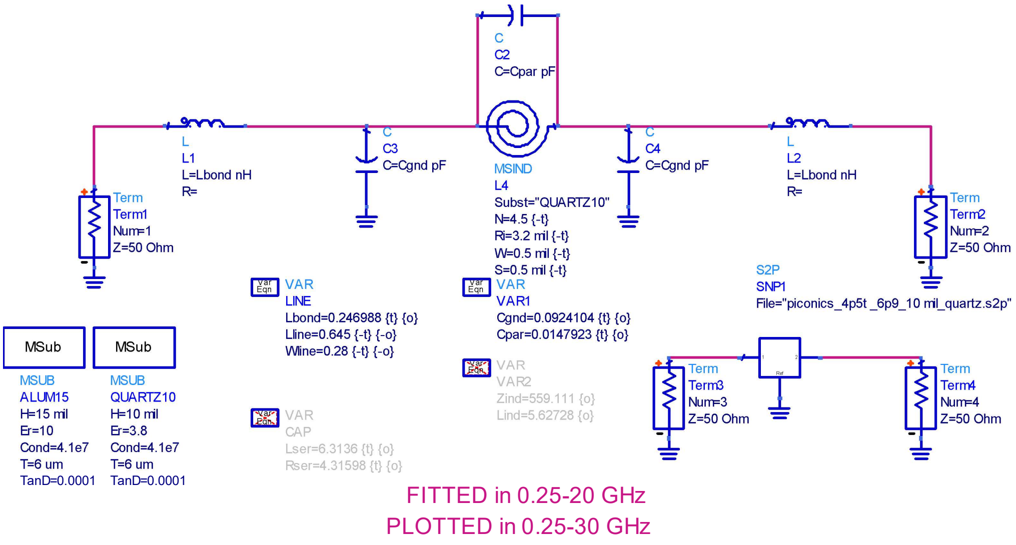
Bond wires:
Lbond=0.19 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_6p9_10mil_qu...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

ADS INTERNAL MODEL

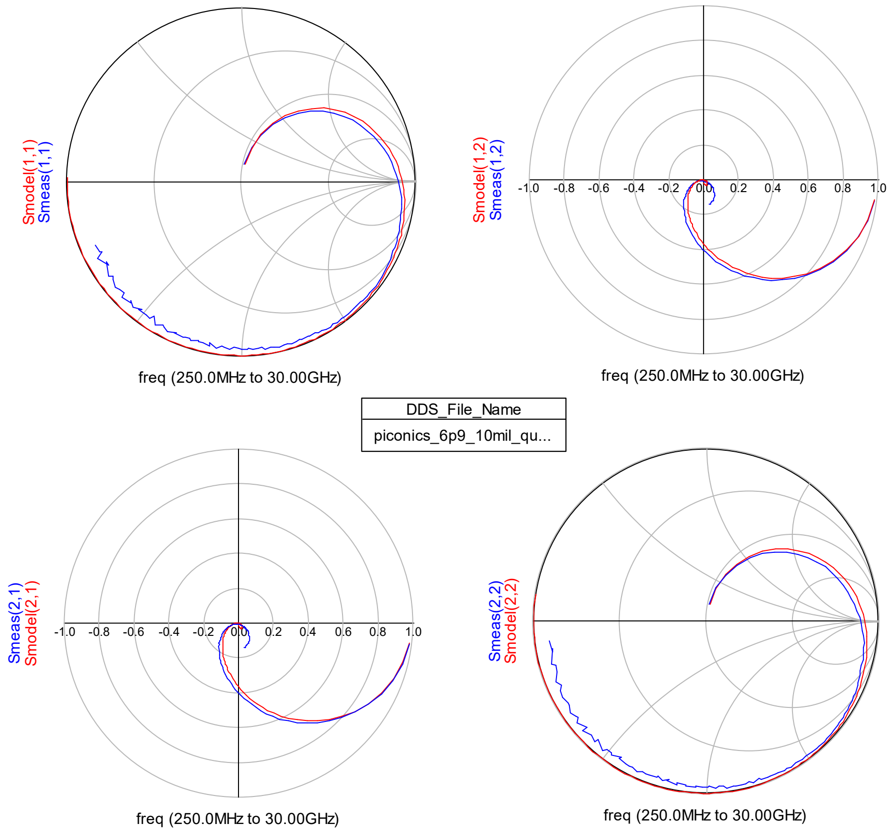
Good up to ≈20 GHz
Capacitosr from input to output and to GND are needed to model S parameters adequately

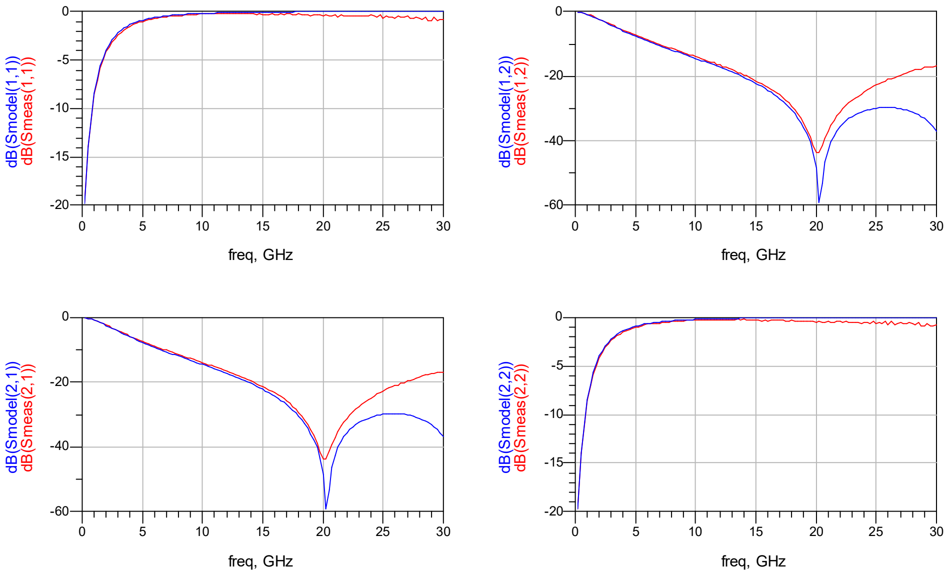


Input-output capacitor:
Cpar=0.015 pF

Capacitors to GND:
Cgnd=0.092 pF

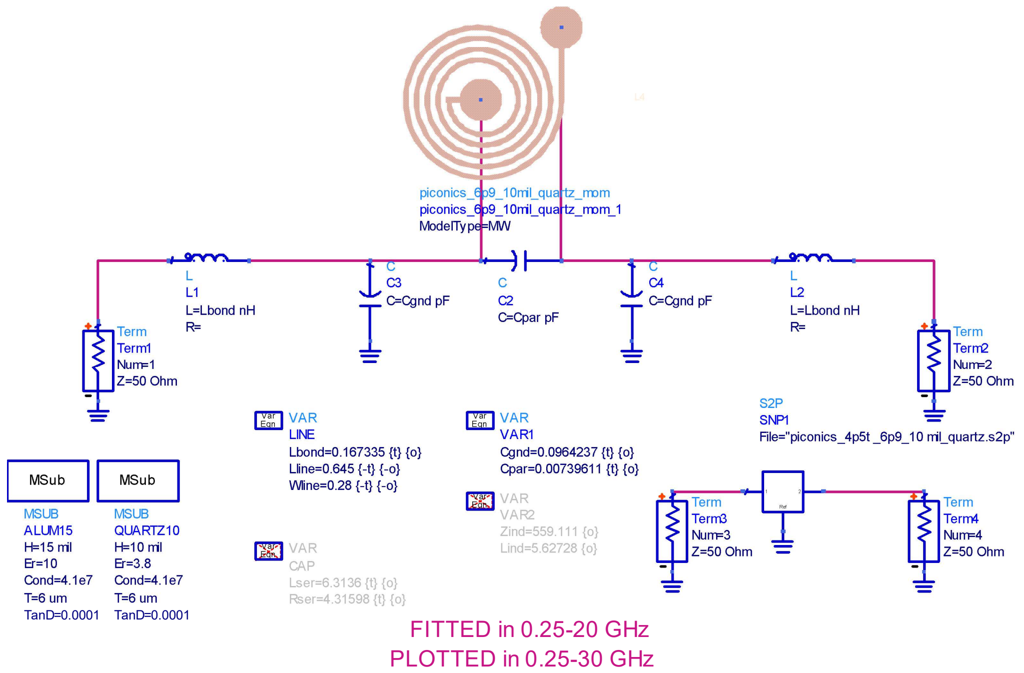
Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_6p9_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

MOMENTUM MODEL

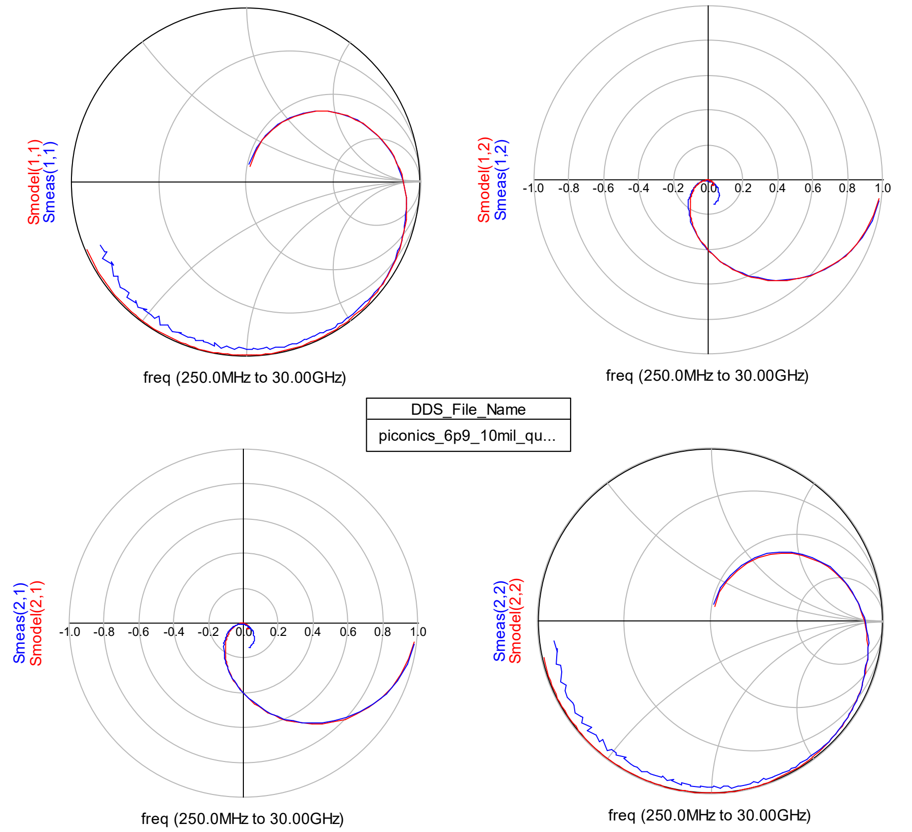
Good up to ≈20 GHz
Capacitors from input to output is needed to model S21 adequately
(Probably due to coupling of input-output bond wires)

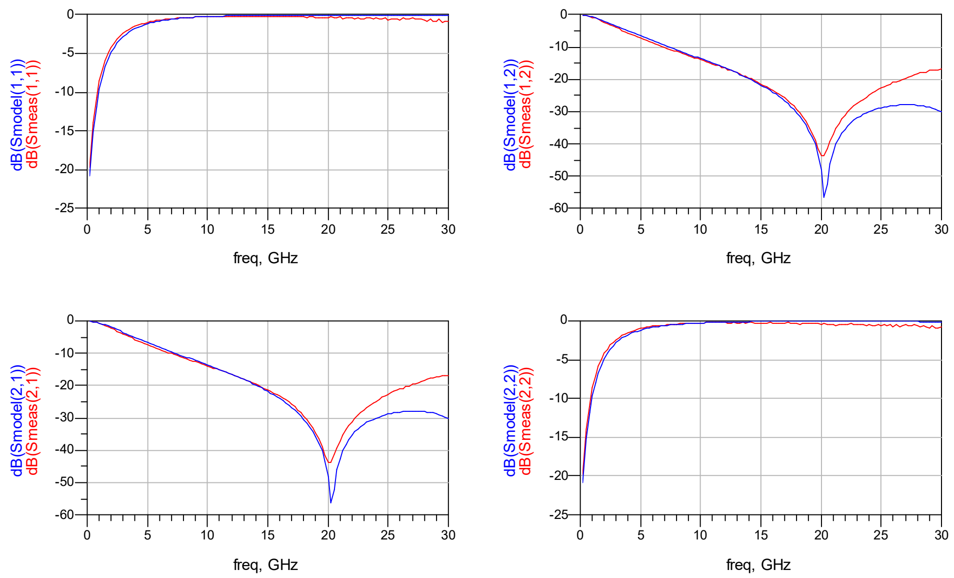


Input-output capacitor:
Cpar=0.007 pF

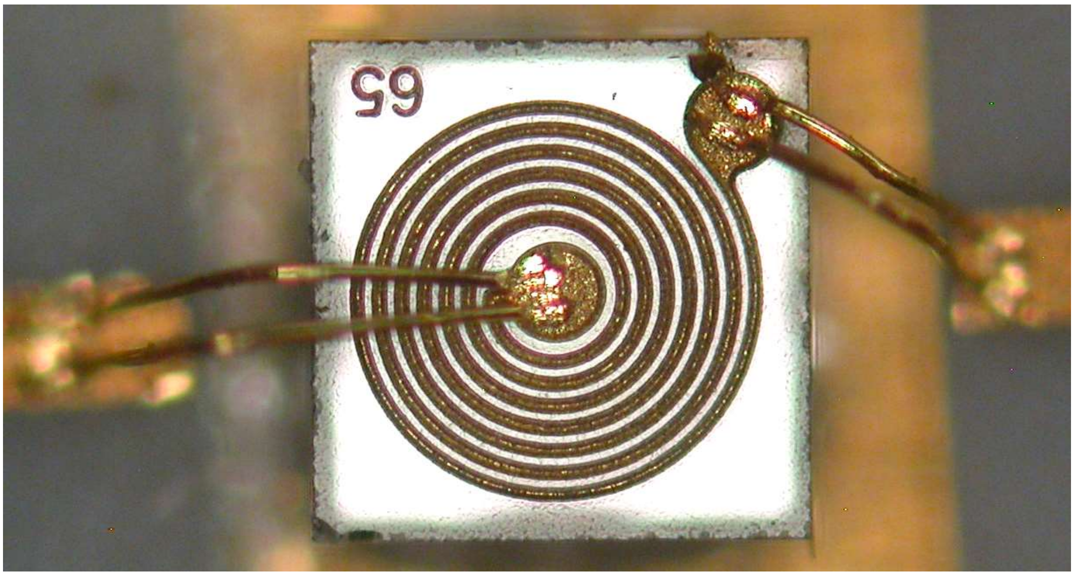
Capacitors to GND:
Cgnd=0.096 pF

Bond wires:
Lbond=0.17 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_6p9_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)

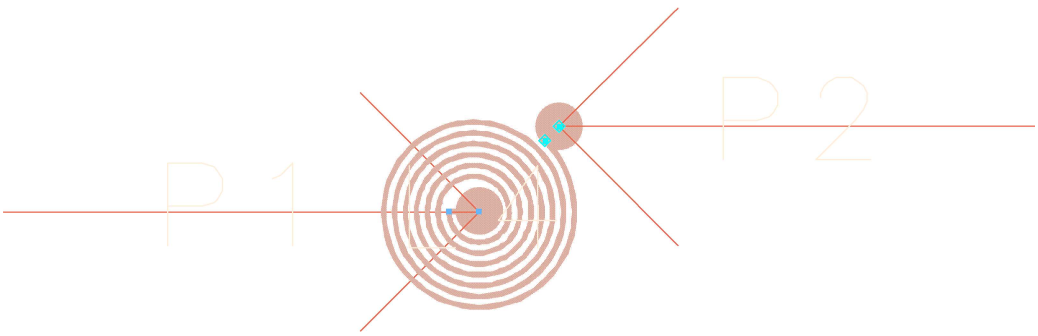

dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

10. Piconics quartz inductor 12 nH 6.5 turns 20x20x10 mil chip



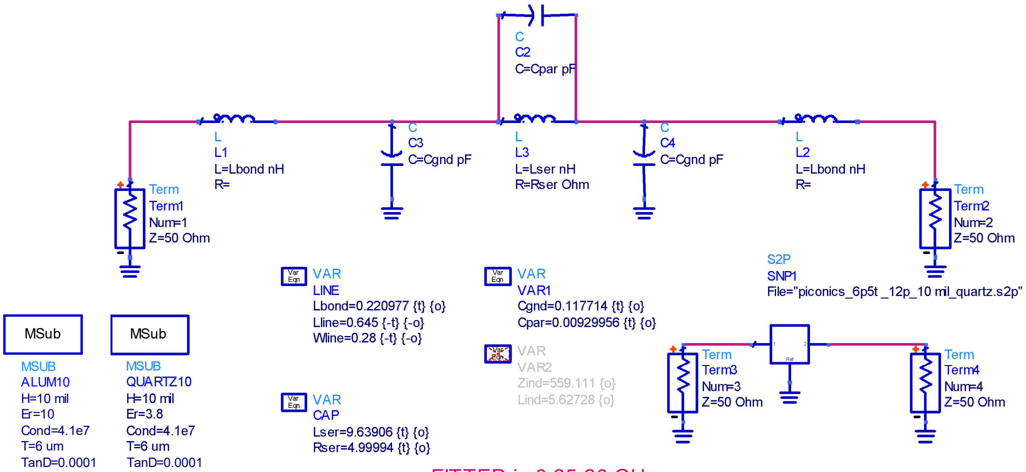
PICONICS model SP6P5-20-QBW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.12 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.450 mm; sep: ~40-60 um; height over chip: ~70 um
Bond wire 2: dia: 17 um; horizontal distance: 0.280 mm; sep: ~35 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate



SIMPLE L-C MODEL

Good up to ≈20 GHz



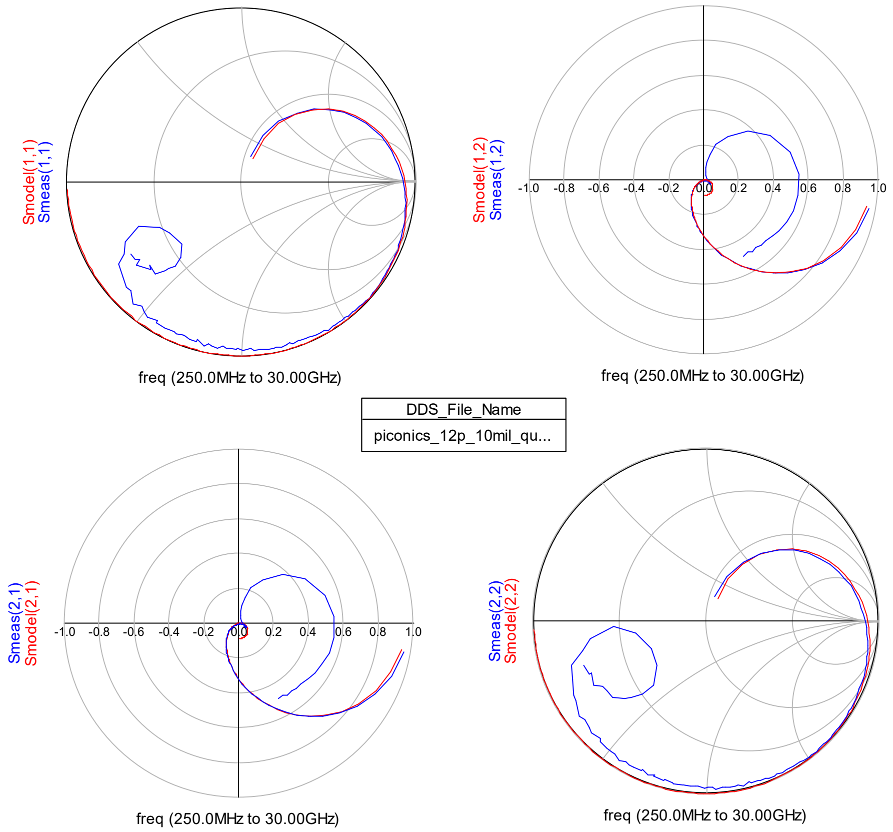
FITTED in 0.25-20 GHz
PLOTTED in 0.25-30 GHz

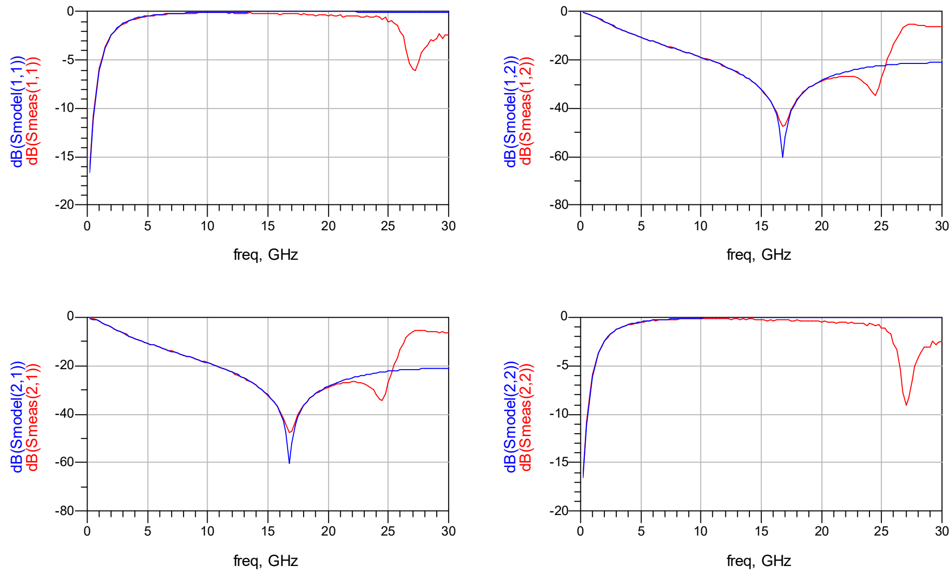
Inductor:
Lser=9.6 nH
Rser=5.0 Ohm

Input-output capacitor:
Cpar=0.009 pF

Capacitors to GND:
Cgnd=0.117 pF

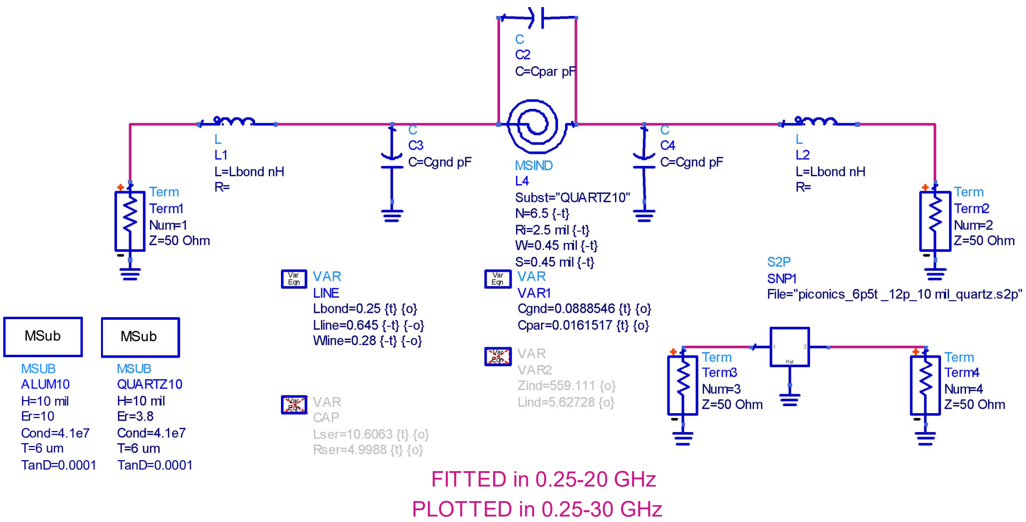
Bond wires:
Lbond=0.22 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

ADS INTERNAL MODEL

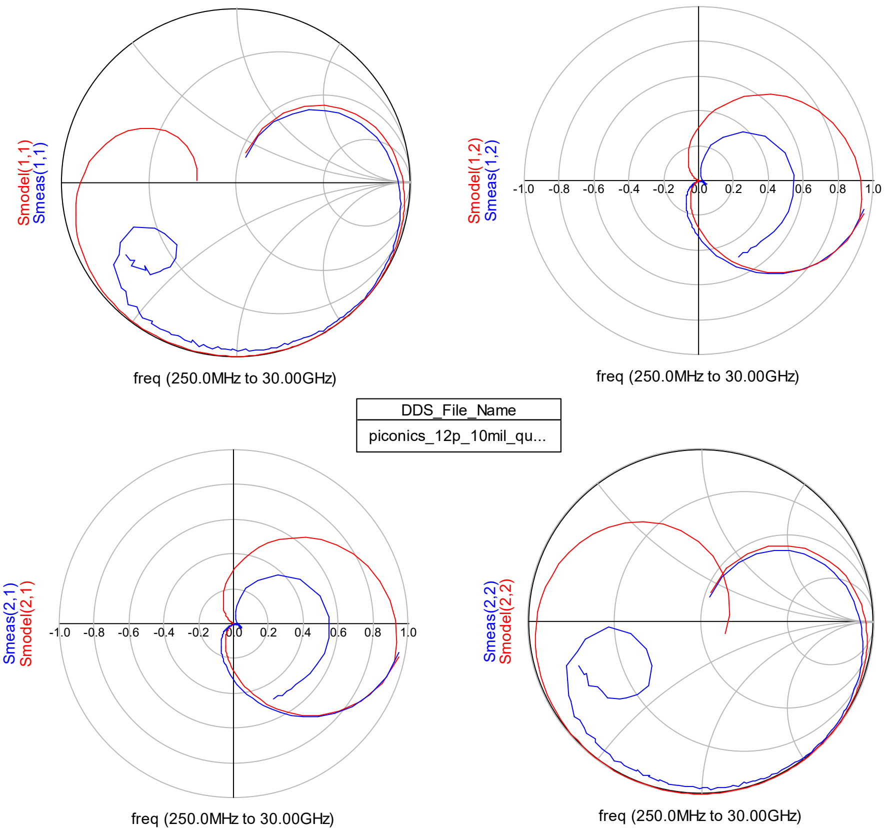
Good up to ≈20 GHz
Capacitors from input to output and to GND are needed to model S parameters adequately.

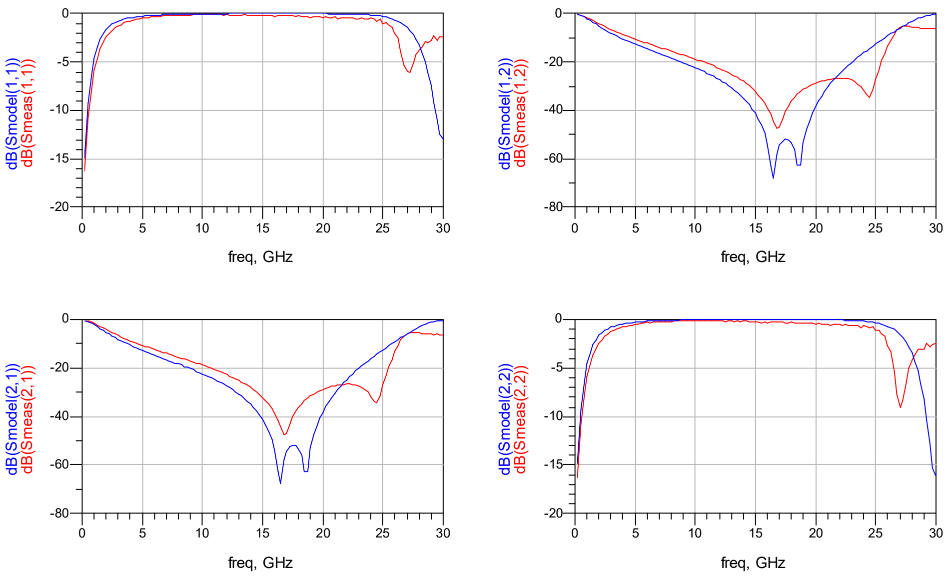


Input-output capacitor:
Cpar=0.016 pF

Capacitors to GND:
Cgnd=0.088 pF

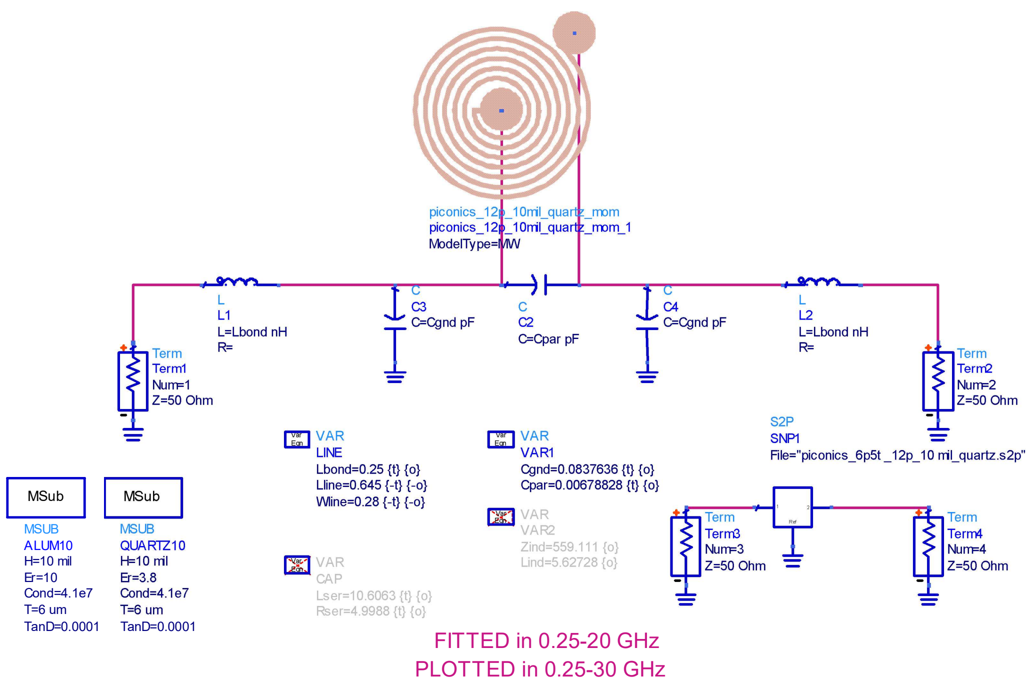
Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

MOMENTUM MODEL

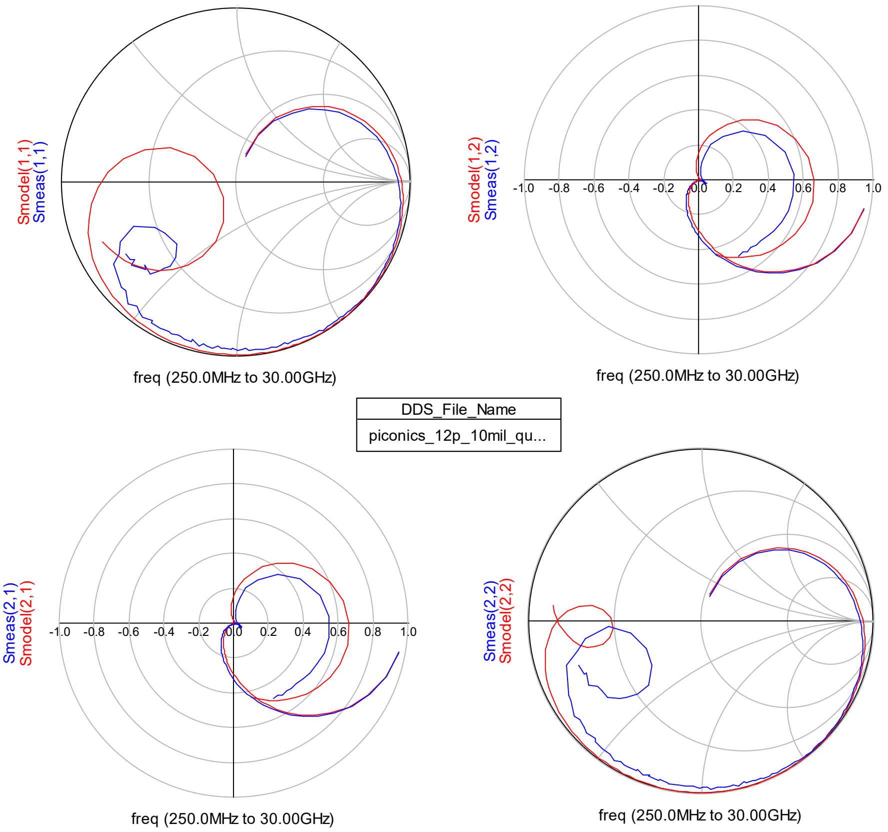
Good up to ≈20 GHz
Capacitors from input to output and to GND are needed to model S parameters adequately.

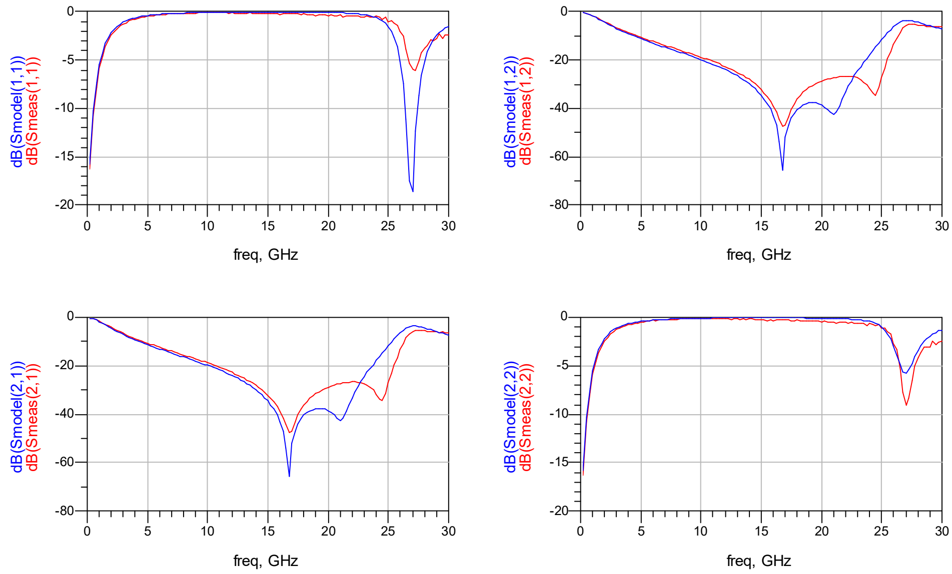


Input-output capacitor:
Cpar=0.007 pF

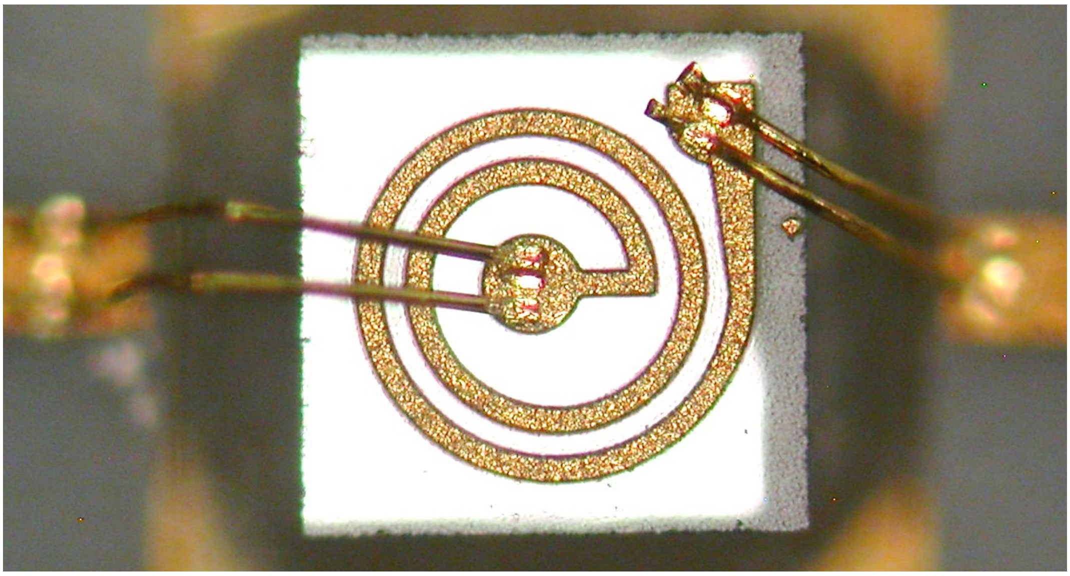
Capacitors to GND:
Cgnd=0.084 pF

Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_10mil_qu...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)

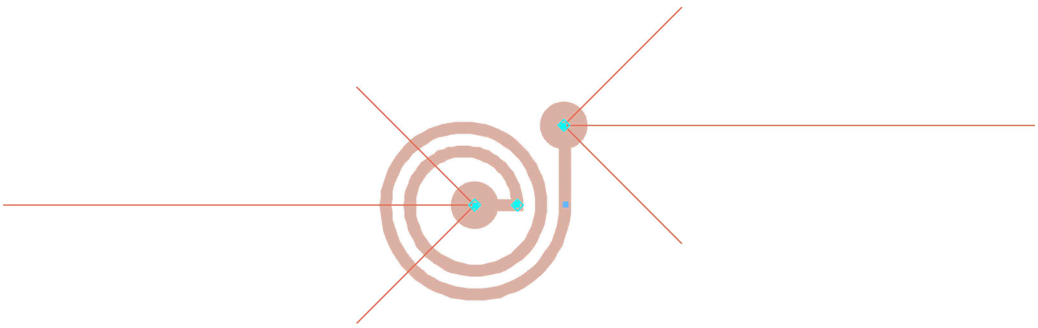

dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

11. Piconics quartz inductor 2.1 nH 2.0 turns[2] 20x20x10 mil chip



PICONICS model SP4P5-20-QBW

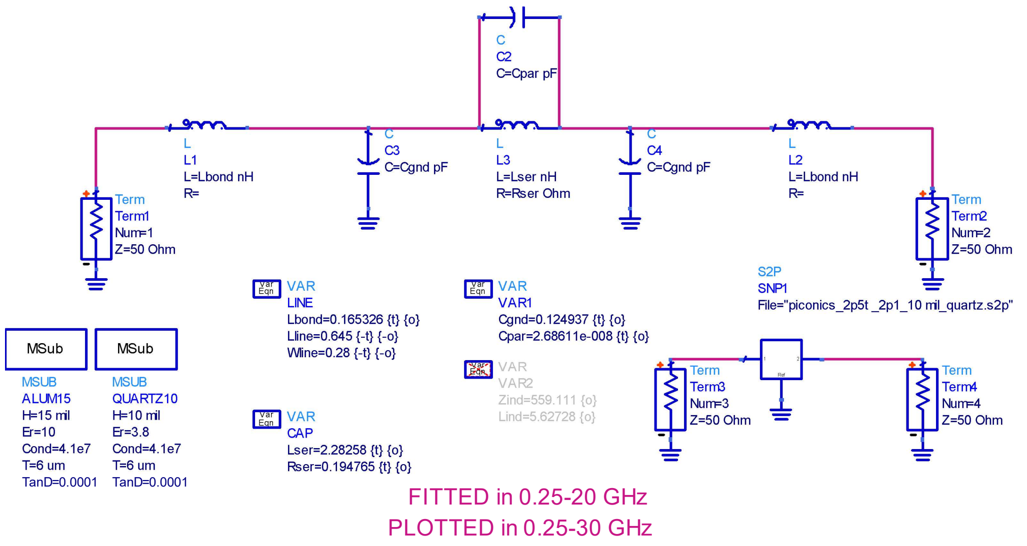
Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.420 mm; sep: ~50-70 um; height over chip: ~60 um
Bond wire 2: dia: 17 um; horizontal distance: 0.280 mm; sep: ~35 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate



[2] Datasheet claims 2.5 turns

SIMPLE L-C MODEL

Good up to ≈20 GHz
Relatively good prediction

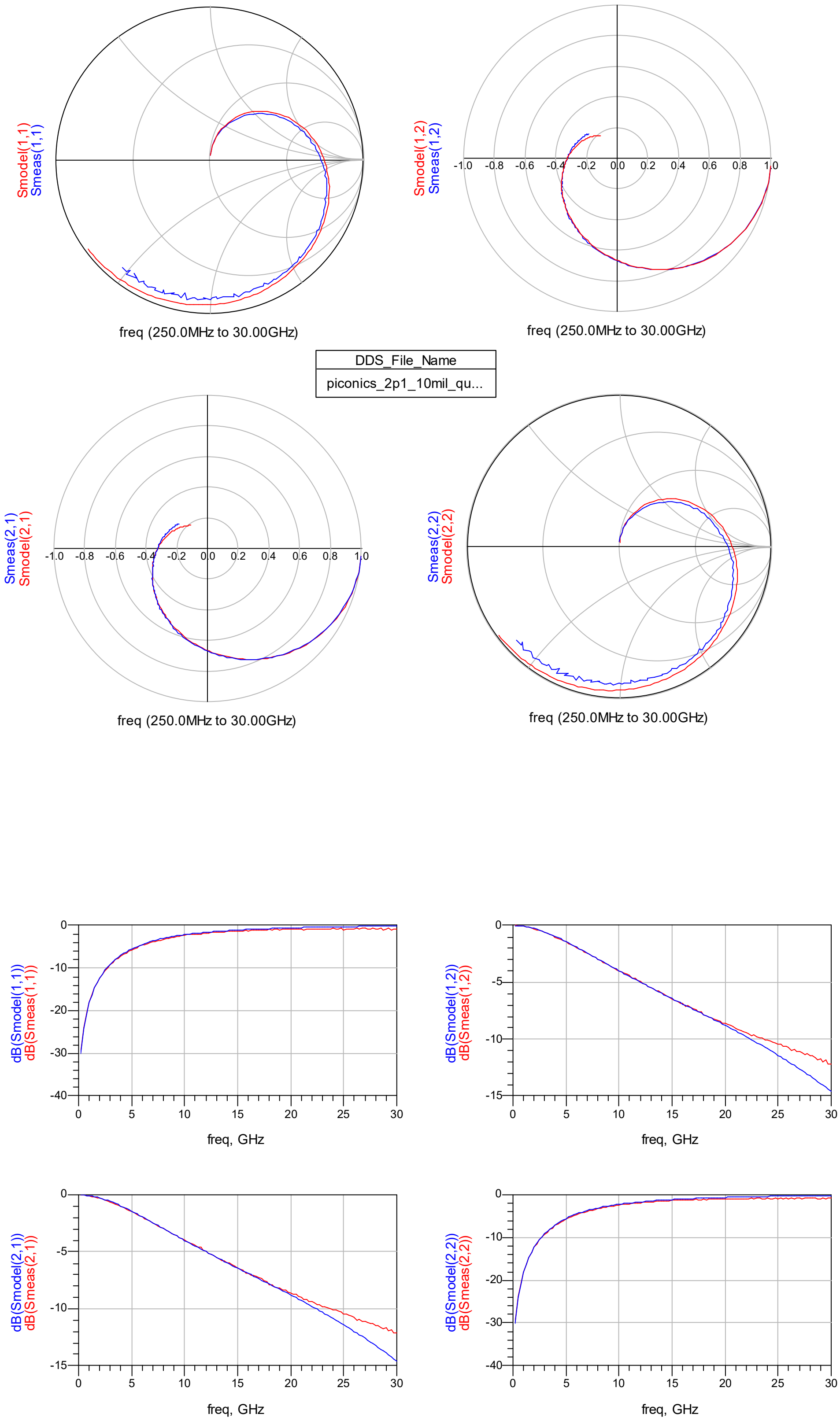


Inductor:
Lser=2.3 nH
Rser=0.2 Ohm

Input-output capacitor:
Cpar=0 pF

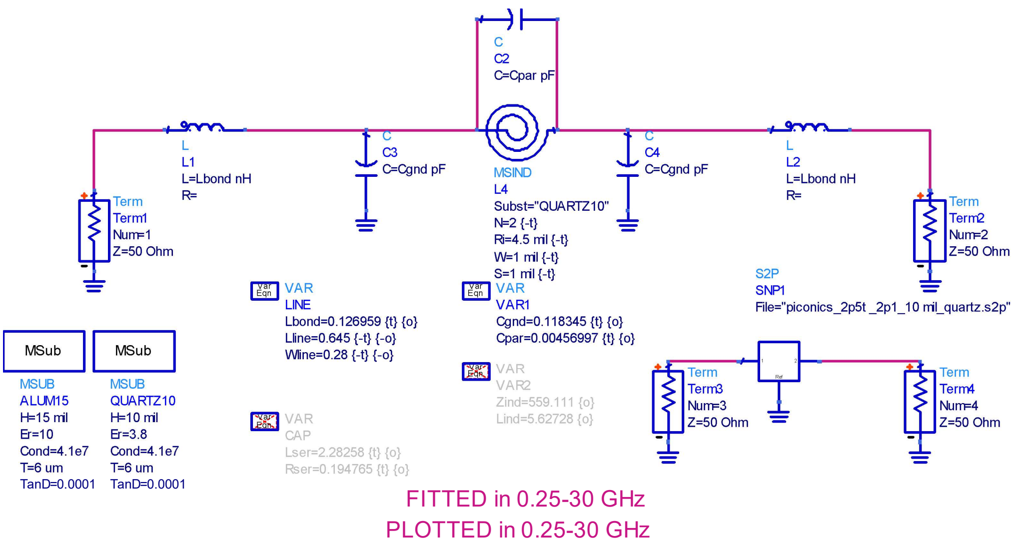
Capacitors to GND:
Cgnd=0.125 pF

Bond wires:
Lbond=0.17 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_2p1_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)
dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

ADS INTERNAL MODEL

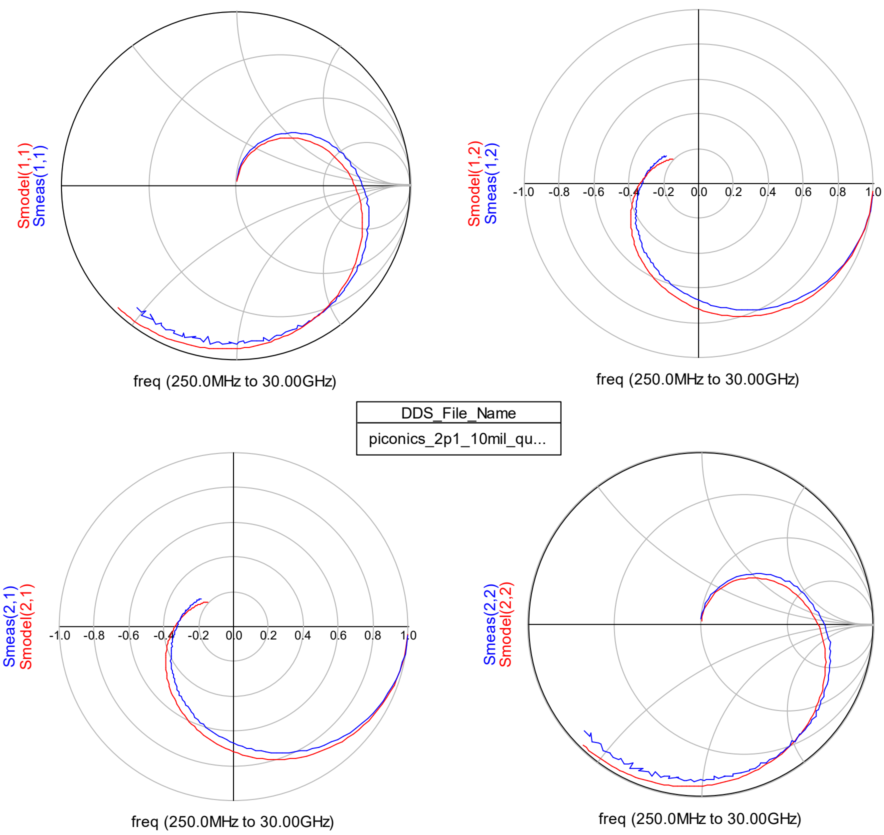
Good up to ≈30 GHz
Capacitors from input to output and to GND are needed to model S parameters adequately.

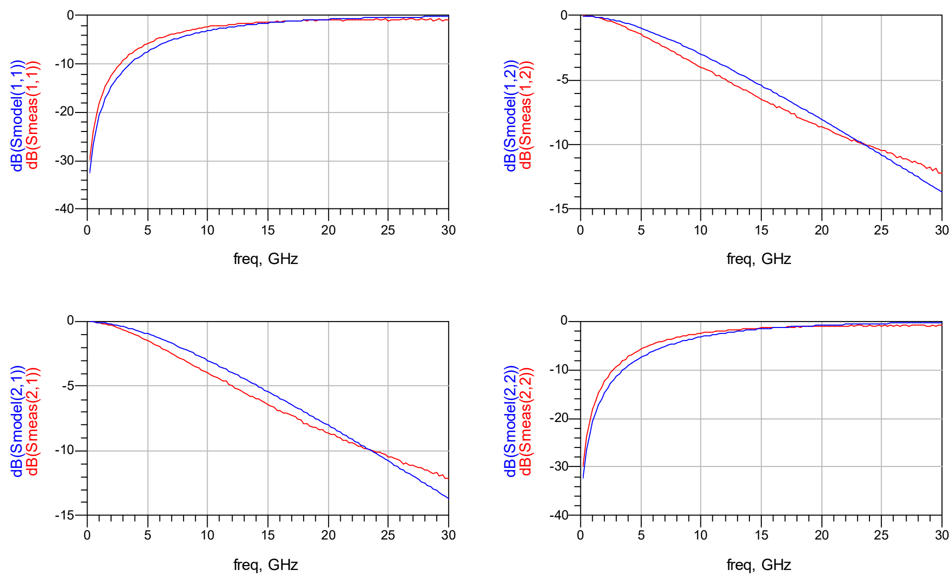


Input-output capacitor:
Cpar=0.005 pF

Capacitors to GND:
Cgnd=0.118 pF

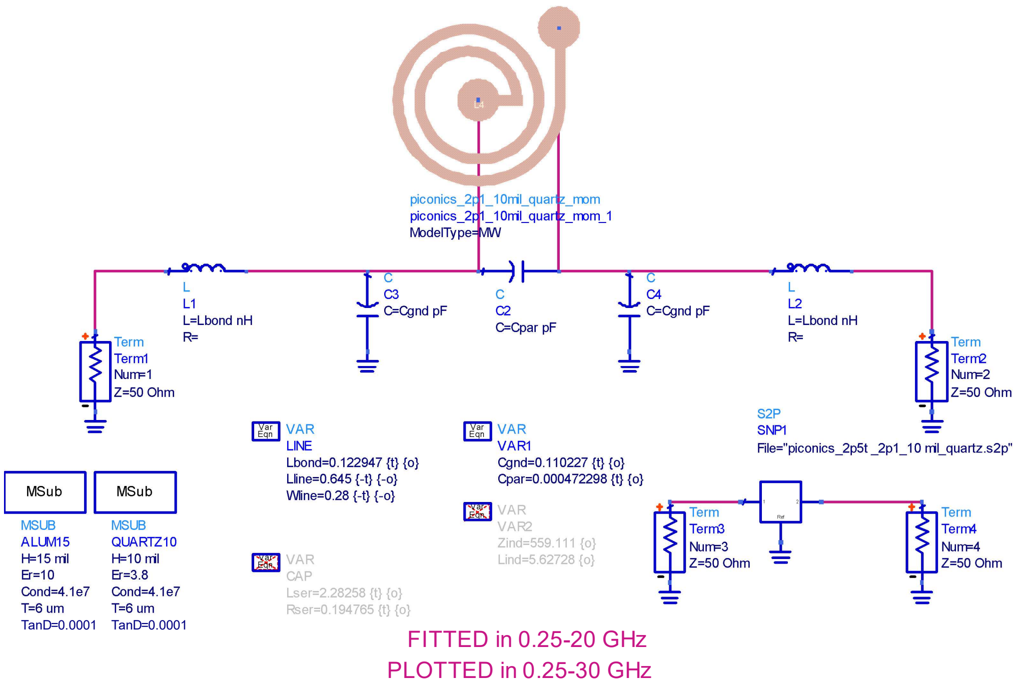
Bond wires:
Lbond=0.127 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_2p1_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

MOMENTUM MODEL

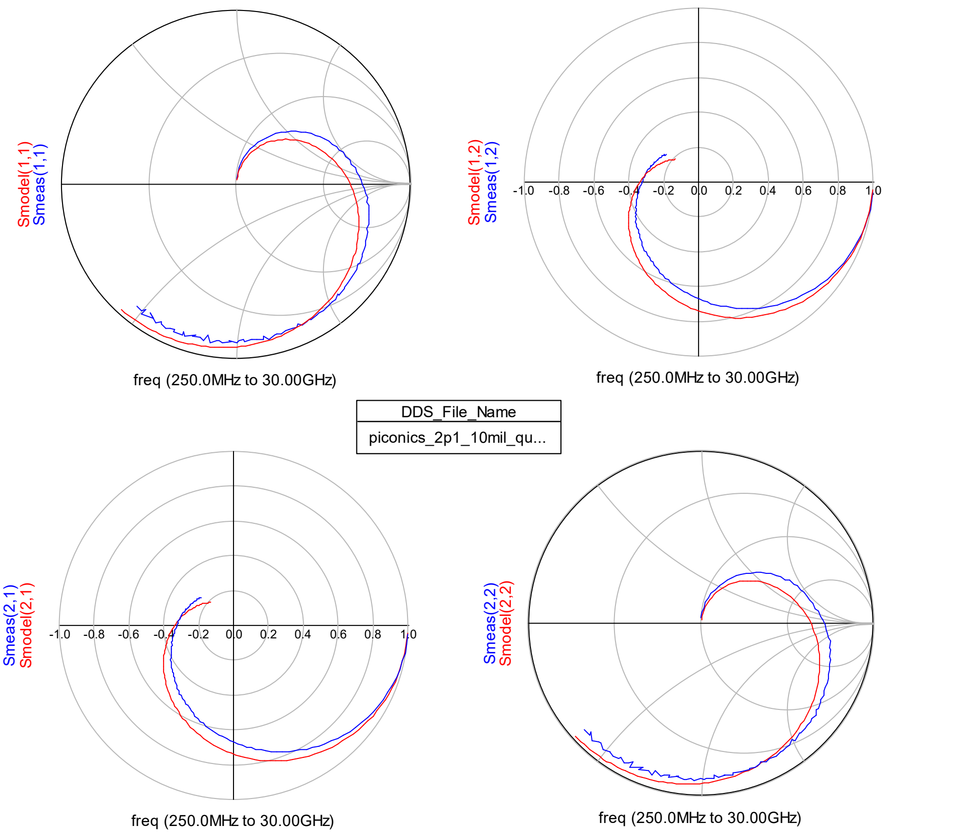
Good up to ≈20 GHz
Capacitors from input to output and to GND are needed to model S parameters adequately.

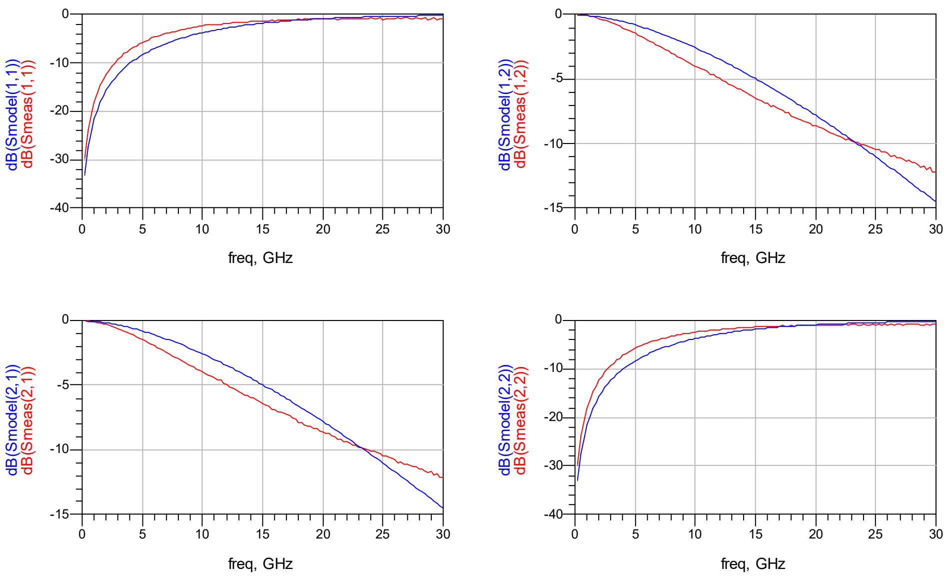


Input-output capacitor:
Cpar=0.0004 pF

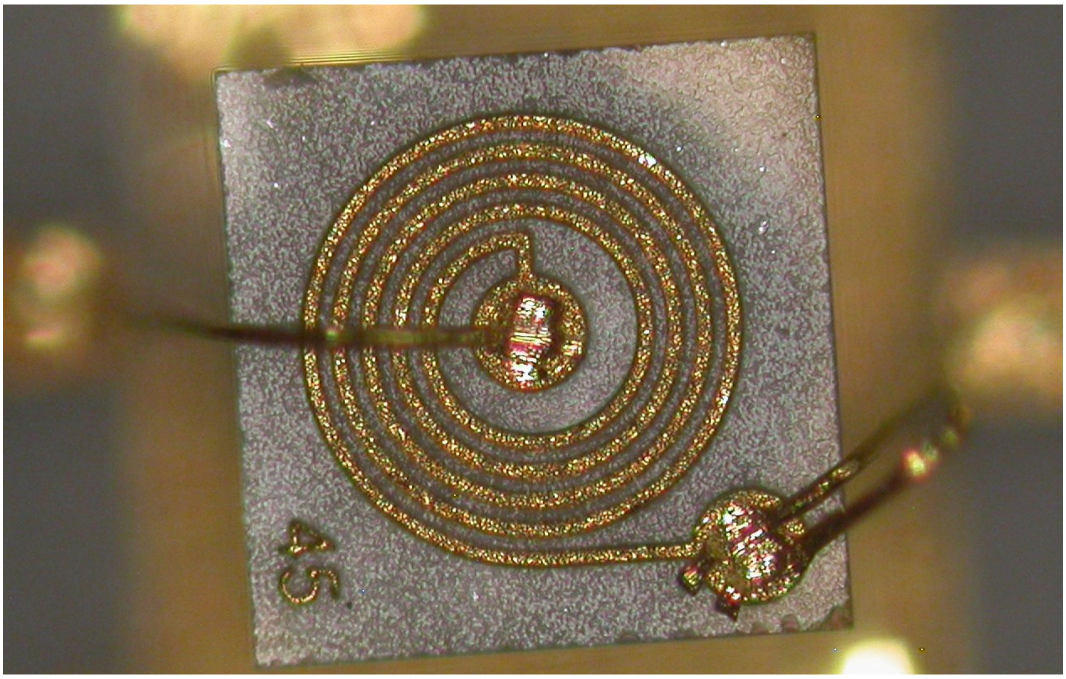
Capacitors to GND:
Cgnd=0.110 pF

Bond wires:
Lbond=0.123 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_2p1_10mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

12. Piconics quartz inductor 6.9 nH 4.5 turns 20x20x15 mil chip

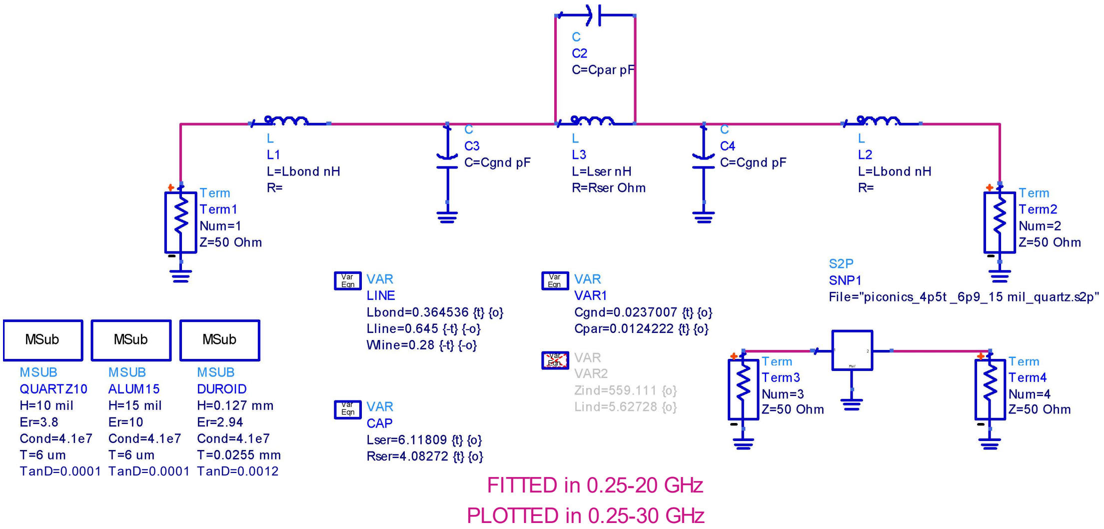


PICONICS model SP4P5-20-QCW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.381 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.370 mm;
sep: - ; height over chip: ~70 um
Bond wire 2: dia: 17 um; horizontal distance: 0.260 mm;
sep: ~30 um; height over chip: ~10/80 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈30 GHz
Relatively good prediction

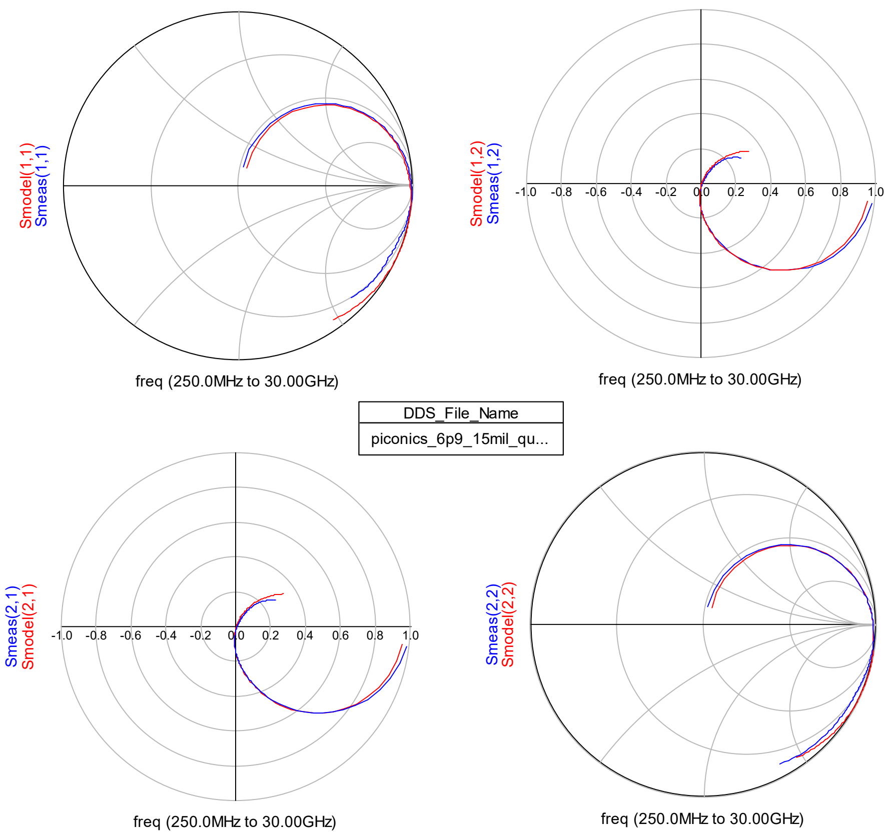


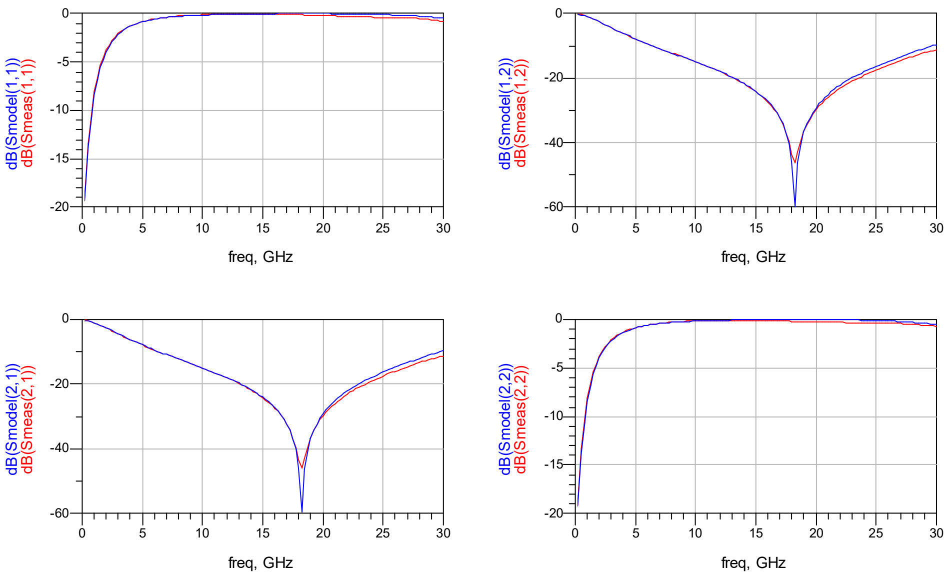
Inductor:
Lser=6.2 nH
Rser=4.1 Ohm

Input-output capacitor:
Cpar=0.012 pF

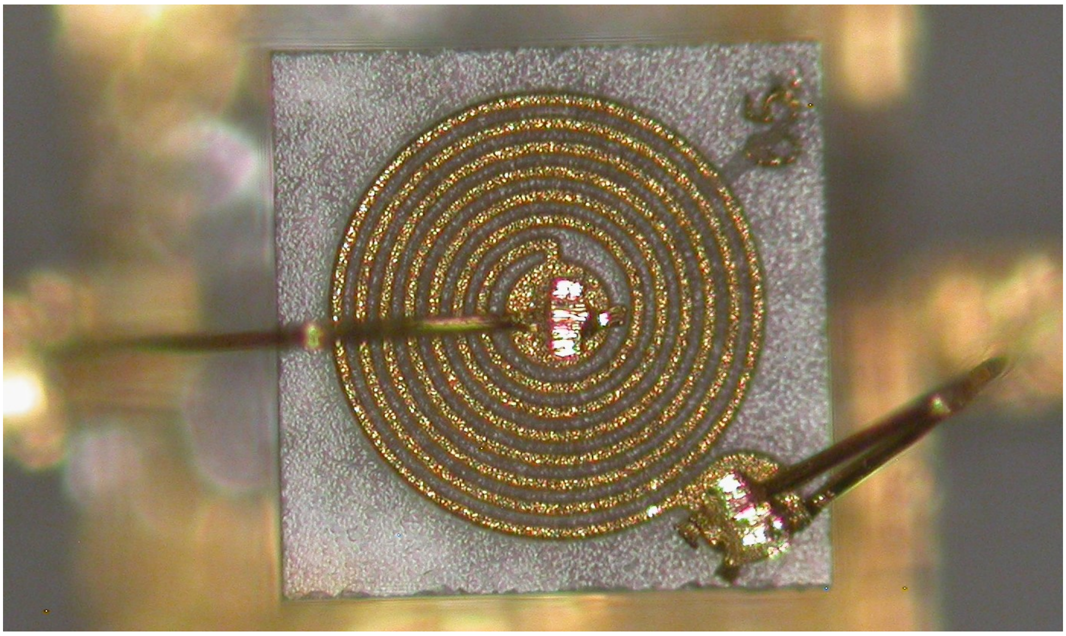
Capacitors to GND:
Cgnd=0.023 pF

Bond wires:
Lbond=0.36 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_6p9_15mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

13. Piconics quartz inductor 12 nH 6.5 turns 20x20x15 mil chip

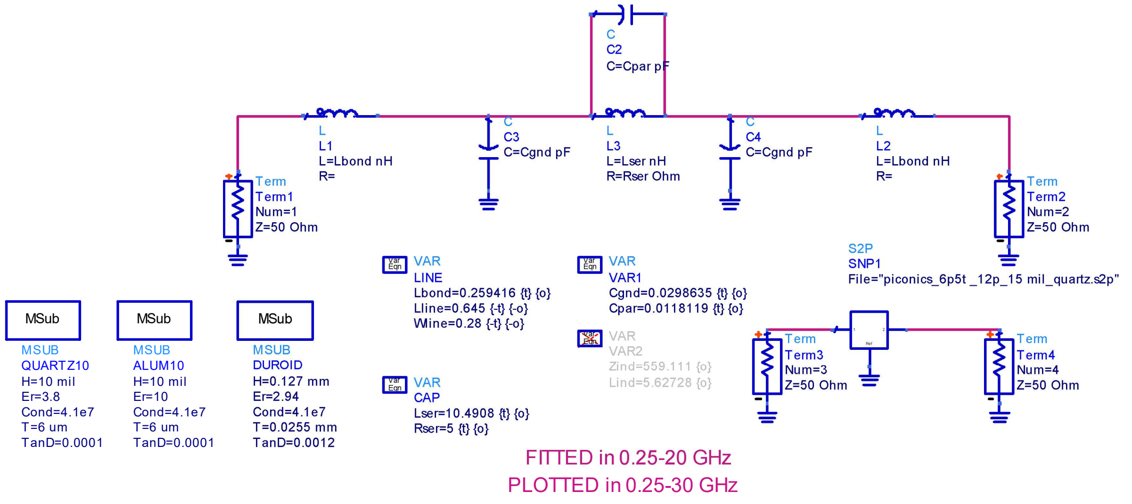


PICONICS model SP6P5-20-QCW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.12 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.381 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.480 mm;
sep: - ; height over chip: ~80 um
Bond wire 2: dia: 17 um; horizontal distance: 0.320 mm;
sep: ~20 um; height over chip: ~50/90 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈20 GHz

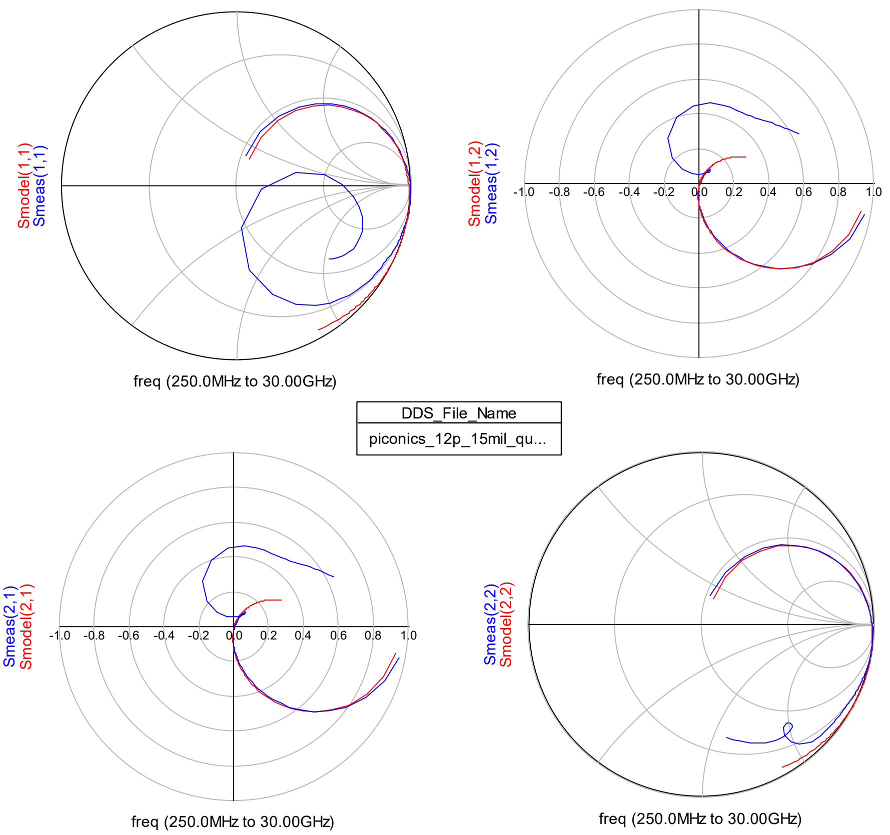


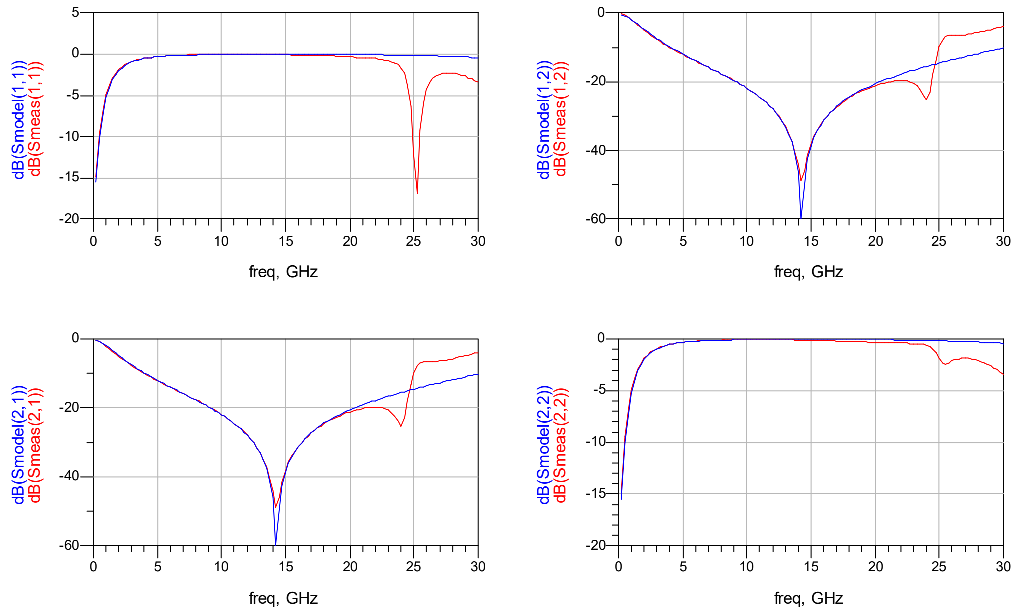
Inductor:
Lser=10.5 nH
Rser=5.0 Ohm

Input-output capacitor:
Cpar=0.012 pF

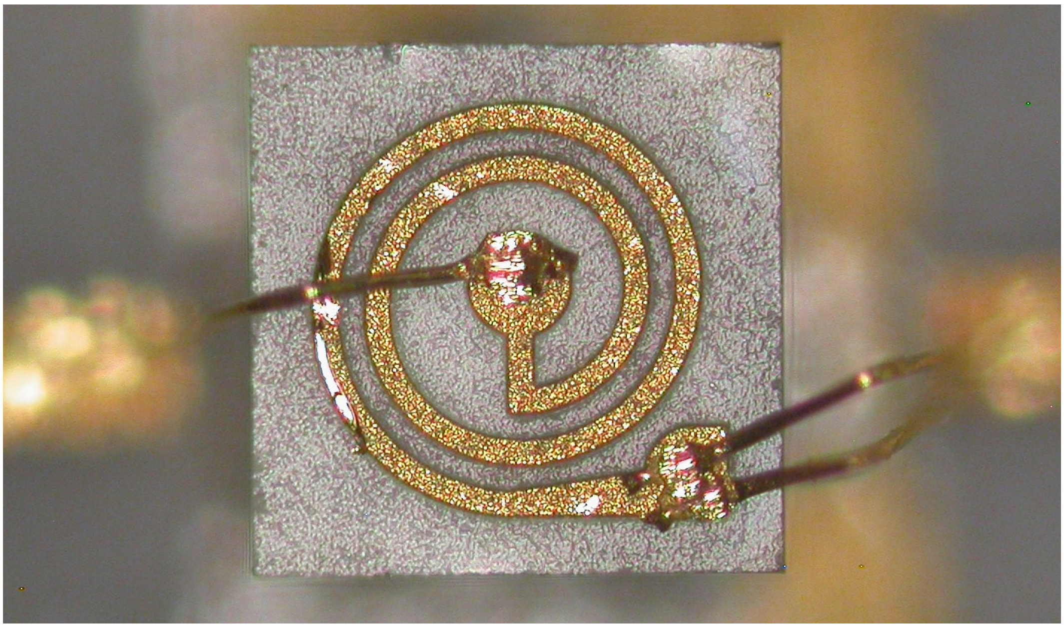
Capacitors to GND:
Cgnd=0.030 pF

Bond wires:
Lbond=0.26 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 30.00GHz)
DDS_File_Name
piconics_12p_15mil_qu...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

14. Piconics quartz inductor 2.1 nH 2.0 turns[3] 20x20x15 mil chip



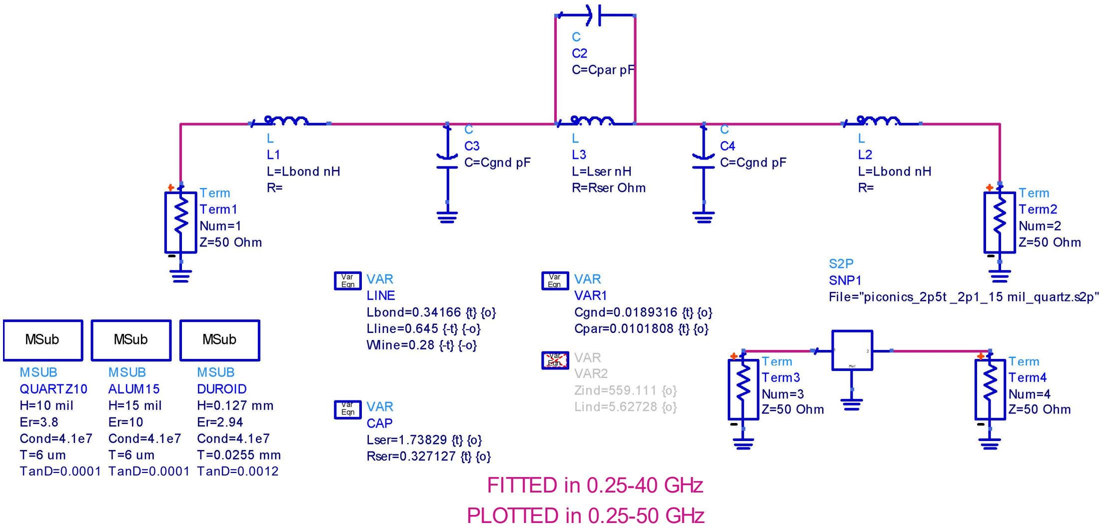
PICONICS model SP4P5-20-QCW

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.508 mm; L= 0.508 mm; h=0.381 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.350 mm;
sep: - ; height over chip: ~40 um
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm;
sep: ~30-50 um; height over chip: ~60 um
Reference planes at the end of Jmicro substrate

[3] Datasheet claims 2.5 turns

SIMPLE L-C MODEL

Good up to ≈35 GHz
Relatively good prediction

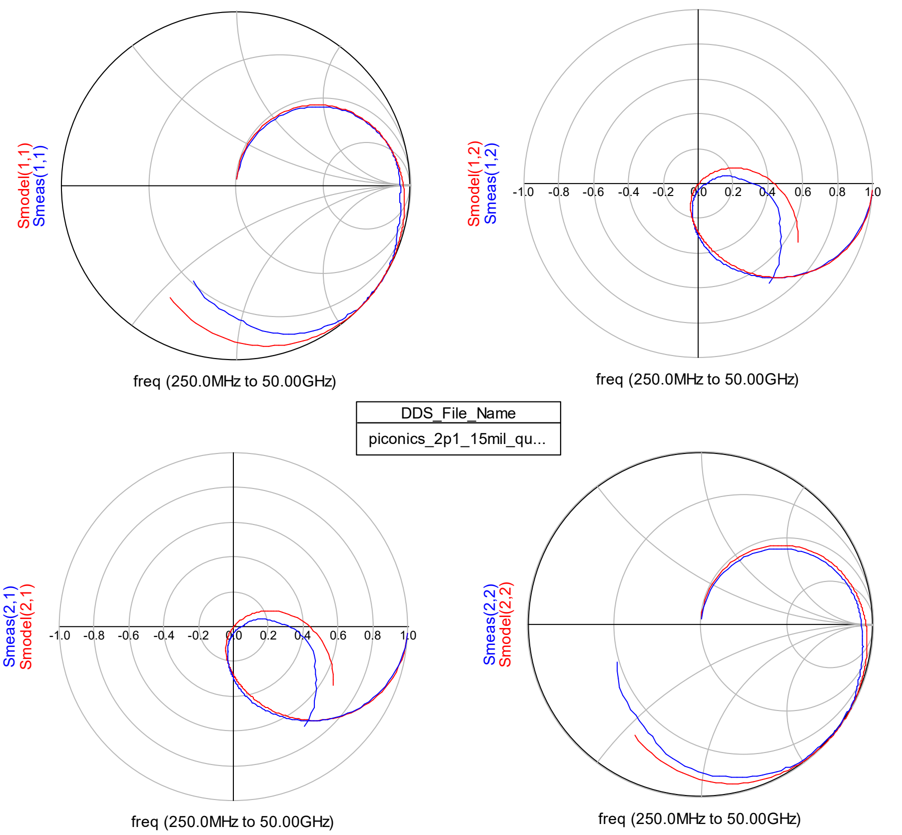


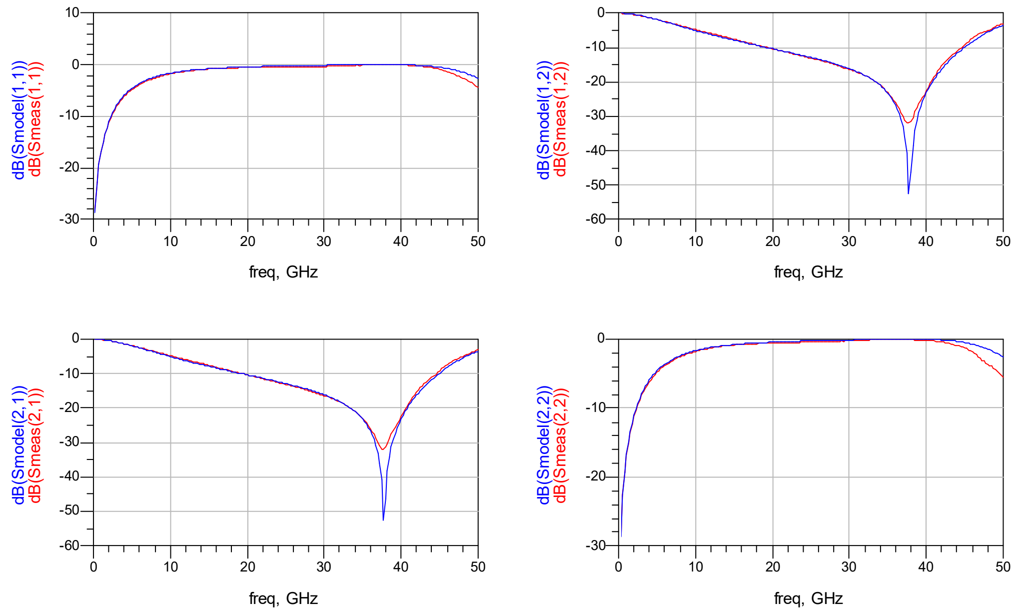
Inductor:
Lser=1.74 nH
Rser=0.3 Ohm

Input-output capacitor:
Cpar=0.010 pF

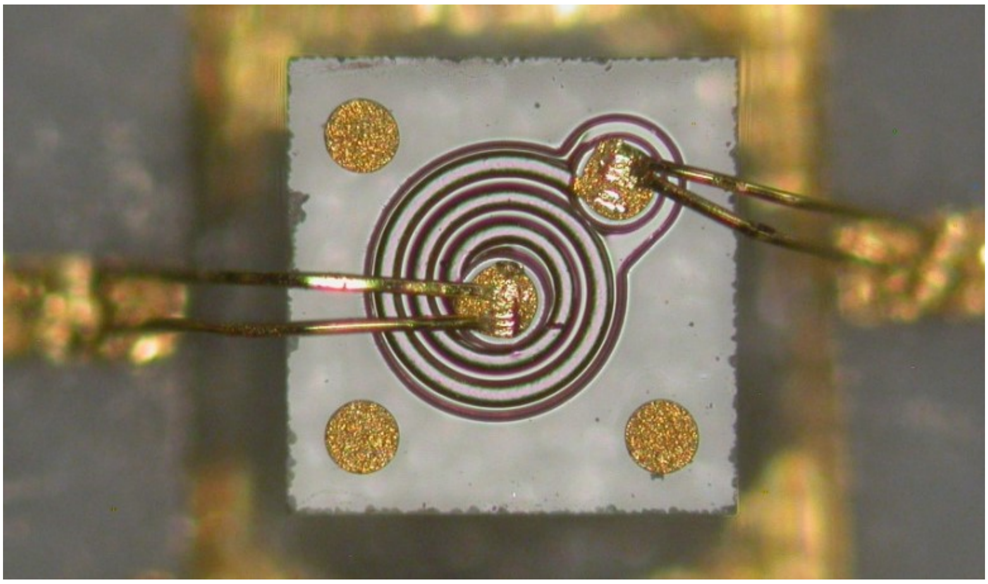
Capacitors to GND:
Cgnd=0.019 pF

Bond wires:
Lbond=0.34 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 50.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 50.00GHz)
DDS_File_Name
piconics_2p1_15mil_qu...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 50.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 50.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

15. ATP quartz inductor 2.2 nH 2.5 turns 22x22x10 mil chip

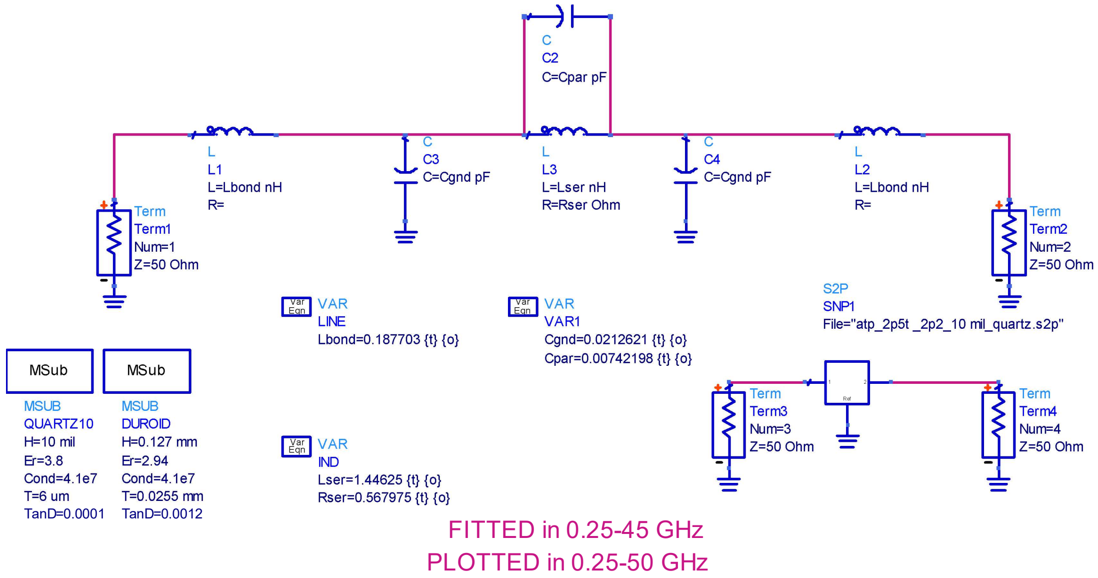


ATP-I-010-Q-022

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.11 mm
Inductor body: W=0.559 mm; L= 0.559 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.520 mm; sep: ~55 um; height over chip: ~30 um
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm; sep: ~50 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈40 GHz
Parallel resonance ≈ 46 GHz
Relatively good prediction

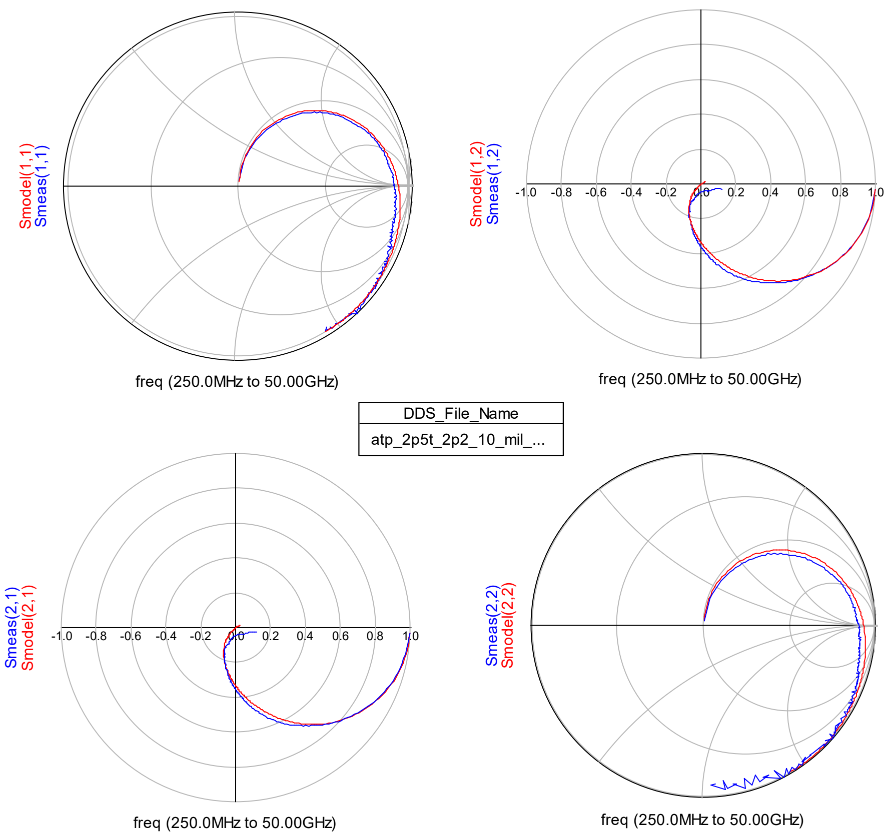


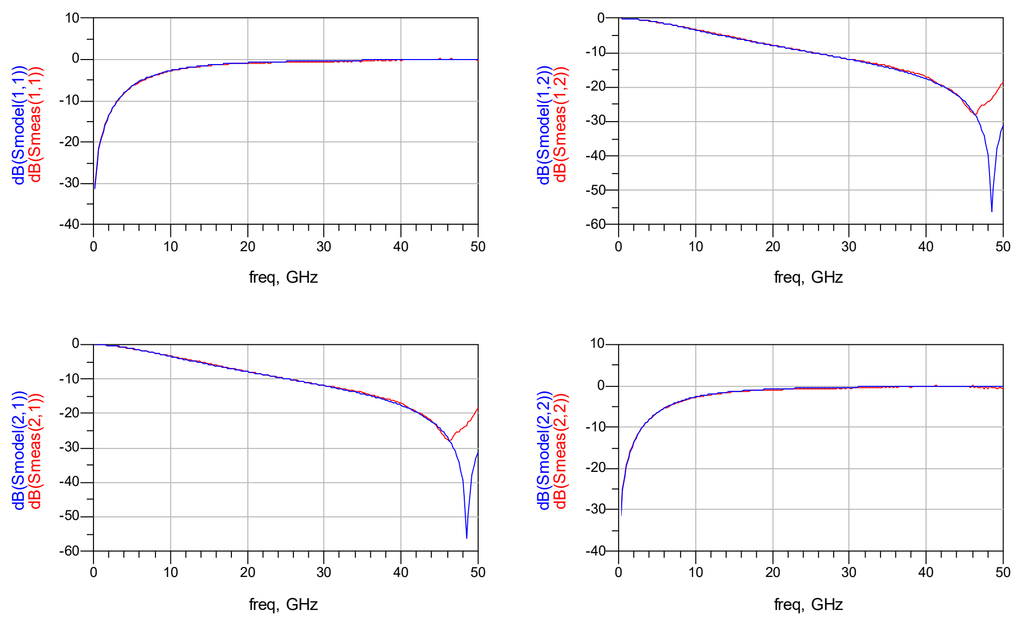
Inductor:
Lser=1.4 nH
Rser=0.6 Ohm

Input-output capacitor:
Cpar=0.007 pF

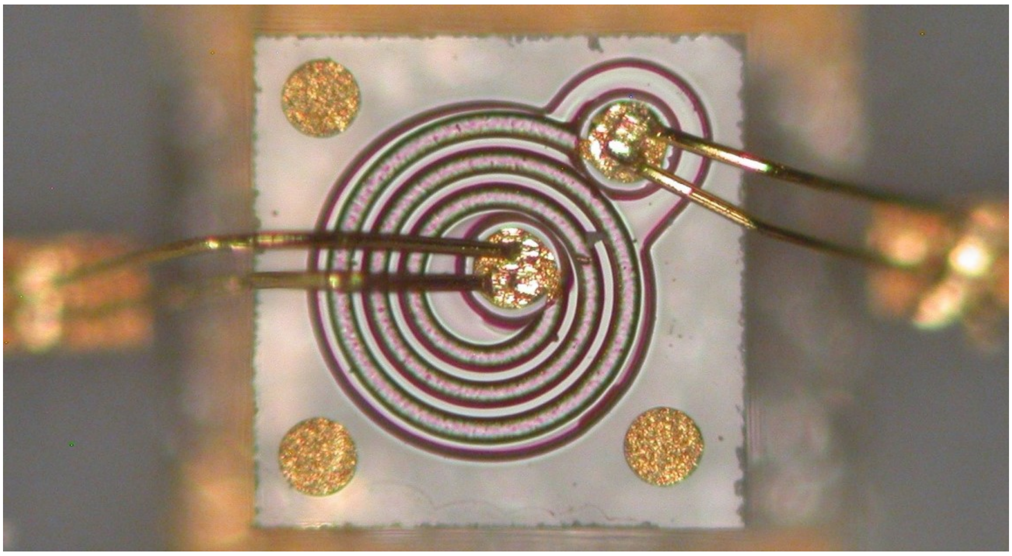
Capacitors to GND:
Cgnd=0.021 pF

Bond wires:
Lbond=0.19 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 50.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 50.00GHz)
DDS_File_Name
atp_2p5t_2p2_10_mil_...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 50.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 50.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

16. ATP quartz inductor 3.5 nH 3 turns 22x22x10 mil chip

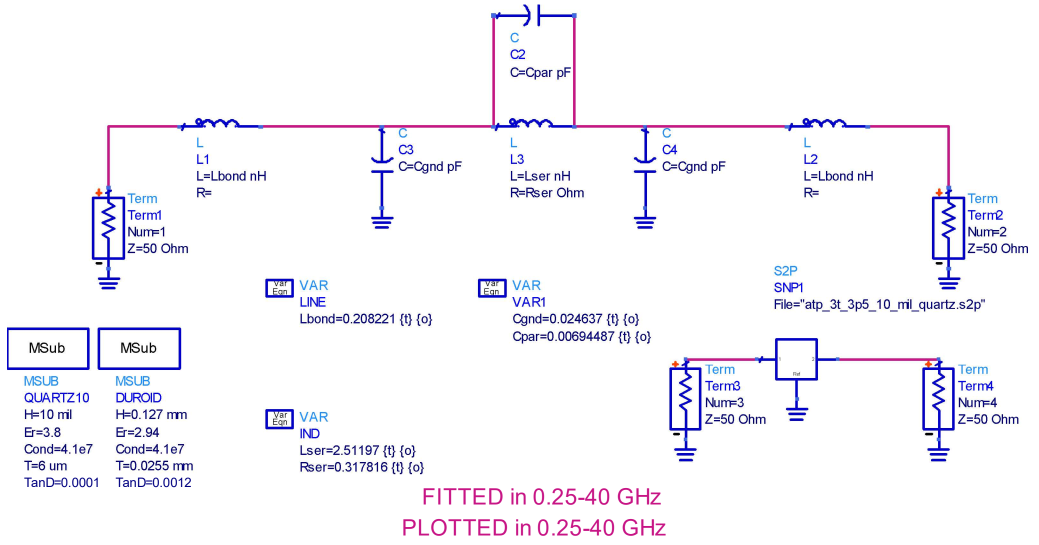


ATP-I-010-Q-350

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.11 mm
Inductor body: W=0.559 mm; L= 0.559 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.500 mm;
sep: ~40-50 um; height over chip: ~70 um
Bond wire 2: dia: 17 um; horizontal distance: 0.360 mm;
sep: ~40-60 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈30 GHz
Parallel resonance ≈ 45 GHz
Relatively good prediction

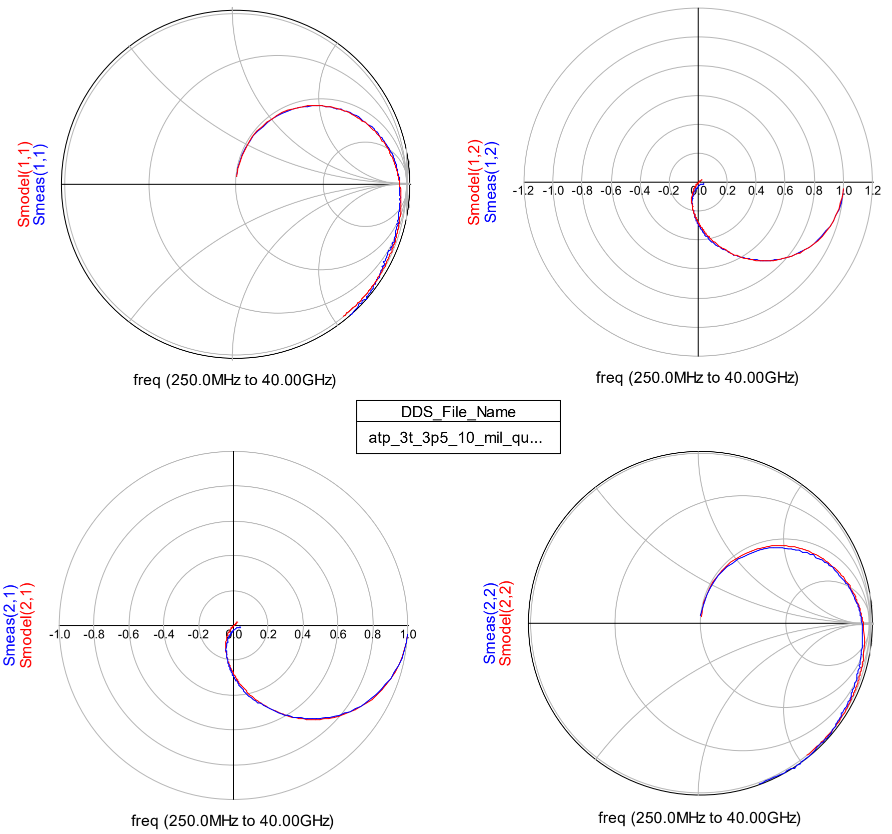


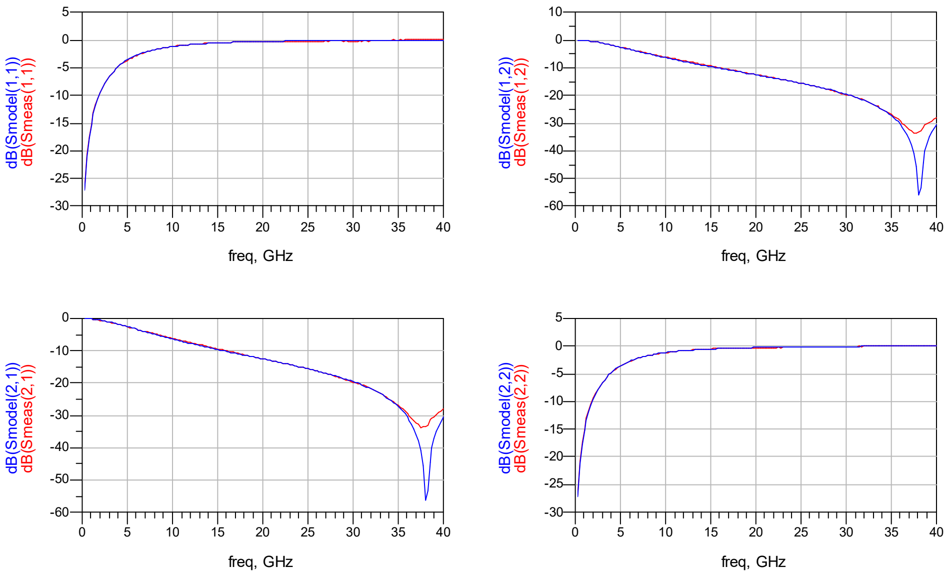
Inductor:
Lser=2.5 nH
Rser=0.3 Ohm

Input-output capacitor:
Cpar=0.007 pF

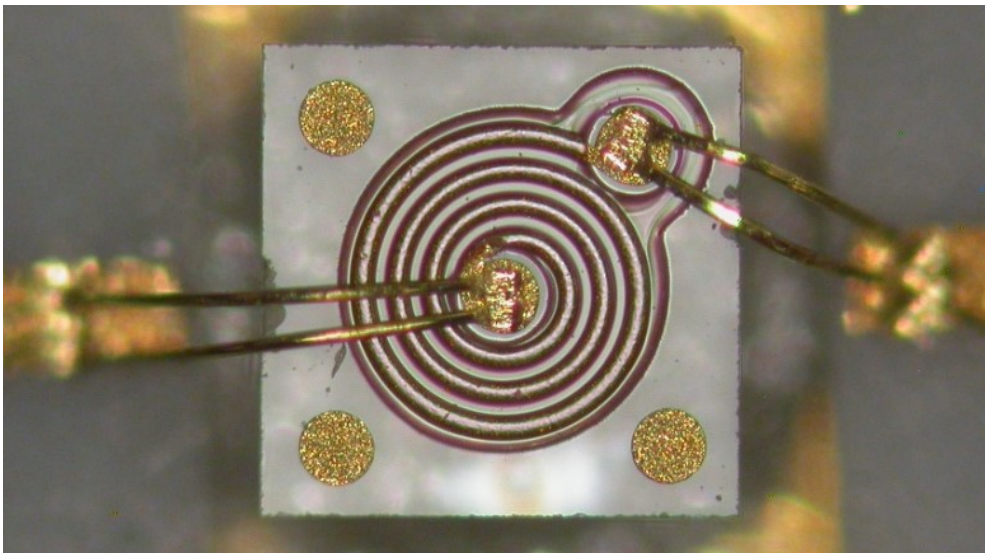
Capacitors to GND:
Cgnd=0.025 pF

Bond wires:
Lbond=0.20 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 40.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 40.00GHz)
DDS_File_Name
atp_3t_3p5_10_mil_qu...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 40.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 40.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

17. ATP quartz inductor 3.9 nH 3.5 turns 22x22x10 mil chip

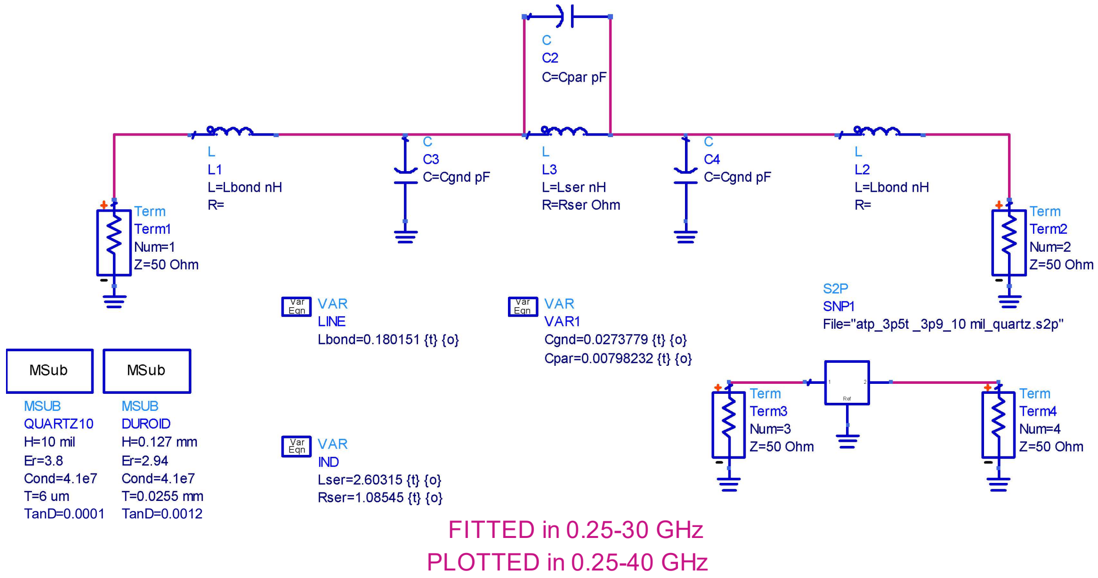


ATP-I-010-Q-390

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.11 mm
Inductor body: W=0.559 mm; L= 0.559 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.500 mm;
sep: ~50 um; height over chip: ~30 um
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm;
sep: ~70 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈25 GHz
Parallel resonance ≈ 35 GHz
Relatively good prediction

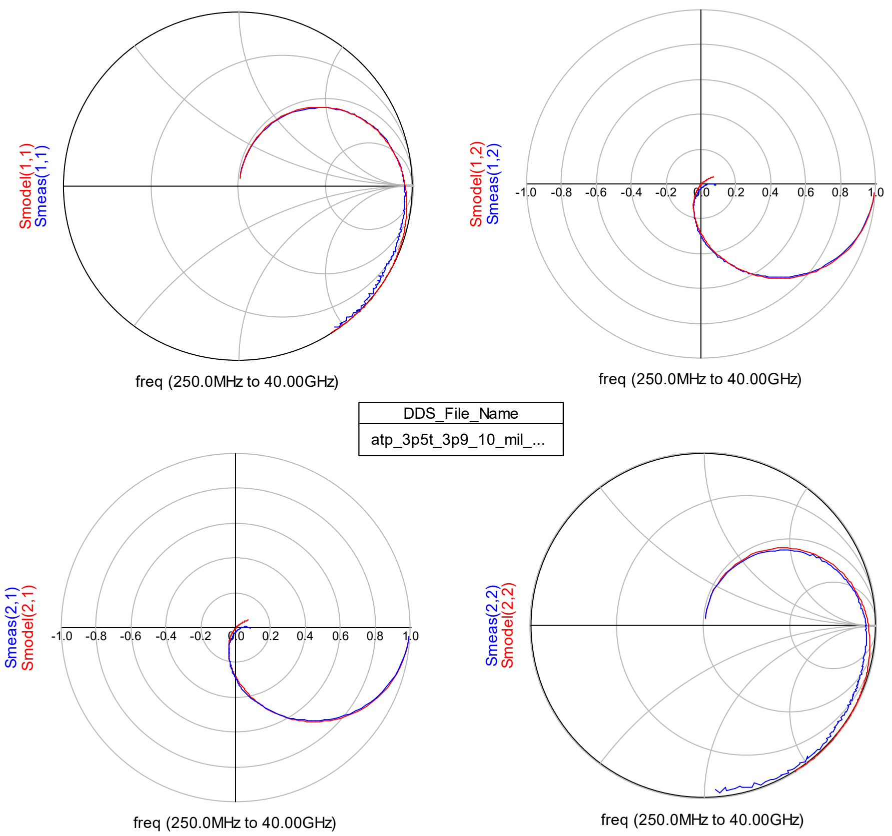


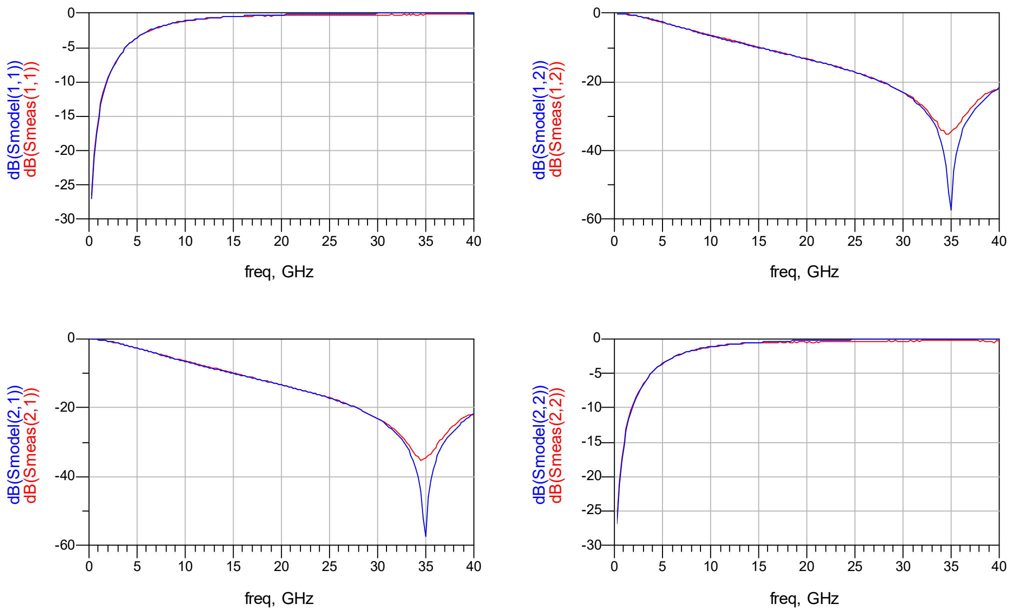
Inductor:
Lser=2.6 nH
Rser=1 Ohm

Input-output capacitor:
Cpar=0.008 pF

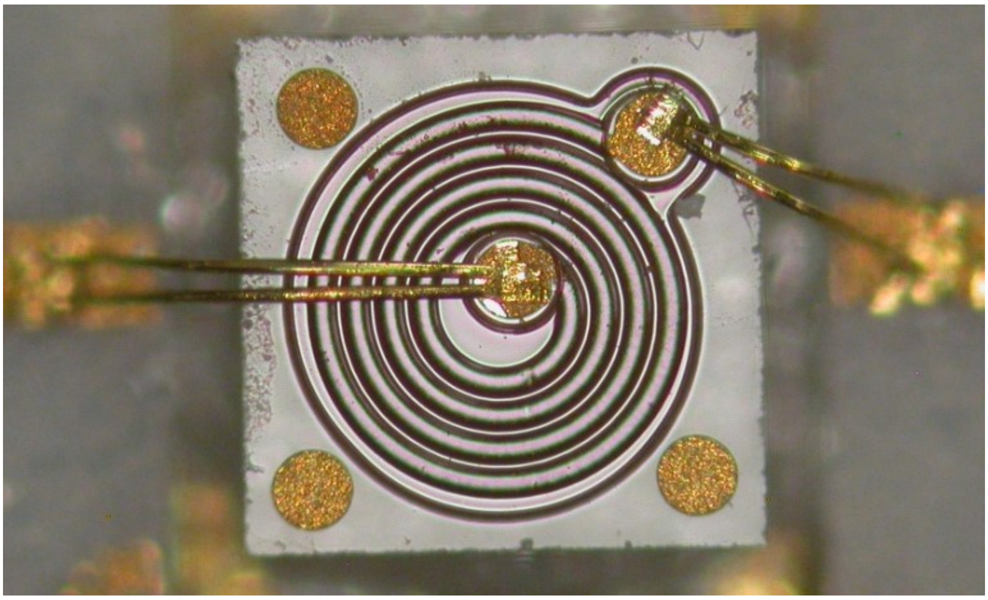
Capacitors to GND:
Cgnd=0.027 pF

Bond wires:
Lbond=0.18 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 40.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 40.00GHz)
DDS_File_Name
atp_3p5t_3p9_10_mil_...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 40.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 40.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

18. ATP quartz inductor 7.3 nH 4 turns 25x25x10 mil chip

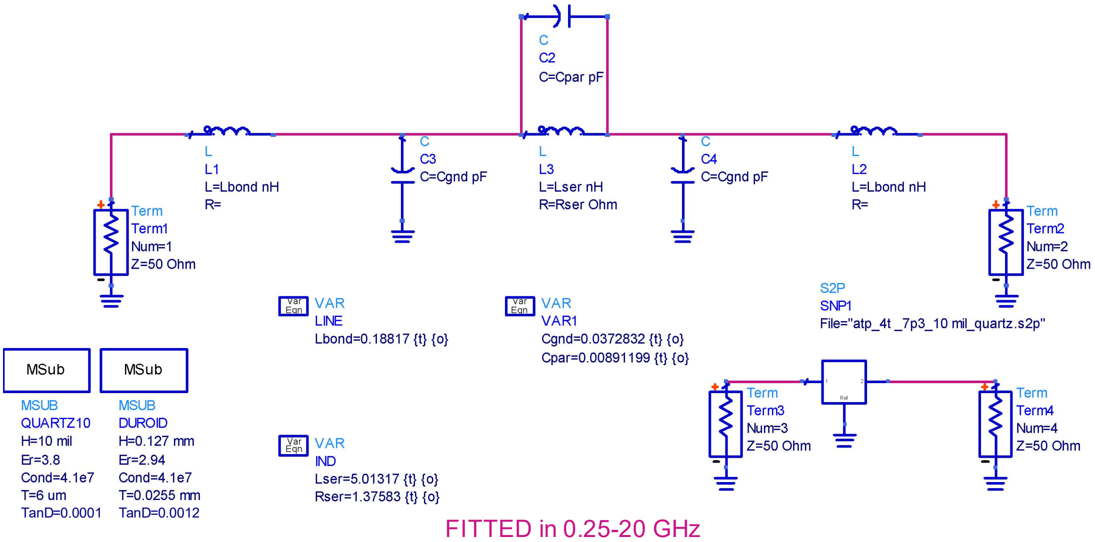


ATP-I-010-Q-730

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.11 mm
Inductor body: W=0.635 mm; L= 0.635 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.540 mm;
sep: ~40 um; height over chip: ~30 um
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm;
sep: ~60 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈20 GHz
Parallel resonance ≈ 25 GHz
Relatively good prediction



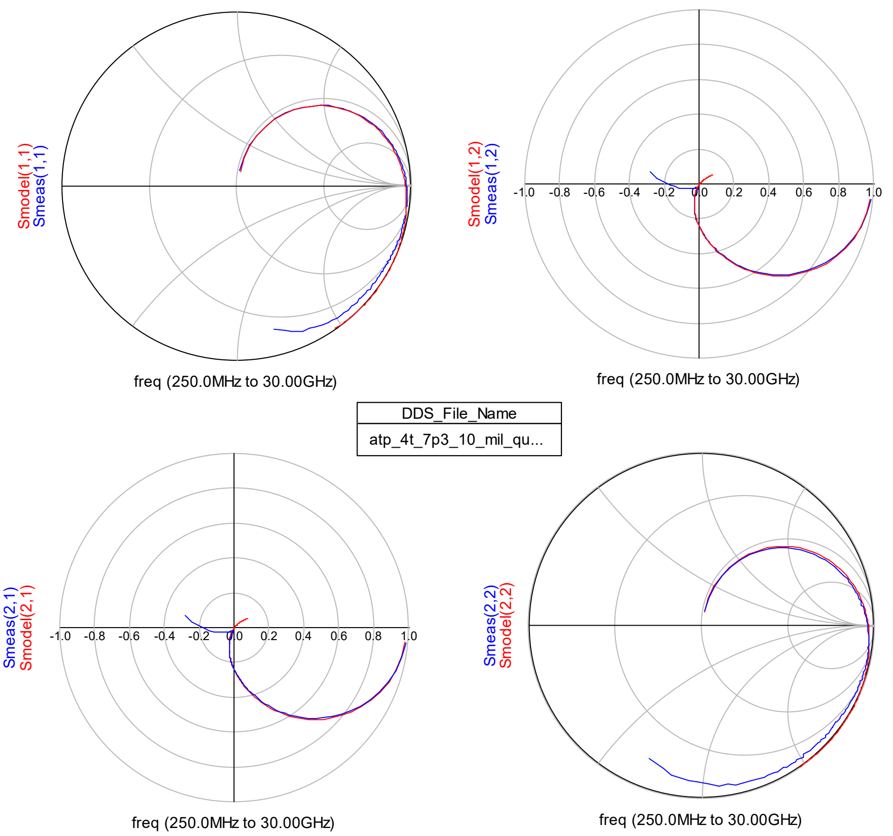
FITTED in 0.25-20 GHz
PLOTTED in 0.25-30 GHz

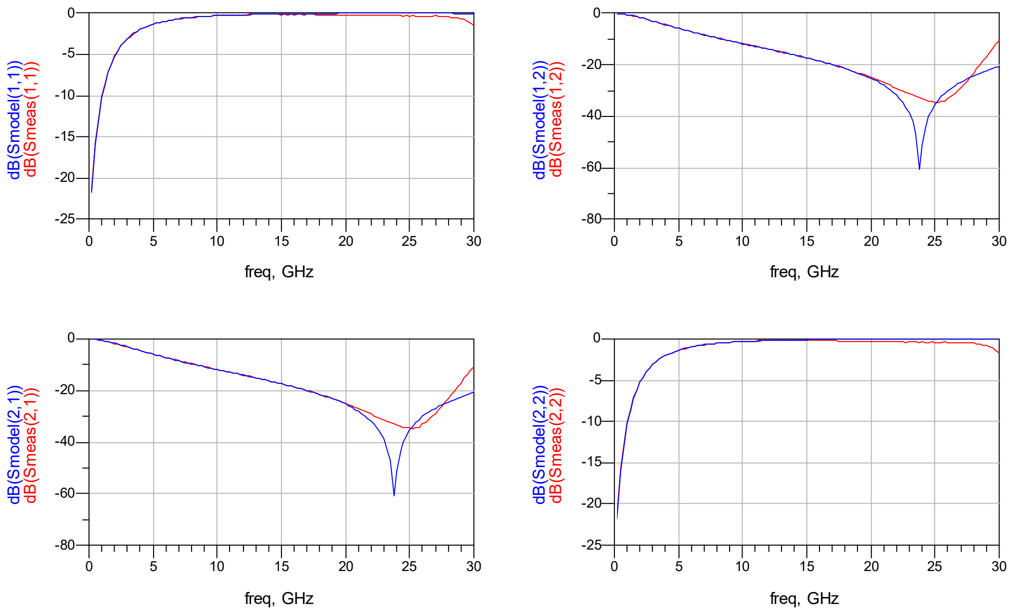
Inductor:
Lser=5.0 nH
Rser=1.4 Ohm

Input-output capacitor:
Cpar=0.009 pF

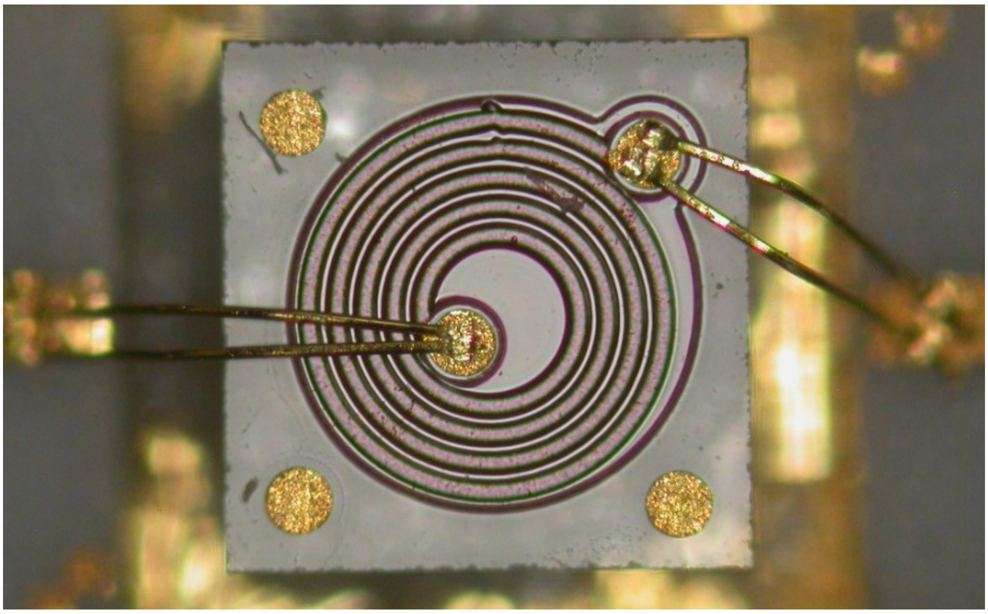
Capacitors to GND:
Cgnd=0.037 pF

Bond wires:
Lbond=0.19 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 30.00GHz)
DDS_File_Name
atp_4t_7p3_10_mil_qu...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

19. ATP quartz inductor 12 nH 4.5 turns 30x30x10 mil chip

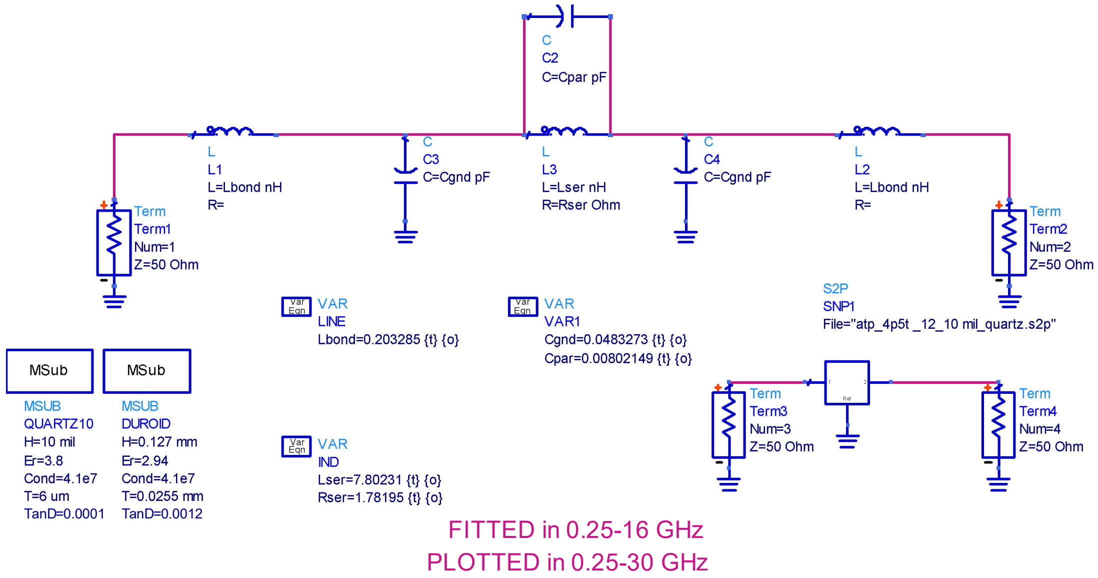


ATP-I-010-Q-120

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.11 mm
Inductor body: W=0.762 mm; L= 0.762 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.530 mm;
sep: ~60 um; height over chip: ~35 um
Bond wire 2: dia: 17 um; horizontal distance: 0.430 mm;
sep: ~100 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈15 GHz
Parallel resonance ≈ 18 GHz
Relatively good prediction

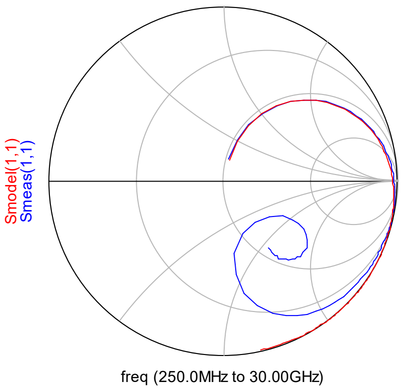


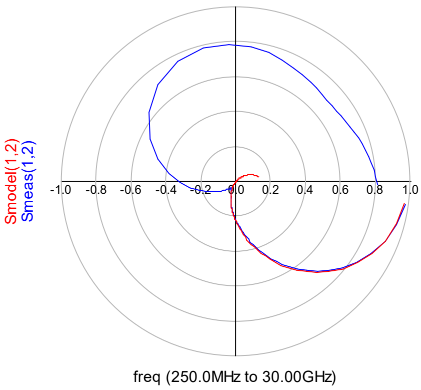
Inductor:
Lser=7.8 nH
Rser=1.8 Ohm

Input-output capacitor:
Cpar=0.008 pF

Capacitors to GND:
Cgnd=0.048 pF

Bond wires:
Lbond=0.20 nH





DDS_File_Name
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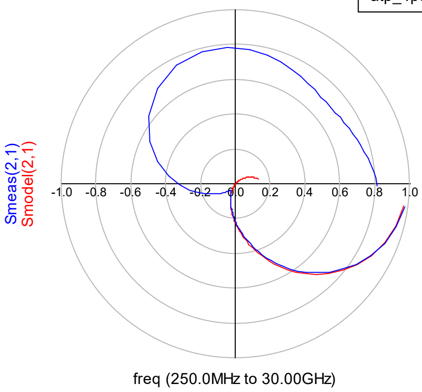
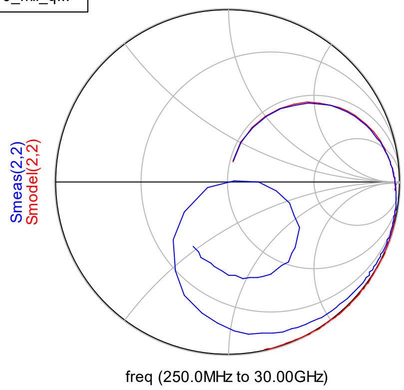
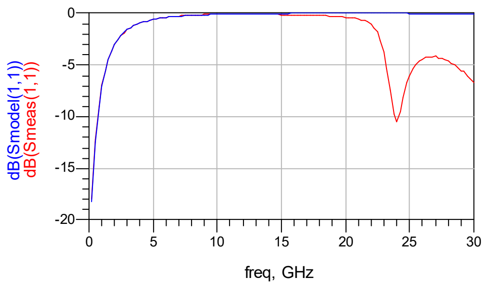
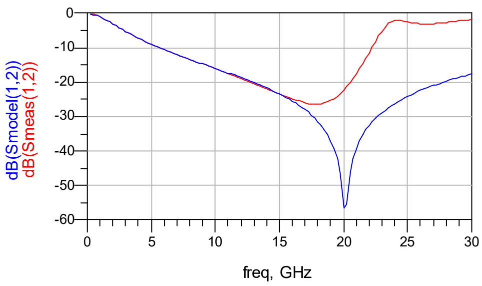
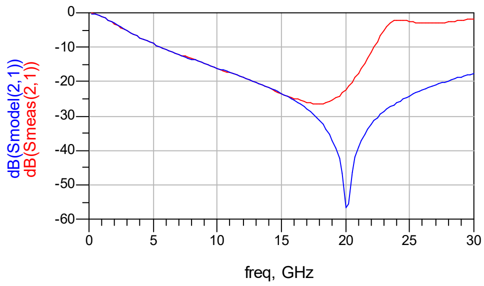
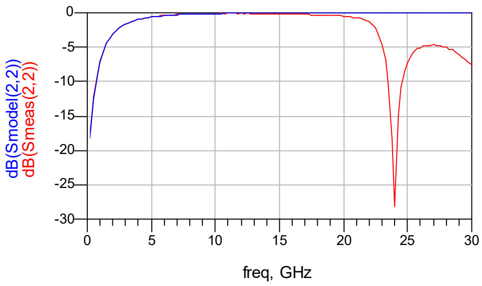




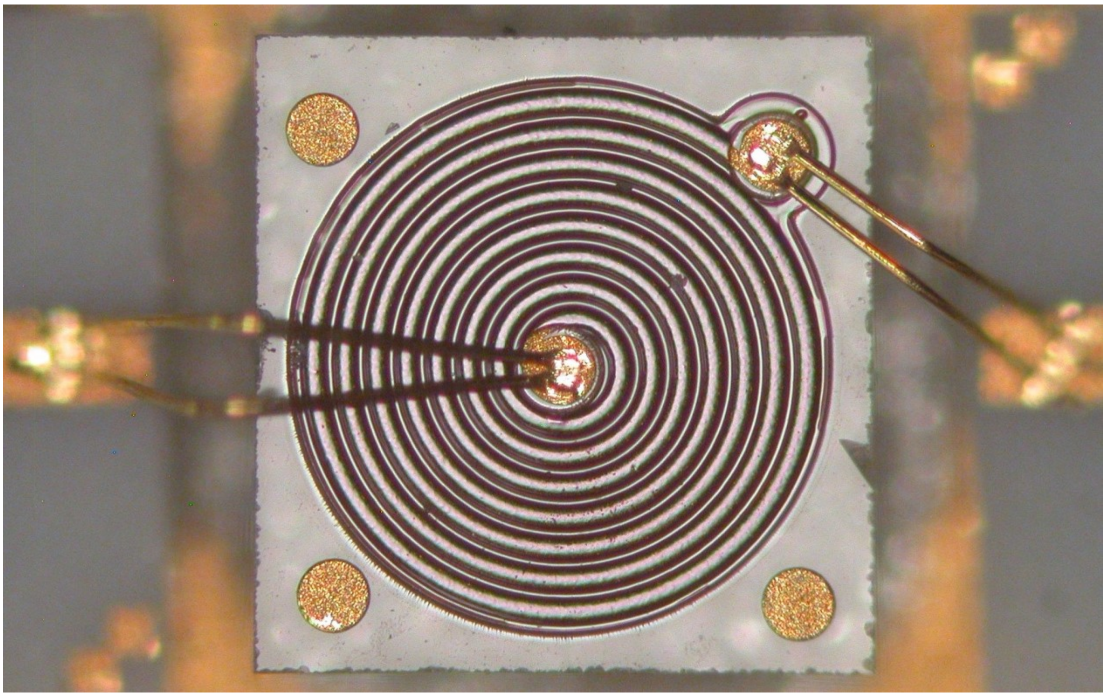








20. ATP quartz inductor 28.2 nH 7.5 turns 32x32x10 mil chip

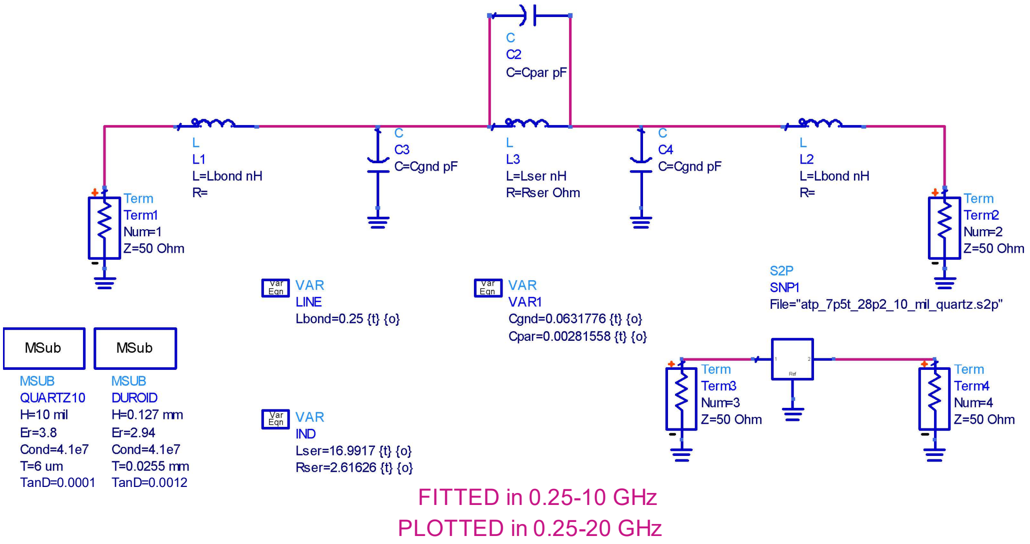


ATP-I-010-Q-282

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.12 mm
Inductor body: W=0.508 mm; L= 0.813 mm; h=0.813 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.610 mm; sep: ~30-100 um; height over chip: ~90 um
Bond wire 2: dia: 17 um; horizontal distance: 0.420 mm; sep: ~40-60 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈10 GHz
Parallel resonance ≈ 14 GHz

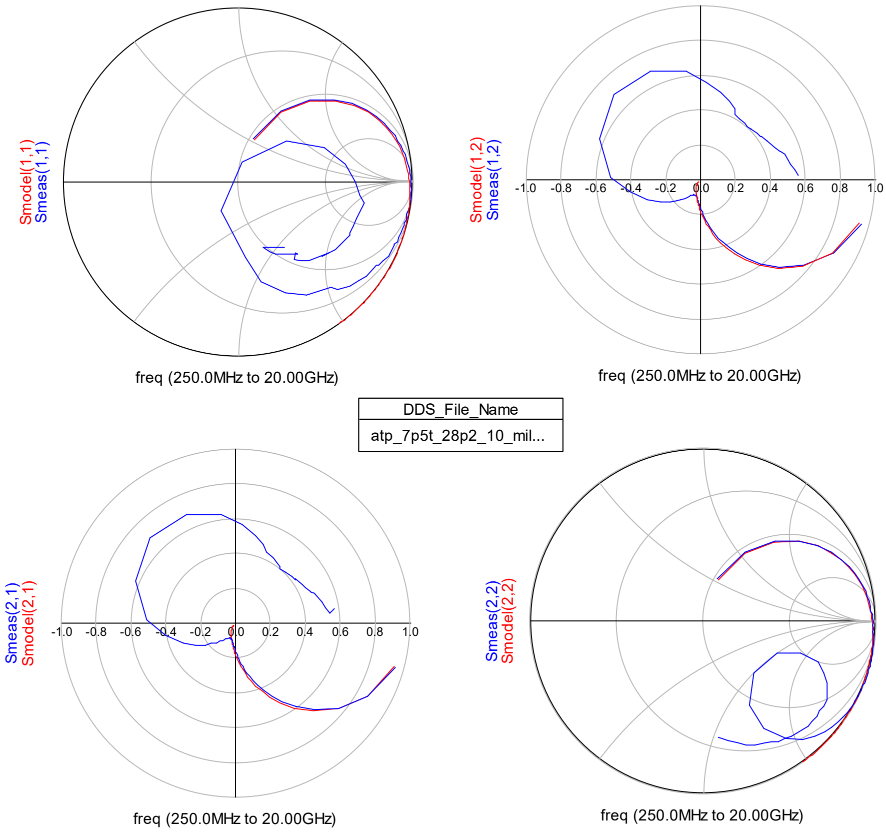


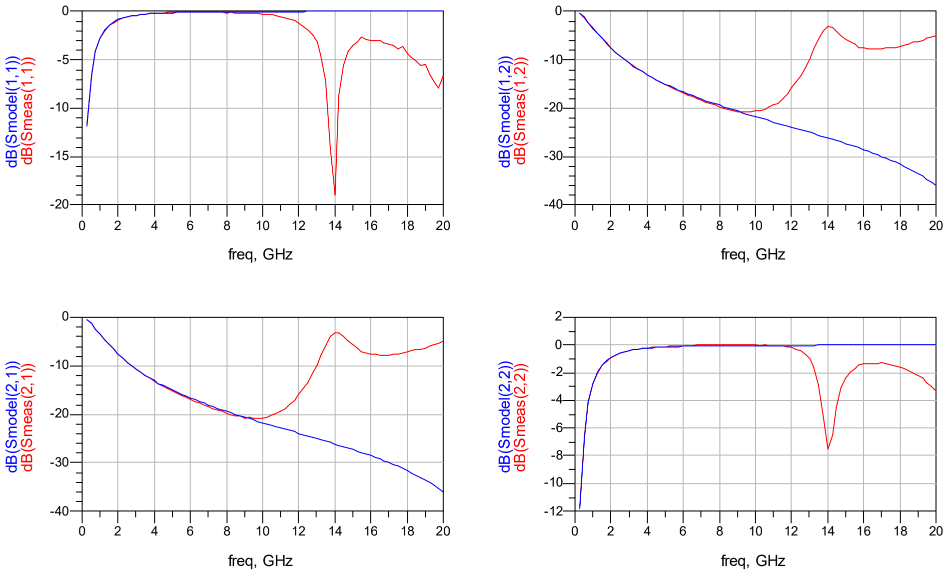
Inductor:
Lser=17.0 nH
Rser=2.6 Ohm

Input-output capacitor:
Cpar=0.003 pF

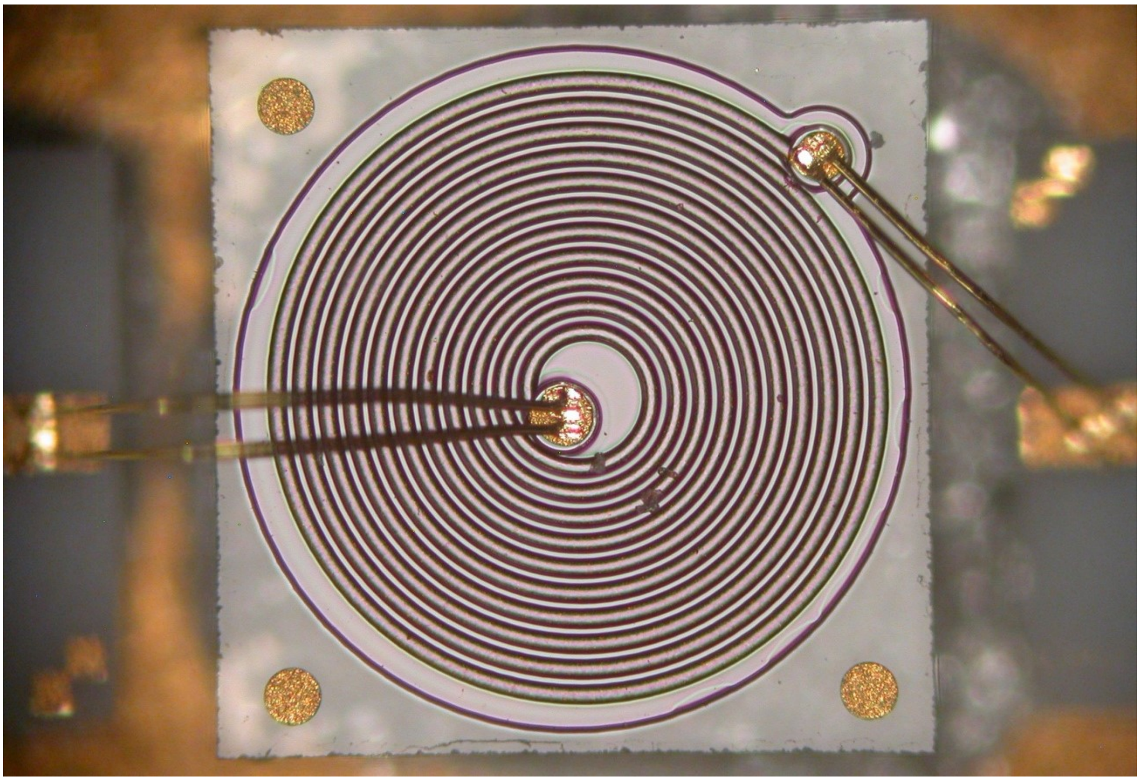
Capacitors to GND:
Cgnd=0.063 pF

Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 20.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 20.00GHz)
DDS_File_Name
atp_7p5t_28p2_10_mil...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 20.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 20.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

21. ATP quartz inductor 87.7 nH 10.5 turns 46x46x10 mil chip

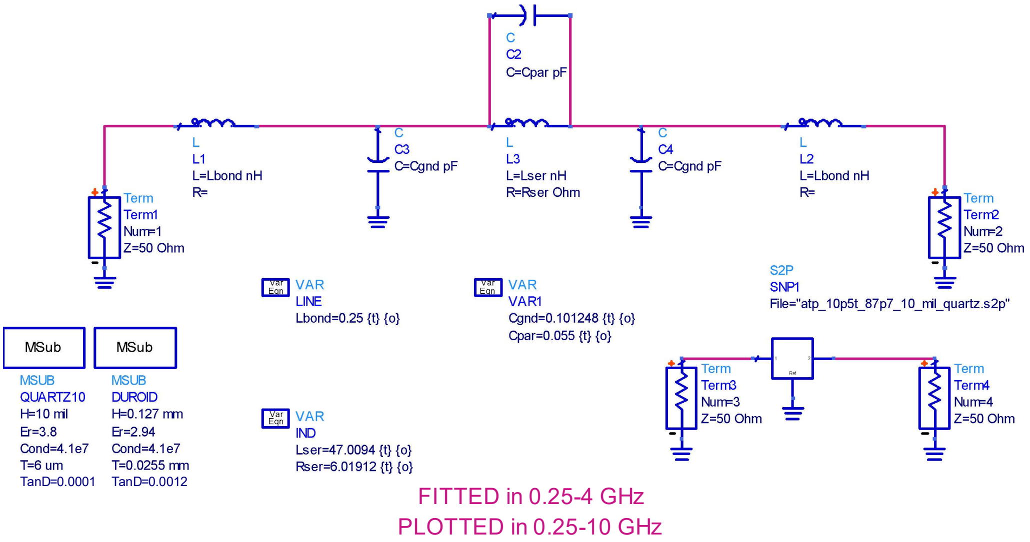


ATP-I-010-Q-877

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=1.168 mm; L= 1.168 mm; h=0.254 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.800 mm; sep: ~30-80 um; height over chip: ~130 um
Bond wire 2: dia: 17 um; horizontal distance: 0.600 mm; sep: ~40-50 um; height over chip: ~50 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈2 GHz
Parallel resonance ≈ 6.2 GHz

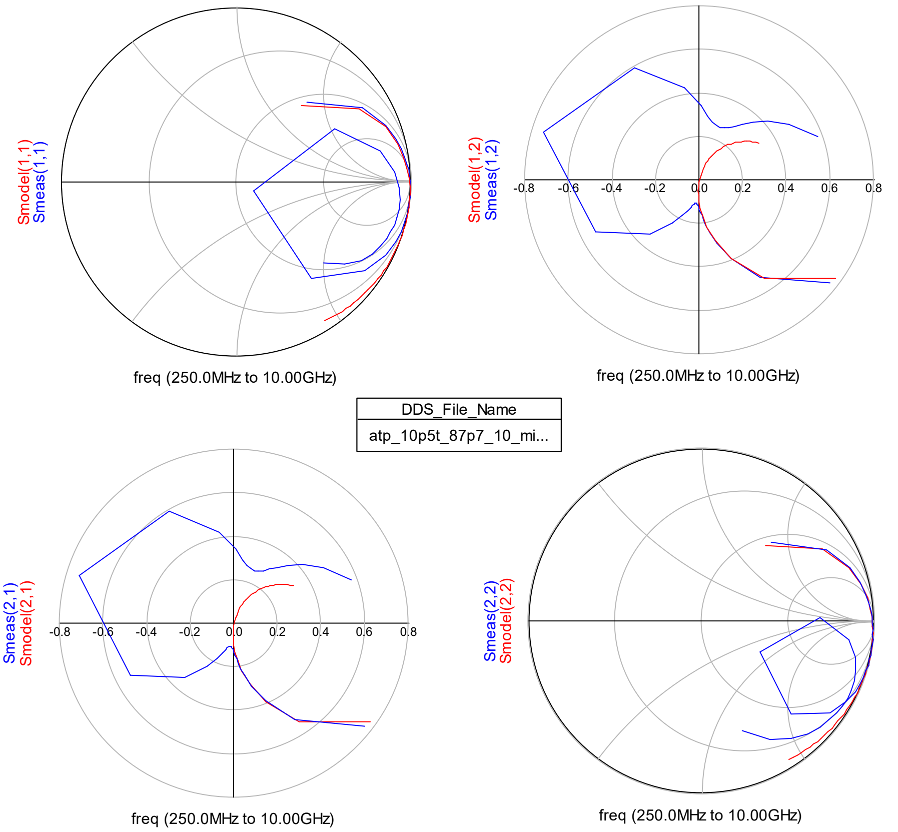


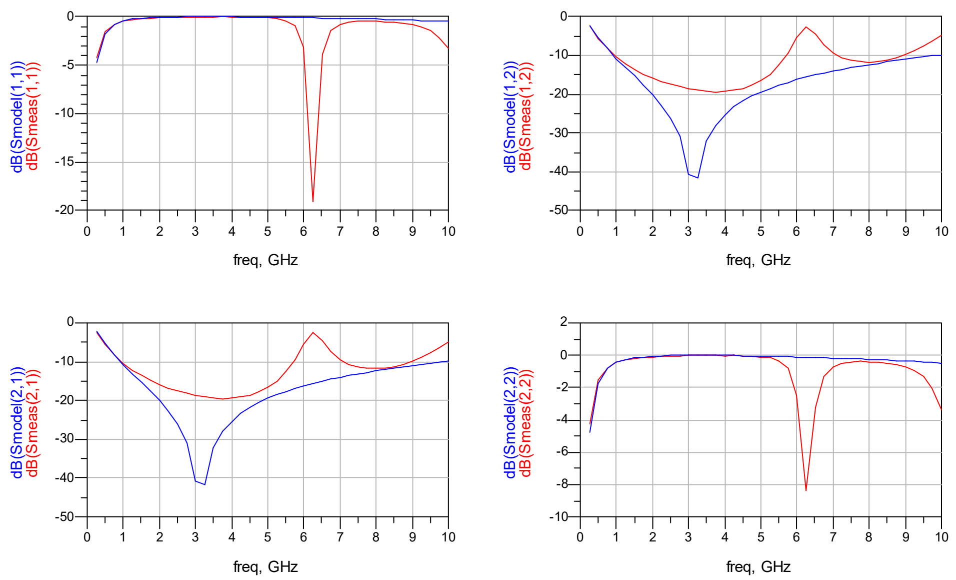
Inductor:
Lser=47.0 nH
Rser=6.0 Ohm

Input-output capacitor:
Cpar=0.055 pF

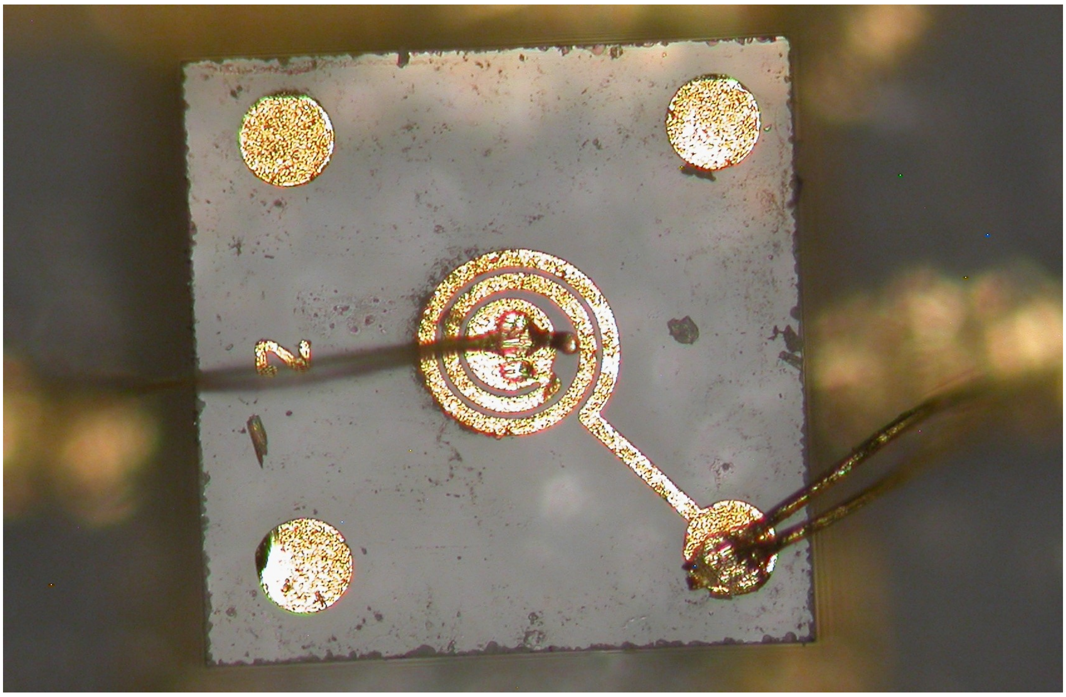
Capacitors to GND:
Cgnd=0.101 pF

Bond wires:
Lbond=0.25 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 10.00GHz)
Smodel(1,2)
Smeas(1,2)
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
freq (250.0MHz to 10.00GHz)
DDS_File_Name
atp_10p5t_87p7_10_mi...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 10.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 10.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

22. US uW quartz inductor 2 nH 2 turns 27x27x20 mil chip

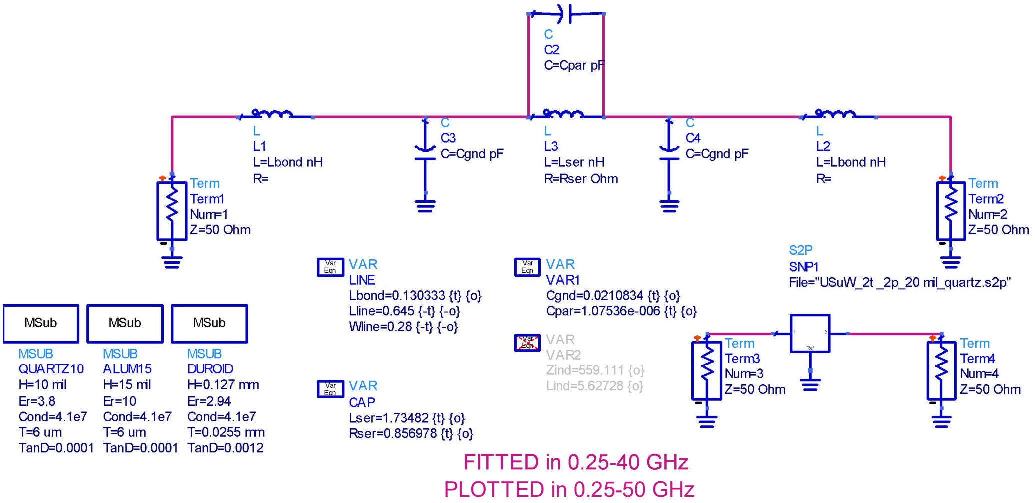


LX2500Q20-L02-02

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.686 mm; L= 0.686 mm; h=0.508 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.560 mm;
sep: - ; height over chip: ~200 um
Bond wire 2: dia: 17 um; horizontal distance: 0.450 mm;
sep: ~30-50 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈35 GHz

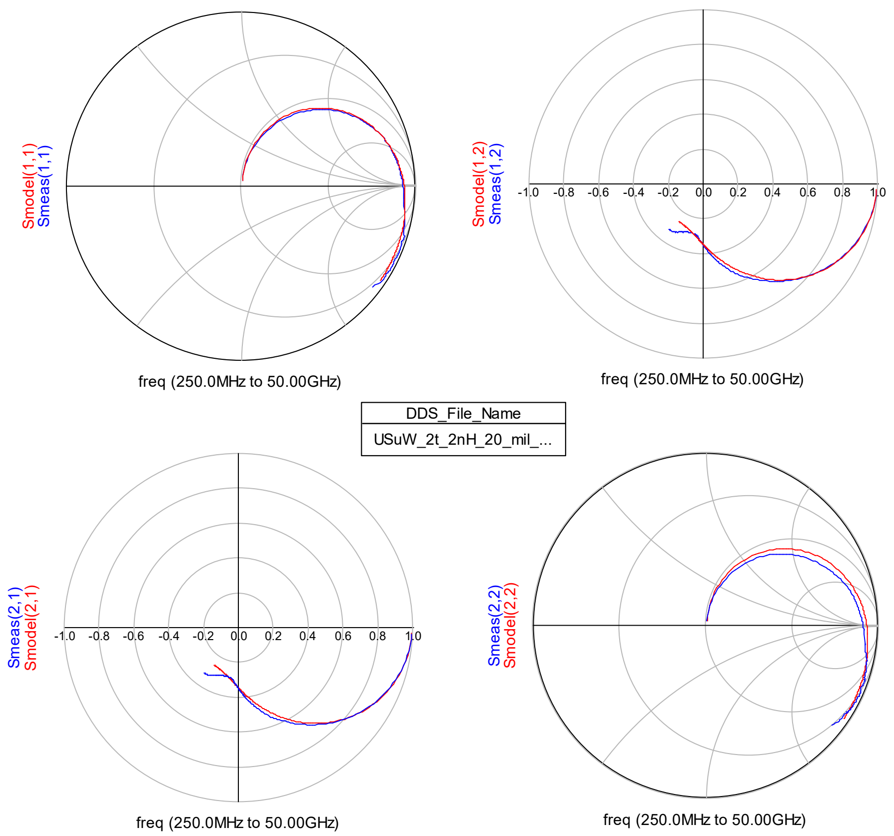


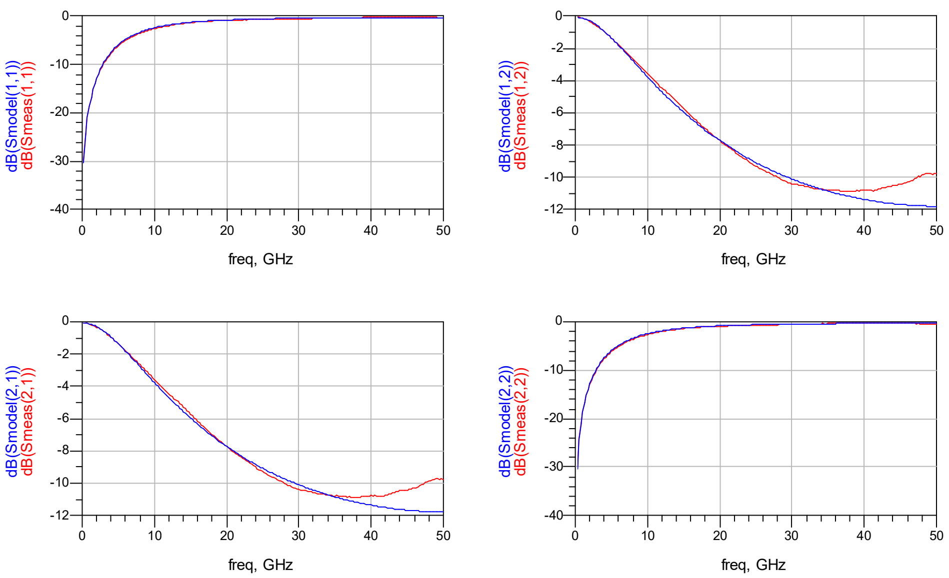
Inductor:
Lser=1.73 nH
Rser=0.8 Ohm

Input-output capacitor:
Cpar=0.000 pF

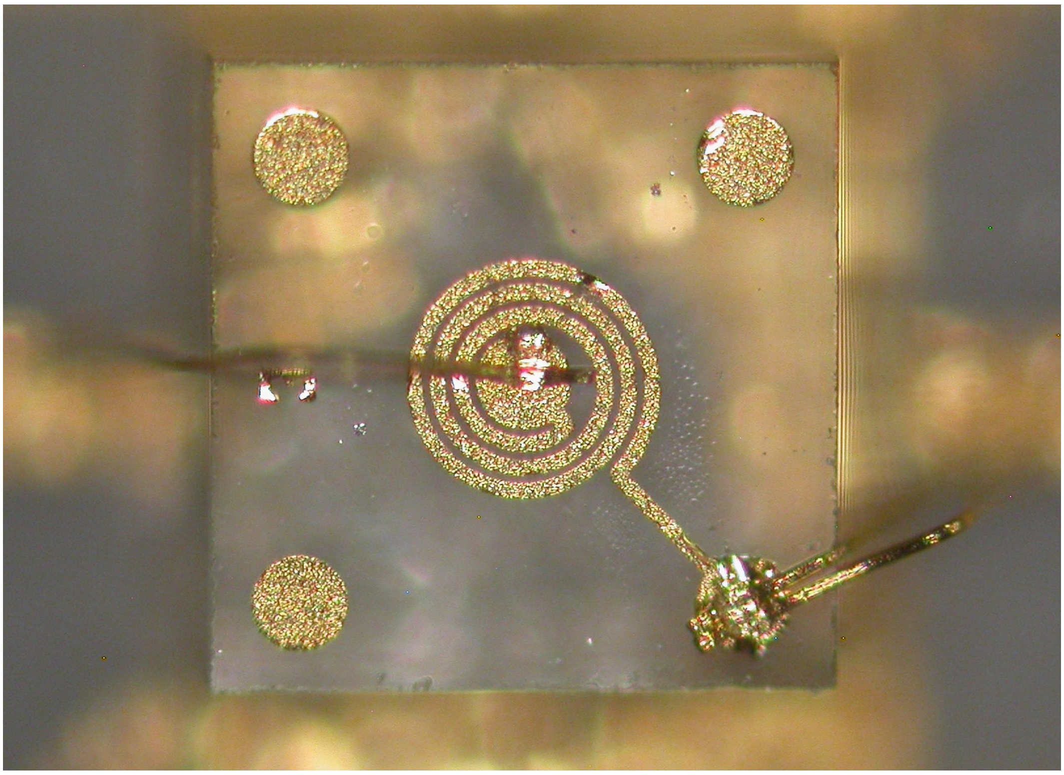
Capacitors to GND:
Cgnd=0.021 pF

Bond wires:
Lbond=0.13 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 50.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 50.00GHz)
DDS_File_Name
USuW_2t_2nH_20_mil_...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 50.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 50.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

23. US uW quartz inductor 4 nH 3 turns 27x27x20 mil chip

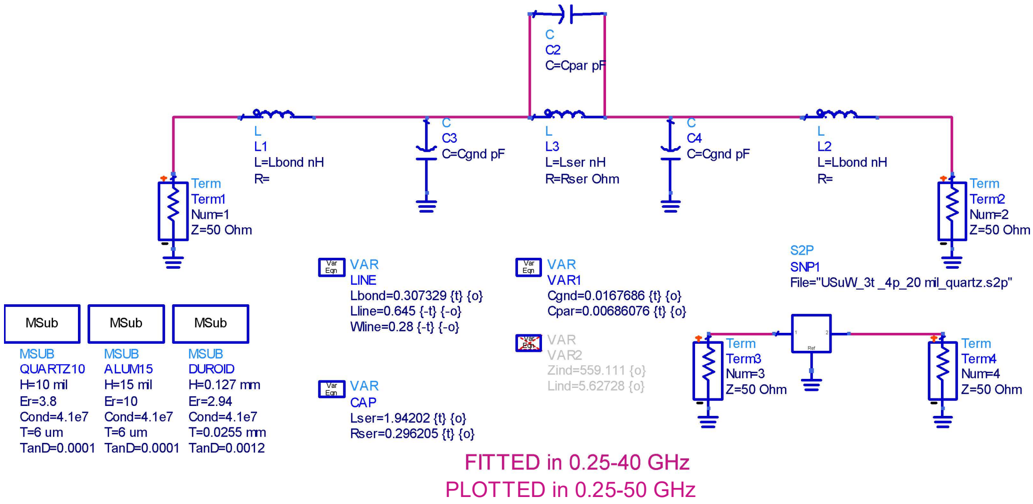


LX2500Q20-L03-04

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.686 mm; L= 0.686 mm; h=0.508 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.460 mm;
sep: - ; height over chip: ~140 um
Bond wire 2: dia: 17 um; horizontal distance: 0.370 mm;
sep: ~20-40 um; height over chip: ~10 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈30 GHz

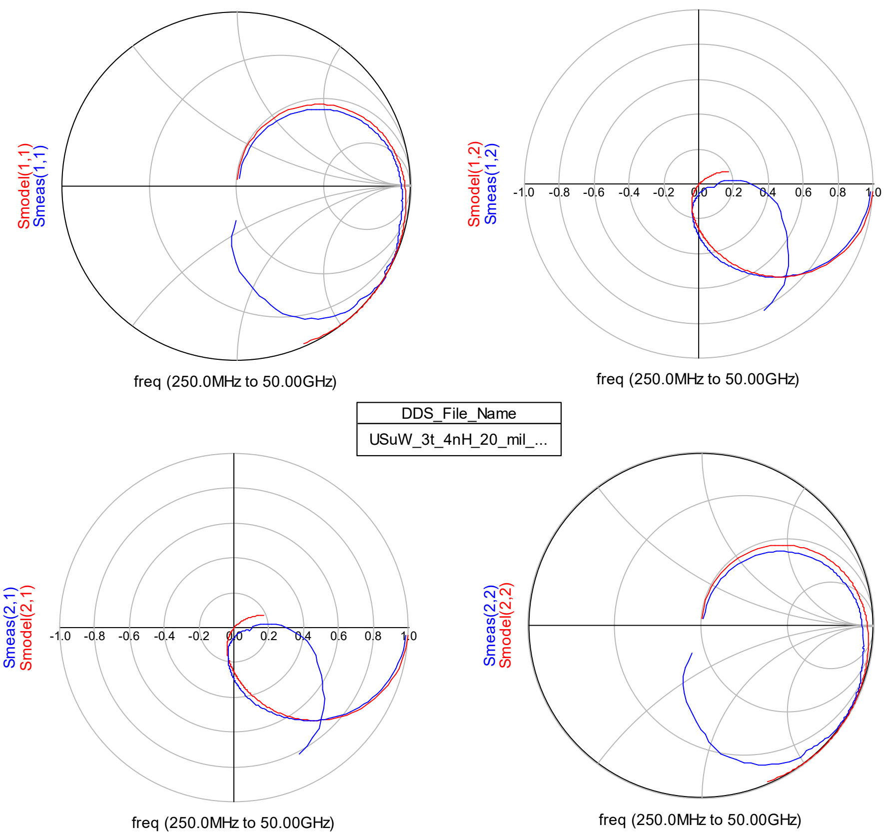


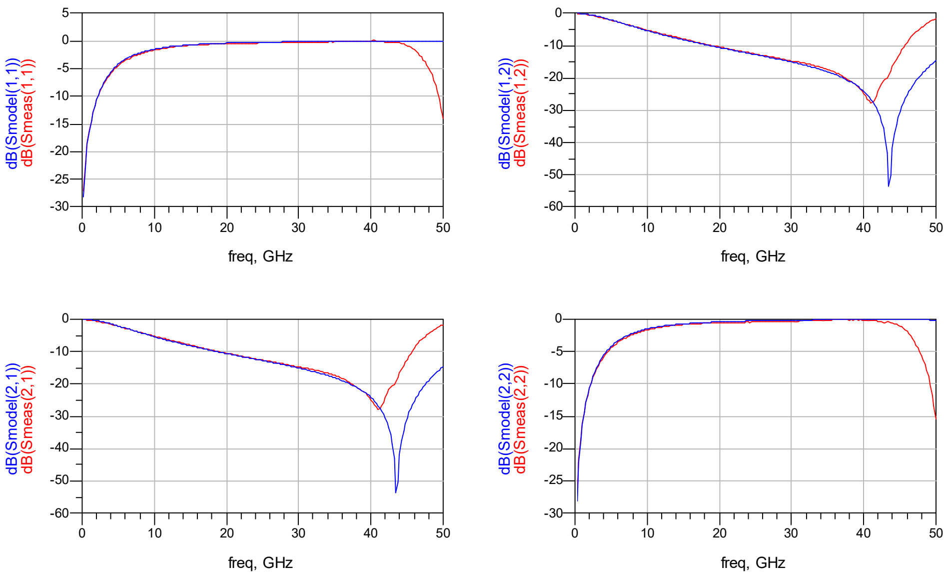
Inductor:
Lser=1.94 nH
Rser=0.3 Ohm

Input-output capacitor:
Cpar=0.006 pF

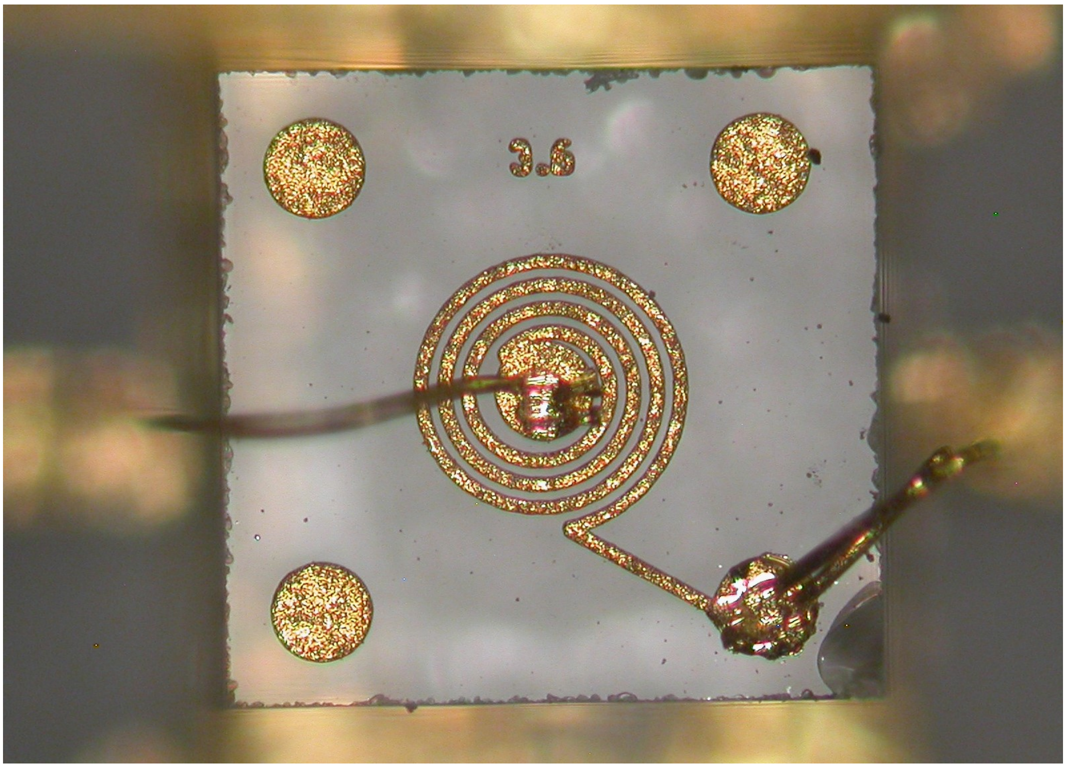
Capacitors to GND:
Cgnd=0.016 pF

Bond wires:
Lbond=0.30 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 50.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 50.00GHz)
DDS_File_Name
USuW_3t_4nH_20_mil_...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 50.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 50.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

24. US uW quartz inductor 7 nH 3.6 turns 27x27x20 mil chip

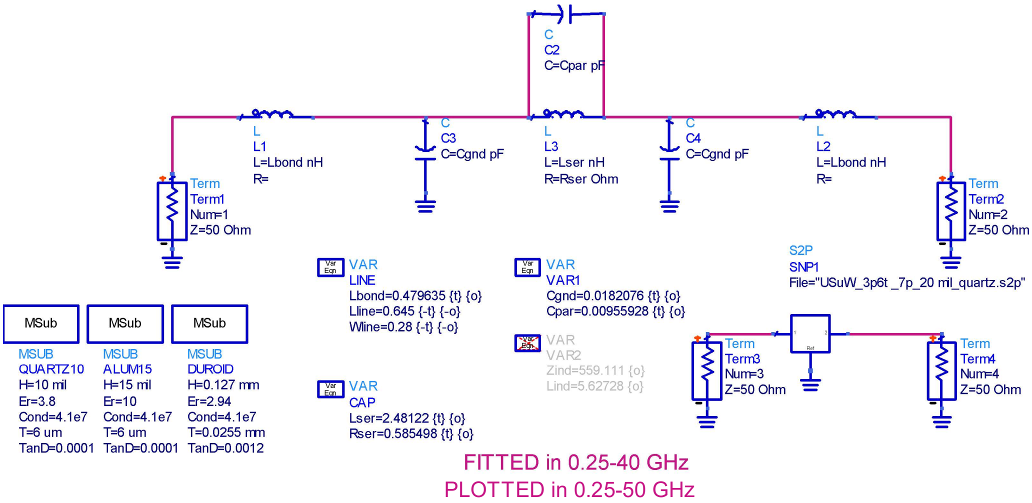


LX2500Q20-L03.6-07

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.686 mm; L= 0.686 mm; h=0.508 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.520 mm; sep: - ; height over chip: ~140 um
Bond wire 2: dia: 17 um; horizontal distance: 0.350 mm; sep: ~20 um; height over chip: ~30-40 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈30 GHz

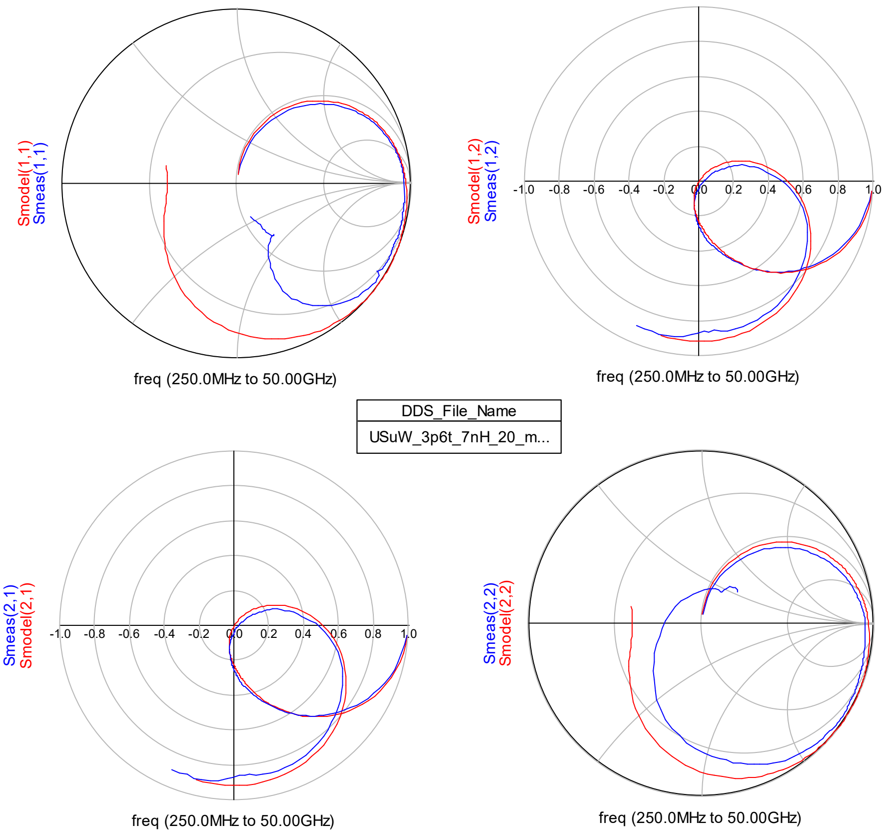


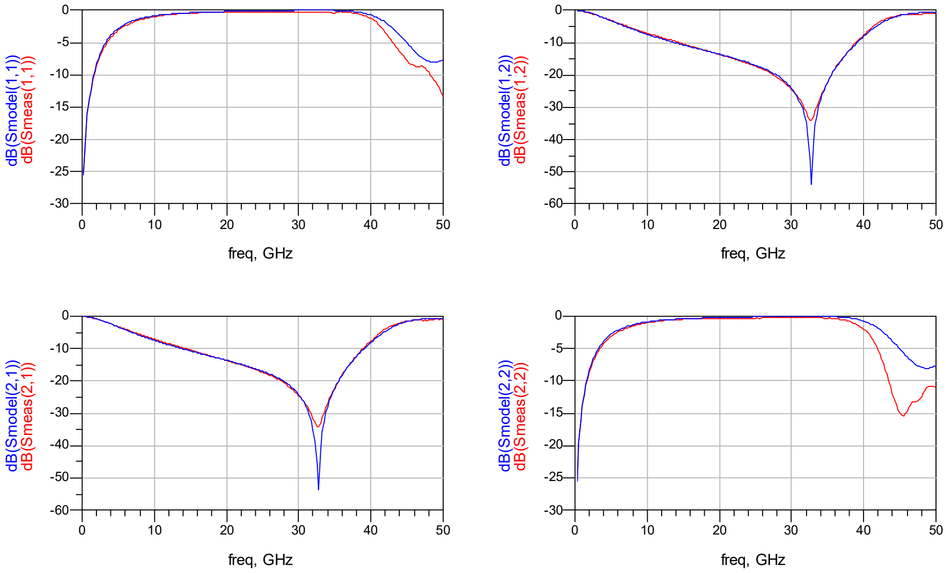
Inductor:
Lser=2.48 nH
Rser=0.6 Ohm

Input-output capacitor:
Cpar=0.010 pF

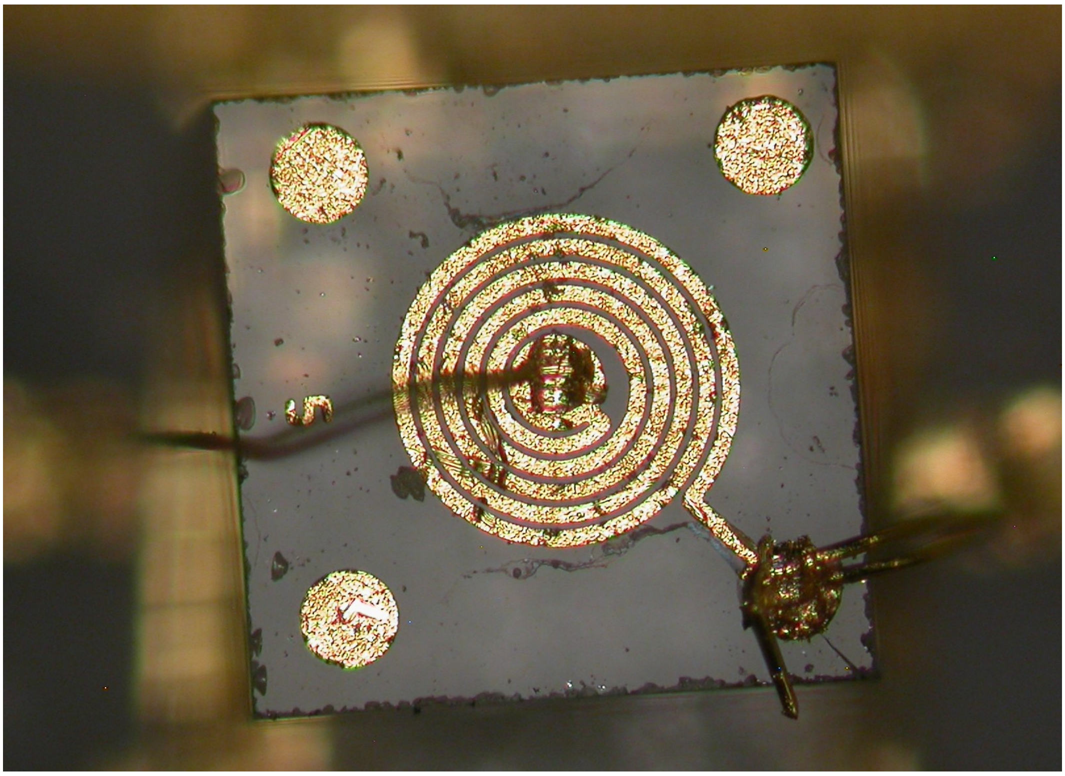
Capacitors to GND:
Cgnd=0.018 pF

Bond wires:
Lbond=0.48 nH


Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 50.00GHz)
Smodel(1,2)
Smeas(1,2)
freq (250.0MHz to 50.00GHz)
DDS_File_Name
USuW_3p6t_7nH_20_m...
Smeas(2,1)
Smodel(2,1)
freq (250.0MHz to 50.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 50.00GHz)


dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

25. US uW quartz inductor 14 nH 5 turns 27x27x20 mil chip

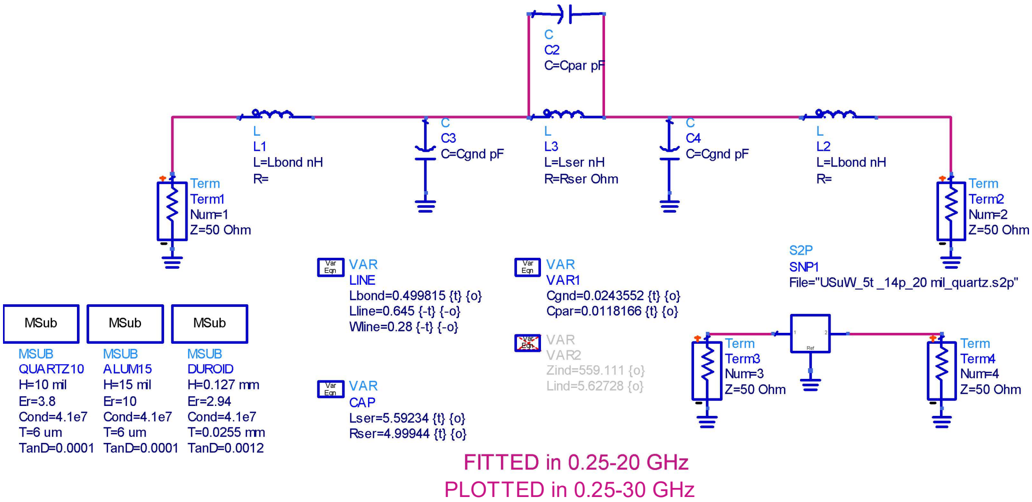


LX2500Q20-L05-14

Measured with Jmicro transitions (5 mil)
Gaps to substrate: ~0.13 mm
Inductor body: W=0.686 mm; L= 0.686 mm; h=0.508 mm
Bond wire 1: dia: 17 um; horizontal distance: 0.560 mm; sep: - ; height over chip: ~230 um
Bond wire 2: dia: 17 um; horizontal distance: 0.300 mm; sep: ~20-30 um; height over chip: ~20 um
Reference planes at the end of Jmicro substrate

SIMPLE L-C MODEL

Good up to ≈20 GHz

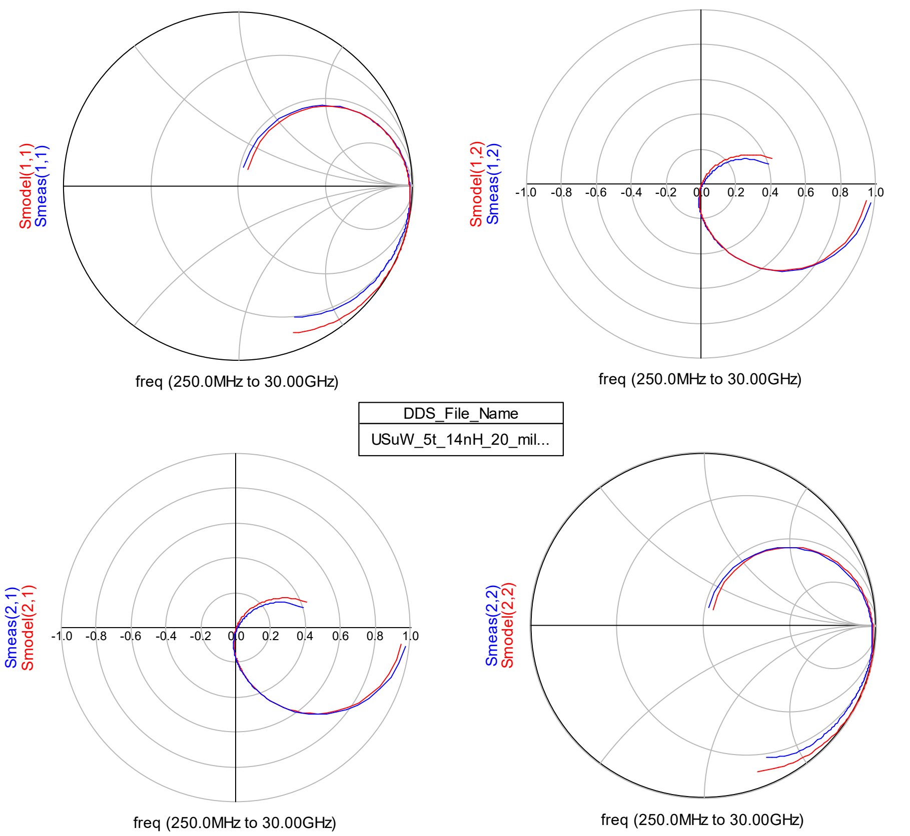


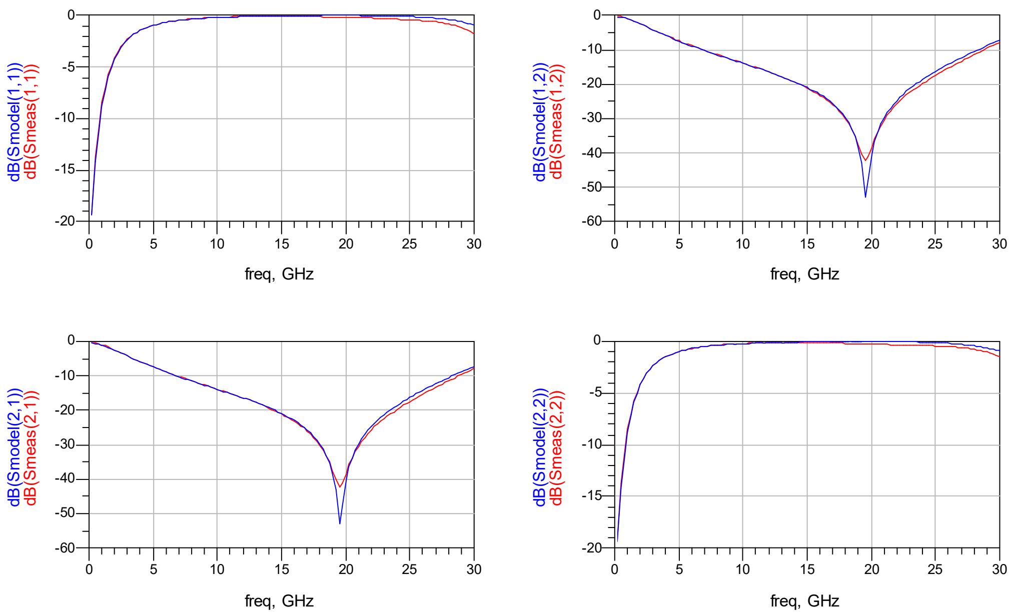
Inductor:
Lser=5.59 nH
Rser=5 Ohm

Input-output capacitor:
Cpar=0.012 pF

Capacitors to GND:
Cgnd=0.024 pF

Bond wires:
Lbond=0.50 nH

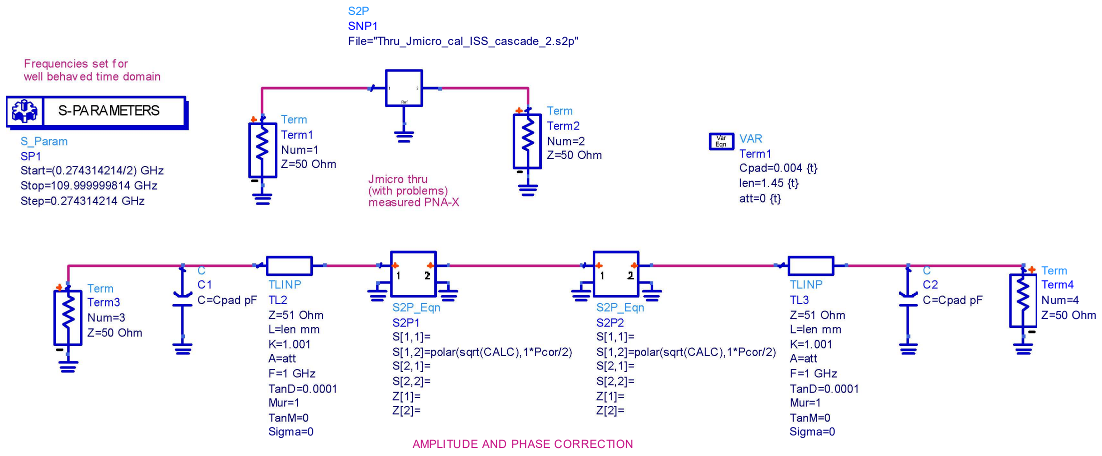

Smodel(1,1)
Smeas(1,1)
freq (250.0MHz to 30.00GHz)
Smodel(1,2)
Smeas(1,2)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
DDS_File_Name
USuW_5t_14nH_20_mil...
Smeas(2,1)
Smodel(2,1)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
freq (250.0MHz to 30.00GHz)
Smeas(2,2)
Smodel(2,2)
freq (250.0MHz to 30.00GHz)

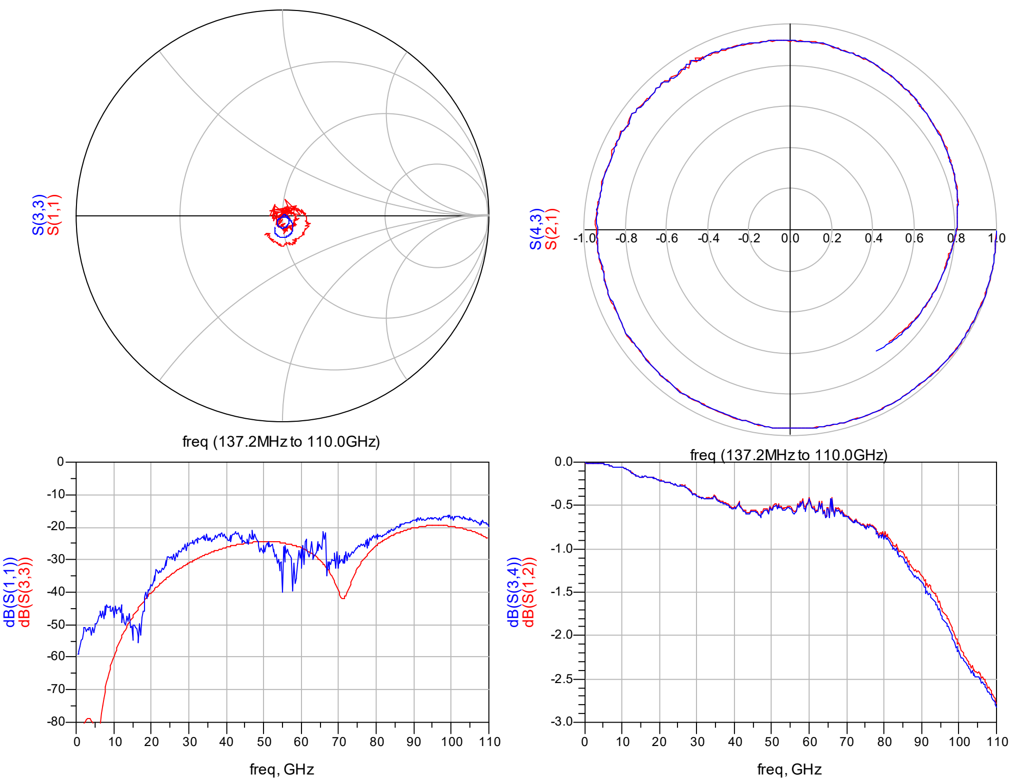

dB(Smodel(1,1))
dB(Smeas(1,1))
freq, GHz
dB(Smodel(1,2))
dB(Smeas(1,2))
freq, GHz
dB(Smodel(2,1))
dB(Smeas(2,1))
freq, GHz
dB(Smodel(2,2))
dB(Smeas(2,2))
freq, GHz

26. Appendix I

Model used for de-embedding J-micro coplanar to microstrip transitions.

(Half of the model is used to generate S2P files used for de-embedding)





27. Appendix II: Datasheets

PICONICS
High-Quality Micro-Electronic Inductors

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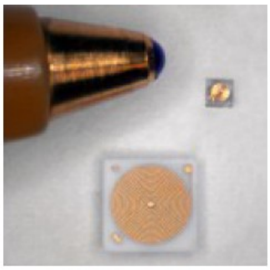
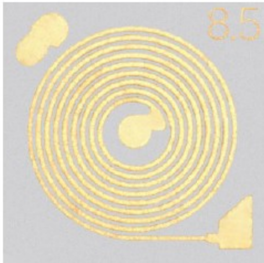
Spiral Chip Inductor



Piconics SP Series is a thin film gold spiral inductor deposited on a ceramic or quartz chip.This style inductor can be used where low inductance values and gold wire bond is the interconnection method.

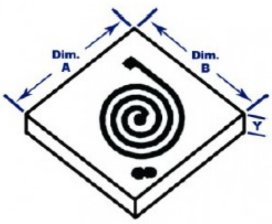


Spiral Chip Inductor

Piconics part #	Part Size	Turns	L in nH	Tol. %	Q @ 200MHz	DCR Ohms	Series SRF on Quartz GHz min.	Series SRF on Alumina GHz min.	Parallel SRF GHz min.	Dim. A Mils	Dim. B Mils
SP2P5-20-xyz	20 x 20	2.5	2.1		2	0.8				20	20
SP4P5-20-xyz	20 x 20	4.5	6.9	10	4	2				20	20
SP5-20-xyz	20 x 20	5	7.3	10	3.5	2.5				20	20
SP6-20-xyz	20 x 20	6	10	10	3.5	3.5				20	20
SP6P5-20-xyz	20 x 20	6.5	12	10	3.5	4				20	20
SP2P5-26-xyz	26 x 26	2.5	2.3	18	5	0.5				26	26
SP3P5-30-xyz	30 x 30	3.5	4.3		5	1				30	30
SP4P5-30-xyz	30 x 30	4.5	7.5		5	1.5				30	30
SP2P5-45-xyz	45 x 45	2.5	4	18	11	0.5	17	17	11	45	45
SP3-45-xyz	45 x 45	3	5.5	15	11	0.6	14	14	9	45	45
SP3P25-45-xyz	45 x 45	3.25	5.8		10	0.5	13	13	8	45	45
SP3P5-45-xyz	45 x 45	3.5	7	15	11	0.8	13	13	8	45	45
SP4-45-xyz	45 x 45	4	9.6	15	10	1	12.5	12.5	7.6	45	45
SP4P5-45-xyz	45 x 45	4.5	11.3	10	10	1	12	12	7	45	45
SP5-45-xyz	45 x 45	5	14.6	10	10	1.5	12	12	7	45	45
SP5P5-45-xyz	45 x 45	5.5	17	10	10	1.5	12	12	6	45	45
SP6-45-xyz	45 x 45	6	21	10	10	2	9	9	6	45	45
SP6P5-45-xyz	45 x 45	6.5	25	10	10	2	7	6	5	45	45
SP7-45-xyz	45 x 45	7	28	10	10	3	5	3	4	45	45
SP7P5-45-xyz	45 x 45	7.5	34	10	10	3	5	3	3.5	45	45
SP8-45-xyz	45 x 45	8	38.5	10	10	3	5	4	3.5	45	45
SP8P5-45-xyz	45 x 45	8.5	45	10	10	4	5	4	3.5	45	45
SP11P5-60-xyz	60 x 60	11.5	80	10	10	9	4	3	3	60	60
SP12P5-61-xyz	61 x 61	12.5	100	10	12	8.5				61	61
SP16-80-xyz	80 x 80	16	219	10		12				80	80

NOTES:

1. Inductance values are measured in free air.
2. Mounting the part on a ground plane will reduce the inductance and SRF. Higher values change more.
3. If part must be mounted on a ground plane it is best to purchase part on a thicker material. Piconics can supply up to 25 mil thick on special order.
4. Attachment is best made with non-conductive epoxy. Using a conductive epoxy will yield the same results as mounting on a ground plane.
5. Only thermosonic wire bonding using 1 mil gold wire is recommended.
6. Bonding pads are .004" diameter min.
7. SRF values are measurements made on 10 mil substrates.



X	Y	Z
A = Alumina	A = .005"	W = GOLD ONE SIDE
Q = Quartz	B = .010"	M = GOLD TWO SIDES
	C = .015"	
	E = .025"	
Add "P" to the end of the Suffix if Polyimide is required.		

Spiral Inductor Notes

SPIRAL INDUCTORS

Spiral inductors are used extensively in microwave circuit resonant elements and as a choke in power supplies. When used as a choke, a low Q is generally desirable to obtain a broadband characteristic. To obtain a high self-resonance, the conductor width is reduced and capacitance between turns is minimized by conductor geometry. Values for chokes are usually not too critical as long as self-resonant frequency is high. Tuned circuits frequently require adjustment of the inductance value. This is accomplished at a modest tooling cost. e.g. The outside turn can be constructed with sufficient width to allow a wire bond position which will bypass some of the winding. Coils can also be fabricated with shorting bars which may be trimmed by use of a laser to vary the inductance.

SUBSTRATE TYPES

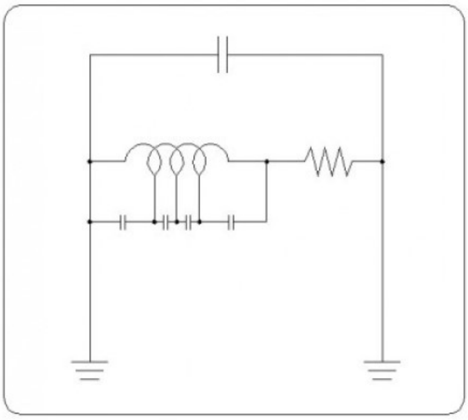
Alumina and Quartz are the two basic materials utilized for the substrate base of spiral inductors. Alumina (99.6%) is a strong material and is relatively inexpensive. It has a fairly high dielectric constant of approximately 10. Quartz is more fragile, smoother and much more expensive, but has a dielectric constant of 4.0. This characteristic permits much higher self-resonant frequencies when produced on quartz Alumina and Quartz are the most common materials although thin film processing occasionally uses other materials. (e.g.beryllia, etc.).

SPIRAL INDUCTORS VS. WOUND INDUCTORS

Spiral inductors generally have somewhat lower Q and SRF compared to wound inductors, but are manufactured with processes which makes them much more uniform. The contacts are wire bonded compared to welded leads which are more difficult to position. Spiral inductors may be mounted on an insulating ground post to reduce capacitance to the ground plane and increase SRF. Orientation is not optional with spirals as they are Thin Film deposited with their axis perpendicular to the ground plane. Spirals are easier to install and save labor in assembly. There are several different inductance geometries which may be used depending on circuit requirements. The most common type features contacts on the top surface for thermosonic gold wire bonding. Single layer devices have a center contact and an edge contact. A minor disadvantage of this geometry is that the gold leads to the center contact can vary in length and cause a small change in value from one circuit to another. Most customers, designers, and engineers, prefer edge contacts to provide short and consistent interconnections with the gold bonding wire. Edge contacts are accomplished by bridging with a wirebond.

EQUIVALENT CIRCUITS

The equivalent circuit of the spiral inductor includes a parallel input capacitance to ground and capacitance from input to output terminals. In addition, there is coupling or capacitance between turns. An equivalent ideal inductor series with a resistor is connected from input to output. The resultant circuit yields many resonances. The first is usually a parallel resonance. The next is a series resonance, then another parallel resonance followed by another series resonance, etc. When inductors are used as chokes the first series resonance is usually the most important. When inductors are used as tuned circuits, the first parallel resonance is usually the most important. Microwave engineers frequently use inductors beyond the first self-resonance.



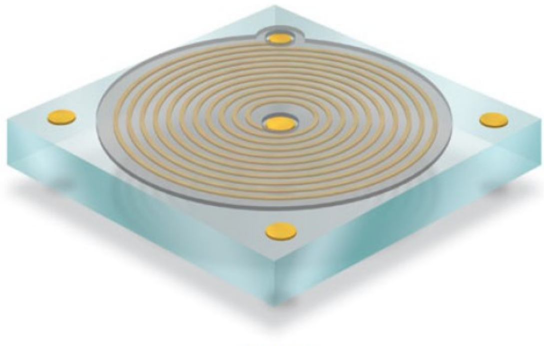
APPLIED THIN-FILM PRODUCTS

COMPANY TECHNOLOGIES CAPABILITIES DESIGN GUIDELINES PRODUCTS CONTACT US HOME CALL ATP AT 510.661.4287

Inductor Coils

ATP introduces a new line of printed spiral inductor coils in a wide range of values from 2.2 nH to 112.7 nH. These coils have been modeled and optimized using advanced computer automated design tools to produce data and graphs to help you utilize these devices in your own thin-film or hybrid designs. These printed inductors can be used in a wide variety of applications from DC and RF filtering to gain shaping and equalization circuits. Use them in a new design approach or to enhance or modify a current design for a specific performance you desire!

These spiral inductors are designed with thick Au conductors on fused silica quartz to minimize series resistance and promote high Q values. The coils are offered with or without backside metallization to offer you the ability to mount in various applications, utilizing isolated or grounded configurations. Supporting graphs and data are available for these two configurations. They also have additional pads located around the coil to help you customize and fine tune in your final values desired. They are also protected with a polyimide coating to help resist in scratching, bridging or shorting during assembly and tuning.



Inductor Coil

Material: 0.010" (0.254 mm) Thick quartz/fused Silica (SiO_2)
Metalization A Side:
• TiW = 400 to 800 Å (0.04–0.08 Microns)
• Au = 250 µ" (6.35 Microns) minimum
No Metalization on B Side
Critical Dimensions:
• Line = 0.0006" ±0.0001 (0.01524 mm ±0.00254)
• Gap = 0.001" ±0.0001 (0.0254 mm ±0.00254)
Polyimide = 3–6 Microns

If you do not see a value that fits your exact application, contact ATP Sales and we will custom fabricate the exact printed coil you desire.

Request a quote for the ATP Inductor Coils. Indicate the quantities below, then submit your RFQ with the Request For Quote button, at right.

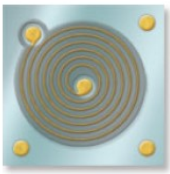
Request For Quote

ATP-I-010-Q-022
Inductor Turns: 2.5
Inductance (L): 2.2nH
Q: 4.5
Part Size: 0.022" x 0.022" (0.559mm x 0.559mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0

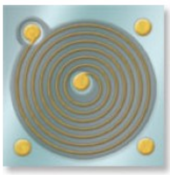
ATP-I-010-Q-350
Inductor Turns: 3.0
Inductance (L): 3.5nH
Q: 4.5
Part Size: 0.022" x 0.022" (0.559mm x 0.559mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0

ATP-I-010-Q-390
Inductor Turns: 3.5
Inductance (L): 3.9nH
Q: 5.2
Part Size: 0.022" x 0.022" (0.559mm x 0.559mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0

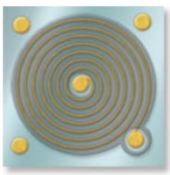
ATP-I-010-Q-730
Inductor Turns: 4.0
Inductance (L): 7.3nH
Q: 5.9
Part Size: 0.025" x 0.025" (0.635mm x 0.635mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



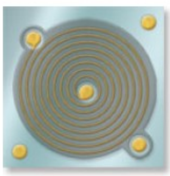
ATP-I-010-Q-219
Inductor Turns: 6.5
Inductance (L): 21.9nH
Q: 9.6
Part Size: 0.034" x 0.034" (0.864mm x 0.864mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



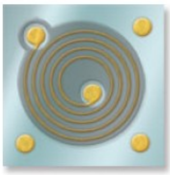
ATP-I-010-Q-264
Inductor Turns: 7.0
Inductance (L): 26.4nH
Q: 9.4
Part Size: 0.032" x 0.032" (0.813mm x 0.813mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



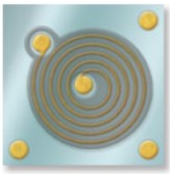
ATP-I-010-Q-282
Inductor Turns: 7.5
Inductance (L): 28.2nH
Q: 8.9
Part Size: 0.032" x 0.032" (0.813mm x 0.813mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



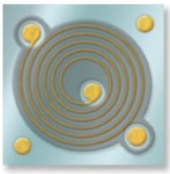
ATP-I-010-Q-406
Inductor Turns: 8.25
Inductance (L): 40.6nH
Q: 10.9
Part Size: 0.038" x 0.038" (0.965mm x 0.965mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



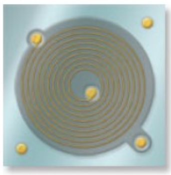
ATP-I-010-Q-120
Inductor Turns: 4.5
Inductance (L): 12.0nH
Q: 7.3
Part Size: 0.030" x 0.030" (0.762mm x 0.762mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



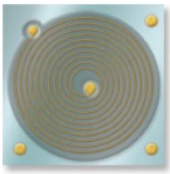
ATP-I-010-Q-158
Inductor Turns: 5.0
Inductance (L): 15.8nH
Q: 8.1
Part Size: 0.030" x 0.030" (0.762mm x 0.762mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



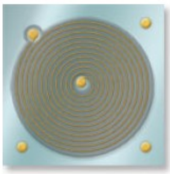
ATP-I-010-Q-196
Inductor Turns: 5.5
Inductance (L): 19.6nH
Q: 8.6
Part Size: 0.032" x 0.032" (0.813mm x 0.813mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



ATP-I-010-Q-783
Inductor Turns: 9.5
Inductance (L): 78.3nH
Q: 18.1
Part Size: 0.050" x 0.050" (1.270mm x 1.270mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



ATP-I-010-Q-877
Inductor Turns: 10.5
Inductance (L): 87.7nH
Q: 14.7
Part Size: 0.046" x 0.046" (1.168mm x 1.168mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0



ATP-I-010-Q-1127
Inductor Turns: 12.0
Inductance (L): 112.7nH
Q: 16.9
Part Size: 0.052" x 0.052" (1.321mm x 1.321mm)
Download Data Sheet in PDF format.*
Request For Quote Quantity: 0

*PDF documents require Adobe Reader.

ATP Part Number	Inductor Turns	Inductance (L)	Q	Part Size	Typical (Rs) Series Resonance	Min Au thickness	Data Sheet
ATP-I-010-Q-022	2.5	2.2nH	4.5	0.022" x 0.022" (0.559mm x 0.559mm)	0.319Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-350	3.0	3.5nH	4.5	0.022" x 0.022" (0.559mm x 0.559mm)	0.471Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-390	3.5	3.9nH	5.2	0.022" x 0.022" (0.559mm x 0.559mm)	0.549Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-730	4.0	7.3nH	5.9	0.025" x 0.025" (0.635mm x 0.635mm)	0.829Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-120	4.5	12.0nH	7.0	0.030" x 0.030" (0.762mm x 0.762mm)	1.139Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-158	5.0	15.8nH	8.1	0.030" x 0.030" (0.762mm x 0.762mm)	1.238Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-196	5.5	19.6nH	8.6	0.032" x 0.032" (0.813mm x 0.813mm)	1.457Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-219	6.5	21.9nH	9.6	0.034" x 0.034" (0.864mm x 0.864mm)	1.719Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-264	7.0	26.4nH	9.4	0.032" x 0.032" (0.813mm x 0.813mm)	1.789Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-282	7.5	28.2nH	8.9	0.032" x 0.032" (0.813mm x 0.813mm)	1.858Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-406	8.25	40.6nH	10.9	0.038" x 0.038" (0.965mm x 0.965mm)	1.996Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-783	9.5	78.3nH	18.1	0.050" x 0.050" (1.270mm x 1.270mm)	3.347Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-877	10.5	87.7nH	14.7	0.046" x 0.046" (1.168mm x 1.168mm)	3.719Ω	250µ" / 6.35µm	PDF*
ATP-I-010-Q-1127	12.0	112.7nH	16.9	0.052" x 0.052" (1.321mm x 1.321mm)	4.635Ω	250µ" / 6.35µm	PDF*

US MICROWAVES

Advanced Microwave Components

HIGH Q FACTOR SPIRAL CHIP INDUCTORS

LX2500Q20-L02-02nH

FEATURES

Spiral chip inductors are available in 3 different die dimensions:

- For 1 turn to 21 turns series the die size is 0.050"x0.050"x0.020".
- For 1 turn to 12 turns the die size is 0.030"x0.030"x0.020".
- For 1 turn to 8 turns the die size is 0.025"x0.025"x0.020".

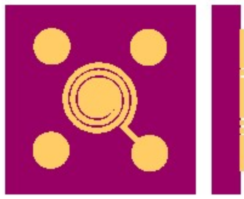
Spiral chip inductors are manufactured on quartz (SiO2), 20 mils thick, for lowest capacitance and highest SRF and PRF. The LX2500Q20-L02-02nH spiral chip inductors are manufactured on quartz (SiO2), 20 mils thick.

APPLICATIONS

These devices can be used over the full military temperature range -55°C to +125°C. Quality and workmanship is per MIL-S-883. Devices are 100% tested, visual inspected and packaged in waffle packs.

Spiral Chip Inductors Lab kits are available from stock: L-Kit

SPIRAL CHIP INDUCTOR



PRODUCT DESCRIPTION AND SHORT APPLICATION NOTE

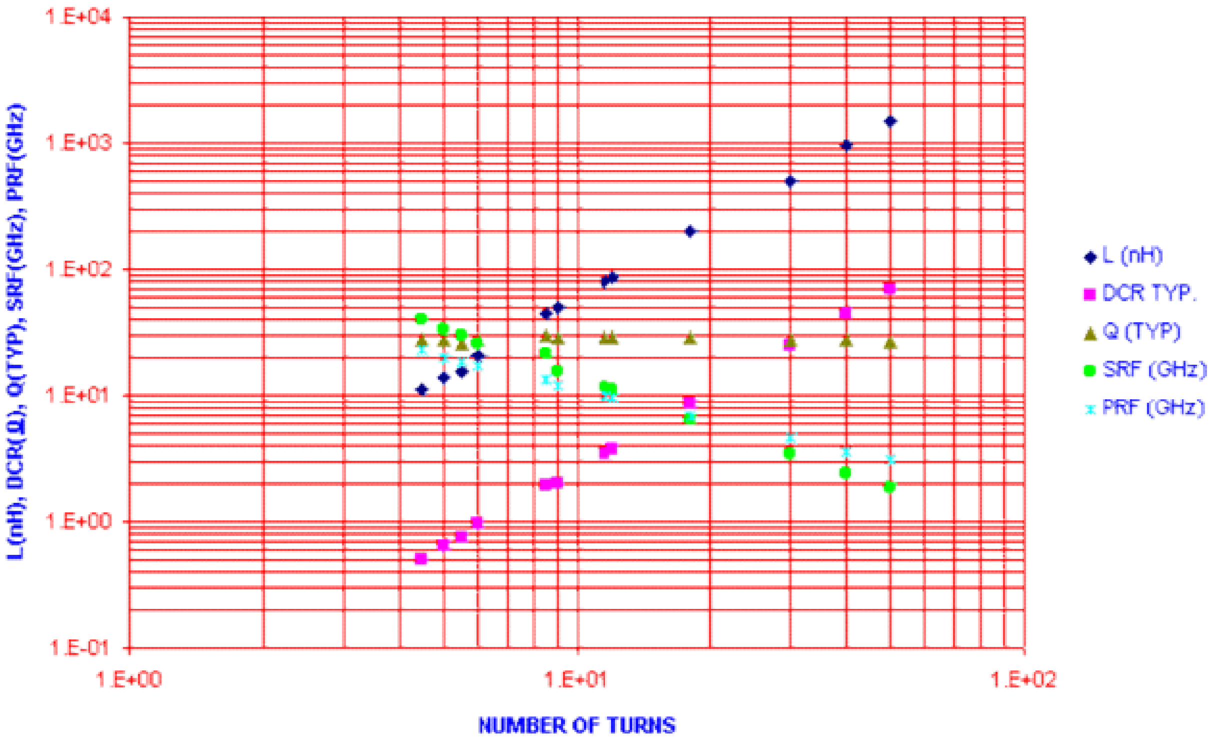
The LX2500Q20-L02-02nH Series of spiral chip inductors are designed to be used in chip and wire hybrid circuits as RF choke in power supplies and microwave circuit resonant elements. When used as chokes, a modest Q is desirable while in oscillators Q has to be as high as possible. U.S. Microwaves advanced thin film technologies allow for an important reduction of the DCR max, which translates into an increased Q. For spirals with w+s=25µm, Q values between 25 and 30 are obtained which represent a better compromise between the two applications. For lowest capacitance and higher self resonance, the LX2500Q20-L02-02nH spiral chip inductors are manufactured on 20 mil thick quartz (SiO2) substrates. Application notes AN 102, AN 112 and AN 113 are describing assembly methods for best performance.
Manufactured with 99.9% pure gold, the spiral inductor chip does not need any protection and can operate even in hostile environments. Designed and manufactured by US Microwaves in 1990 for military and industrial applications, the spiral chip inductors now can find their place in optoelectronic and wireless consumer products as well.

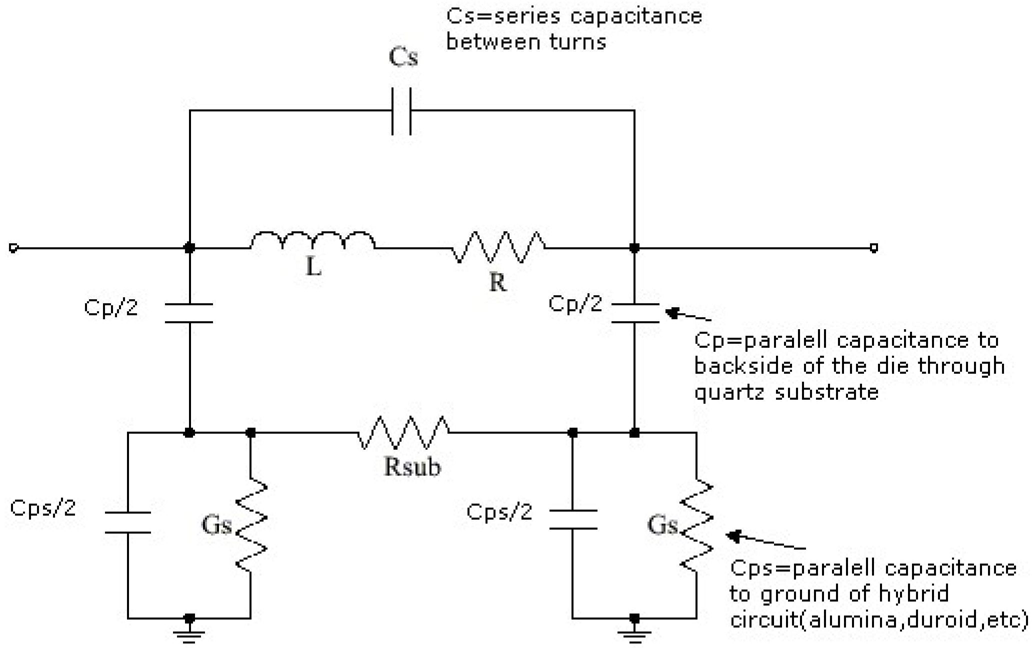
TECHNOLOGY DESCRIPTION: SEMICONDUCTOR-THIN FILM MANUFACTURING

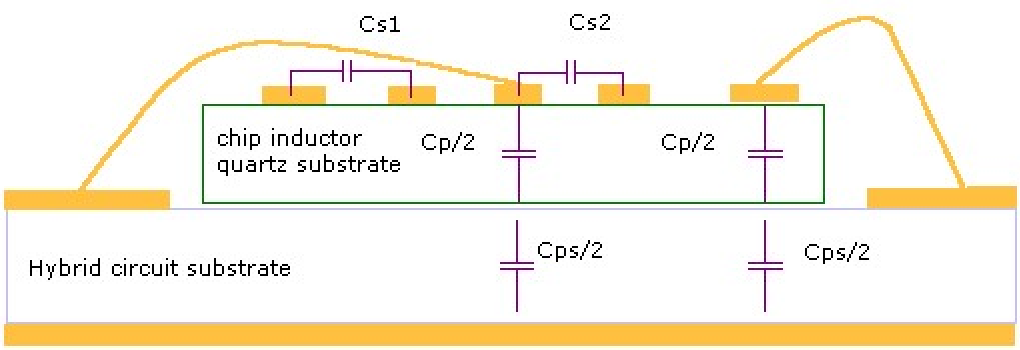
All thin film microwave products are manufactured using advanced semiconductors and thin film technologies including ultra-stable and self passivating Tantalum Nitride resistors, gold interconnect metallization and reliable MNOS capacitors to achieve excellent uniformity, performance and reliability. Thin film technology is the preferred solution for all applications that require low noise, long term stability and excellent performance at very high frequencies. US Microwaves employs proprietary thin film technologies for deposition of a wide range of resistive films with sheet resistance films from 1Ω/sq to 10,000Ω/sq. All US Microwaves products are available in die form and are ideal for high reliability hybrid and multi chip module applications. All US Microwaves products are manufactured using GOLDCHIP TECHNOLOGY™ a trade mark of Semiconix Corporation.

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUE	UNITS
Number of turns	2	
Inductance	2	nH
Inductance Tolerance: Absolute, +25°C	±20.0	%
DC Resistance	typ. 0.4	Ω
Current Rating: Max. @ + 70°C	typ. 100	mA
Quality Factor Q @ 100MHz	typ. 26.1	
Series Self Resonance SRF	typ. 78	GHz
Parallell Self Resonance PRF	typ. 39.5	GHz
Operating Temperature Range	- 55 to + 125	°C
Storage Temperature Range	-55 to +125	°C





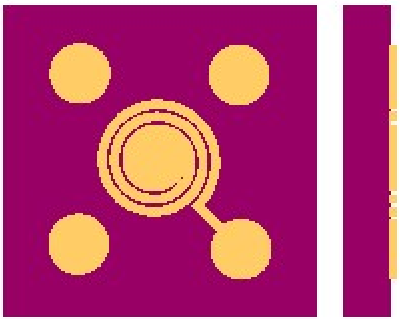


Capacitance modeling for Spiral chip inductors mounted on thick insulating substrate.
Example shows a 2 turns spiral inductor.

GENERAL DIE INFORMATION				
Substrate	Thickness (mils)	Die size (mils)	Bonding pads	Backside metal
SiO2 - Quartz	20±1	25x25±3	min 4x4 mils, 3µm thick, 99.99% electroplated gold with a TiW barrier	Backside of the die is NOT metallized. Standard TiW/Au or custom metallization is available for special orders.

All US Microwaves products are available in die form. Typical delivery for die products is 2-3 weeks ARO. For Custom designs, delivery is 3-4 weeks ARO. Certain items may be available from stock. Inventory is periodically updated. All devices for chip and wire applications are 100% tested, visual inspected and shipped in waffle packs (WP). For high volume automated assembly, MIS chip capacitors are supplied as 4" wafers 100% tested, inked and diced on expanded film frame (FF).

DIE LAYOUT - MECHANICAL SPECIFICATIONS



US MICROWAVES

Advanced Microwave Components

HIGH Q FACTOR SPIRAL CHIP INDUCTORS

LX2500Q20-L03-04nH

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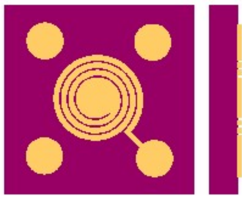
Spiral Chip Inductors Lab kits are available from stock: L-Kit

SPIRAL CHIP INDUCTOR



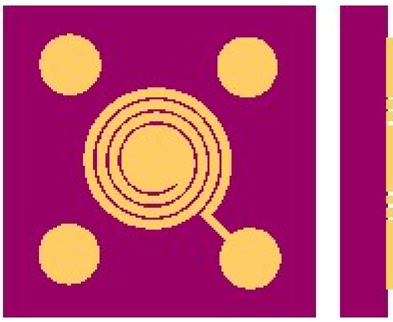
PRODUCT DESCRIPTION AND SHORT APPLICATION NOTE

The LX2500Q20-L03-04nH Series of spiral chip inductors are designed to be used in chip and wire hybrid circuits as RF choke in power supplies and microwave circuit resonant elements. When used as chokes, a modest Q is desirable while in oscillators Q has to be as high as possible. U.S. Microwaves advanced thin film technologies allow for an important reduction of the DCR max, which translates into an increased Q. For spirals with w+s=25µm, Q values between 25 and 30 are obtained which represent a better compromise between the two applications. For lowest capacitance and higher self resonance, the LX2500Q20-L03-04nH spiral chip inductors are manufactured on 20 mil thick quartz (SiO2) substrates. Application notes AN 102, AN 112 and AN 113 are describing assembly methods for best performance.
Manufactured with 99.9% pure gold, the spiral inductor chip does not need any protection and can operate even in hostile environments. Designed and manufactured by US Microwaves in 1990 for military and industrial applications, the spiral chip inductors now can find their place in optoelectronic and wireless consumer products as well.

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUE	UNITS
Number of turns	3	
Inductance	4	nH
Inductance Tolerance: Absolute, +25°C	±20.0	%
DC Resistance	typ. 0.7	Ω
Current Rating: Max. @ + 70°C	typ. 100	mA
Quality Factor Q @ 100MHz	typ. 26.7	
Series Self Resonance SRF	typ. 63	GHz
Parallell Self Resonance PRF	typ. 32.9	GHz
Operating Temperature Range	- 55 to + 125	°C
Storage Temperature Range	-55 to +125	°C

DIE LAYOUT - MECHANICAL SPECIFICATIONS



US MICROWAVES

Advanced Microwave Components

HIGH Q FACTOR SPIRAL CHIP INDUCTORS

LX2500Q20-L05-14nH

FEATURES

Spiral chip inductors are available in 3 different die dimensions:
- For 1 turn to 21 turns series the die size is 0.050"x0.050"x0.020".
- For 1 turn to 12 turns the die size is 0.030"x0.030"x0.020".
- For 1 turn to 8 turns the die size is 0.025"x0.025"x0.020".

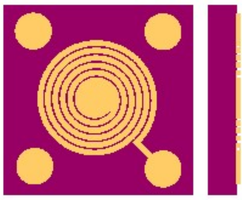
Spiral chip inductors are manufactured on quartz (SiO_2), 20 mils thick, for lowest capacitance and highest SRF and PRF. The LX2500Q20-L05-14nH spiral chip inductors are manufactured on quartz (SiO_2), 20 mils thick.

APPLICATIONS

These devices can be used over the full military temperature range -55°C to +125°C. Quality and workmanship is per MIL-S-883. Devices are 100% tested, visual inspected and packaged in waffle packs.

Spiral Chip Inductors Lab kits are available from stock: L-Kit

SPIRAL CHIP INDUCTOR



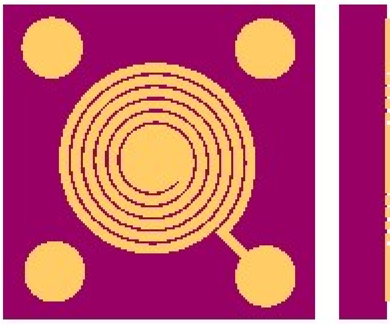
PRODUCT DESCRIPTION AND SHORT APPLICATION NOTE

The LX2500Q20-L05-14nH Series of spiral chip inductors are designed to be used in chip and wire hybrid circuits as RF choke in power supplies and microwave circuit resonant elements. When used as chokes, a modest Q is desirable while in oscillators Q has to be as high as possible. U.S. Microwaves advanced thin film technologies allow for an important reduction of the DCR max, which translates into an increased Q. For spirals with w+s=25µm, Q values between 25 and 30 are obtained which represent a better compromise between the two applications. For lowest capacitance and higher self resonance, the LX2500Q20-L05-14nH spiral chip inductors are manufactured on 20 mil thick quartz (SiO_2) substrates. Application notes AN 102, AN 112 and AN 113 are describing assembly methods for best performance.
Manufactured with 99.9% pure gold, the spiral inductor chip does not need any protection and can operate even in hostile environments. Designed and manufactured by US Microwaves in 1990 for military and industrial applications, the spiral chip inductors now can find their place in optoelectronic and wireless consumer products as well.

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUE	UNITS
Number of turns	5	
Inductance	14	nH
Inductance Tolerance: Absolute, +25°C	±20.0	%
DC Resistance	typ. 1.7	Ω
Current Rating: Max. @ + 70°C	typ. 100	mA
Quality Factor Q @ 100MHz	typ. 27.9	
Series Self Resonance SRF	typ. 33	GHz
Parallell Self Resonance PRF	typ. 19.7	GHz
Operating Temperature Range	- 55 to + 125	°C
Storage Temperature Range	-55 to +125	°C

DIE LAYOUT - MECHANICAL SPECIFICATIONS



US MICROWAVES

Advanced Microwave Components

HIGH Q FACTOR SPIRAL CHIP INDUCTORS

LX2500Q20NH-L3.6T-7nH

FEATURES

Spiral chip inductors are available in 3 different die dimensions:

- For 1 turn to 21 turns series the die size is 0.050"x0.050"x0.020".
- For 1 turn to 12 turns the die size is 0.030"x0.030"x0.020".
- For 1 turn to 8 turns the die size is 0.025"x0.025"x0.020".

Spiral chip inductors are manufactured on quartz (SiO2), 20 mils thick, for lowest capacitance and highest SRF and PRF. The LX2500Q20NH-L3.6T-7nH spiral chip inductors are manufactured on quartz (SiO2), 20 mils thick.

APPLICATIONS

These devices can be used over the full military temperature range -55°C to +125°C. Quality and workmanship is per MIL-S-883. Devices are 100% tested, visual inspected and packaged in waffle packs.

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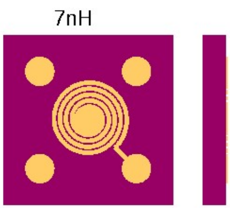
SPIRAL CHIP INDUCTOR



PRODUCT DESCRIPTION AND SHORT APPLICATION NOTE

The LX2500Q20NH-L3.6T-7nH Series of spiral chip inductors are designed to be used in chip and wire hybrid circuits as RF choke in power supplies and microwave circuit resonant elements. When used as chokes, a modest Q is desirable while in oscillators Q has to be as high as possible. U.S. Microwaves advanced thin film technologies allow for an important reduction of the DCR max, which translates into an increased Q. For spirals with w+s=25µm, Q values between 25 and 30 are obtained which represent a better compromise between the two applications. For lowest capacitance and higher self resonance, the LX2500Q20NH-L3.6T-7nH spiral chip inductors are manufactured on 20 mil thick quartz (SiO2) substrates. Application notes AN 102, AN 112 and AN 113 are describing assembly methods for best performance. Manufactured with 99.9% pure gold, the spiral inductor chip does not need any protection and can operate even in hostile environments. Designed and manufactured by US Microwaves in 1990 for military and industrial applications, the spiral chip inductors now can find their place in optoelectronic and wireless consumer products as well.

ELECTRICAL CHARACTERISTICS

PARAMETER	VALUE	UNITS
Number of turns	3.6	
Inductance	7	nH
Inductance Tolerance: Absolute, +25°C	±20.0	%
DC Resistance	typ. 1.4	Ω
Current Rating: Max. @ + 70°C	typ. 100	mA
Quality Factor Q @ 100MHz	typ. >25	
Series Self Resonance SRF	typ. 24.4	GHz
Parallell Self Resonance PRF	typ. 15.6	GHz
Operating Temperature Range	- 55 to + 125	°C
Storage Temperature Range	-55 to +125	°C

DIE LAYOUT - MECHANICAL SPECIFICATIONS