Nízkošumové zesilovače pro 10 GHz a jejich měření

Mirek Kasal, OK2AQ

ok2aq@amsat.org

mirek@kasals.com

EME a MW seminář 2014

Tři Studně, Duben 11- 13, 2014

Přehled

1. Úvod
2. Výběr aktivních prvků pro LNA na 10 GHz
3. Lineární model dvoustupňového LNA
4. Vazba s vlnovodem
5. Layout a konstrukce LNA
6. Měření šumového čísla
7. Měření LNA s ozařovačem
8. Závěr

Úvod

Eltasat.cz

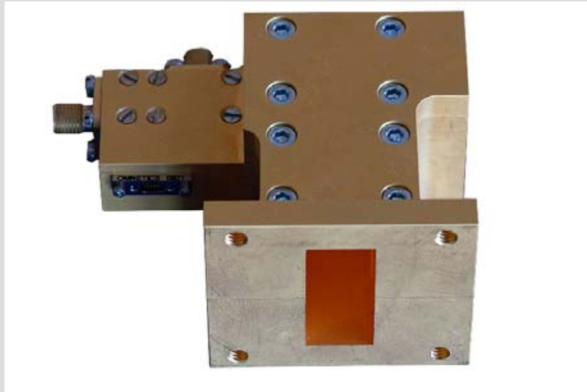
F = 0,1 dB 459.- Kč

Eltasat.cz

F = 0,3 dB 99.- Kč

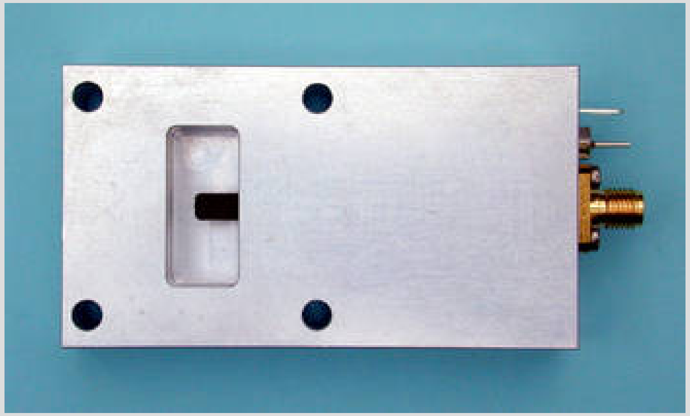
lownoisefactory.com

F = 0,09 dB

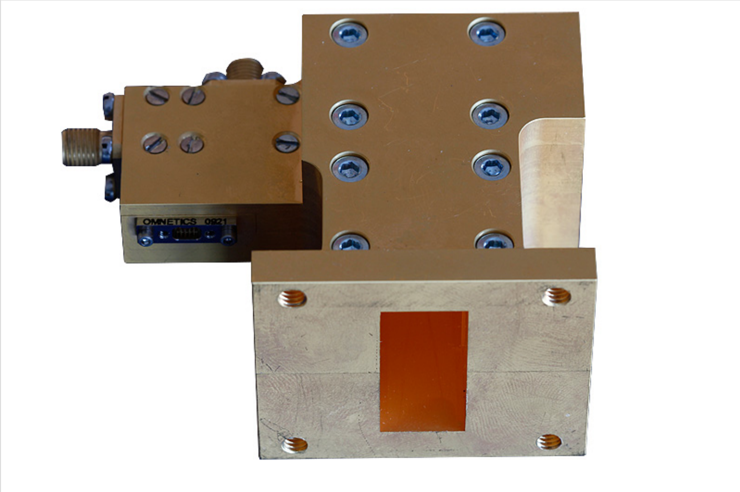


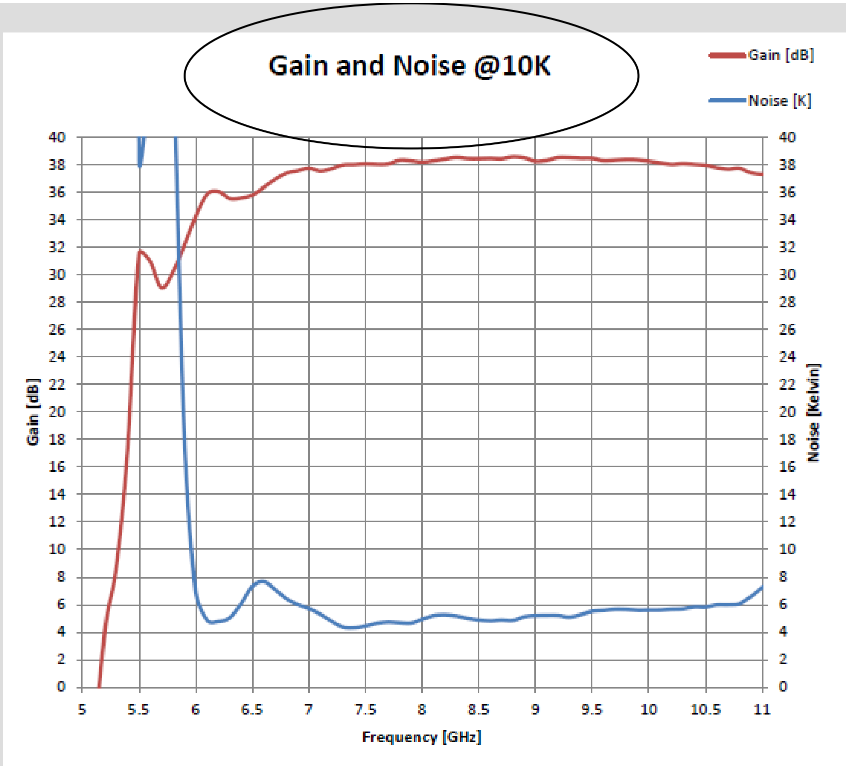
DB6NT

F = 0,7 dB&18C
G = 22 dB
R100
239 €

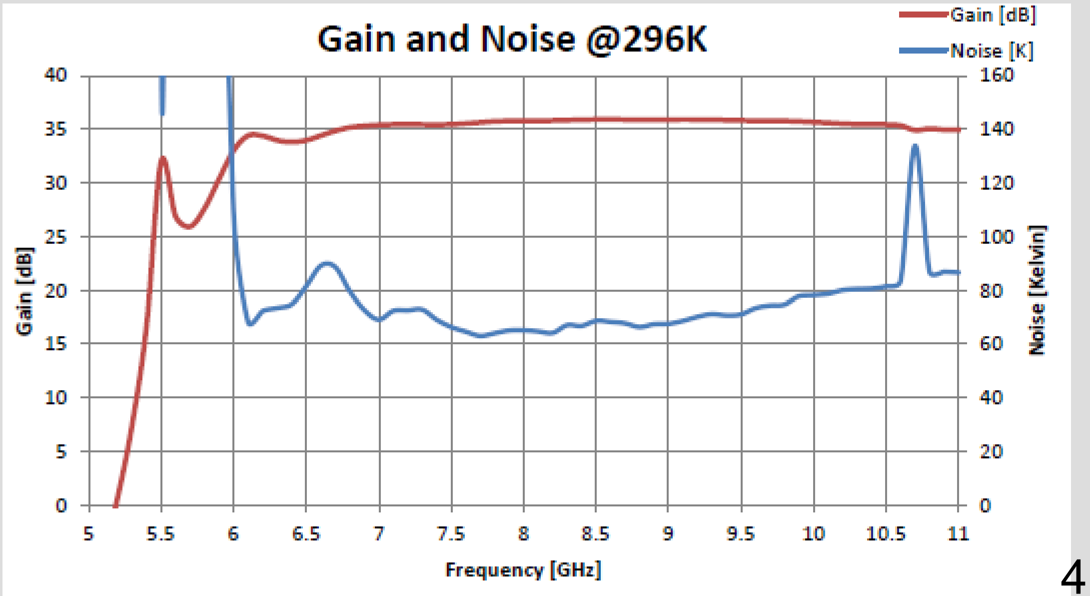


lownoisefactory.com





Te = 6 K => F = 0,09 dB & 296 K



Te = 80 K => F = 1,04 dB & 296 K

< Low Noise GaAs HEMT >

MGF4953A

Leadless ceramic package

DESCRIPTION

The MGF4953A super-low noise InGaAs HEMT (High El
Transistor) is designed for use in C to K band amplifiers.
The lead-less ceramic package assures minimum parasitic

FEATURES

Low noise figure @ f=12GHz
NFmin. = 0.35dB (Typ.)
High associated gain @ f=12GHz
Gs = 13.5dB (Typ.)

NEC

ULTRA LOW NOISE PSEUDOMORPHIC HJ FET

NE32584C

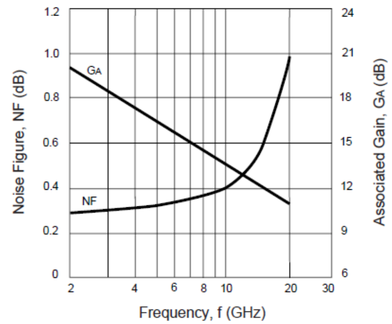
FEATURES

- **VERY LOW NOISE FIGURE:** 0.45 dB Typical at 12 GHz
- **HIGH ASSOCIATED GAIN:** 12.5 dB Typical at 12 GHz
- **$L_G \leq 0.20$ µm, $W_G = 200$ µm**
- **LOW COST METAL CERAMIC PACKAGE**
- **TAPE & REEL PACKAGING OPTION AVAILABLE**

DESCRIPTION

The NE32584C is a pseudomorphic Hetero-Junction FET that uses the junction between Si-doped AlGaAs and undoped InGaAs to create very high mobility electrons. The device features mushroom shaped TiAl gates for decreased gate resistance and improved power handling capabilities. The mushroom gate also results in lower noise figure and high associated gain. This device is housed in an epoxy-sealed, metal/ceramic package and is intended for high volume consumer and industrial applications.

NOISE FIGURE & ASSOCIATED GAIN vs. FREQUENCY
$V_{DS} = 2$ V, $I_{DS} = 10$ mA



CEL

HETERO JUNCTIO

NE3511S02

X TO Ku BAND SUPER LOW NOISE AMPLIFIER N-CHANNEL HJ-FET

FEATURES

- Super low noise figure and high associated gain
  NF = 0.30 dB TYP., G_a = 13.5 dB TYP. @ f = 12 GHz
- Micro-X plastic (S02) package

TRANSCOM

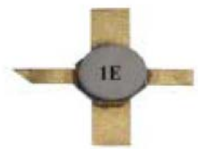
TC2281
REV4_20070504

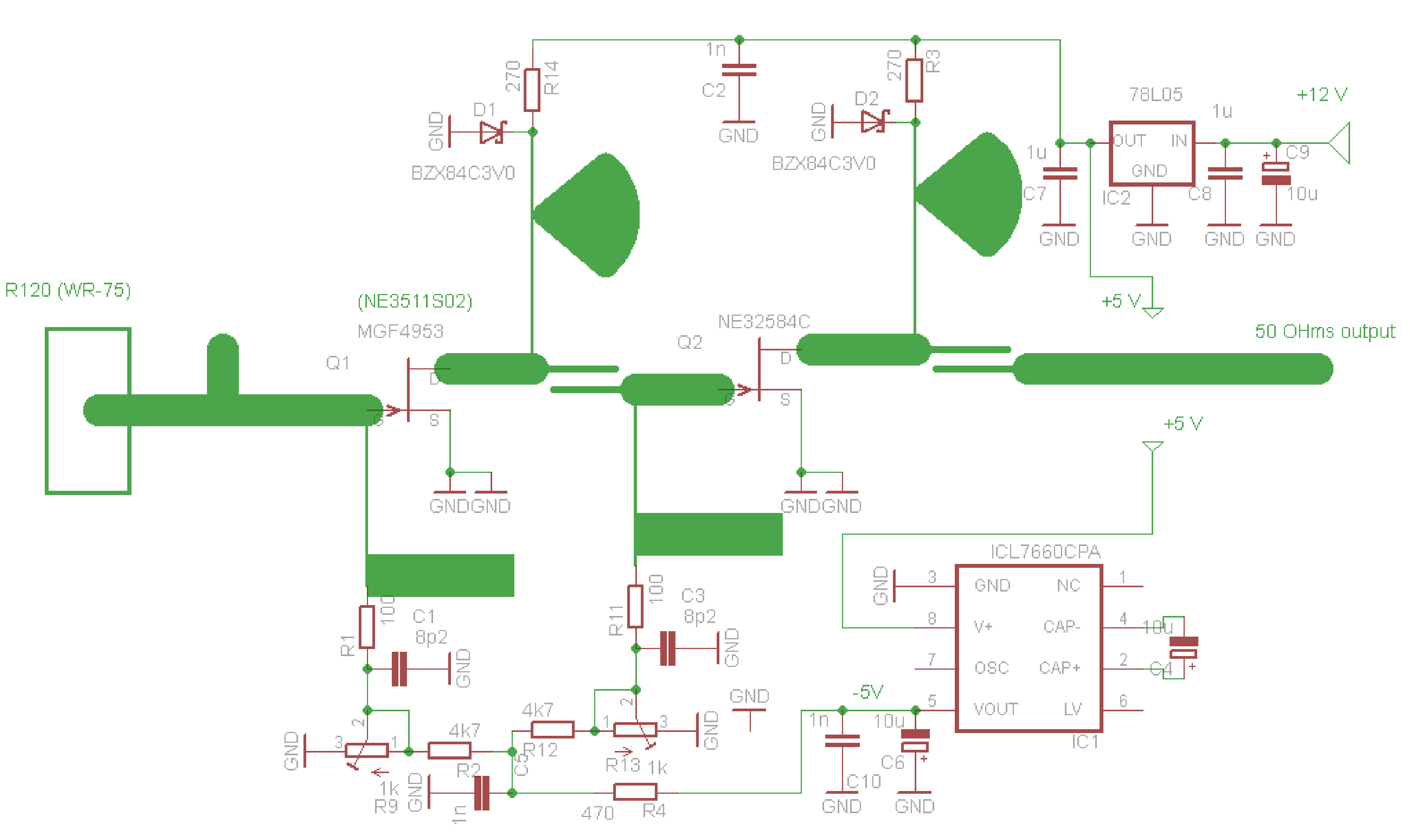
Low Noise and High Dynamic Range Packaged GaAs FETs

FEATURES

- 0.5 dB Typical Noise Figure at 12 GHz
- High Associated Gain: Ga = 12 dB Typical at 12 GHz
- 21.5 dBm Typical Power at 12 GHz
- 12 dB Typical Linear Power Gain at 12 GHz
- Breakdown Voltage : $BV_{DGO} \geq 9$ V
- Lg = 0.25 µm, Wg = 300 µm
- Tight Vp ranges control
- High RF input power handling capability

PHOTO ENLARGEMENT




R120 (WR-75)
(NE3511S02)
MGF4953
Q1
Q2
NE32584C
D1
D2
BZX84C3V0
BZX84C3V0
270
R14
270
R3
1n
C2
GND
78L05
+12 V
1u
C9
10u
OUT
IN
GND
IC2
C8
1u
C7
+5 V
50 OHms output
+5 V
ICL7660CPA
GND
NC
V+
CAP-
OSC
CAP+
VOUT
LV
IC1
10u
C4
-5V
1n
10u
C6
C10
100
R1
C1
8p2
100
R11
C3
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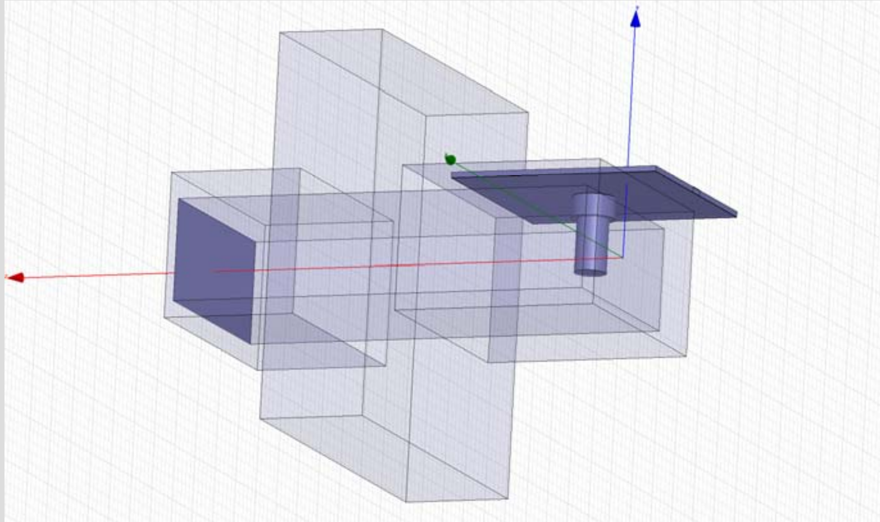
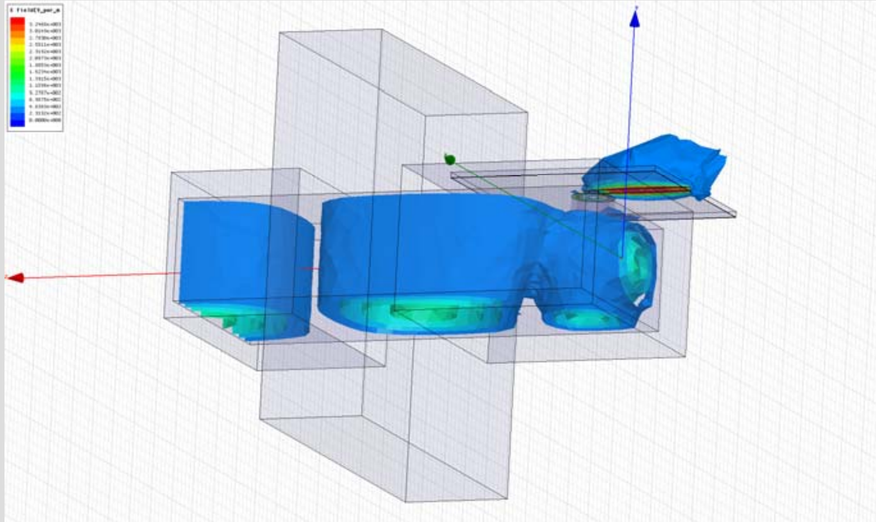
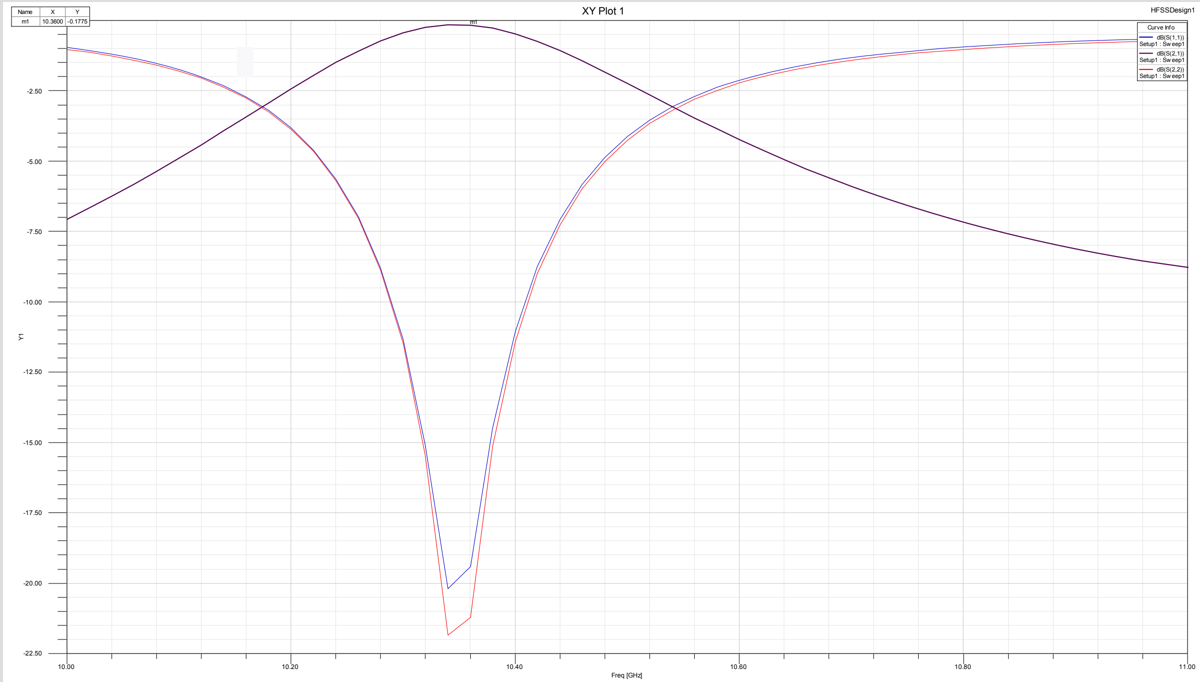
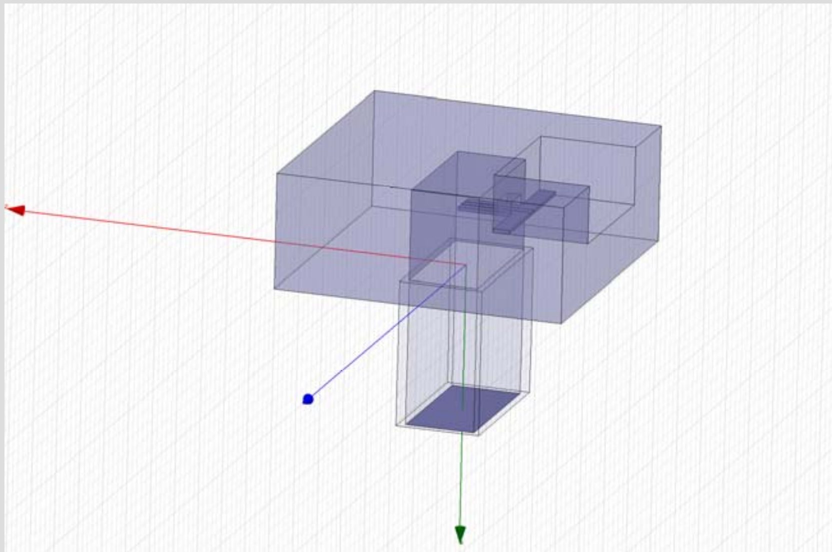
4k7
R2
4k7
R12
C5
R13
1k
1k
R9
1n
470
R4

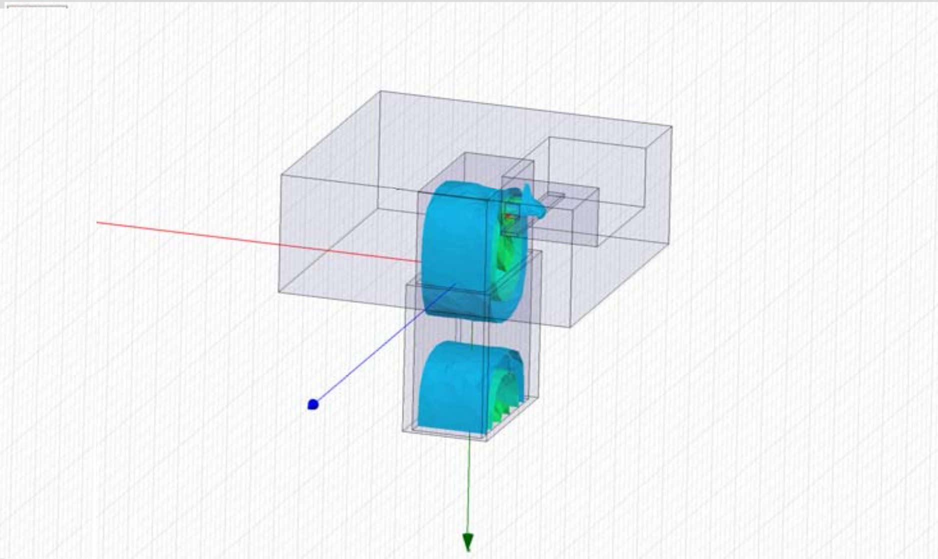


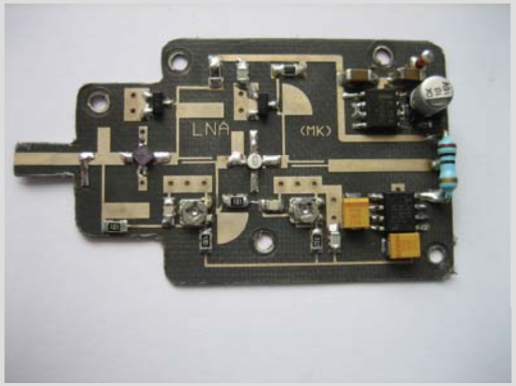


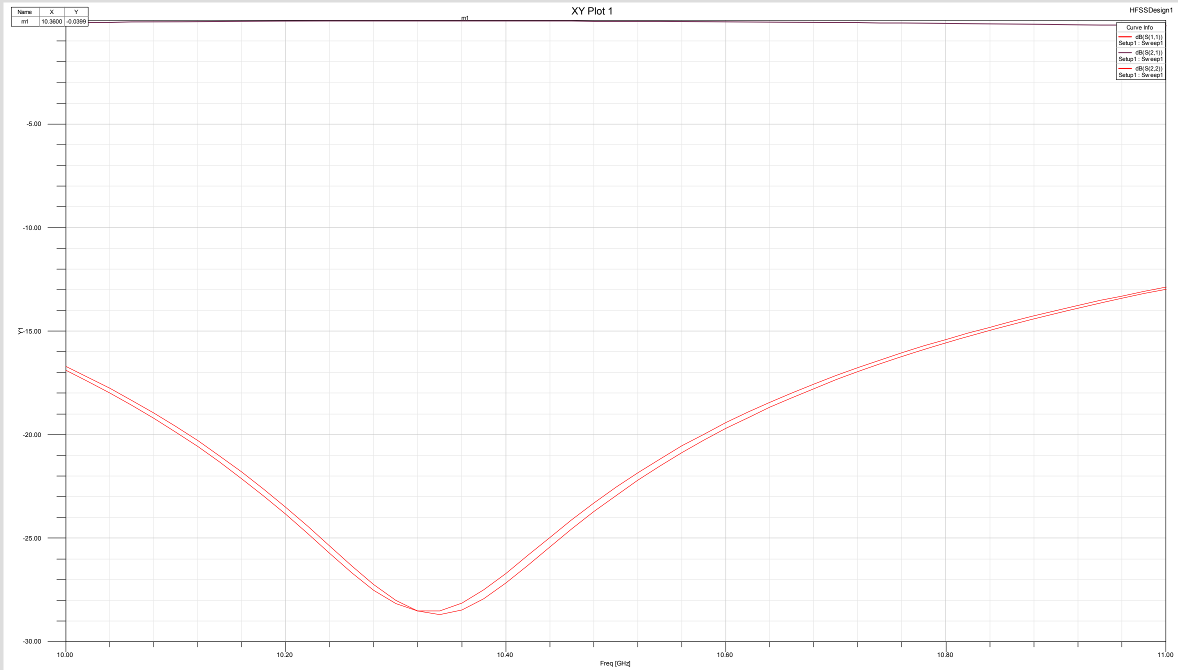


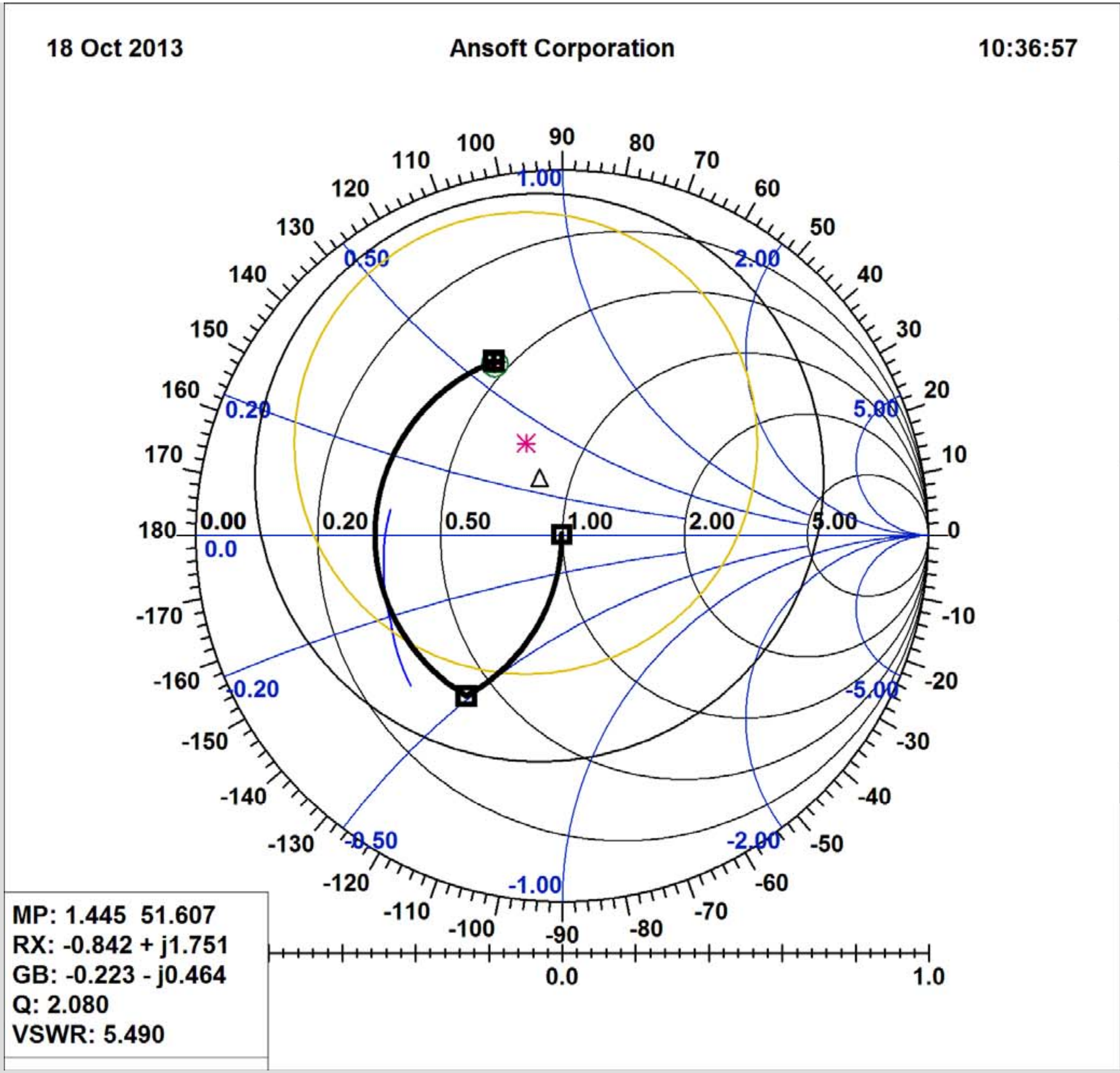
XY Plot 1
HFSSDesign1
Name X Y
m1 10.3600 -0.1775
Curve Info
dB(S(1,1)) Setup1 : Sweep1
dB(S(2,1)) Setup1 : Sweep1
dB(S(2,2)) Setup1 : Sweep1
-2.50
-5.00
-7.50
-10.00
-12.50
-15.00
-17.50
-20.00
-22.50
Y1
10.00
10.20
10.40
10.60
10.80
11.00
Freq [GHz]






LNA
(MK)


Name X Y
m1 10.3600 -0.0399
XY Plot 1
HFSSDesign1
m1
Curve Info
dB(S(1,1)) Setup1 : Sweep1
dB(S(2,1)) Setup1 : Sweep1
dB(S(2,2)) Setup1 : Sweep1
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
Y1
10.00
10.20
10.40
10.60
10.80
11.00
Freq [GHz]



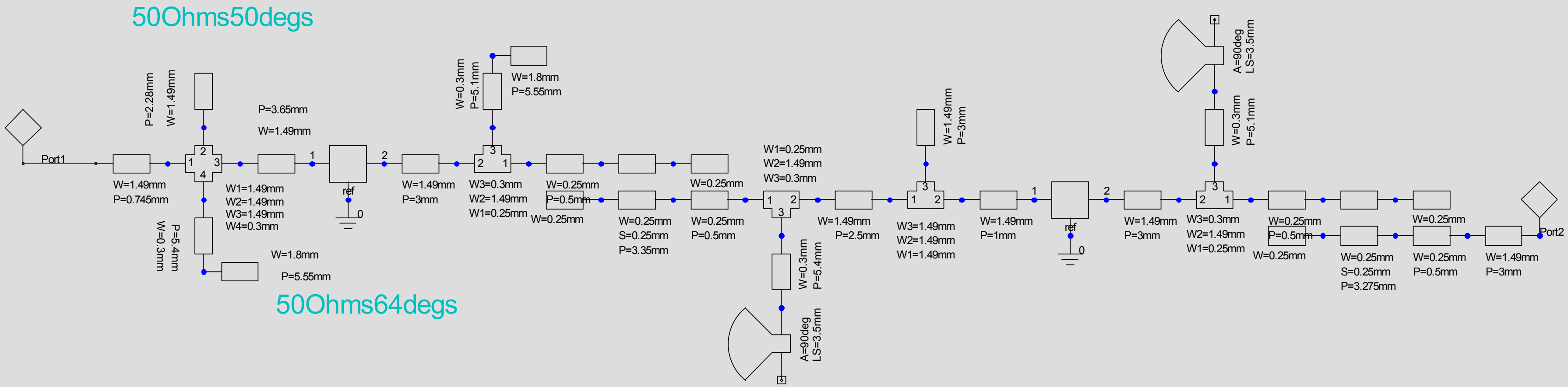
S11
9.00GHz-12.00GHz
NWA1

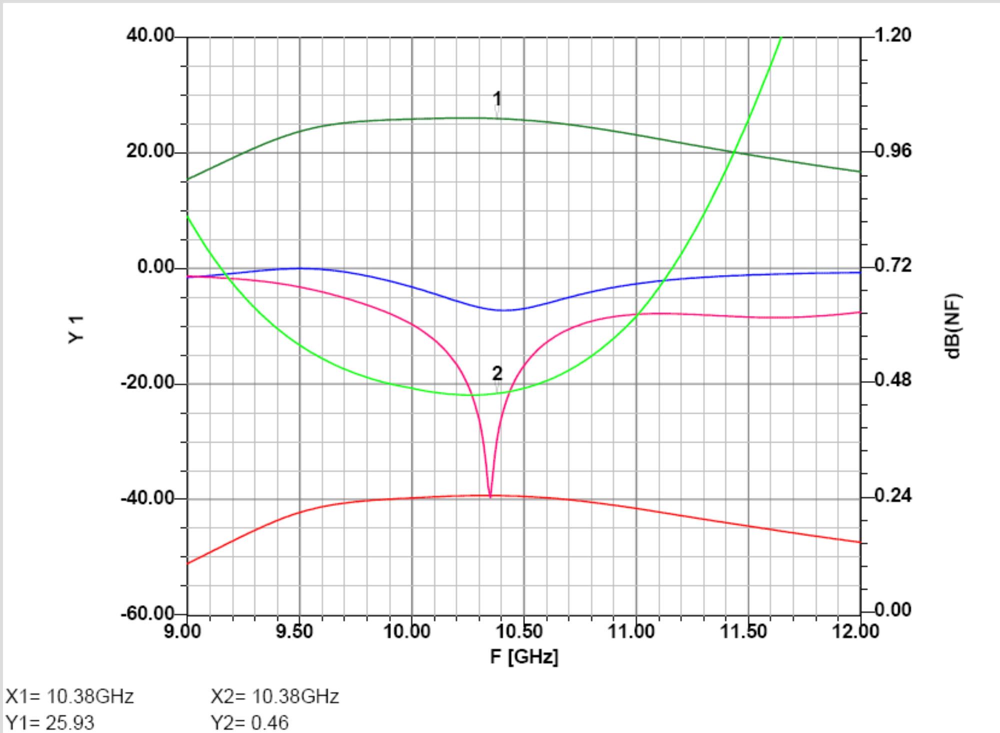
NC(ckt = Circuit1 value = 0.36dB)
10.37GHz
NWA1

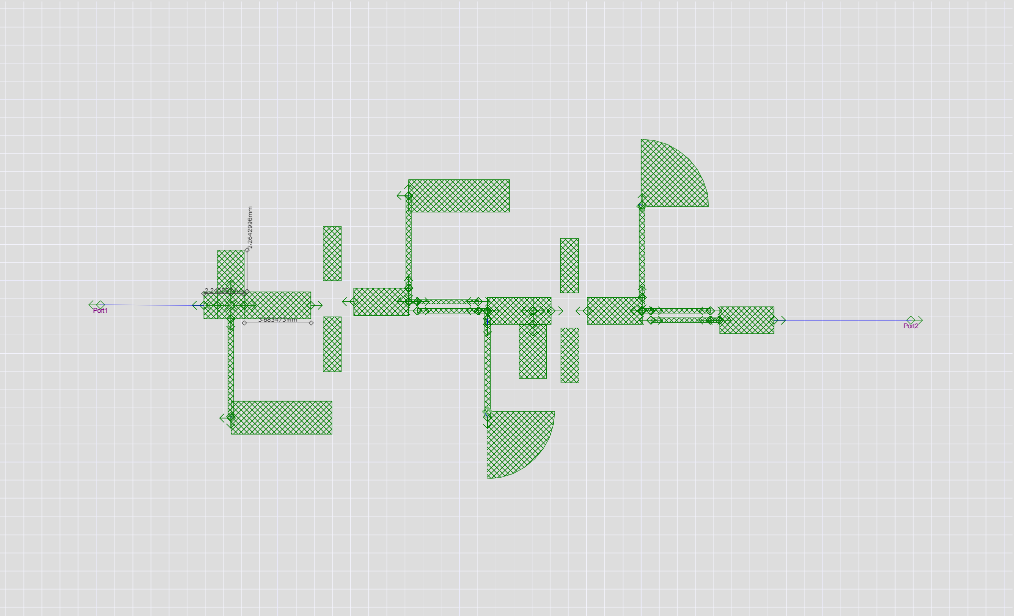
NC(ckt = Circuit1 value = 0.36dB)
10.37GHz
NWA1

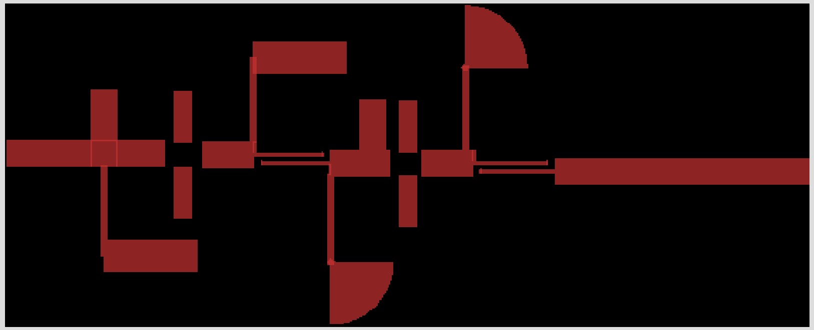
NC(ckt = Circuit1 value = 1.36dB)
10.37GHz
NWA1

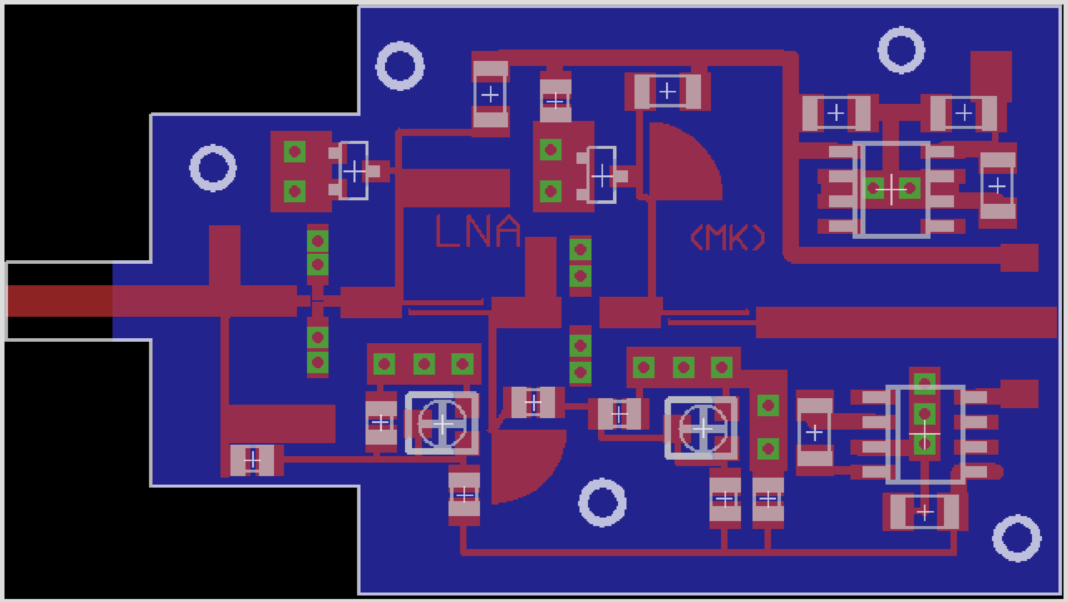
NC(ckt = Circuit1 value = 2.36dB)
10.37GHz
NWA1

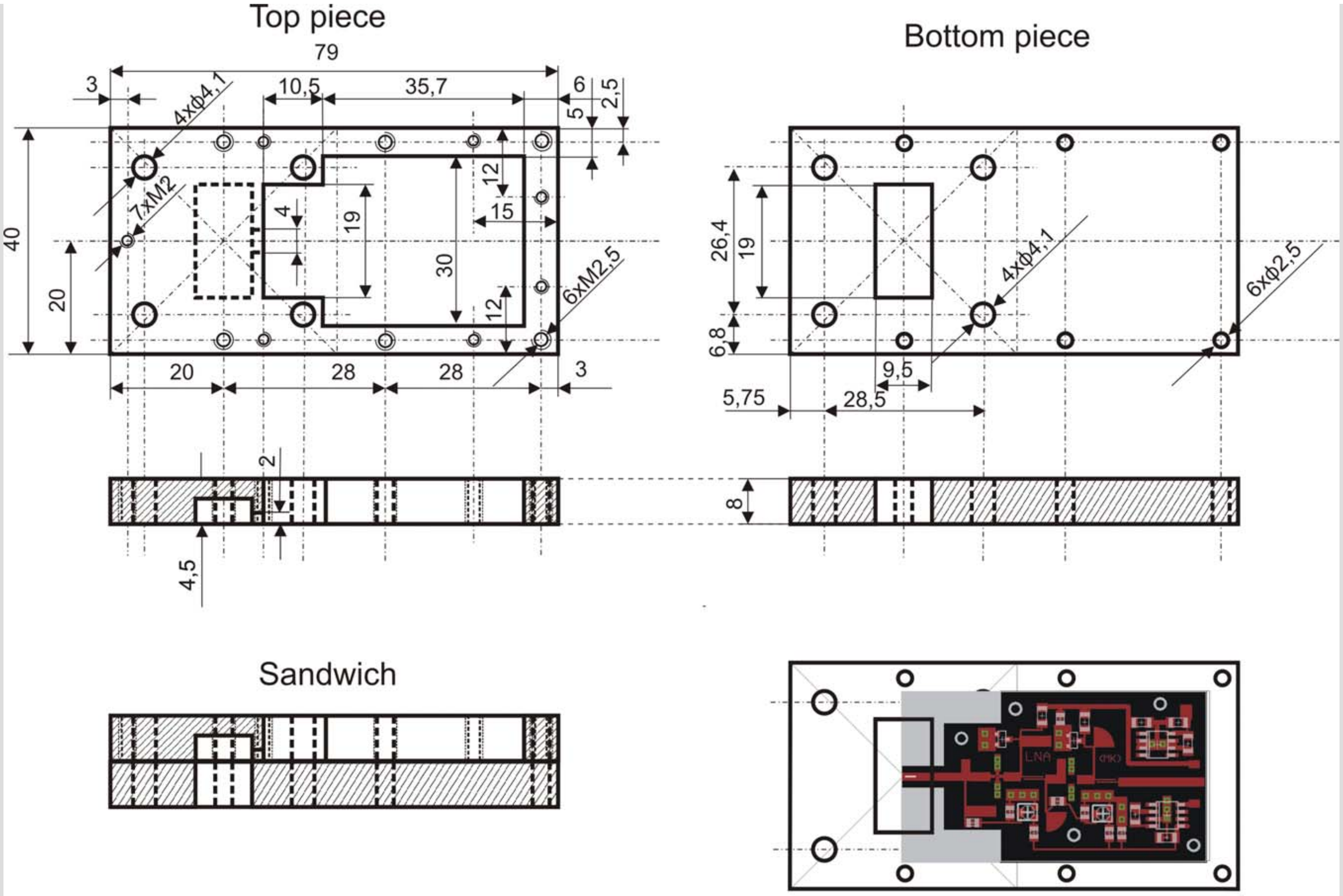

50Ohms50degs
50Ohms64degs
Port1
Port2


Y 1
dB(NF)
F [GHz]
X1= 10.38GHz
Y1= 25.93
X2= 10.38GHz
Y2= 0.46

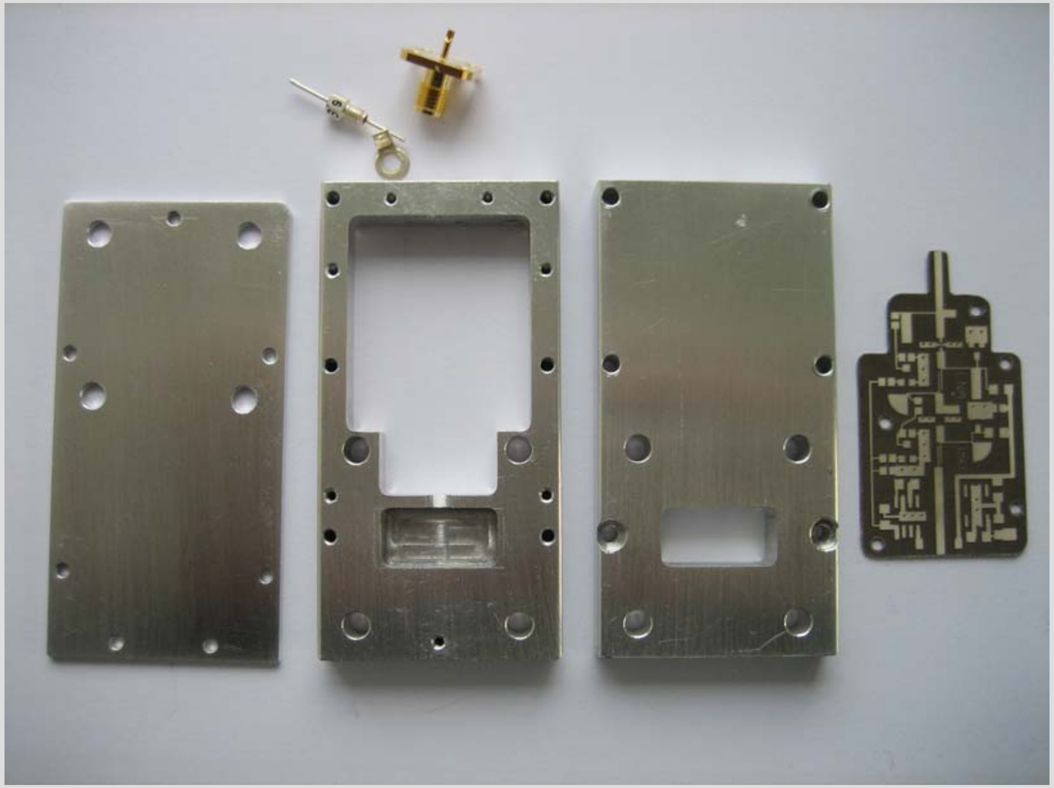


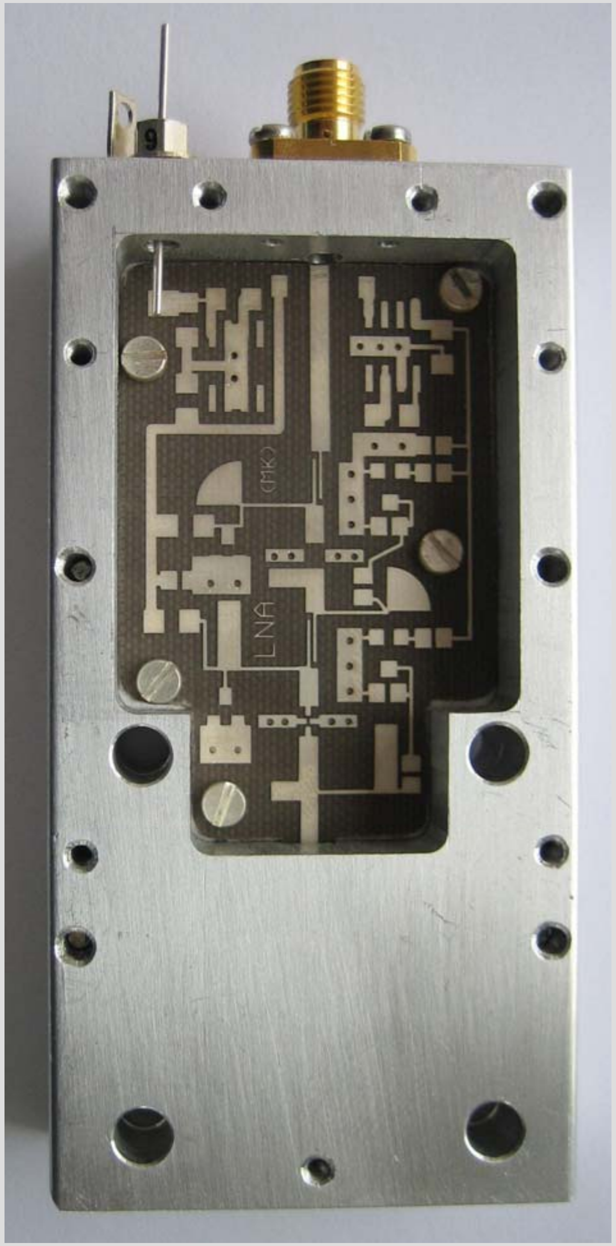


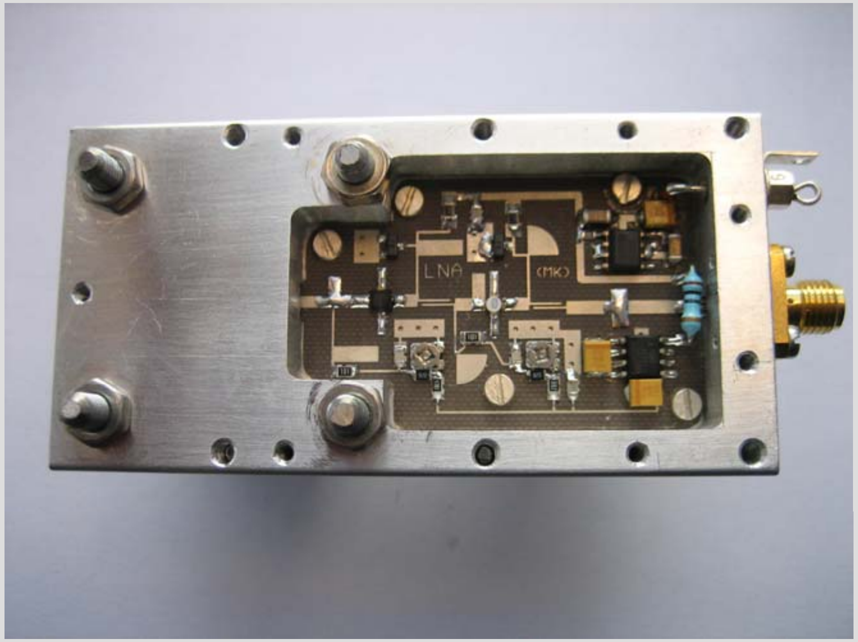

LNA
<MK>


Top piece
Bottom piece
Sandwich
79
3
10,5
35,7
6
2,5
5
4x⌀4,1
7xM2
6xM2,5
4
19
30
12
15
12
40
20
20
28
28
3
2
4,5
8
26,4
19
6,8
4x⌀4,1
6x⌀2,5
9,5
5,75
28,5
LNA

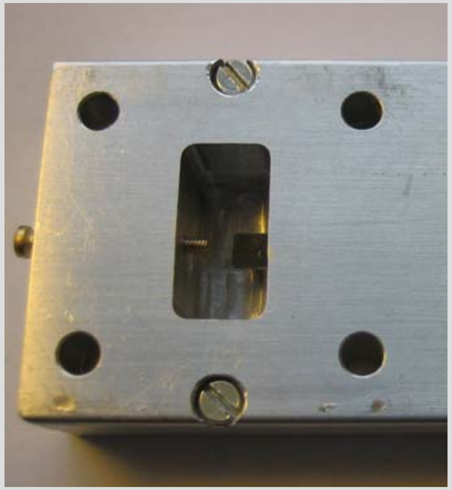
X-Band LNA (MK)

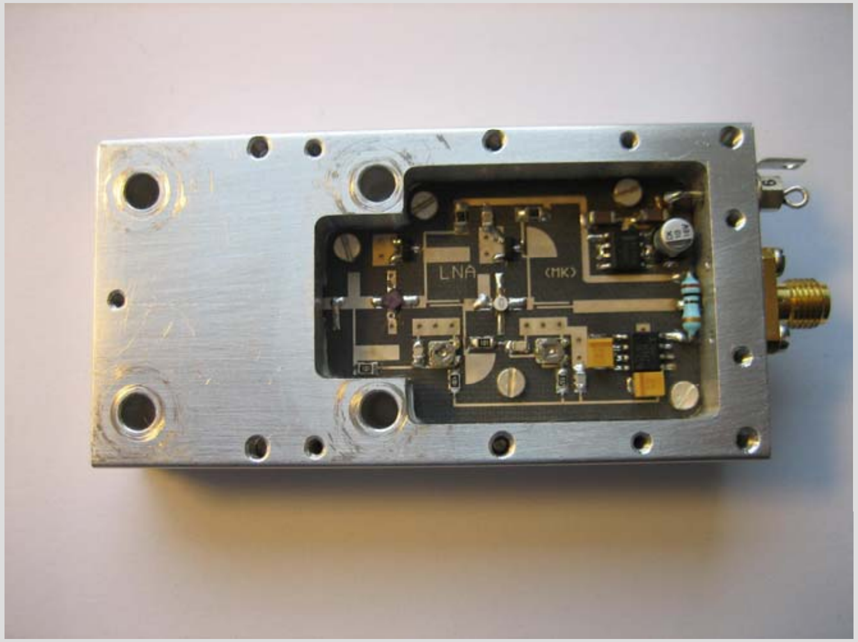




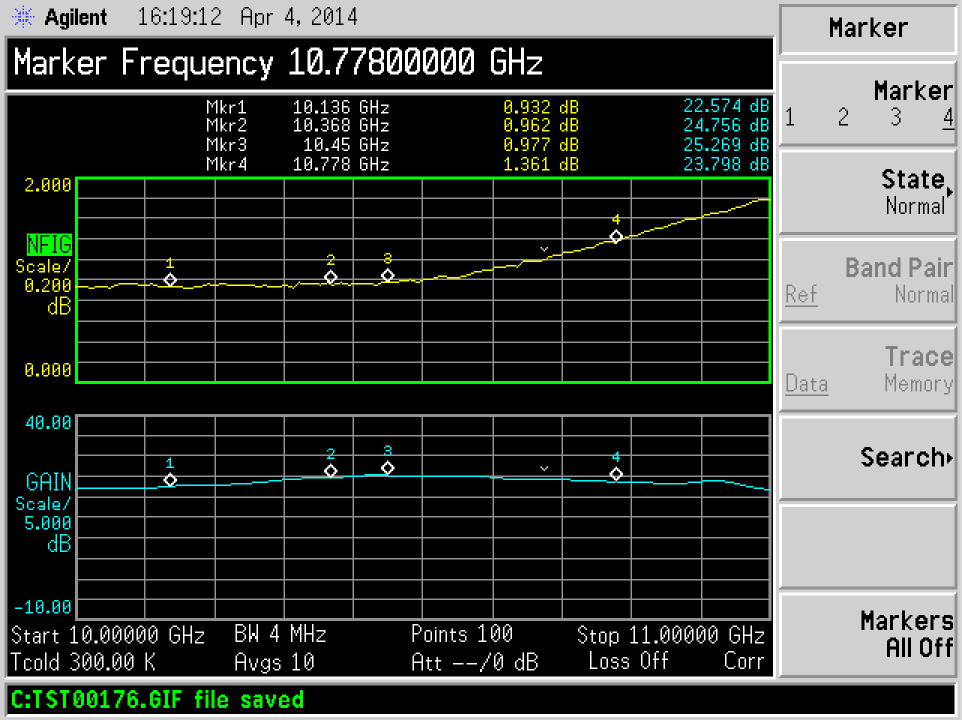


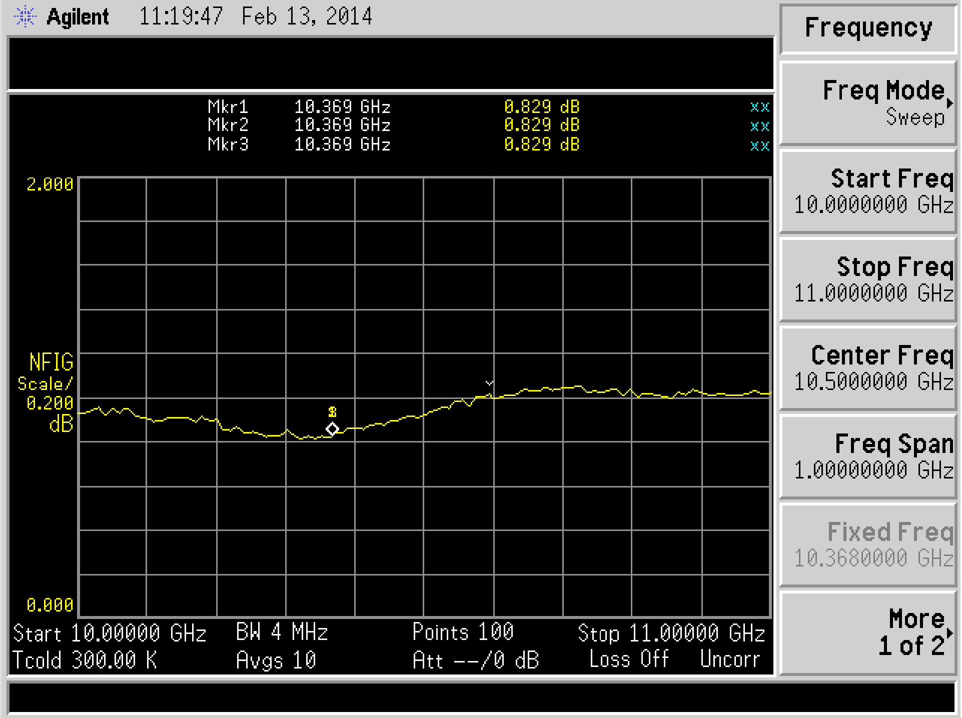
NE3511S02
DiCLAD 870





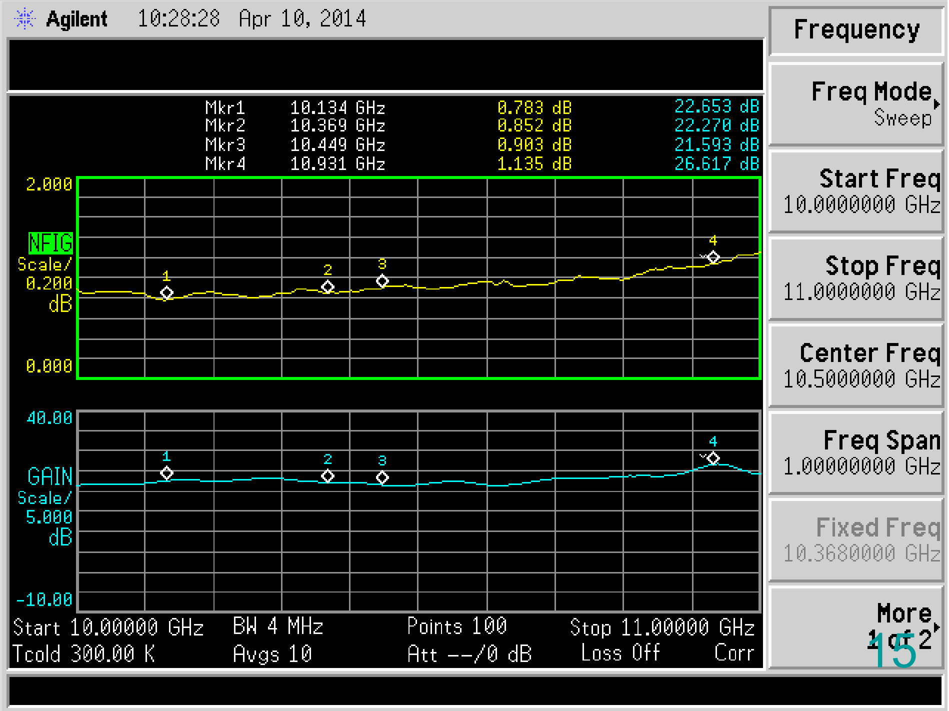
MGF4953A
Duroid 5880





MGF4953A

NE3511S02



$$F(\mathrm{dB}) = 10\log F$$

$$T_e = T_0(F-1) \qquad F = \frac{T_0 + T_e}{T_0}$$

$$T_{Rx} = 290(10^{0,7/10} - 1) = 50,7\ \mathrm{K}$$

$$F = \frac{ENR(T_c / T_0)}{Y-1}$$

N.F. Analyzer Agilent N8975A

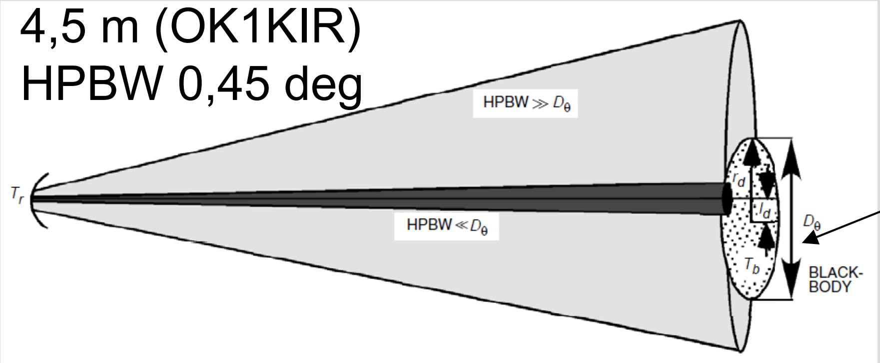
D	f	η	G	θ_{3dB}	SN	MN
m	MHz		dBi	deg	dB	dB
0,6	10368	0,6	34,1	3,38	3,504	0,076
0,8	10368	0,6	36,6	2,53	5,059	0,135
1	10368	0,6	38,5	2,03	6,480	0,208
1,8	10368	0,6	43,6	1,13	10,852	0,642
2,4	10368	0,6	46,1	0,84	13,192	1,083
3	10368	0,6	48,0	0,68	15,054	1,591
4,2	10368	0,6	51,0	0,48	17,910	2,711
4,5	10368	0,6	51,6	0,45	18,50	3,00

$$MN_{KIR} = 3\,\text{dB} \qquad \Delta G = G_{KIR} - G_{AQ} = 8\,\text{dB}$$

$$MN_{KIR} = \frac{N_M + N}{N} = \frac{N_M}{N} + 1 = 2 \Rightarrow \frac{N_M}{N} = 2 - 1 = 1 = 0\,\text{dB}$$

$$\left(\frac{N_M}{N}\right)_{AQ} = \left(\frac{N_M}{N}\right)_{KIR} - \Delta G = 0\,\text{dB} - 8\,\text{dB} = -8\,\text{dB} = 10^{-8/10} = 0{,}158$$

$$MN_{AQ} = \left(\frac{N_M}{N}\right)_{AQ} + 1 = 1{,}158 = 0{,}64\,\text{dB}$$



$$T_{bM} \approx 200\ \mathrm{K}$$

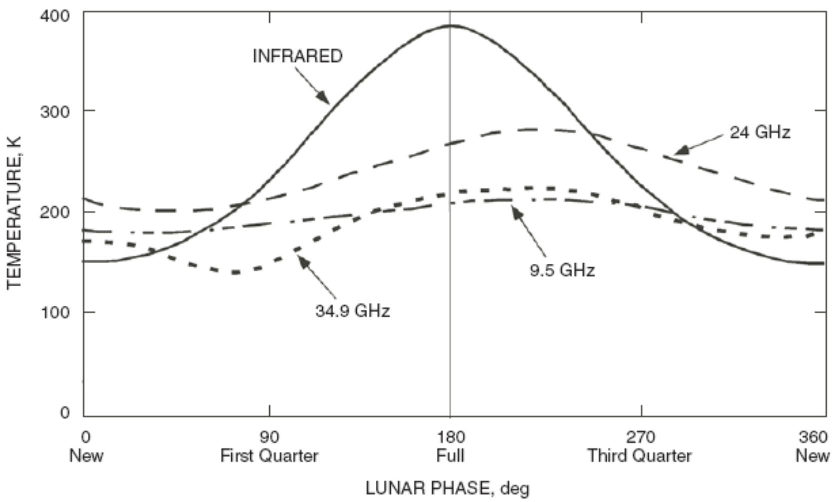
$$T_S = T_{SKY} + T_G + T_{bM} + T_{Rx}$$

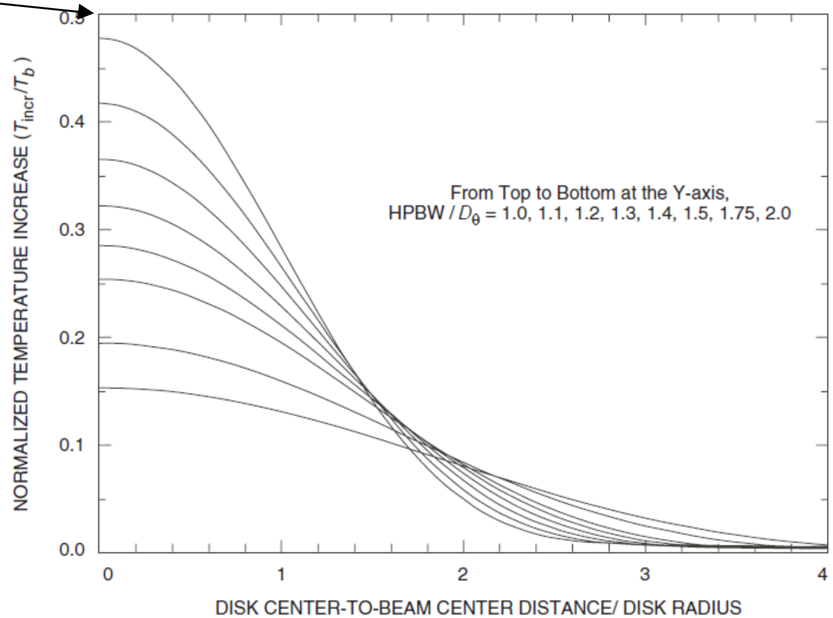
$$T_{SCS}^{F=0,7\,dB} = 5 + 40 + 0 + 52 = 97\ \mathrm{K}$$

$$T_{Moon}^{F=0,7\,dB} = 5 + 40 + 100 + 52 = 197\ \mathrm{K}$$

$$\frac{HPBW}{D_\Theta} = \frac{0,45}{0,5} = 0,9$$

$$MN = 10\log(T_{Moon} / T_{CS}) = 10\log(197/97) = 3,07\ \mathrm{dB}$$

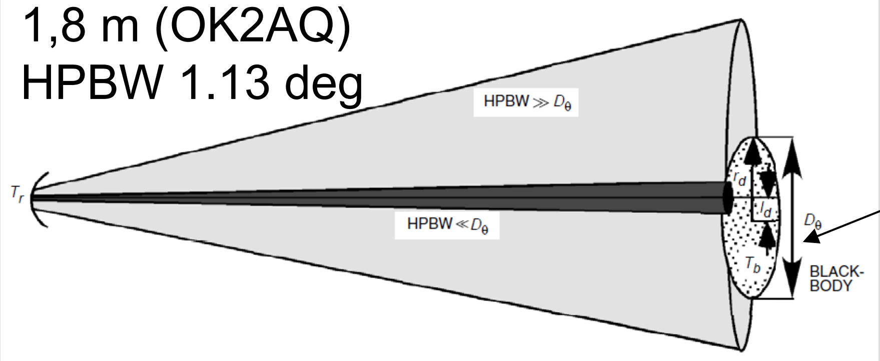




$$T_{SCS}^{F=1dB} = 5 + 40 + 0 + 77 = 122\ \mathrm{K}$$

$$T_{Moon}^{F=1dB} = 5 + 40 + 100 + 77 = 222\ \mathrm{K}$$

$$MN = 2,6\ \mathrm{dB}$$



$$T_{bM} \approx 200\ \mathrm{K}$$

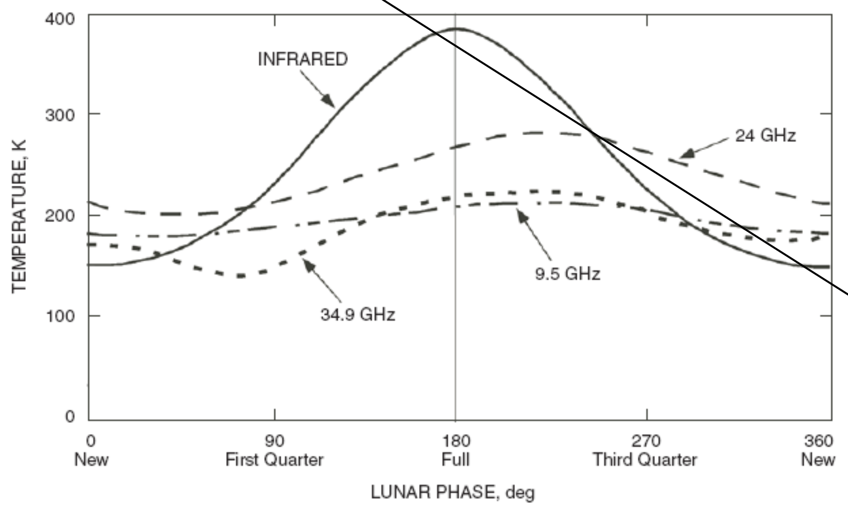
$$T_S = T_{SKY} + T_G + T_{bM} + T_{Rx}$$

$$T_{SCS}^{F=0,7dB} = 5 + 40 + 0 + 52 = 97\ \mathrm{K}$$

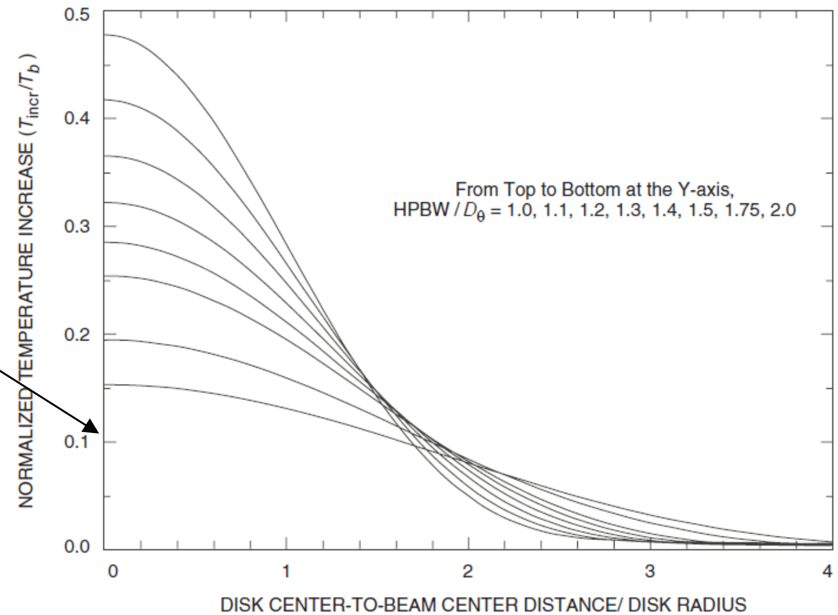
$$T_{Moon}^{F=0,7dB} = 5 + 40 + 20 + 52 = 117\ \mathrm{K}$$

$$\frac{HPBW}{D_\Theta} = \frac{1{,}13}{0{,}5} = 2{,}26$$

$$MN = 10\log(T_{Moon} / T_{CS}) = 10\log(117/97) = 0{,}81\ \mathrm{dB}$$



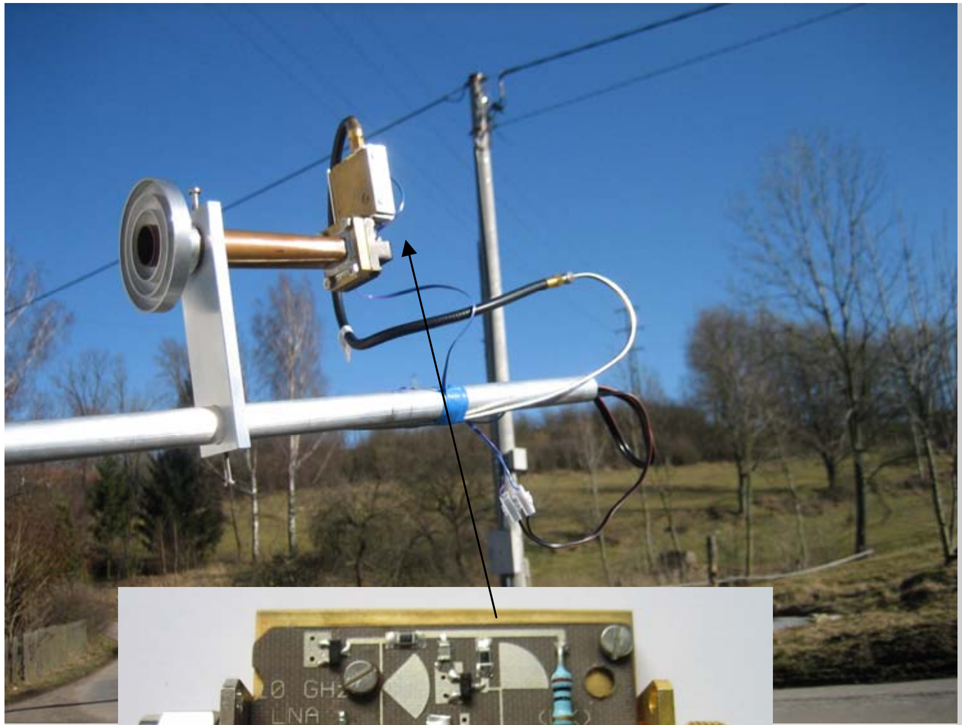
1,8

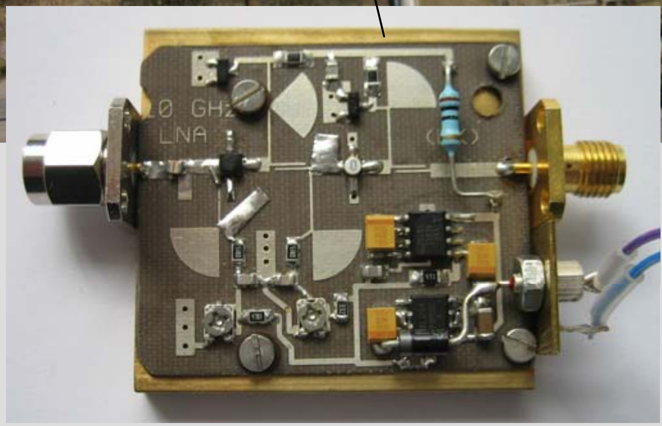


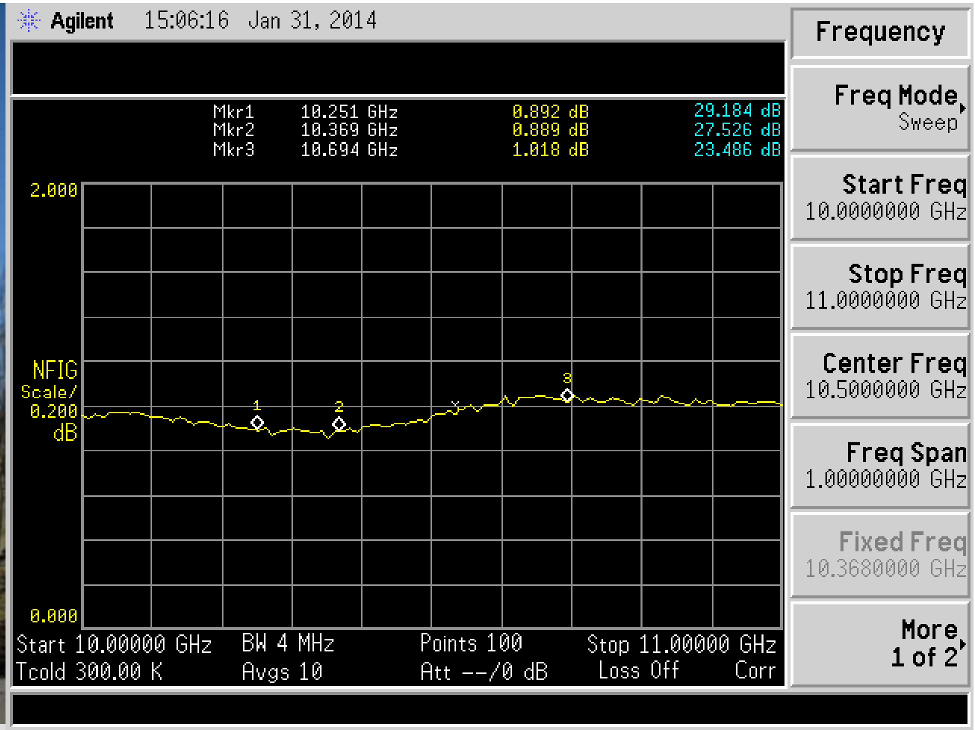
$$T_{SCS}^{F=1dB} = 5 + 40 + 0 + 77 = 122\ \mathrm{K}$$

$$T_{Moon}^{F=1dB} = 5 + 40 + 20 + 77 = 142\ \mathrm{K}$$

$$MN = 0{,}66\ \mathrm{dB}$$







24. 2. 2014 (SFU = 150)
1,8 m dish
SN = 10,5 dB
MN = 0,6 dB