COMPUTATION BOOK

NAME Jack Welch

Course ATA #6

#22-157 • Made in Mexico

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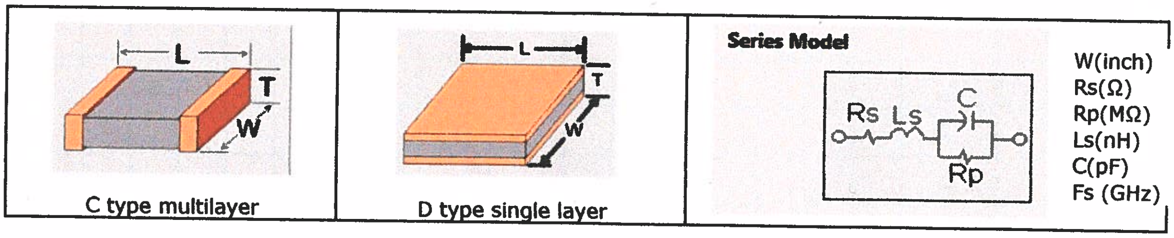
12/20/14

⟨ An improved input filter for the wideband feed. ⟩

The first discussion of this is in II p. 27, where a good matching filter is made by splitting the central wire of the coax cable that goes over to the input of the feed antenna and putting in a capacitor to ground. The sections of the central wire become inductors, and the added capacitor to ground at the halfway all form a Tchebycheff filter. The model from Zverev p 175 is a $\rho = 0.1$ voltage reflection optimum filter. A slightly newer realization is designed in order to make the soldering of the capacitor bottom lead to the ground of the pyramid more practical.

The filter requires a series inductance attached to the shunt capacity. We have found a capacitor from Dielectric Labs that has both a correct capacitance value for the shunt and also the correct series inductance for a filter that goes out to 15 GHz. The cap self resonant frequency is ~80 GHz. For item #4 in the part description below L = .04 nH and C = 0.1 pF for the capacitor. These are close to the (15 GHz) tabular component values in Zverev p. 175.

Data about capacitors from Dielectric Laboritories



Item	Part Number	W	L	T	Rs	Rp	Ls	C	Fs
1	C06 CF R15 A - 9 Z N - X	0.0320	0.0630	0.0330	0.263	2.1	0.232	0.15	27.003
2	C06 CF 0R1 A - 9 Z N - X	0.0320	0.0630	0.0330				0.10	
3	C04 UL 0R1 A - 6 S N - X	0.0200	0.0400	0.0250	0.222	4.8	0.335	0.10	27.490
4	D15 CF 0R1 A 1 P X	0.0135	0.0140	0.0060	0.198	244.9	0.040	0.10	79.457

In the following we calculate the expected frequency response from the actual components above.

{ The new connection between the tip of the coax cables leading from the LNA, to the feed tip:

for Arm to cap ~ 42 thou line .042″
and cap to coax ~ 35 thou line
use 40 thou as the average to calculate filter properties.
40 thousanths gives: with 4-6 thou for the wire diameter,
and using $L = 2l \times 10^{-7} \ln\left(\frac{2l}{r}\right)$, get 1 nH, 10^{-9} henry

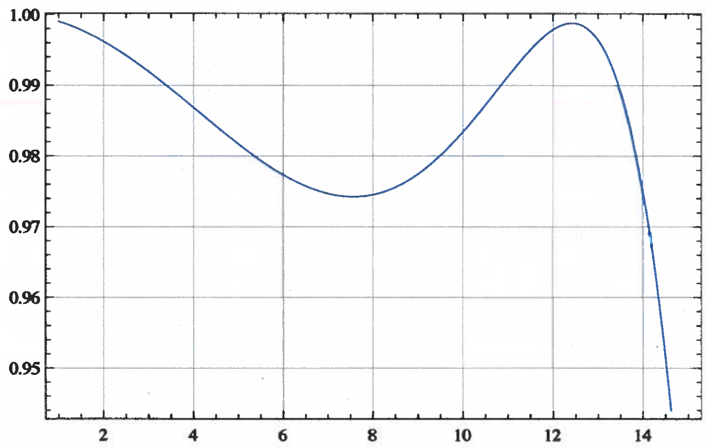
→ ~~for each short lead of average inductance of~~ $\cancel{\sim 1\times 10^{-9}}$ ~~henry~~
The cap is 0.1 pf (and it's series inductance is .335 nH.) which we ignore

The actual filter tabular values are $L_1 = L_3 = 10^{-9}$ henry for the tabular filter of Zverev.
~~The series inductance is~~

Below we plot the calculated transmission from the coaxial lines to the feed tips. These are the coaxial lines from the new LNAs. It's a balanced line from the LNA to the feed input. ≅ 200 ohm balanced! It should work well. 100 ohms for each half fills it out. (Cable is 95 Ω)

```
In[77]:= f1[x_] := 100 + I (6.28 x)

In[78]:= f2[x_] := I (2.01 x - 1 / (.000628 x))

In[80]:= f3[x_] := 100 + I (8.28 x - 1 / (.000628 x))

In[81]:= f4[x_] := 100 / (100 + I (6.28 x))

In[82]:= f5[x_] := 100 + I (6.28 x) + f1[x] f2[x] / f3[x]

In[83]:= G2 = Plot[Abs[2 f1[x] f2[x] f4[x] / (f3[x] f5[x])]^2,
   {x, 1, 15}, Frame → True, GridLines → Automatic]
```

Out[83]=



For the small chip cap: $C_p = 0.1$ pf and $L_3 = .335$ nH (series)

The series inductances of the wires is: 1 nH. $= 10^{-9}$

For the wires and their series inductance: $L_1 = L_3 = 1.0\times10^{-9}$ (not $.95\times10^{-9}$)

~~$f_1[x] = R + j\omega L_3 = 100 + I($~~

$f_g = x \equiv \text{GHz}$

$$\omega L_1 = 2\pi f_g \times 10^9 \times 1\times10^{-9} = 6.28 f_g$$

$$\omega L_2 = 2\pi f_g \times 10^9 \; .32\times10^{-9} = 2.0 f_g$$

$$\omega C_2 = 2\pi f_g \times 10^9 (.1\times10^{-12}) = .628 f_g \times 10^{-3}$$

$$f_1[x] = (R + j\omega L_3) = 100 + I(6.28 x)$$

~~or $f_g = x$ (GHz)~~

$$f_2[x] = j\omega L_2 + \frac{1}{j\omega C_2} = I(2.01x - 1/(.000628x))$$

$$f_3[x] = R + j\omega L_3 + j\omega L_2 + 1/j\omega C_2 = 100 + I(8.28x - 1/.000628x)$$

$$(Z_6 = f_1[x]\, f_2[x] / f_3[x])$$

$$f_4[x] = R/(R + j\omega L_3) = 100/(100 + I\, 6.28x)$$

$$f_5[x] = j\omega L_1 + R + Z_6 = 100 + I\, 6.28x + f_1[x]\, f_2[x] / f_3[x]$$

Transfer voltage $= \dfrac{2 f_1[x]\, f_2[x]\, f_4[x]}{f_3[x]\, f_5[x]}$

For power transfer:

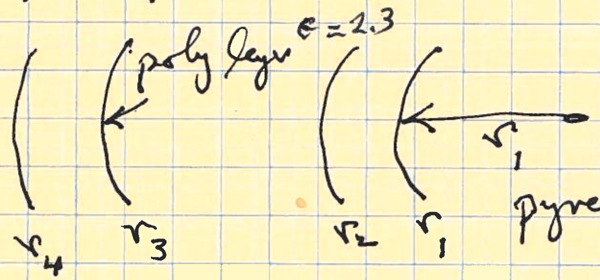
$$\text{Plot}\left[\text{Abs}\left[\frac{2 f_1 f_2 f_4}{f_3 f_5}\right]^{\wedge}2, \{x,1,15\}, \text{Frame} \to \text{True}, \text{GridLines} \to \text{Automatic}\right]$$

← power plot

The plastic lens for the pyrex bottle 12/25/14

At this point the precise thickness of the pyrex is uncertain. With its dielectric coefficient of 5.1, the correction lens will be more critical. We study a range of polyethelene lenses ($\epsilon = 2.3$) outside of a pyrex bottle of 3" radius and .050" thickness. The final glass dimension choices are not yet certain. This study should show what to expect for transmission that can be attained.

Geometry



Parameters

$\gamma_0 = \omega\sqrt{\mu_0\epsilon_0} = .2095 f_g$; f_g in GHz

IV(96) $\gamma_g = \omega\sqrt{\mu_0(5.1)\epsilon_0} = \gamma_0\sqrt{5.1} = .4731 f_g$ glass

$\gamma_t = \omega\sqrt{\mu_0(2.3)\epsilon_0} = .3177 f_g$ plastic layer

$\eta_0 = 377\,\Omega$; $\sqrt{\frac{\mu_0}{\epsilon_0}}$ $\qquad \sqrt{5.1} = 2.2583$, $\sqrt{2.3} = 1.5166$

$\eta_g = \sqrt{\frac{\mu_0}{5.1\epsilon_0}} = \cancel{}\ 166.9397$

$\eta_t = \sqrt{\mu_0/2.3\epsilon_0} = 248.5864$

$r_1 = 3'' = 7.620$ cm

$r_2 = r_1 + .05'' = 7.620 + .1270 = 7.7470$

$r_3 = r_2 + 0.4\text{cm} = 8.1470$

$r_4 = r_3 + .12\text{cm} = 8.2670$

initial values

$r_2 - r_1 = 0.1270$ cm

$r_1 + r_2 = 15.3670$ cm

The basic memo is (V 12-19], 20-23). The necessary relations are V p 122-125.

Various factors $\frac{\eta_g}{\eta_0} = .4428$, $\frac{\eta_0}{\eta_g} = 2.2583$, $\frac{\eta_t}{\eta_0} = 0.6594$, $\frac{\eta_0}{\eta_t} = 1.5166$

The various factors in the equations of p. 124 (V)

$$\left(1+\frac{\eta_g}{\eta_0}\right)\left(1+\frac{\eta_0}{\eta_g}\right) = (1.4428)(3.2584) = 4.7012$$

$$\left(1-\frac{\eta_g}{\eta_0}\right)\left(1+\frac{\eta_0}{\eta_g}\right) = (.5572)(3.2584) = 1.8156$$

$$\left(1-\frac{\eta_g}{\eta_0}\right)\left(1-\frac{\eta_0}{\eta_g}\right) = (0.5572)(-1.2584) = -.7012$$

$$\left(1+\frac{\eta_g}{\eta_0}\right)\left(1-\frac{\eta_0}{\eta_g}\right) = (1.4428)(-1.2584) = -1.8156$$

$$\left(1+\frac{\eta_t}{\eta_0}\right)\left(1+\frac{\eta_0}{\eta_t}\right) = (1.6594)(2.5186) = 4.1760$$

$$\left(1-\frac{\eta_t}{\eta_0}\right)\left(1-\frac{\eta_0}{\eta_t}\right) = (.3406)(-.5166) = -.1760$$

$$\left(1+\frac{\eta_t}{\eta_0}\right)\left(1-\frac{\eta_0}{\eta_t}\right) = (1.6594)(-.5166) = -.8570$$

$$\left(1-\frac{\eta_t}{\eta_0}\right)\left(1+\frac{\eta_0}{\eta_t}\right) = (.3406)(2.5166) = .8572$$

The exponential and multiplicative factors for a 3" bottle with $\epsilon = 5.1$ p146 (I

The transmission equations for the pyrex bottle alone:

$$4 = E\left\{\left(1+\frac{\eta_g}{\eta_0}\right)\left(1+\frac{\eta_0}{\eta_g}\right)e^{-i\gamma_g(r_1-r_2)} + \left(1-\frac{\eta_g}{\eta_0}\right)\left(1-\frac{\eta_0}{\eta_g}\right)e^{i\gamma_g(r_1-r_2)}\right\}$$

becomes:

$$4 = E\left\{4.7011 e^{i(.0601)f_g} - 0.7011 e^{-i(.0601)f_g}\right\}$$

Define $g_6[x] = 4.7011 e^{i(.0601)f_g} - .7011 e^{-i(.0601)f_g}$

and ~~put~~ add this into the plot command for the ~~plastic layer~~. bottle transmission.

After some experimentation we found a series of spacings that led to a good transmission curve over the whole band. There may be additional optima with other parameters. In this sequence, all radii are kept constant except ~~for~~ outer outer boundary of the lens. Thus the lens thickness and outer radius are varied. Other trials may be made beginning with this optimum, perhaps making ~~a~~ variation into ~~the~~ another parameter, such as simple lens thickness, ~~or possibly the~~

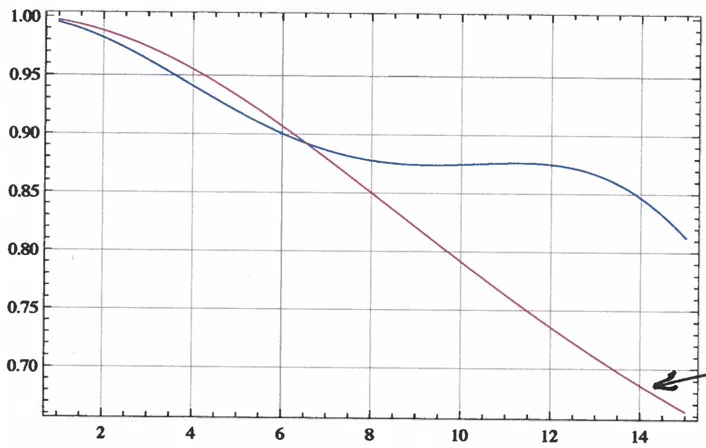
In this first sequence, going from #3 to #4, we increased the outer 'lens' radius from 1.2 mm to 1.4 mm, an increase of only 0.2 mm.

```
In[40]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]
In[41]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]
In[42]:= g3[x_] := 4.1760 Exp[I (.013) x] - .1760 Exp[-I (.0633) x]
In[43]:= g4[x_] := -.8572 Exp[-I (3.367) x] + .8572 Exp[-I (3.4434) x]
In[44]:= g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]
In[45]:= G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
           {x, 1, 15}, Frame → True, GridLines → Automatic]
```

#3

$r_1 = 7.620$ cm
$r_2 = 7.7470$
$r_3 = 8.0671$
$r_4 = 8.1871$ cm

Out[45]=



power transmission

'no lens' transmission curve $g_6[x]$

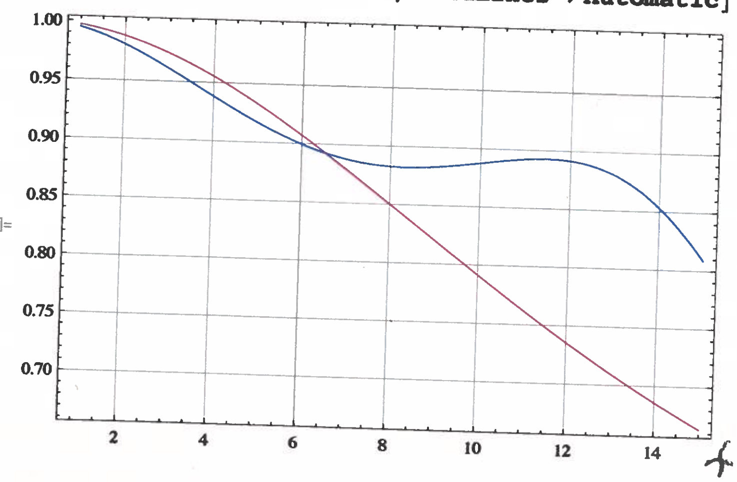
frequency: GHz →

```
In[48]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]
In[49]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]
In[50]:= g3[x_] := 4.1760 Exp[I (.015) x] - .1760 Exp[-I (.0738) x]
In[51]:= g4[x_] := -.8572 Exp[-I (3.3659) x] + .8572 Exp[-I (3.4537) x]
In[52]:= g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]
In[53]:= G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
           {x, 1, 15}, Frame → True, GridLines → Automatic]
```

#4

$r_1 = 7.620$ cm
$r_2 = 7.7470$
$r_3 = 8.0671$
$r_4 = 8.2270$

Out[53]=

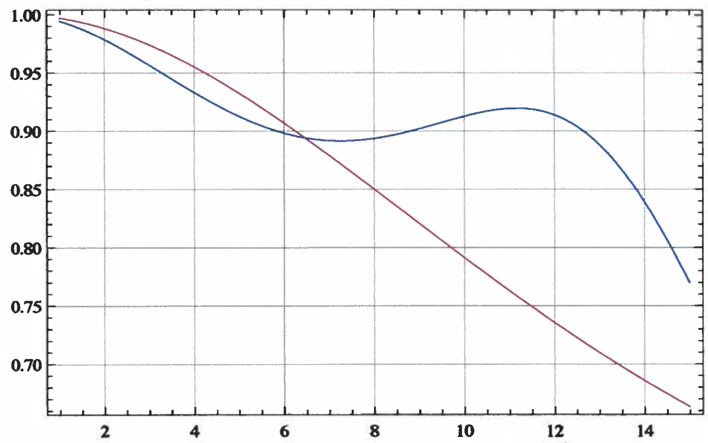


f → GHz

5

```
In[84]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]

In[85]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]

In[87]:= g3[x_] := 4.1760 Exp[I (.0195) x] - .1760 Exp[-I (.0948) x]

In[88]:= g4[x_] := -.8572 Exp[-I (3.3651) x] + .8572 Exp[-I (3.4750) x]

In[89]:= g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]

In[90]:= G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
           {x, 1, 15}, Frame → True, GridLines → Automatic]
```

Out[90]=

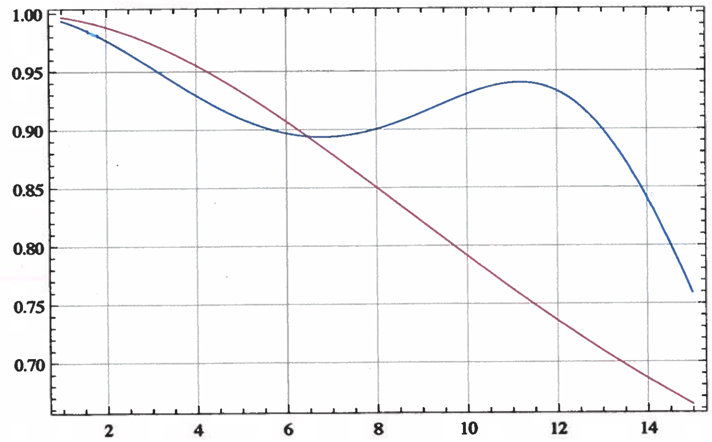


$r_1 = 7.620$ cm
$r_2 = 7.7470$
$r_3 = 8.0671$
$r_4 = 8.2470$

6

```
In[96]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]

In[97]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]

In[98]:= g3[x_] := 4.1760 Exp[I (.0216) x] - .1760 Exp[-I (.1054) x]

In[99]:= g4[x_] := -.8572 Exp[-I (3.3585) x] + .8572 Exp[-I (3.4855) x]

In[100]:= g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]

In[101]:= G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
            {x, 1, 15}, Frame → True, GridLines → Automatic]
```

Out[101]=

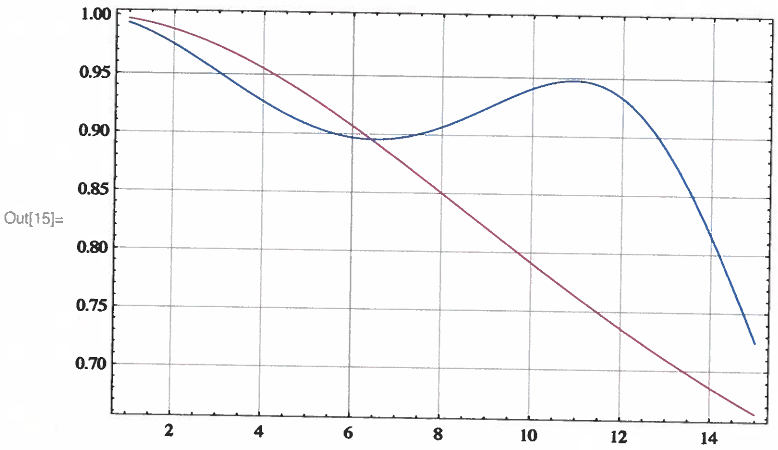


$r_1 = 7.620$
$r_2 = 7.7470$
$r_3 = 8.0671$
$r_4 = 8.2670$

```
In[2]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]
In[3]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]

In[10]:= g3[x_] := 4.1760 Exp[I (.0238) x] - .1760 Exp[-I (.1159) x]
In[14]:= g4[x_] := -.8572 Exp[-I (3.35850) x] + .8572 Exp[-I (3.496) x]
In[8]:= g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]
In[15]:= G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
    {x, 1, 15}, Frame → True, GridLines → Automatic]
```

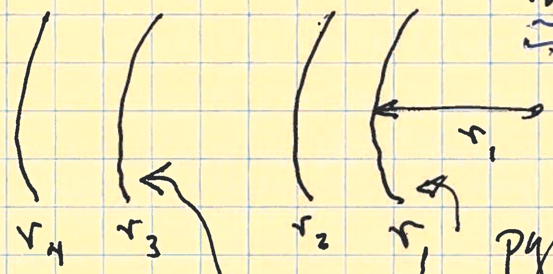
#7

Out[15]=



$r_1 = 7.620''$ cm
$r_2 = 7.7470''$ cm
$r_3 = 8.0671''$ cm
$r_4 = 8.2870''$ cm

This looks optimum.



pyrex glass $\epsilon = 5.1$

poly layer $\epsilon = 2.3$ r ~~in~~ in cm,

Only r_4 was adjusted for the optimum after an initial random set of dimensions (r_3 and r_4) were tried.

☆ This is the optimum lens for the Pyrex bottle, with r_3 fixed, as well as the no lens case.

$r_4 - r_3 = .087''$ (87 thousandths) thickness
Gap, $r_3 - r_2 = .3201$ cm $\Rightarrow$ $0.126''$ Gap. ; i.e. 126 thousandths

Continuation from p. 5: p11

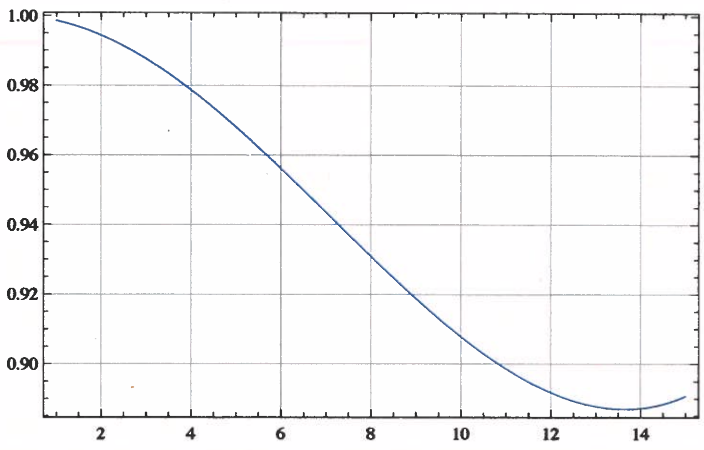
To get the good transmission filter for each coax cable to the feed tip, we have assumed that capacitance to gnd will be provided by the Rogers material 3000 even at the low physical temperature. It is assumed to have $\epsilon \cong 10$ even as it does at room temperature. That gives us the 0.1 pf capacitance for the good filter match. In fact, Rogers has not verified that the material will maintain its room temperature ϵ of 10 at the low temperature.

Suppose it's ϵ drops to 5 (1/2 of its room temp value). Then the capacitor will be only .05 pf

We plot below the transmission of the low pass filter in that case. The filter of p. 4 is pretty good. If ϵ drops to 5, we get the following filter performance.

```
In[1]:= f1[x_] := 100 + I (5.34 x)

In[2]:= f2[x_] := I (2.01 x - 1 / (.000314 x))

In[4]:= f3[x_] := 100 + I (7.35 x - 1 / (.000314 x))

In[8]:= f4[x_] := 100 / (100 + I (5.34 x))

In[6]:= f5[x_] := 100 + I (5.34 x) + f1[x] f2[x] / f3[x]

In[10]:= G2 = Plot[Abs[2 f1[x] f2[x] f4[x] / (f3[x] f5[x])]^2,
           {x, 1, 15}, Frame → True, GridLines → Automatic]
```

Out[10]=



Continuation from p. 10

Continuation the optimisation by moving the plastic lens from where it was for ~~#~~ 7 keeping the plastic lens thickness constant at 0.2199 cm $= r_4^? - r_3$.

The new r_4 and r_3 are: $r_4 = 8.2870$ cm and $r_3 = 8.087$ cm

We move the lens out by .2 mm, or .02 cm.

The new radii are: $7.620\text{ cm} = r_1$

$7.7420\text{ cm} = r_2$ } 3.45 mm 0.136"

$8.087\text{ cm} = r_3$ }

$8.3070\text{ cm} = r_4$ } 2.27 mm 0.087"

The amplitude factors remain the same.

see p. 124 II for the algebra.

$r_4 - r_3 = .22$ cm , the same

$r_3 - r_2 = .34$ cm , different. ; old $r_3 - r_2 = 0.32$ cm. ✓

new $r_3 - r_2 = 0.34$ cm

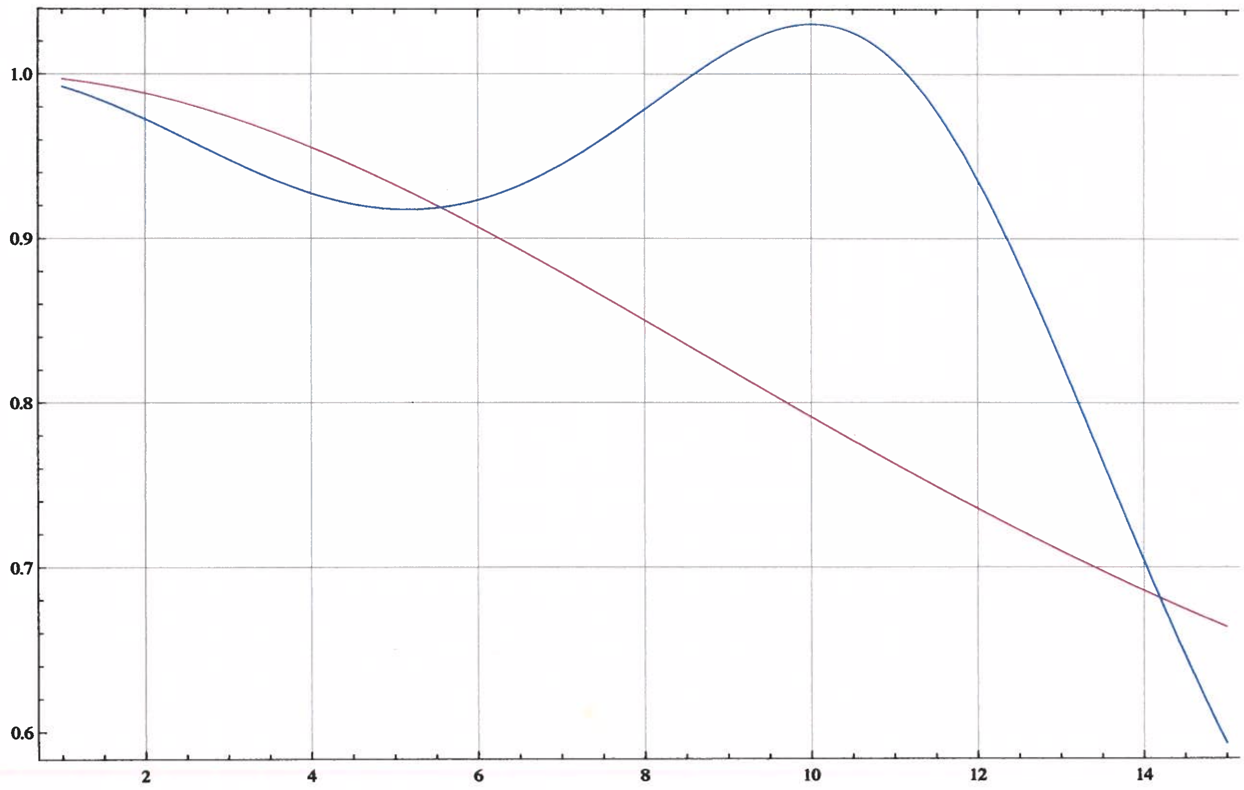
It's the $f_7 + f_8 = g_4$ term that has a phase change.

The other terms remain the same, including $g_6(x)$

The increase in the gap is .02 cm = .2 mm ⇒ 50 thousandths

#8

```
In[11]:= g1[x_] := 4.7012 Exp[I (.0335) x] - .7012 Exp[-I (.0821) x]

In[12]:= g2[x_] := 1.8156 Exp[I (3.2795) x] - 1.8156 Exp[I (3.1639) x]
         g3[x_] := 4.1760 Exp[I (.0238) x] - .1760 Exp[-I (.1159) x]
         g4[x_] := -.8572 Exp[-I (3.3647) x] + .8572 Exp[-I (3.5544) x]
         g6[x_] := 4.7011 Exp[I (.0601) x] - .7011 Exp[-I (.0601) x]
         G = Plot[{Abs[16 / (g1[x] g3[x] + g4[x] g2[x])]^2, Abs[4 / g6[x]]^2},
             {x, 1, 15}, Frame → True, GridLines → Automatic]

Out[12]= Null^4
```



Note the overshoot.

Matt goes to Canada, returns on Friday

From Niklas, expect Chalmers LNAs, enough for 6 feeds; he also has Fraunhofer LNAs (lower gain)

Enough parts for 10 feeds in hand otherwise

Bellows: #316 original and #325 alloys, 3 more to try, one with the new alloy has failed

One new feed

3 new at HC, 3 at minex with repair issues).

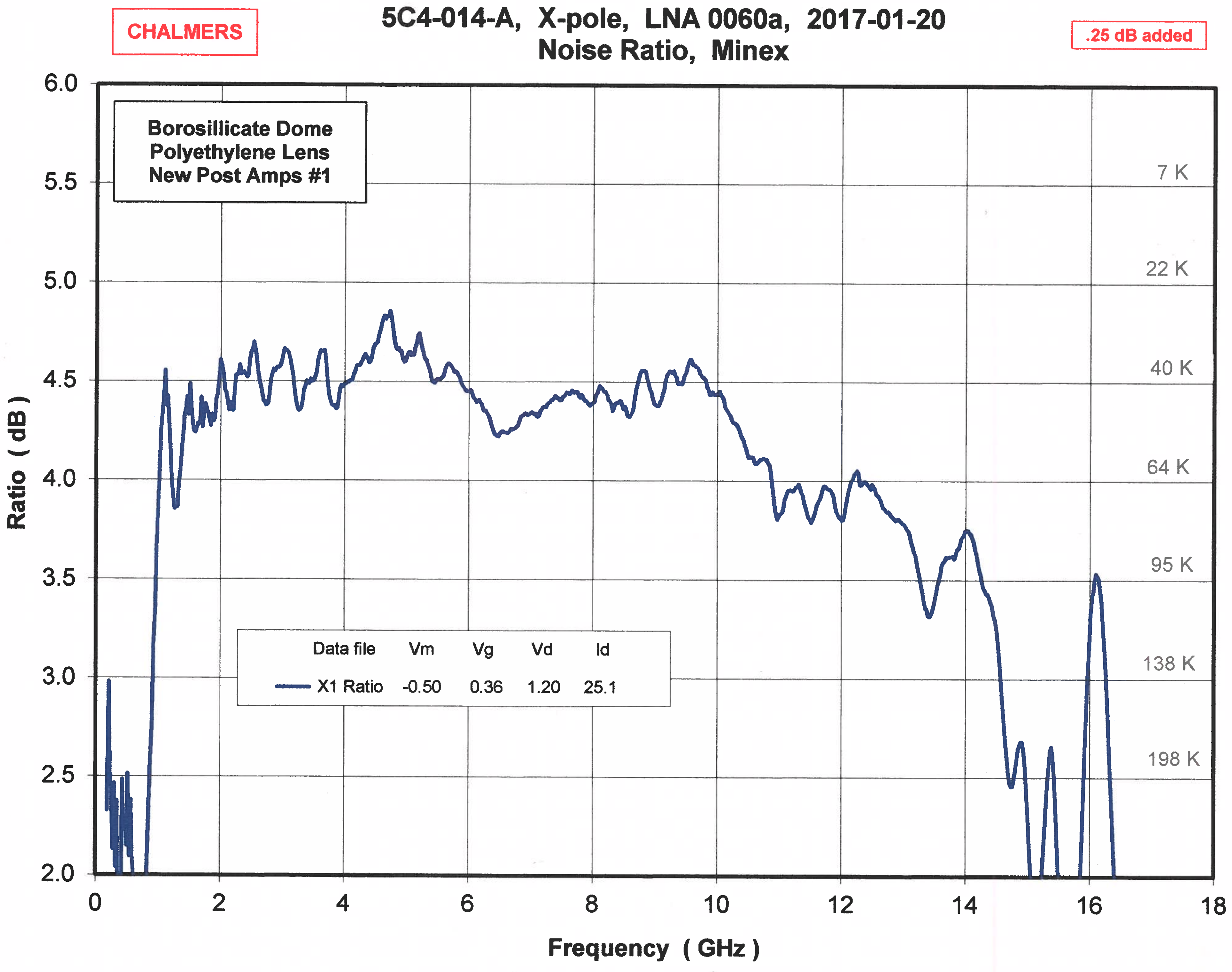
With enough LNAs and working bellows, there is enough for 10 feeds. Bellows and LNAs are a problem.
delivery

~~One more bottle~~

Orders from SETI: just 6 feeds

A sequence of new feeds tested in the screen room with liquid N_2

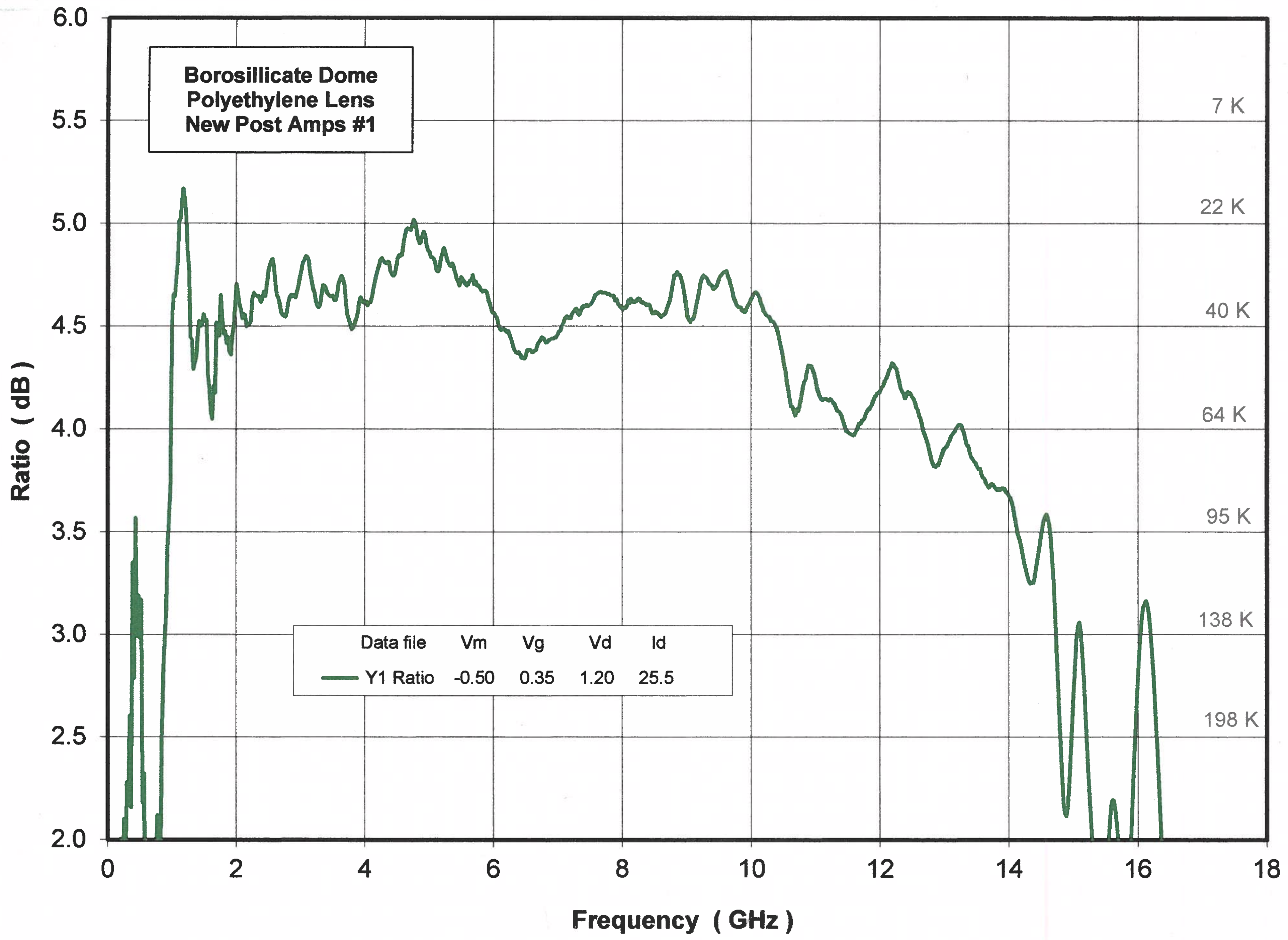
→

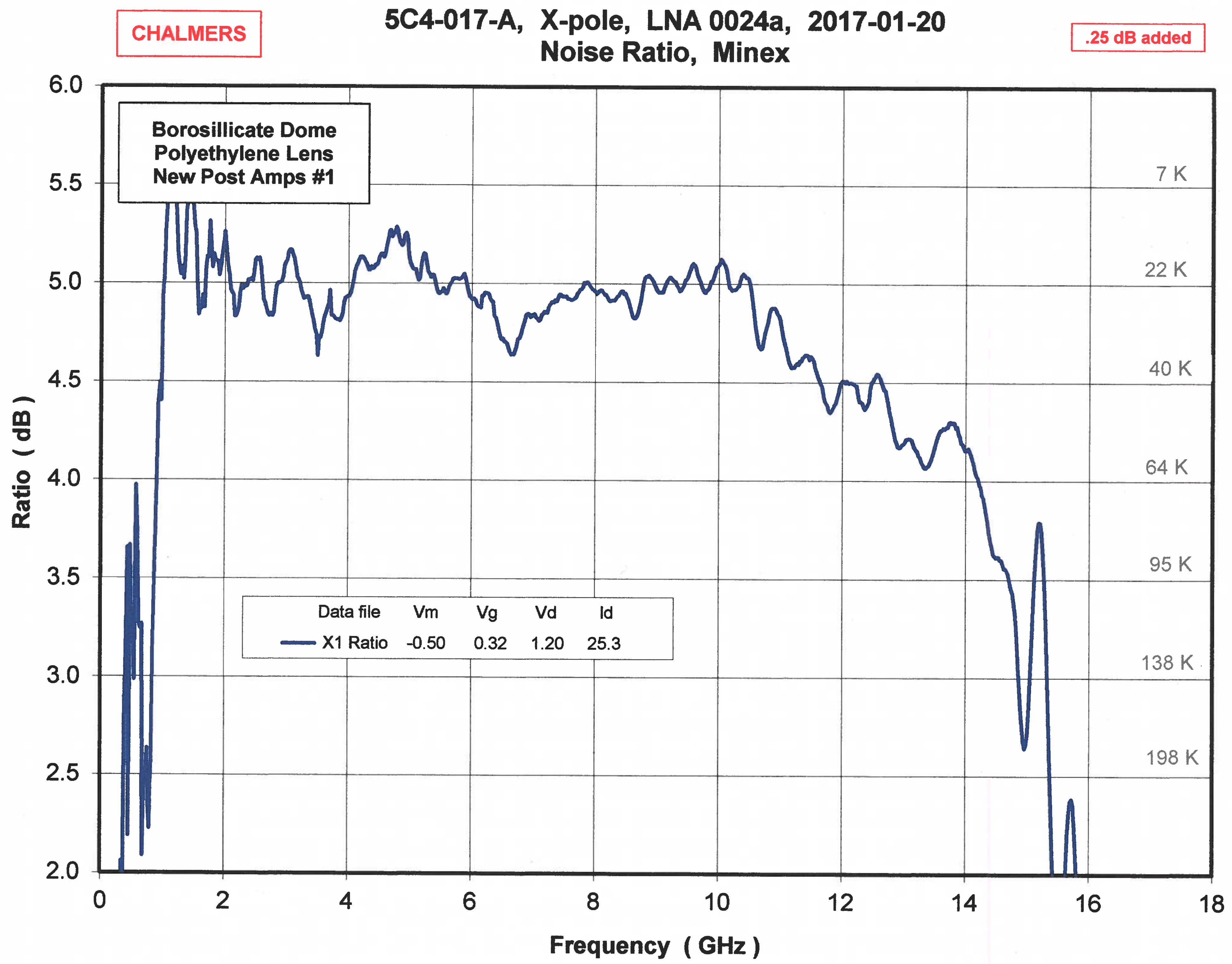

CHALMERS
5C4-014-A, X-pole, LNA 0060a, 2017-01-20
Noise Ratio, Minex
.25 dB added
Borosillicate Dome
Polyethylene Lens
New Post Amps #1
Ratio (dB)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
7 K
22 K
40 K
64 K
95 K
138 K
198 K
Data file Vm Vg Vd Id
X1 Ratio -0.50 0.36 1.20 25.1
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)

CHALMERS

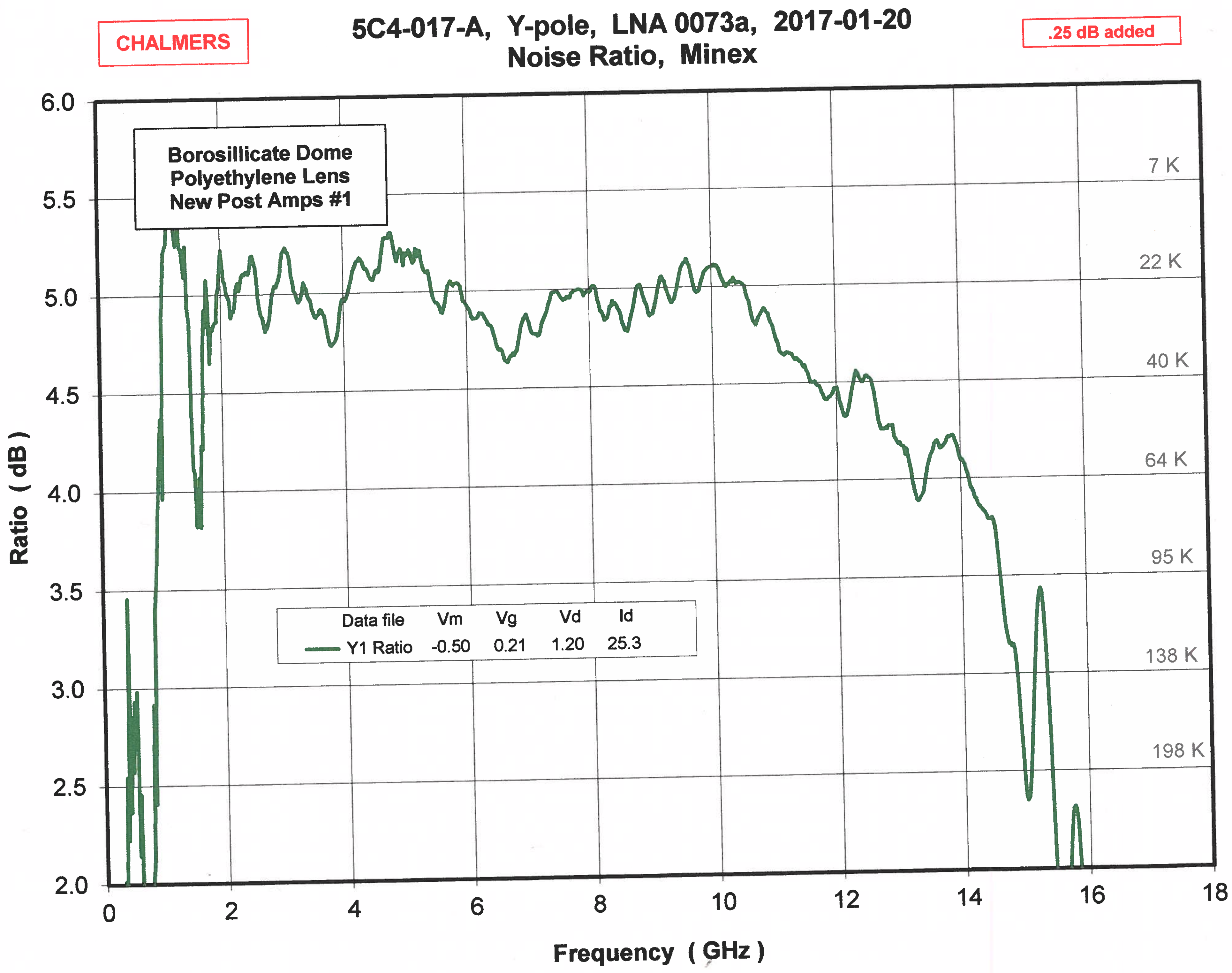
5C4-014-A, Y-pole, LNA 0064a, 2017-01-20
Noise Ratio, Minex

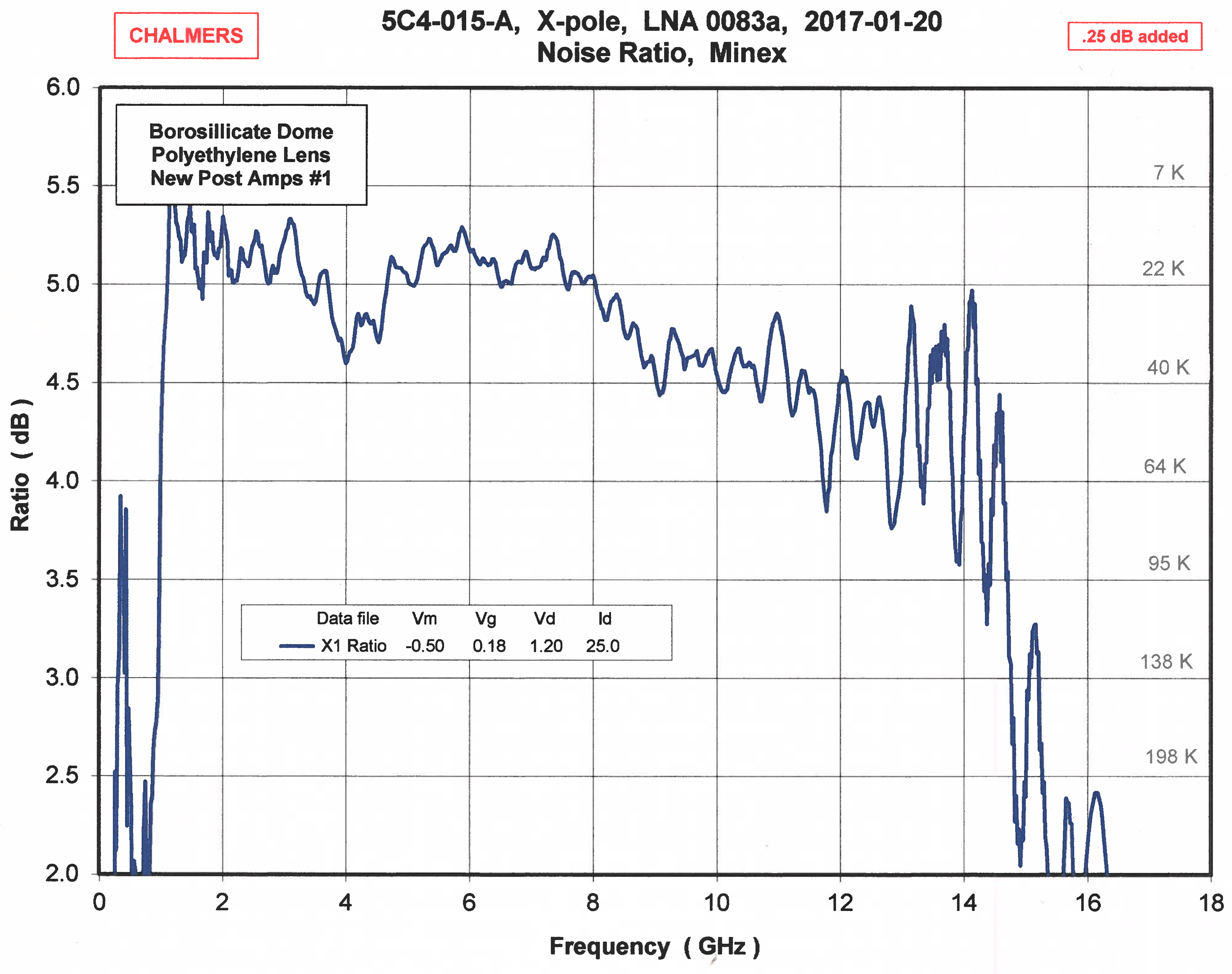
.25 dB added

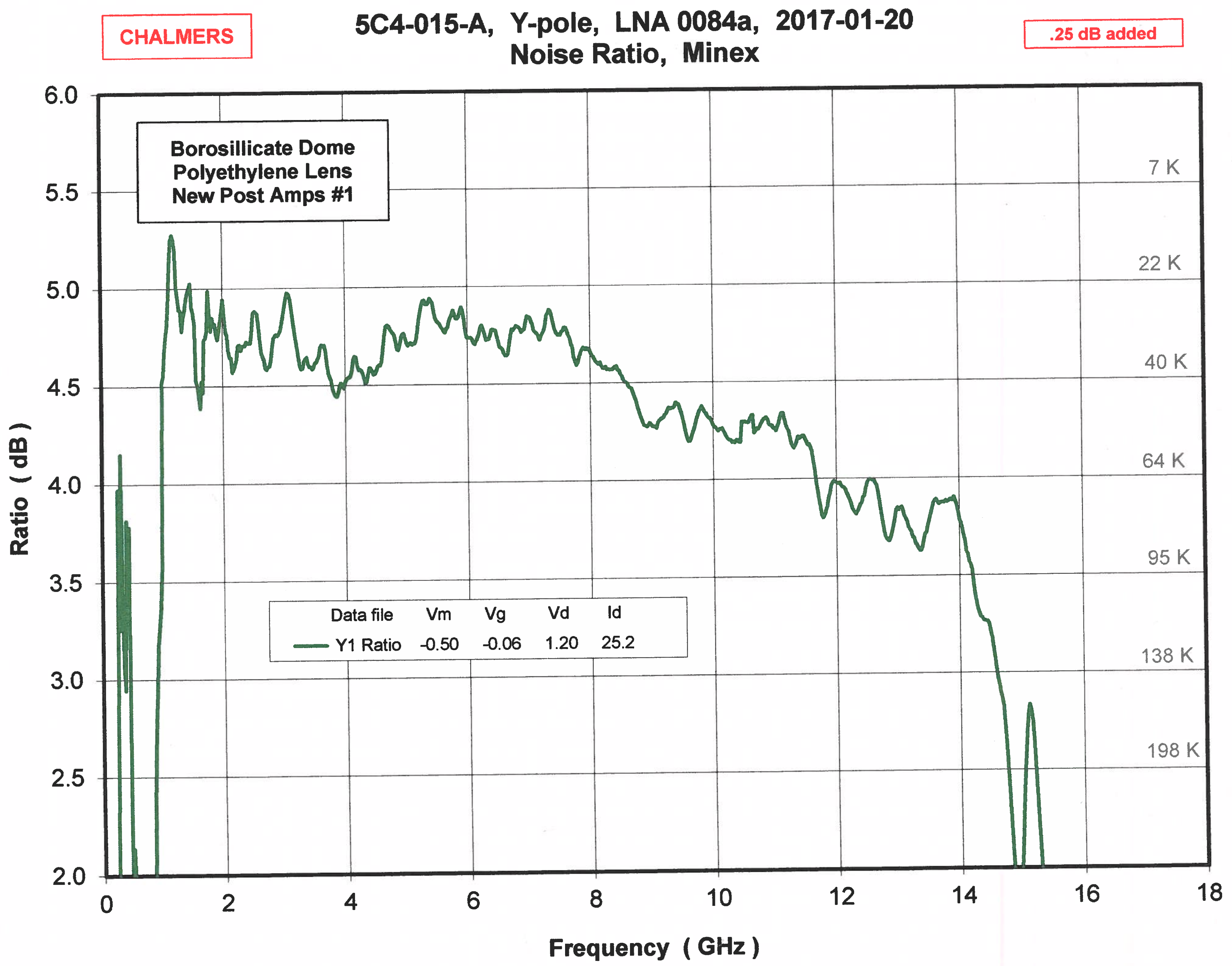




CHALMERS
5C4-017-A, X-pole, LNA 0024a, 2017-01-20
Noise Ratio, Minex
.25 dB added
Borosillicate Dome
Polyethylene Lens
New Post Amps #1
Ratio (dB)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
7 K
22 K
40 K
64 K
95 K
138 K
198 K
Data file Vm Vg Vd Id
X1 Ratio -0.50 0.32 1.20 25.3
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)


CHALMERS
5C4-017-A, Y-pole, LNA 0073a, 2017-01-20
Noise Ratio, Minex
.25 dB added
Borosillicate Dome
Polyethylene Lens
New Post Amps #1
Data file Vm Vg Vd Id
Y1 Ratio -0.50 0.21 1.20 25.3
Ratio (dB)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
7 K
22 K
40 K
64 K
95 K
138 K
198 K
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)


CHALMERS
5C4-015-A, X-pole, LNA 0083a, 2017-01-20
Noise Ratio, Minex
.25 dB added
Borosillicate Dome
Polyethylene Lens
New Post Amps #1
Data file Vm Vg Vd Id
X1 Ratio -0.50 0.18 1.20 25.0
Ratio (dB)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
7 K
22 K
40 K
64 K
95 K
138 K
198 K
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)


CHALMERS
5C4-015-A, Y-pole, LNA 0084a, 2017-01-20
Noise Ratio, Minex
.25 dB added
Borosillicate Dome
Polyethylene Lens
New Post Amps #1
Data file Vm Vg Vd Id
Y1 Ratio -0.50 -0.06 1.20 25.2
7 K
22 K
40 K
64 K
95 K
138 K
198 K
Ratio (dB)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
2
4
6
8
10
12
14
16
18
Frequency (GHz)

Status Feed at Minex 2017-03-15

	Bellows Test Burn-in	~~Feed~~ LNA Installed	Feed Tested
Feed 12	2wks	Yes	~~No~~ yes
Feed 13	2wks	No (Wed. test)	No
Feed 16	2wks	Yes	No

Three new feeds to Hat Creek; after successful testing

a) 3 new bellows makers have been Contacted.

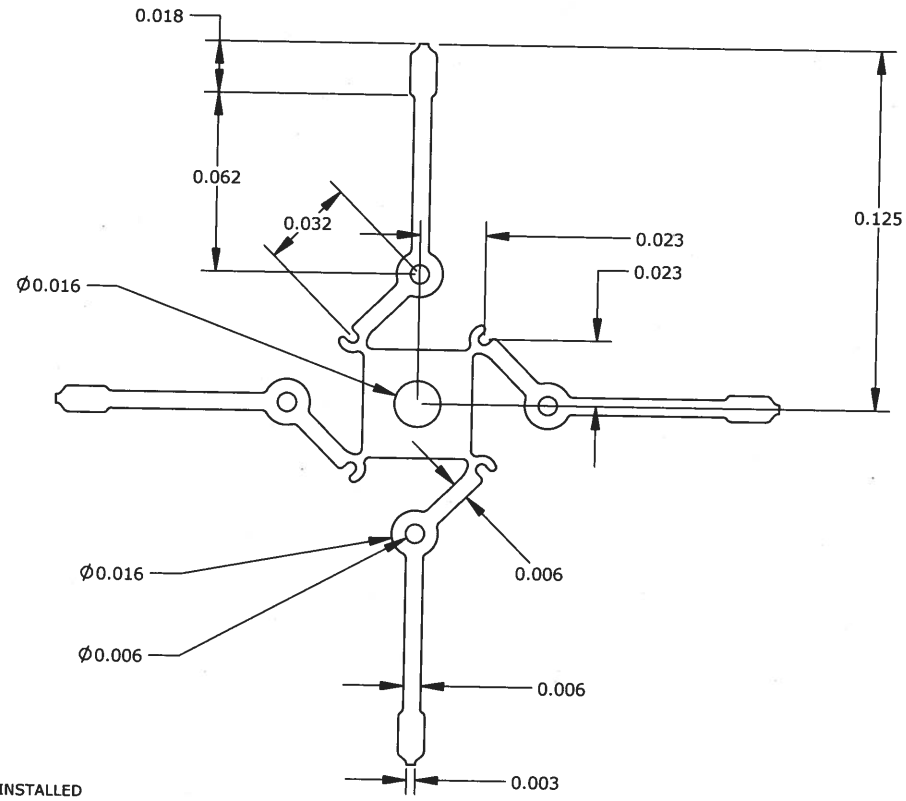
b) Tomorrow we will order 3 units from each of 2 makers. (for test 2 new types)
{expect bellow delivery in ~2 weeks} (May 3)

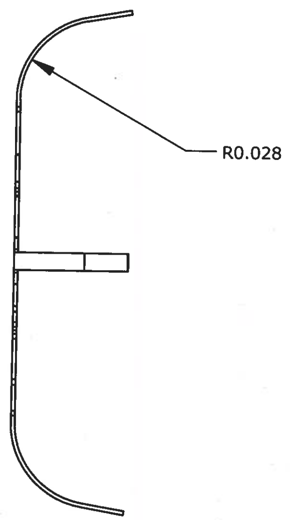
c) We have 2 bellow units left from old order.

d) SETI PO 3228 for 6 Feed 4 at HCO 2 at Minex
Invoice 2530 for 4 Feeds (waiting)

e) SETI PO NEXT for 3 Feeds (waiting) to be ordered.
10 LNA's in stock, all channels

REV	DESCRIPTION	ZONE	DATE	NAME





INSTALLED

FILE NAME: 30-29-277-E Tip Arm Link
LAST SAVED: Wednesday, July 15, 2015 10:55:05 AM

	NAME	DATE
DRAWN:	M C Fleming	2015-07-15
CHECKED:	M C Fleming	2015-07-15

MATERIAL: ASTM A36 Steel , ρ = 0.284

FINISH:

WEIGHT: 0.000 lbs

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN: Inches

TOLERANCES:	LINEAR	ANG°
FRACTIONAL ±	1/32	
DECIMAL X.X ±	0.100	0.10
DECIMAL X.XX ±	0.010	0.01
DECIMAL X.XXX ±	0.003	

BREAK SHARP EDGES:
MACHINED FINISHED: < 125 x u-INCH

SCALE: 24:1

Minex Engineering Corp.
1000 Apollo Ct. Unit G, Antioch, CA 94509
Tel: 925-757-6785 Fax: 925-757-1083

ATA Cooled Feed
Tip Arm Link

SIZE	DWG NUM	REV
B	30-29-277-E	A