UVLBI MEMO #005

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To: Millimeter VLBI Group

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Subject: Phase noise tests of HP8662/3 and phase locked sources

Phase noise test were made using a HP8662 as a reference in the typical set-up shown in Figure 1. The high frequency phase noise was made using a spectrum analyzer and "close in" phase noise using a low frequency FFT analyzer. All phase noise measurements were extrapolated to 230 GHz and expressed as a loss at 230 GHz using the following method.

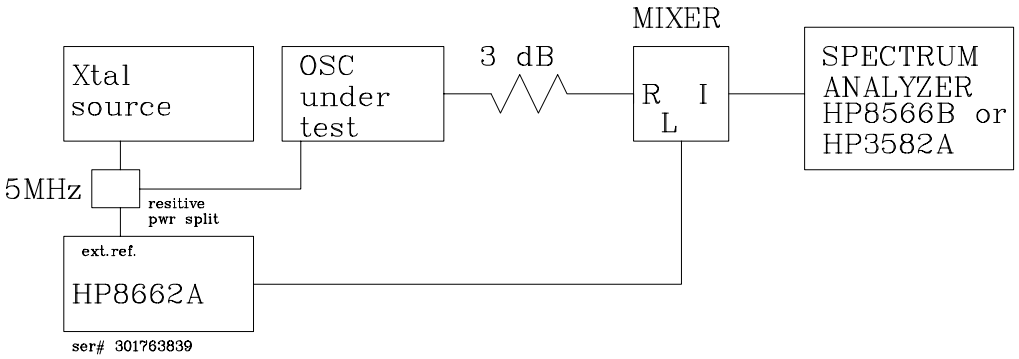


Fig. 1 Typical set-up – see appendix for details

$$Loss = 10\log(w/b) - c + 20\log(230/f)$$

Where *Loss* = loss at 230 GHz in dB
w = equivalent width of phase noise pedestal
b = spectrum analyzer resolution
c = height of carrier above pedestal in dB
f = frequency of intercomparison in GHz

In the cases that the phase noise was measured using oscilloscope to measure the phase noise.

$$Loss\ \ factor = 10\log\left(e^{-\phi^2/2}\right)$$

where $\phi = (2/\pi)(p/4)(2/v)$ = phase noise in radians

where p = peak to peak voltage
v = peak to peak voltage with frequency offset

Results:

Osc1 Under test	Ref1	Osc2 reference	Ref2	Comparison frequency	High freq loss	Close in loss	Total	Total ref. removed
CTI A	5 MHz	8662	5 MHz	2005	1%	20%	21%	19%
CTI B	5 MHz	8662	5 MHz	2005	1%	20%	21%	19%
CTI A	5 MHz	CTI B	5 MHz	2005	1%	34%	35%	16%
CTI D	5 MHz	8662	5 MHz	2020	12%	0%	12%	10%
CTI C	5 MHz	8662	5 MHz	2005	1%	90%	91%	89%
8663	10 MHz	8662	10 MHz	2000	2%	0%	2%	0%
8663	10 MHz	8662	5 MHz	1120	2%	3%	5%	2%

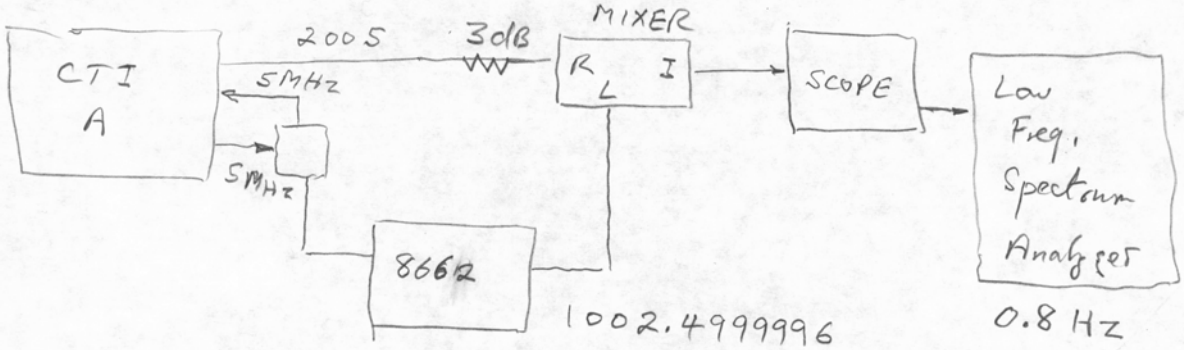
Comments:

The last column of the table is an estimate of the loss at 230 GHz of the oscillator with the contribution of the reference oscillator removed. Clearly the HP8662/3 have the best performance. Next best is the tunable CTI phased locked cavity oscillator.

Appendix

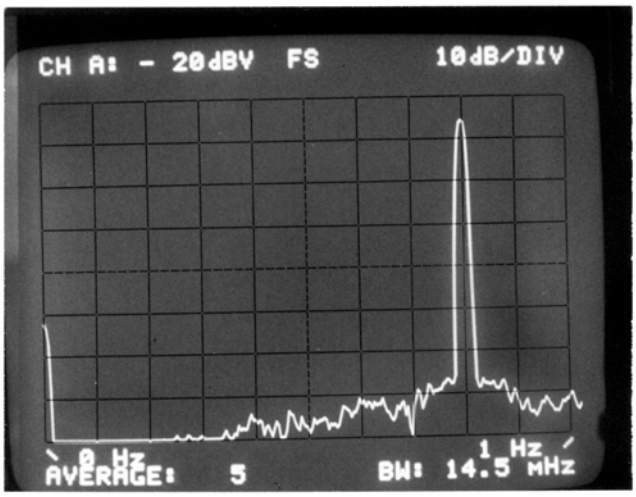
(1)

21 Sep 05

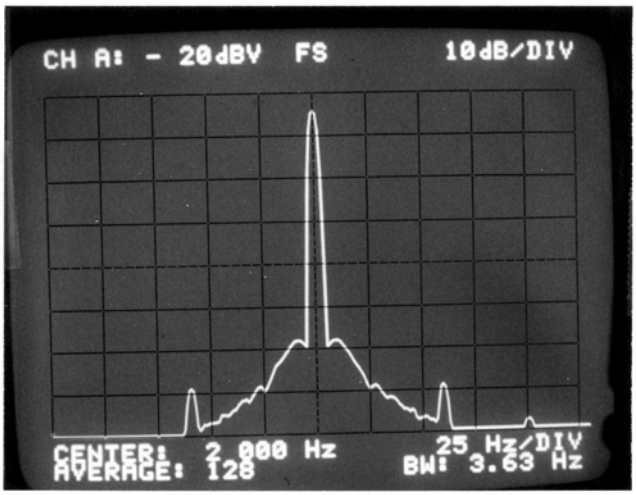


1002.4999996
MHz

0.8 Hz
center.



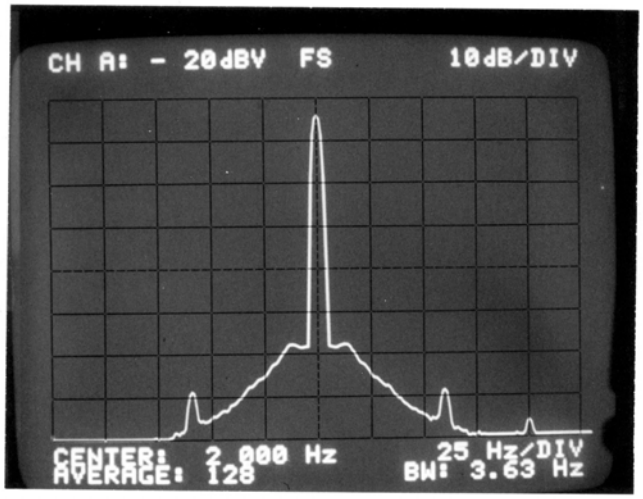
2 GHz → 230 GHz
41 dB



HP8662
vs CTI 2005 A
box open

Loss 230 GHz
≈ 20%

(2)



HP8662

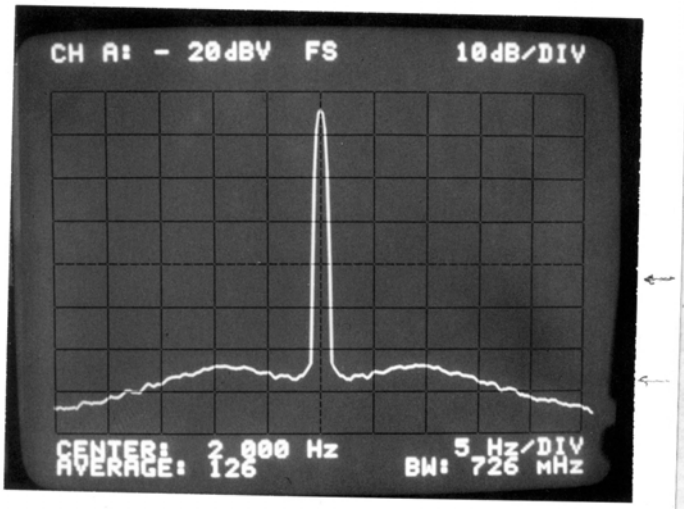
1002.499 ~~X~~ 2

CTI VS

2005 B

Loss 230 GHz

≈ 20%



8662 V

CTI 2005 A

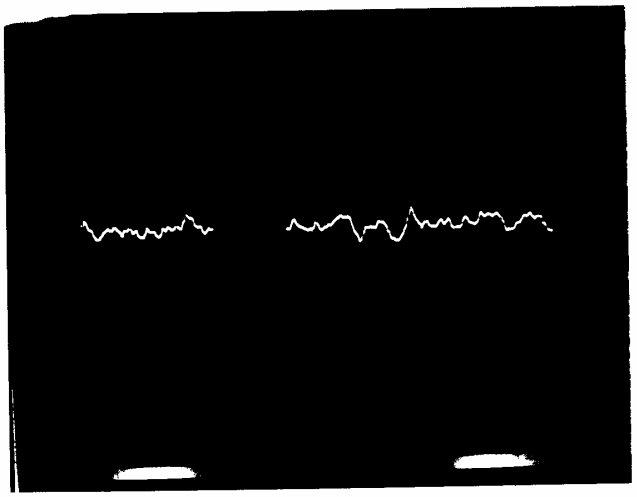
Loss $\frac{5/0.7 \times 2 \times 2}{100 \times 1.5}$ ≈ 20%

(3)

2005 v 2005

p-p phase noise = $\frac{95\,mV}{0.3v} \times \frac{2}{\pi} \times 15 \times \frac{360}{2\pi} \times \frac{1}{4}$

= 52° rms



loss = 34%

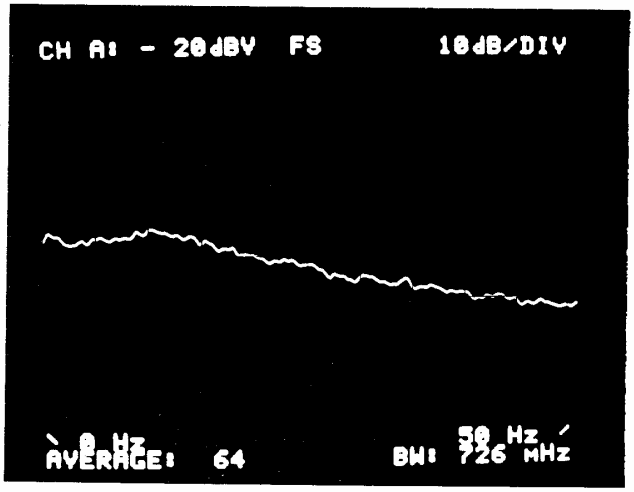
20mv/div

15mV

unlock

0.6 p-p

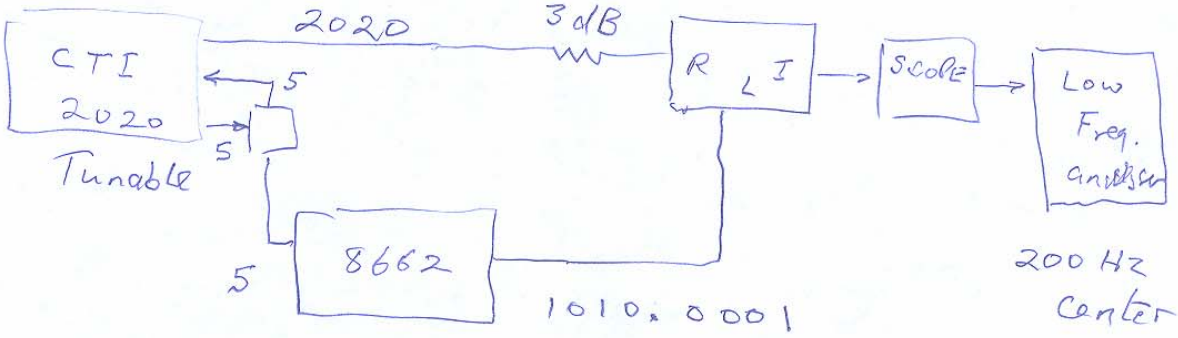
0.1 sec/div

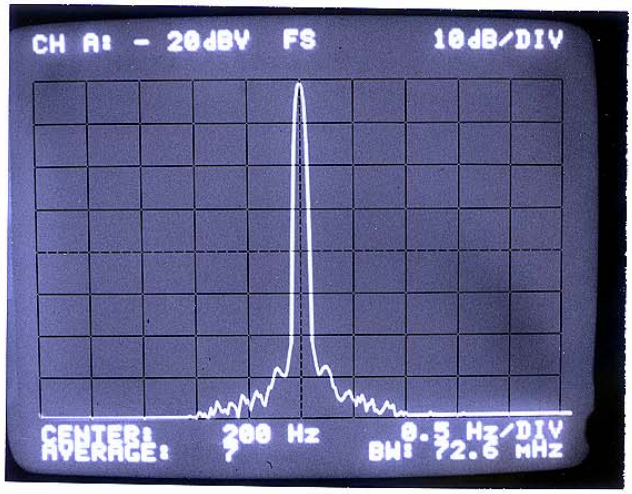


spectrum of noise between CTI units

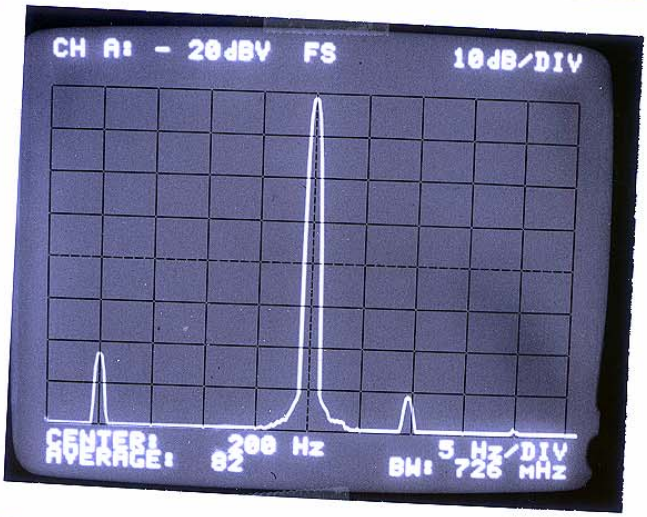
D.C. excluded - measured separately

④

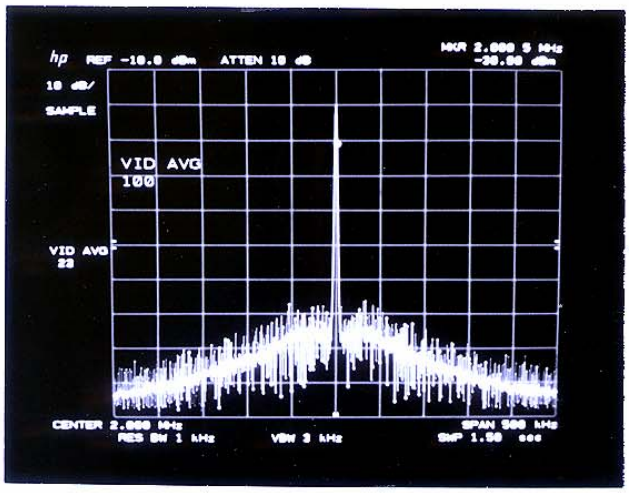




close in noise essentially zero!



(5)

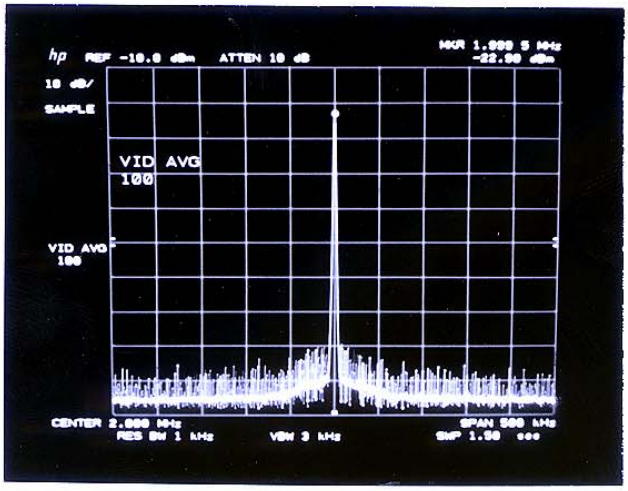


Noise at 2300 GHz

$\frac{50 \times 1}{400} \approx 12\%$

20 − 70 + 41 =

Tunable 2020



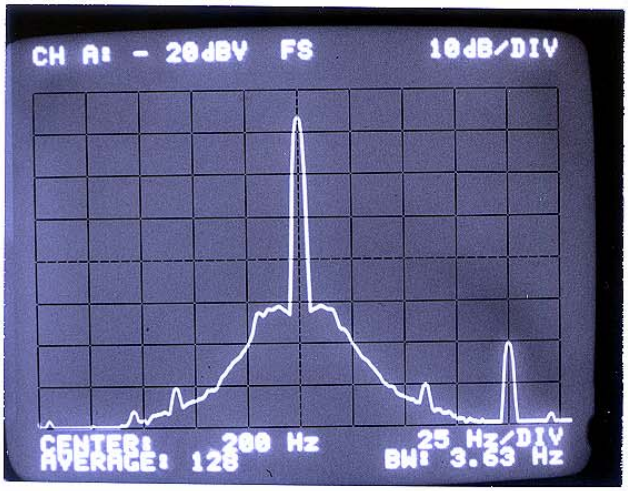
2005

B

17 − 78 + 41

= −20 = 1%

(6)



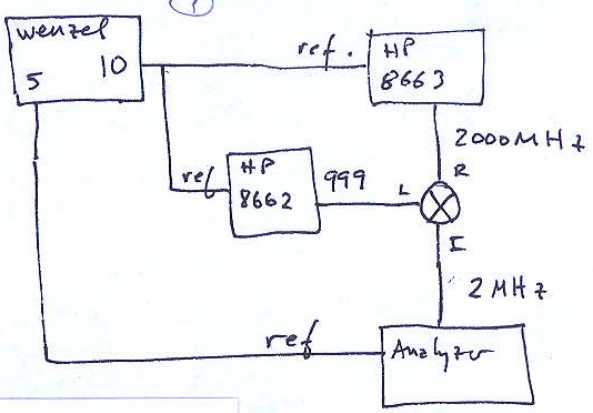
Fixed
2005
C
(small unit)
vs HP8662

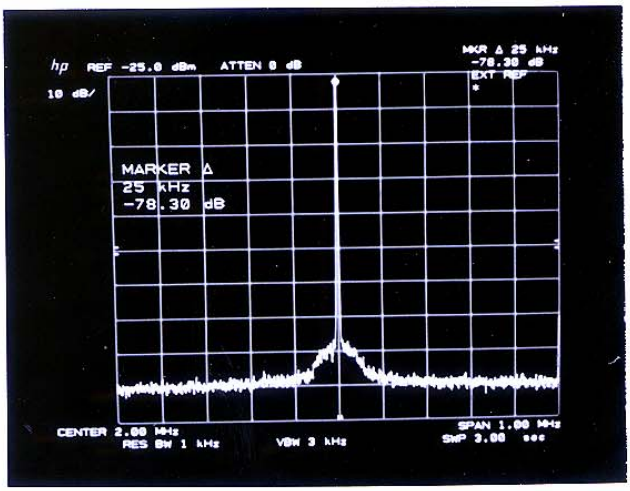
Very poor. ~ 90% loss
at 230 GHz

HP8663 vs HP8662.

(7)

30 sept 05





19 - 78 + 41 = -18

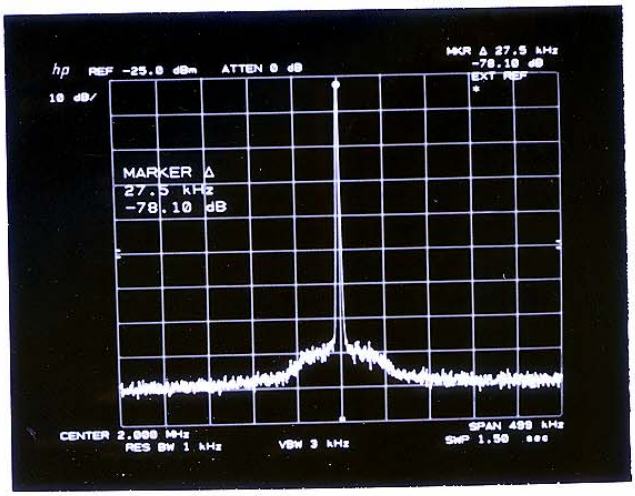
photos: C, D, E, F, G.

High frequency loss

Loss at 230 GHz

2%

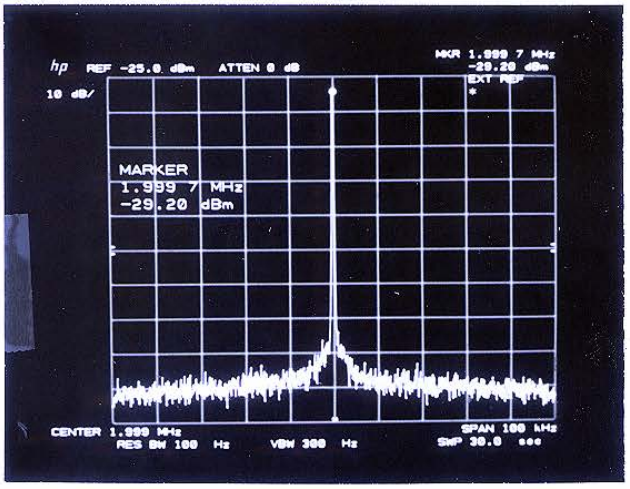
or 1% each

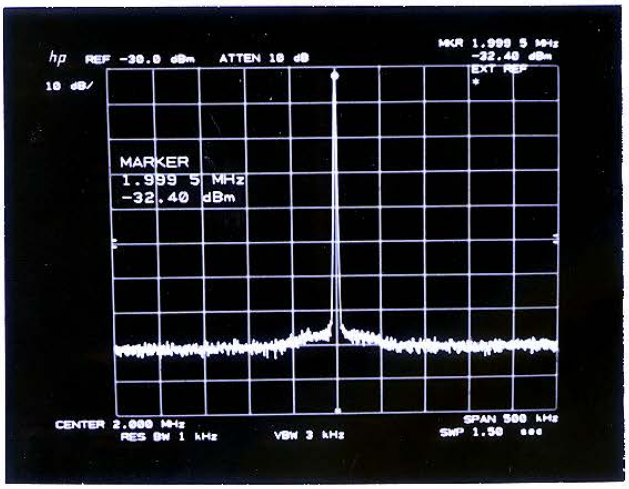


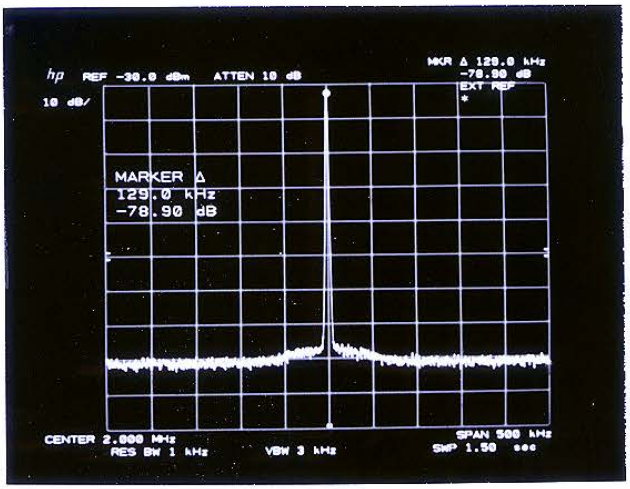
(7b)

8662 vs 8663

continued.

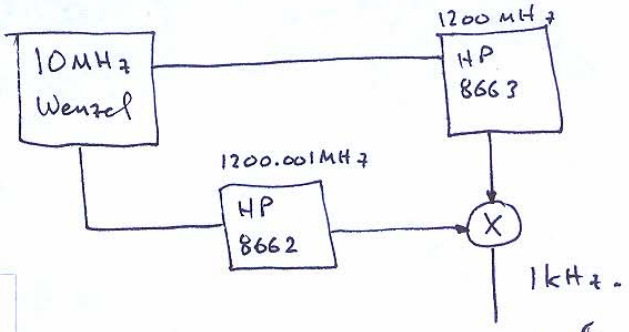




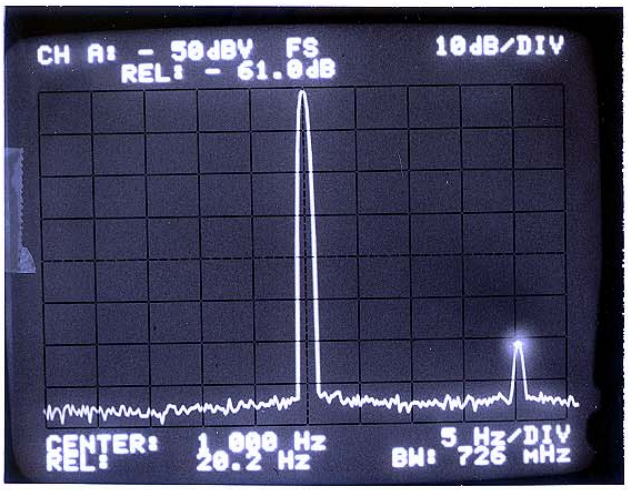


HP8662 vs. HP8663

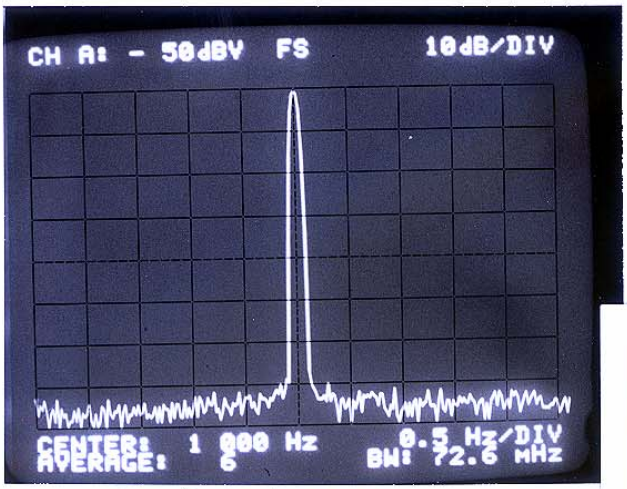
(8)



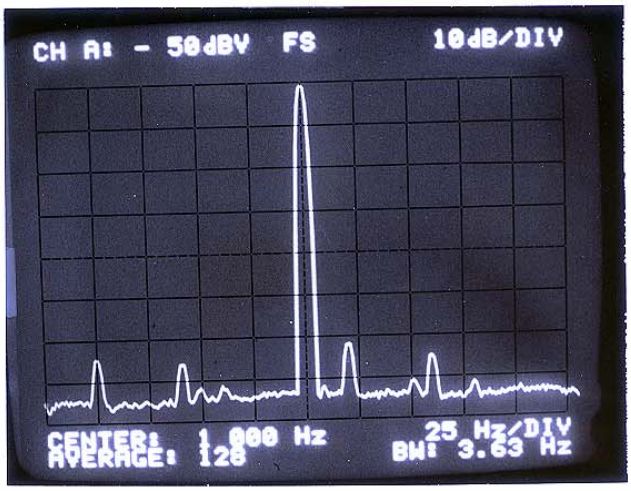
30 sept 05

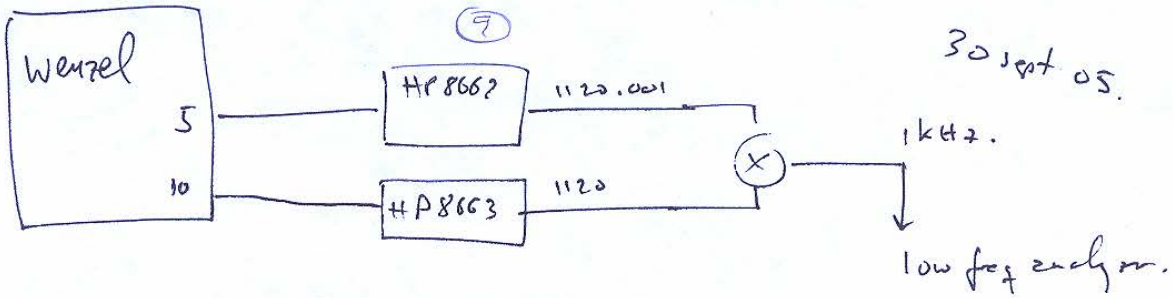


photos: H, I, J.



10 MHz / 10MHz

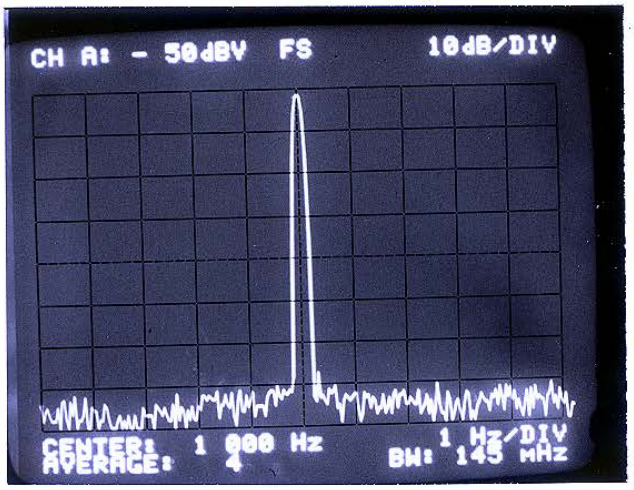




(9)

30 Sept 05.

Photos: A, B



Loss at 230 GHz
Close in -
separate references
3%