

The background of the slide is a brown spiral-bound notebook. The spiral binding is on the left side, and the notebook pages are visible, showing a light beige color with faint horizontal lines. The title text is centered on the right page.

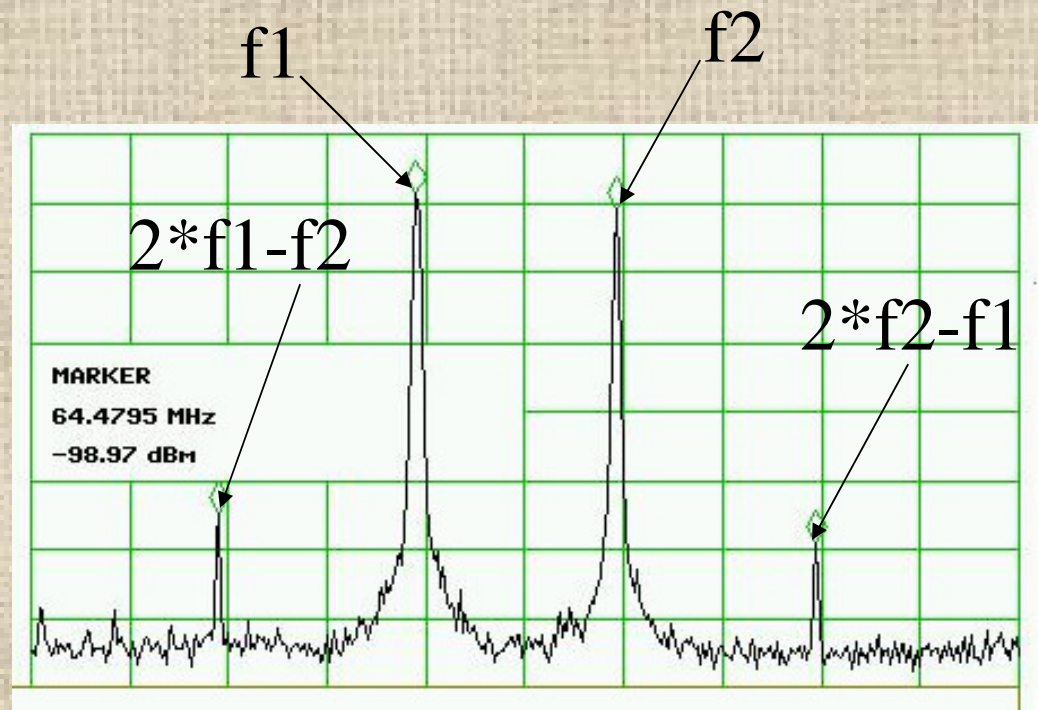
Where the Competitive Receiver Starts

-The First Mixer

Bob DePierre
August, 2009

Out-of-Passband Signals Cause In-Passband Interference

- Once it gets through the mixer, no filter can get rid of it.
- Third-order distortion usually dominates.
- Some mixers handle overload better than others.

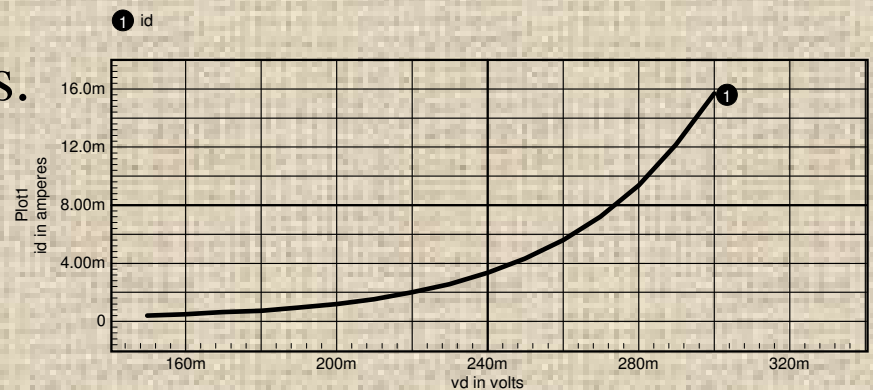


Mixer = Distortion Device

- 1960's breakthrough was the balanced mixer.
- SBM => RF balanced out.
- DBM => LO also balanced out.
- Exponential behavior really bad for giant signals.

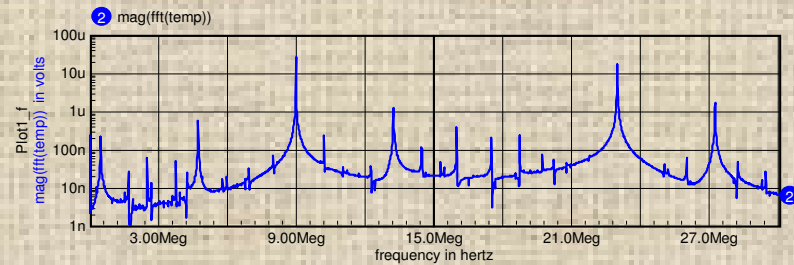
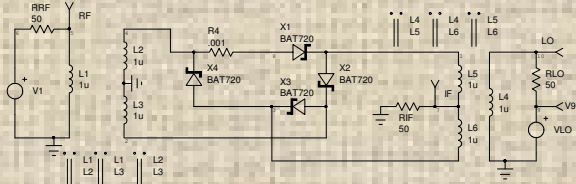
$$i = I_S \left(e^{\frac{v}{V_T}} - 1 \right)$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots$$

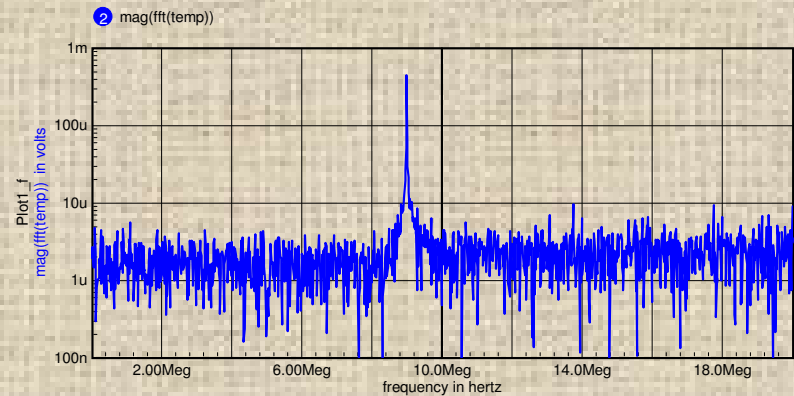
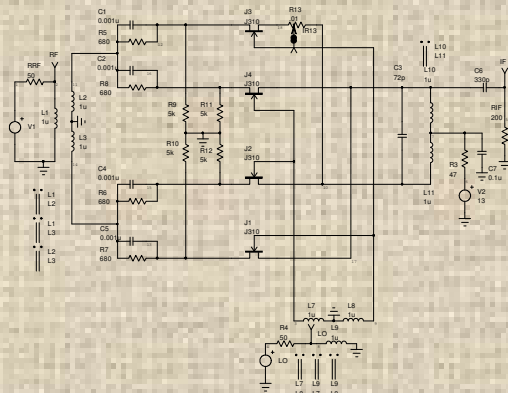


Why the FET Mixer?

Diode Ring DBM - Exponential

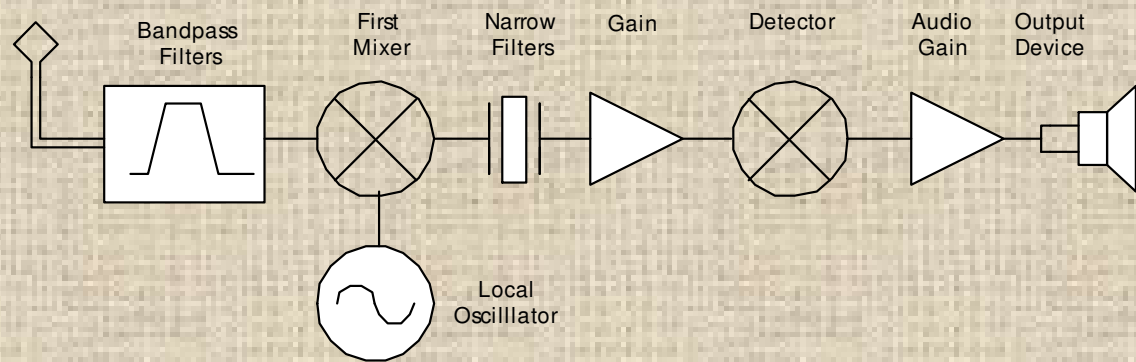


Orion 4 JFET DBM – Square Law

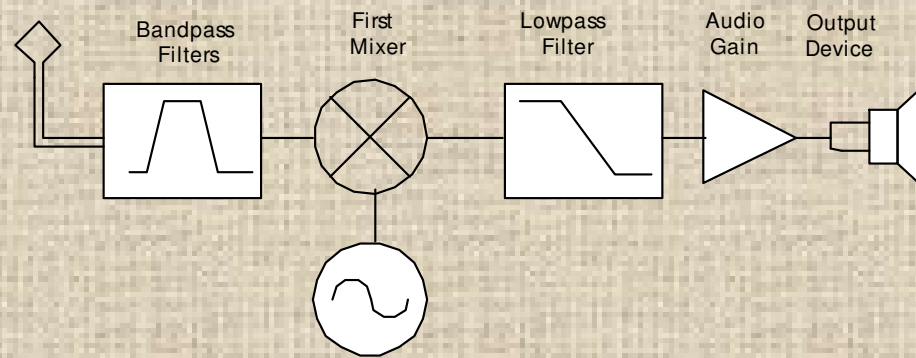


Receiver Architectures

- Superheterodyne

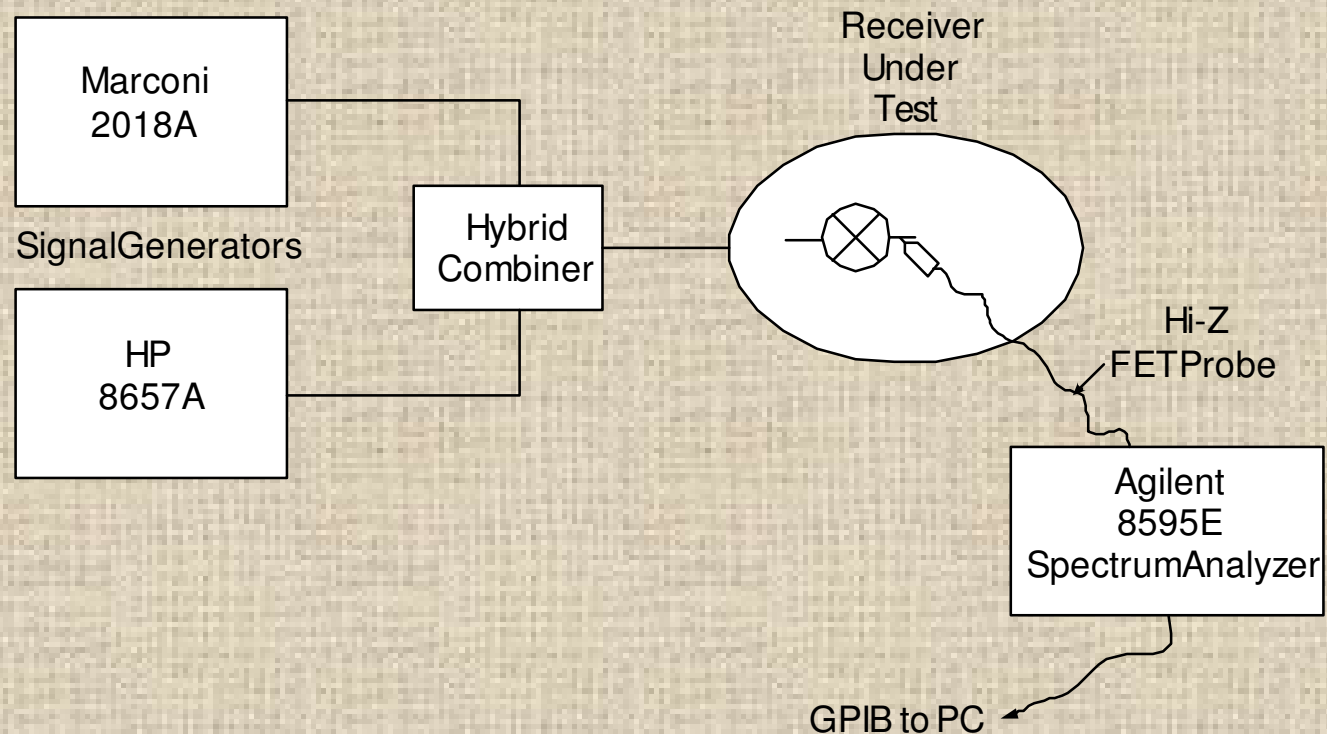


- Direct Conversion



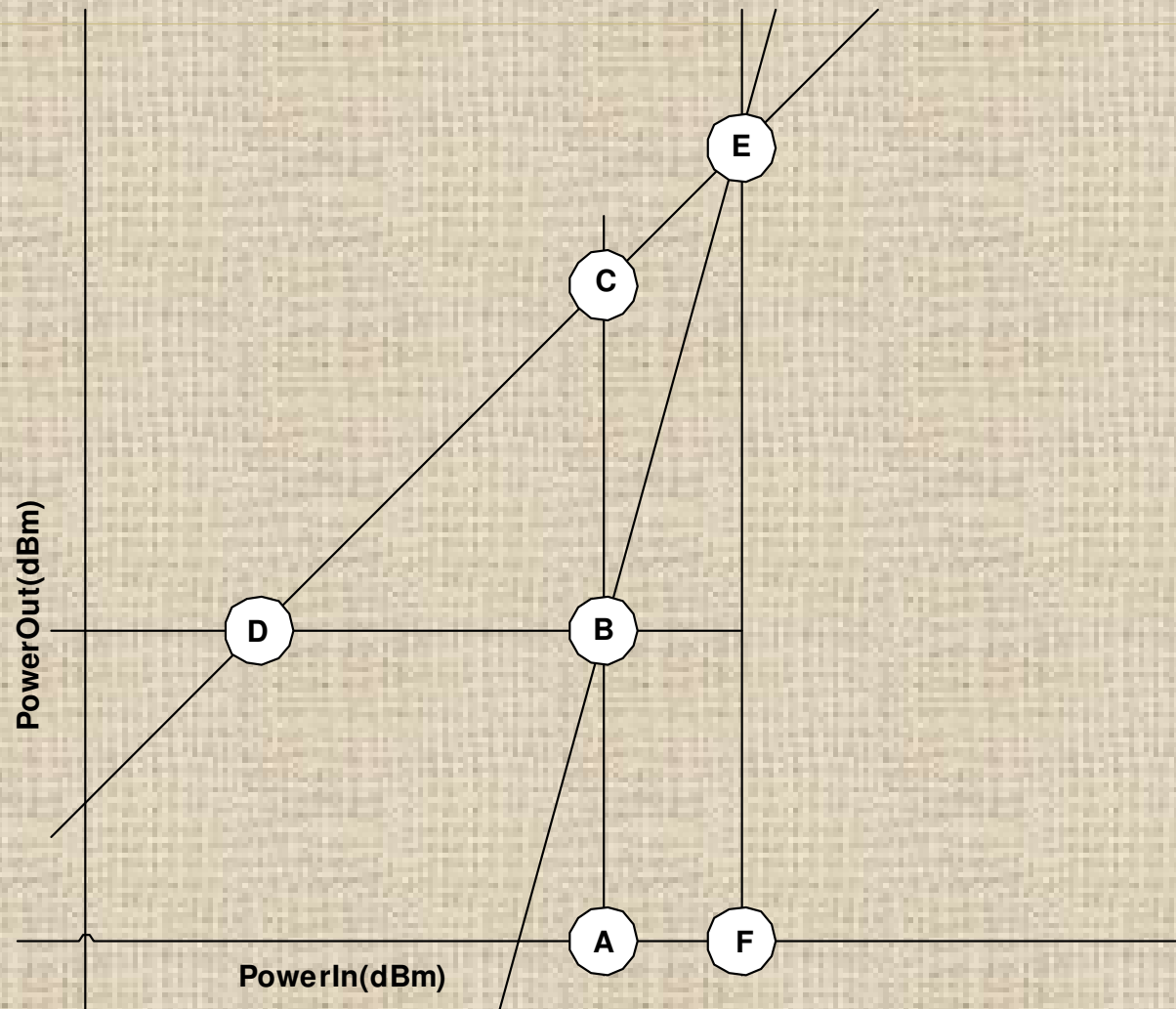
Mixer Test Procedures

- Input Signals = -25dBm, Spacing 20 kHz, 2 kHz
- “Invasive” Measurement at Output Port of First Mixer



Intercept Graph

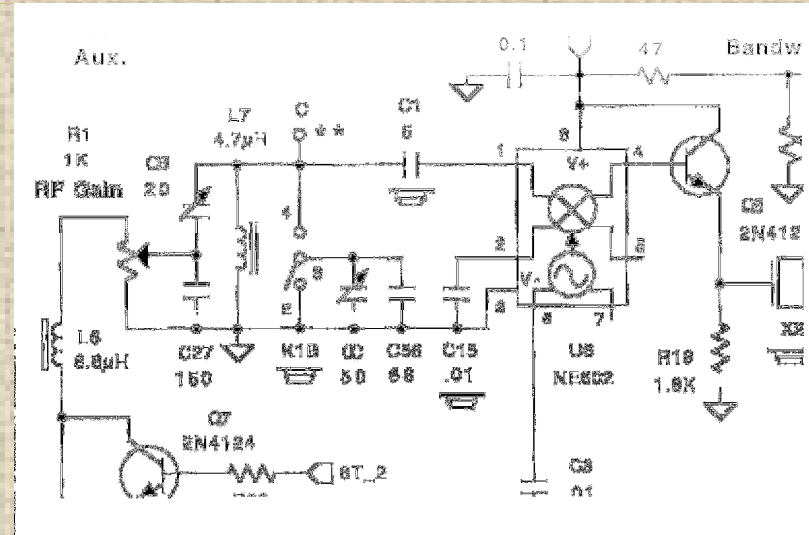
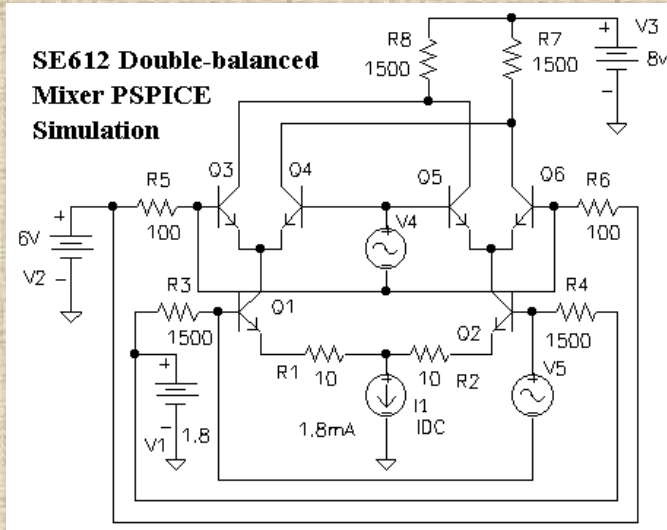
Used to Calculate the IP



Mixer Structures

- BJT Gilbert Cell
- Diode DBM
- 2 JFET SBM
- 4 JFET DBM
- Fast Switching Multiplexer

BJT Gilbert Cell

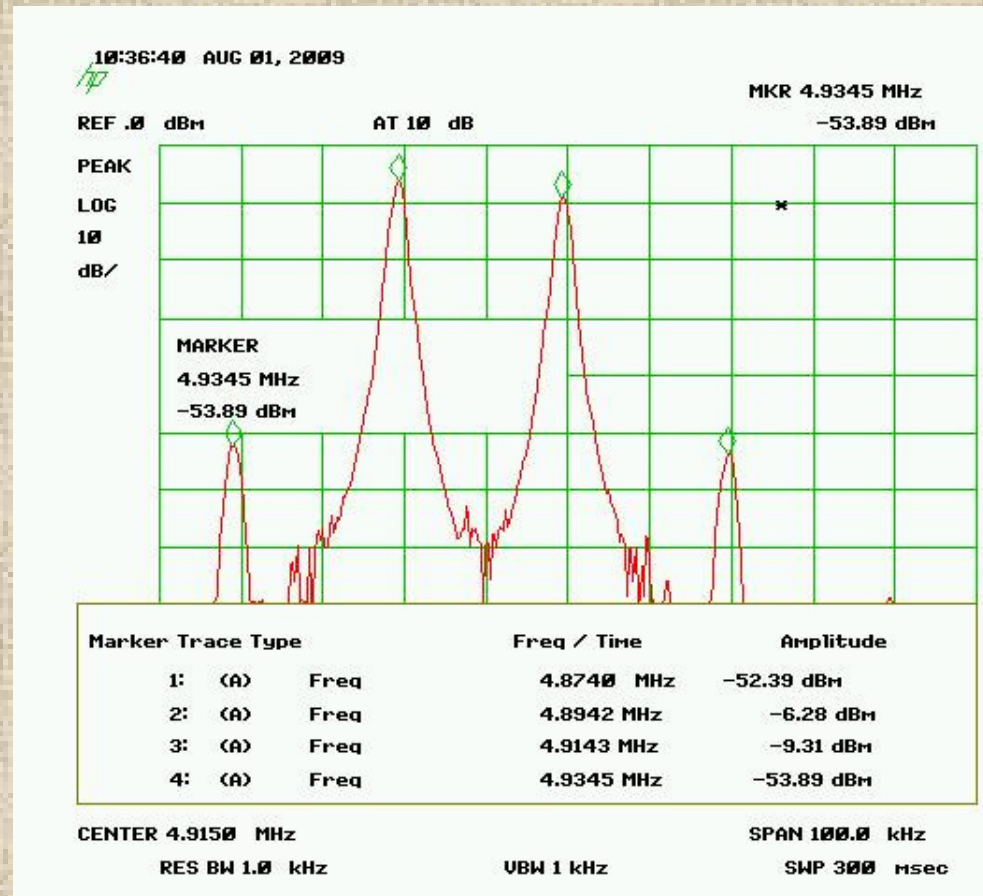


- SA612 chip in wide use
- Double Balanced, but with no transformers
- Elecraft KX-1
- Q-Track receivers

BJT Gilbert Cell in KX-1

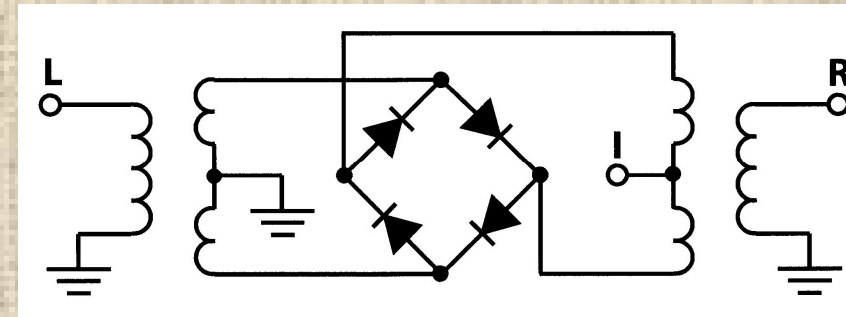
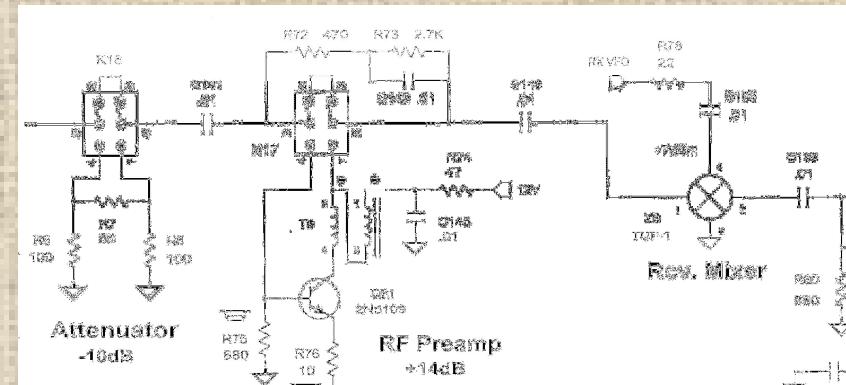
Wide Spacing

- Gain= +18.7 dB
- Distortion= 46.1dB down
- IP= -1.9 dBm



Diode DBM Mixer

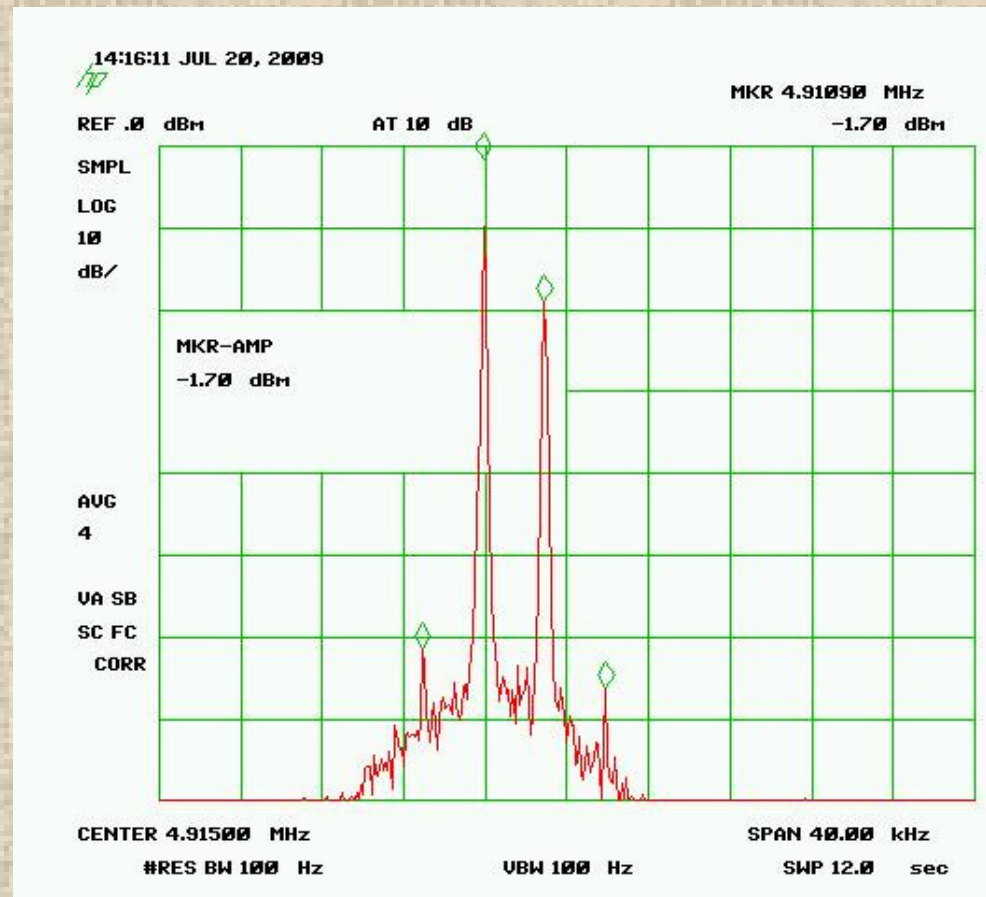
- MiniCircuits TUF-1 in Elecraft K2
- Workhorse high performance mixer of the 80's—90's
- Transformers balance the RF and LO signals out of the IF port



Diode DBM Mixer in K2

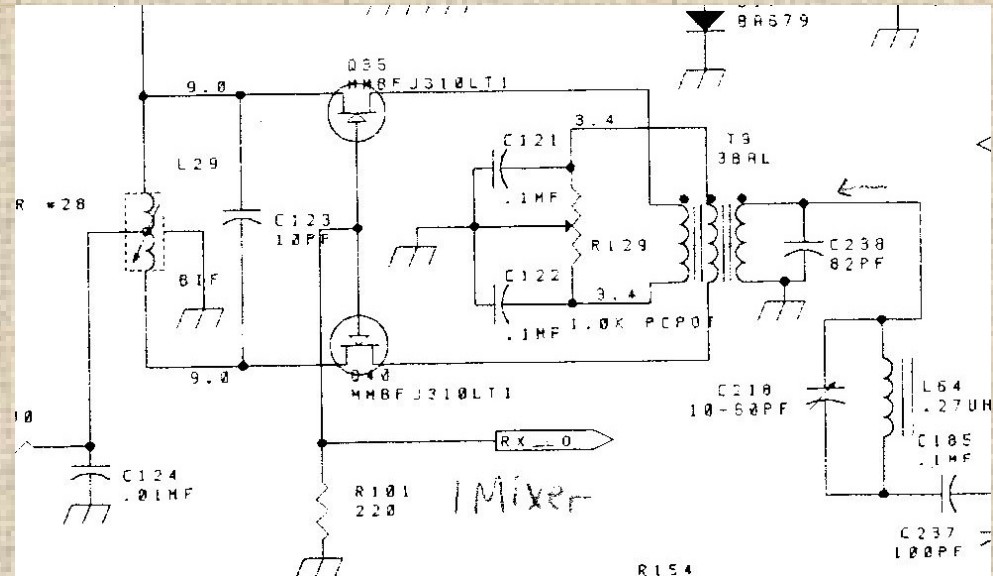
ATTN off; 3 kHz Spacing

- 14dB Preamplifier On
- Gain= +11.2dB
- Distortion 46dB down
- IP= +4.85dBm
- Phase noise very close in only



2 JFET SBM in Pegasus

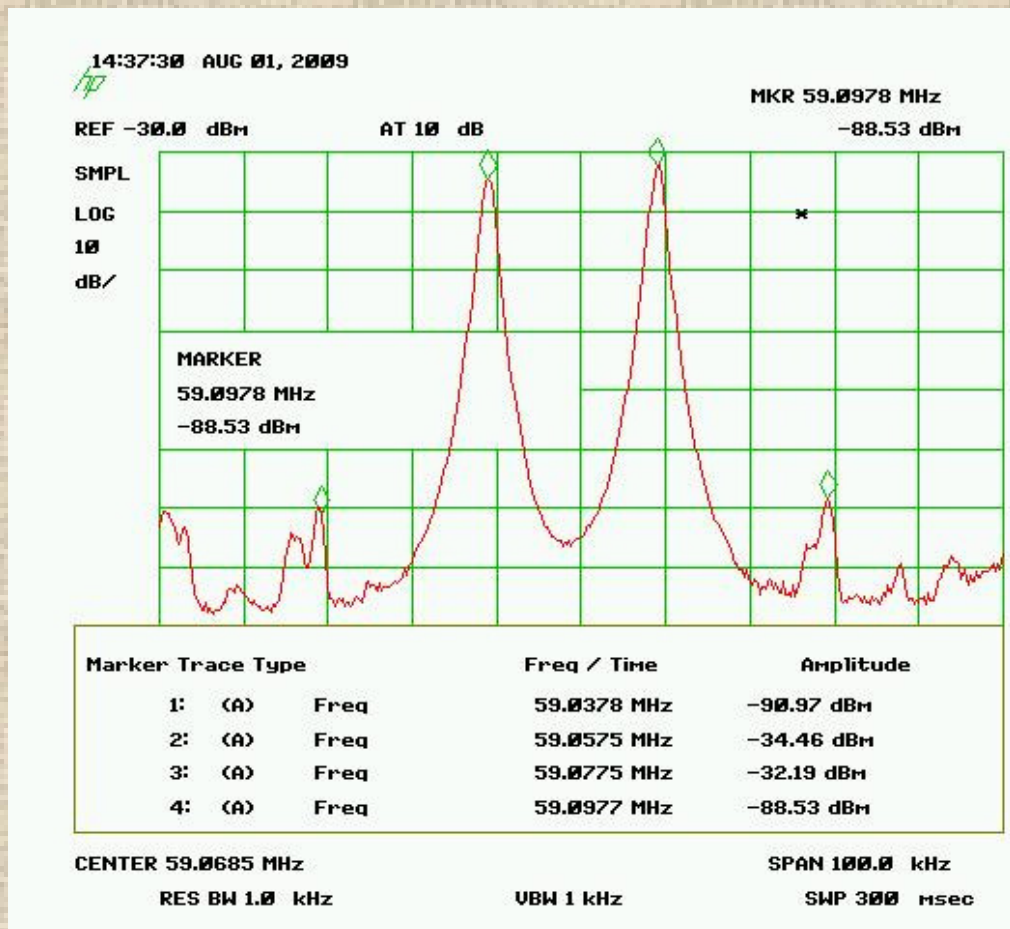
- Balanced only at RF port
- Standard J310 FETs



2 JFET SBM in Pegasus

ATTN off, 20 kHz Spacing

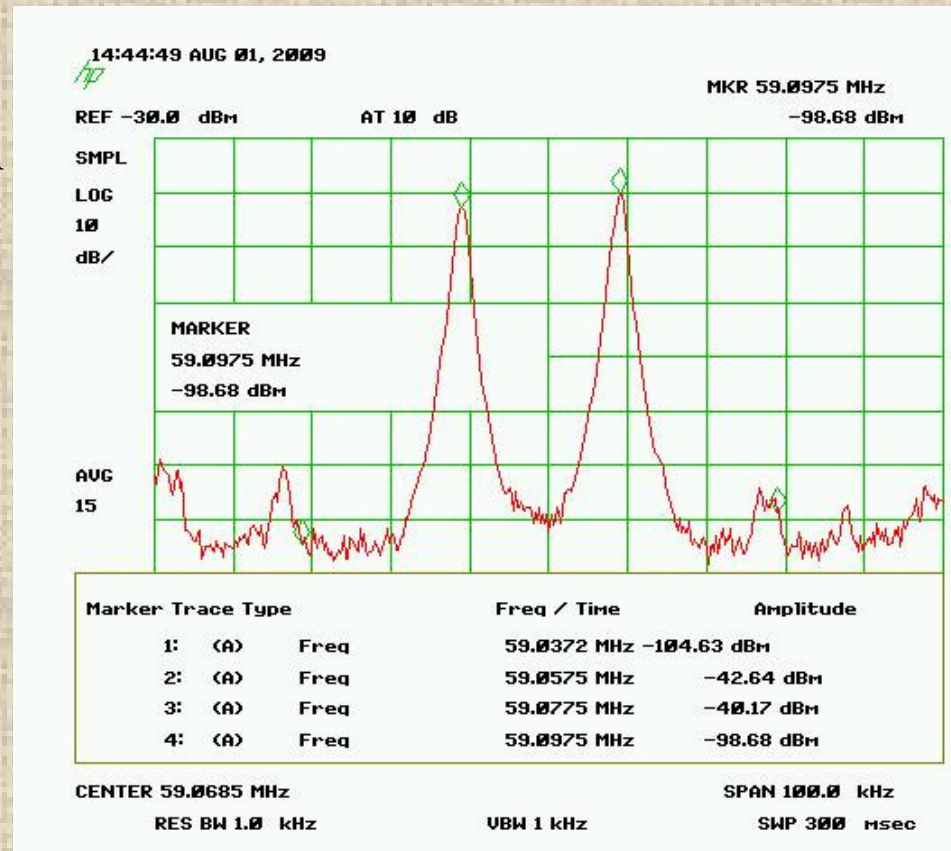
- Gain= -9.5dB
- Distortion 56.2dB down
- IP= +3.3dBm
- Noise at graph edge -100dBm



2 JFET SBM in Pegasus

ATTN on, 20 kHz Spacing

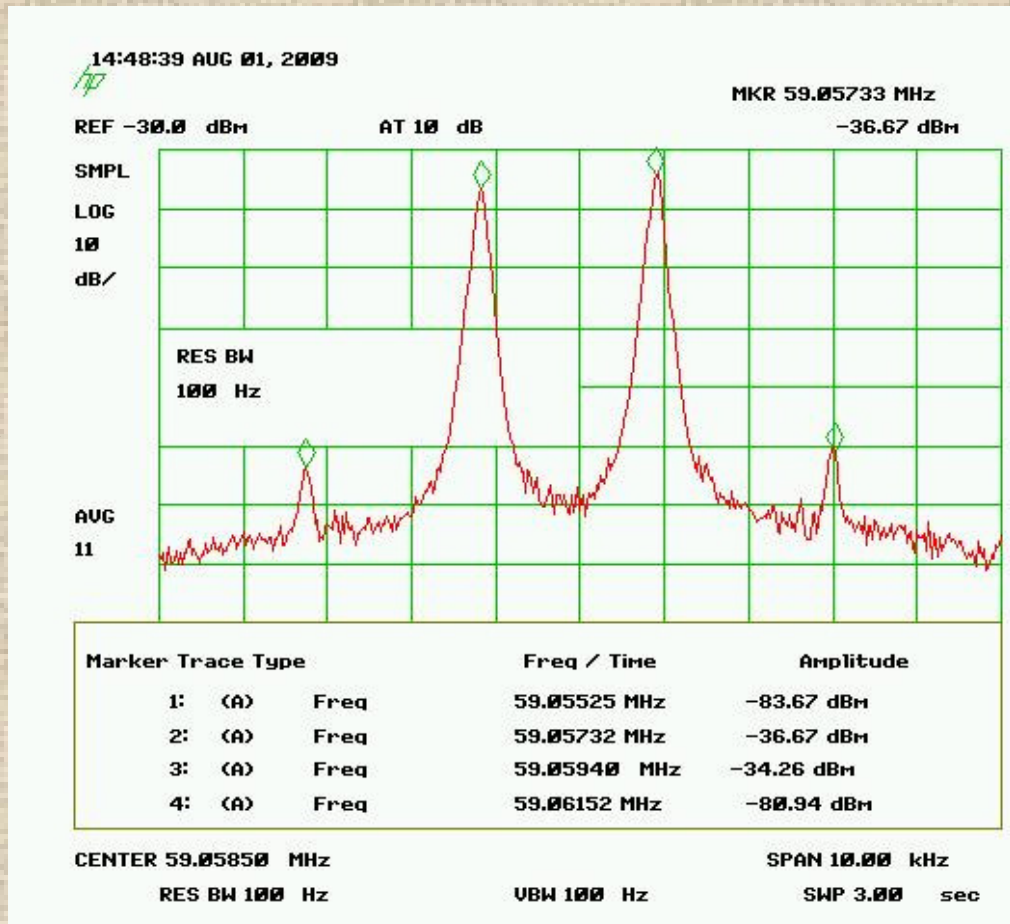
- Gain= -17.6dB
- Distortion 62dB down
- IP= +6dBm
- Noise at graph edge -95dBm



2 JFET SBM in Pegasus

ATTN off, 2 kHz Spacing

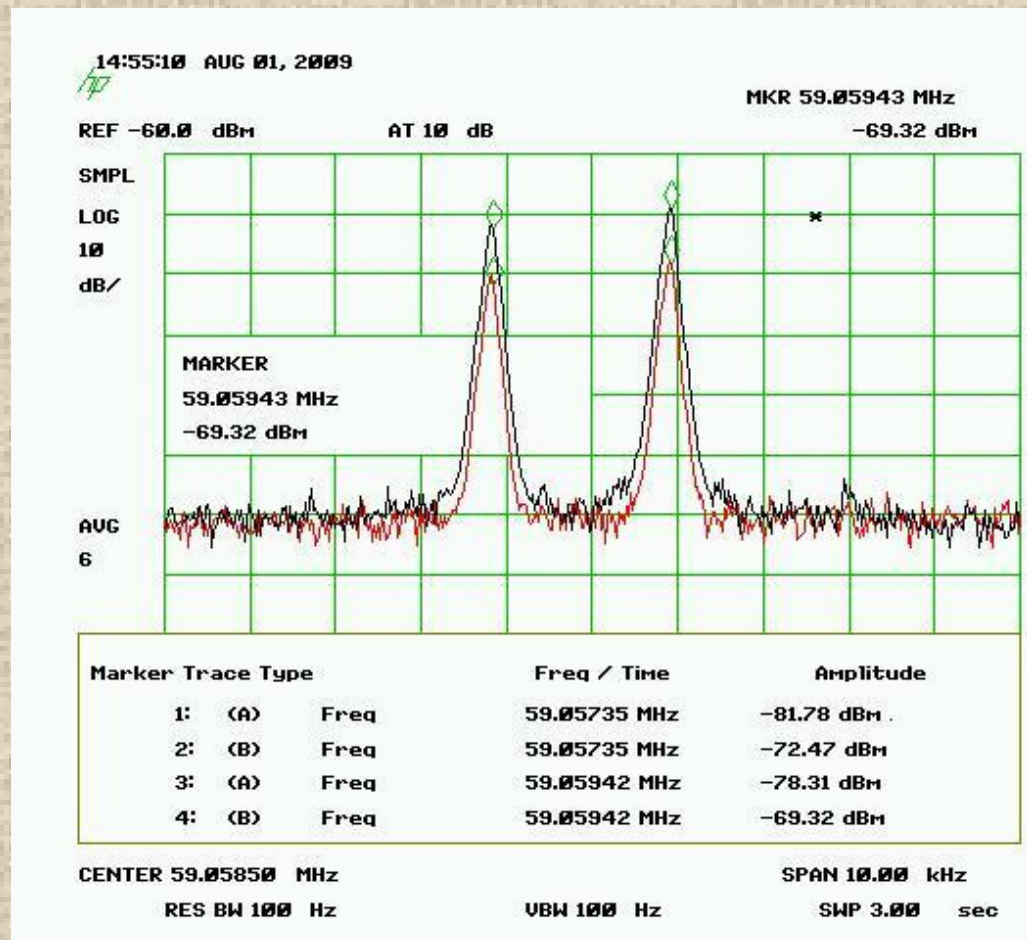
- Gain= -11.7dB
- Distortion 47dB down
- IP= -1.5dBm
- Noise at graph edge -98dBm



2 JFET SBM in Pegasus

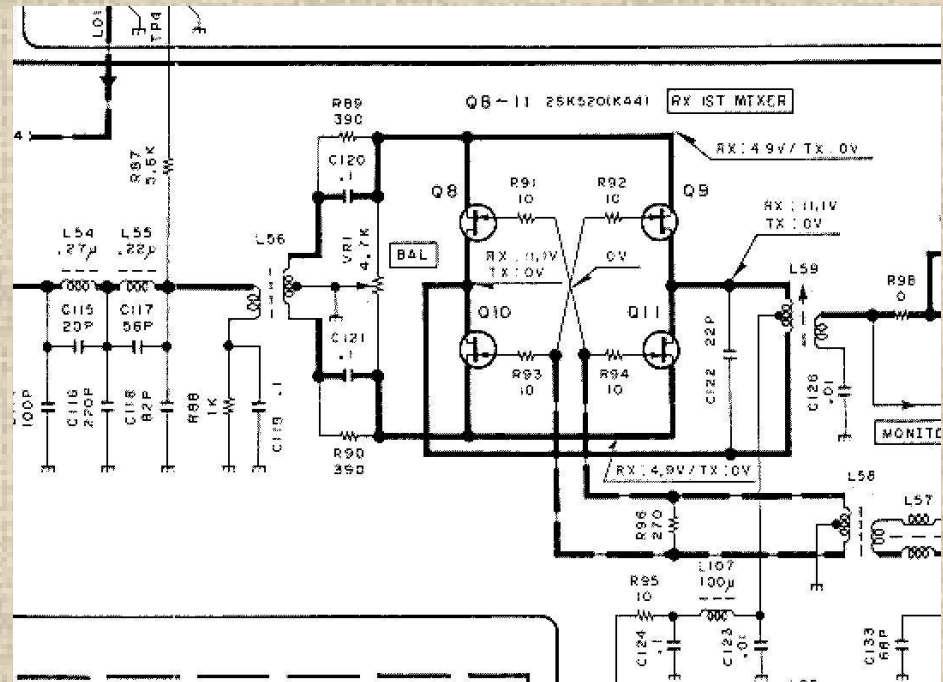
ATTN Switched, 2 kHz Spacing

- ATTN on/off



4 JFET DBM in TS850

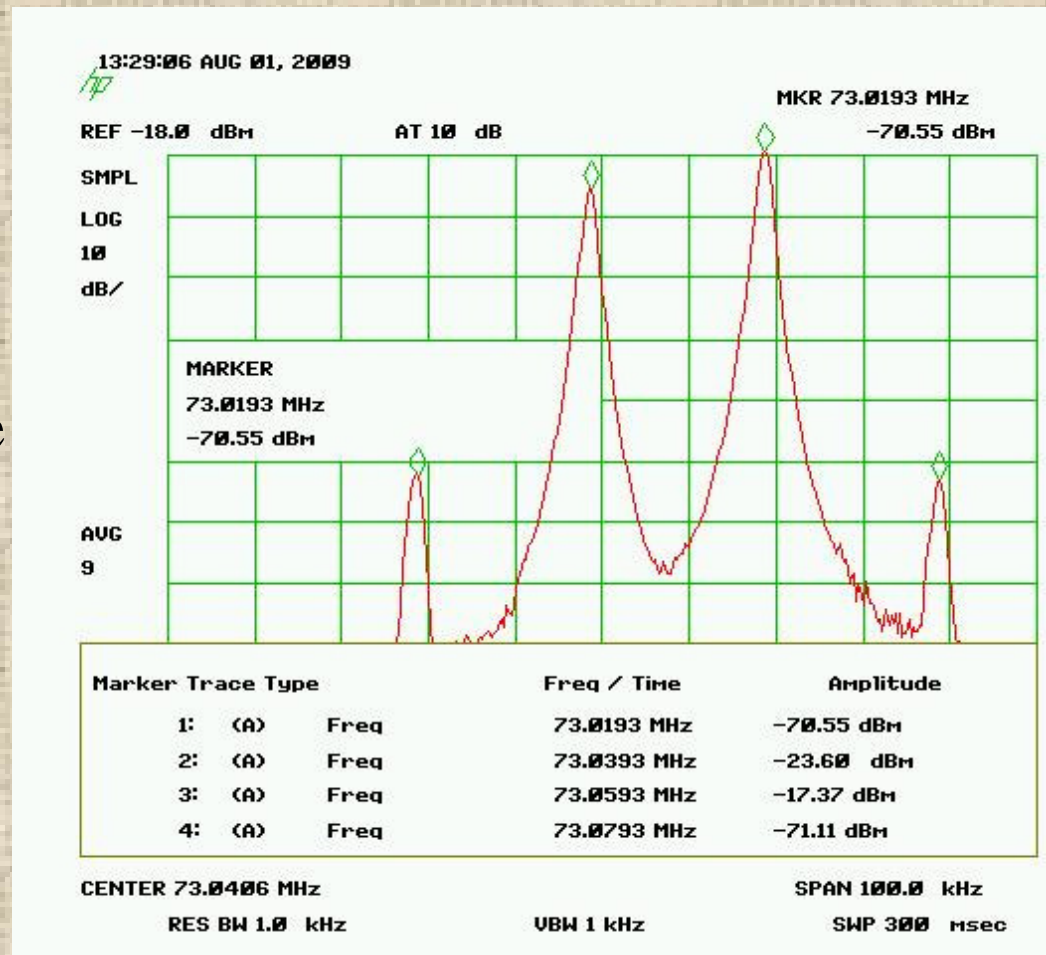
- Discrete components
- All 3 ports have balancing transformers



4JFET DBM in TS850

Preampl On, 20 kHz Spacing

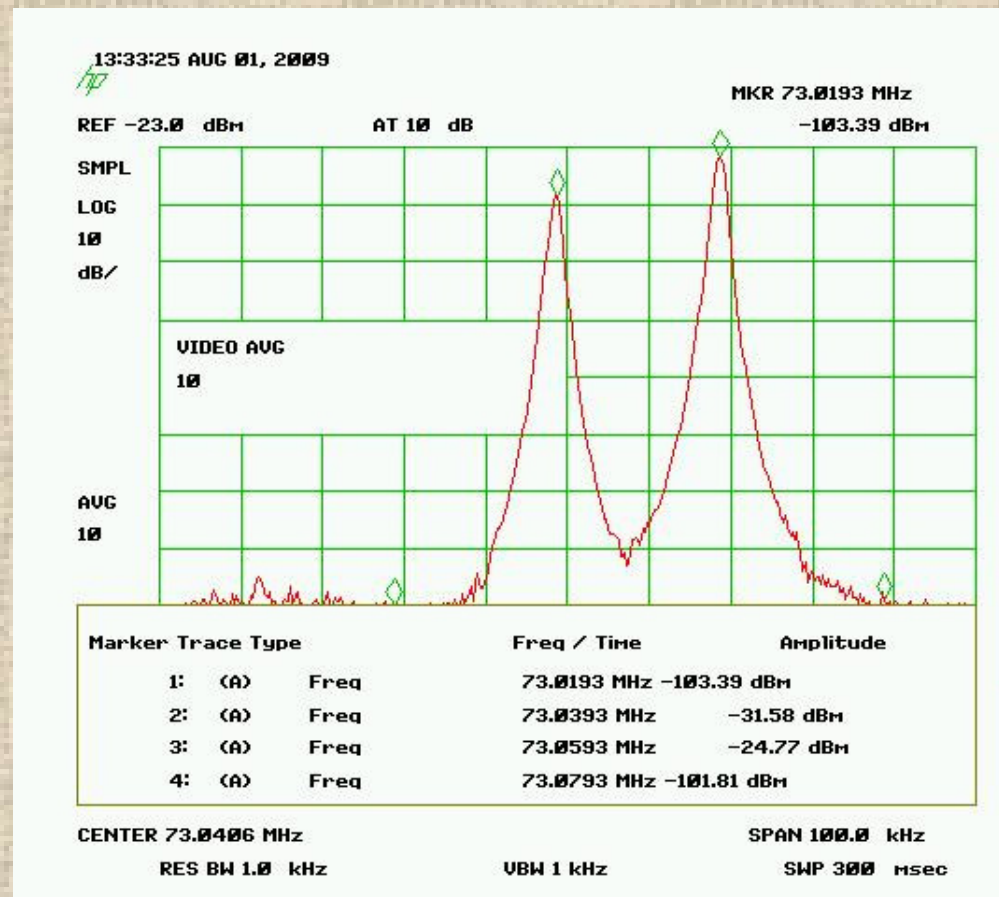
- Gain= +1.4dB
- Distortion 47dB down
- IP= -1.5dBm
- Noise at graph edge -110dBm



4 JFET DBM in TS850

Preamp Off, 20 kHz Spacing

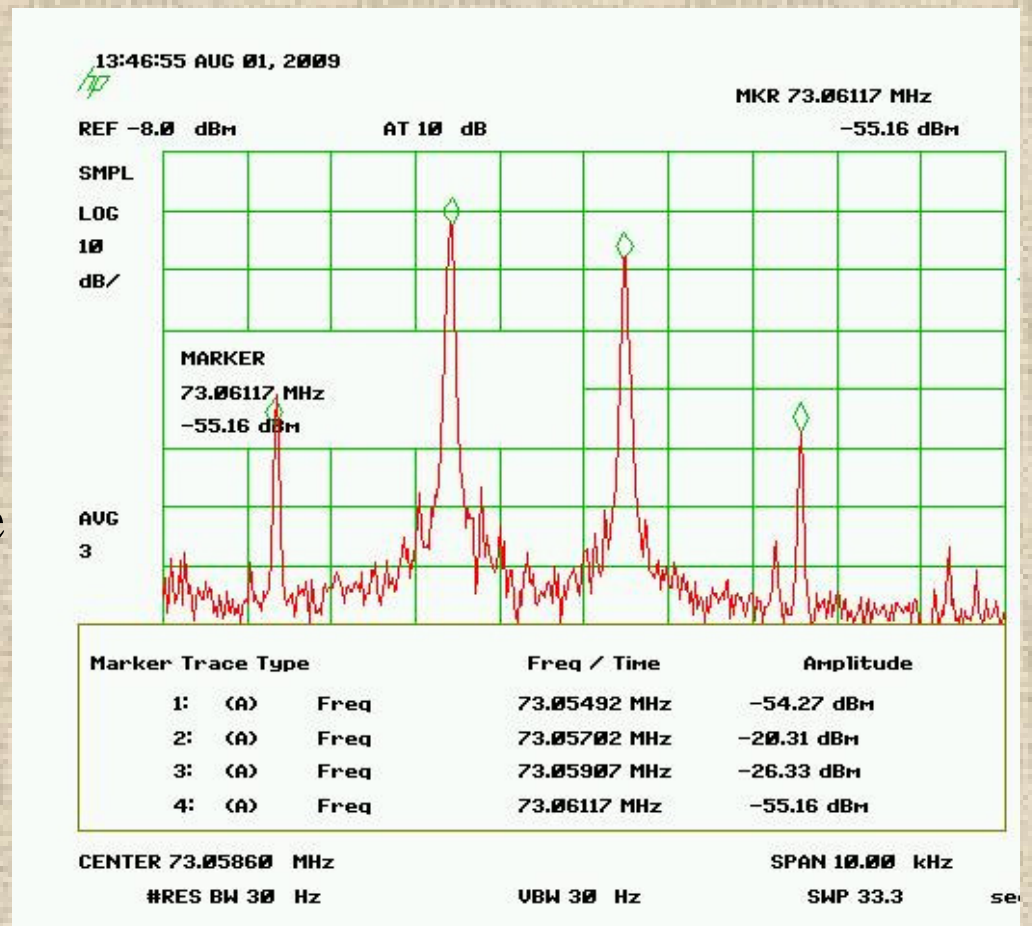
- Gain= -6.6dB
- Distortion >71.8dB down
- IP= +13.55dBm
- Noise at graph edge -105dBm



4 JFET DBM in TS850

Preampl On, 2 kHz Spacing

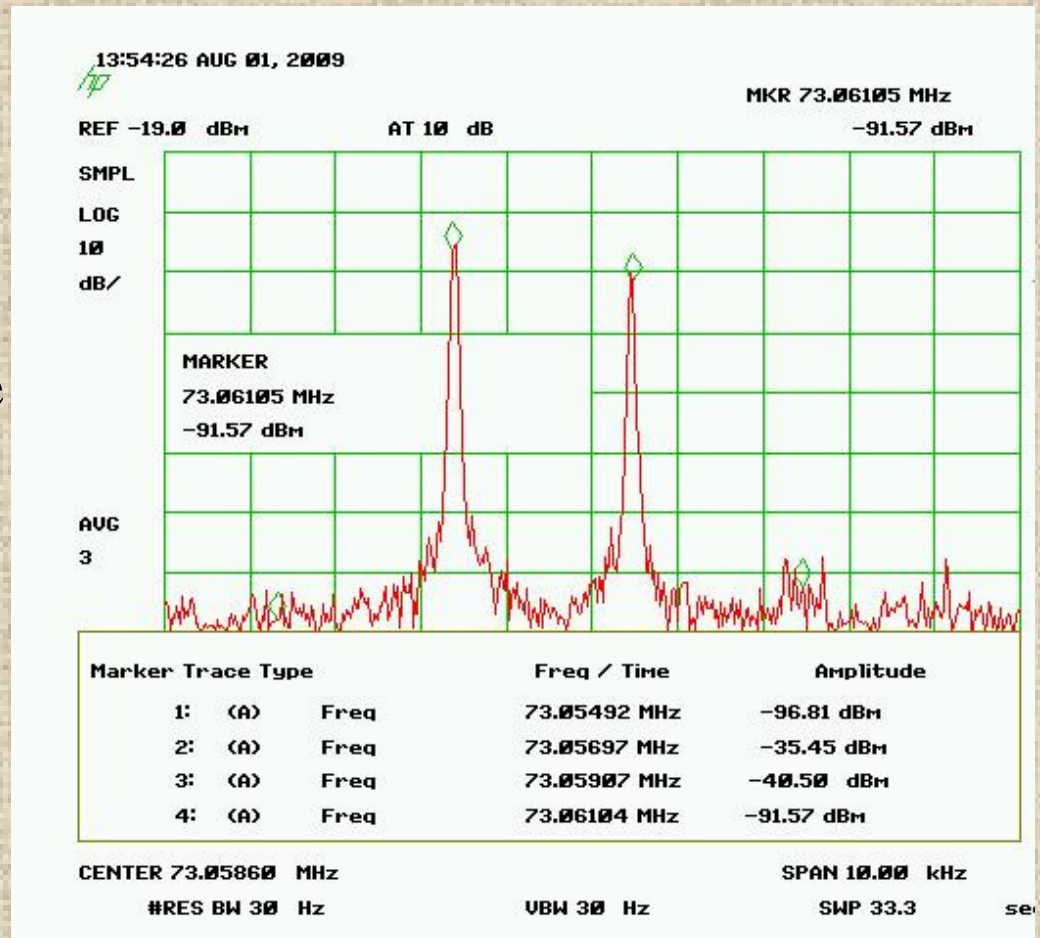
- Gain= +4.7dB
- Distortion 34dB down
- IP= -8.0dBm
- Noise at graph edge -85dBm



4 JFET DBM in TS850

Preampl Off, 2 kHz Spacing

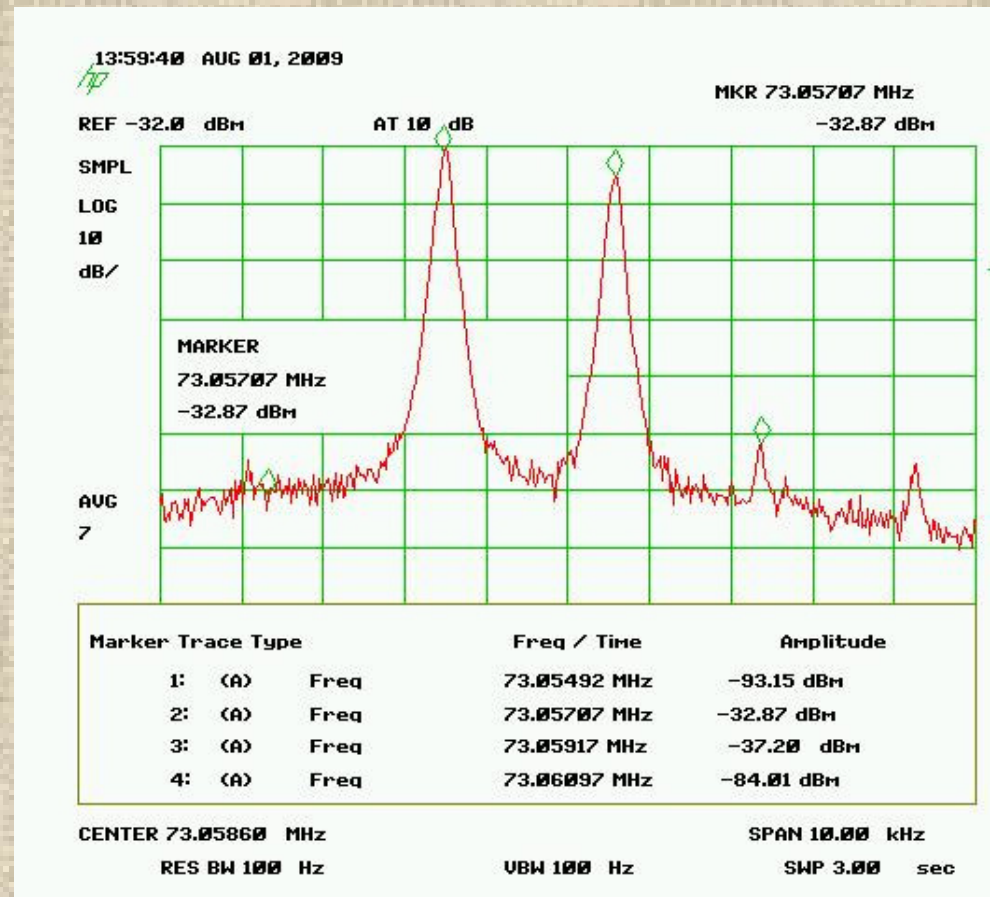
- Gain= -10.5dB
- Distortion 61.4dB down
- IP= +5.7dBm
- Noise at graph edge -95dBm



4 JFET DBM in TS850

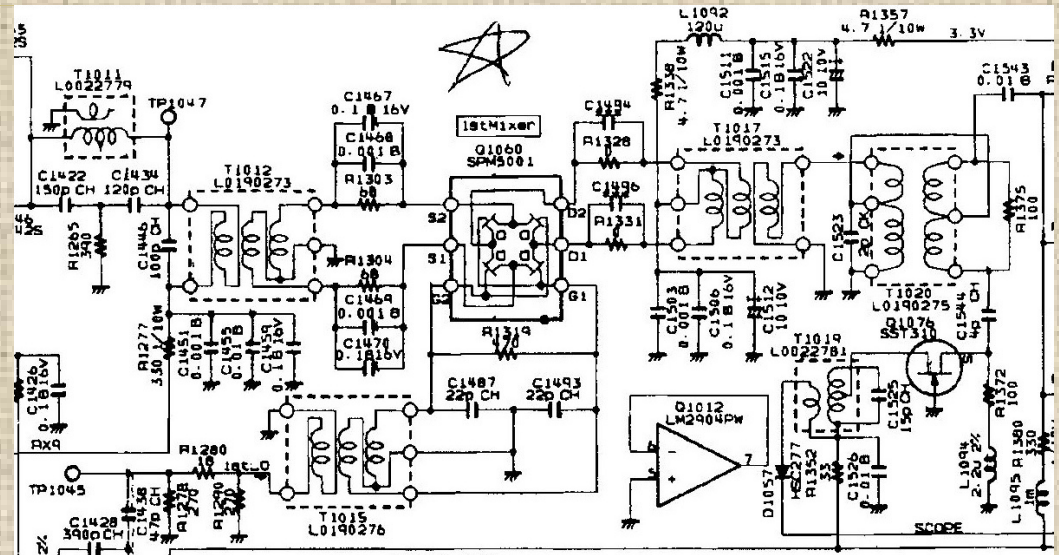
Preampl Off, 2 kHz Spacing

- Gain= -7.9dB
- Distortion 60.3dB down
- IP=+5.1dBm
- Noise at graph edge -100dBm



4 JFET DBM in FT950

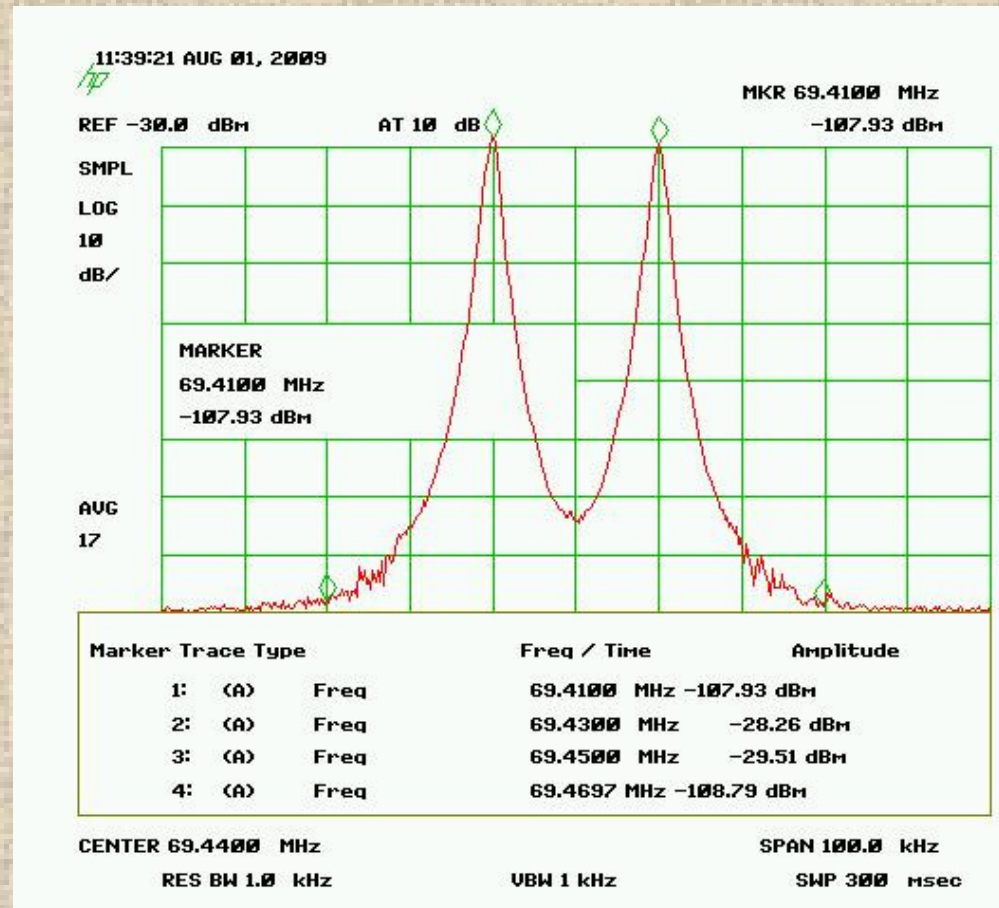
- JFETs and transformers in modules
- All 3 ports have balancing transformers



4 JFET DBM in FT950

Preamps Off, 20 kHz Spacing

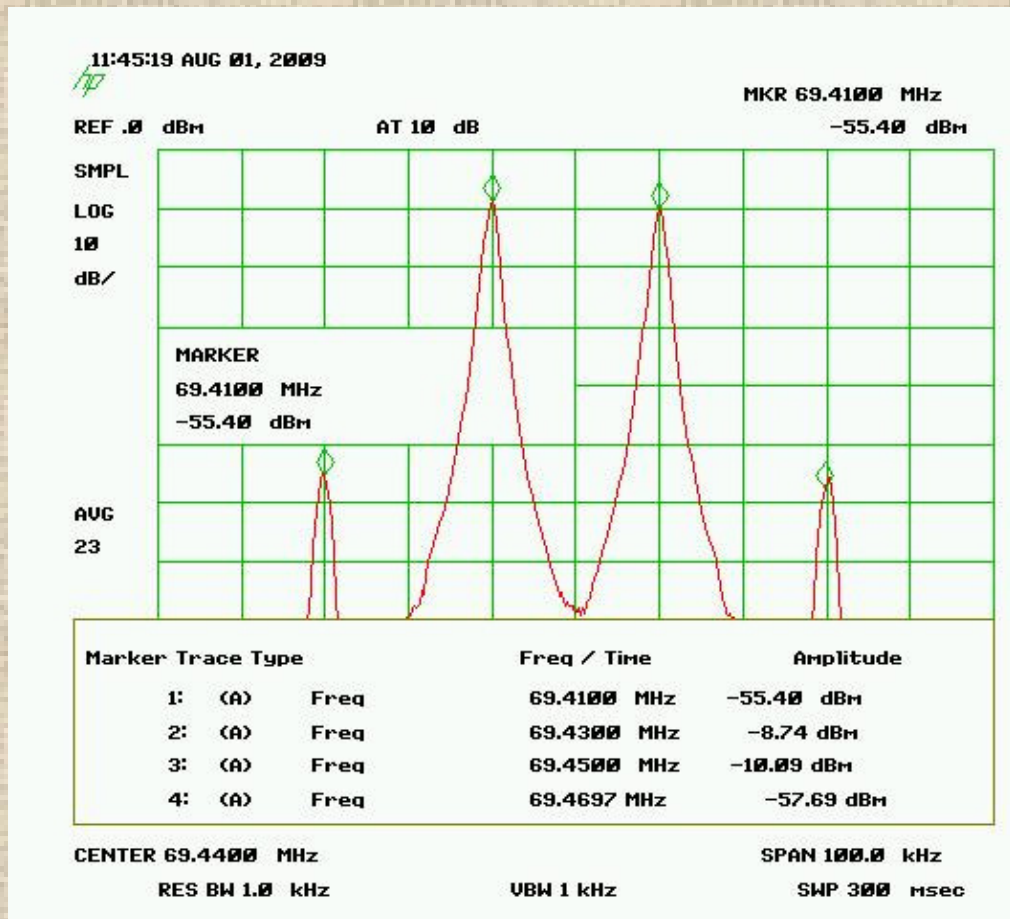
- Gain=-3.3dB
- Distortion >80dB down
- IP>+14.8dBm
- Noise at graph edge -110dBm



4 JFET DBM in FT950

Preamps On, 20 kHz Spacing

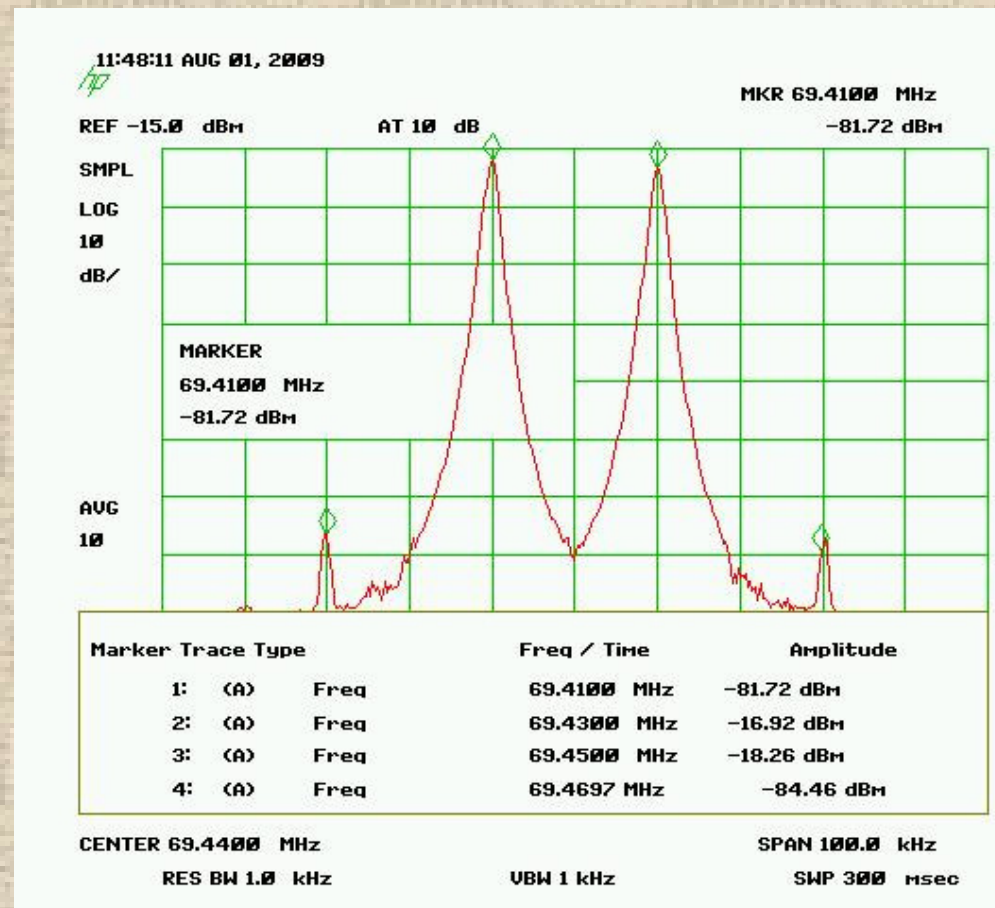
- Gain= +16.3dB
- Distortion 46.7dB down
- IP= -1.7dBm



4 JFET DBM in FT950

Preamplifier #1 On, 20 kHz Spacing

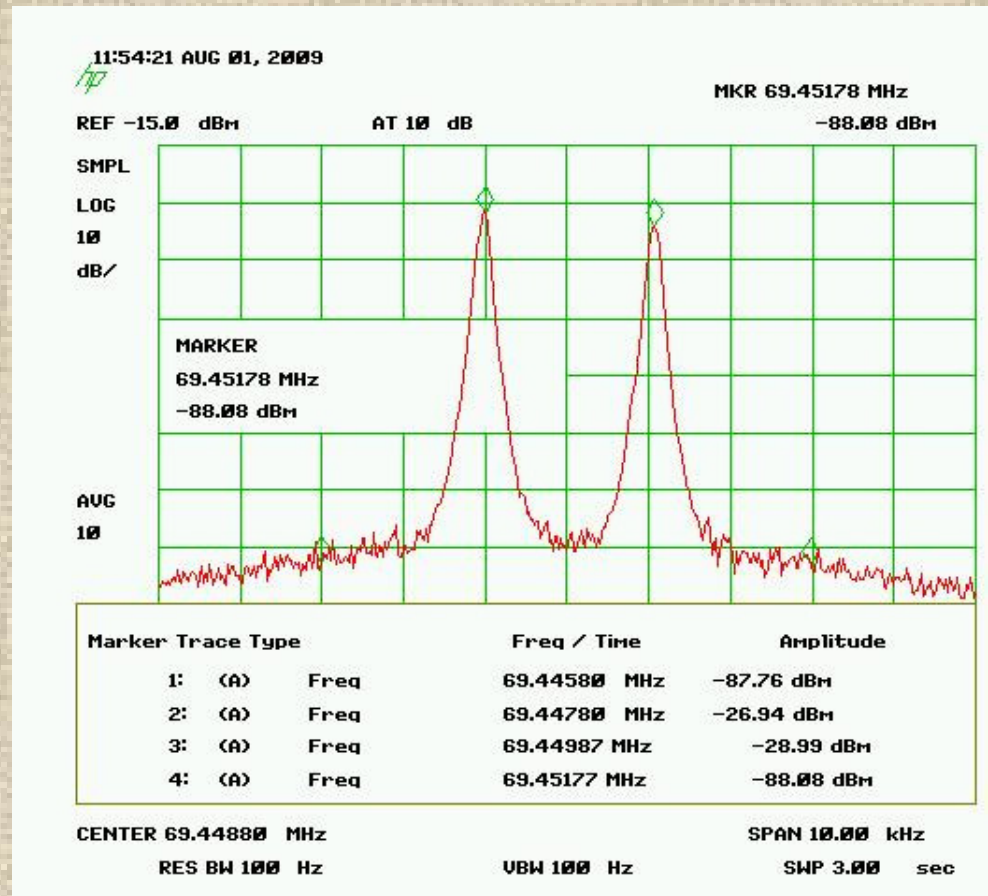
- Gain = +8.1 dB
- Distortion 64.9 dB down
- IP = +7.4 dBm
- Noise at graph edge -100 dBm



4 JFET DBM in FT950

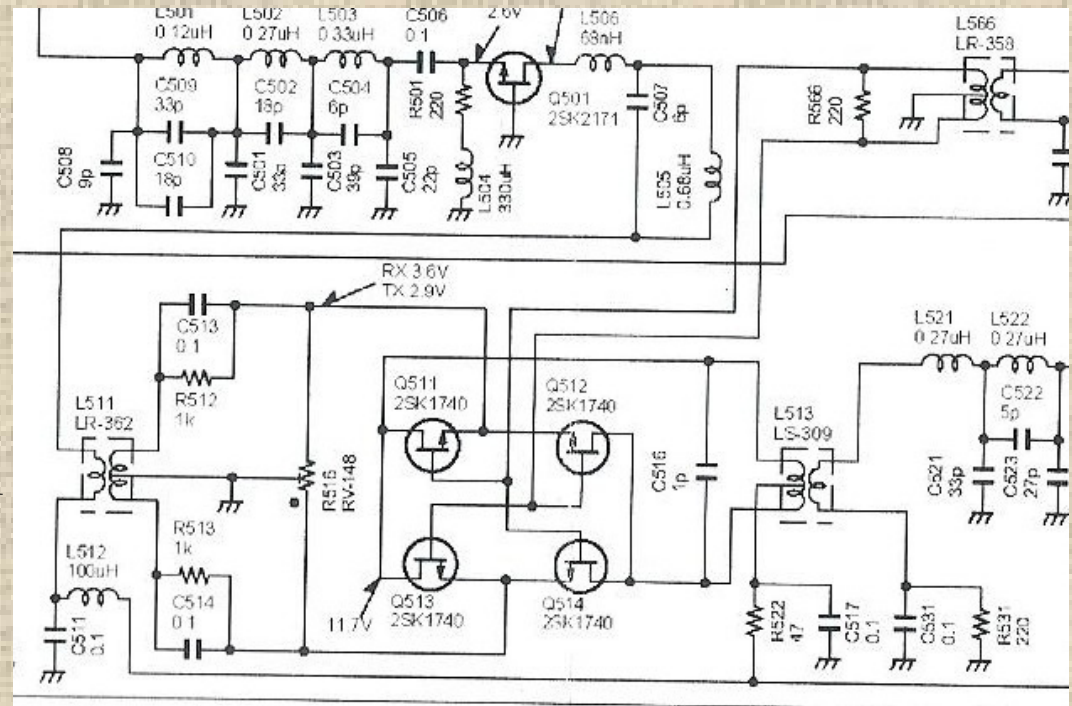
Preamps Off, 2 kHz Spacing

- Gain= -2 dB
- Distortion >60.8dB down
- Noise at graph edge -92dBm



4 JFET DBM in IC756Pro

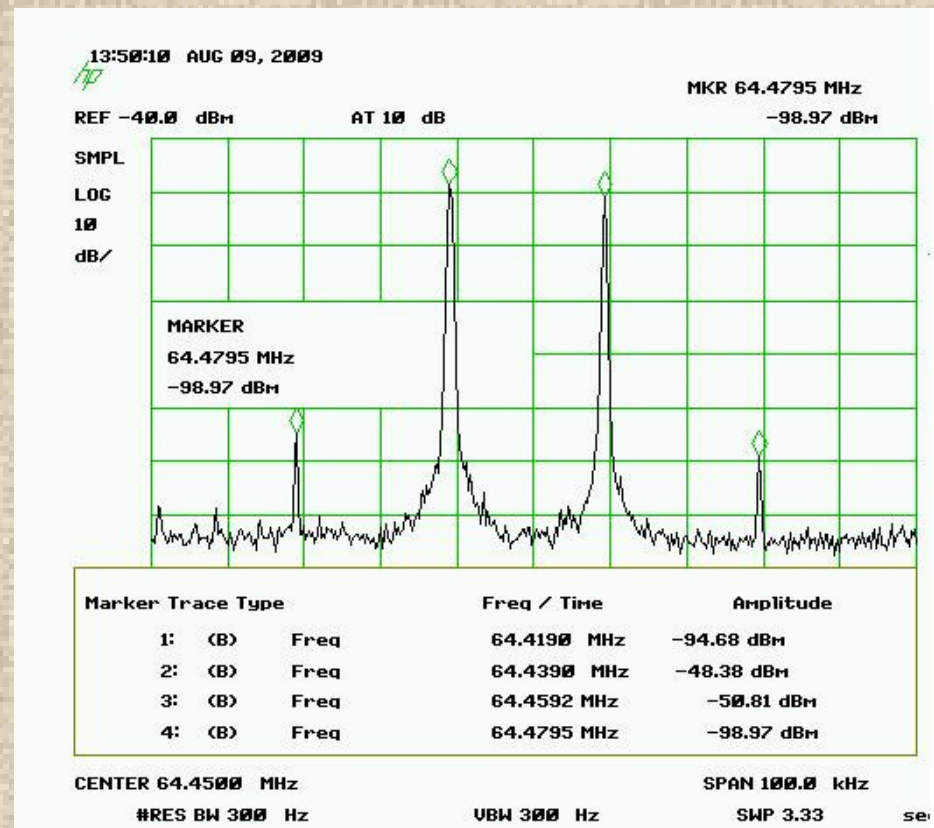
- Components inside well shielded enclosures
- Measured outside enclosure at Q501



4 JFET DBM in IC756Pro

Preamp #2 On, 20 kHz Spacing

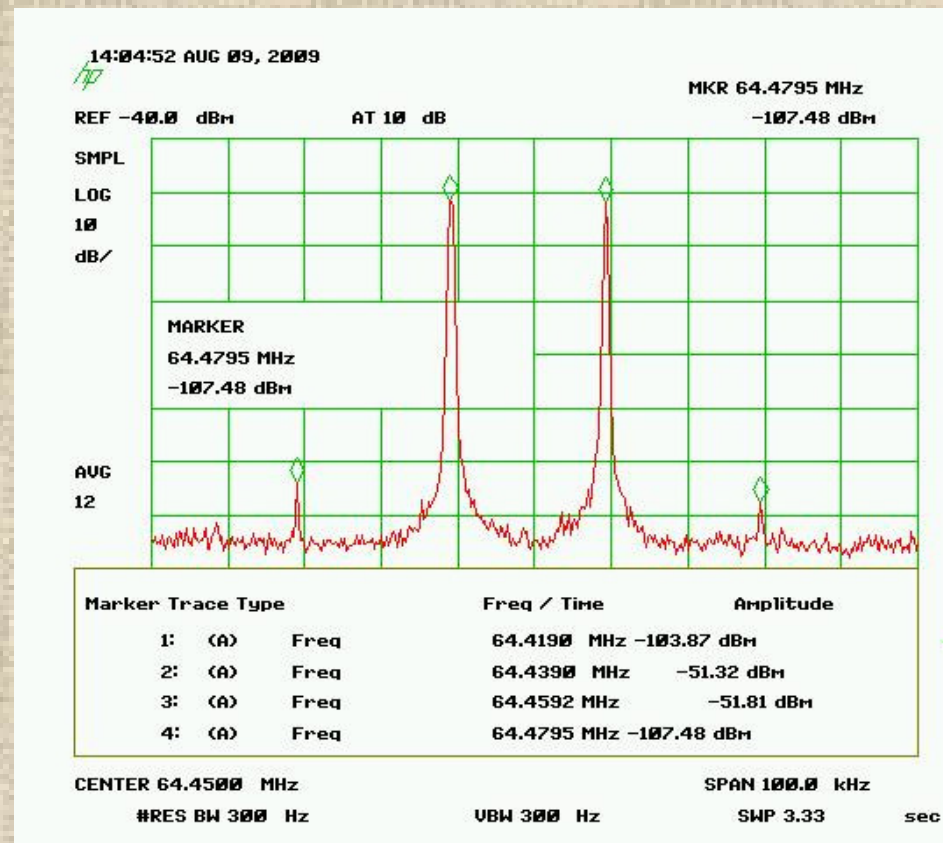
- Input= -25dBm
- Gain= -23.4dB
- Dist 46.3dB down
- IP= -1.85dBm
- Noise at graph edge -113dBm



4 JFET DBM in IC756Pro

Preamplifier #1 On, 20 kHz Spacing

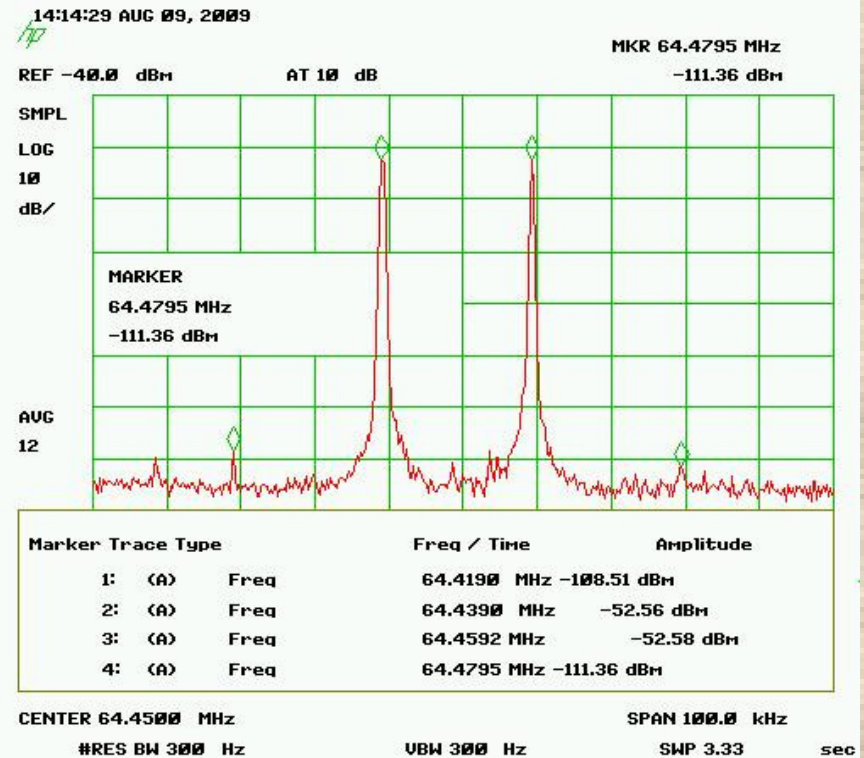
- Input = -20 dBm
- Gain = -31.3 dB
- Dist 55.2 dB down
- IP = +6.3 dBm
- Noise at graph edge -115 dBm



4 JFET DBM in IC756Pro

Preamps Off, 20 kHz Spacing

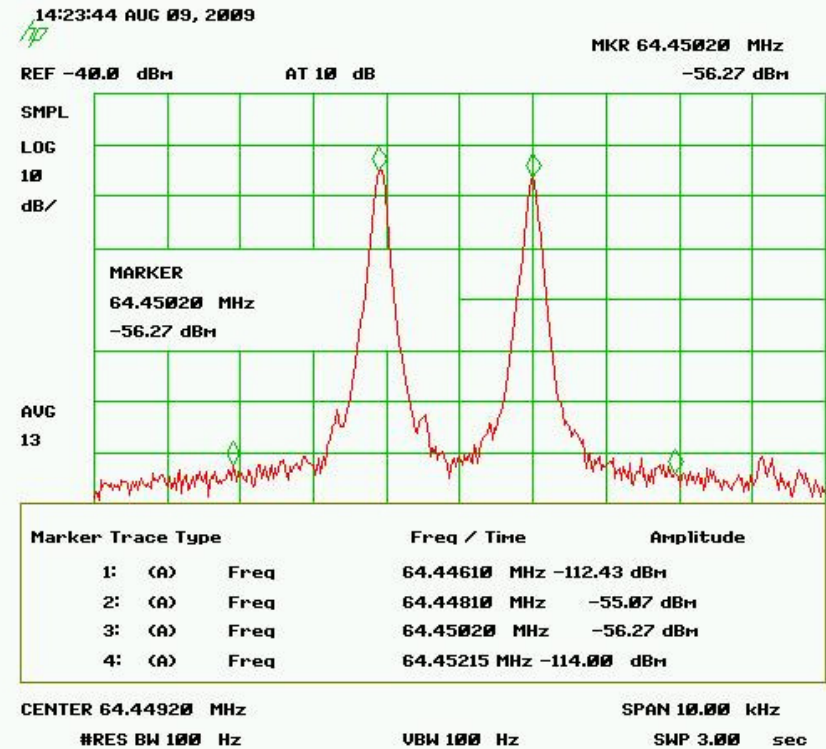
- Input= -10dBm
- Gain= -42.5dB
- Dist 48dB down
- IP= +14.0dBm
- Noise at graph edge -115dBm



4 JFET DBM in IC756Pro

Preamps Off, 2 kHz Spacing

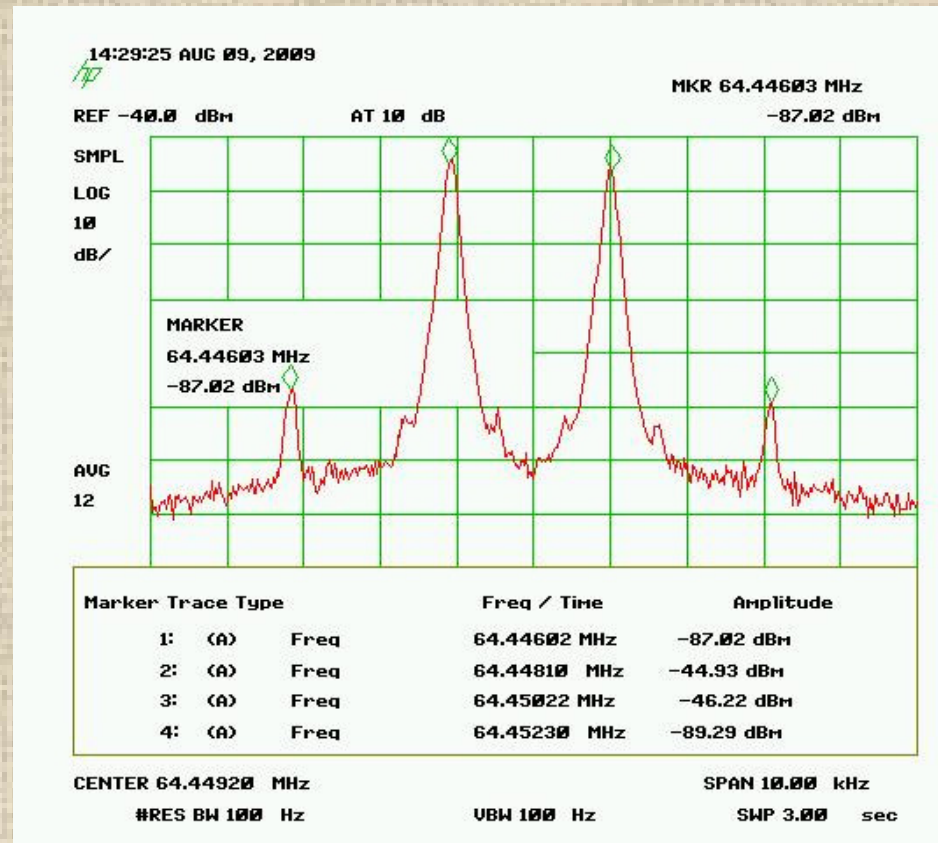
- Input= -15dBm
- Gain= -40dB
- Phase Noise Covers the Distortion
- IP= +13.7dBm
- Noise at graph edge -115dBm



4 JFET DBM in IC756

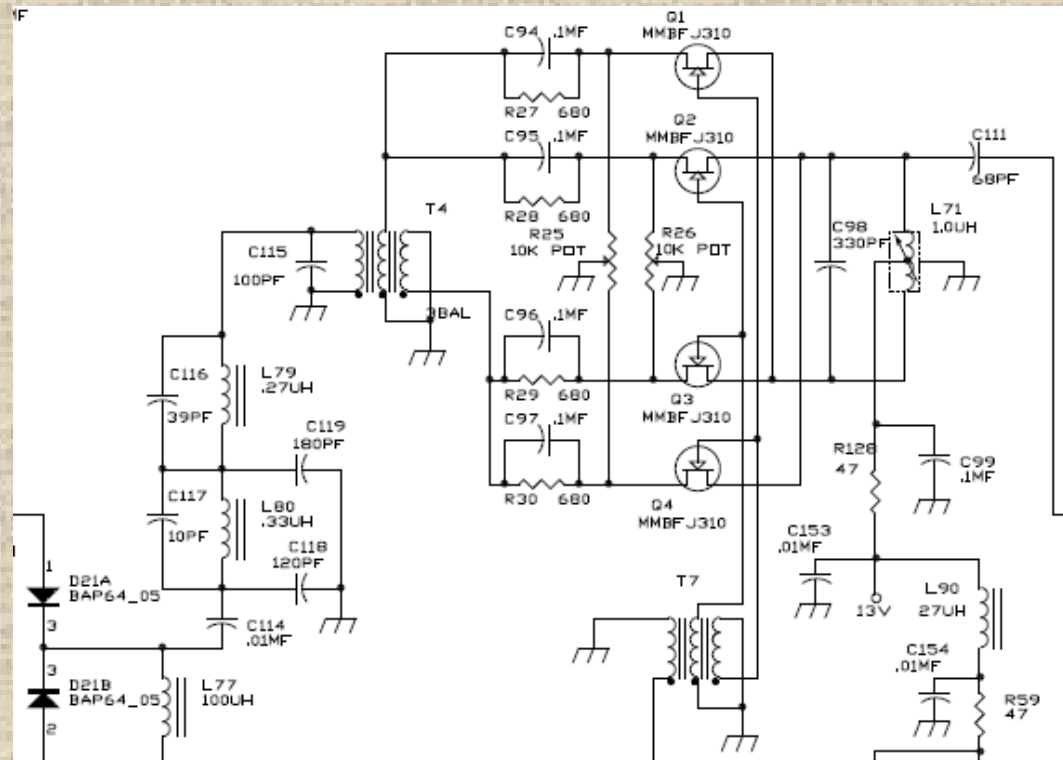
Preamplifier #1 On, 2 kHz Spacing

- Input = -15 dBm
- Gain = -30 dB
- Dist 42 dB down
- IP = +6.0 dBm
- Noise at graph edge -108 dBm



4JFET DBM in Orion

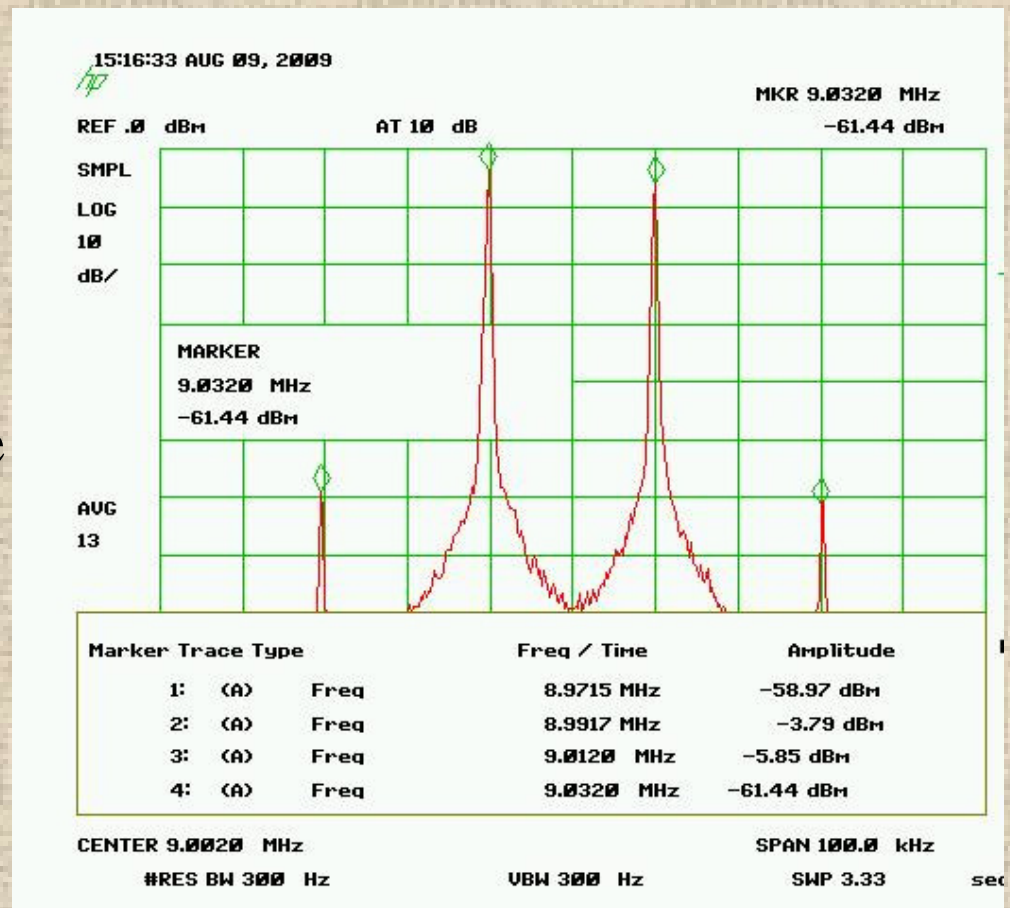
- Discrete components
- Balancing transformers at 2 ports



4 JFET DBM in Orion

Preamplifier Off, 20 kHz Spacing

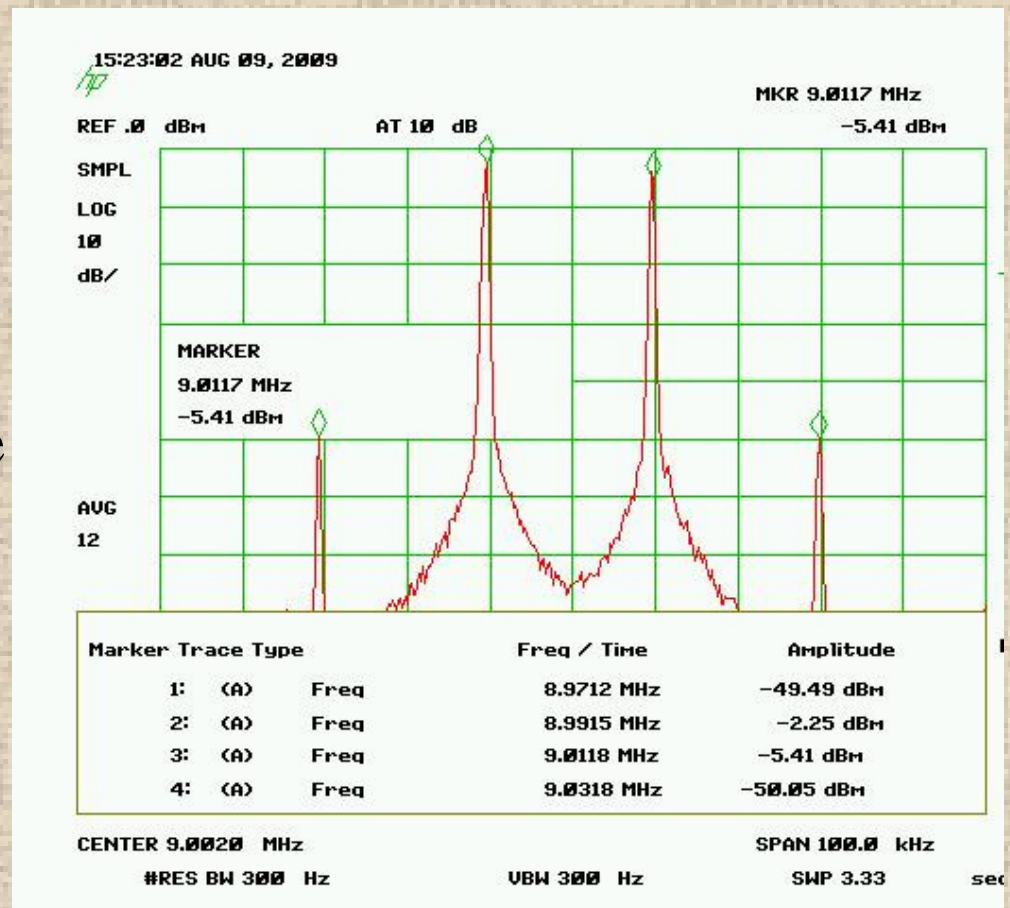
- Input = -15 dBm
- Gain = +11.2 dB
- Dist 55 dB down
- IP = +12.6 dBm
- Noise at graph edge -120 dBm



4 JFET DBM in Orion

Preamplifier On, 20 kHz Spacing

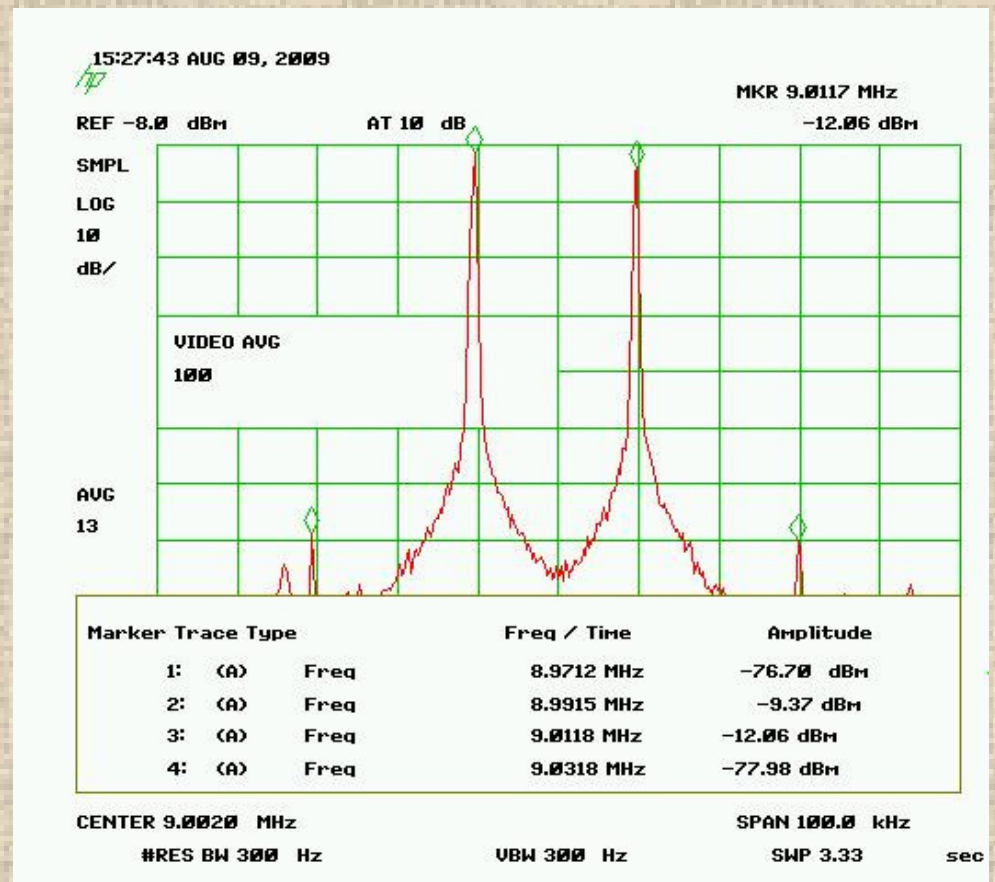
- Input = -25 dBm
- Gain = +22.7 dB
- Dist 47.2 dB down
- IP = -1.38 dBm
- Noise at graph edge -115 dBm



4 JFET DBM in Orion

Preampl Off, 20 kHz Spacing

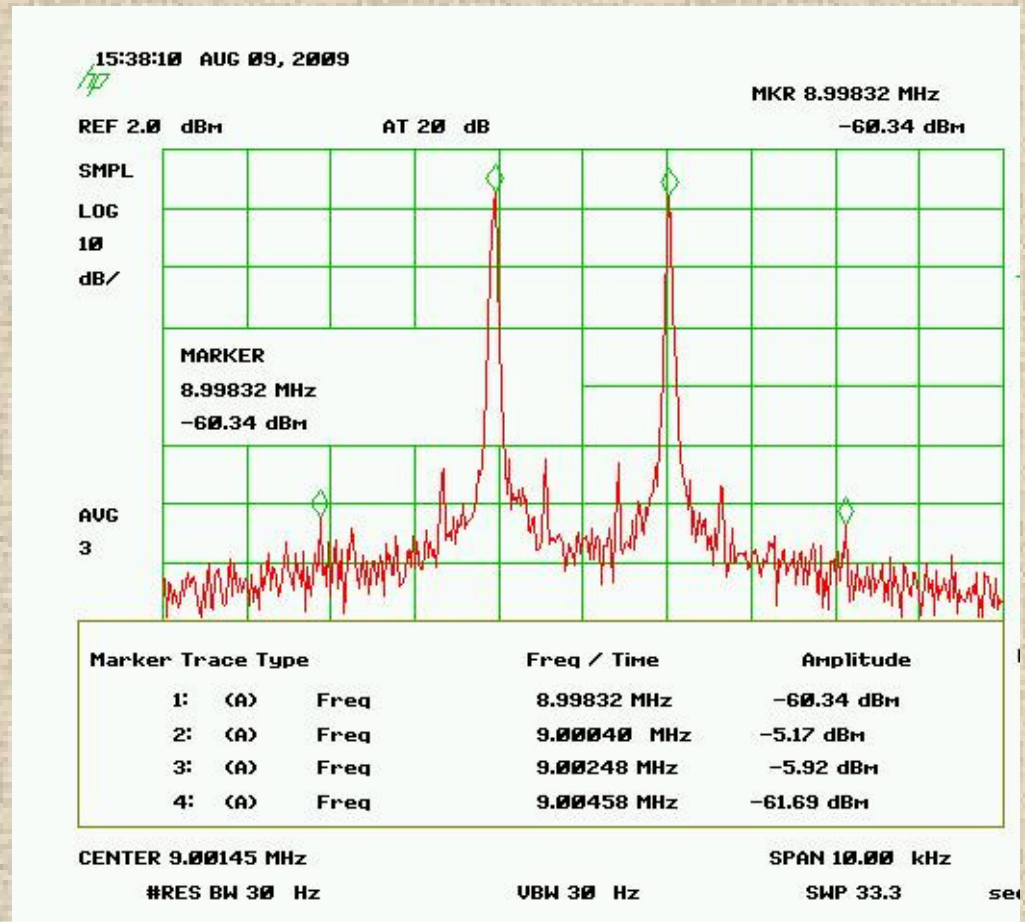
- ATTN= 6dB
- Input= -15dBm
- Gain= +5.6dB
- Dist 67.3dB down
- IP= +18.7dBm
- Noise at graph edge -95dBm



4 JFET DBM in Orion

Preamp Off, 2 kHz Spacing

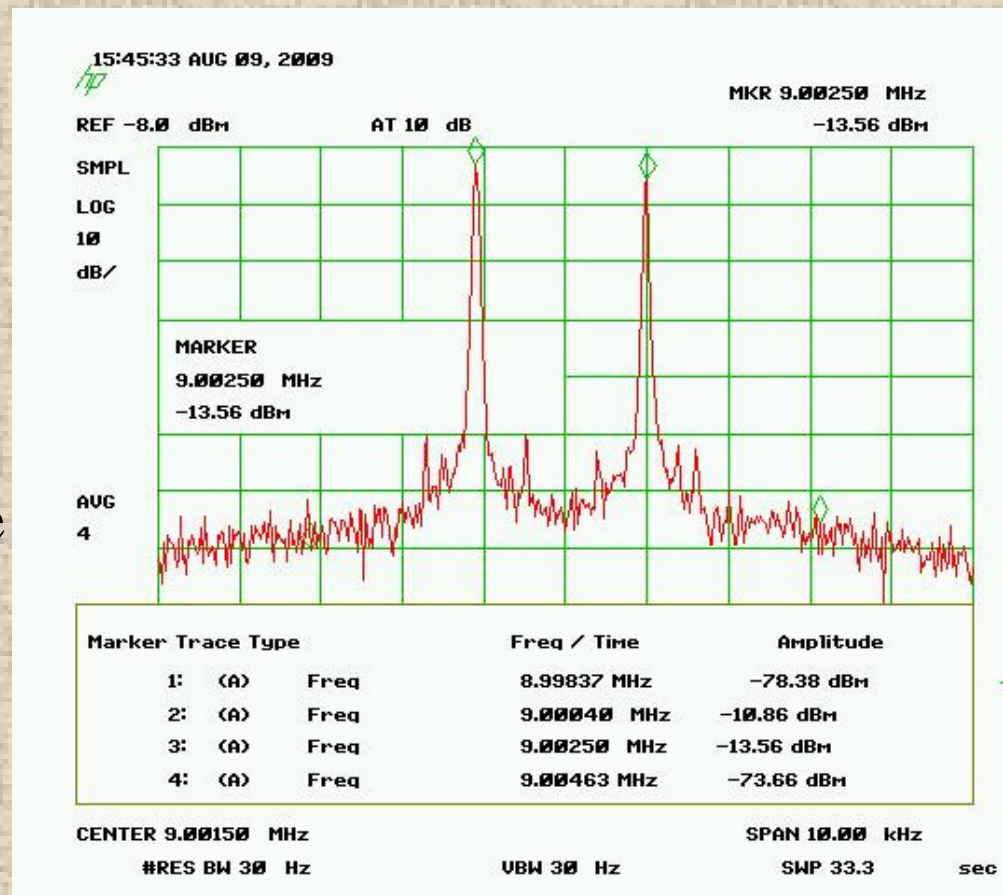
- ATTN= 6dB
- Input= -10dBm
- Gain= +4.8dB
- Dist 55dB down
- IP= +17.6dBm
- Noise at graph edge -73dBm



4 JFET DBM in Orion

Preampl On, 2 kHz Spacing

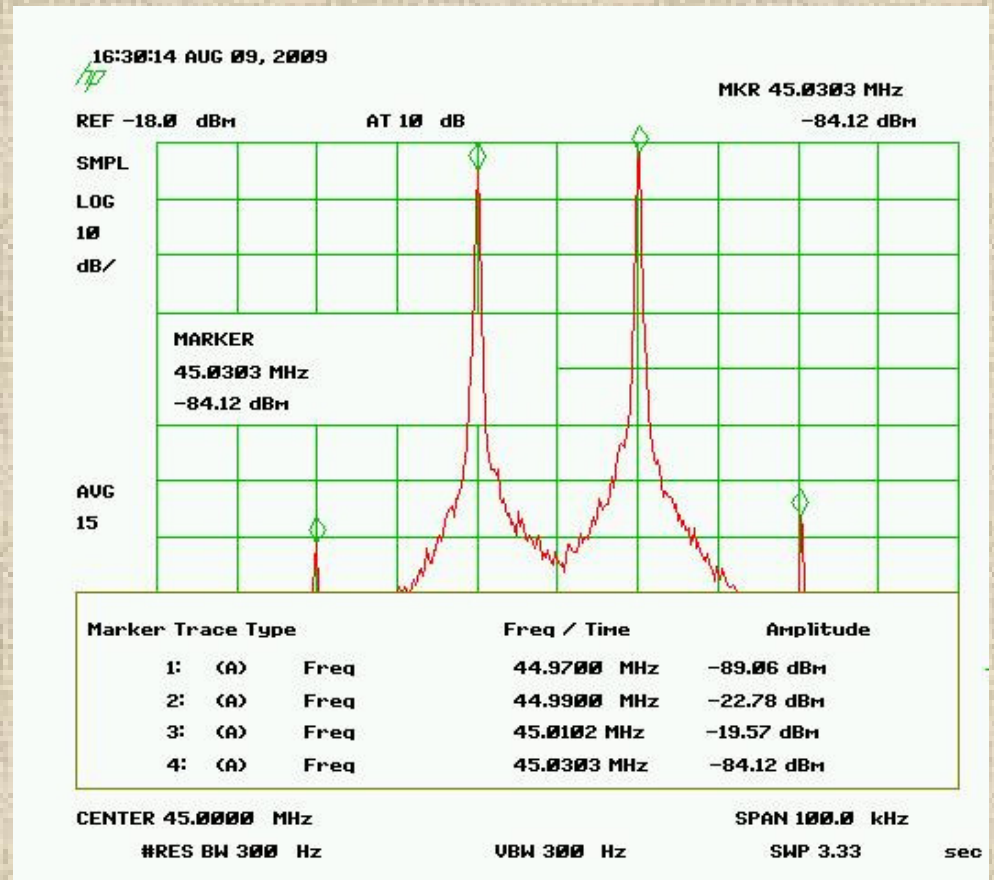
- Input= -35dBm
- Gain= +24.1dB
- Phase Noise covers the Distortion
- IP= -1.2dBm
- Noise at graph edge -79dBm



2 JFET SBM in Orion Sub

20 kHz Spacing

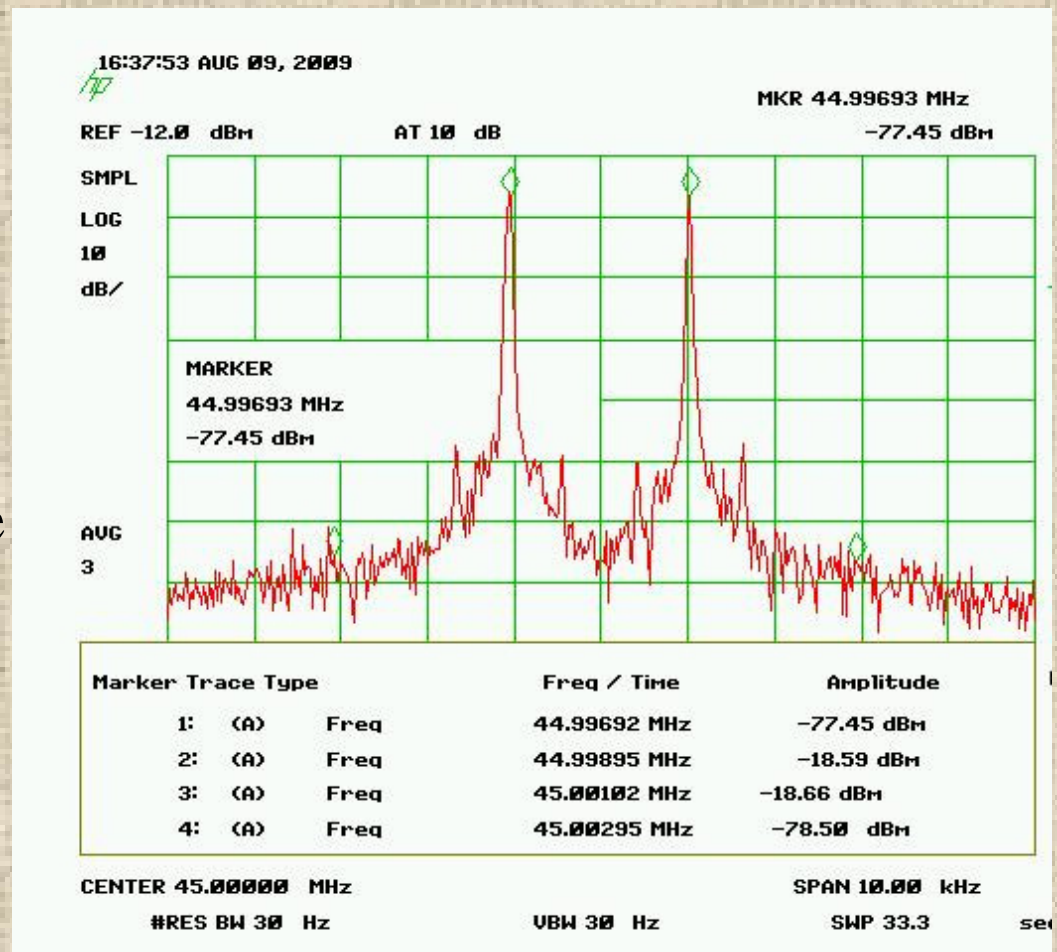
- Input = -25dBm
- Gain= 2.2dB
- Dist= 66.2dB down
- IP= +8.1dBm



2 JFET SBM in Orion Sub

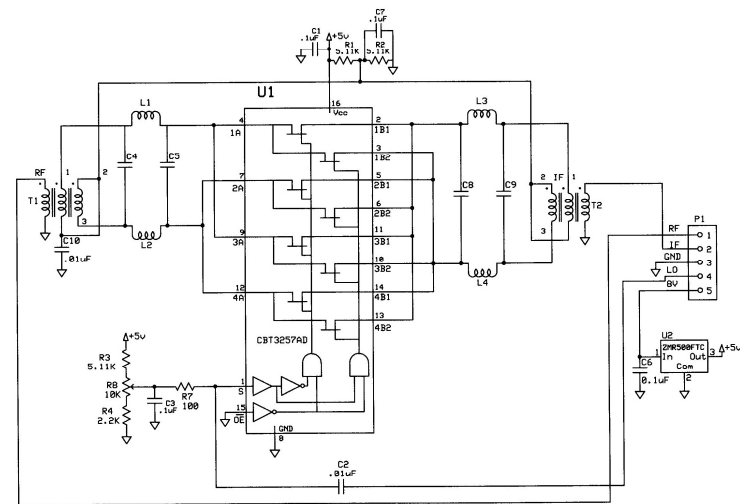
2 kHz Spacing

- Input= -25 dBm
- Gain= +6.4dB
- Phase Noise covers the Distortion
- IP= +4.4dBm
- Noise at graph edge -83dBm



Mux Mixers – K3

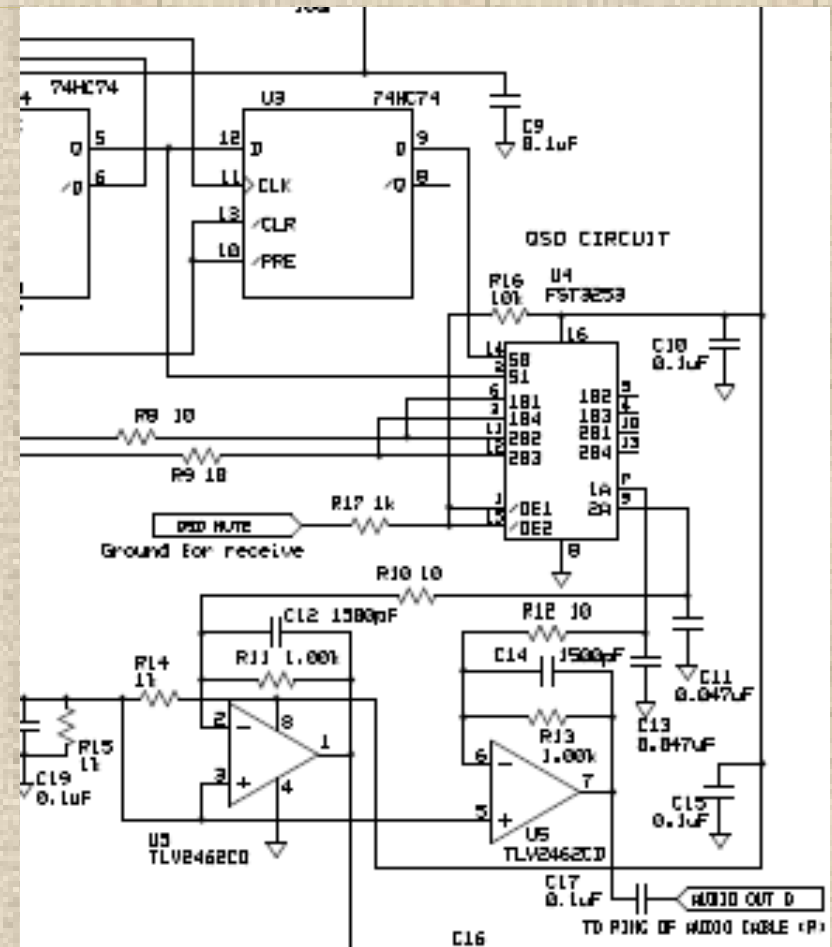
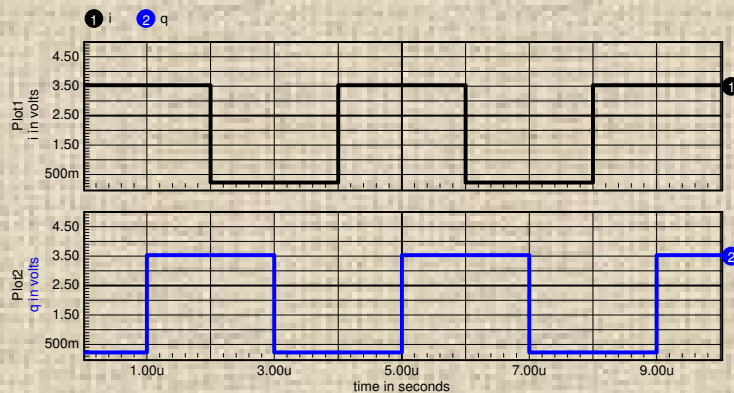
- Double Balanced With transformers at 2 ports
- CBT3257 chip, 21¢



Elecraft		
KR MIXER		
W. Burdick	Rev XC 2/11/2007	Page 1 of 1

Mux Mixers – Softrock & Flex

- Tayloe Mixer
 - Sampling Integrator
 - Direct Conversion Receiver Only
- FST3253 chip, 17¢
- Requires I/Q Inputs



Mixer vs Rig Rundown

Mixer Type	Rig	IP Range
BJT Gilbert Cell	Elecraft KX-1	< 0 dBm
Diode Double Balanced	Elecraft K-2	0 to +5dBm
2 JFET Single Balanced	TenTec Pegasus, Jupiter, Orion Sub, IC-746	0 to +5 dBm
4 JFET Double Balanced	FT950, TS850, IC756, Orion Main	+10 to +15 dBm
Fast Switching Multiplexer	K-3, Flex, Softrock	

The “Ultra” Rigs

20 kHz Spacing

Orion +12.0 dBm (+18.6 dBm with 6dB ATTN)

TS850 +13.55 dBm

IC756 Pro +14.0 dBm

FT950 +14.8 dBm

2 kHz Spacing

IC756 Pro +13.7 dBm

Orion +17.6 dBm (with 6dB ATTN)

A spiral-bound notebook with a brown cover and a light beige, textured page. The spiral binding is on the left side. The text is written in a dark brown, serif font.

And the Conclusion is:

The 4 JFET DBM has become
so good that it doesn't pay to
improve it until we improve
phase noise at its output!