

# 78 GHz LNA Project Status Report

WA1MBA MUD 2010

# Outline

- **History**
  - **How did we get here?**
- Repeatability
  - Can we do this fifty times?
- Next Steps
  - Set up to do a batch
- Cost and build
  - How much? How do I get one?

# Background

- About 5 years ago, idea came to someone to begin a 78 GHz amplifier project
- AD6FP, VE4MA, W5LUA, AA6IW, N0IO, WA1ZMS, RW3BP, W0EOM, WA1MBA
- Interest both terrestrial and EME
- Made first purchase of chips
- Began circuit design, bias design
- First matching circuit designed late 2005
- MUD status reports every year

# History – How did we get here

- Second version – better but still oscillated
- Third version – worked but needed lots of tweaking – Reported MUD and Martlesham 2008 on air
- Reported MUD 2009 attempt to improve and reproduce
- Version 4 – in-line WG ports, tested at MUD 2009 but with questionable noise figure and gain results

# History Version 4

- Had trouble with RF board manufacturer, so made up a few units using a prototype board milling machine
- Made some 6 to 7 dB nf and 15 dB gain measurements at home, but questioned ENR
- Brought units to MUD but had poorer results
- Left a few units with AI W5LUA to develop repeatable and verifiable nf and gain measurements

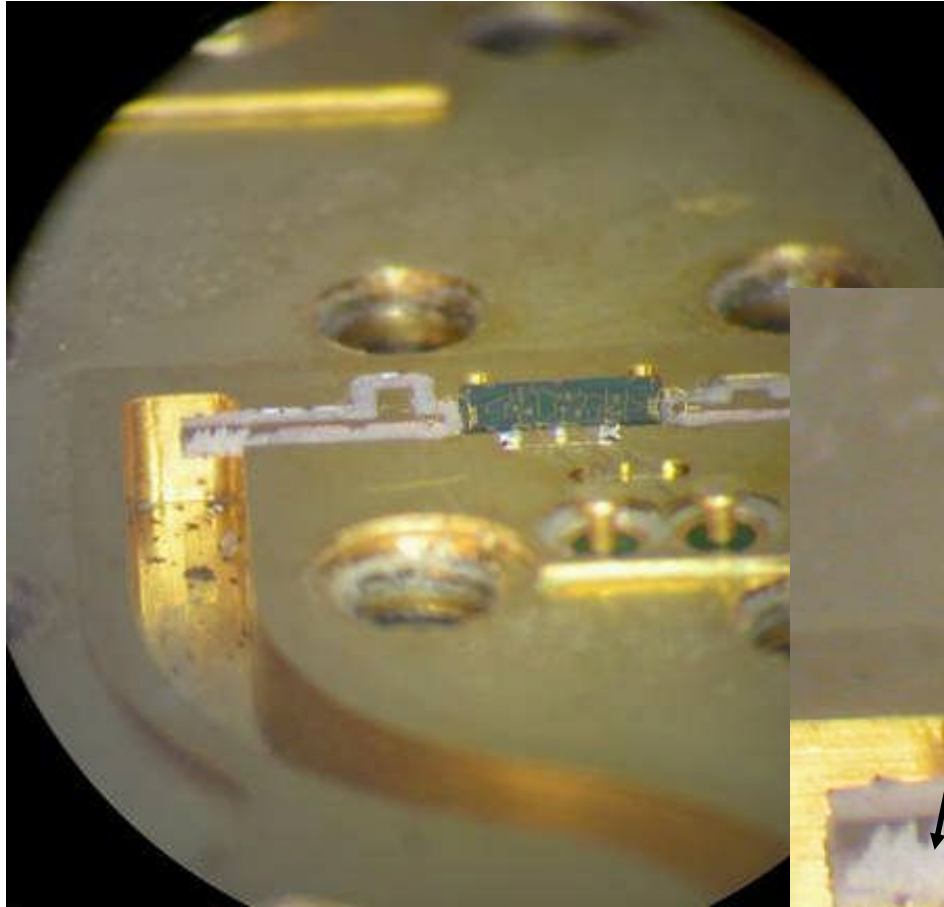
# History Version 4

- During 2009/2010 AI measured poor results and found that with the addition of external tuner could improve from 11-ish dB nf to 7-ish dB
- Output external tuner could improve gain from 12-ish dB to 20-ish dB
- I asked for units back
- I reviewed the internals and saw two things wrong

# History Version 4

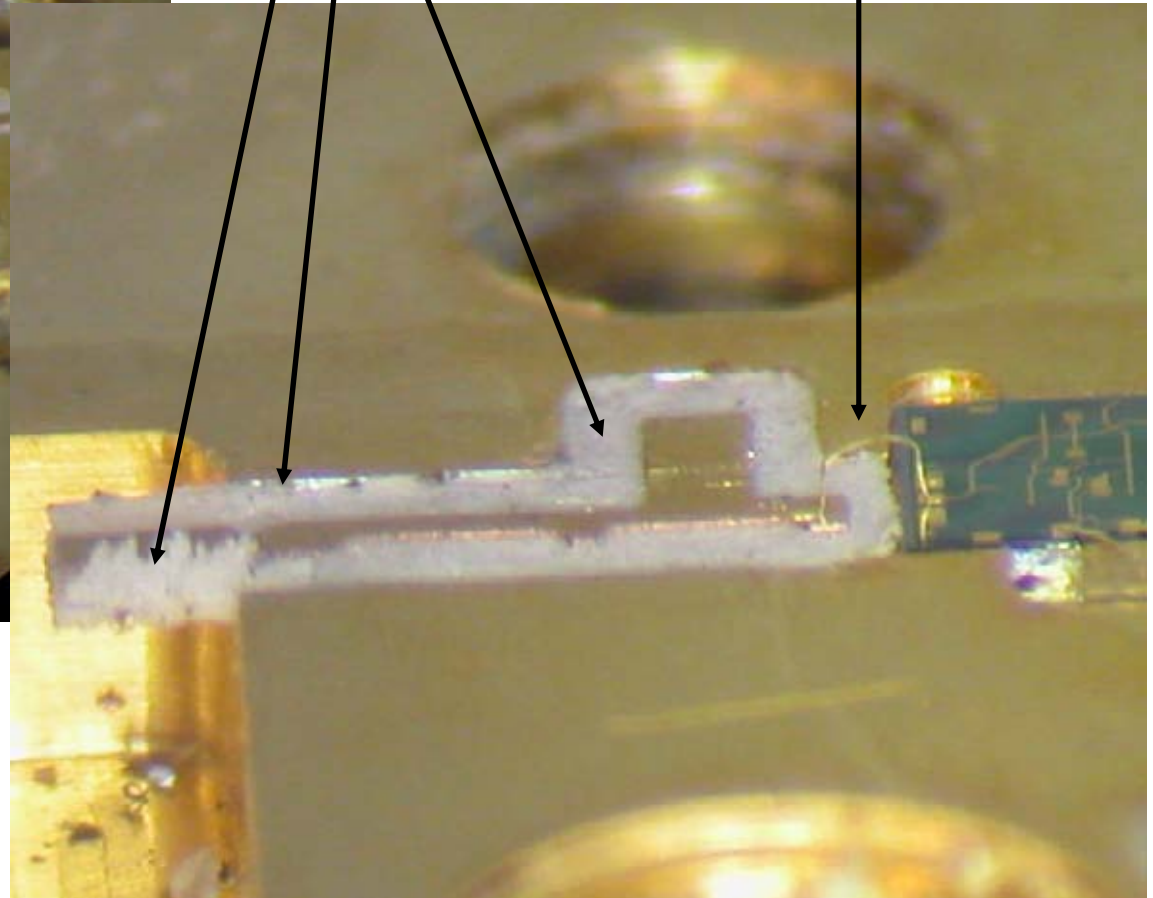
- Firstly, all those units were constructed with prototype milled RF boards.
  - Their traces were OK, but were not nearly as clean edged as (subsequently) professionally made ones.
  - They had some surface dielectric milled away
- Secondly, all prototypes had long ribbon bonds in an attempt to simulate relatively high inductance wire bonds
  - This was basically a mistake
  - Ribbon (wedge) bonds are far superior, lower inductance and the longer ribbons just made things worse

# Poor boards, Long bonds



Rough board surface,  
cut below proper level

Very long bond ribbons

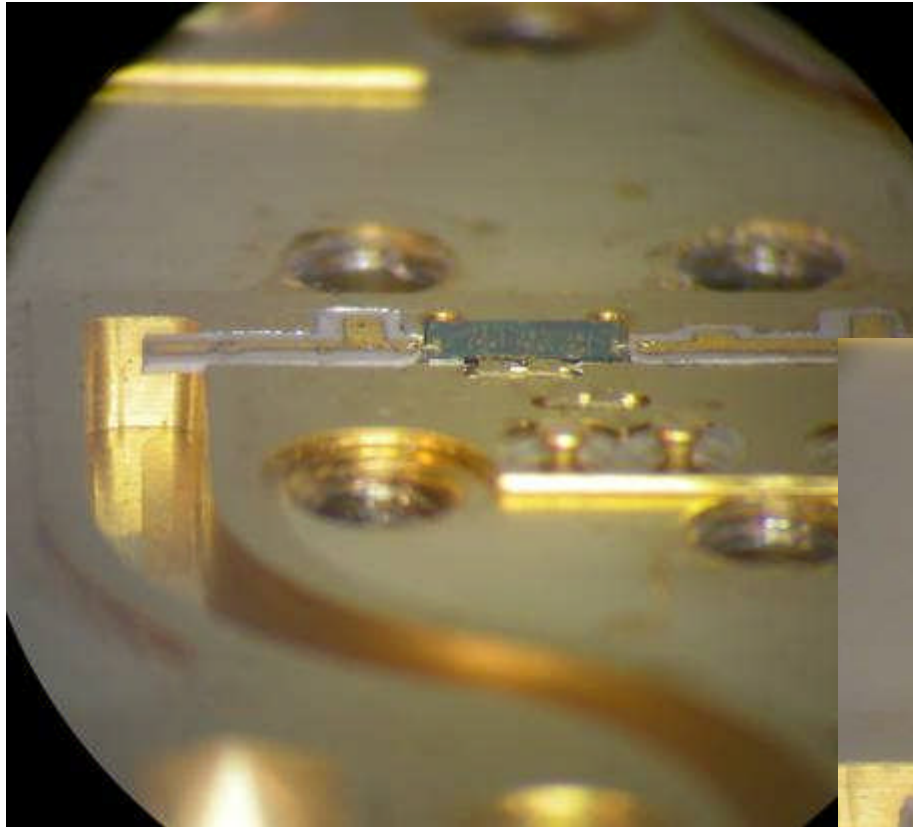




# History Version 4

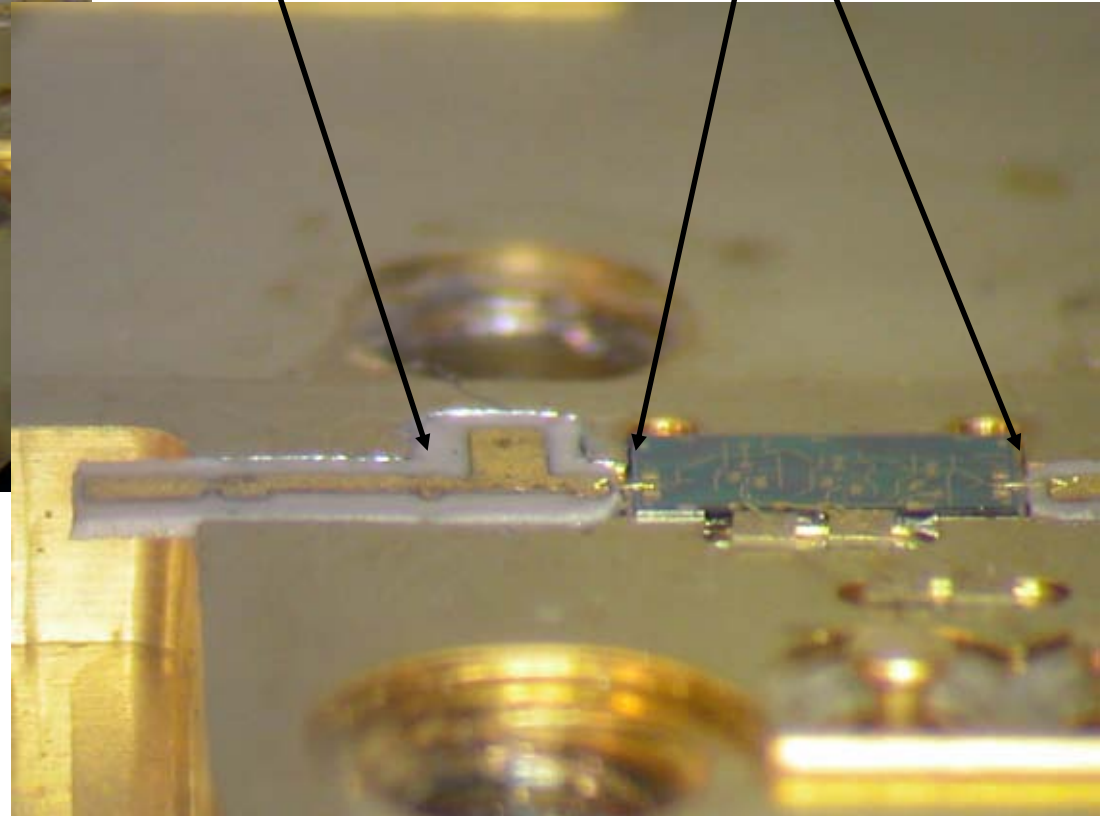
- Replaced RF boards with professionally fabricated ones
- Replaced long ribbons with very short ribbons
- Sent two units to AI for testing
- Gain went up to 26 to 29 dB
- Nf went down to below 4 dB ! ! ! ! !
- Both units were nearly the same

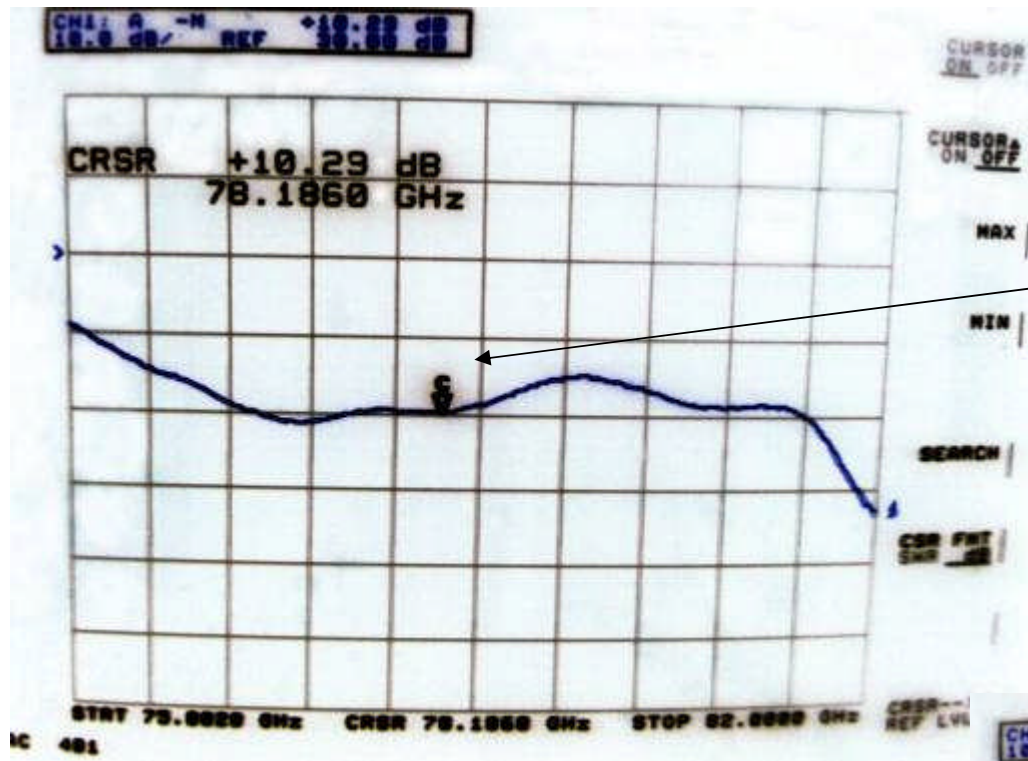
# Good boards, Short bonds



Smooth board surface, good etching

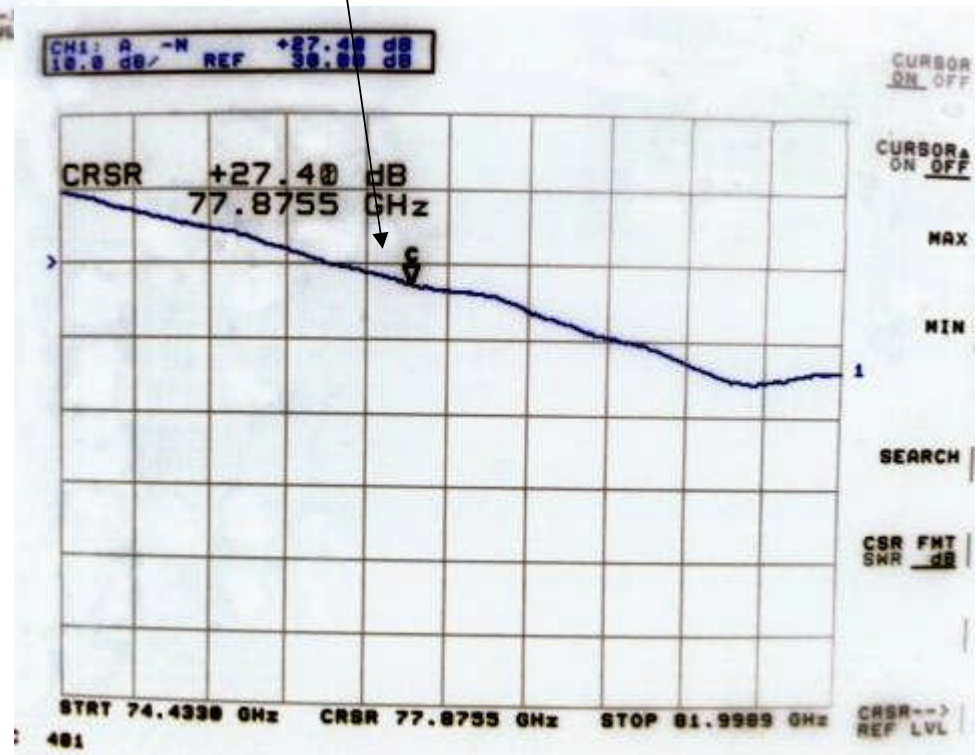
Shorter bonds, nearly flat



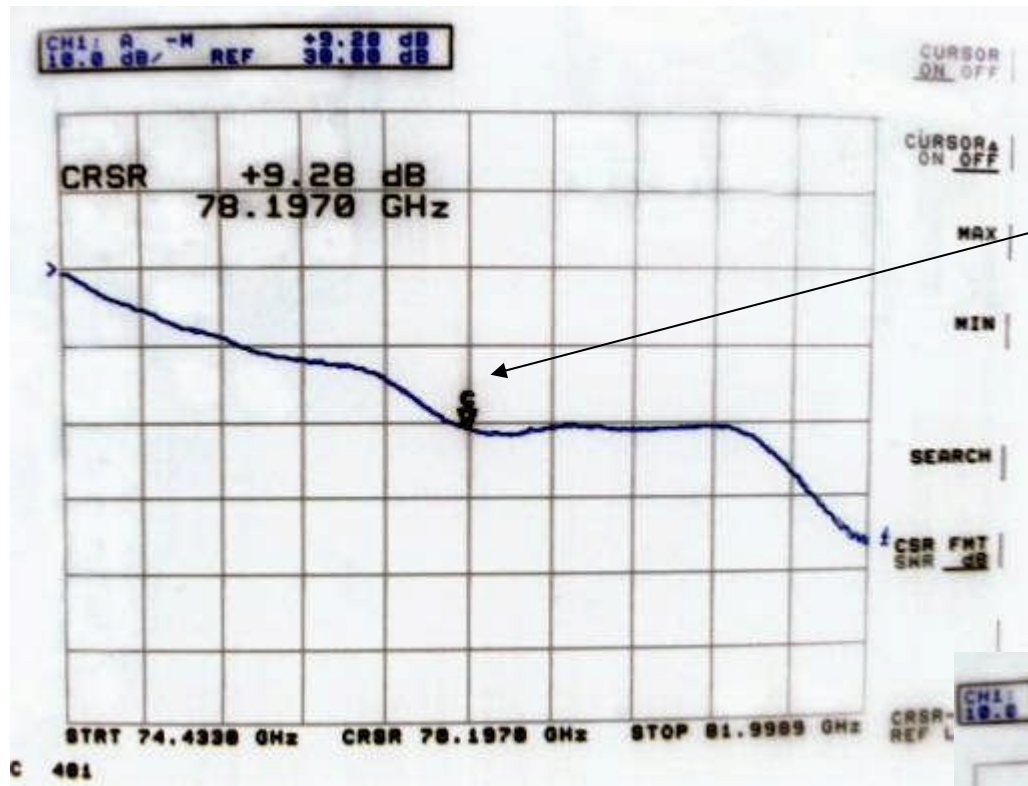


Before

**Unit 1**  
**Gain went from 10.3 dB**  
**To 27.5 dB by changing**  
**Boards and shortening**  
**Ribbon bonds**  
**Noise figure went from 9**  
**dB to 3.16 dB No Tuner**



After

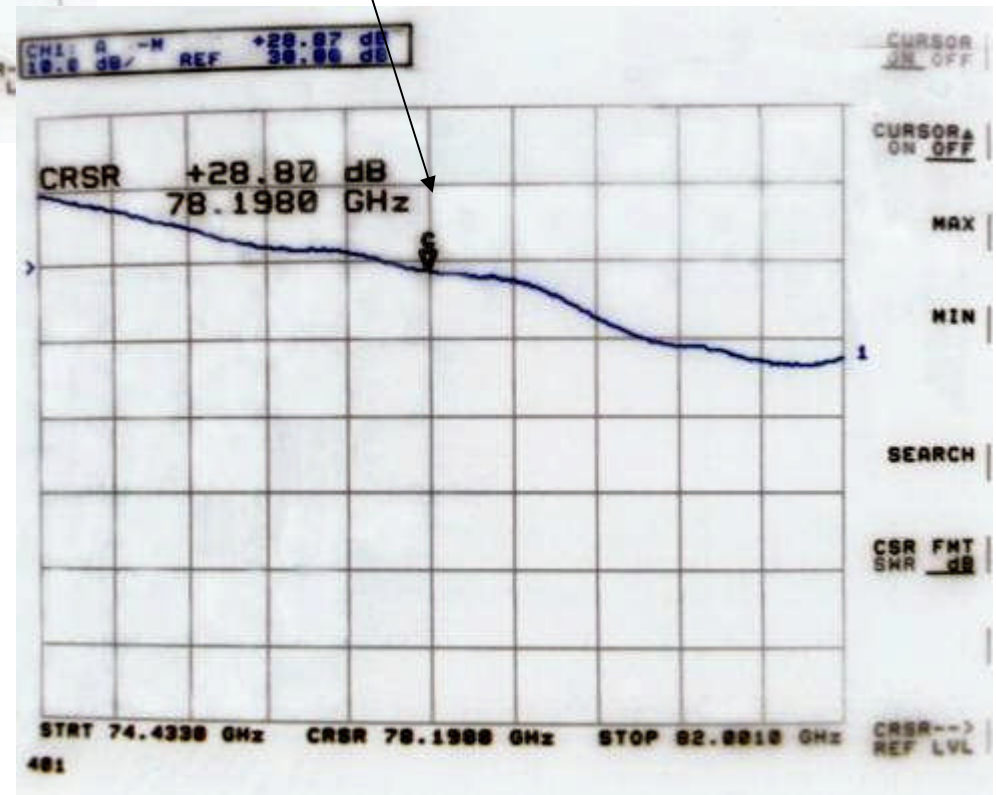


Before

## Unit 6

Gain went from 9.3 dB  
To 28.9 dB by changing  
Boards and shortening  
Ribbon bonds

Noise Figure went from  
10 dB to 3.0 dB, improved  
to 2.9 dB with a tuner



After



# Outline

- History
  - How did we get here?
- **Repeatability**
  - **Can we do this fifty times?**
- Next Steps
  - Set up to do a batch
- Cost and build
  - How much? How do I get one?

# Repeatability

- Continued to replace boards and bond ribbons on two more units
- Sent those to AI
- Continued to get superior results
  - Unit      Gain      noise figure
  - #6        29.7 dB    3.0 dB
  - #1        27.7 dB    3.16 dB
  - #3        30.5 dB    3.37 dB
- Now external tuning will make only a small difference
- Clearly, this is a repeatable design, re-working two more
- **YES, I can repeat this, its time to build**



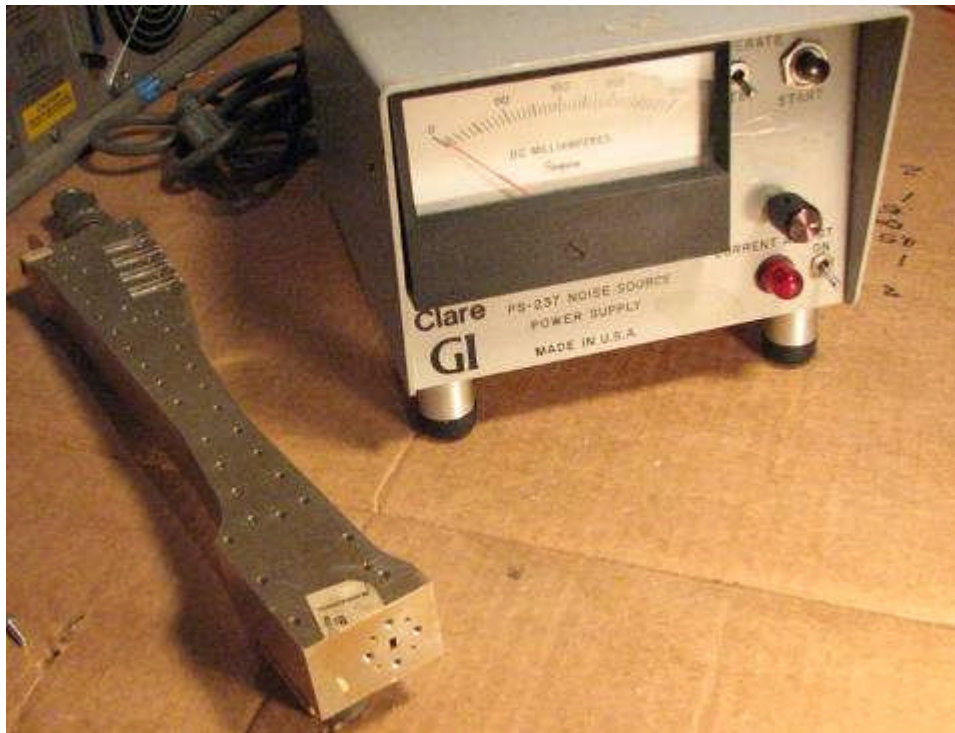


# Outline

- History
  - How did we get here?
- Repeatability
  - Can we do this fifty times?
- **Next Steps**
  - **Set up to do a batch**
- Cost and build
  - How much? How do I get one?

# Next Steps

- We need to have additional noise figure setups, especially one at WA1MBA
- First attempt will be to use a gas tube with an external modulator



# Next Steps

- Second attempt will be to use a solid state noise source
- A fundamental mixer is in hand, and a Gunn source for the LO
- The LO should be tamed so that the results are consistent
- Fallback is to use WA1MBA 78 GHz field radio as the down converter for the nf meter

# Next Steps

- Bodies need slight modifications in order to prevent damage to MMICs during assembly and to accept slight mfg errors in professionally made RF boards – less than 6 weeks
- Build sufficient bias boards
- Insert and glue die, chip caps and feed-thrus
- Ribbon bond
- DC Test -> rework as needed
- RF and NF test -> rework as needed

# Next steps

- Live with the dimensions of the existing unit to prevent extra cost of another design cycle
- Determine the exact number for the build
- Provide external tuner for the few who think they need the last  $\frac{1}{4}$  dB of performance? Maybe, maybe not.



# Outline

- History
  - How did we get here?
- Repeatability
  - Can we do this fifty times?
- Next Steps
  - Set up to do a batch
- **Cost and build**
  - **How much? How do I get one?**

# Cost and build

- Cost for a unit will be combination of
  - Cost sunk so far divided by total number of build - known
  - Cost to build and test each unit – good estimate
  - Cost for rework of all units divided by total number of build – estimate at 20%



Cost - 78 GHz Amp Project

**PARTS**

Digikey	\$18.30
Thunderline Z	\$7.52
ATC Chip Caps	\$6.14
bias boards	\$3.60
RF Boards	\$29.92
Feed Thru 4/40	\$2.62
RF boards	\$33.56
Bodies	\$60.00
Plating	\$24.00
MMICs	\$100.00

**LABOR**

fabricate bias board	\$30.00
prepare bias board	\$5.00
prepare RF boards	\$26.00
prepare bodies	\$10.00
attach: die, chip cap, feed thrus, MMICs	\$20.00
ribbon bonding	\$20.00
testing	\$20.00

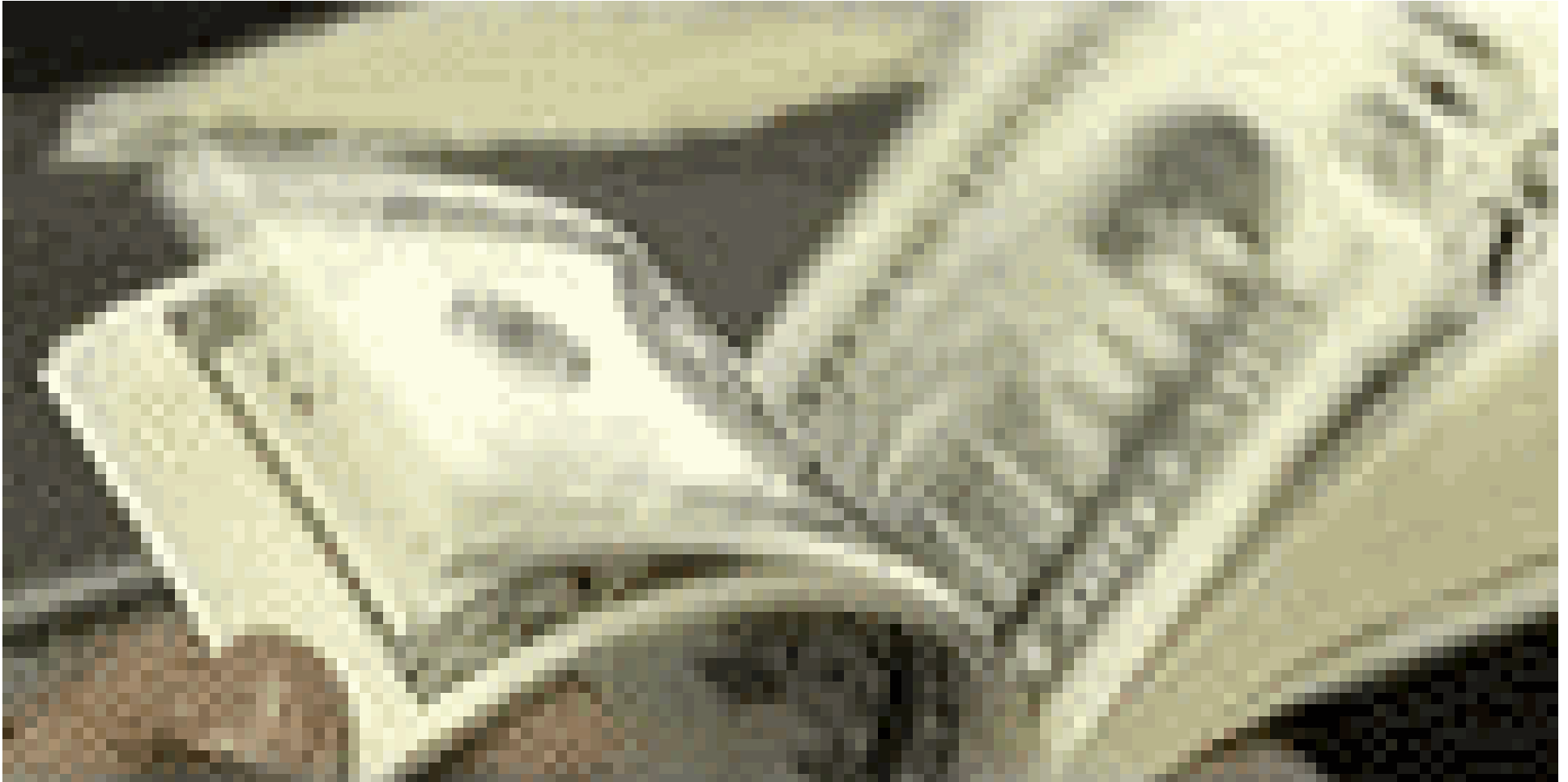
**OVERHEAD**

Loss/scrap 20%	\$83.33
Development / 50	\$55.00

**Total    \$554.99**

Suggested Up Front                      **\$600.00**

# Cash up front



# Process of Ordering

- Money will have to be up front (I can't afford \$30,000)
- I will set accept through Pay Pal or personal check
  - STEP ONE: Tell me by EMAIL how many you want (yourself, your club, whatever) I will deal with individual people only. I will send this notice out on the microwave reflector as well.
  - SETP TWO: WAIT for me to respond BEFORE you send any money. I will send out the notice to everyone at once. It will probably be in one or two months – anticipate December '10 or January '11.
  - STEP THREE: Send money (right now expect it to be \$600)
  - STEP FOUR: Build – I will keep everyone informed with regular status reports – it will probably be several months total.
  - STEP FIVE: Test and Send – The shipments will all happen within a couple of weeks when they do, but I will try to keep them in approximate order in which I receive the up-front payments

