A Flexible Direct Frequency Synthesiser

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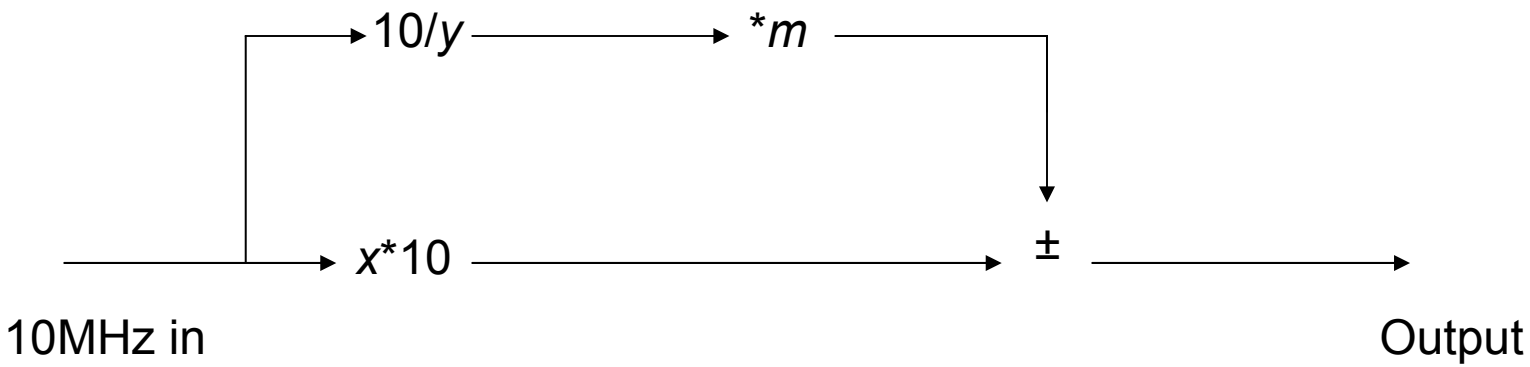
Introduction

- On the higher bands, and with the advent of digital modes, precise frequency control aids operating success
- Amongst many methods, the DFS has been promoted by WA1ZMS, G4DDK and WW2R/G4FRE
- This paper presents an increment on that work, enabling a wider range of output frequencies to be generated.

Single loop schema



$$F(10)=x*10\pm(m*10/y)$$

The single loop DFS

- Range of frequencies obtainable with single loop design is limited to:

$$x*10\text{MHz} \pm (m*10/y)$$

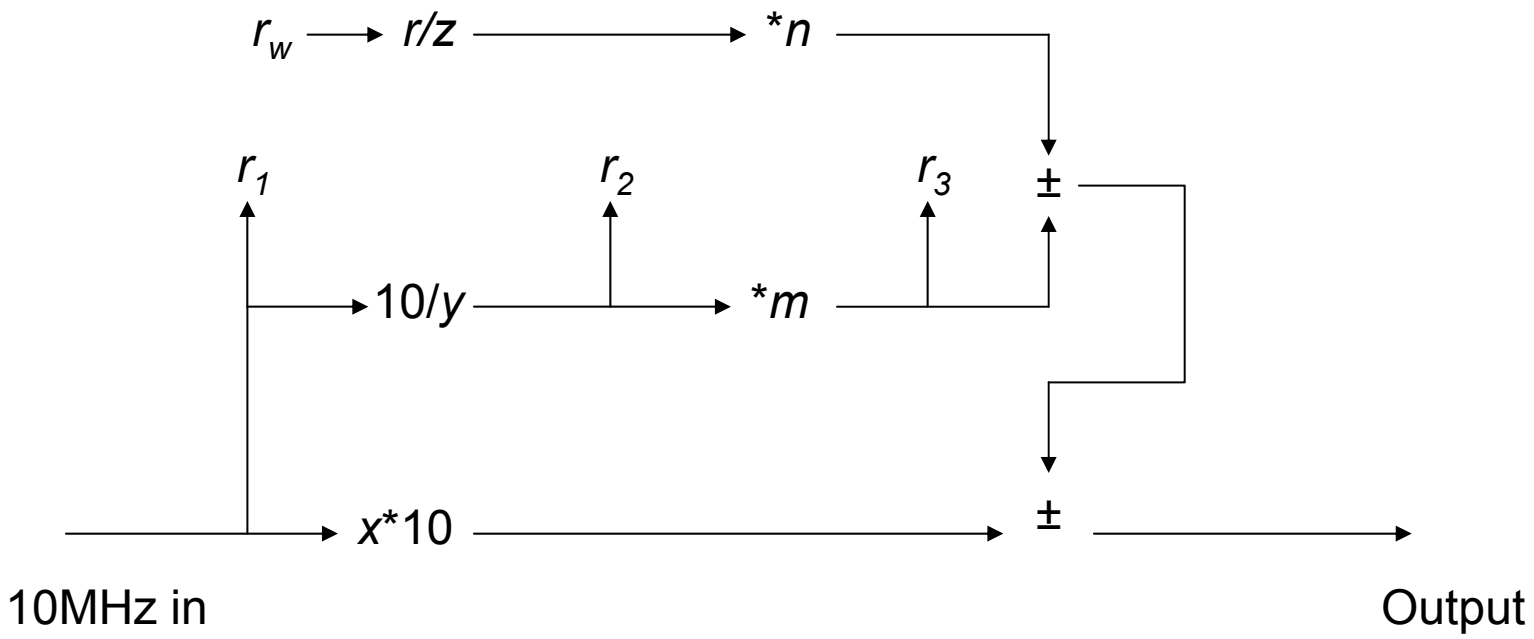
where x is typ 9
m is typ 1 to 5
and y is in range 2 to 16

- Frequency resolution is thus restricted by this algorithm

Why two loops?

- Adding a second divider and mixer loop immediately expands the potential frequency resolution
- There are several possible algorithms depending on how the input for the second divider is derived

Two loop schema



$$F(10)=x*10\pm((m*10/y)\pm(n*r_w/z))$$

Further options.....

- Further, more complex, options exist to be investigated, such as:

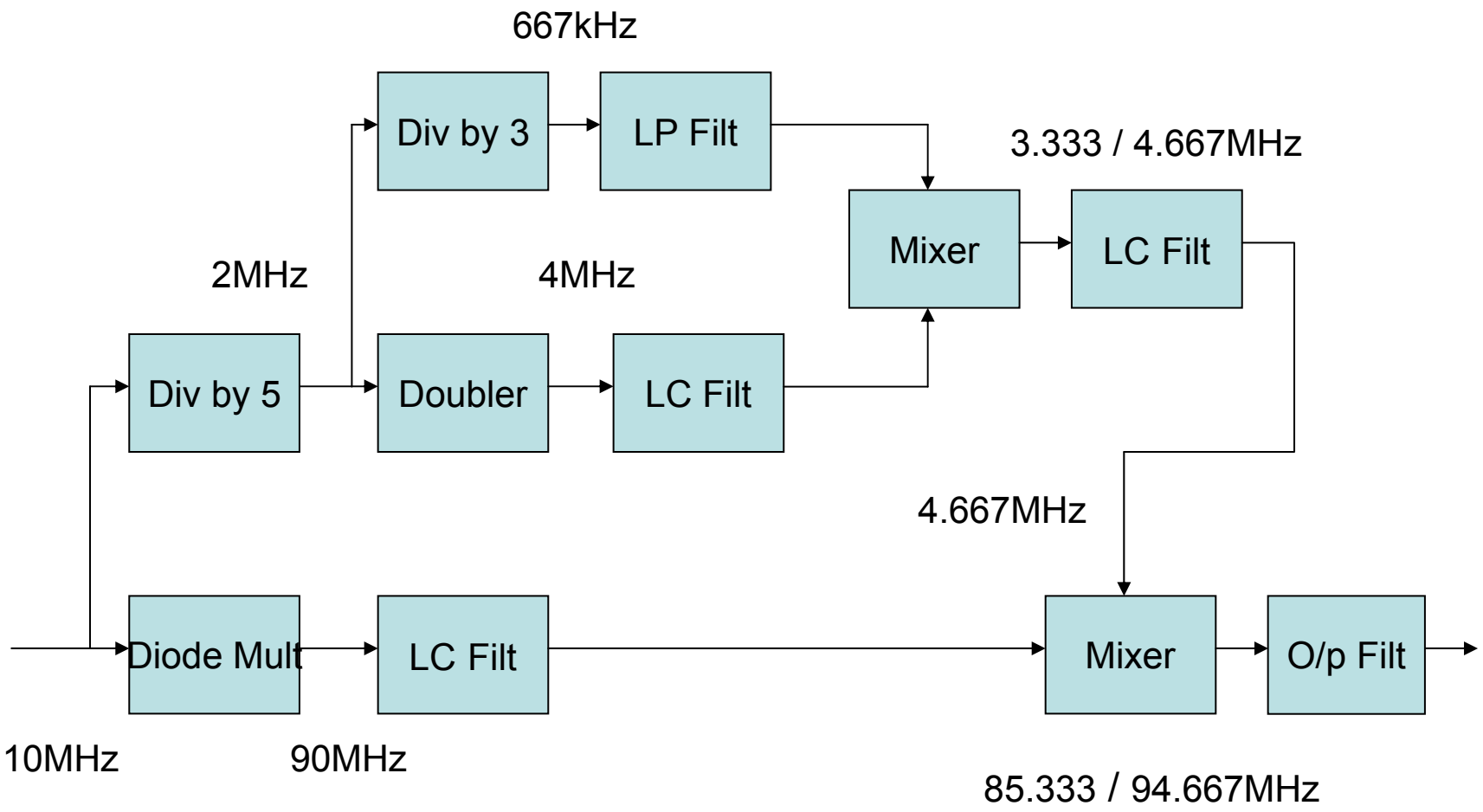
  - feeding the low loop mixer directly from the *y* divider, but multiplying that frequency before its input to the *z* divider

  - taking another multiple of the 10MHz input and feeding it into the dividers – eg 30MHz /4 to get 7.5MHz

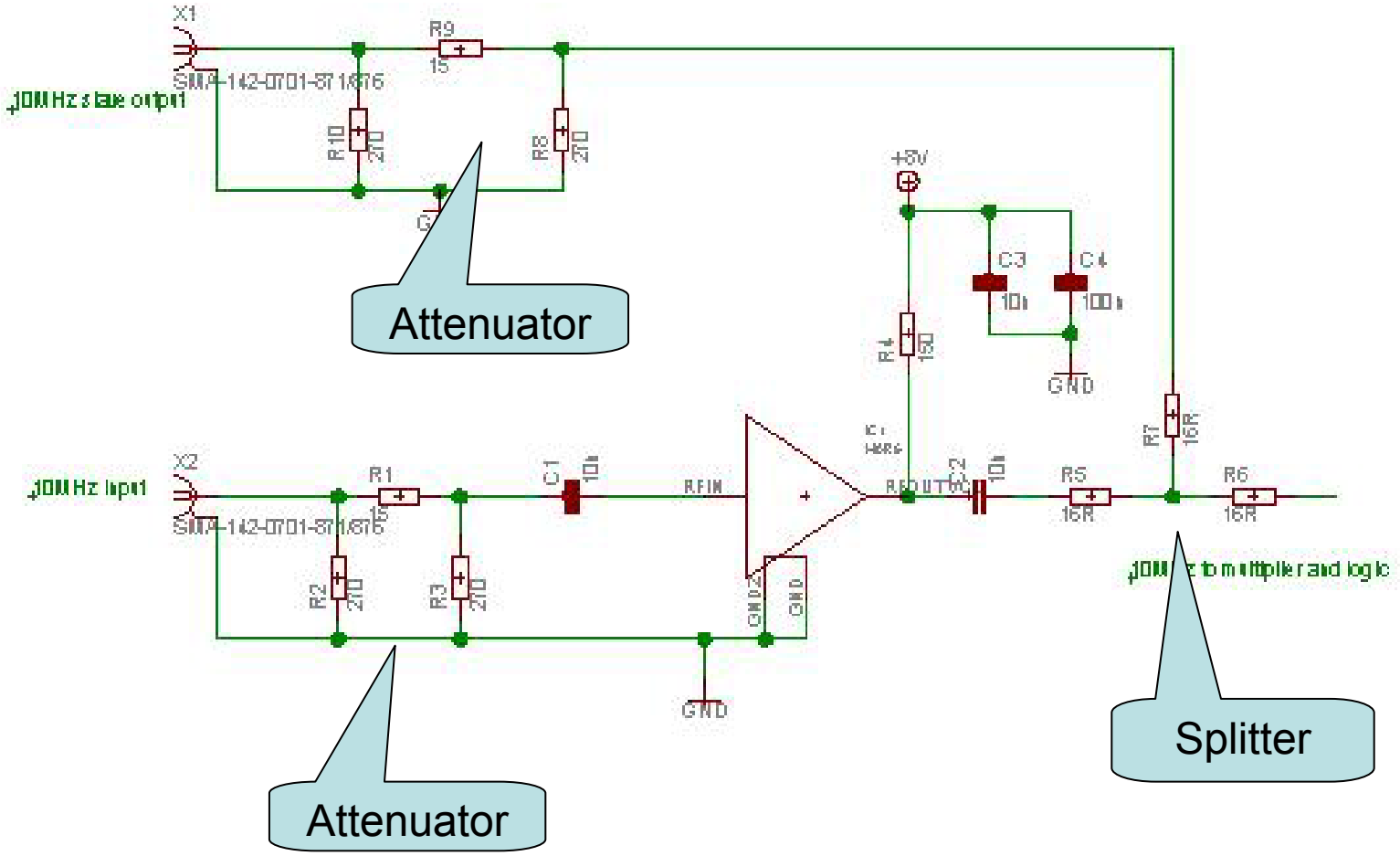
FDFS 94.667MHz

- Prime driver for this work is the WC8VOA 10GHz EME station – the DEMI transverter has a frequency offset and has temperature variations
- GPS locking to Z3801A will eliminate these problems
- A DFS at 94.667MHz can be doubled to 189.333 – the DEMI xvtr xtal freq.

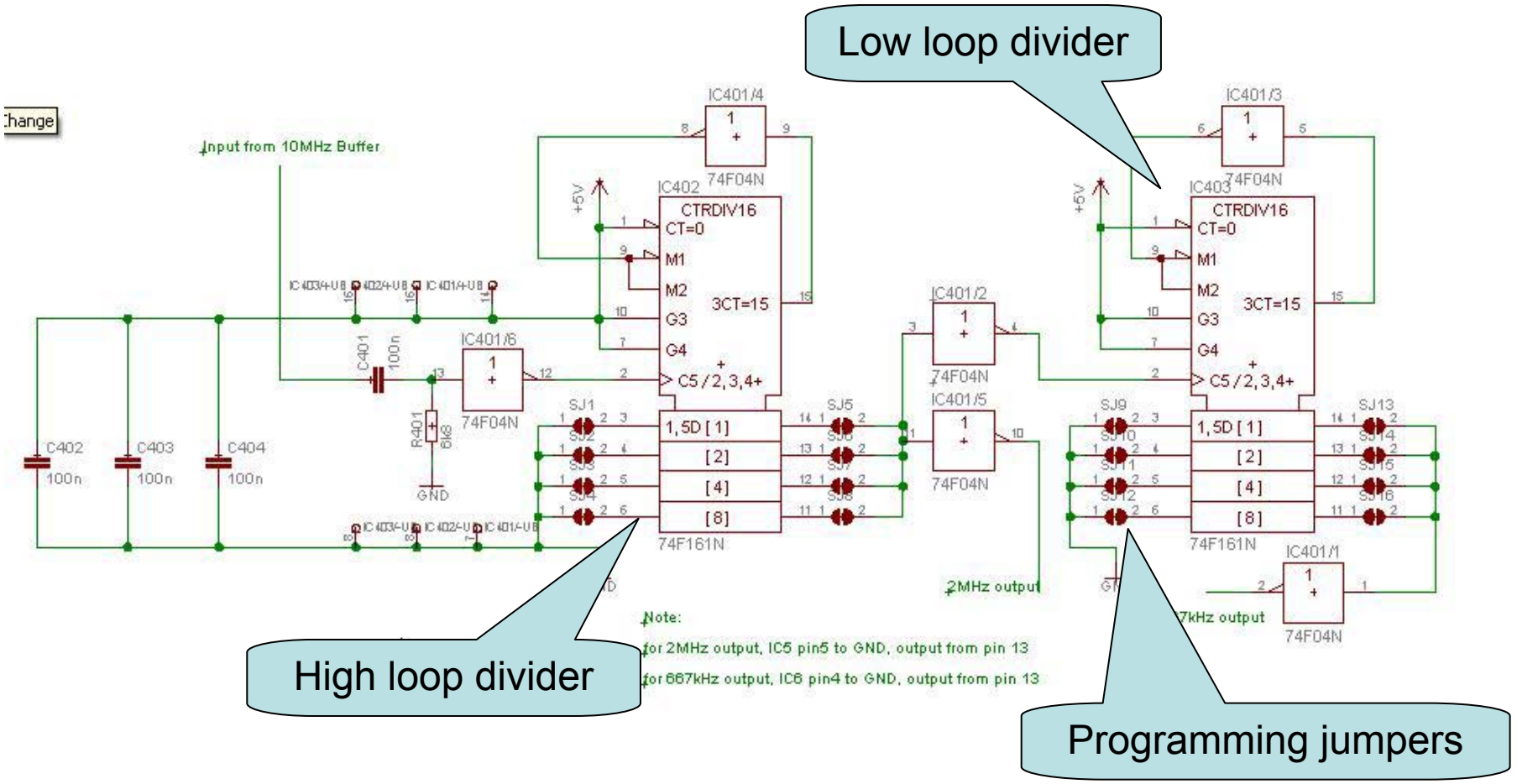
Dual Loop Synthesiser



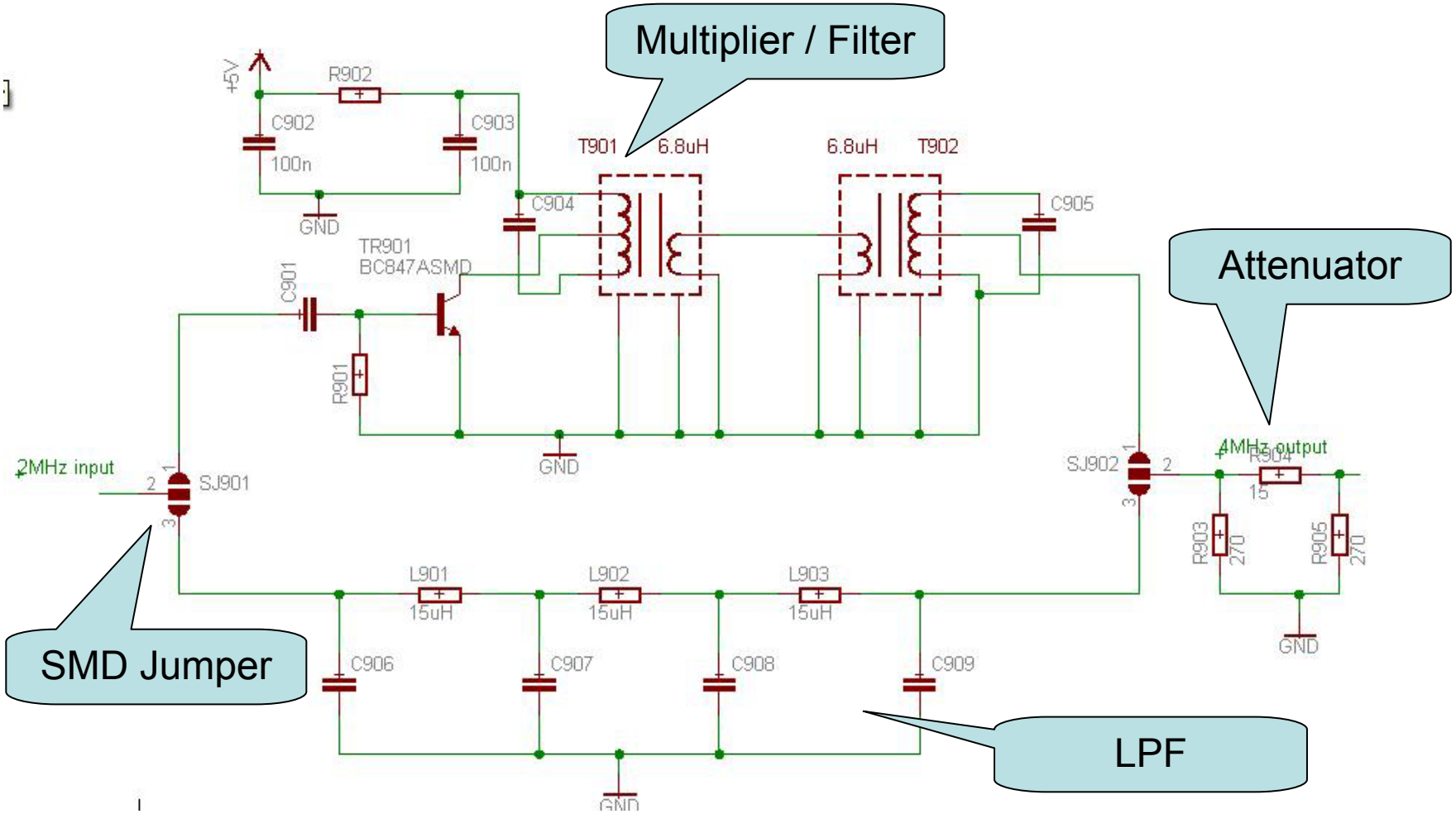
Input Buffer



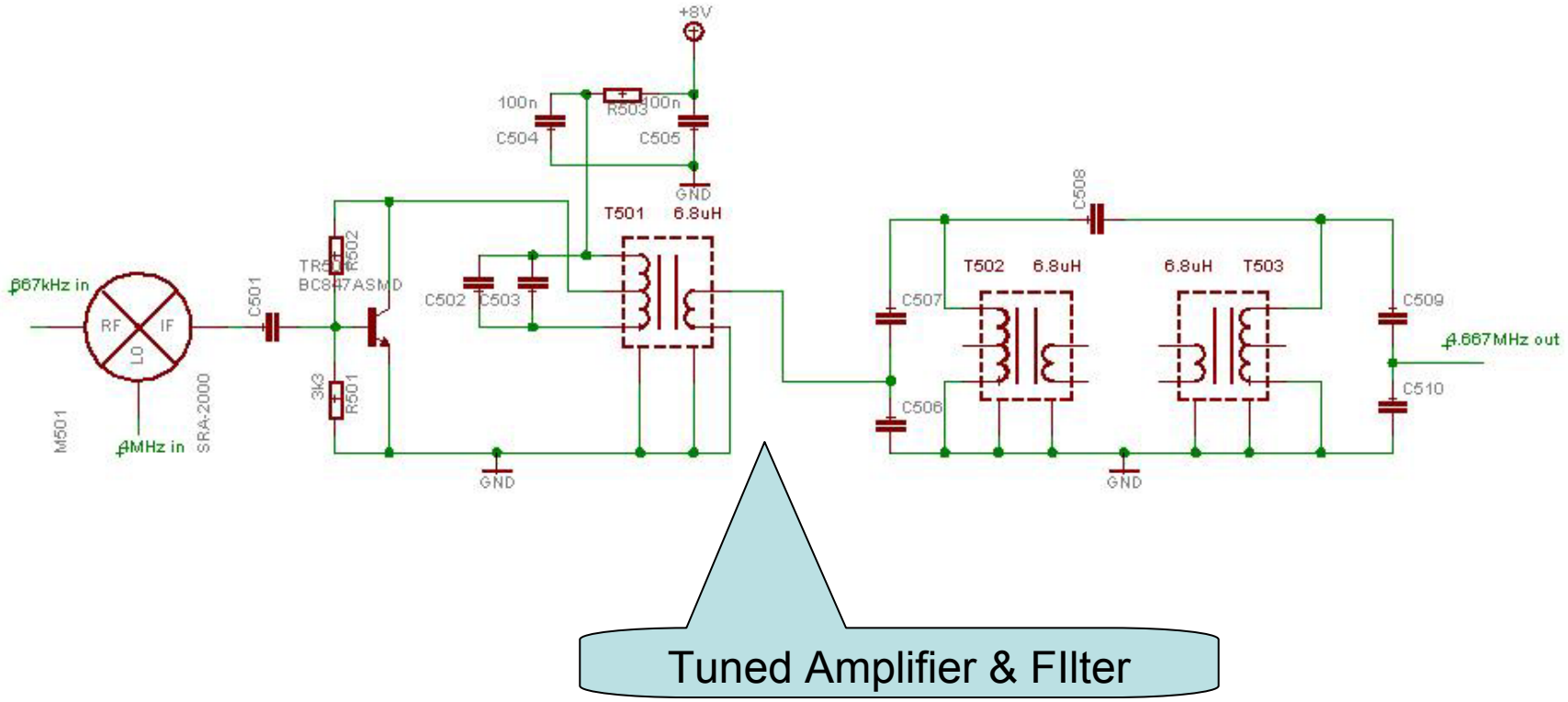
Divider Logic



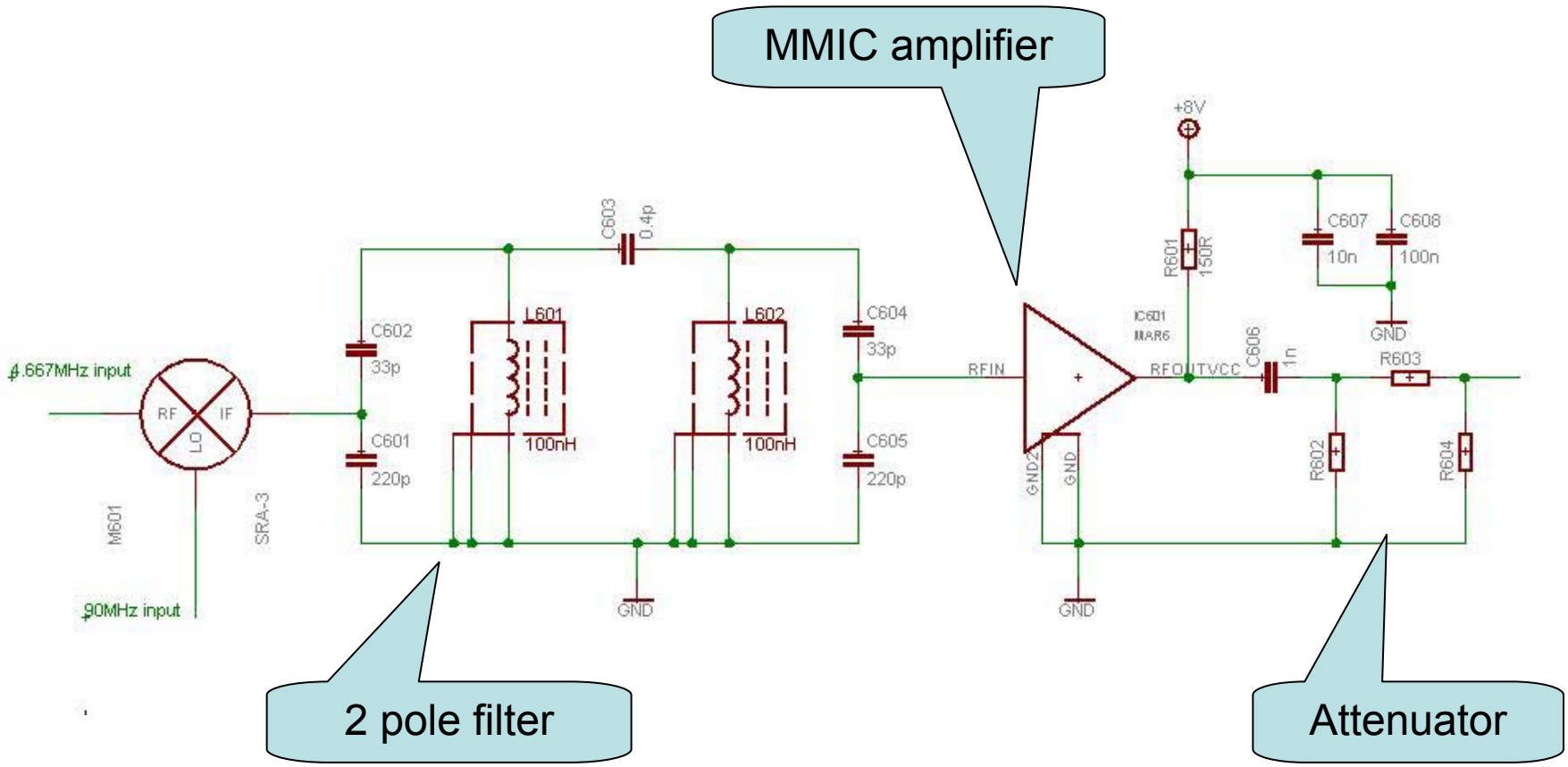
4MHz Multiplier



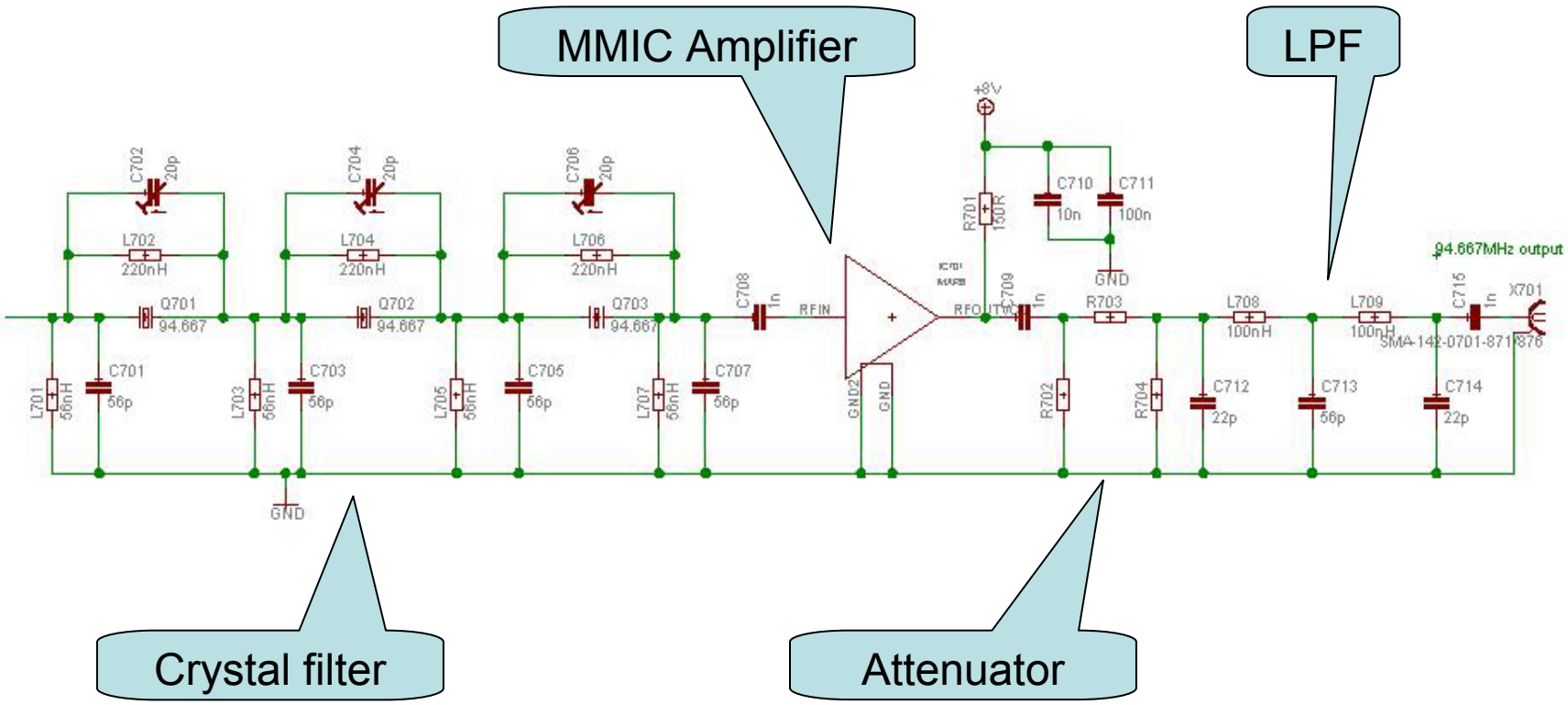
Low Freq Mixer



High Freq Mixer



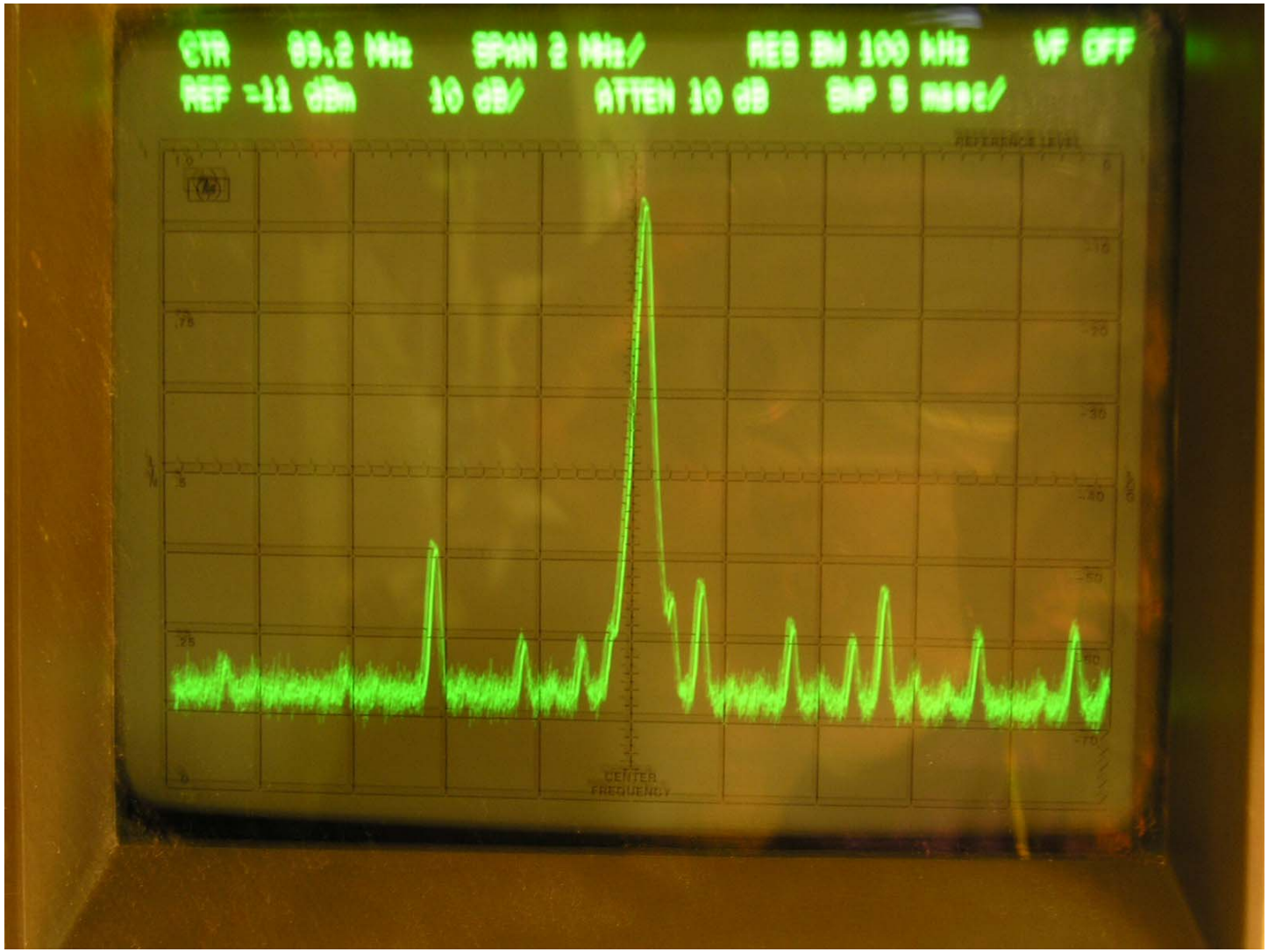
Output Amplifier and Filters



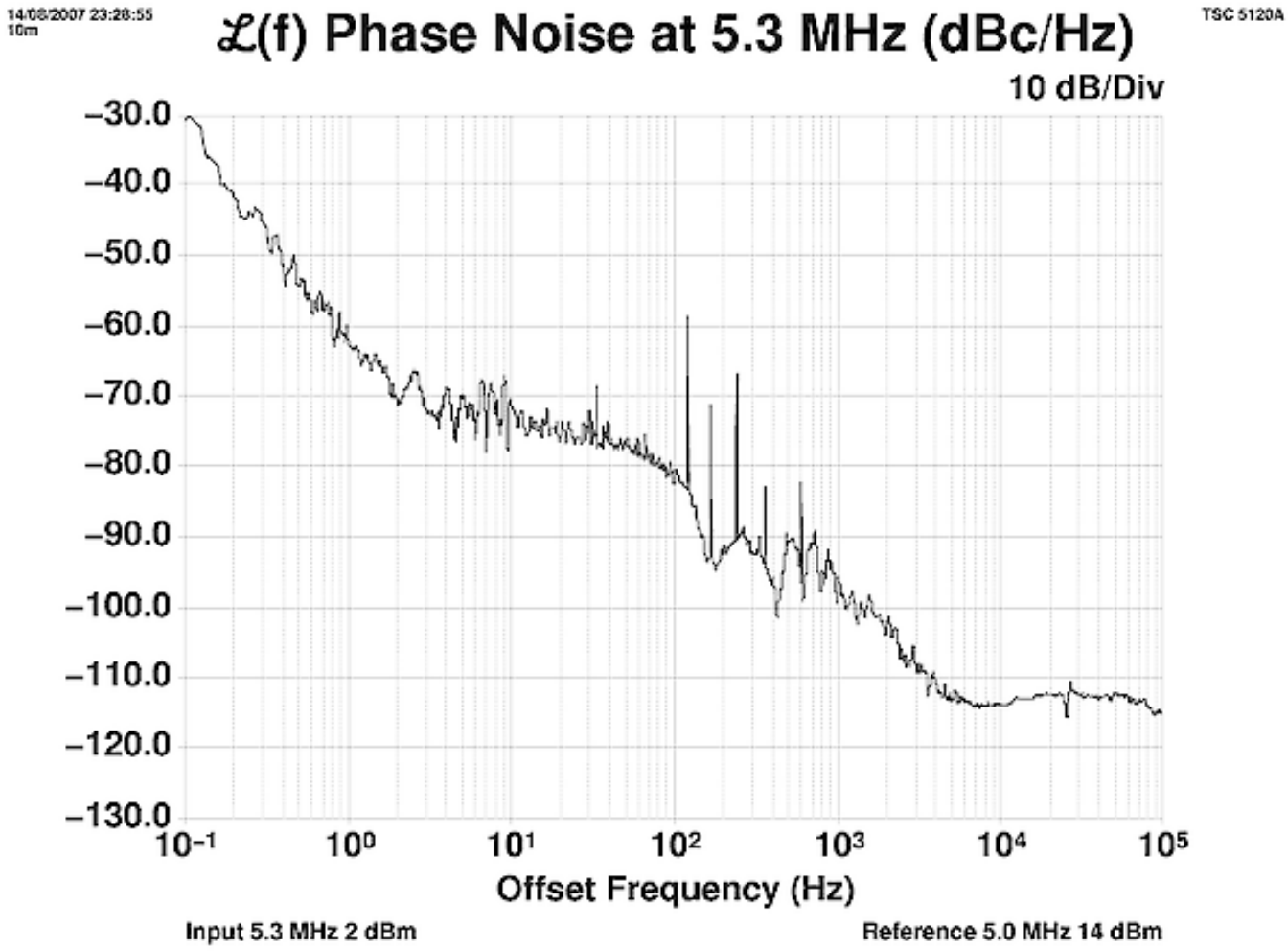
Implementation

- Prototype built ‘ugly style’ – achieved -45dBc for spurious signals
- Phase noise comparable to professional synthesiser (PTS) – measurement by N8UR
- Draws approx 300mA at +13.8v

Output Spectrum - Prototype



Prototype Phase Noise



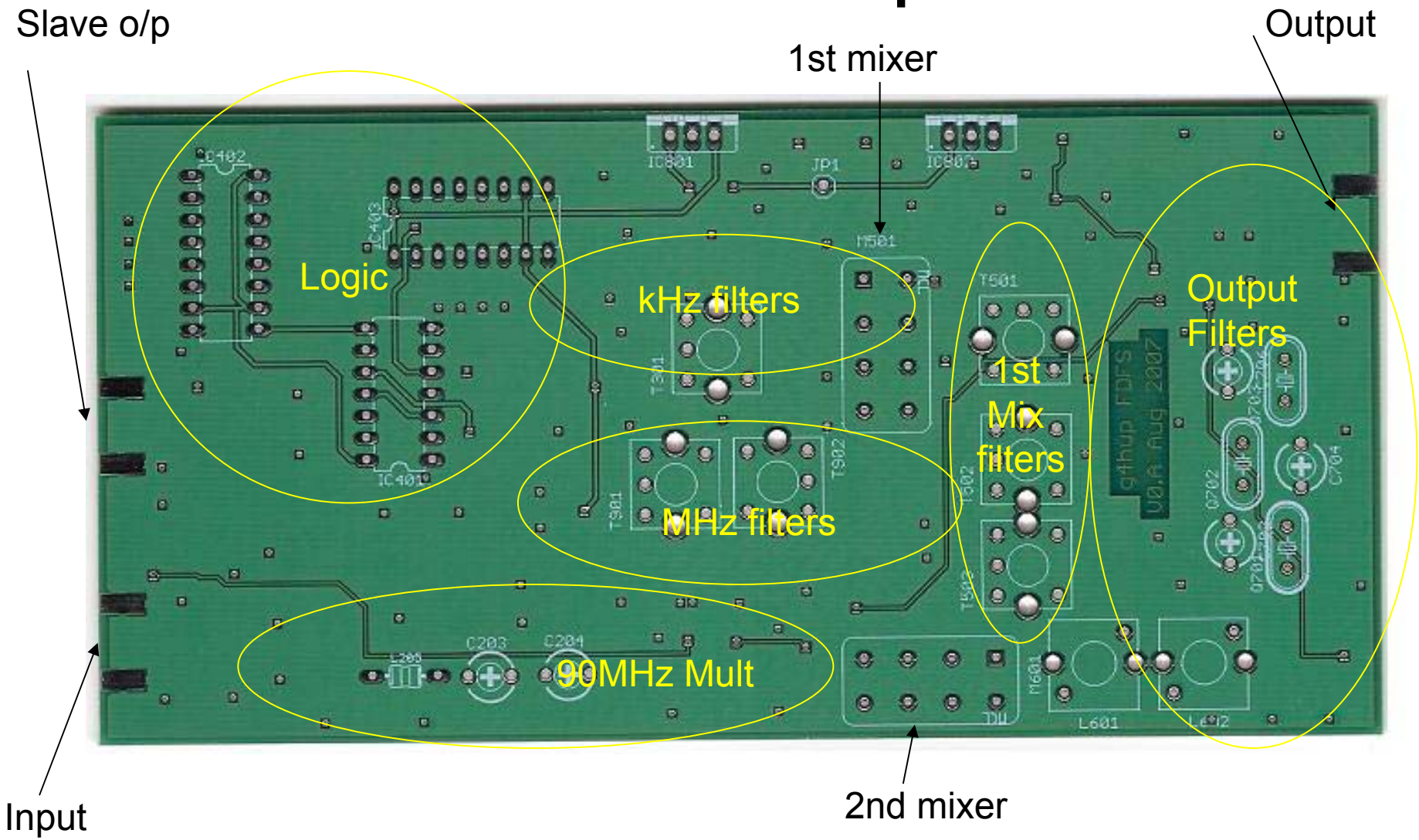
PCB Implementation

- Converting design to mainly SMD, the entire FDFS fits on a 148 x 73mm PCB
- This includes the extra options for filtering and logic programming, and the buffered 10MHz output
- Phase noise measurement not yet performed
- Spurious signals -60dBc

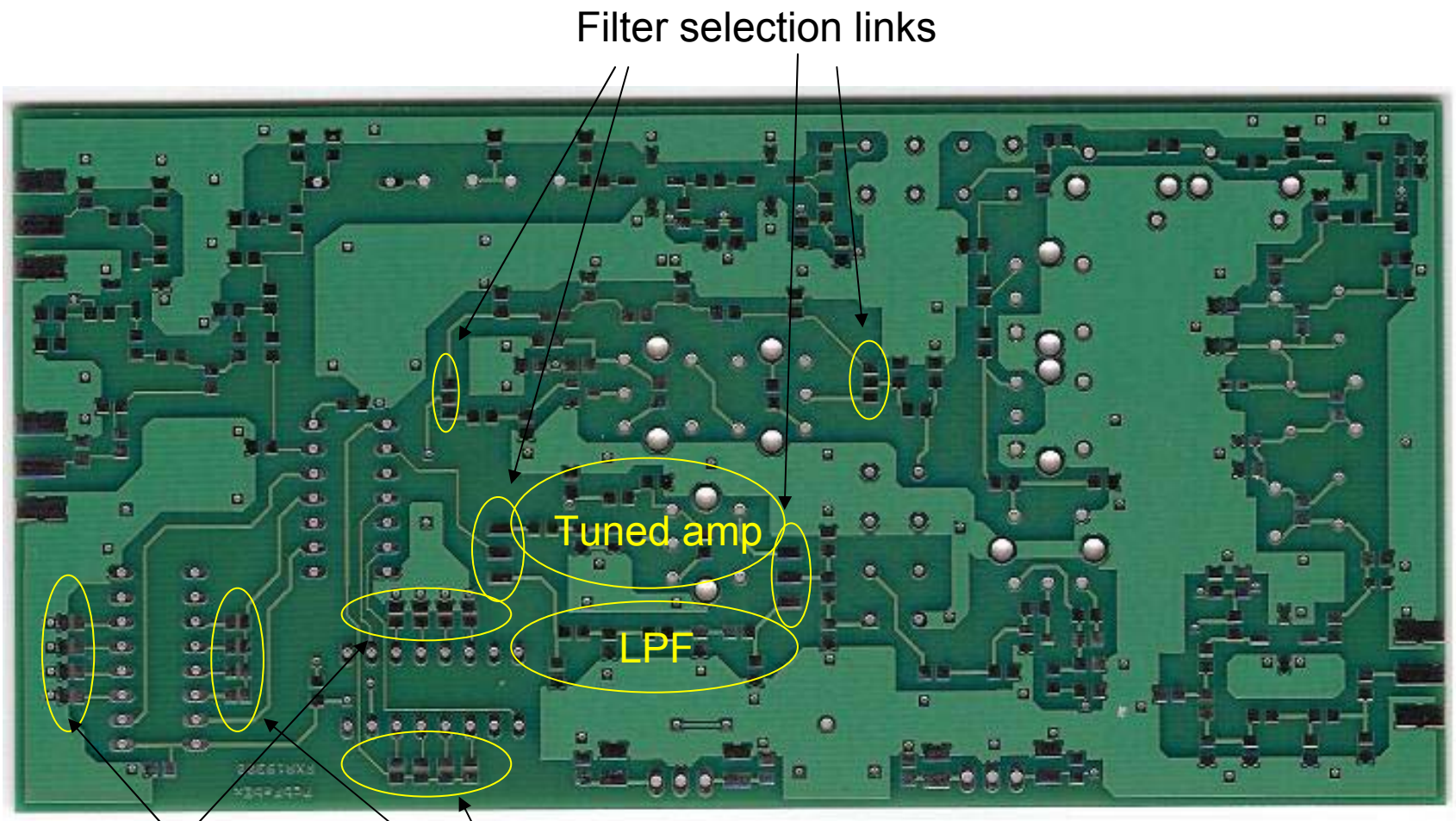
Benefits of the PCB

- Not dedicated to 94.667MHz!
- Dividers can be programmed for ratio, and ouput selected by jumper
- LPF/tuned multipliers selected by SMD jumper
- r1,2,and 3 not selectable on current PCB implementation – cut & strap
- Single loop DFS can be built on same board

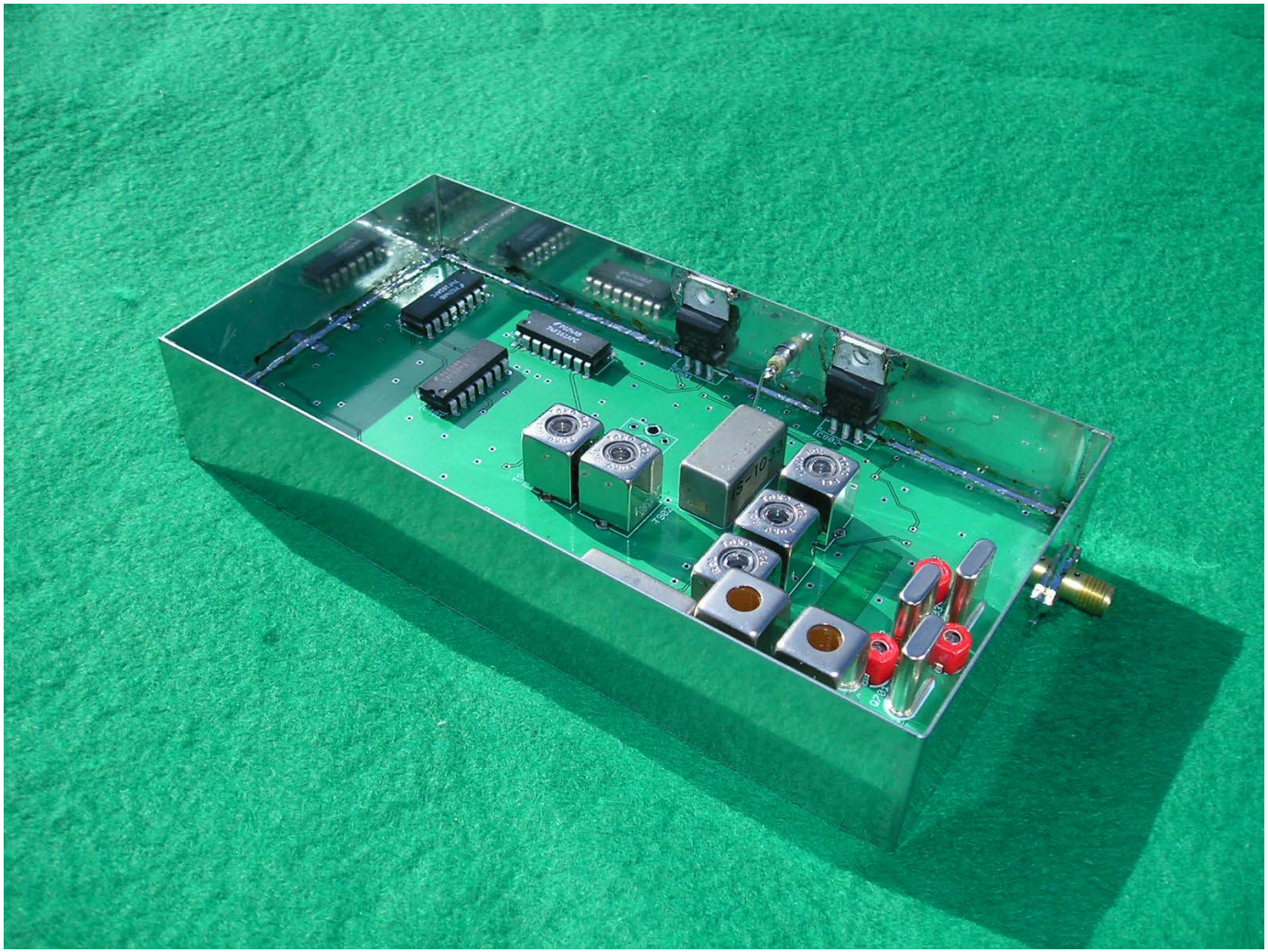
PCB View – Top side



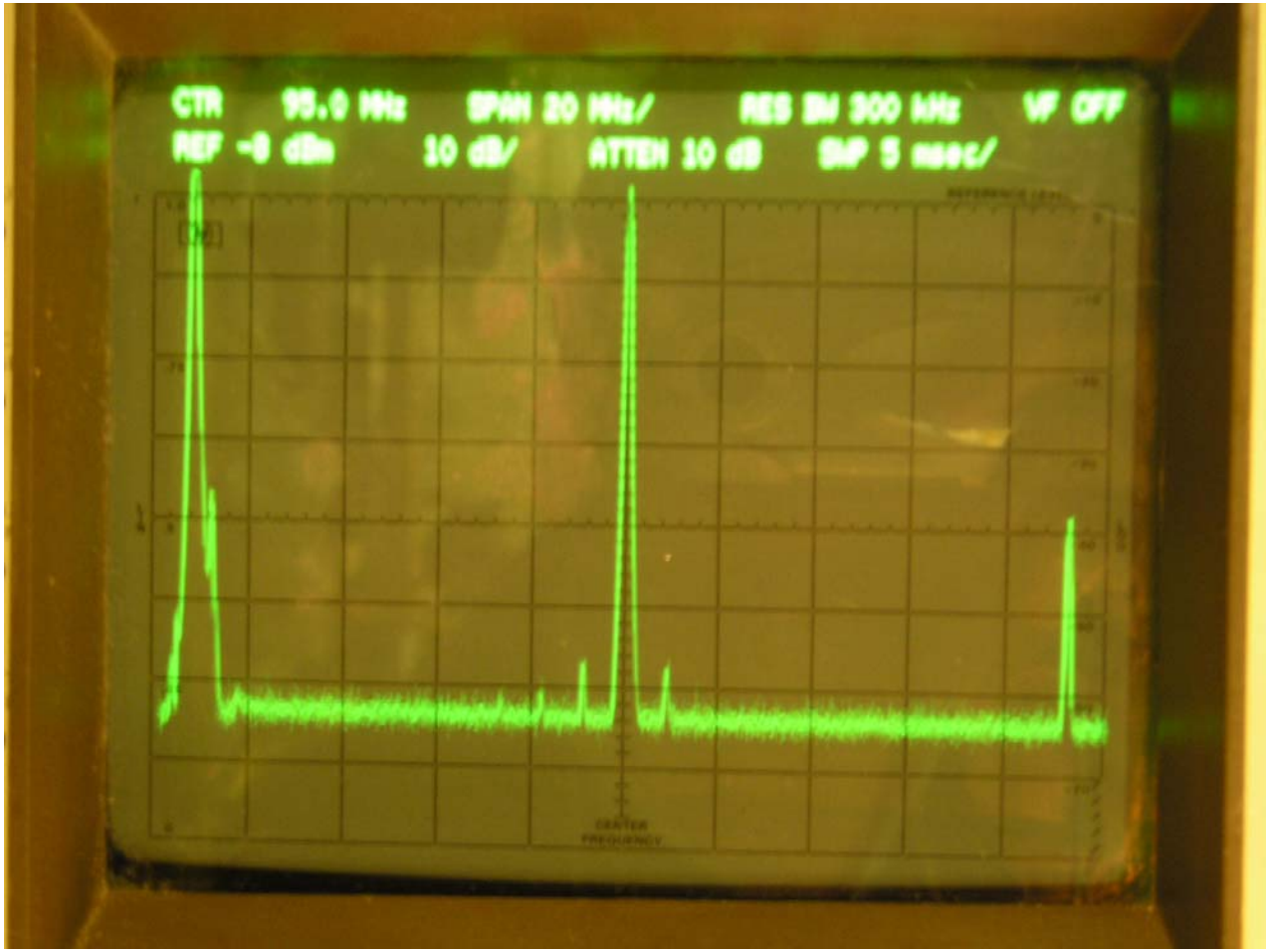
PCB View – lower side



The First Sample...



Spectral Output



106.5MHz Synthesis Example

- Can be derived as 90 + 15 +1.5 MHz
  - High loop div by 2, mult by 3
  - Low loop div by 5, mult by 3
- Also as 110 – (3 +0.5) MHz
  - High loop div by 10, mult by 3
  - Low loop div by 2, LPF
- Mixing products are much closer in on final mix from second option – prefer first

But.....

- Those options assumed 10MHz input
- If 15MHz is used as the input freq, then the options are different:

  15 x 7 = 105MHz

  15 / 10 = 1.5MHz
- 105 + 1.5 = 106.5MHz – ie a single loop implementation!
- Most surplus commercial GPSDO's reaching the ham market these days are 15MHz

Availability

- For anyone who wants to play with this technique, I have PCB's, boxes and will be making some of the parts available as kits
- Information about the filters and attenuator settings is available on my website – http://g4hup.com/
- Full diagrams and construction information also on the site
- As more information becomes proven I will add it to the postings

Conclusions

- Dual Loop DFS increases frequency options for LO locking to GPS
- OCXO can be used for input if you have no GPSDO
- Acceptable spurious performance can be achieved
- Compact implementation suitable for fixed and portable use
- Flexible PCB design for maximum utility

Acknowledgements

- G4DDK
- G3NYK
- N8UR
- Bill Pollock of Arcstart

References

- WA1ZMS – 89.333MHz DFS
- G4DDK – 96MHz DFS – UK uG Scatterpoint
- WW2R/G4FRE – DFS90/96, NTMS Feedpoint