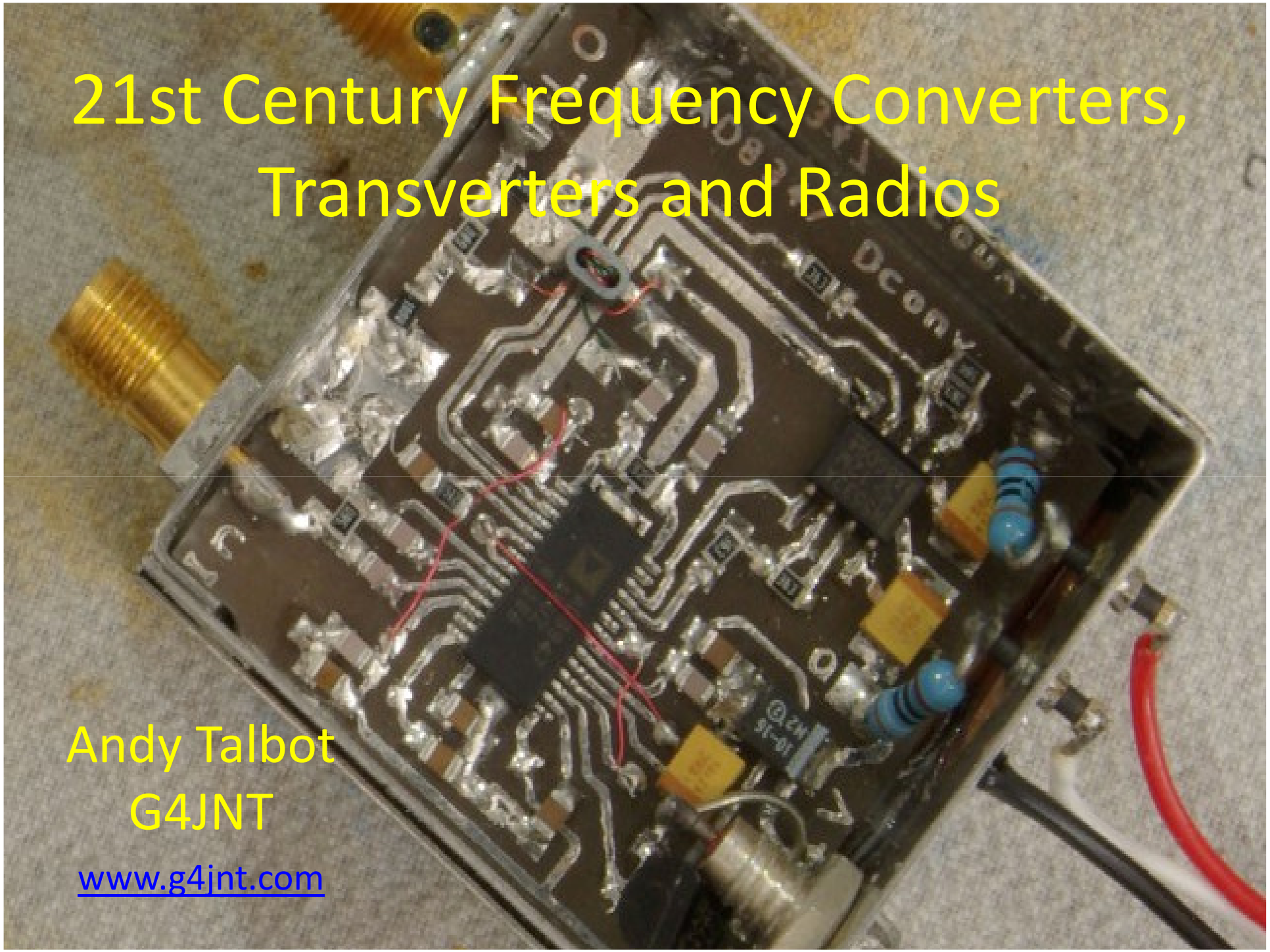
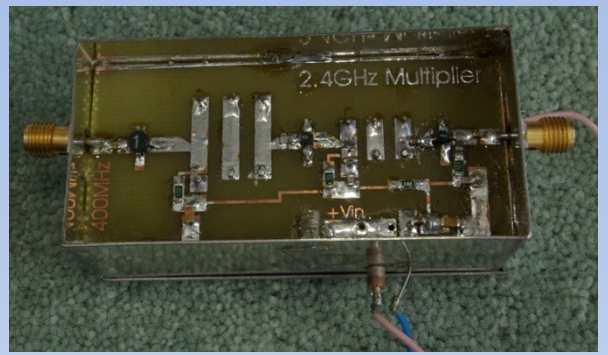
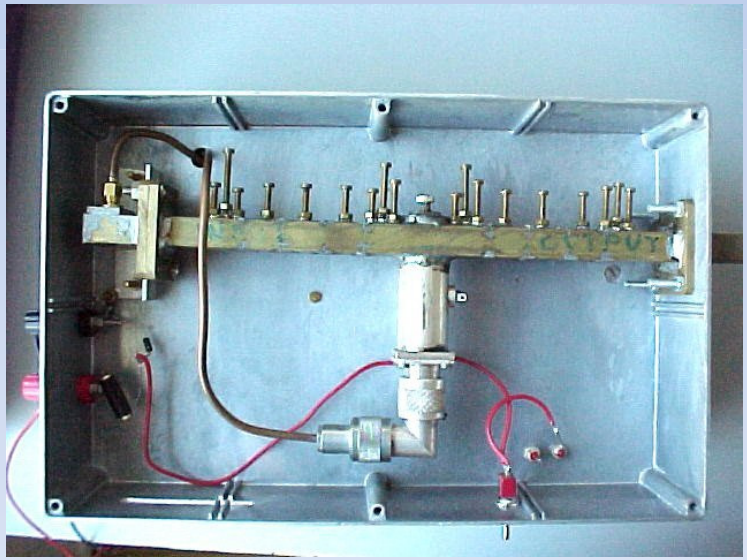

21st Century Frequency Converters, Transverters and Radios
Andy Talbot
G4JNT
www.g4jnt.com

What we used to build





Replace with minimum tuning, wideband integrated solutions

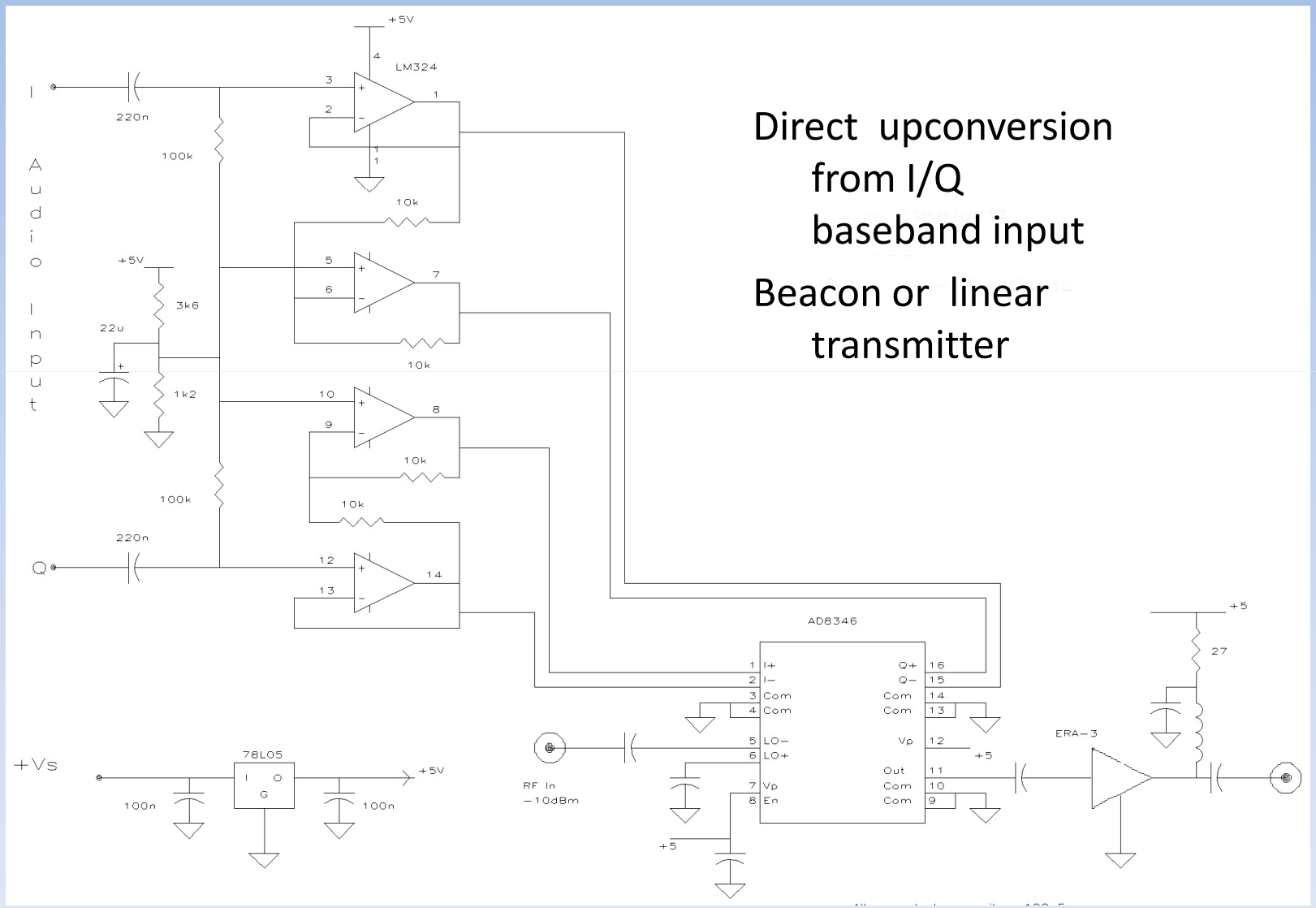
Background

- The mobile phone and modern RF industry give us nice RF chips - for peanuts
- Frequency Converters and Synthesizers
  - AD8347 £15
    - 0.8 – 2.6GHz Downconverter,
    - 60dB gain and AGC.
  - AD8346 Upconverter £12
  - LMX2326 Fixed synth – 2.6GHz £2.93 (RS)
  - LMX2470 2.5GHz FractN synth, £6

Frequency Conversion

- Single Chip Up and Down convert.
- 800 – 2600MHz – but will usually work higher
  - Other chips cover HF to UHF
- IF DC – 50MHz
  - Baseband or IF
- Low RF input power -15dBm
  - Linearity similar to diode mixers
- Downconverter - 60dB DC gain control

1.3 and 2.3GHz Tx Source



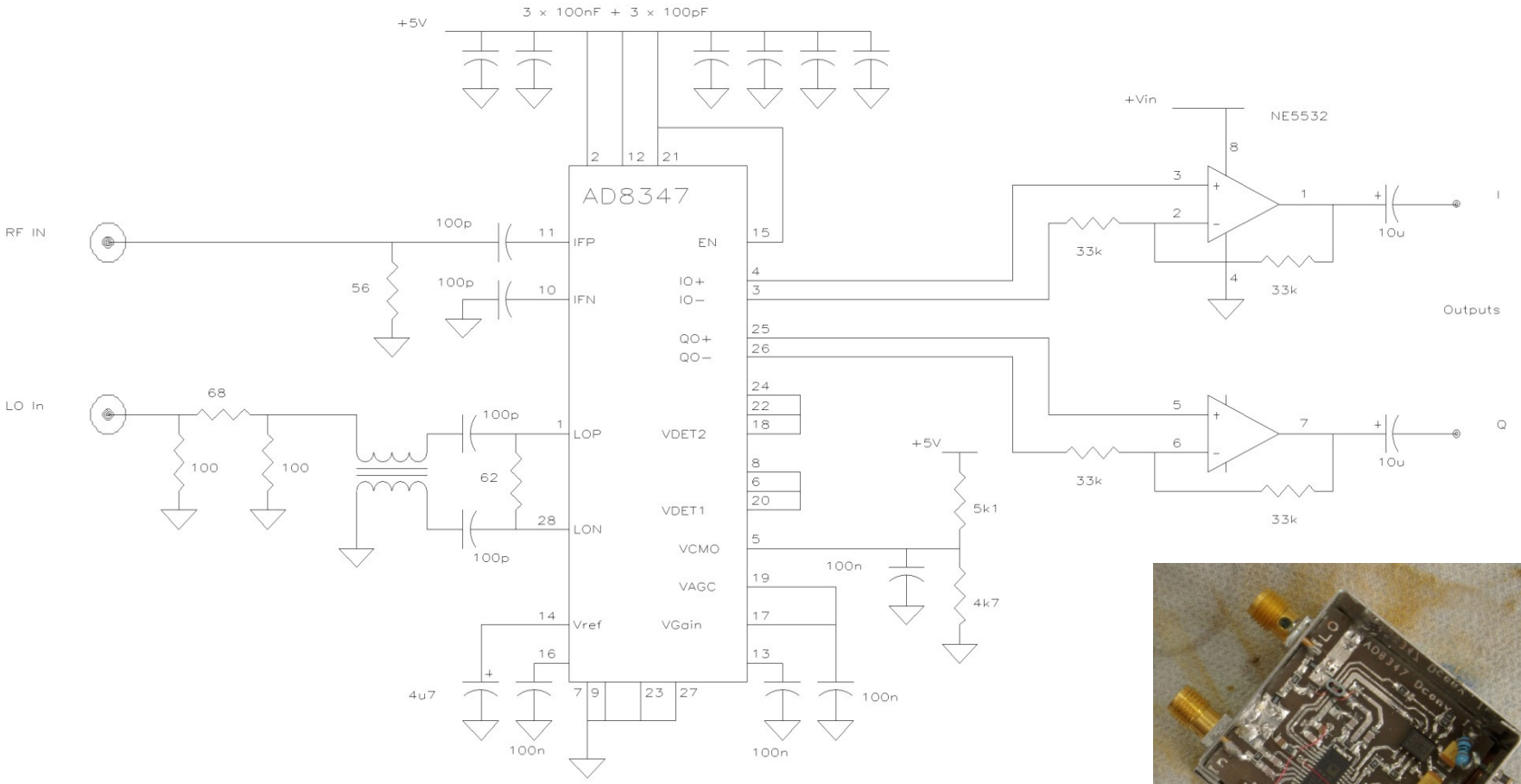
Direct upconversion from I/Q baseband input

Beacon or linear transmitter

Baseband processing

- Replacement for the Transceiver
- SDR Software, Soundcard input / output
  - Limited Tuning over few tens of kHz
  - WinRad, Rocky, SDRadio.....
  - Filters galore
- Standalone hardware
  - Kit/Module with DSP chip, audio amp – SDR2GO
- Polyphase / Audio 90 degree networks

Direct Conversion Receiver 1.3GHz, 2.3GHz, (3400MHz)

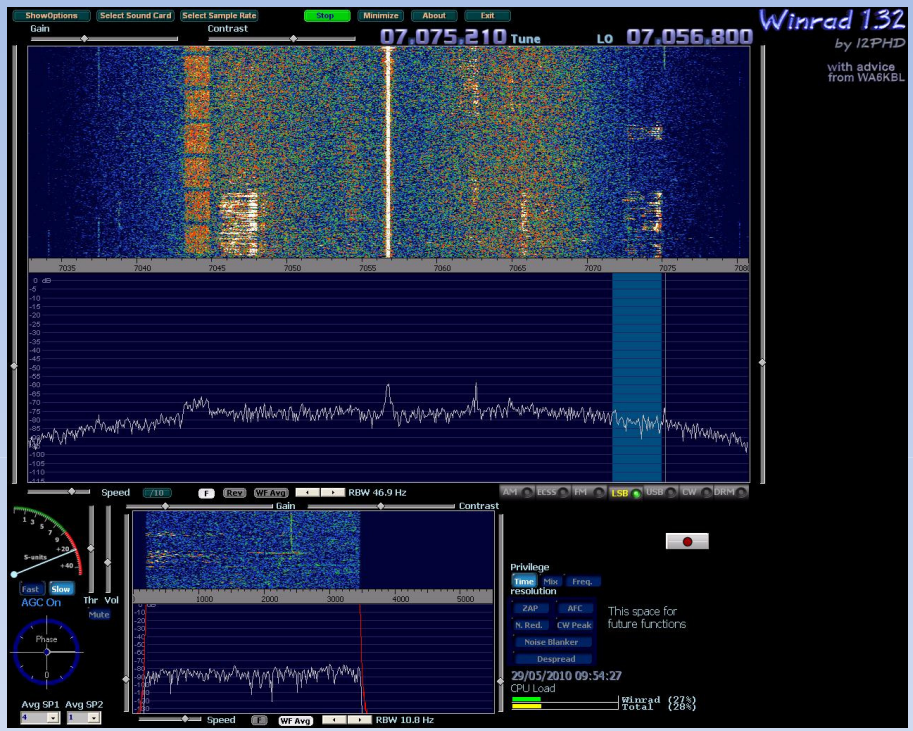


Direct Conversion Software

Plenty of Receiver software.
Typically allows tuning ±24kHz

Not much for Tx.
G3PLX basic prog
mic input, IQ out,
±800Hz tuning.
+ AM/FM

USB / Bluetooth Headset Mic Input



Rx & Tx standalone (no PC)

SDR2GO – Baseband I/Q Mod/Demod

(Si570 control not used)

SSB with mic or line input

On-Off carrier (with audio sidetone)

The Downside

- Direct Conversion suffers from input rectification.
  - GSM, 3G, DECT , WLAN
  - MASSIVE pulsed signals in local environment
- Input filtering
- Ok for use out in field,
  - Beacon monitor works OK –

OR the Conventional Route

IQ Conversion to RF & 28MHz Transceiver

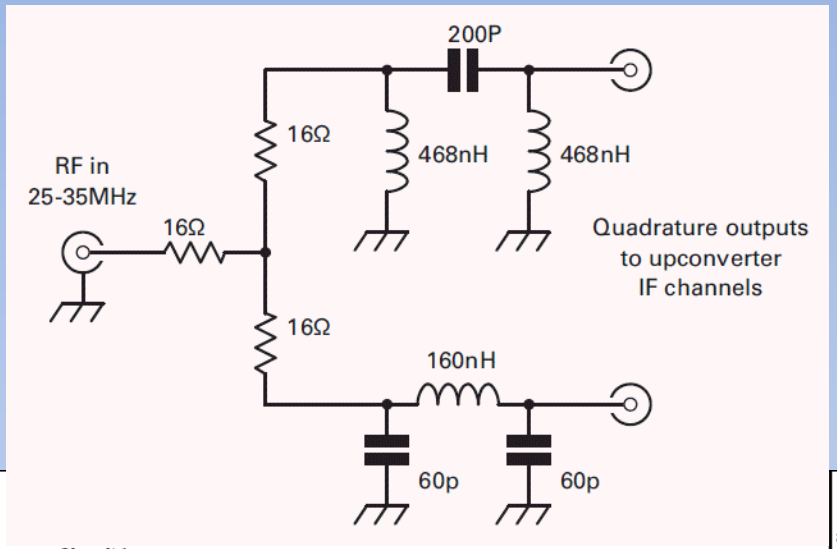
The AD8346 and ’47 work with IFs to >50MHz

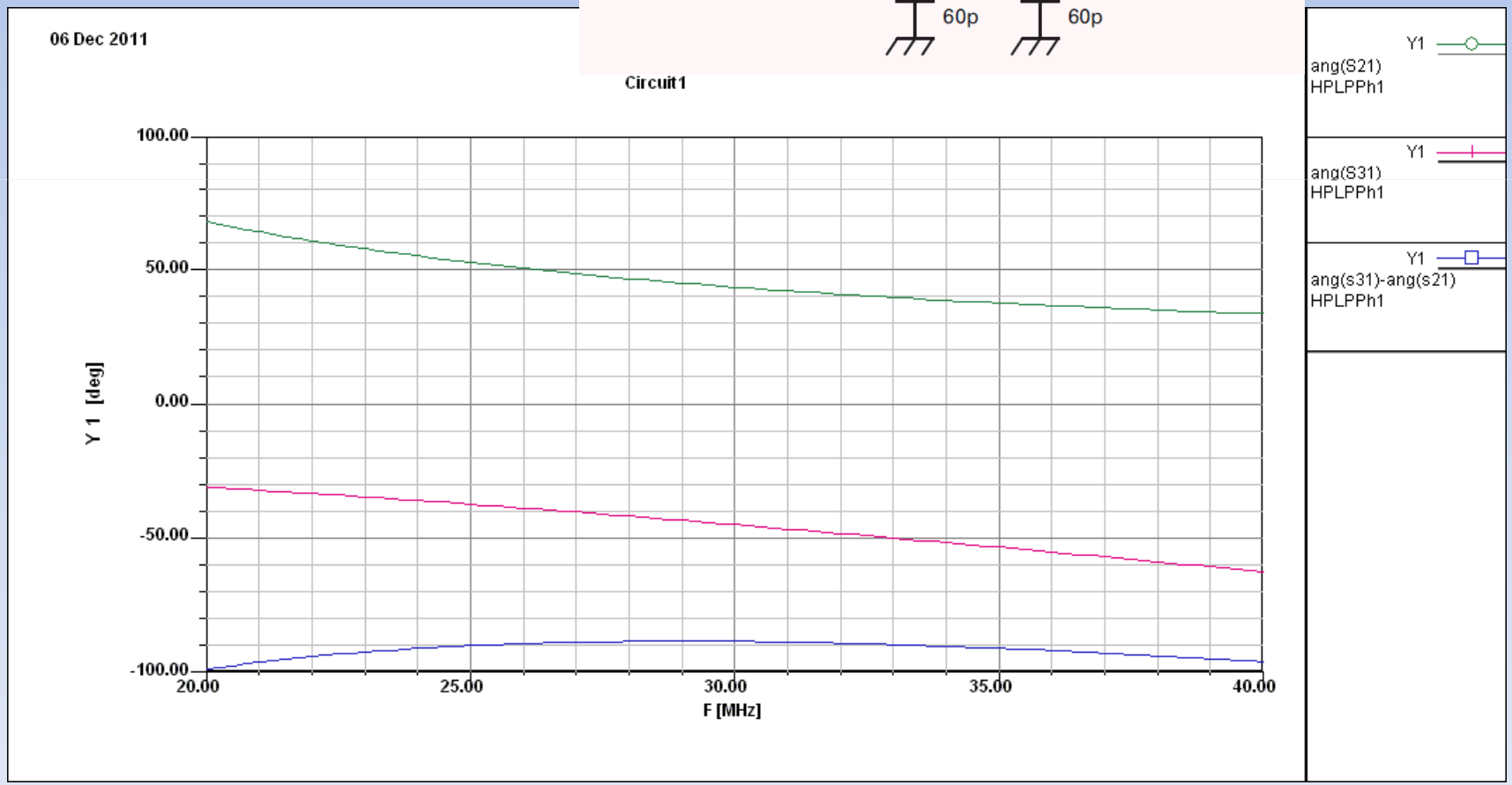
IQ network for conventional transverter design no need for serious image filtering.

Off-the-shelf Minicircuits PSCQ-2-40 quad hybrid 23 – 40MHz
35dB sideband rejection

LOW IF – 100kHz to MHz. RC tuned 2nd LO

Hi/Low Pass 90º phase shifter





Local Oscillators

Fixed Frequency Synthesizer

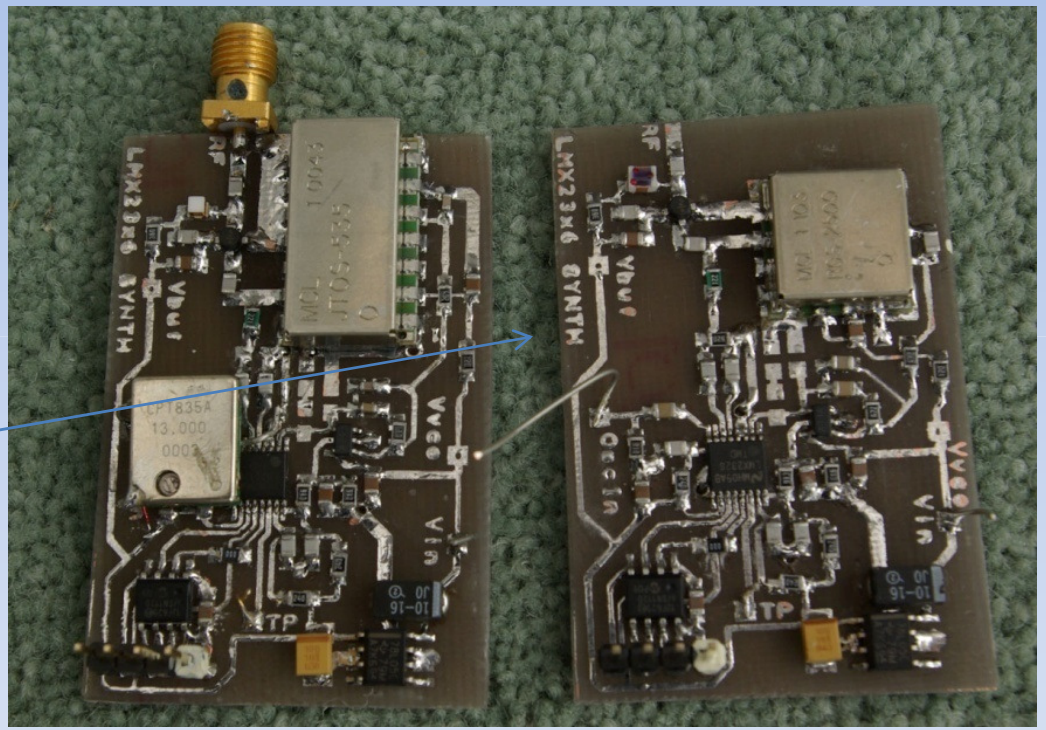
Ideal for

Transverter LOs

LMX2326 to 2.6GHz

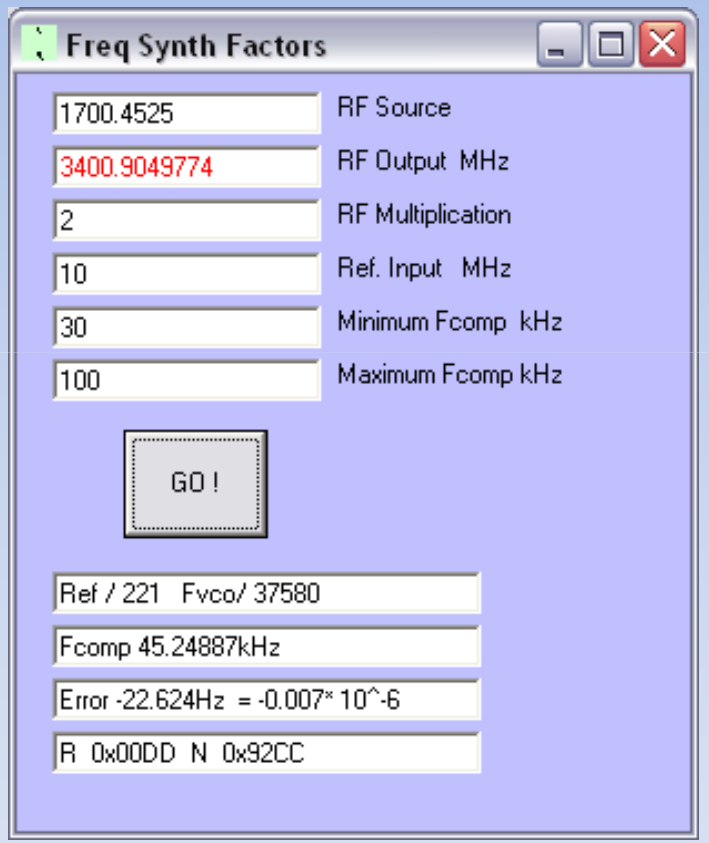
OR

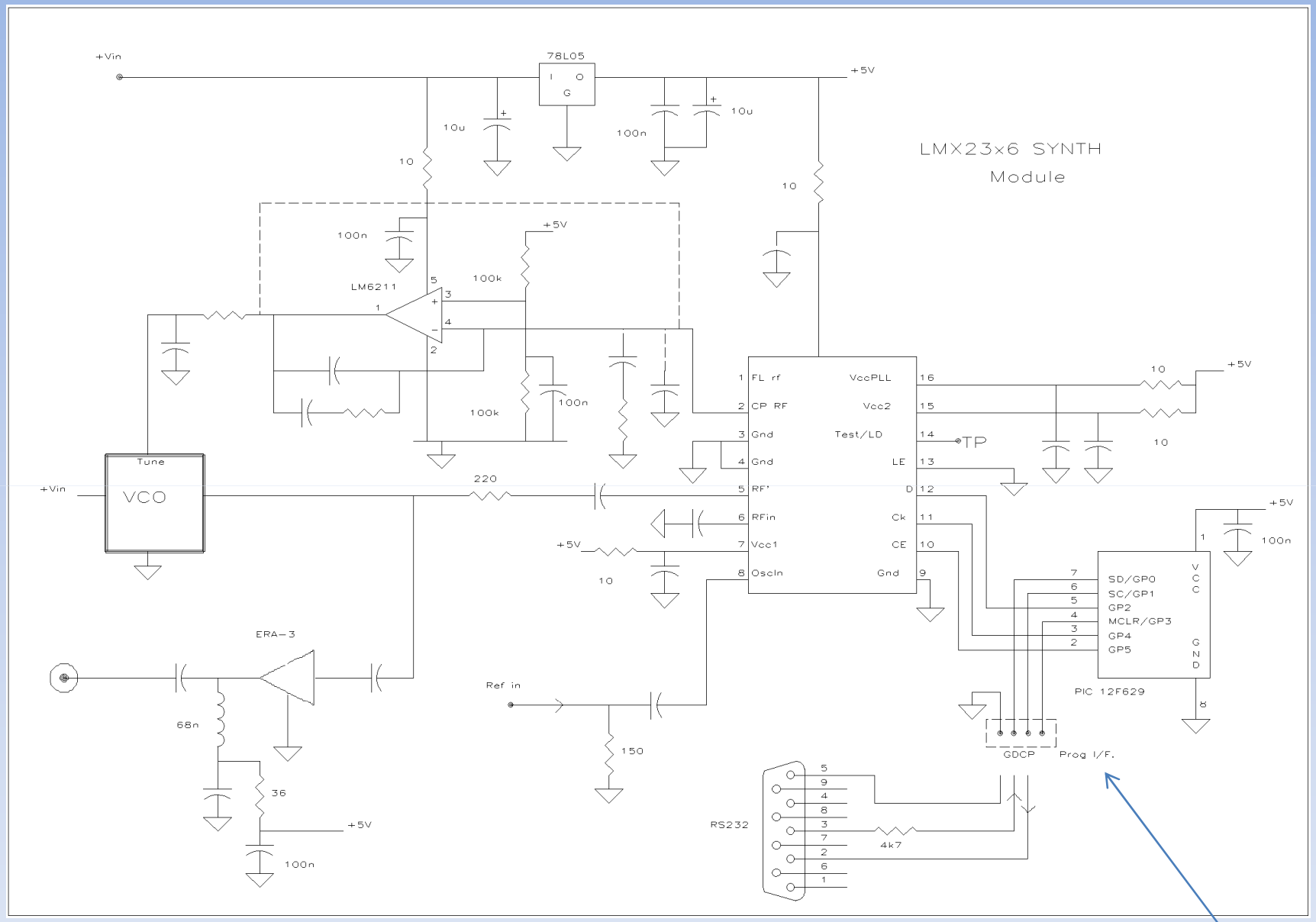
AD41020 to 18GHz



Integer N

- LMX2326 is typical – and getting on a bit now!
- 100MHz to 2.6GHz input
  - R divider (R = 3 to 16383)
  - N divider (N = 32 to 262175)
    - Some flexibility for odd freqs
- Fout = Fref * N / R
  - VCO Drive 0 – 5V,
  - Loop filter ~ 3 Caps, 2 Rs
  - LM6211 opamp Vtune > Vcc





RS232 programming

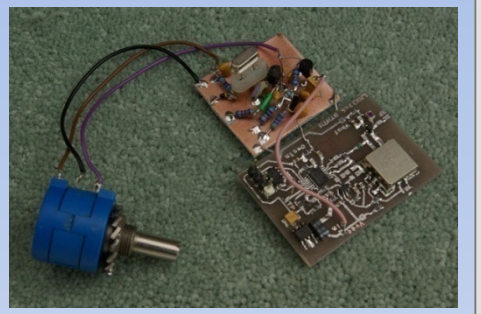
Continuous Tuning

- Transverters for full tuning at IF
  - so a fixed LO is no problem

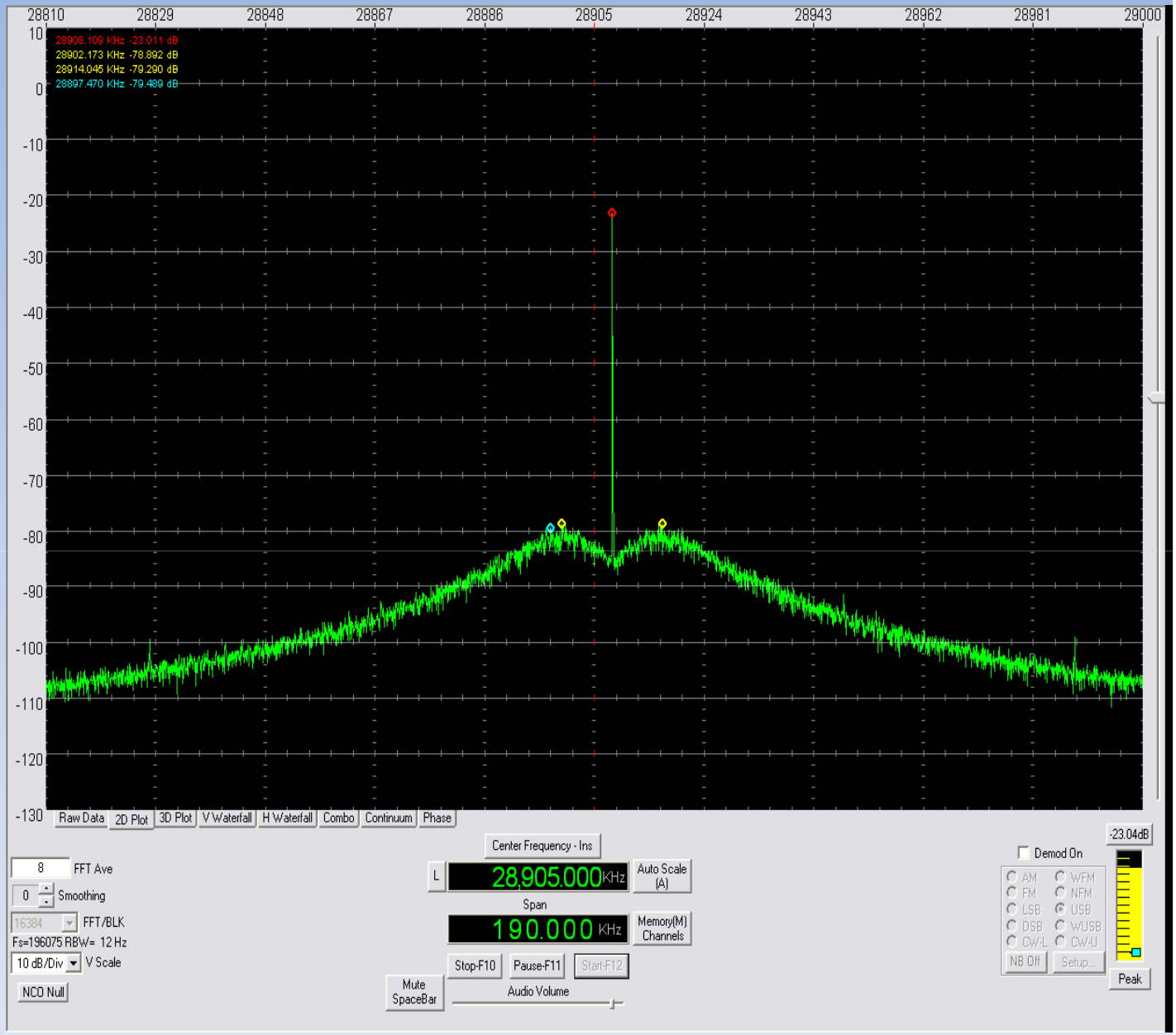
- Direct Conversion or fixed IF receivers give at most a few kHz, or no tuning at all.
  - So.....
  - We Need a tuneable LO at microwaves

KISS

- Pull the synthesizer reference input
  - Typical || resonant at 10MHz will pull 30 – 50ppm depending on wanted stability.
  - 100kHz at 2.3GHz, 400kHz at 10g
  - Ceramic resonator even more !
  - Play with R and N values. Any surplus crystal.
    - ‘Intelligent’ Freq counter display on Xtal freq.
- Low IF at 100kHz, RC tuned LO.
- These are NOT LOCKED ! IC202 equivalent
  - Use DDS as reference. Locked, but not too clean



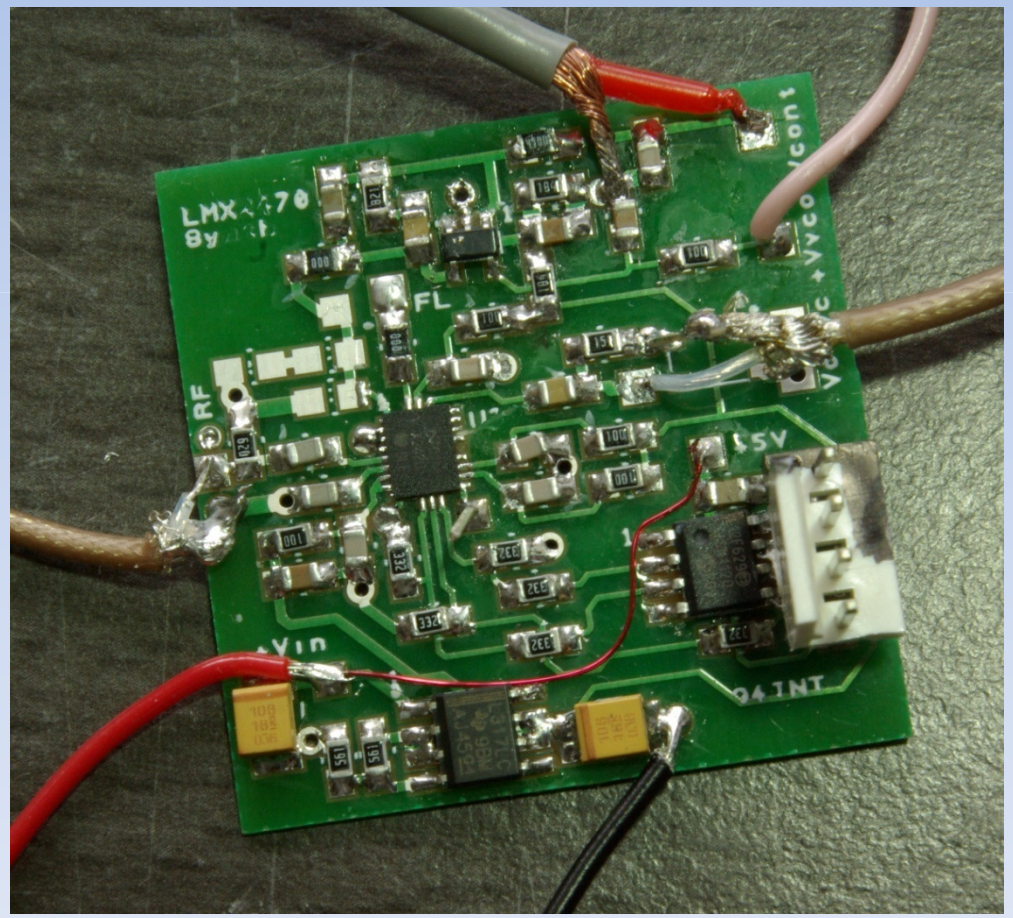
Nominal Centre Freq	2320.9 MHz
Nominal Crystal	10 MHz
Pulling Range	40 +/- ppm
Approx Fref	454 kHz
Actual R	22
Actual N	5106
Fmin	2320.8163 MHz
Fmax	2321.0019 MHz
Delta	185.67 kHz

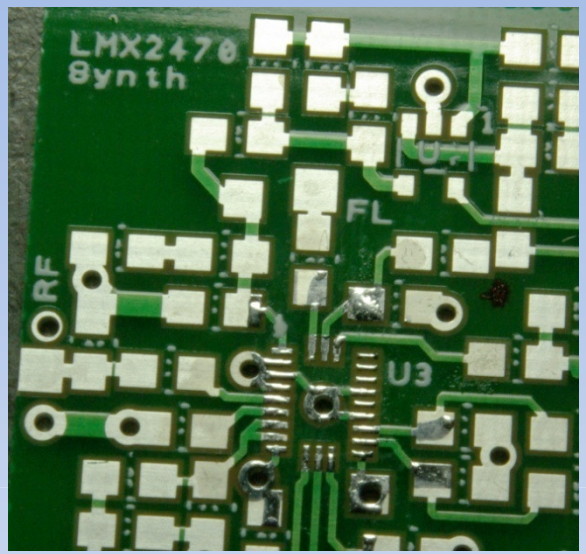


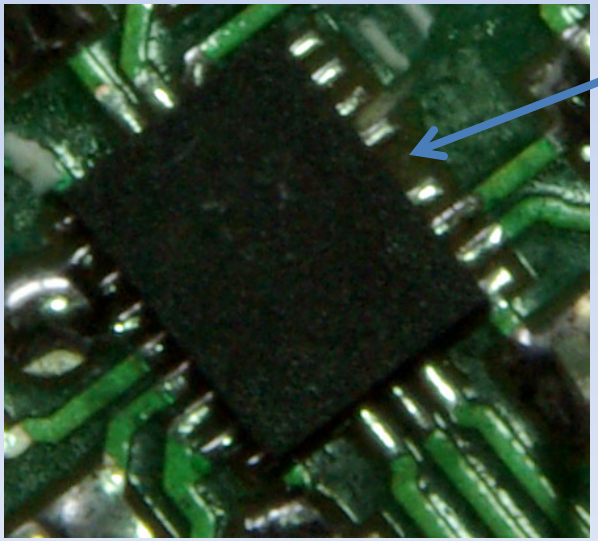
Fractional N Synthesizer

- Generate directly at GHz
  - LMX2470 to 2.5GHz, LMX2487 to 6GHz
- Locked to Master Reference input
- Tiny step size – few Hz
- Fout = Fref / R * (N + F / D)
  - Let R = 1 for 10MHz ref (or X2)
  - D = 1000000 for 10Hz steps
  - Loop BW 30 - 100kHz for low cost VCO

LMX2470 Synth PCB







OOPS !

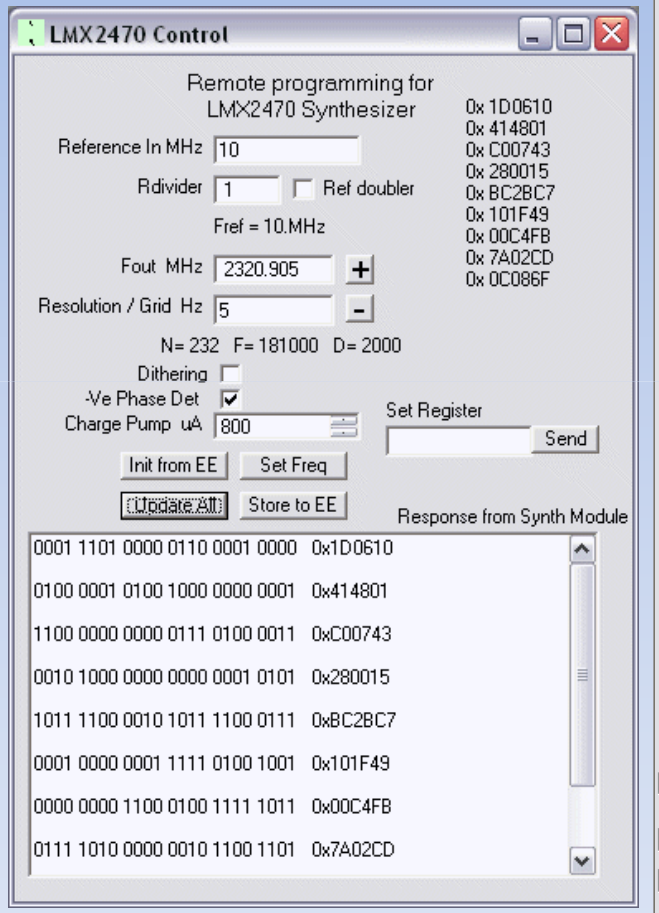
Data Modes

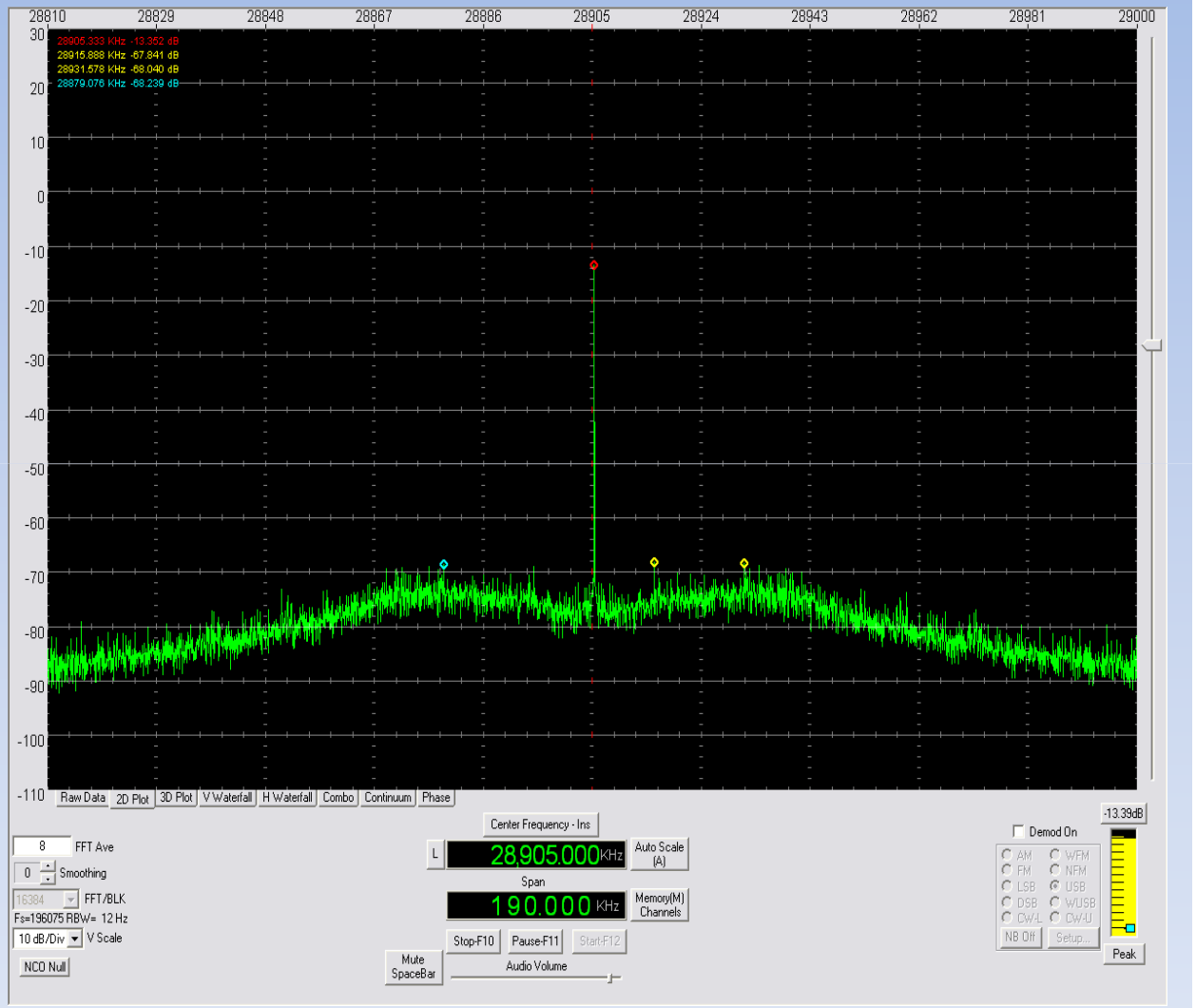
- Set tuning grid to the tone spacing
  - JT65c 10.7666Hz
  - JT4g 315Hz
- Send codes to change F register
- Standalone Beacon Source
  - Faster switching than RDDS
  - Accurate tone spacing at 10GHz and up

Phase noise and Spurii

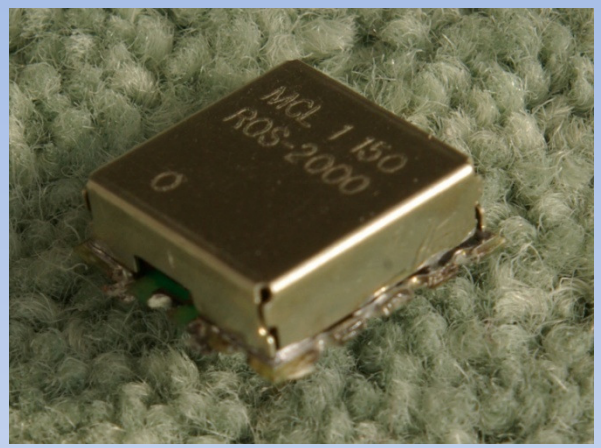
- Always a problem with synths – isn't it?
  - BUT .... Is phase really an issue ?
  - We want narrowband signalling.
    - Any modern synth with Fref > 50kHz and loop BW > 8kHz will "sound clean",
    - Unnoticed on SSB or audio tones.
  - Strong signals / other stations nearby
  - Close in spurs typical -60 to -80dBc,
  - Big effort needed with contest stations
  - Make sure the reference input is clean

5Hz tuning grid at 2320MHz



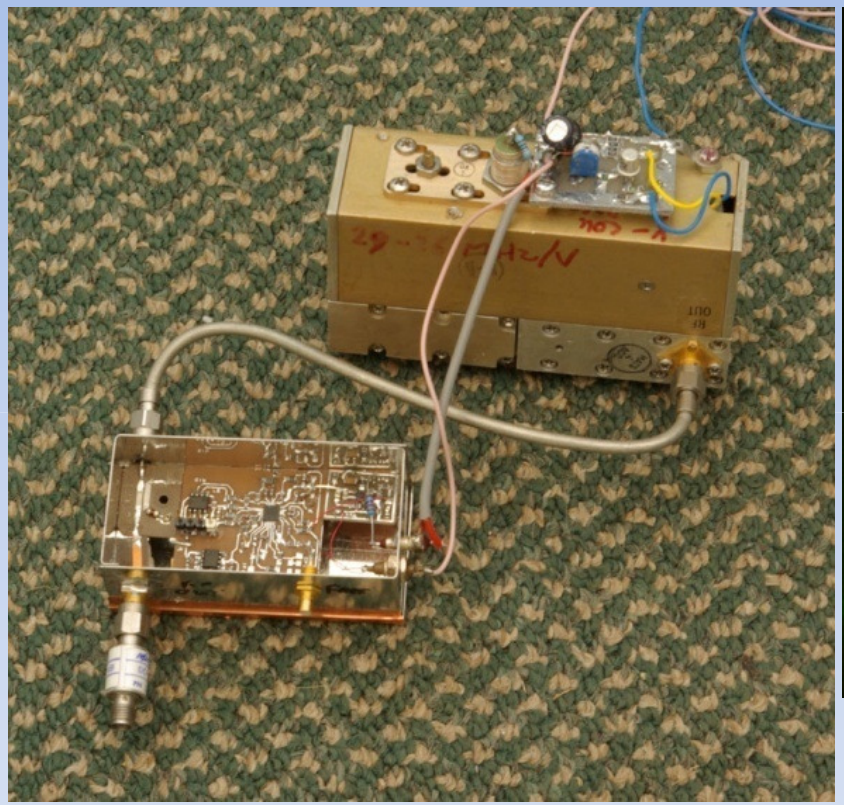


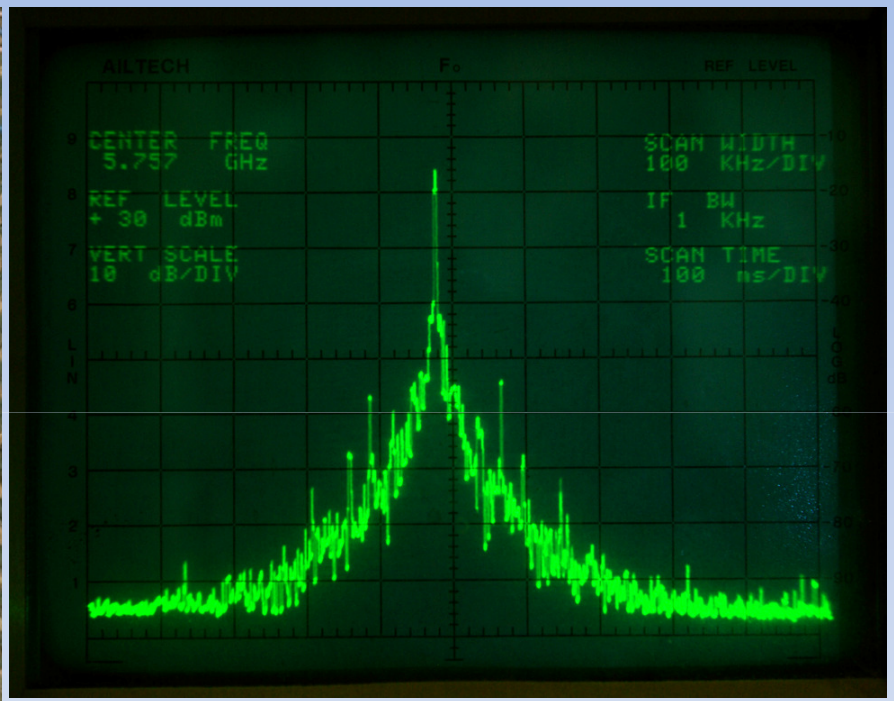
VCOs



- Minicircuits packaged –
  - low(ish) cost
  - Known spec, MHz/V
- Surplus
  - Old ‘Brick’ sources excellent 1.4 – 1.8GHz typical
  - Multipliers that are easily retuned
- Discrete
  - Some good designs wanted
  - Cavity / coax / stripline / LC

LMX2487 + ‘Brick’ LO at 5.76GHz

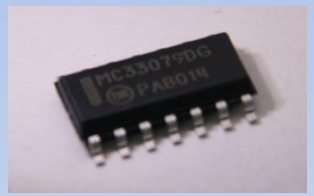


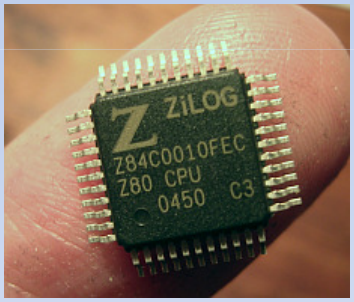


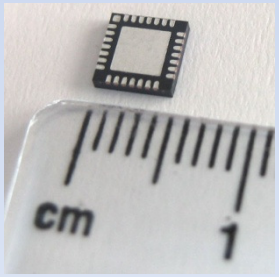
Discrete Spurii are on the 10MHz GPSDO reference input.

The SMALL PRINT

- Surface Mount small components
  - SOIC 1.27mm pin spacing
  - TSSOP QFP
  - Thin-Shrink Small Outline Package, Quad Flat Pack)
    - 0.64mm pin spacing
    - Easily hand soldered (flux and wipe)
  - QFN (Quad Flat No leads)
    - LMX2470/ 87
- The PIN ‘0’ bottom pad.







Soldering

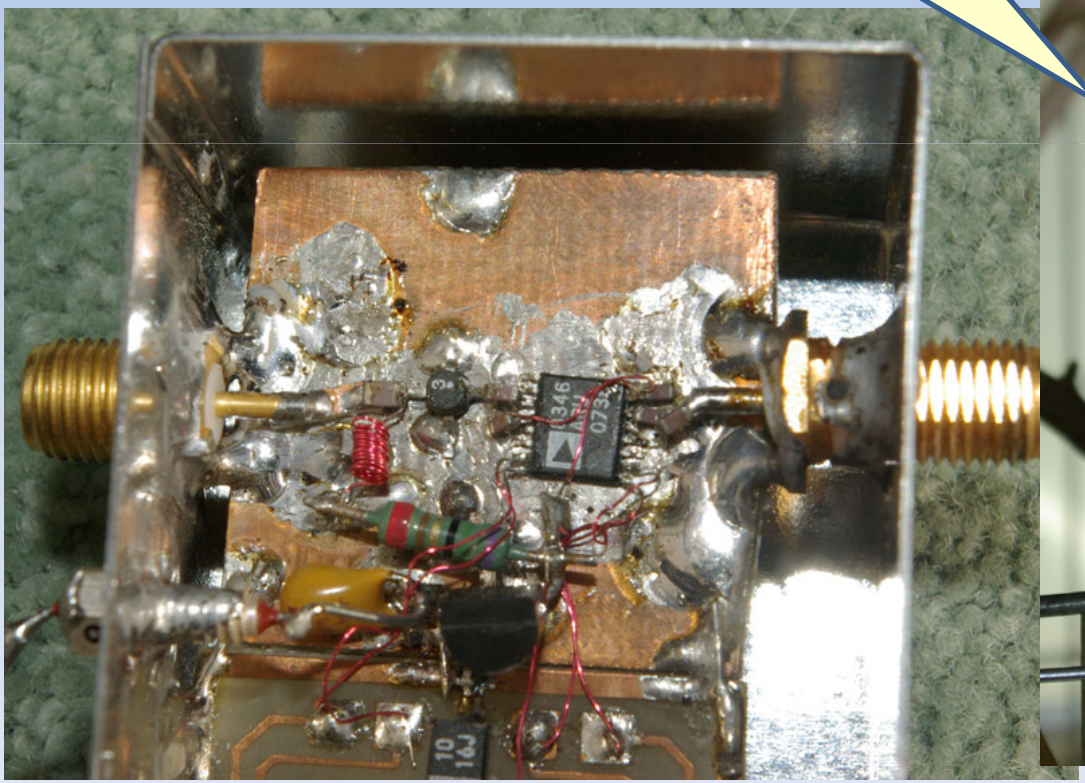
- Decent iron with small bit
  - Higher temp, solder flows better
- Separate flux
  - Prevents bridging
- Solder braid
  - Just In case
- Use leaded solder
  - Its going to be around for a long time yet

The Upside

- Robust chips
  - A lot better than earlier devices
  - Better static protection
  - Designed for higher soldering temperature
  - Never damaged one from handling – and that includes removal twice!

PCBs aren’t Compulsory !

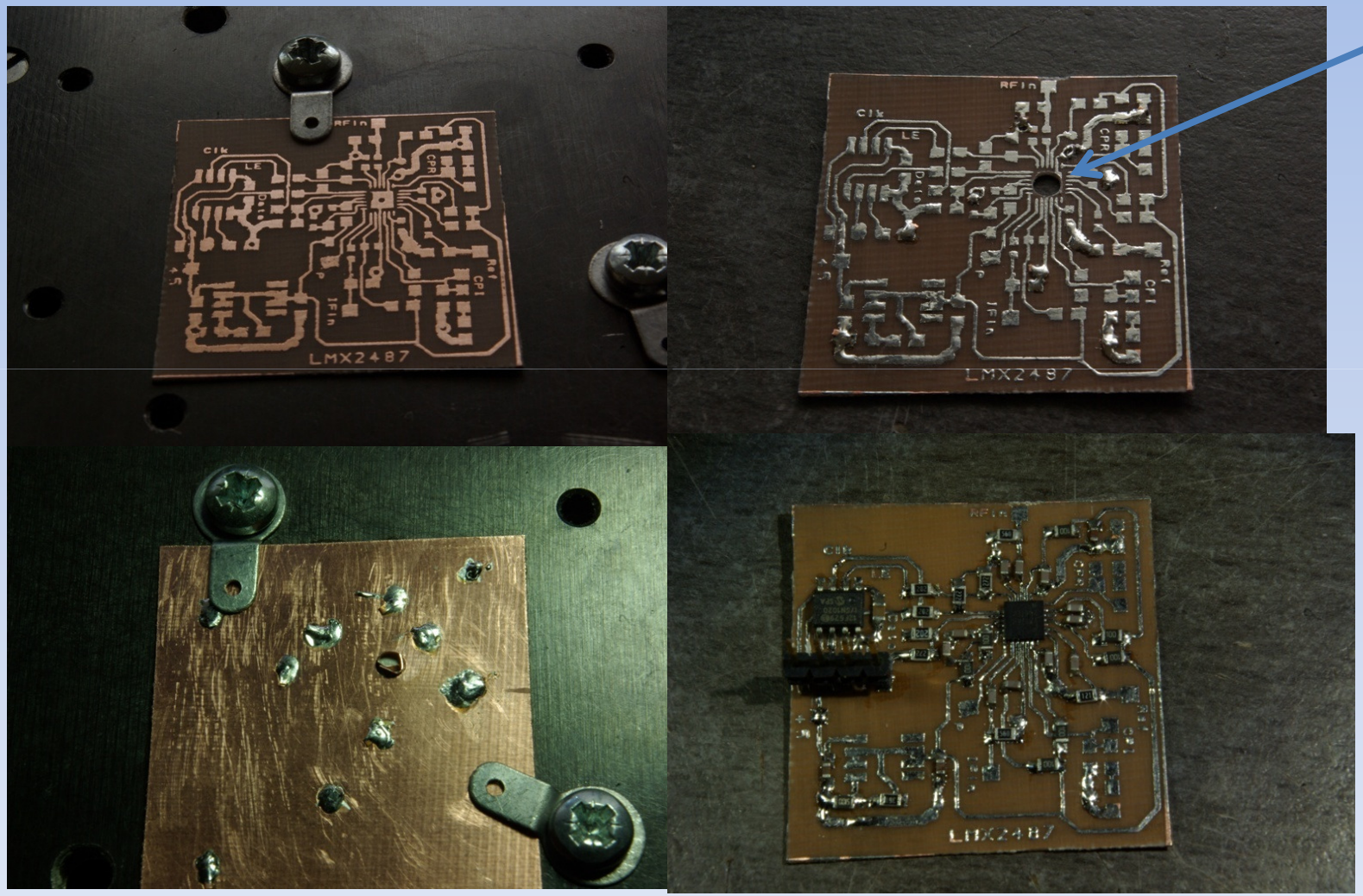
“Rats Nest“
Construction,
Please , NOT
“Birds Nest”



But PCBs do make life easier...

- Homebrew
- Laser printer and Press-N-Peel OR
- Acetate and UV light box
- Both will cope with TSSOP (0.64mm pin spacing)
- P-n-P OK with QFP (0.5mm pad spacing) for fract N synths
  - This is probably about the limit ?

Homebrew PCBs



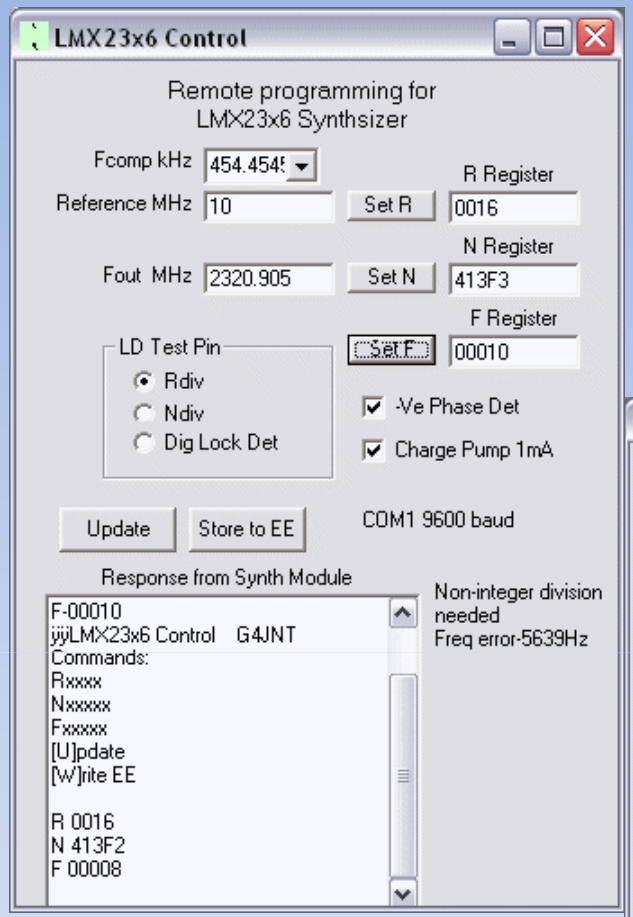
Other Skills

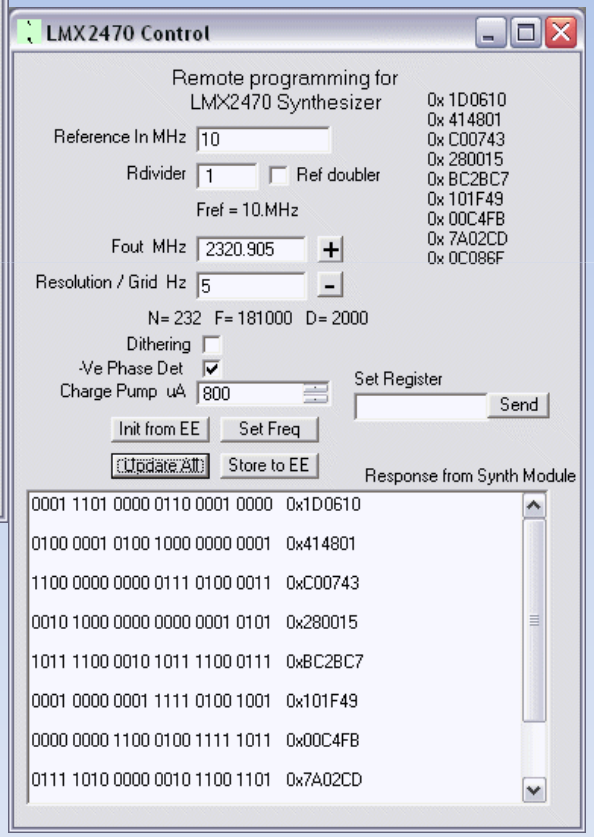
- Synth chips want serial programming –
  - PIC interface
- Plenty of code already out there to do the job
  - **GET or make a PIC programmer and at least be able to blow your own devices from published code.**
- BETTER STILL
  - Assemble code from published sources
  - Do your own customisation, callsigns, frequencies

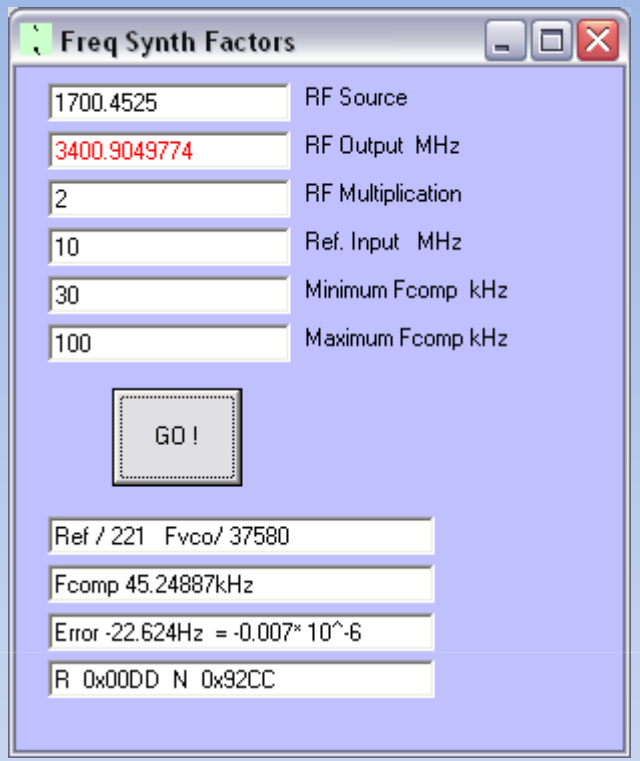
‘JNT PIC “Operating System”

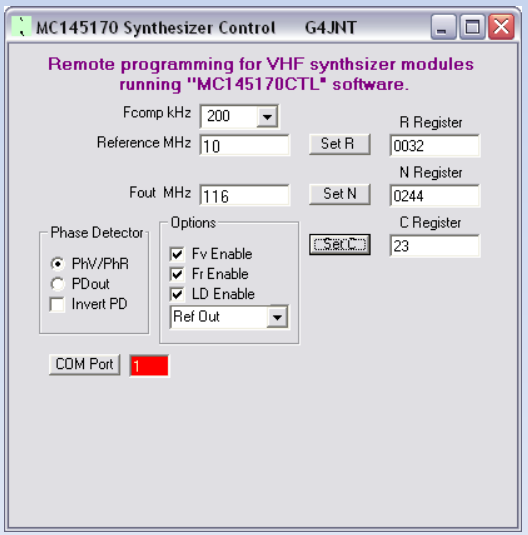
- Each synth chip needs custom serial programming
- Small 8-pin 12F629 PIC with standardised set of connections
- RS232 serial programming
  - instant self-boot at turn on
- Easy access to synth-chip registers
- Some customised driver code

Driver Progs









Talk to PIC OS. /
Synth on Serial
Interface


Questions