

■ Third Method LF Upconverter

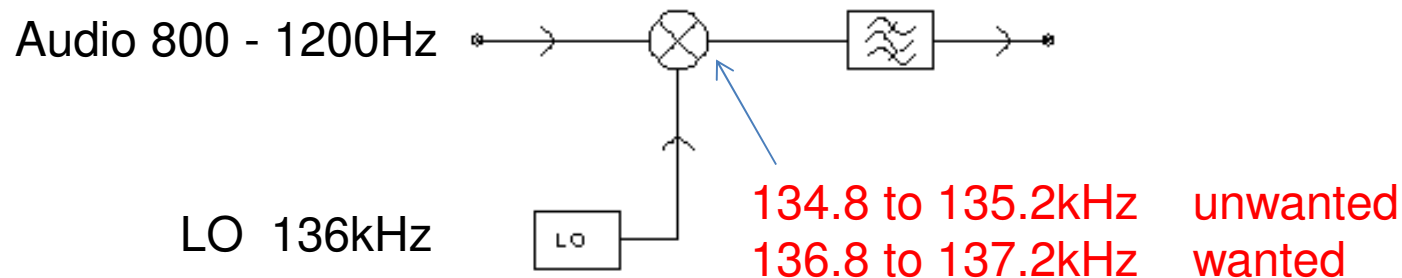
Andy Talbot G4JNT / G8IMR



The Problem

- Translate Soundcard audio up to 137kHz or 475kHz for modern data modes that cannot be generated directly from an RF source
- With good stability and frequency accuracy
 - At HF to SHF we'd just use an SSB transmitter
- Use a Transverter ?????
 - Mix to LF from an HF transceiver
 - not a very elegant solution
 - and all LOs need to be locked for frequency accuracy

Traditional (Filter) Upconverter



Output filtering is difficult, as the image is close and falls out of band.

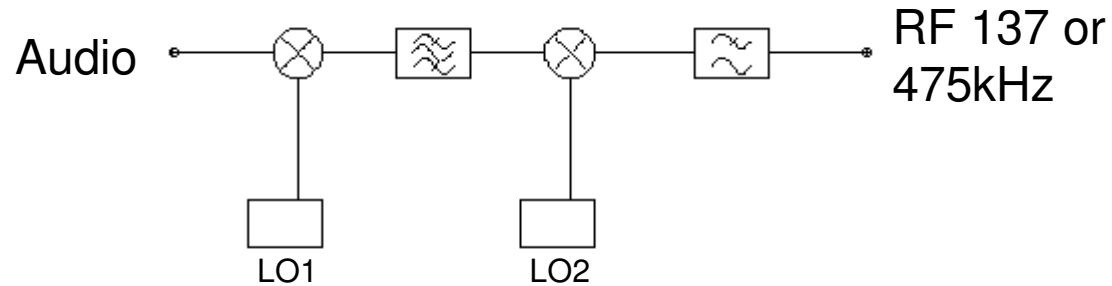
Just 1.6kHz guard band and we need better than -60dB rejection for out of band products

Especially so if the output needs to **cover a range of transmission frequencies**

So we need a better solution

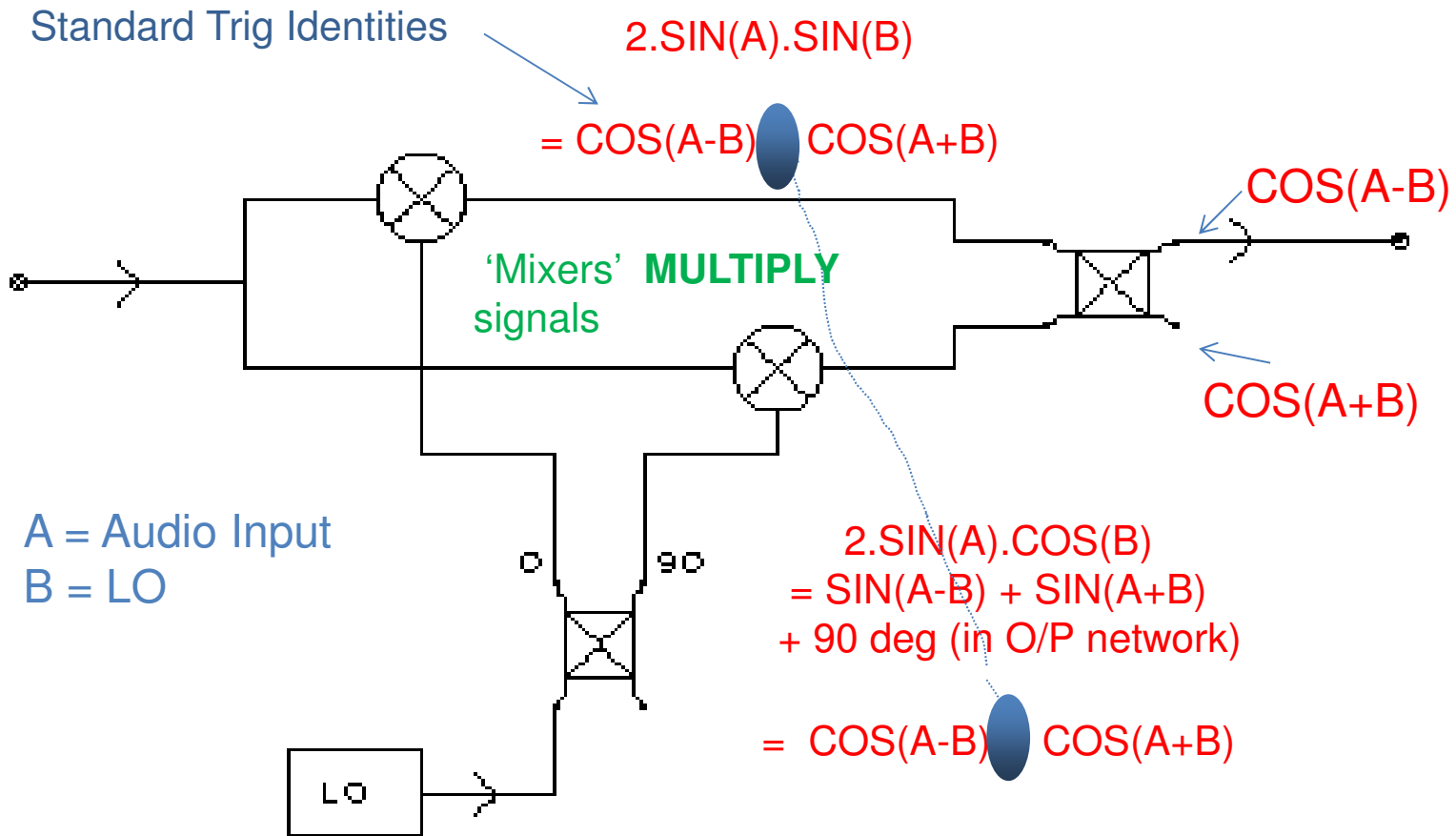
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Double Conversion

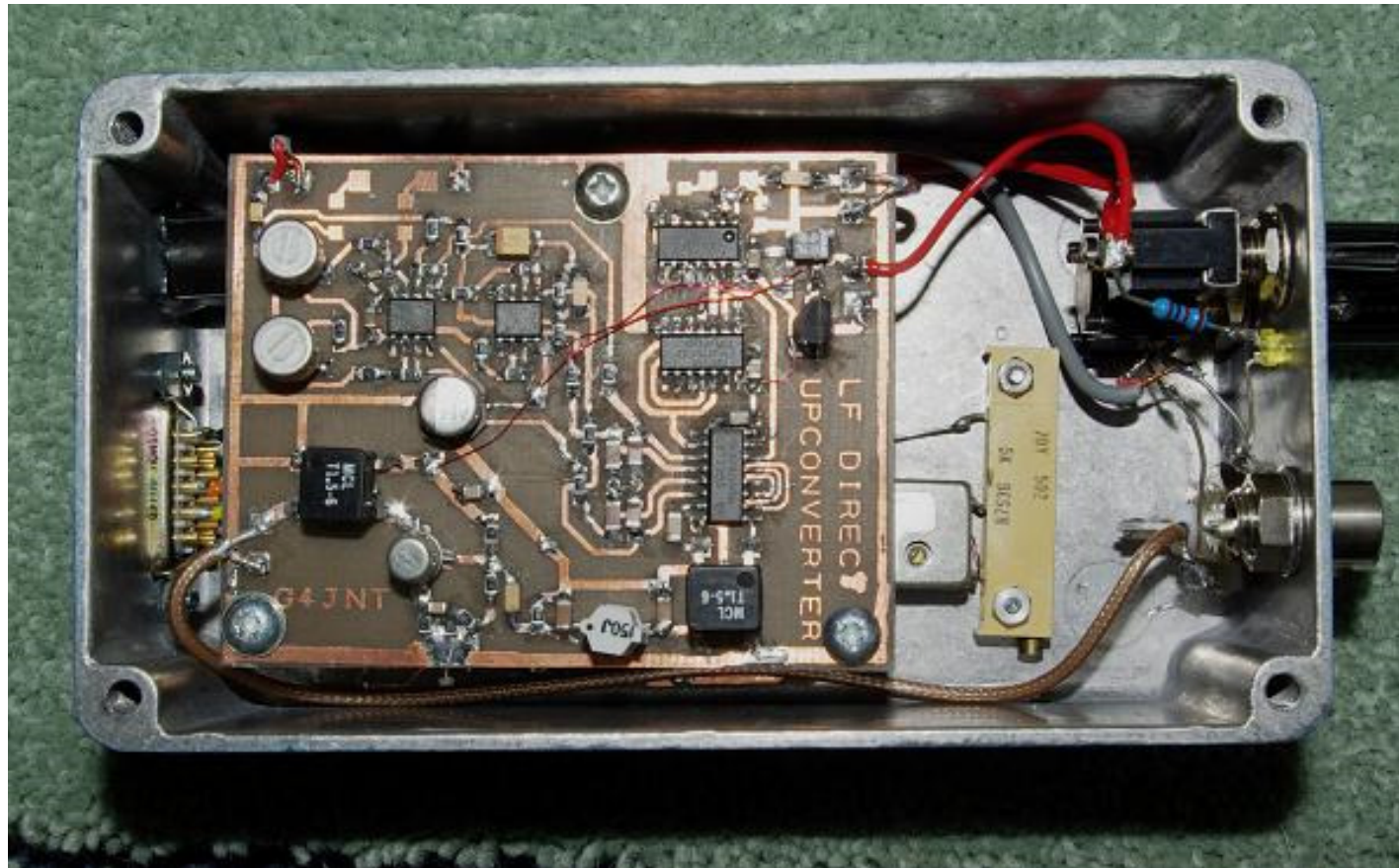


- High first IF, eg 10.7MHz
- Two high stability LOs - locked
- SSB Filter
 - Expensive,

Quadrature (I/Q) Mixing



Single Conversion can be made to work OK >>>>

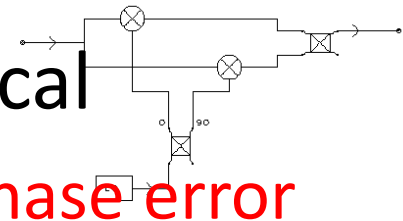


DDS supplies LO signal, controlled via PC (serial) interface
OP-Amp Audio phase shifter works over $\sim 200\text{Hz}$ bandwidth
for narrowband data centred on 1500Hz

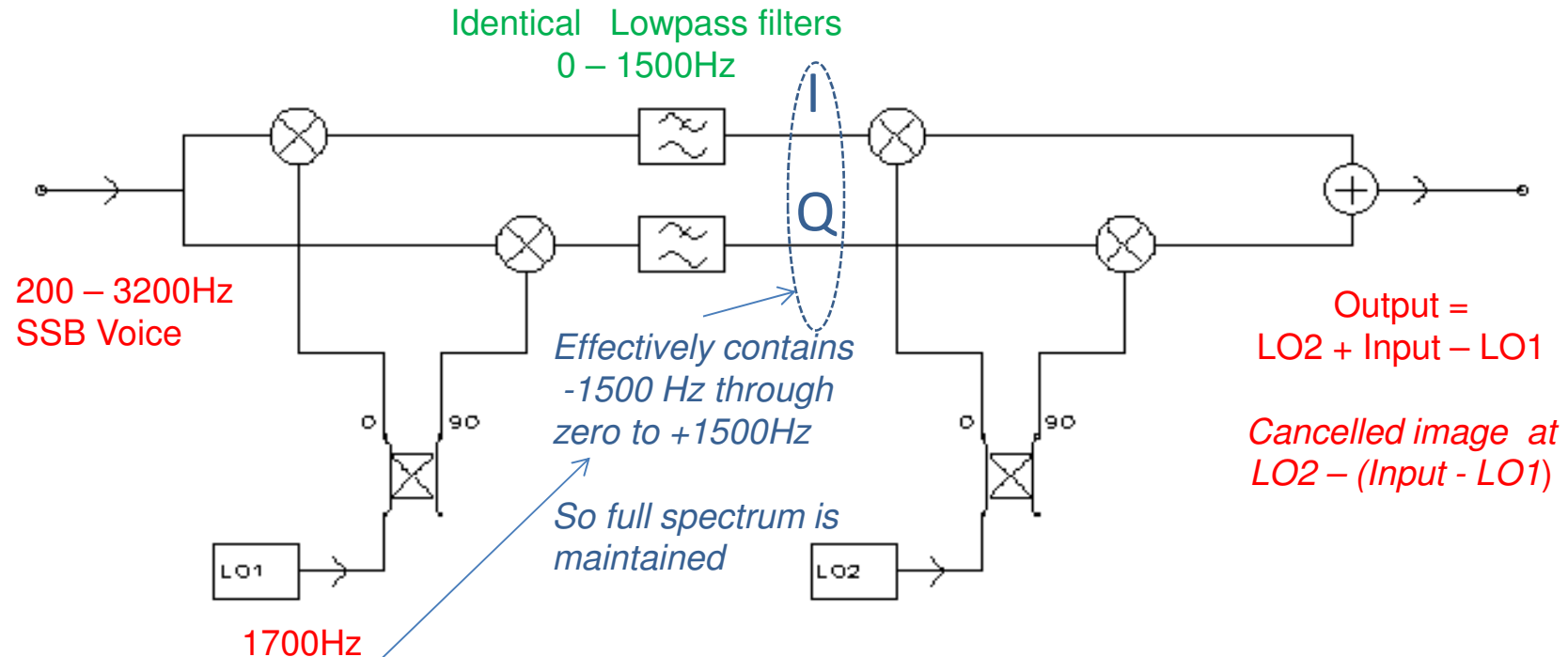
But there is a snag >>>>>>>>>>

Problem with Quadrature mixing

- Cancellation is never perfect
- I and Q channels have to be identical
 - 0.5dB I/Q imbalance (10%) or 5° phase error gives 20dB sideband cancellation
 - 0.08dB or 0.5° phase for 40dB isolation
- For out of band we should be aiming for less than -60dB spuri, which is possible, but fiddly.
 - Third Order Term can be very Troublesome



Third Method (Weaver)



Unwanted 2nd Mixer Image falls on top of itself – not out of band

Think “Negative Frequencies” in I/Q processing !

Things to Watch out for in 3rd Method converters

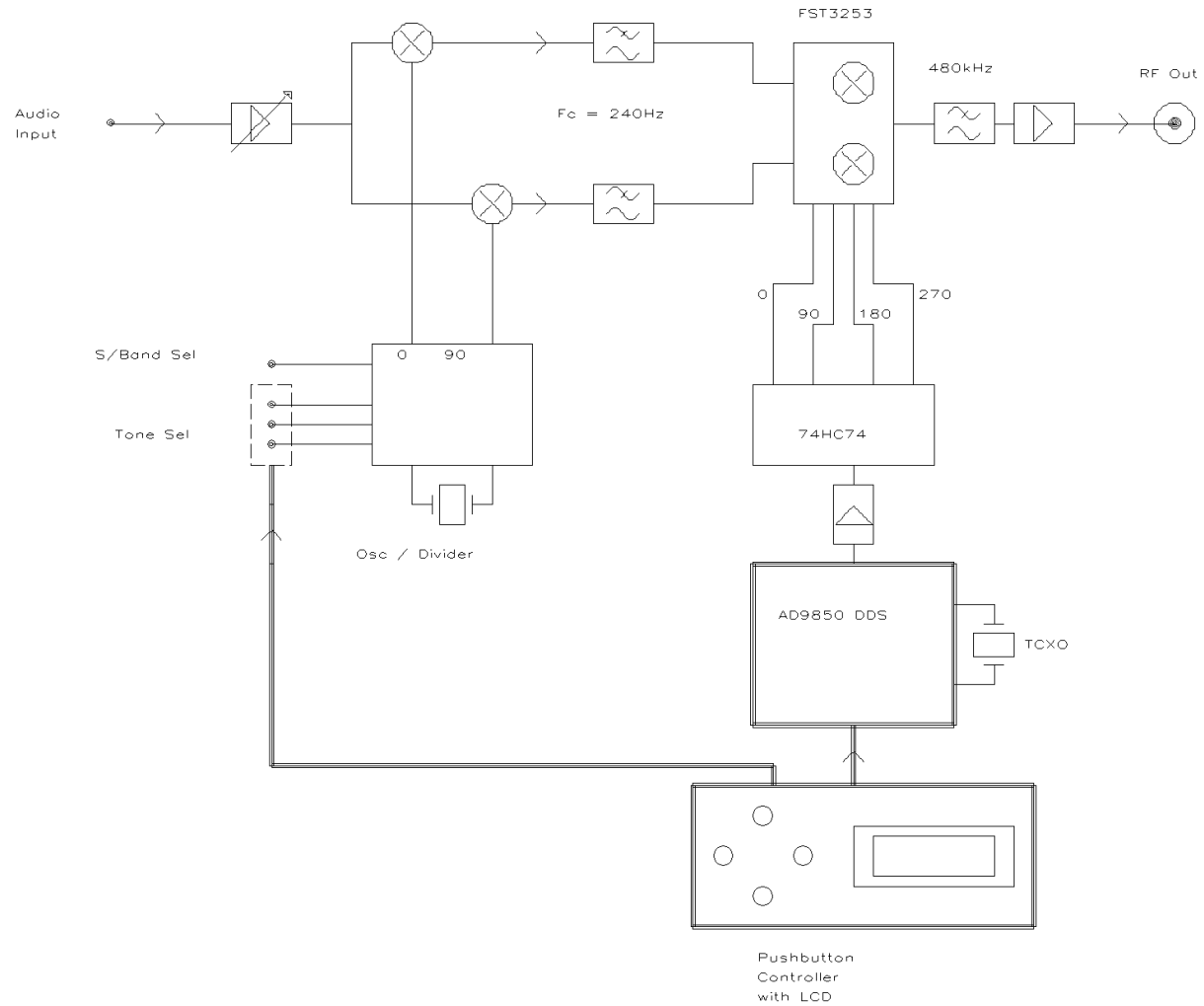
- First set of mixers have to work at AUDIO
- Baseband channel must work down to DC
 - Otherwise, there will be a hole in the middle of the final spectrum.
- Inverted image falls on top of itself
 - Poor cancellation of voice gives a high pitched wrong sideband superimposed.
 - But even a poor 20dB cancellation is quite adequate for data modes.
- Third Order Term can STILL be Irksome

So what is this Third Order Problem?

- I/Q signals input at 0 and 90 degrees
- Third harmonic is 0 / 270 degrees
- Which is the same as 0 / -90 degrees
 - Which is mixed with a square wave LO
- So the OPPOSITE sideband is now reinforced
 - Keep the mixers in linear region and this product should remain low enough.
 - But check !

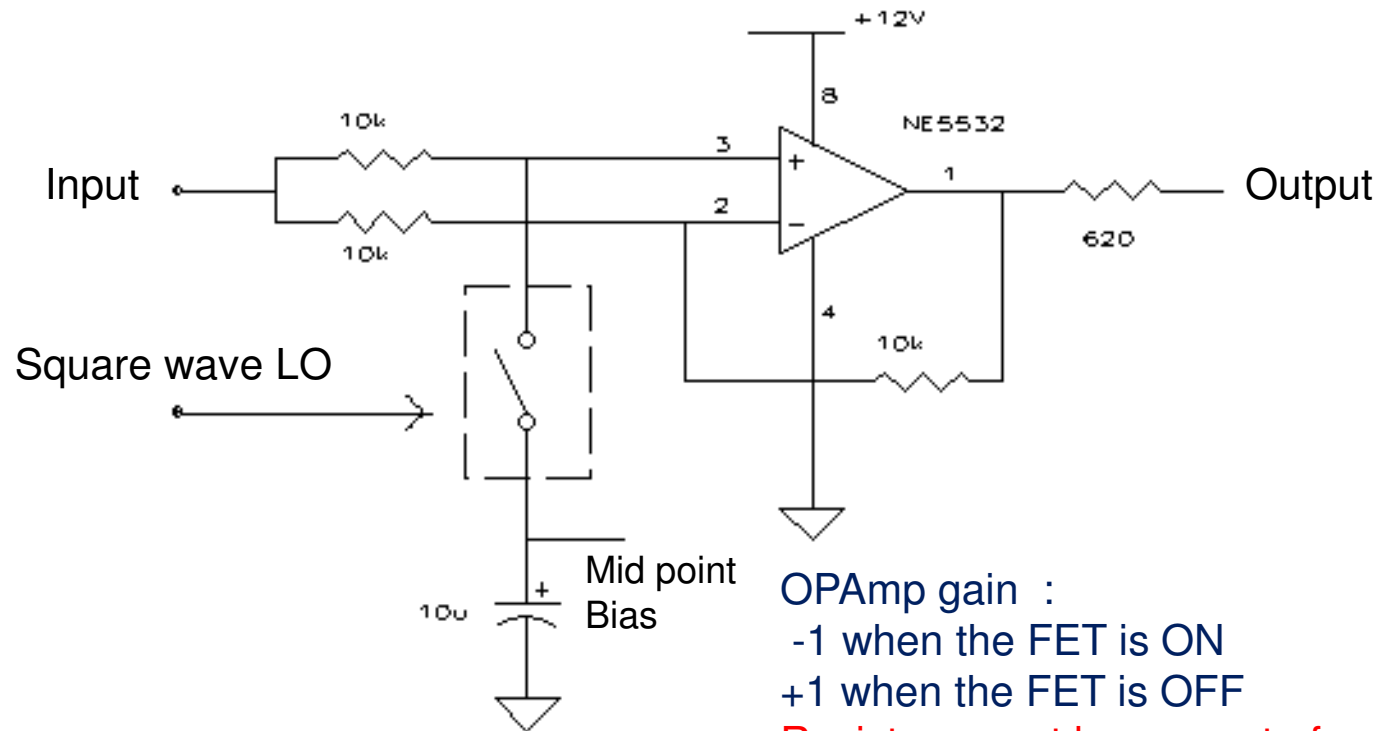
The Hardware

Block Diagram



Audio Mixer

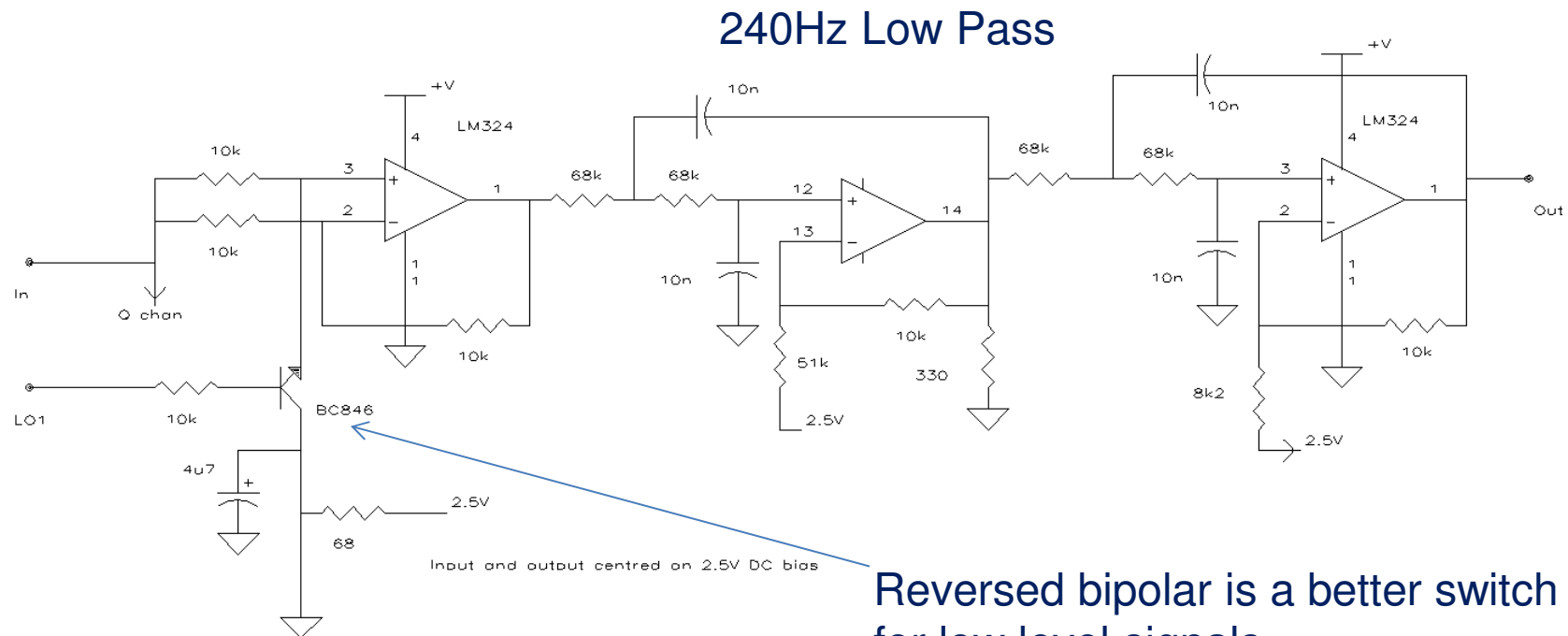
- Single balanced mixer using opamp and Switch



OPamp gain :
-1 when the FET is ON
+1 when the FET is OFF

Resistors must be accurate for -1

Baseband Mixer and Filter



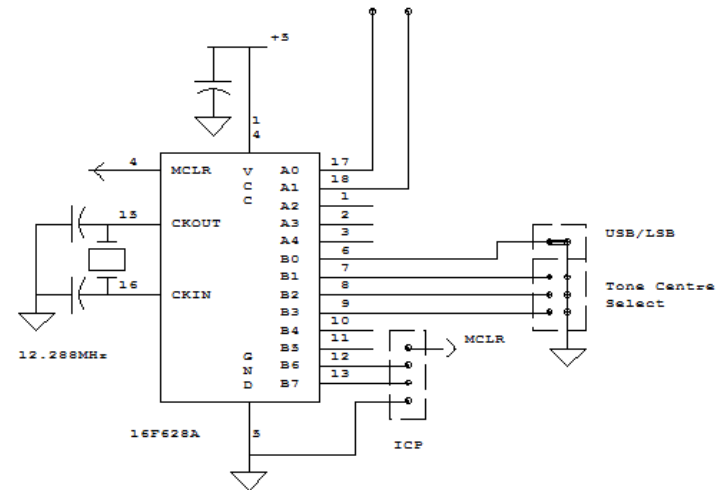
I/P and O/P all centred on 2.5V
Generated from low noise supply

Mix-Down Tone Frequencies

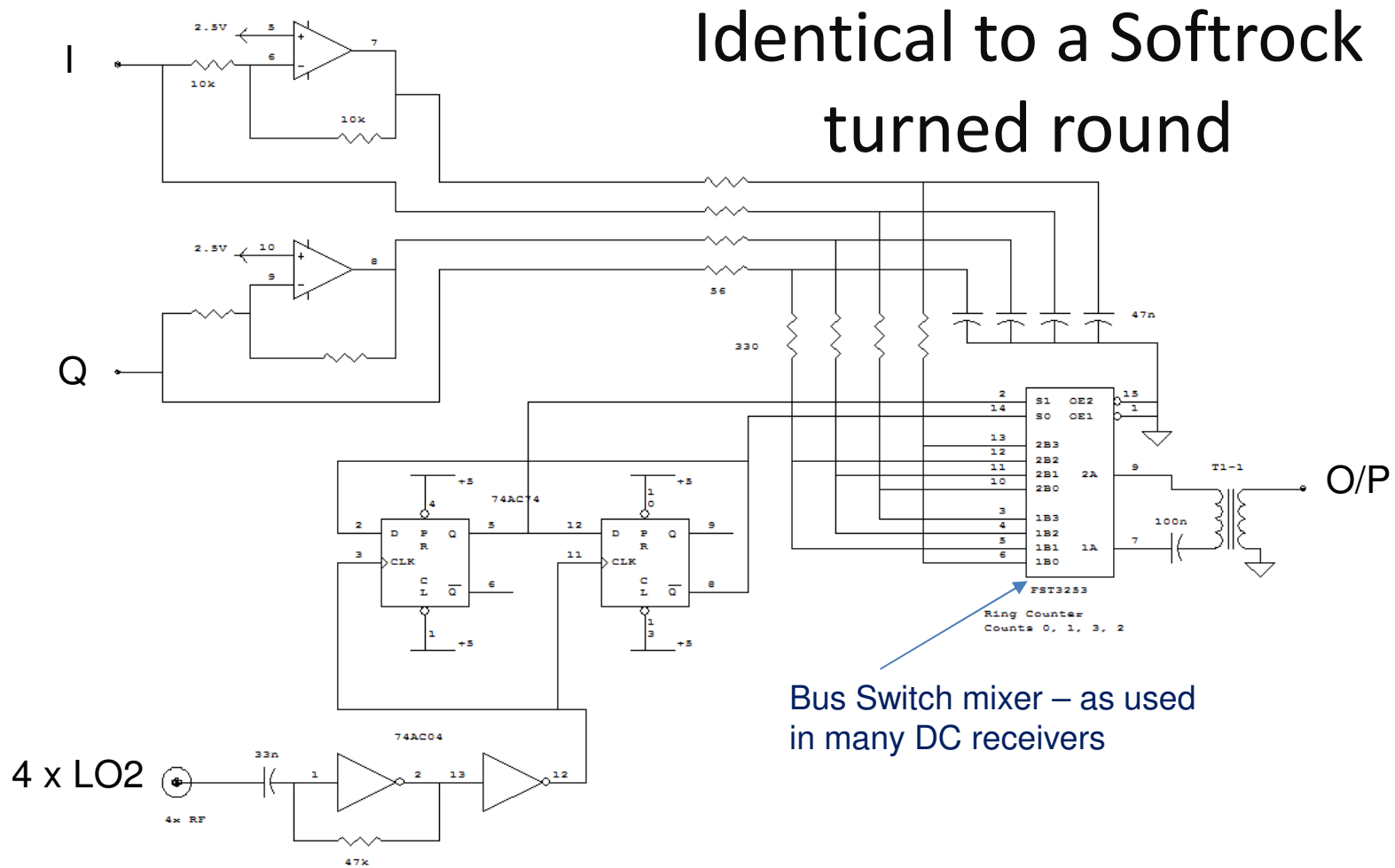
- Soundcard datamode software usually offers a choice of centre frequencies – *but not always*
 - So eight selectable choices
 - 600 750 800 1000 1200 1500 1600 2000Hz
- Three programming lines select tone. Allows user selection from the front panel.
- Link selects sideband polarity
 - Final setting up

First LO / Tone Generator

- Need to generate a Quadrature square wave for audio mixer
- PIC 16F628 chip does everything
- Centre frequency commanded via 3-wire bus
- I and Q outputs
- Select sideband (final setup) link – saves resoldering!
- Integral crystal oscillator 12.288MHz

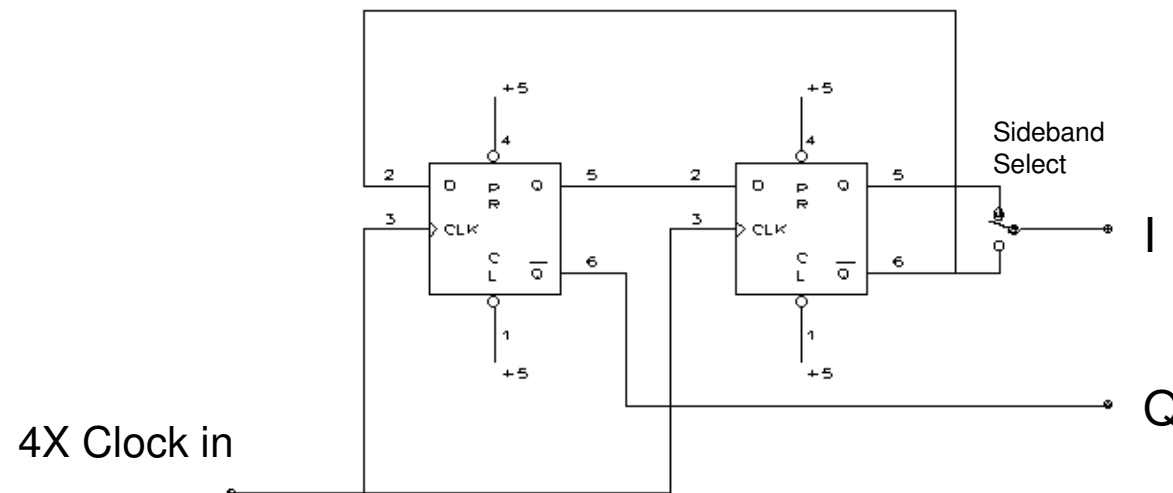


RF Upconverter



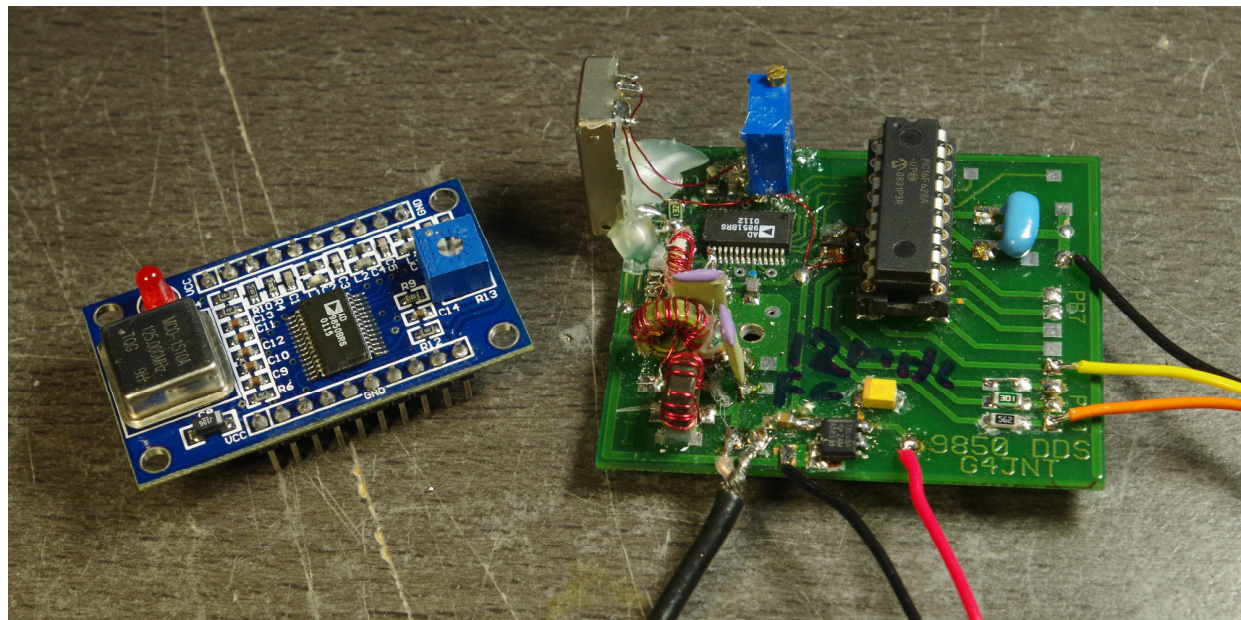
Local Oscillator (LO2)

- Generate 4X and use ring counter



DDS RF Source

- AD9850 tuned with LCD and up/down / set buttons.
- TCXO Reference



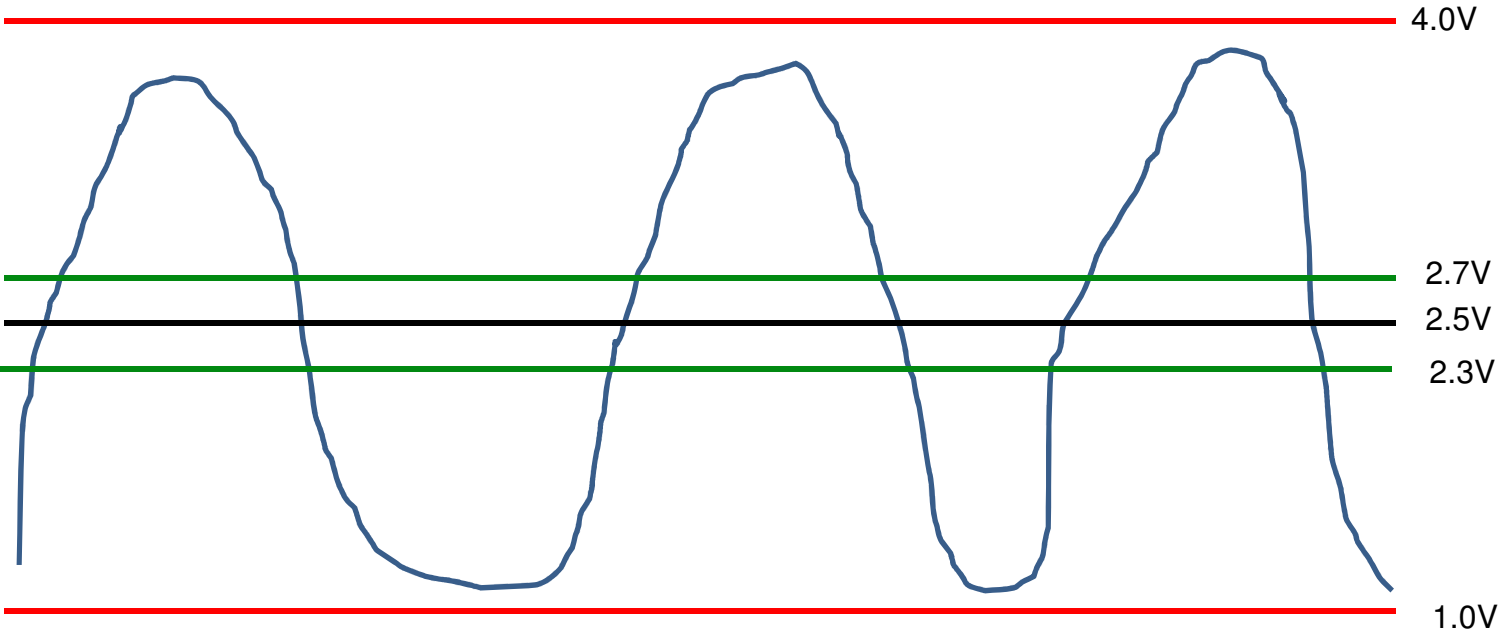
Master Controller

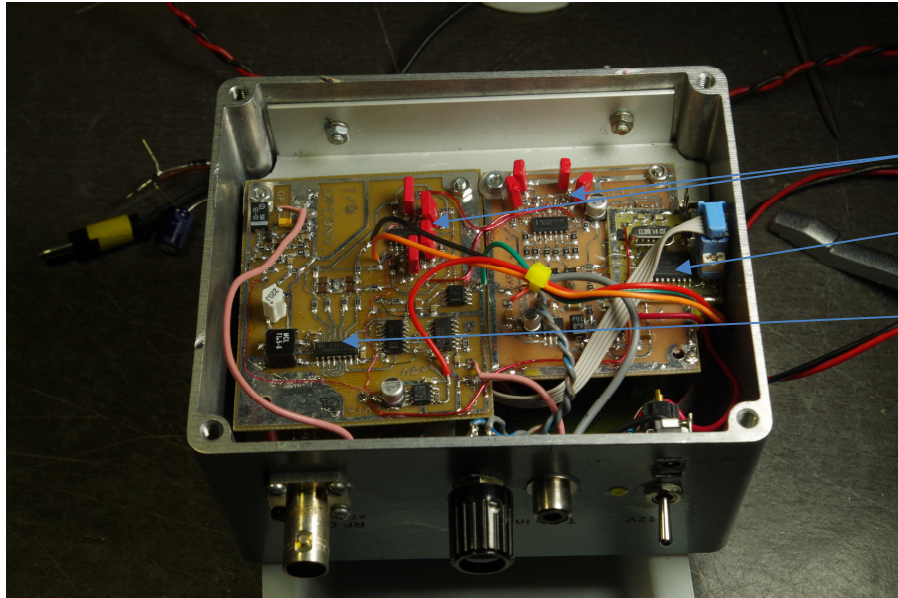
- Set DDS Frequency and 1st conversion tone
- Pushbuttons on front panel give 1Hz steps
- Liquid Crystal Display of frequency
- 16 Memories, individually programmed

Level / Drive Monitor

- Linearity is paramount: drive to the 2nd mixer must not exceed linear / clip levels - opamps
 - Around 3V pk-pk, centred on 2.5V bias
- 12F675 PIC with A/D converters monitors the baseband drive on I and Q channels
 - If voltage falls below 1V or above 4V flash red LED for overload
 - If voltage is above 2.7 or below 2.3, flash green LED for OK - ie. above minimum

Level Detector Thresholds





240Hz LP I/Q filters

Tone Generator

Second Mixer



Questions ?



■ **Find out more...**

www.g4jnt.com

www.rsgb.org

