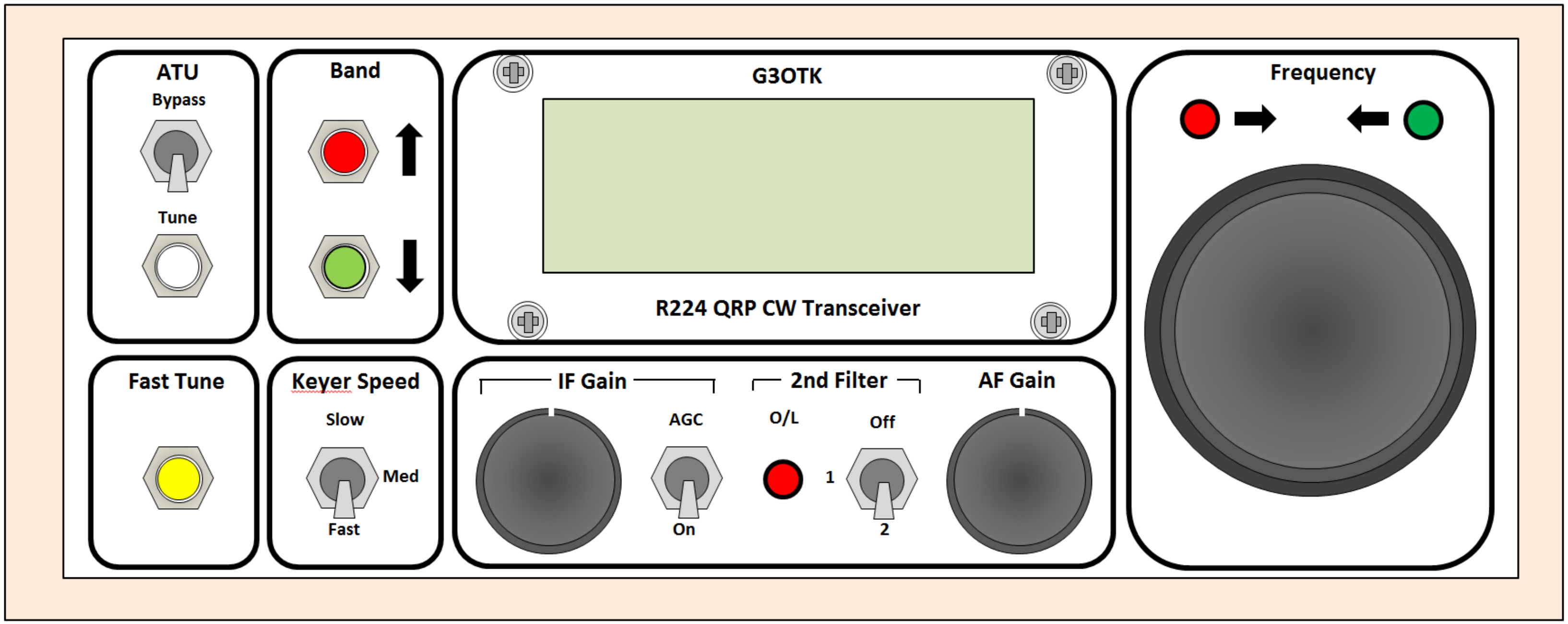
A 3 Band QRP CW Transceiver



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Tonight's Presentation

A look at what may be some of the more unusual features, at least for a home-brew CW transceiver, and the reasons for incorporating them.

I will describe my approach to minimising transmitted bandwidth and maintaining CW wave-shape in the receiver

Headline Features

- 80m, 40m, and 20m CW Transceiver
- 3W RF output
- Auto-ATU
- Electronic keyer
- Integrates with logging program such as N1MM+ or SD

Features - Receive

- DDS VFO
- 6 crystal linear-phase IF filter
- 3 crystal linear-phase post-IF filter
- RX input filter – 3 pole LC BPF
- 2 x 16 OLED display of frequency & S-meter

Features - Transmit

- Efficient Class-E PA 3W output
- Output RF waveform rise and fall shaped to minimise transmitted bandwidth
- TX output filtered by same BPF filter as RX input
- Semi-automatic break-in CW operation with sent CW delayed by 0.4 sec

Controlled by 7 PICAXE µPs

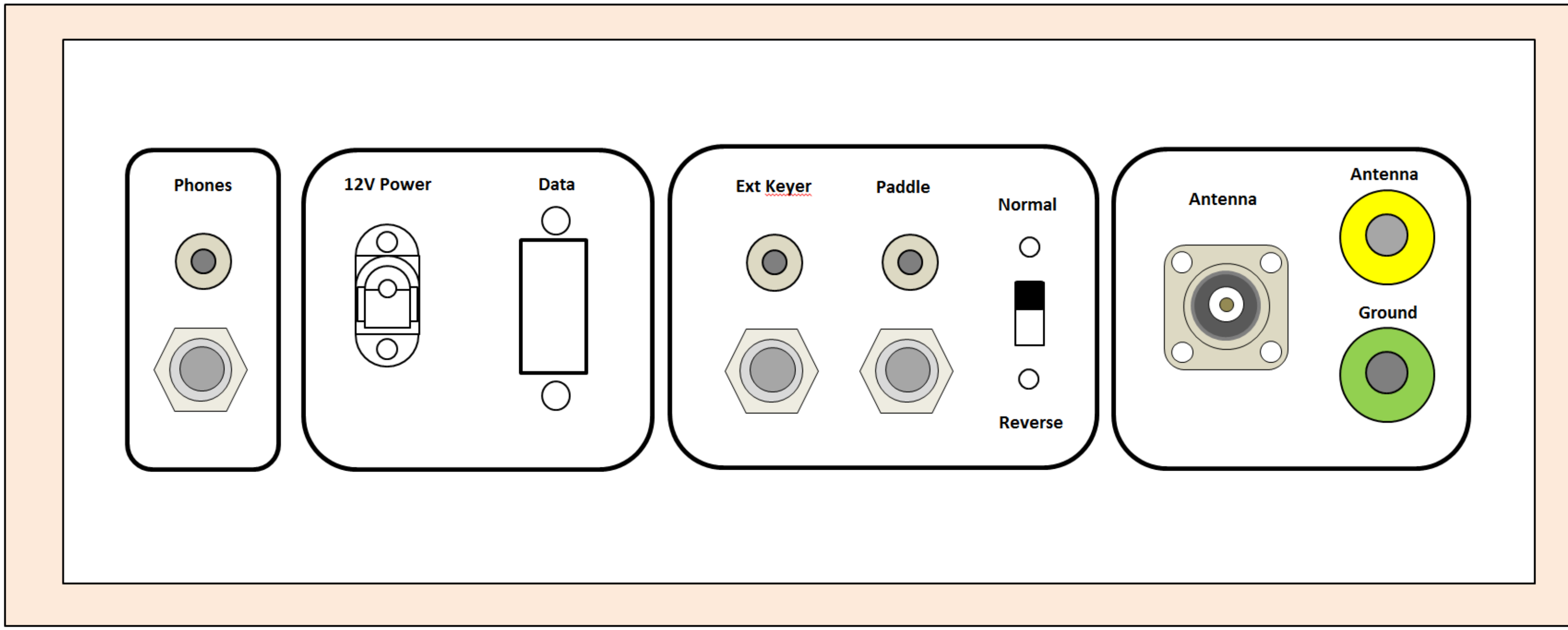
- A PICAXE is a PIC with an integral "PICAXE basic" interpreter – easy to program
- Interpreted programs run slower than compiled programs (e.g. Arduino)
- 8 and 16 bit integer arithmetic only

Distributed Processing

- DDS Controller
- OLED Display Controller
- OLED Display Decoder (ASCII to characters)
- Electronic Keyer
- CW Delay, TX/RX & PA driver control
- Auto-ATU Controller
- Interface to PC running logging program

Connectivity

Both 3.5mm and ¼ inch (6.35mm) jack sockets are fitted



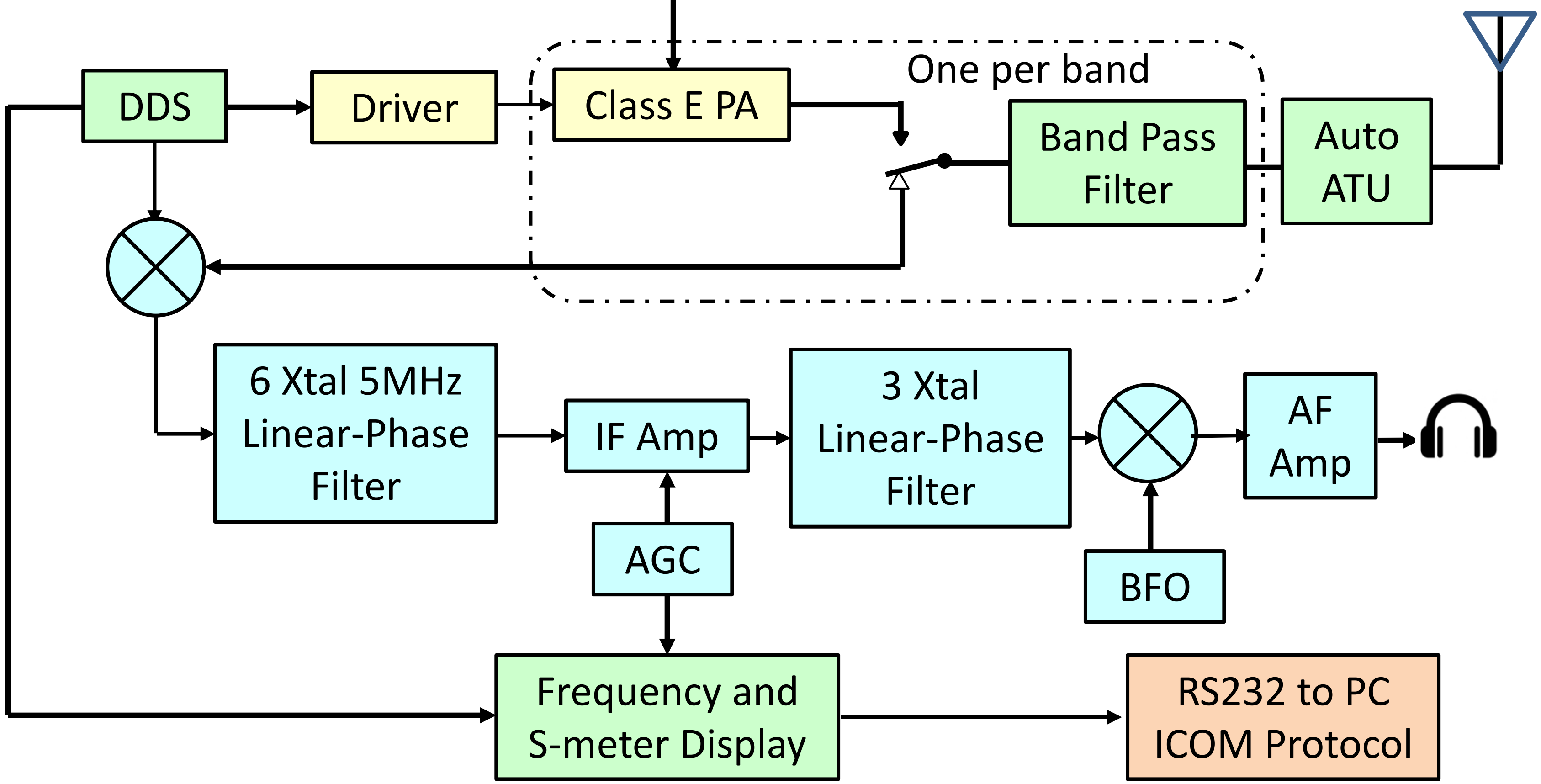
Headphones

Power & serial data

Morse key & paddle

Antenna

Block Diagram



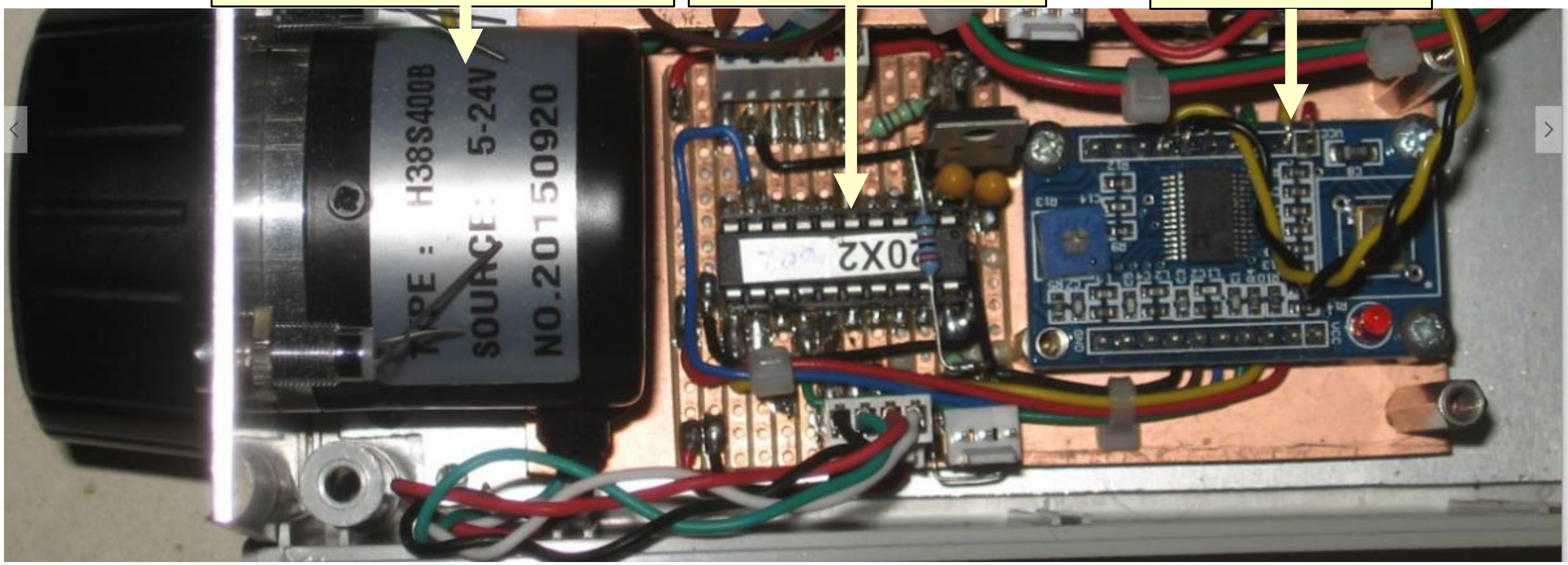
DDS VFO

Direct Digital Synthesiser

400 steps/rev
Optical incremental
Encoder (from China)

DDS Controller
PICAXE 20X2

DDS PCB
AD9851
(from China)



10.7288 Hz/steps, tuning by 400 steps/rev optical incremental encoder
Normal tune rate 4.3kHz/rev
Fast tune 39kHz/rev
DDS update rate 1,000/sec

Transmitter Section
Controlling the Bandwidth

TX Bandwidth - Licence Requirements

- Note (a) of the UK Licence states that:

The bandwidths of emissions should be such as to ensure the most efficient utilisation of the spectrum. In general this requires that bandwidths be kept at the lowest values which technology and the nature of the service permit.

- Excessive bandwidth CW transmissions are heard as “key-clicks” on adjacent frequencies

Bandwidth and CW Readability

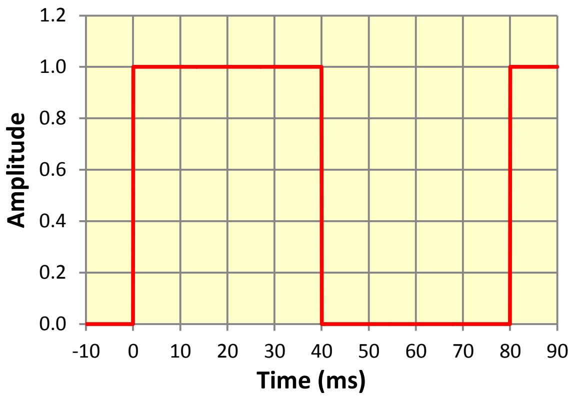
- Bandwidth of transmitted signal
  - The faster the rise and fall times of dots/dashes the wider the bandwidth
  - Sudden changes in the slope of the rise and fall times broadens the transmitted signal
- CW Readability - ARRL Recommendation
  - Non-fading circuit: 30 wpm, rise & fall times 10ms
  - Fading circuit: 30 wpm, rise & fall times 5ms

(For detailed analysis see “Key-clicks and CW Waveform Shaping” on IVARC web site)

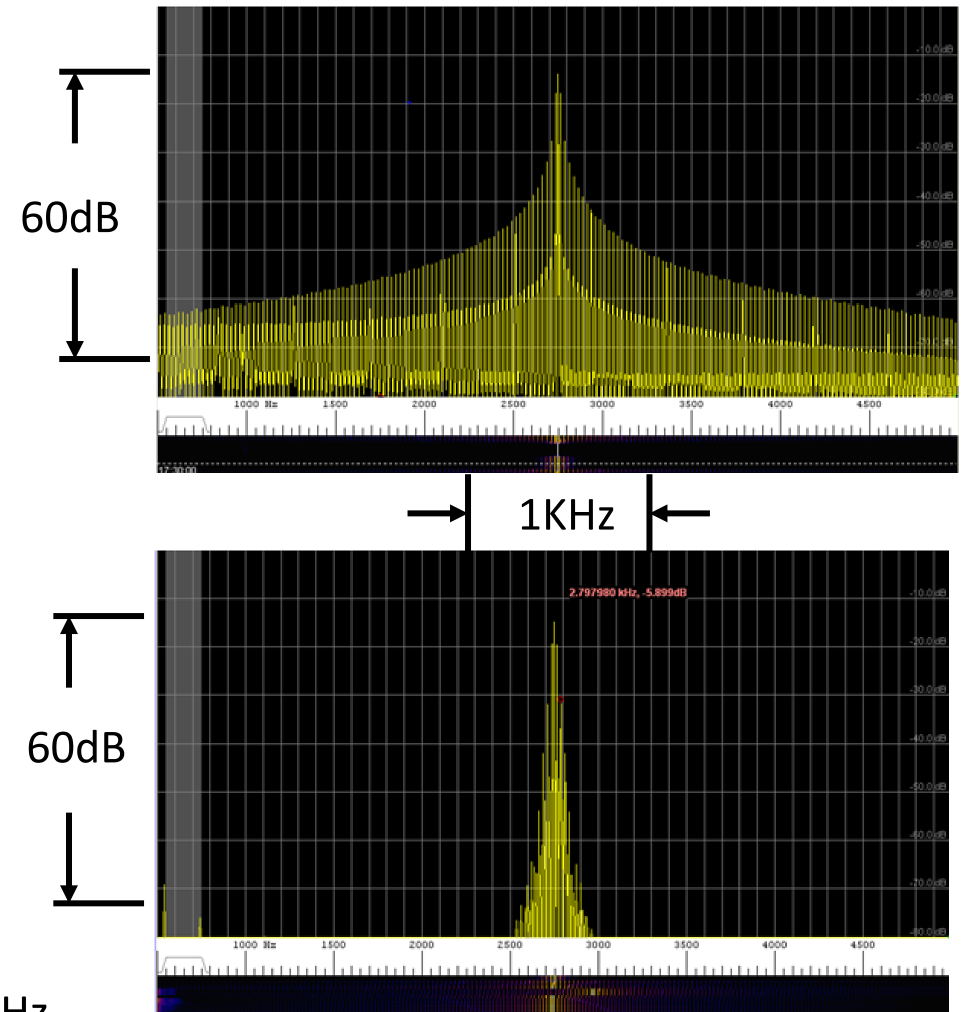
CW Signal Bandwidth

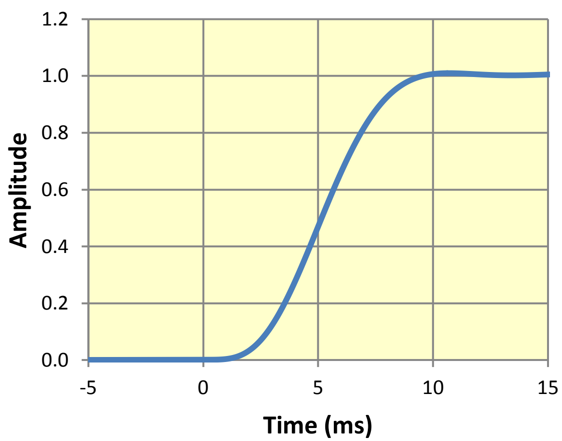
- How can we define “bandwidth” of a CW signal? My thoughts:
- Consider:
  - Wanted station A is strength S4 (easily readable)
  - Nearby station B is strength S9 + 30dB
  - B is 60dB stronger than A (6dB/S-point)
  - If B is not to interfere unduly with A then sidebands must be about -60dBc in A’s receiver.
  - So I use -60dBc to define bandwidth of a CW TX

Shaping of Transmitted CW



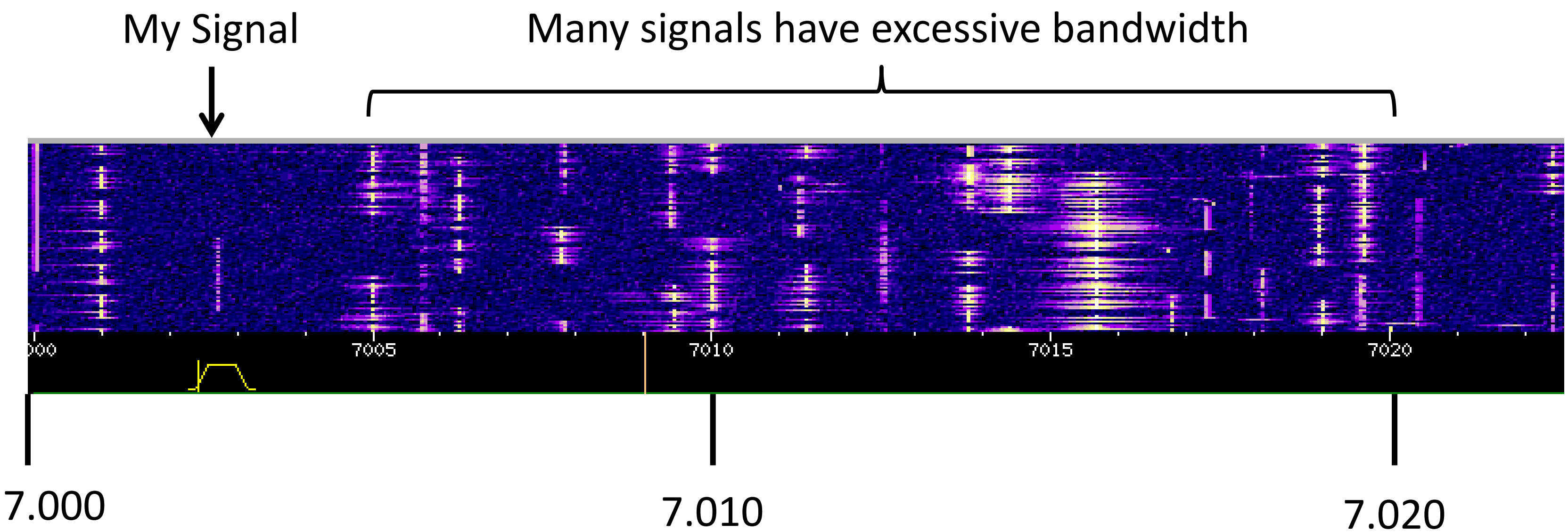
On-off keying, no shaping





4 Pole Gaussian to 6dB LPF Fc = 70Hz

40m during a CW contest

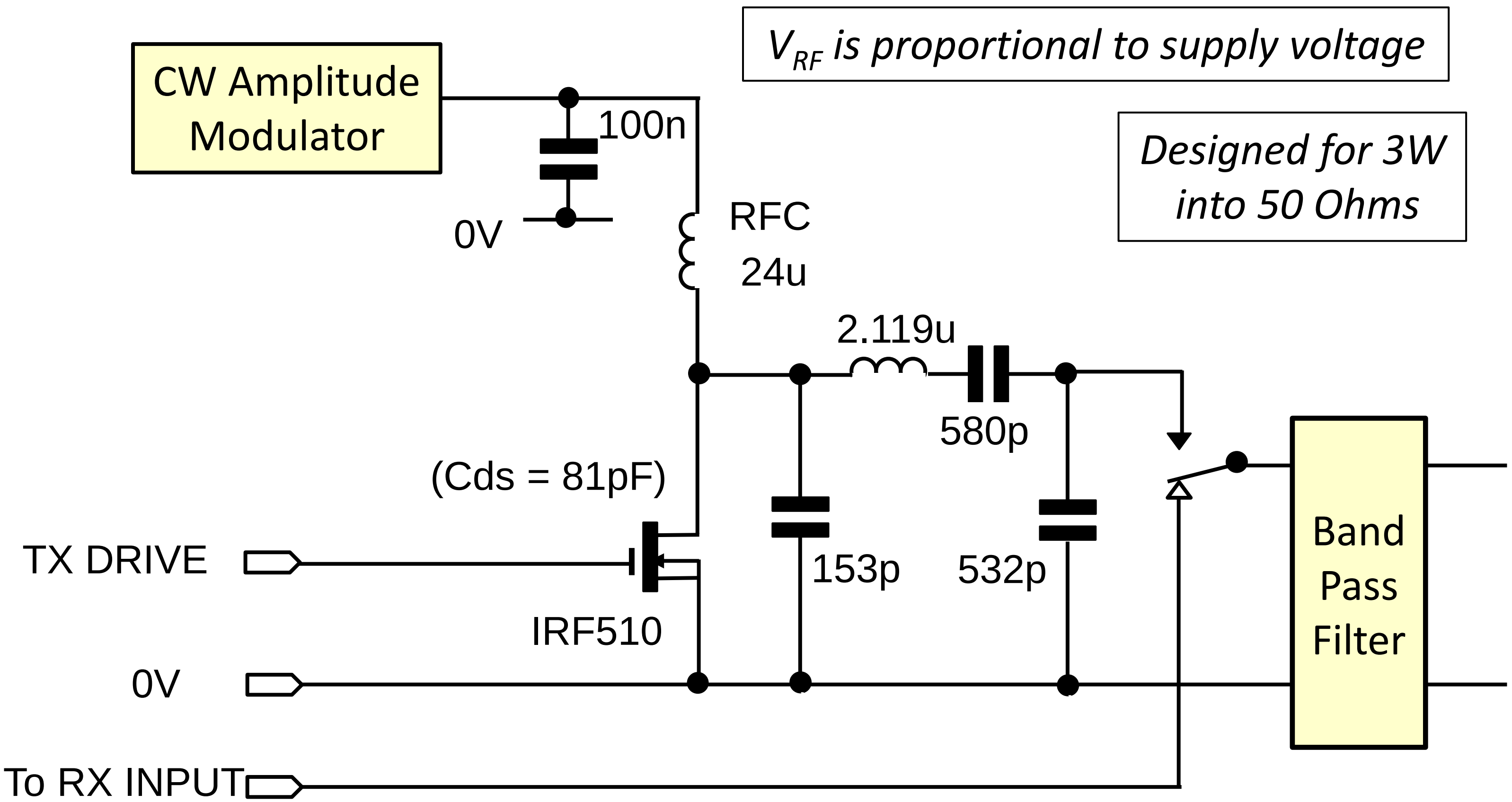


University of Twente SDR (12 Nov 16)

Class-E PA (40m Version)

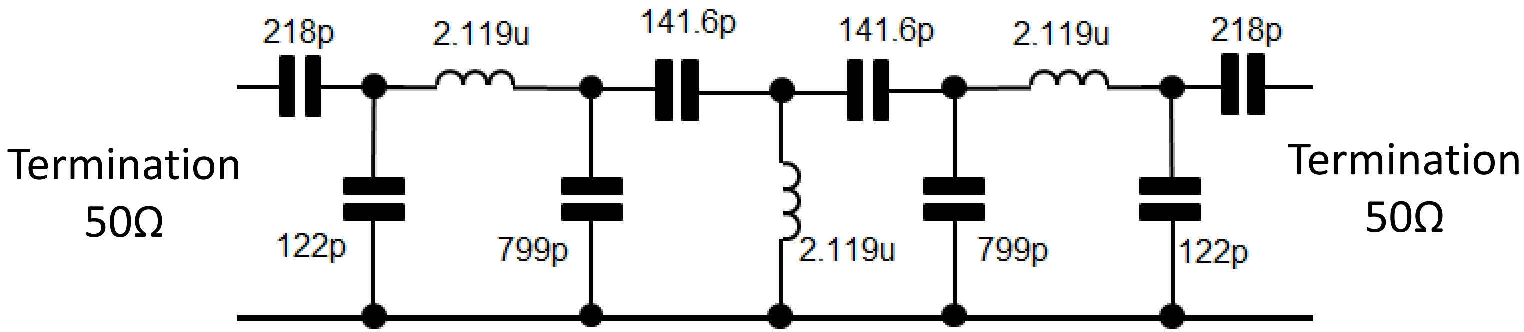
(Nathan Sokal WA1HQC – Class-E Power Amplifiers – QEX Jan/Feb 2001)

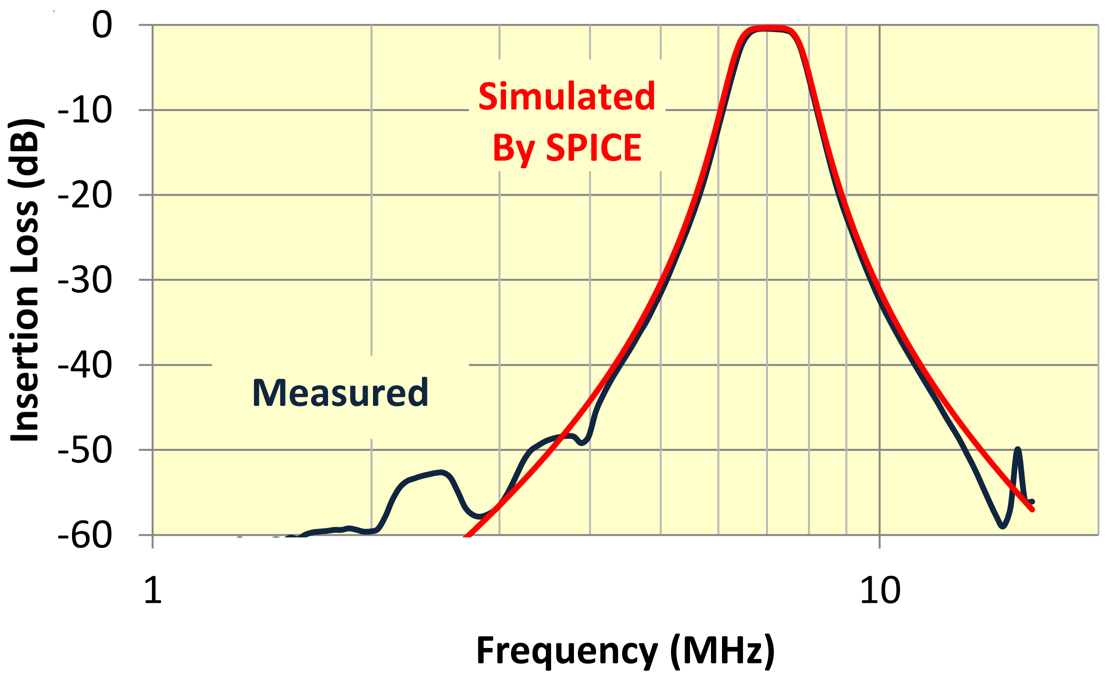
Design Software at http://www.tonnesoftware.com/)



40m TX/RX Band Pass Filter

(Fc = 7.05MHz Butterworth Fbw = 1.5MHz L = 2.119 µH Rt = 50 Ω)

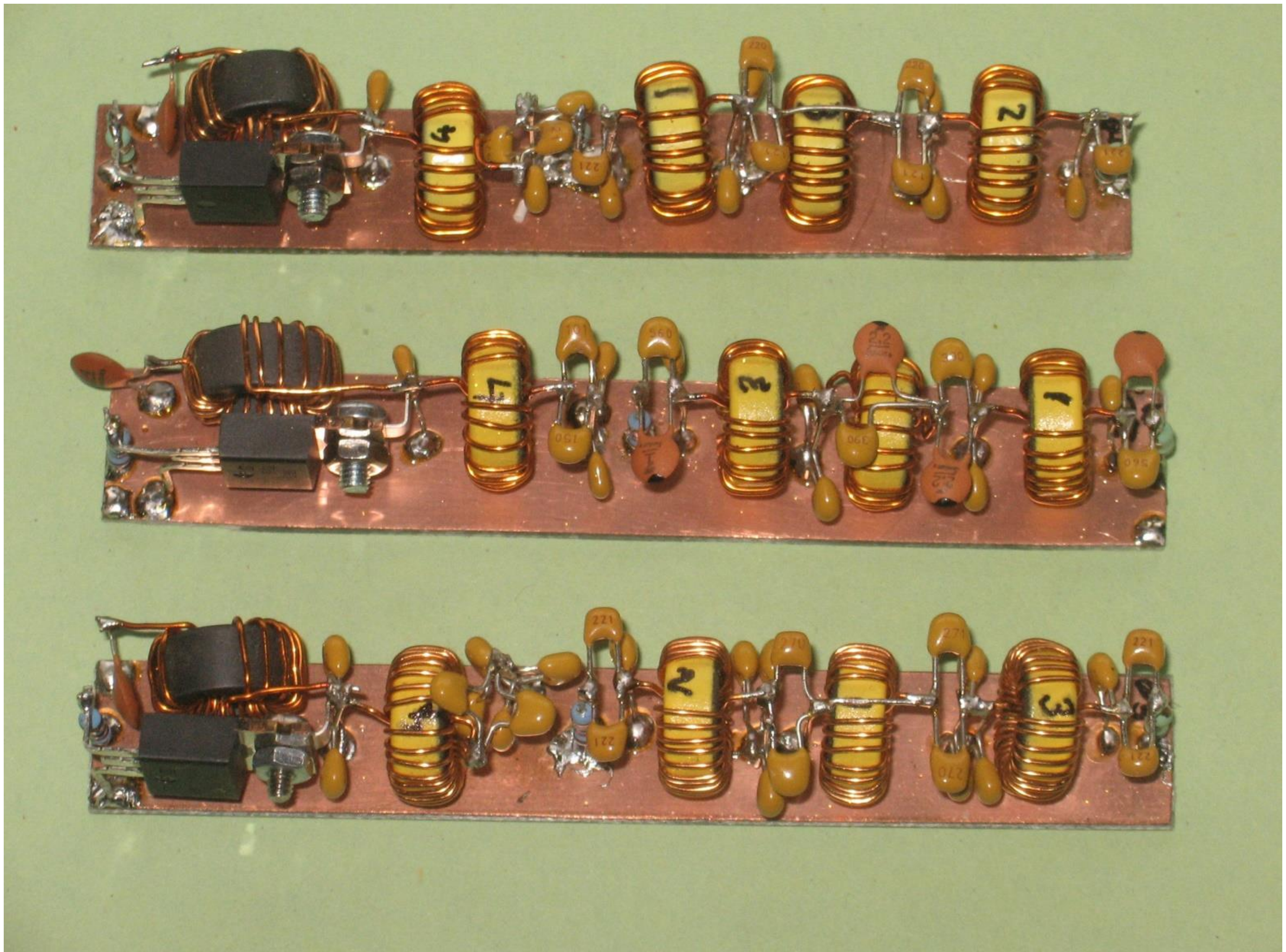




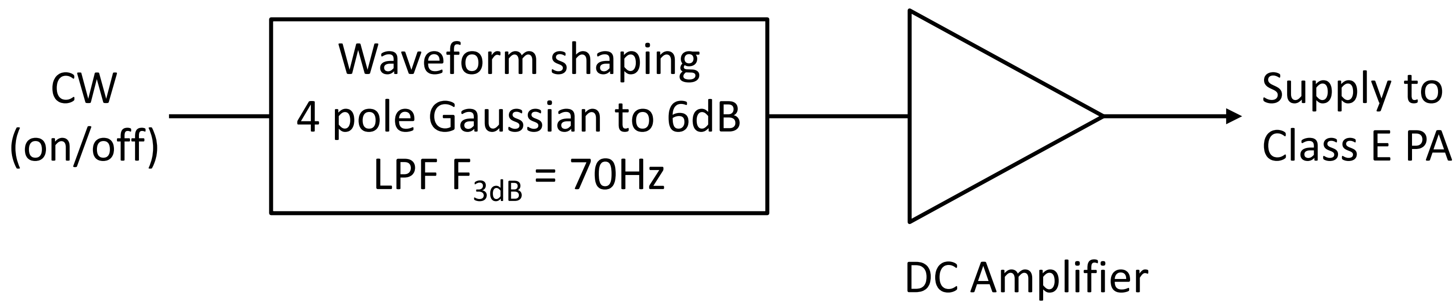
Qu = 235

I.L. = 0.35dB

80m, 40, & 20m 3W TX Strips

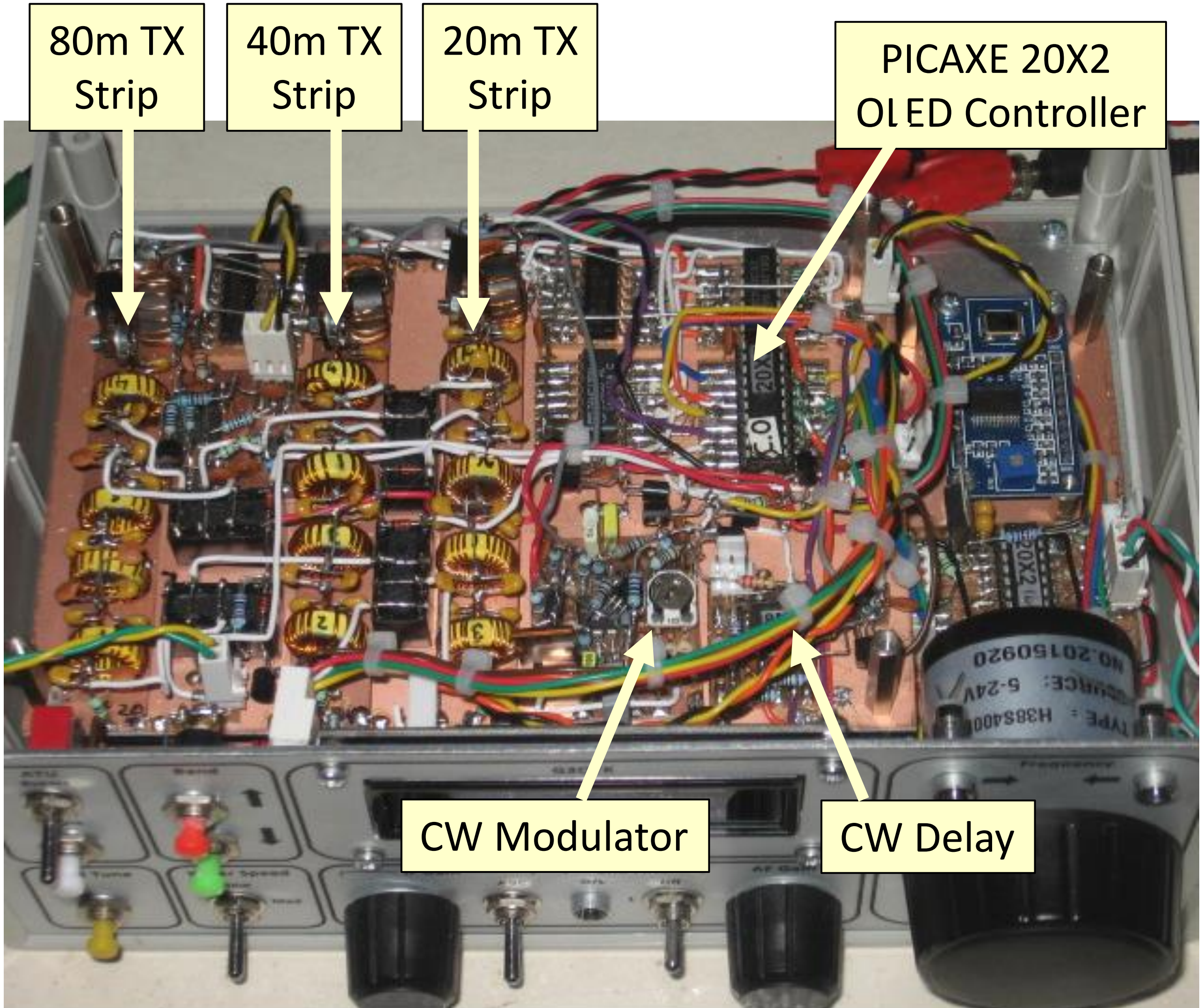


CW Modulator



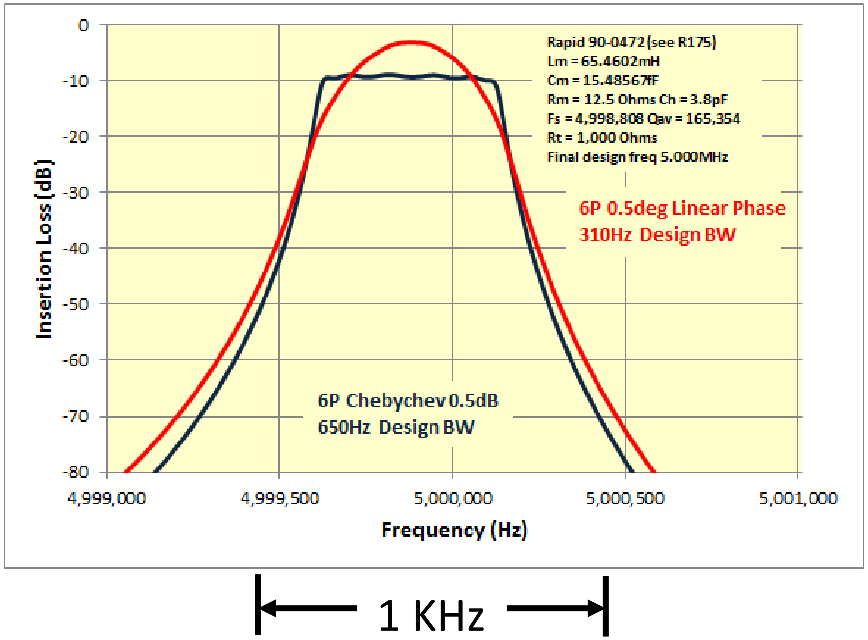
CW RF shaped rise and fall times

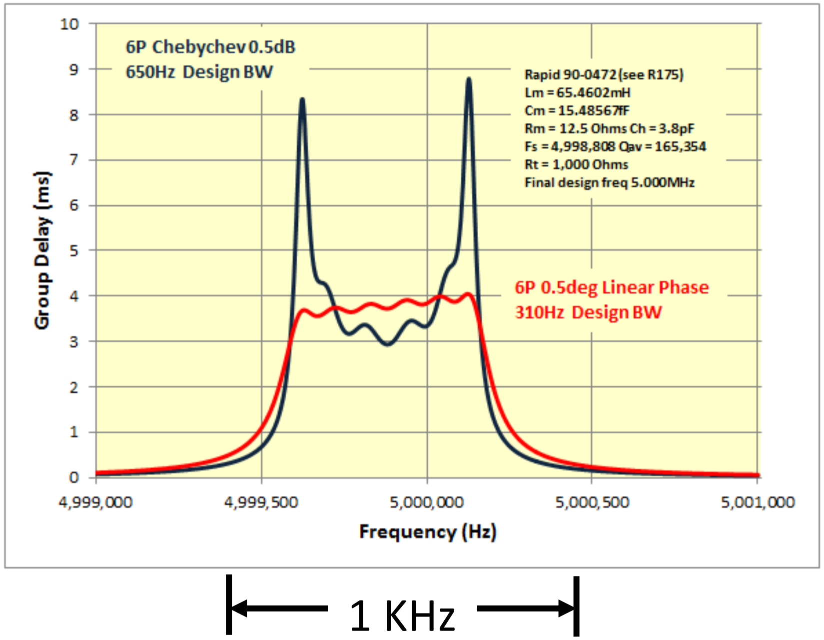
Transmit Board



Receiver Section
CW Waveform Preservation

IF Filter Amplitude & Group Delay Response





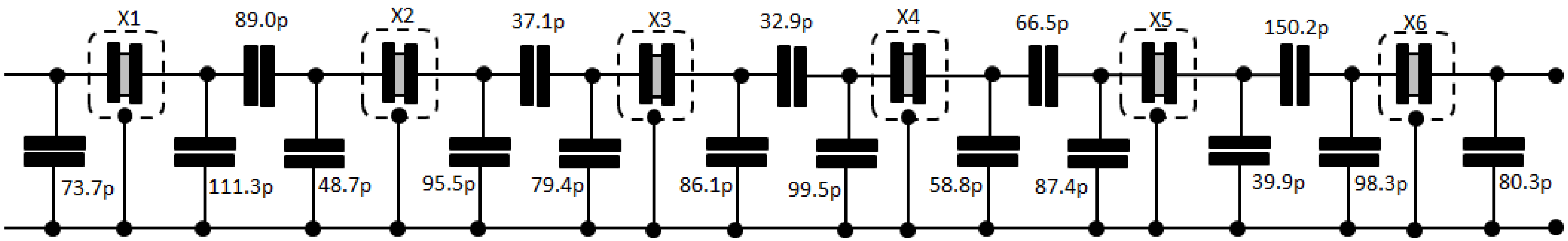
SPICE simulation using same crystals

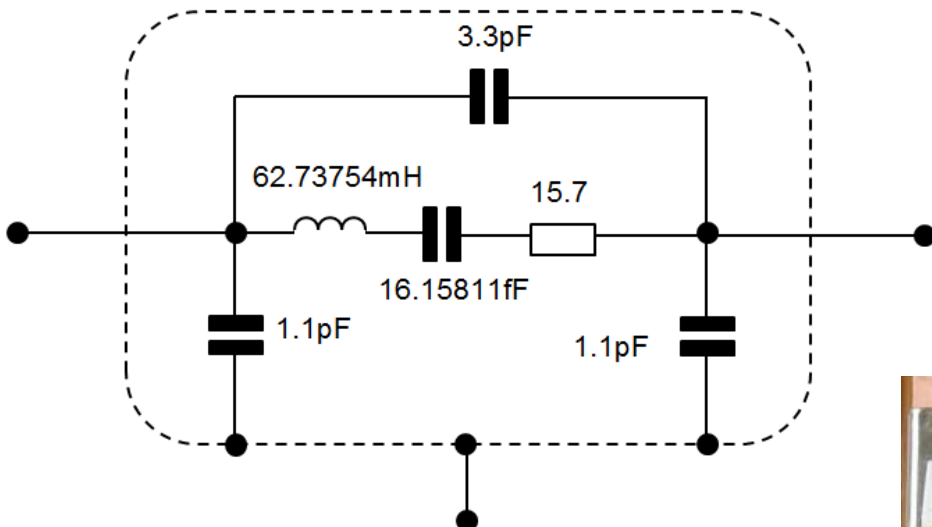
Blue - 6 crystal pre-distorted Chebychev 0.5dB ripple 650Hz design bandwidth

Red - 6 crystal pre-distorted 0.5 deg ripple linear phase 310Hz design bandwidth

6 Xtal Linear Phase Pre-distorted IF Filter

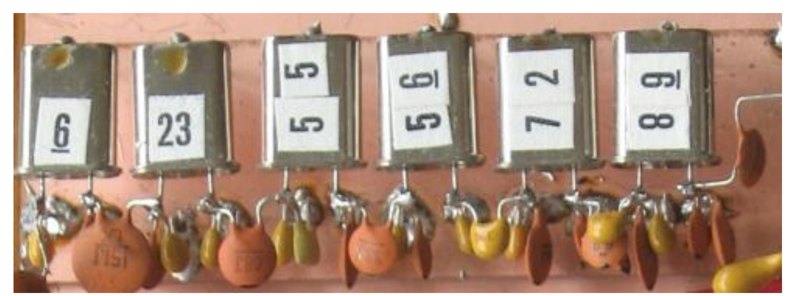
Filter Termination 1,000 Ohms



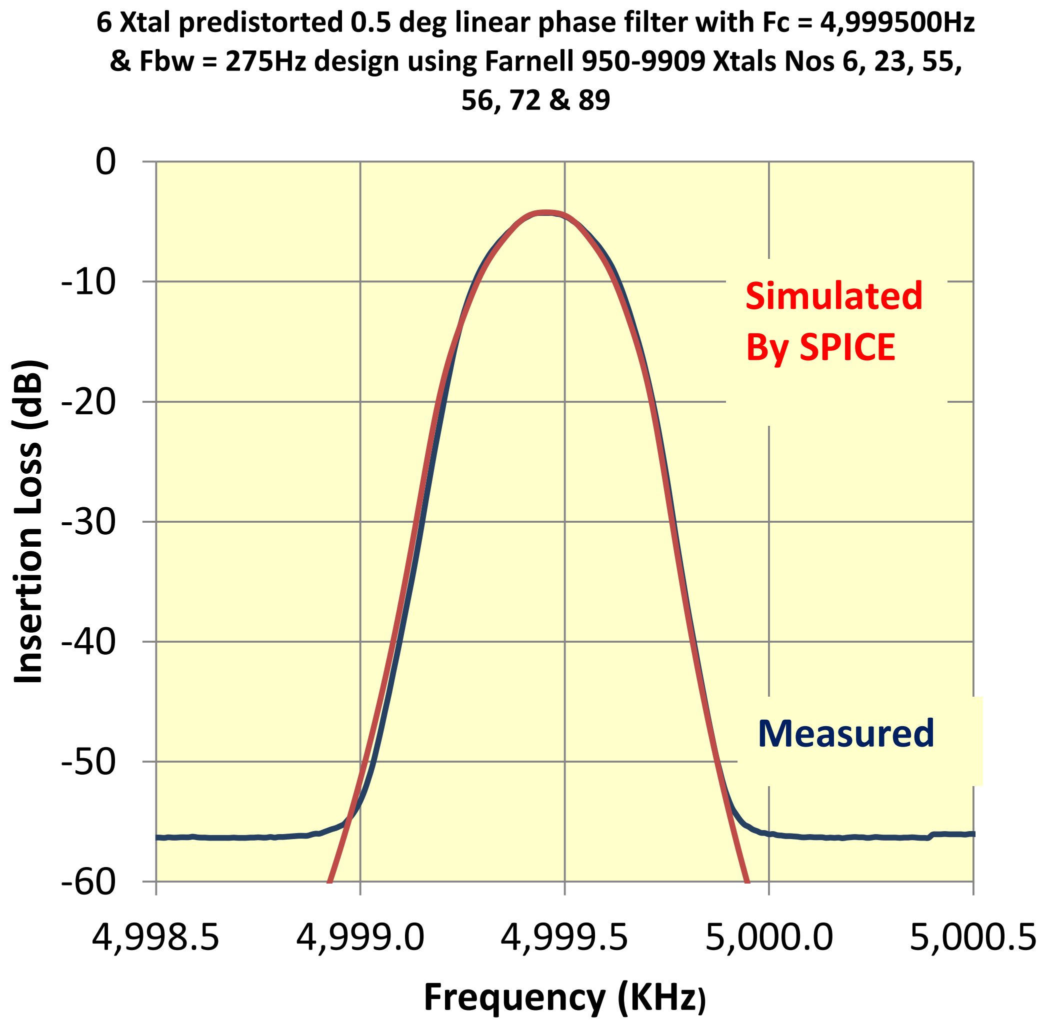


Measured using the method that I described in QEX Nov/Dec 13

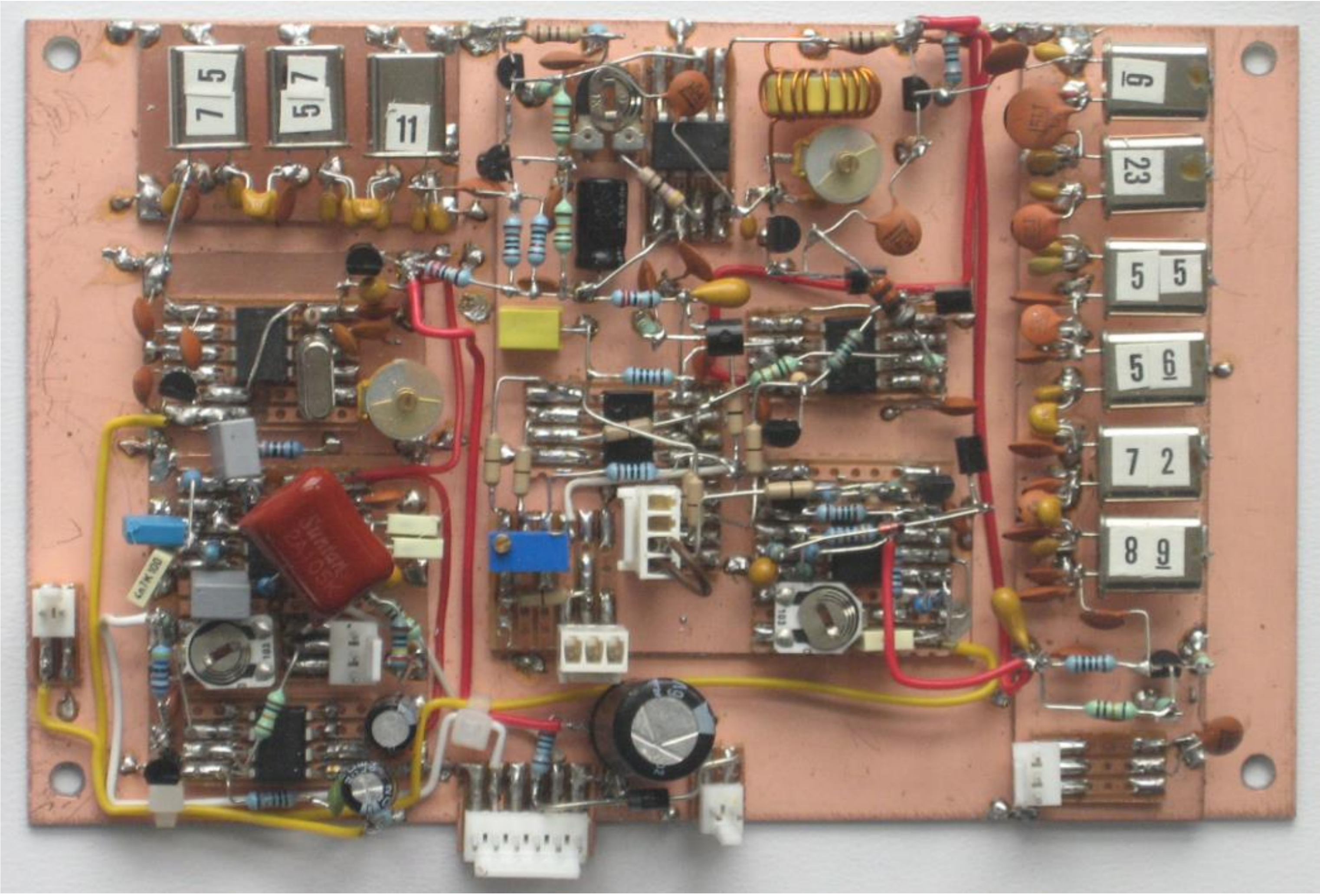
Average of six Farnell 950-9909 5 MHz Xtals used to construct the filter



6 Crystal Linear Phase IF Filter as Built



IF/AF Board



TX/RX Changeover

TX/RX Changeover

- Semi-automatic break-in used (similar to VOX)
  - Goes to transmit as soon as Morse is key pressed
  - Stays on transmit while keying (keying resets a timer)
  - 0.4 sec after last dot/dash it then switches to receive

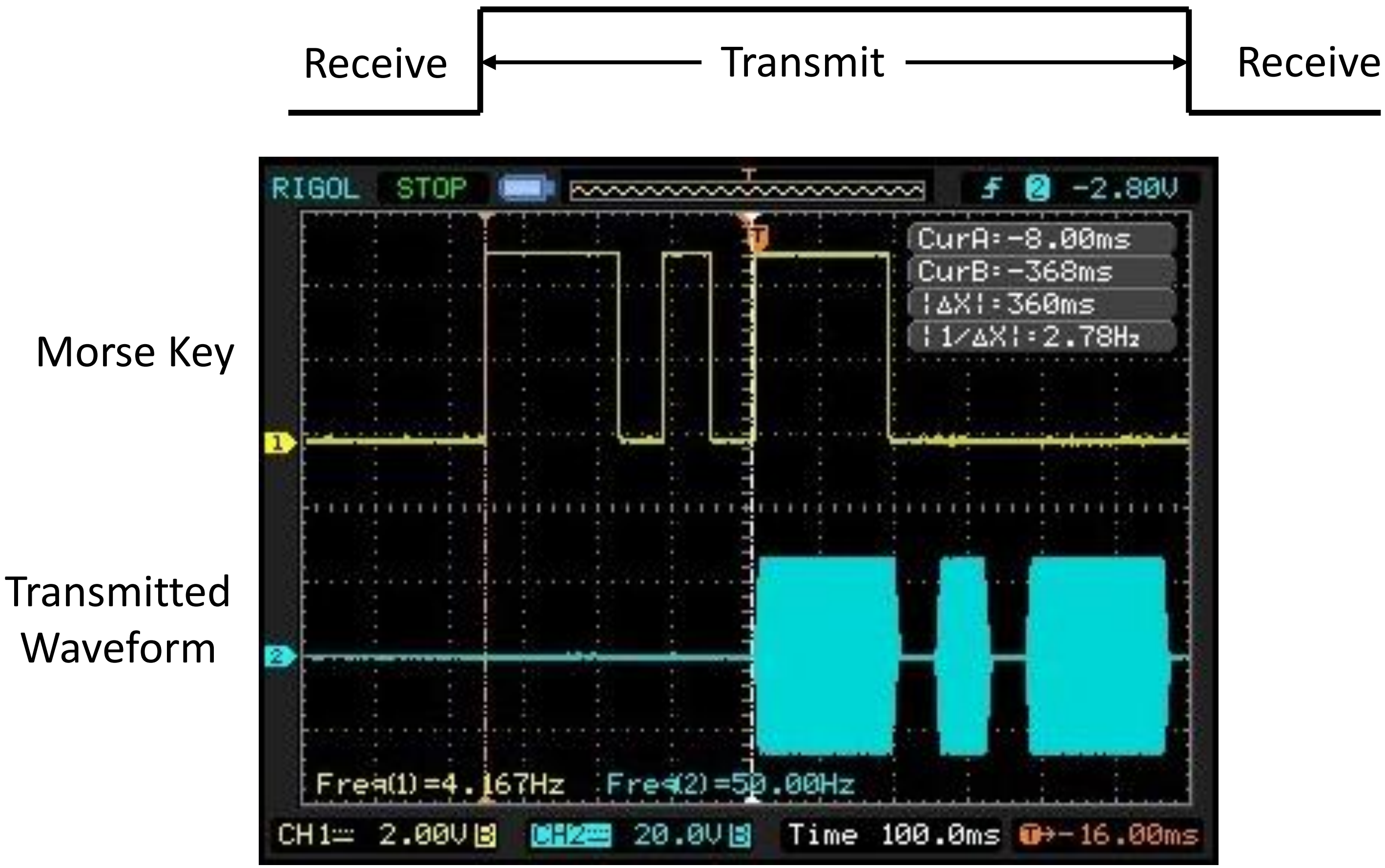
BUT

- The other station may start sending before the receiver is active, so can miss part of call sign
  - In 80m Club Contest I read DQ6Q as IQ6Q
  - I missed the first dash because still on transmit

My Solution

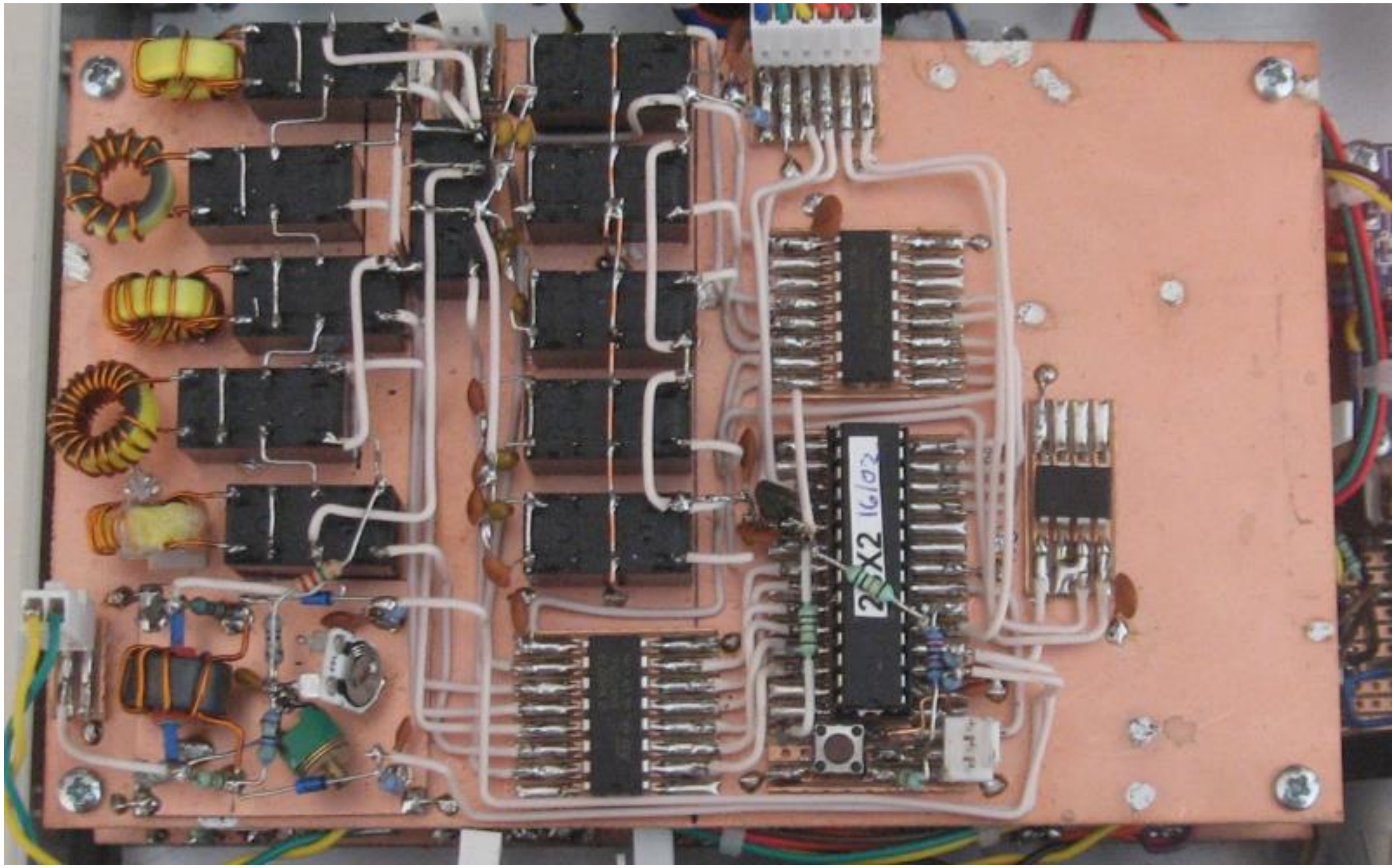
- Delay transmitted CW by 0.4 sec
- Goes to receive just after last dot/dash is sent
- Delay now at start of sending so helping other stations using semi-automatic break-in
- PICAXE µP programmed to look after the delay, TX/RX control and PA driver control.

CW Transmit Delay



Auto ATU

Auto ATU



Some Results with 3W RF Power

- Breadboard versions
  - Jul 16 – Low Power Contest – 2nd out of 6 entries in 3W Fixed category using 80 & 40m dipoles at 3m
- With completed transceiver:
  - 8 Jan – AFS Contest – 106 stations in 4 hours on 40m and 80m using dipoles at 3m height (9th out of 14 entries)
  - 19 Feb – Completed transceiver with 8m of wire indoors – worked US stations on 20m in contest
  - 23 Feb – 80m CW Club Contest - 61 contacts – best DX SM and OK with dipole at 3m

End