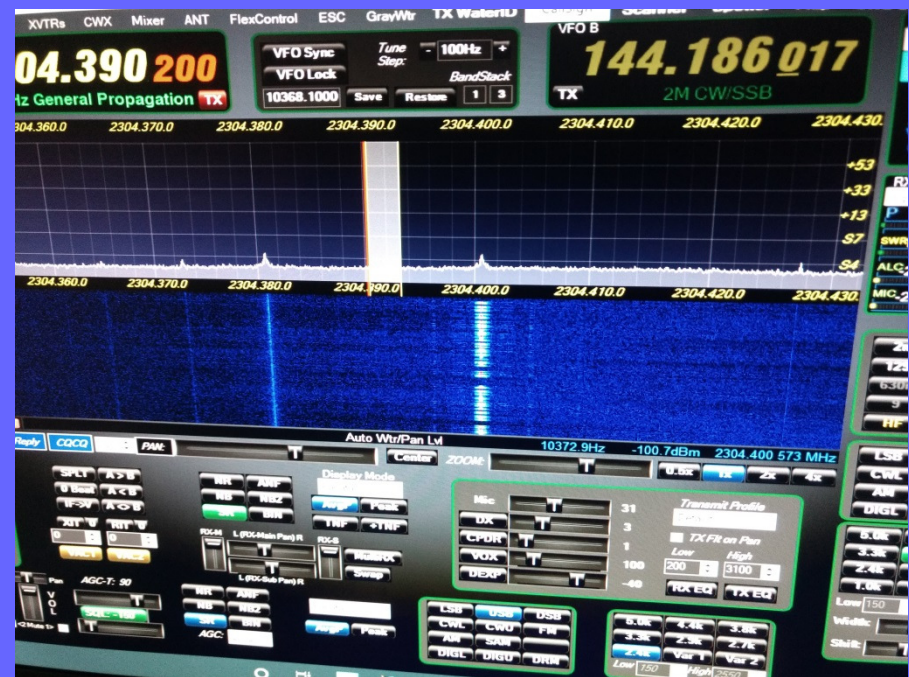
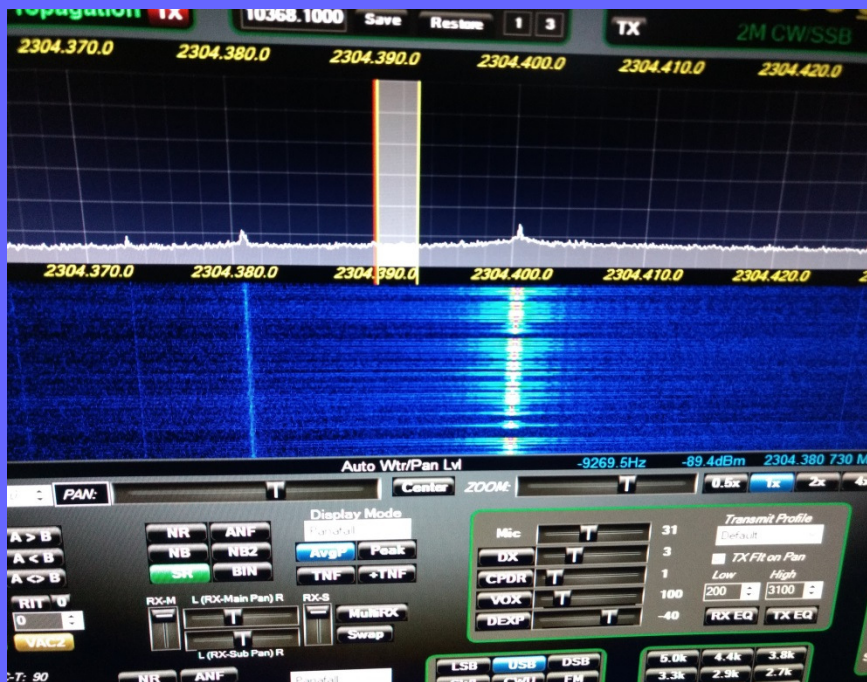


Reducing Key Clicks on Beacons with Envelope Shaping



Rene Barbeau
VE2UG. 2020

Living close to a beacon...

- ◆ Key clicks, elevated noise.
- ◆ Beacons are often homebrew repurposed FM crystal gears.
- ◆ Simple keying, fast rise/fall time add bandwidth, many KHz away.
- ◆ OK if beacon is weak. Over S9? :-/
- ◆ Disabling noise blanker help but not a solution.
- ◆ Had to close 2M beacon at VE2FUT.

Example – Beacon with Keyclicks

The screenshot displays the FlexRadio Systems PowerSDR v2.6.4 interface. The main window title is "FlexRadio Systems™ PowerSDR™ v2.6.4 FLEX-1500: 2910-0543". The menu bar includes Setup, Memory, Wave, Equalizer, XVTRs, CWX, Mixer, Antenna, FlexControl, ESC, Get Help, Heros, and About.

VFO A: 28.060 300, 10M CW, TX. VFO Sync, VFO Lock, 7.000000, Tune Step: - 50Hz +, Save, Restore.

VFO B: 144.315 101, TX, 2M Satellite.

RX1 Meter: Signal, TX Meter: Fwd Pwr, -109 dBm.

AF: 50, AGC-T: 95, Drive: 50, AGC Preamp: Med +20, SQL: -150.

Buttons: MON, TUN, MOX, MUT, REC, PLAY, VHF+, WWV, GEN, LSB, USB, DSB, CWL, CWU, FM, AM, SAM, SPEC, DIGL, DIGU, DRM, 1.0k, 800, 750, 600, 500, 400, 250, 100, 50, 25, Var 1, Var 2, Low 225, High 975, Width, Shift, Reset.

Scope: Scope, Speed: 14 WPM, Pitch Freq (Hz): 600, Break In: [x] Enabled Delay (ms): 300, [x] Sidetone, [x] Show TX CW Frequency, MultiRX, Swap.

System Info: 10/10/2013, LOC 10:32:06, CPU %: 51.7.

Keyclicks 19 dB down

The screenshot displays the FlexRadio Systems PowerSDR v2.6.4 interface for a FLEX-1500 radio. The main window shows two VFOs: VFO A is tuned to 28.060 MHz (300 kHz bandwidth) with a 10M CW signal, and VFO B is tuned to 144.315 MHz (101 kHz bandwidth) with a 2M Satellite signal. The spectrum plot shows a signal at 28.060 MHz and a keyclick at 144.315 MHz. The RX1 Meter shows a signal level of -108 dBm. The interface includes various controls for setup, memory, wave, equalizer, XVRTs, CWX, mixer, antenna, flexcontrol, and ESC. The bottom panel shows speed and pitch controls, a break in control, and a shift control.

FlexRadio Systems™ PowerSDR™ v2.6.4 FLEX-1500: 2910-0543

Setup Memory Wave Equalizer XVRTs CWX Mixer Antenna FlexControl ESC Get Help Heros About

STOP

MON TUN
MOX
MUT
REC PLAY

AF: 50
AGC-T: 95
Drive: 50
AGC Preamp
Med +20
SQL: -150

RX PA
TX PA

10/10/2013
LOC 10:26:24
CPU %: 23.3

VFO A
28.060 300
10M CW TX
VFO Sync
VFO Lock
7.000000
Tune Step: - 50Hz +
Save Restore

VFO B
144.315 101
TX
2M Satellite

RX1 Meter TX Meter
Signal Fwd Pwr
-108 dBm

160 80 60
40 30 20
17 15 12
10 6 2
VHF+ WWV GEN

LSB USB DSB
CWL CWU FM
AM SAM SPEC
DIGL DIGU DRM

1.0k 800 750
600 500 400
250 100 50
25 Var 1 Var 2
Low 225 High 975
Width:
Shift: Reset

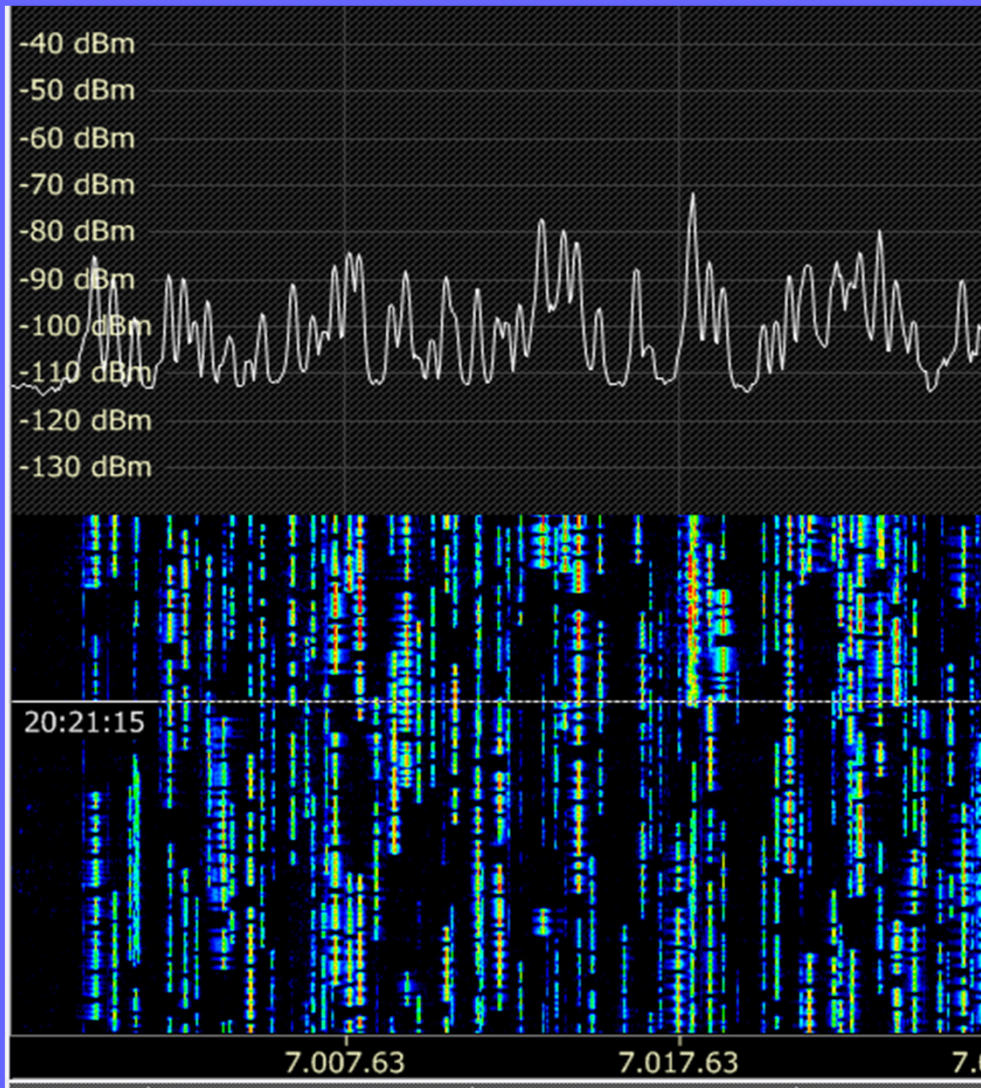
506.1Hz -108.8dBm 28.060 206 MHz

Pan: Center Zoom: 0.5x 1x 2x 4x

SPLT A > B NR ANF Panadapter
0 Beat A < B NB NB2 AVG Peak
IF->V A <> B SR BIN TNF +TNF
XIT 0 RIT 0
0 0 MultiRX
VAC1 VAC2 Swap

Speed: 14 WPM Pitch Freq (Hz): 600
Break In: Enabled Delay (ms): 300
 Iambic
 Sidetone
 Show TX CW Frequency

Mitigation methods



- ◆ HF operation in contests gives a clue.
- ◆ Limit bandwidth!

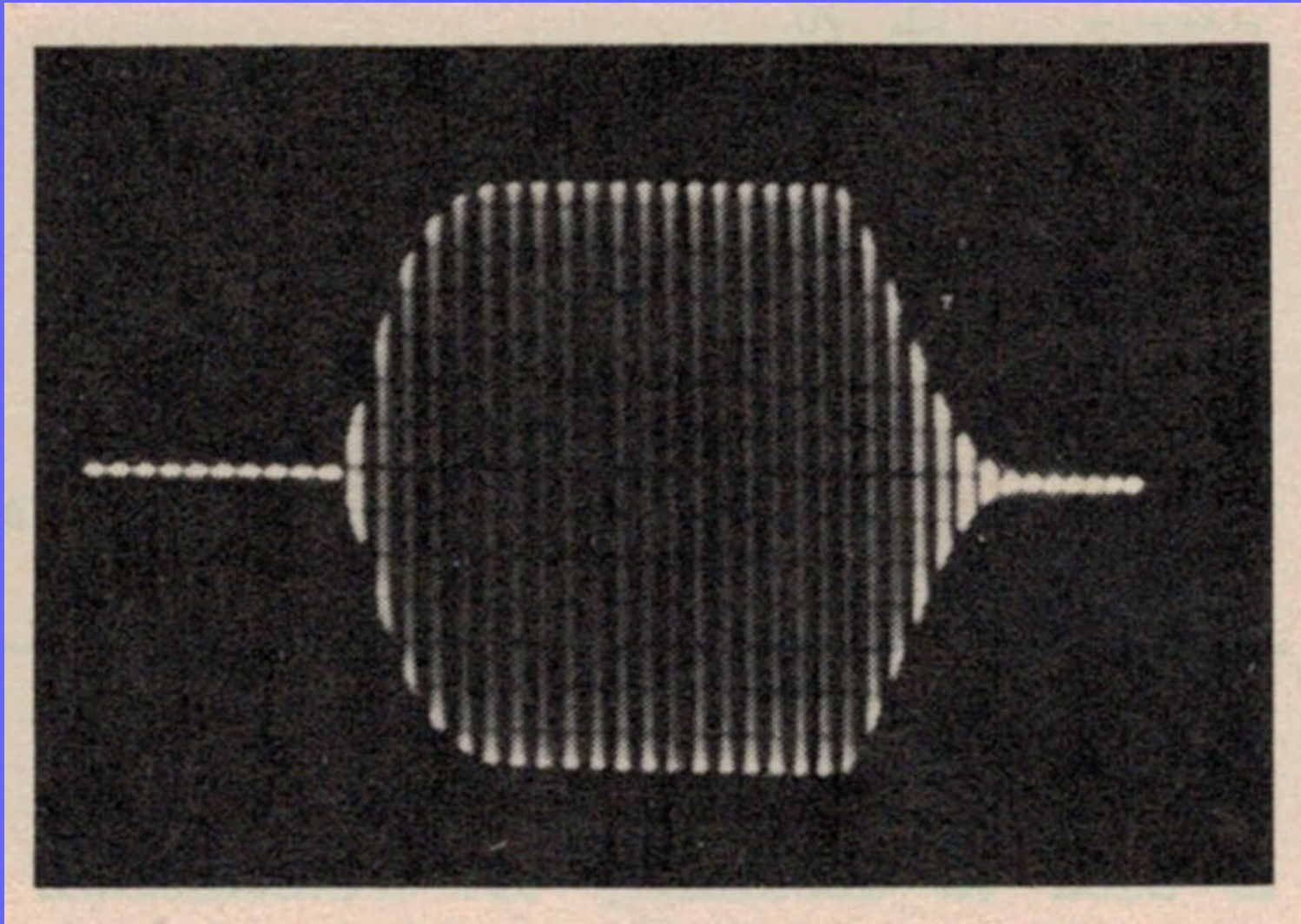
Mitigation methods

- ◆ With quality radios and SDR it is possible to have many strong signals within a few KHz. TX purity is key.
- ◆ How to implement TX purity on a beacon ? A few solutions exists.
- ◆ Normally, simple and effective are mutually exclusive..

RC keying of radio

- ◆ RC keying, good, not perfect.
- ◆ Used in early radios.
- ◆ Easily done at low stages, difficult with PAs. Backwave difficult to control.
- ◆ If too close of crystal oscillator it will induce chirps.
- ◆ Rise and fall time partially controlled, still fair amount of key clicks.

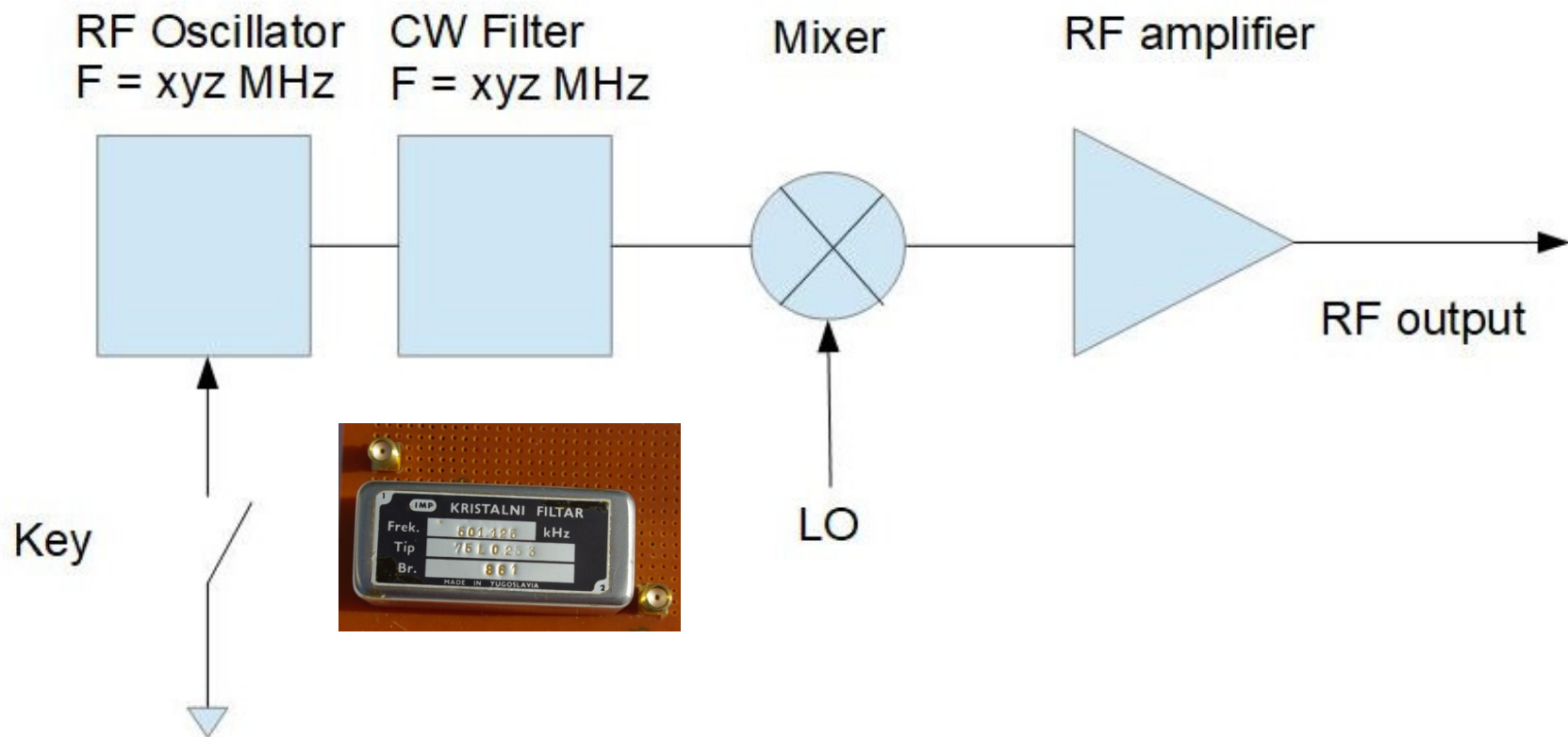
RC keying of radio



Use of SSB/CW filter

- ◆ Some quality radios use their receive filter in transmit.
- ◆ CW modulated IF pass through the filter, which hard limit the bandwidth. SSB filter is good. CW filter, 250/500 Hz, is better.
- ◆ Add complexity to a beacon. You need to work with an IF, filter, mixer, LO...

Use of SSB/CW filter



Dedicate a all modes rig

- ◆ Simple but expensive.
- ◆ Old radios with VFO will drift and still have key clicks (RC keying).
- ◆ Modern radios will do but who will dedicate a IC-375A on 222 MHz?
- ◆ Still limited to VHF and UHF. No microwave all modes rigs exists.
- ◆ HF rig and transverter will work.

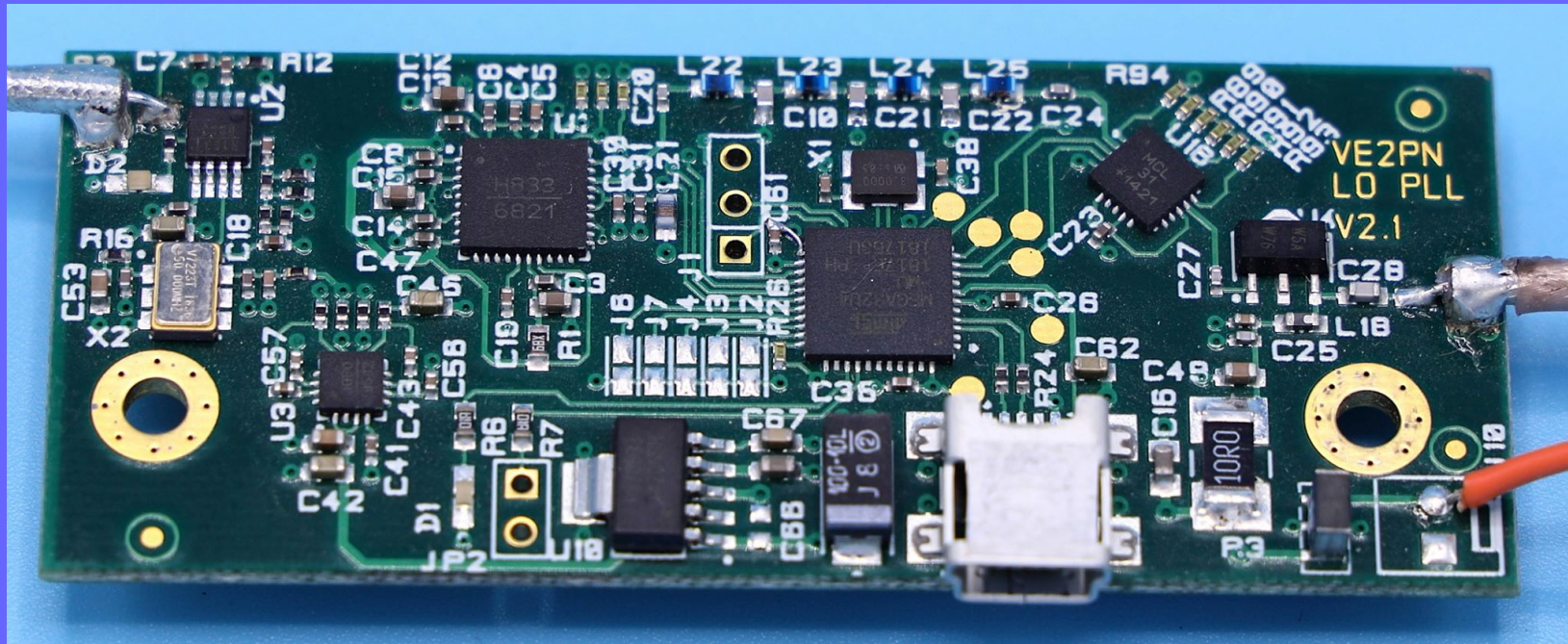
RF Envelope Shaping

- ◆ QRP Labs use it on his 5W amplifier. D/A controlling the PA supply.
- ◆ Gaussian, or Raised Cosine, are best to limit bandwidth.
- ◆ Can be used up to 6M, but not higher in frequency. PCB and FET not designed for it.
- ◆ We need a way to accurately control the RF output.

Digital RF attenuators

- ◆ 31 dB digital attenuator from Mini-Circuits DAT-31A.
- ◆ Crude Offset Cosine in 20 steps with lookup table. 1 step every 250 microseconds, ~5 milliseconds total.
- ◆ Only 31 dB of depth. Not good to tame backwave.
- ◆ We can still play with other stages at low level to add isolation.

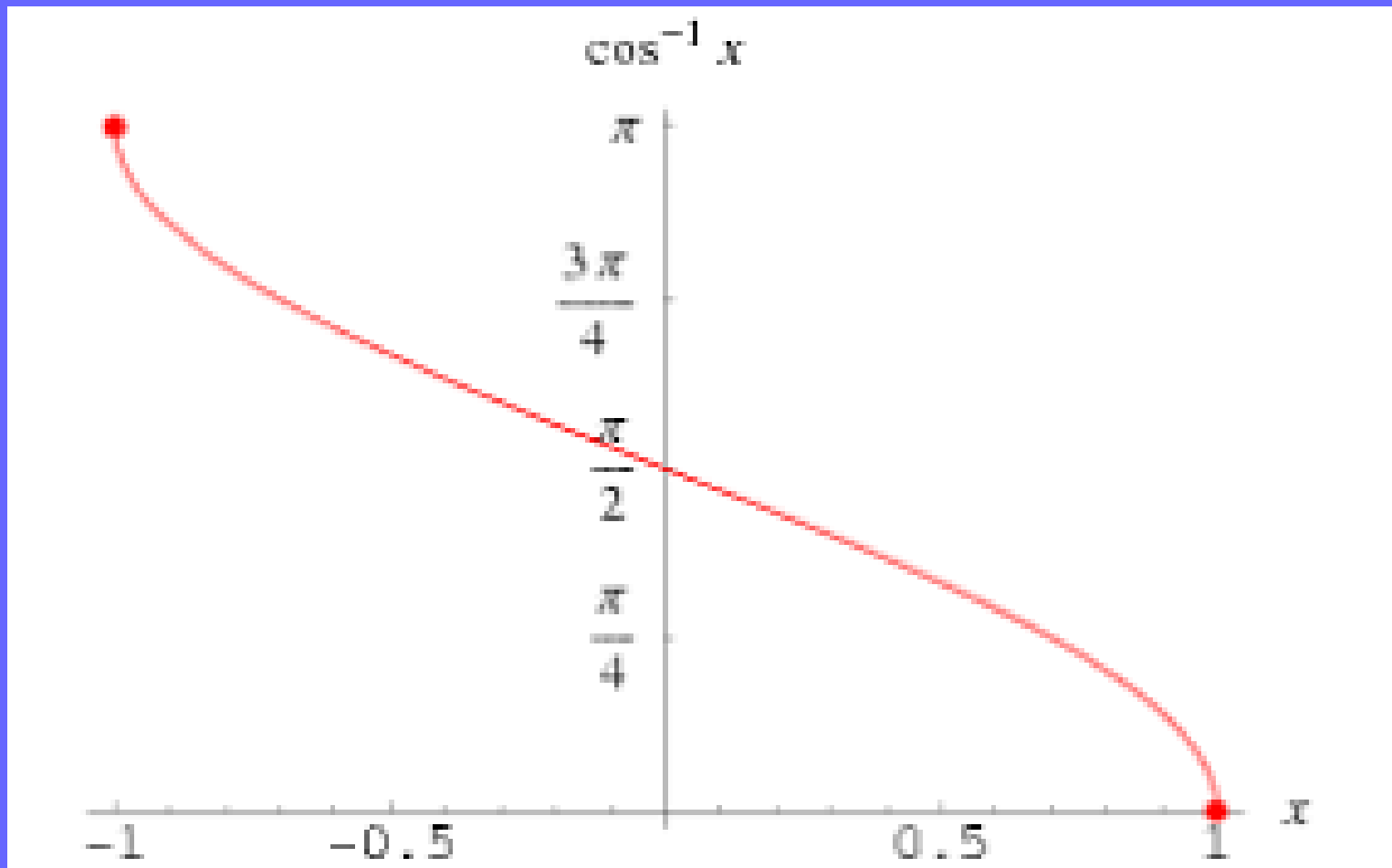
VE2PN PLL Board



VE2PN PLL Board

- ◆ HMC833 PLL 50-6000 MHz, HMC1031 Jitter filter. SPI digital attenuator.
- ◆ Pololu 32U4 with Arduino bootloader. Programmable with Arduino IDE. Runs at 8, not 16 MHz.
- ◆ [The .json file is configured for 8 MHz.](#)
- ◆ http://www.alphatronique.com/package_VE2PN_index.json
- ◆ PLL, digital attenuator and some IO pins all programmable.

“Offset Cosine” $1-\cos(\theta)$



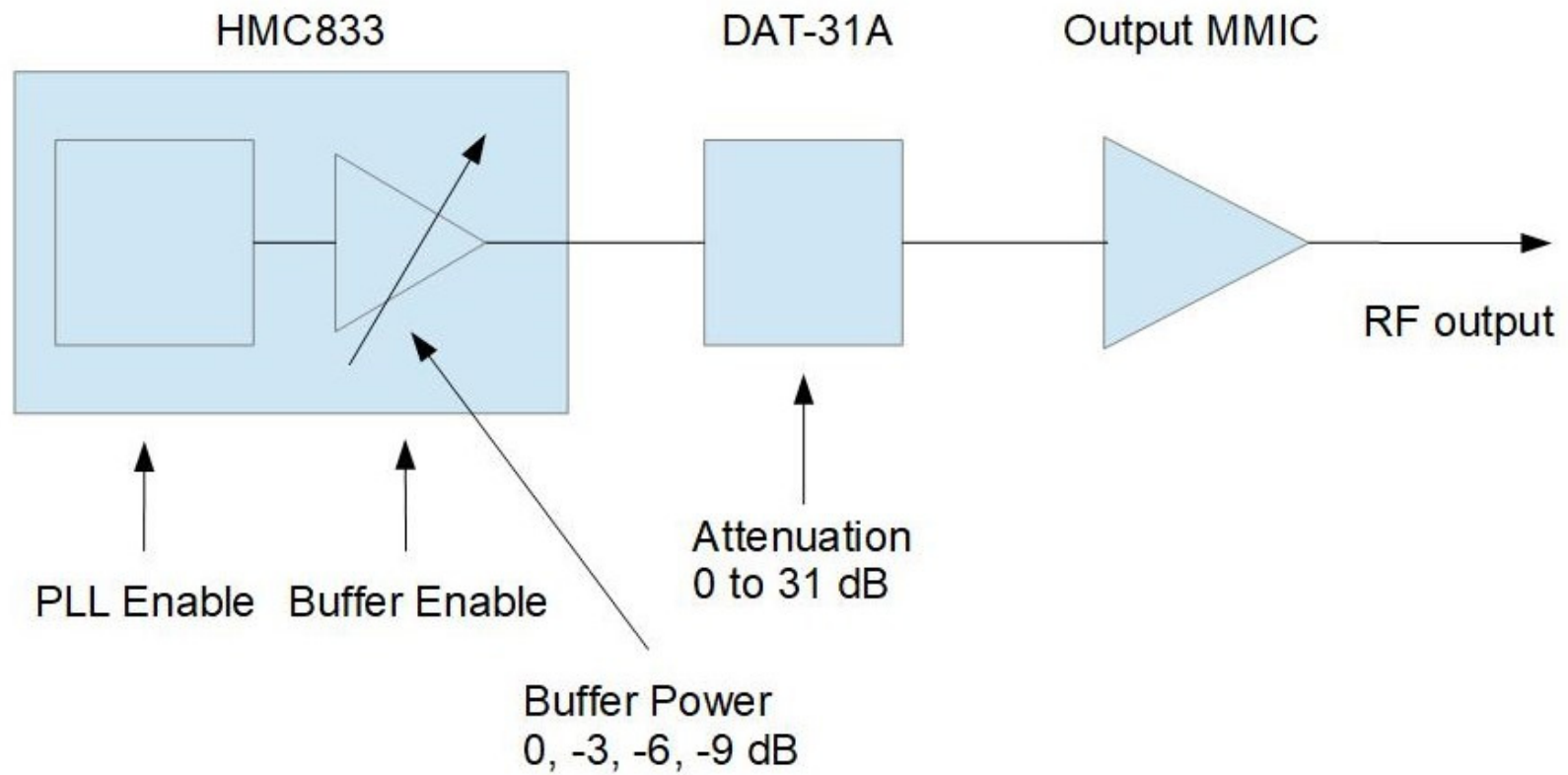
How to limit backwave

Ramp-Up sequence:

- ◆ HMC833 PLL Enable.
- ◆ External control of multipliers/PA supply with IO pin.
- ◆ HMC833 Internal Buffer.
- ◆ Attenuator ramp

Ramp-Down reverse the steps

PLL Controls



Ramp-Up

T	Angle	Angle radians	Cosine	1-Cosine	10Log(1-Cosine))	Attenuation dB
0	0	0	1	0	No output	Synth ON
0	0	0	1		Very Low	PA/Mult ON
0	0	0	1	0	Low	PLL Buffer ON, Att = 31
1	4,5	0,07853982	0,99691733	0,00308267	-25,1107349	25
2	9	0,15707963	0,98768834	0,01231166	-19,09683408	19
3	13,5	0,23561945	0,97236992	0,02763008	-15,58617864	16
4	18	0,31415927	0,95105652	0,04894348	-13,10305122	13
5	22,5	0,39269908	0,92387953	0,07612047	-11,18498553	11
6	27	0,4712389	0,89100652	0,10899348	-9,625994975	10
7	31,5	0,54977871	0,85264016	0,14735984	-8,316208715	8
8	36	0,62831853	0,80901699	0,19098301	-7,190052762	7
9	40,5	0,70685835	0,76040597	0,23959403	-6,205239996	6
10	45	0,78539816	0,70710678	0,29289322	-5,332906832	5
11	49,5	0,86393798	0,64944805	0,35055195	-4,552476106	5
12	54	0,9424778	0,58778525	0,41221475	-3,848764746	4
13	58,5	1,02101761	0,52249856	0,47750144	-3,210253187	3
14	63	1,09955743	0,4539905	0,5460095	-2,627998007	3
15	67,5	1,17809725	0,38268343	0,61731657	-2,094920672	2
16	72	1,25663706	0,30901699	0,69098301	-1,605326337	2
17	76,5	1,33517688	0,23344536	0,76655464	-1,154568854	1
18	81	1,41371669	0,15643447	0,84356553	-0,738811723	1
19	85,5	1,49225651	0,0784591	0,9215409	-0,354853831	0
20	90	1,57079633	6,1257E-17	1	-4,82164E-16	0

Going without VE2PN board

- ◆ The Arduino program can be modified for other PLLs, attenuators.
- ◆ If using external PLL just comment the PLL configuration and controls.
- ◆ The attenuator can be external. You can buy a SPI DAT-31A, or RF Step Attenuator SPI Module from SV1AFN.
- ◆ No need to change the routine. They have the same command structure.

Staying linear

- ◆ Output MMIC have lot of gain at low frequency.
- ◆ We need to adjust HMC833 power to prevent saturation at VHF.
- ◆ Internal buffer have a range of 9 dB in 4 steps. Code added to adjust.
- ◆ Later stages should be linear to prevent distortion of the ramp.
- ◆ Could be a problem with multipliers.

Staying linear

- ◆ Bit manipulation without affecting others.

```
//Set HMC833 buffer power to -9 dB from maximum (bit 14 = 0, bit 13 = 0).  
//To keep output MMIC from saturating.  
  
VCO_Reg_Buffers[2] &= ~(1<<14); // Set 14th bit of VCO_Reg_Buffers[3] to 0.  
//VCO_Reg_Buffers[2] |= (1<<14); // Set 14th bit of VCO_Reg_Buffers[3] to 1.  
  
VCO_Reg_Buffers[2] &= ~(1<<13); // Set 13th bit of VCO_Reg_Buffers[3] to 0.  
//VCO_Reg_Buffers[2] |= (1<<13); // Set 13th bit of VCO_Reg_Buffers[3] to 1.  
writeRegister( VCO_Reg_Buffers[2]); // Writer buffer power value in PLL.
```

We cannot shape everything

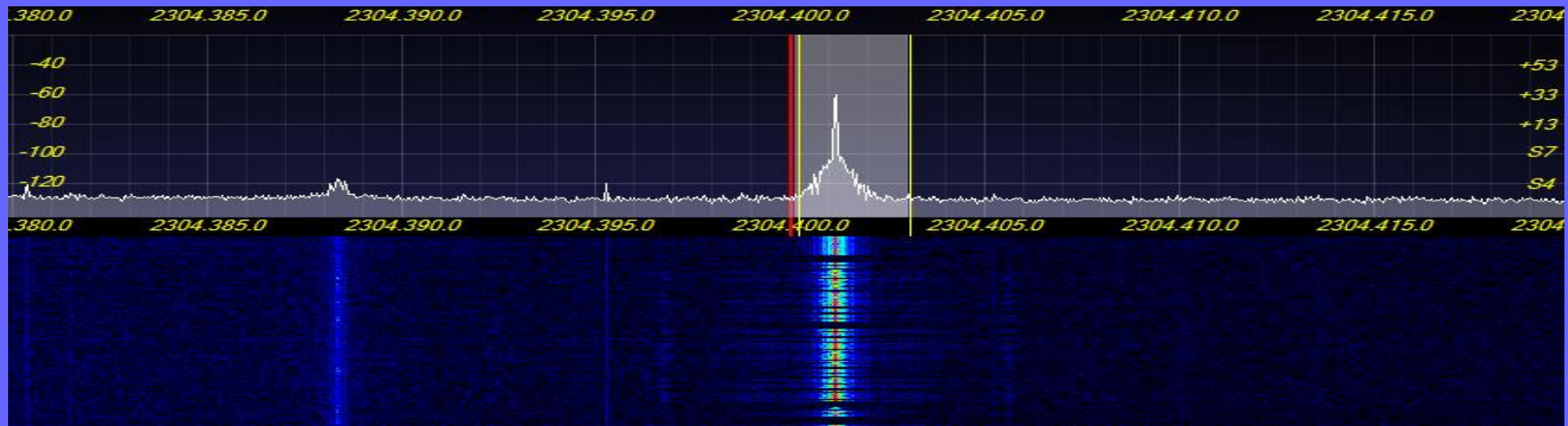
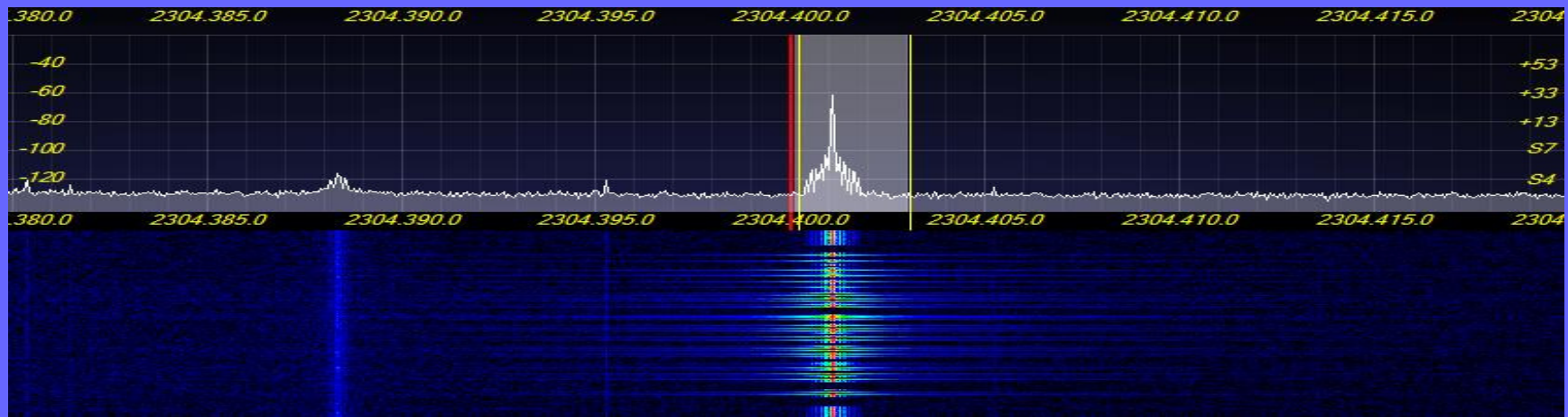
- ◆ **Phase noise.**

- ◆ It is there whenever the carrier is present.
- ◆ It will varies with the digital attenuator, but cannot be removed.
- ◆ Definitely there from VHF to microwaves, on strong signals.
- ◆ Good PLL design is important.

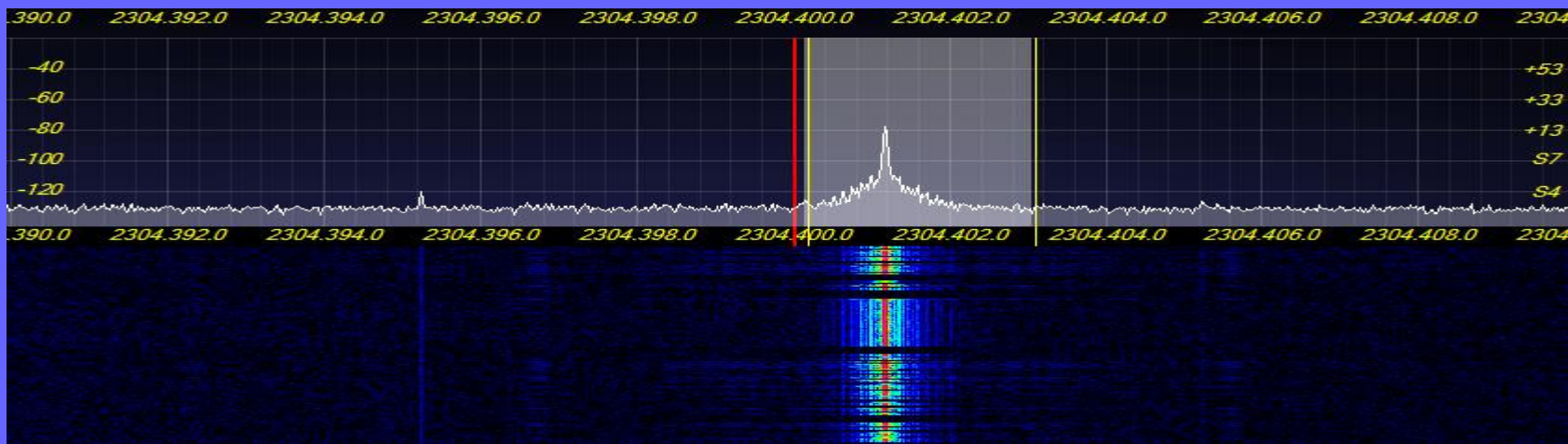
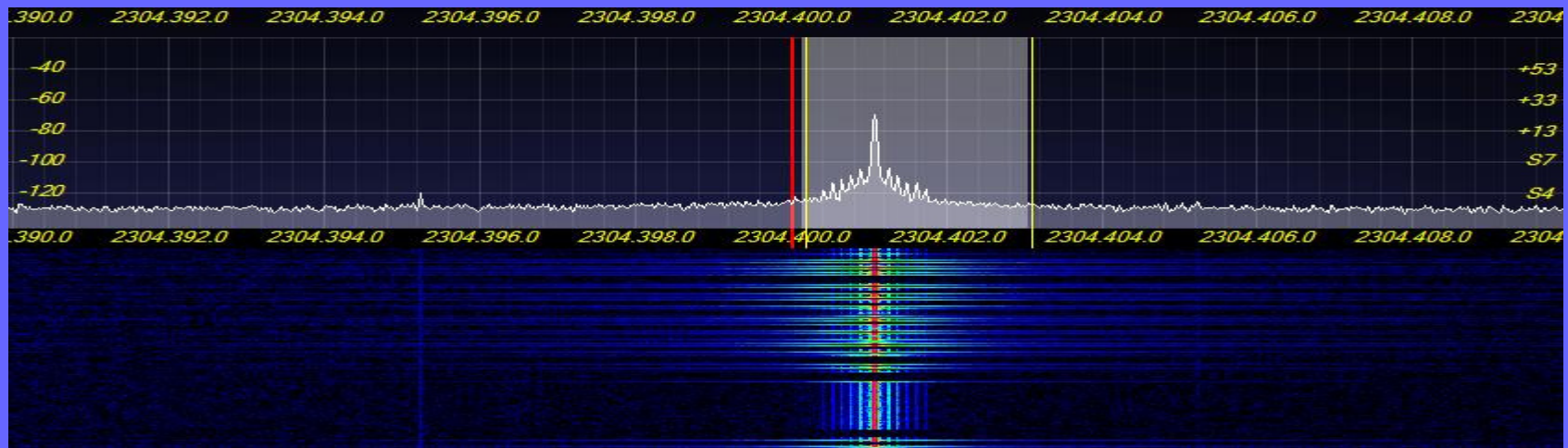
Internal Keyer

- ◆ Written by Mark VandeWettering K6HX.
- ◆ Free to use with mention of the author.
- ◆ Easy to change Message/Speed.
- ◆ Added function to insert long carrier at the end.

Without and with shaping



Without and with shaping



Videos...

Wrap-Up

- ◆ Envelope control can help a beacon be a good neighbor.
- ◆ Can be programmed from VHF to the lower microwaves bands.
- ◆ VE2PN is working on a lower cost board. HMC833 really expensive.
- ◆ Reference Conditionner really help taming noisy references.

Future work

- ◆ All is not lost with those converted FM beacons.
- ◆ Will test envelope control using power control loop/SWR protection.
- ◆ IF OK we might use a D/A and custom ramp to control the RF.
- ◆ No end to experiments!

Special Thanks

- ◆ Thanks to Marc VE2PN!
- ◆ He had the the foresight to add a controllable digital attenuator, and designed from the ground up for low phase noise.
- ◆ Arduino a real plus for custom applications.

◆ Questions?