Sound Card Oscilloscopes and Digital Modes

K3EUI
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Hardware for Digital Modes

Interface - between computer and radio by two audio cables or by a single usb cable

Sound Card INPUT - from speaker/headphone
or DATA jack (constant vol)

Sound Card OUTPUT – to MIC or Data jack

PTT - usb/serial or VOX (SignaLink)

GND - common ground cable

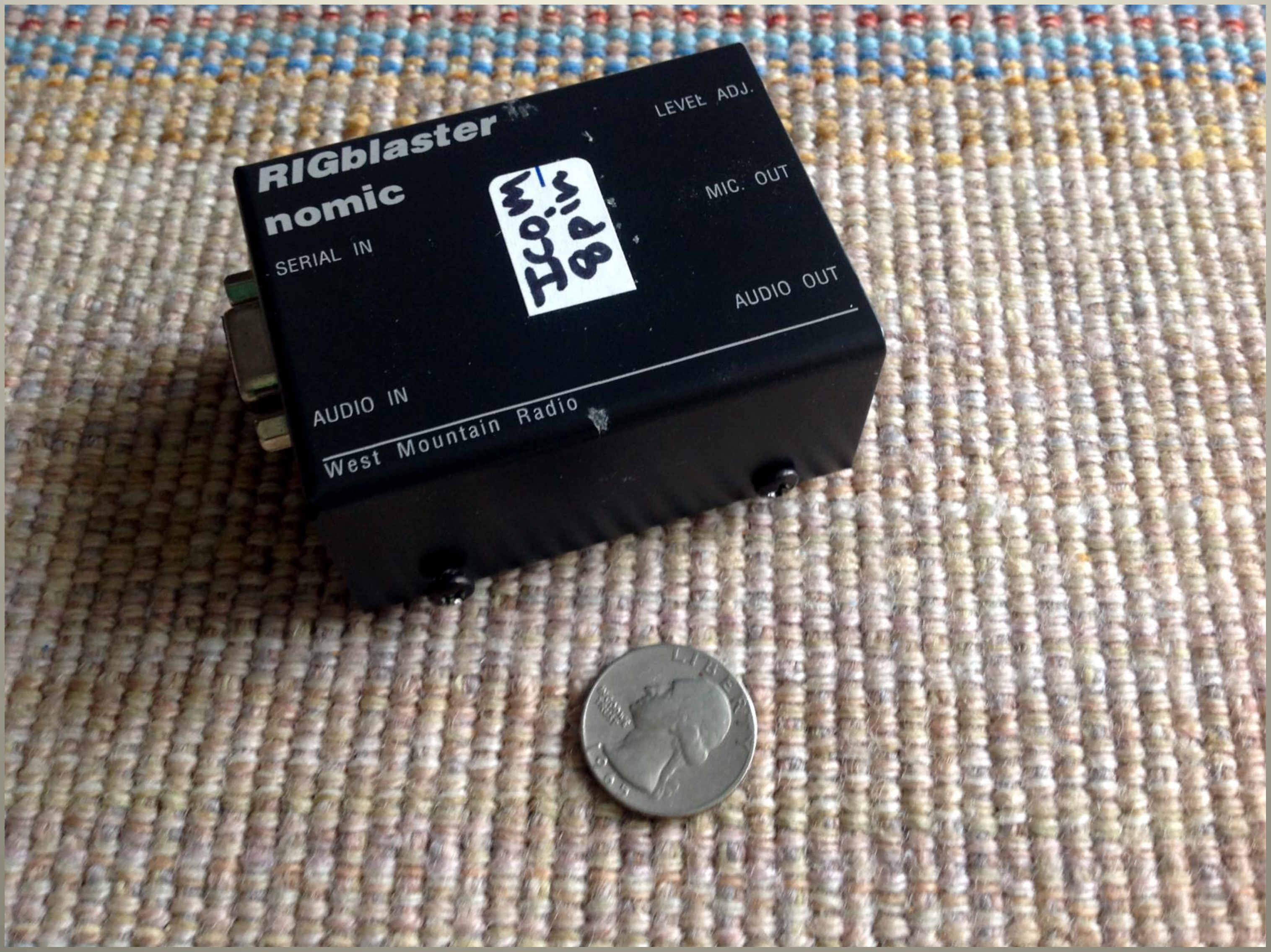
Goals: set proper RX and TX levels
optical isolation of audio lines
avoid RF feedback

Tigertronics SignaLink (usb) both RX and TX audio connects to DATA jack or MIC jack cost about $100

Rigblaster: uses sound chips in computer
allows for L/R/both audio for TX
Designed to plug into a MIC jack
VOX or PTT circuit via a COM port
cost about $50 used market

Rigblaster "Advantage"
usb port with built-in low-noise sound chips
cost about $150

Simple Rigblaster "nomic"
only handles sound card TX audio (no mic connection)
cost well under $100



External USB Sound Blaster usb hardware
very high quality, low-noise sound chips ($100)

Simple 2-cond shielded cable with TX and RX audio via 1:1 isolation transformers

What is the “best” interface?

Oscilloscopes

How do hams use these in the radio shack?

(stand up if you have a "scope" in your shack)

Physical Oscilloscopes vs. Sound Card Oscilloscopes

- analog with CRT beam vs. Digital and LCD display
- useful frequency range (Radio frequencies vs. audio freq)
- cost comparison
  - Tektronics scope 50 MHz about $500
  - Rigol scope 50 MHz about $350
  - Sound Card (audio) Oscilloscope - most are FREE

What is a “sound card oscilloscope” ?

An oscilloscope is just a
fast graphic voltmeter
allowing you to “see”
the shapes of AC voltages over time

You can use an oscilloscope to

measure period or frequency
measure peak voltages
measure rise/fall times
check for clipping
check for harmonics

Most modern oscilloscopes can do "math" functions
like a FFT calculation
to plot a frequency spectrum

"Fast Fourier Transform"
breaks up a complex wave into its sine-wave components

Sound Card Oscilloscopes

use the PC's built in soundcard for the audio analog/digital (A/D) conversion

How can we use Sound Card Oscilloscope apps with our radios?

Examine shapes of RX and TX signals
Examine audio bandpass
Look for 60 Hz hum
Examine the envelopes of digi signals

Oscilloscope apps for Windows machines

Christian Zeitnitz: Sound Card Scope

Soundcard Scope 1.46

This Software is NO Freeware !
Usage of the program incl. documentation is granted free of charge for private and public educational usage.
Any commercial application, distribution or sale is prohibited. Obtain a commercial or re-sale license of the program. See the website given below.

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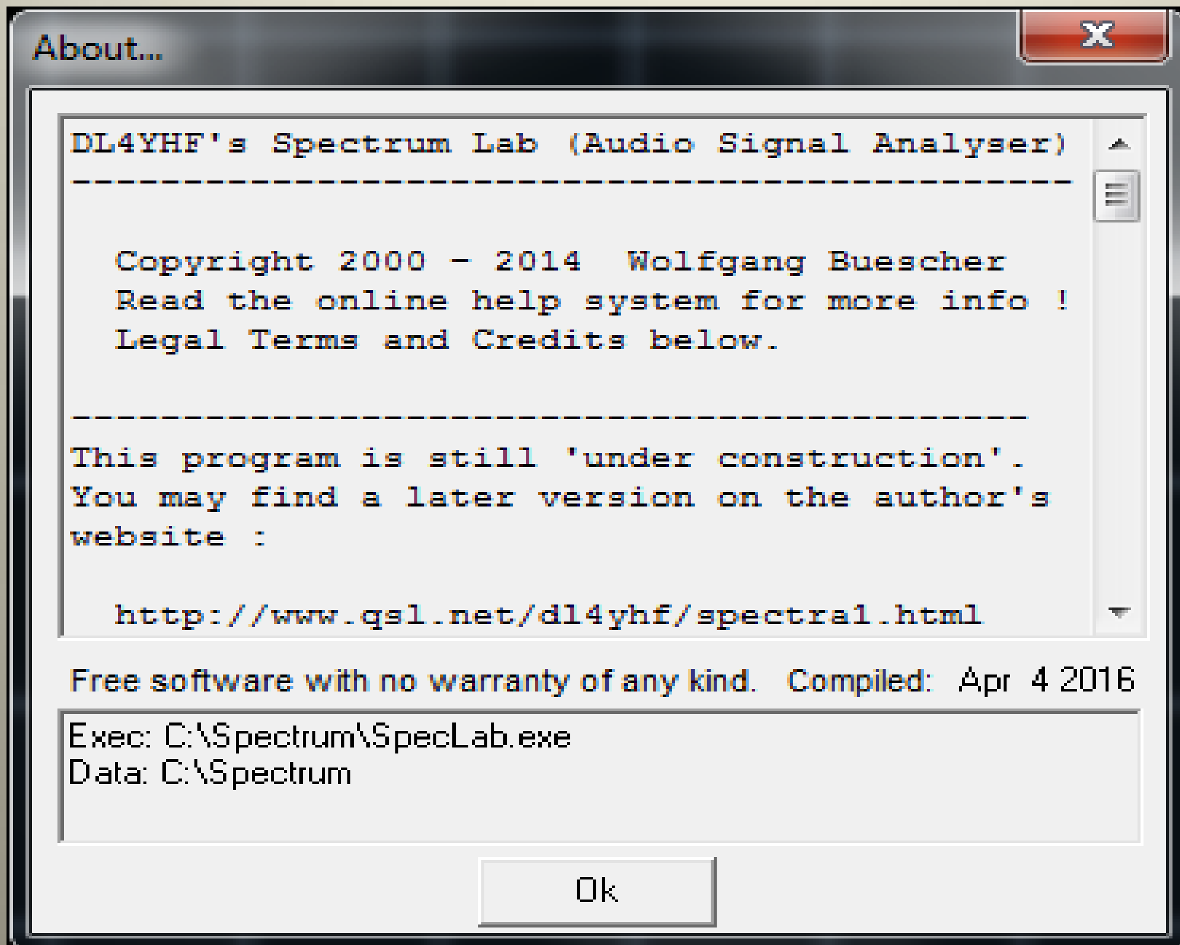
Christian@Zeitnitz.de
http://www.zeitnitz.de/Christian/scope_en

OK

DL4YHF Spectrum Lab



Spectrum Labs
Sound Card Oscilloscope

More powerful FFT analysis

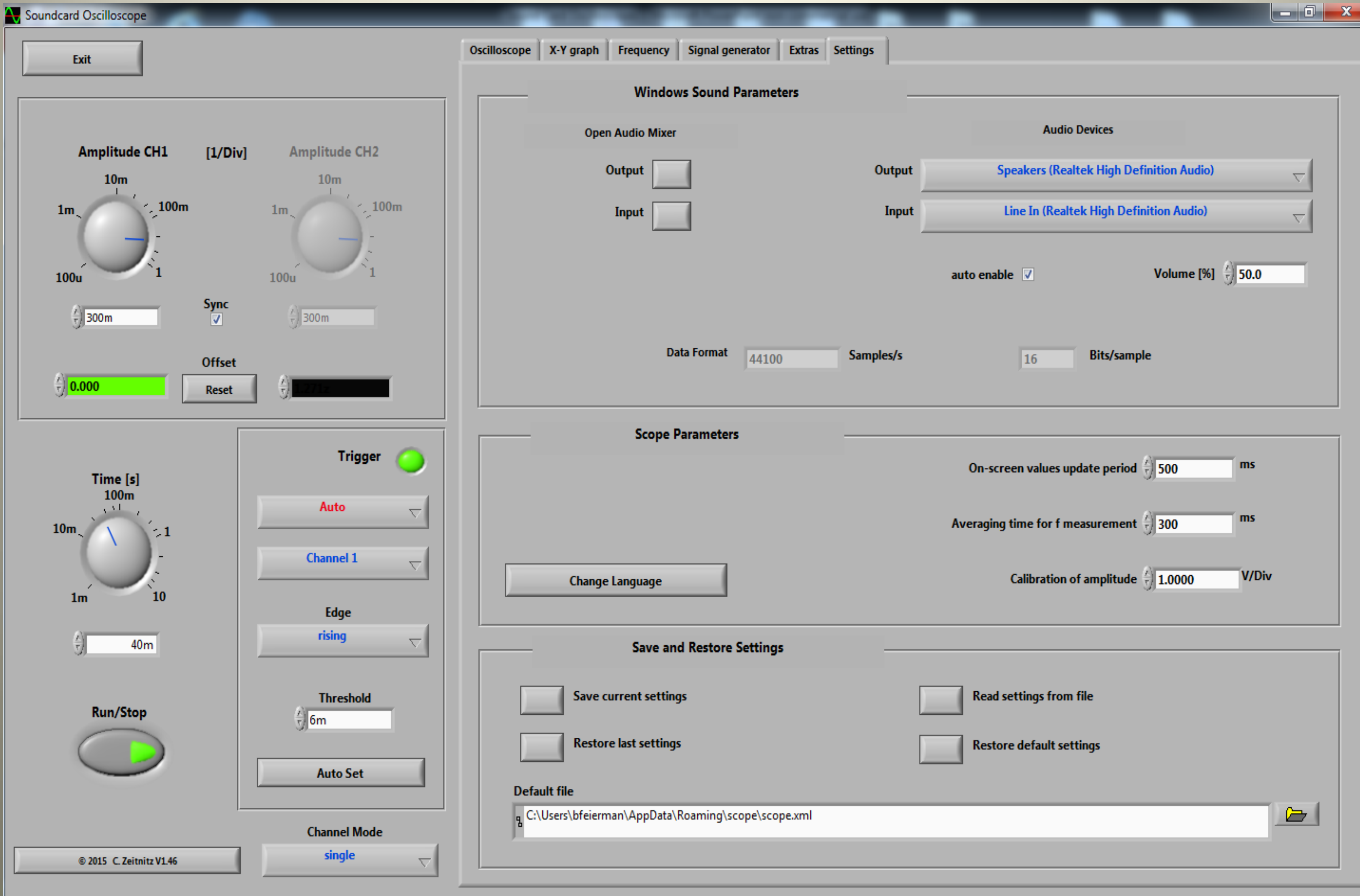
Finer resolution in Hz bins

Larger Screen Size

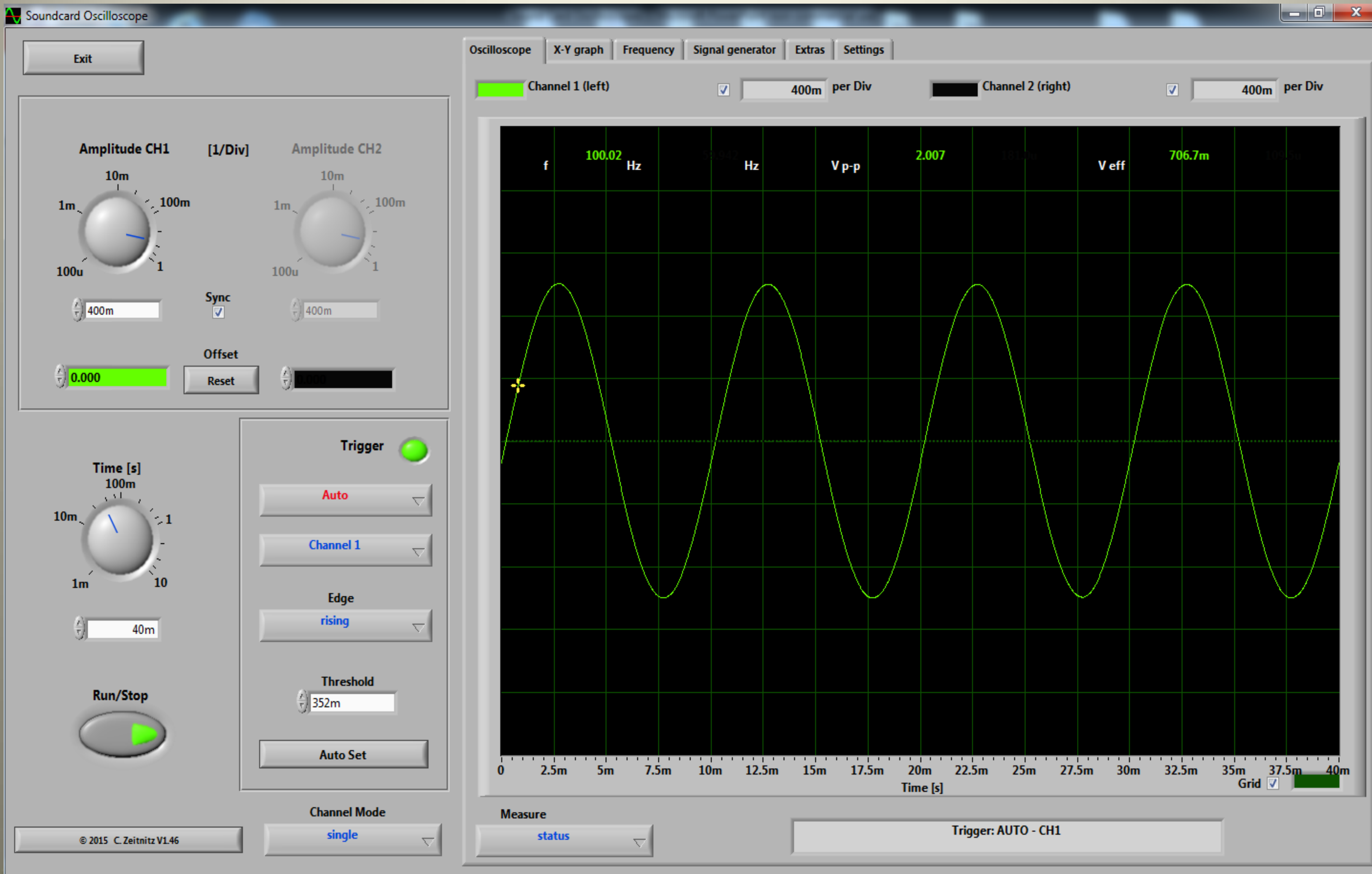
Many more options for averaging

Needs a faster processor

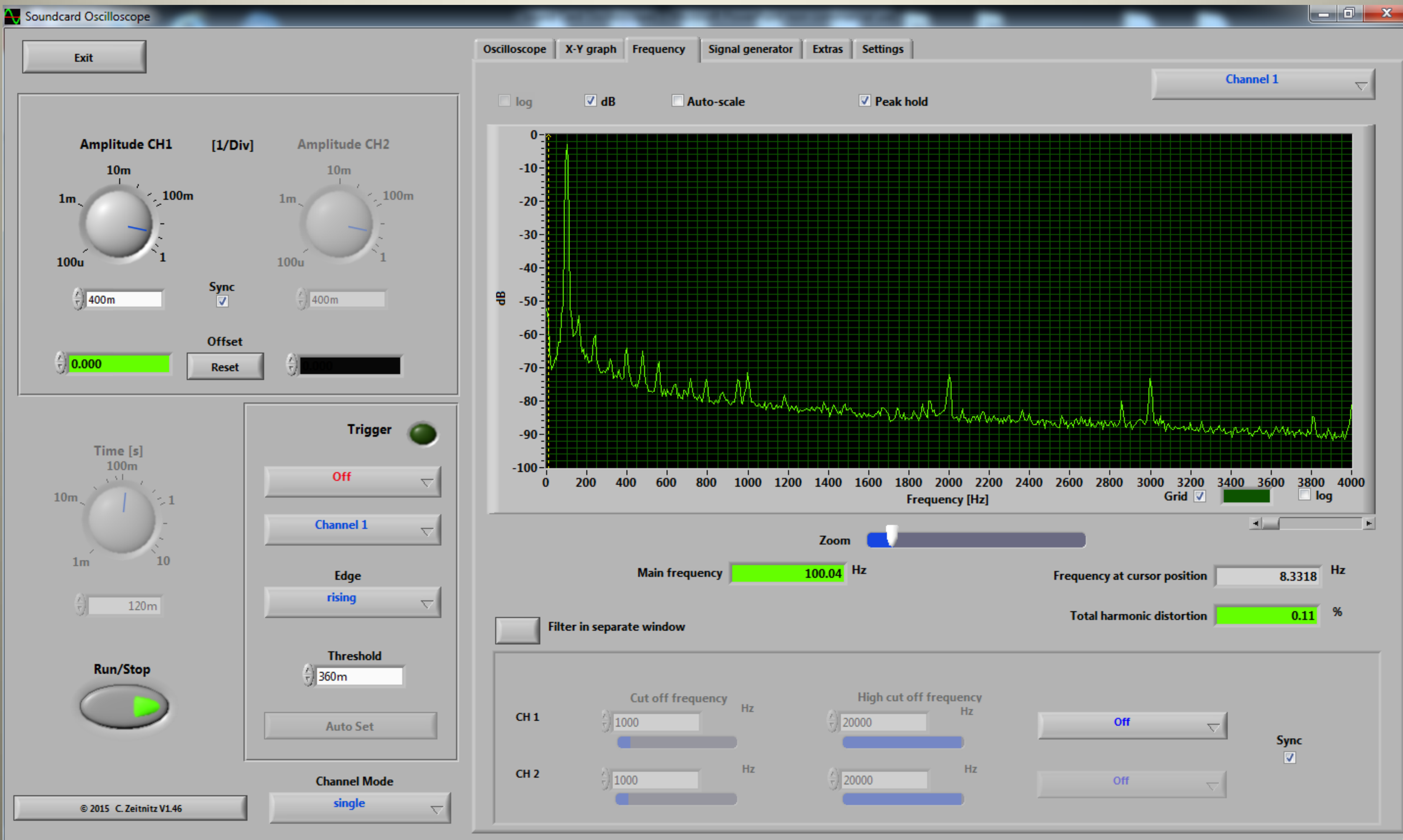
Zeitnitz's Settings: choose sound card input and output, Y and X scale values, type of triggering, channel (L/R)



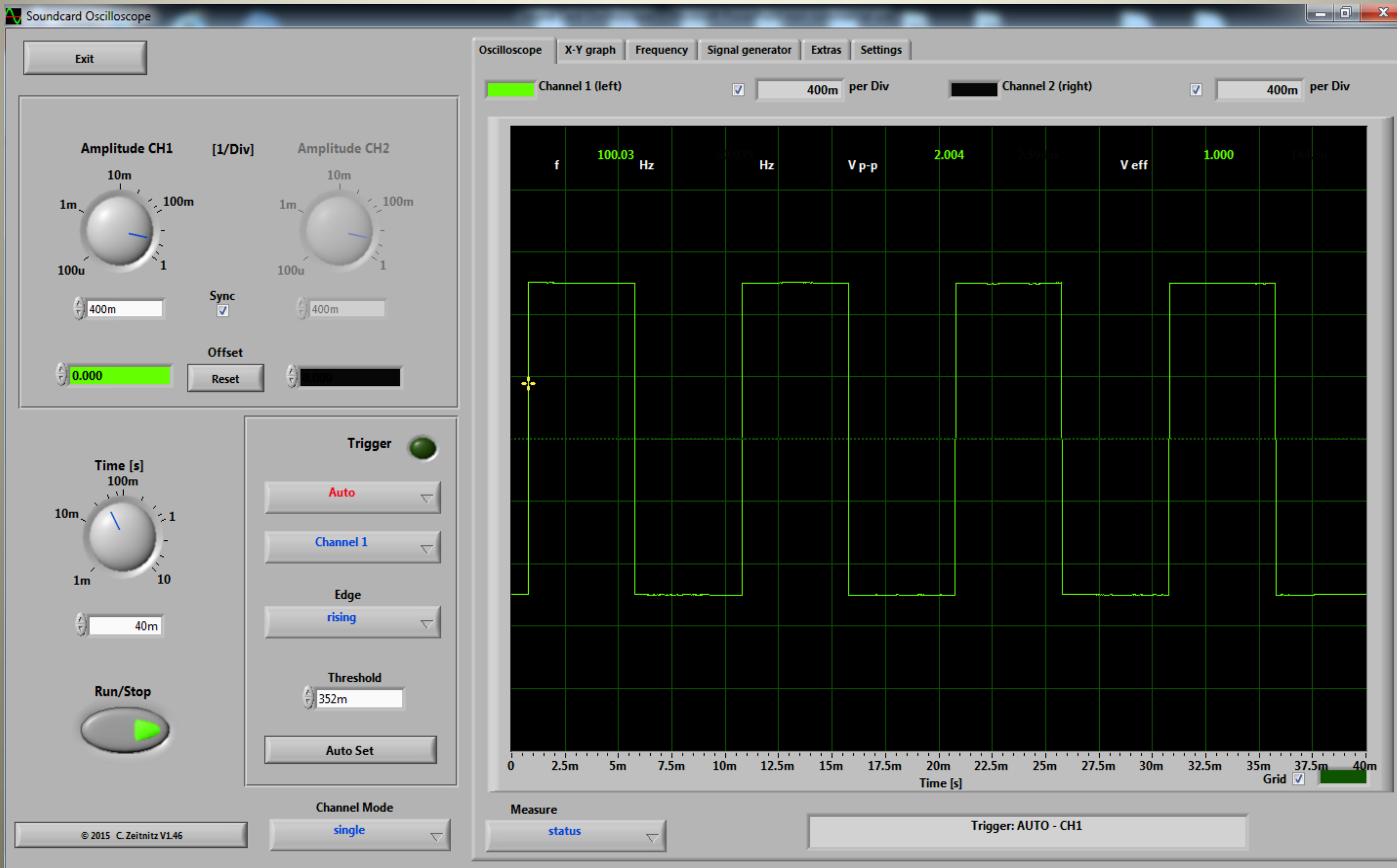
Oscilloscope Screen: Y = amplitude X = time
100 Hz sine wave: 2 volts peak/peak: 10 ms period



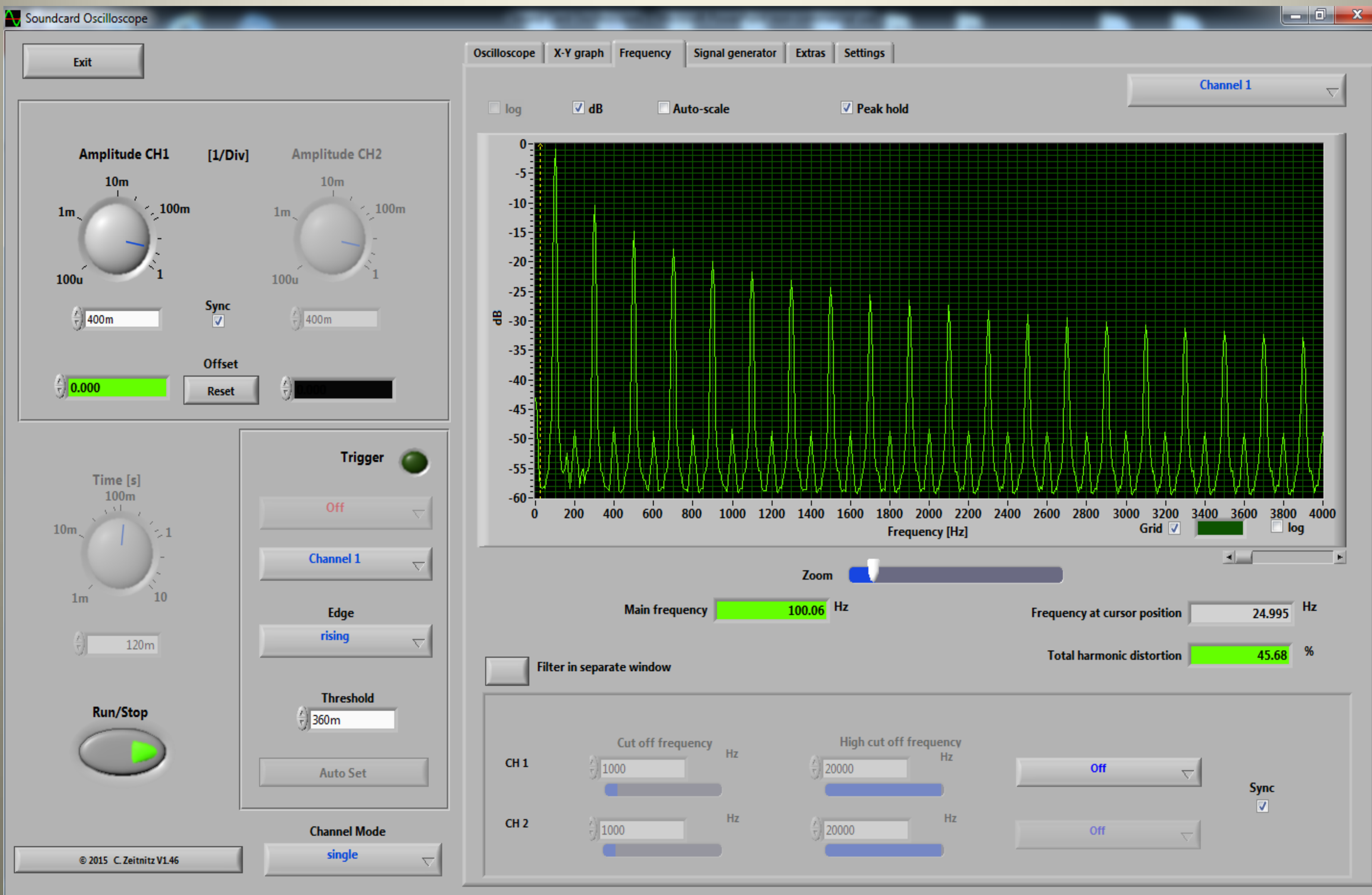
Viewing the frequency distribution (FFT) of a 100 Hz sine wave, looking for harmonics



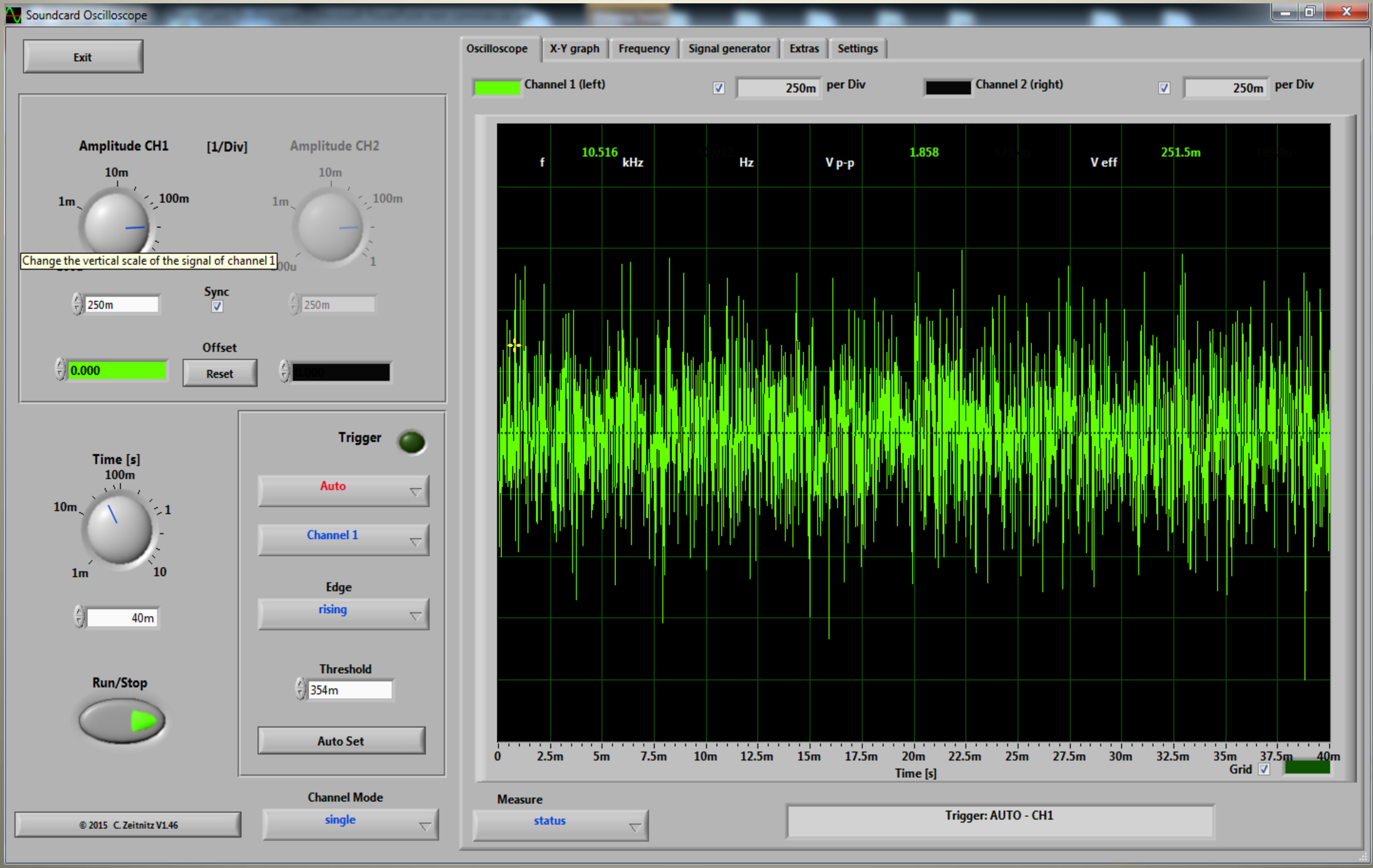
Oscilloscope Screen: 100 Hz "square wave"
A square wave has many "odd" harmonics



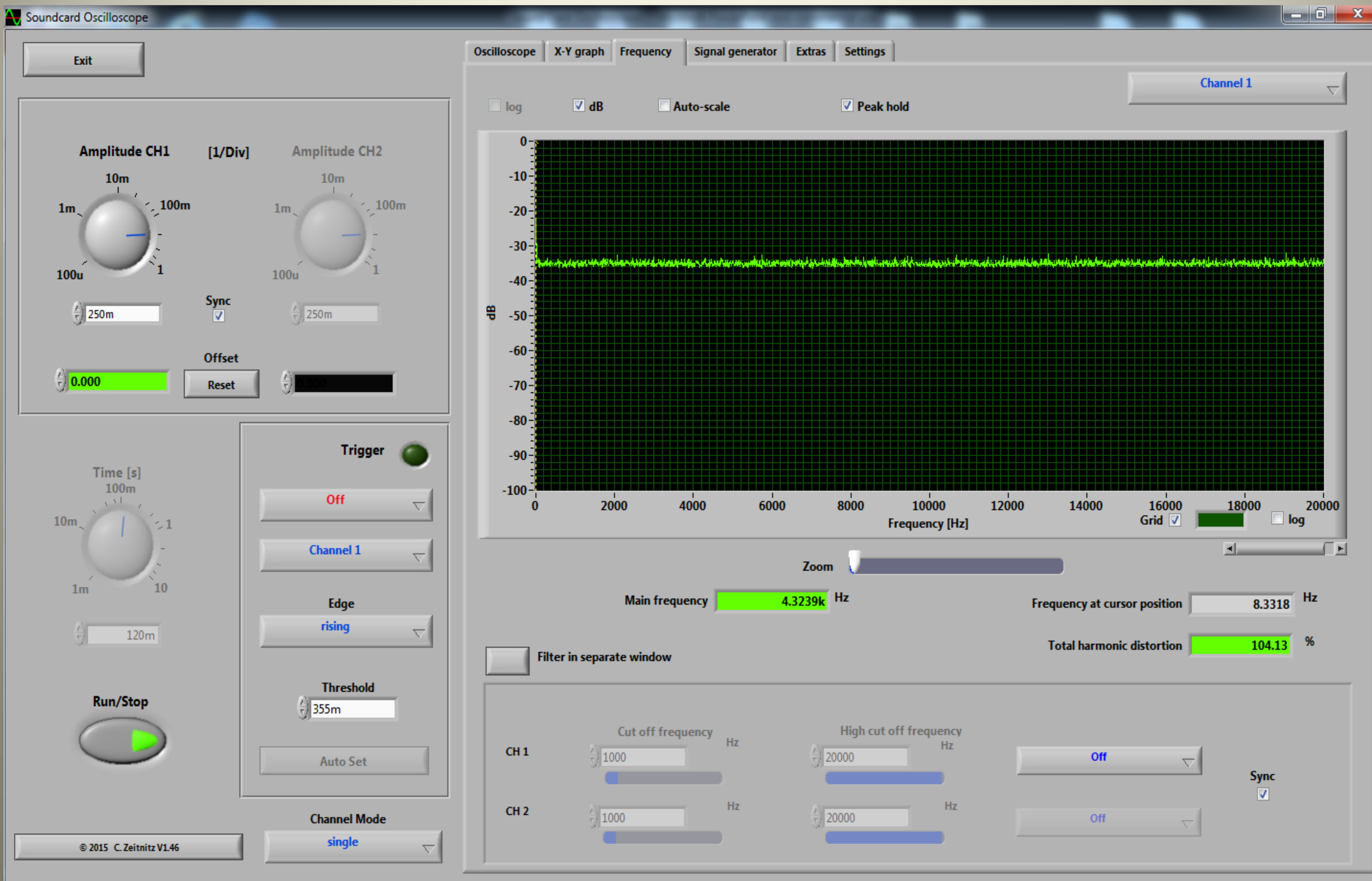
Frequency Distribution of 100 Hz square wave
note all "odd" order harmonics (100,300,500,700 Hz)



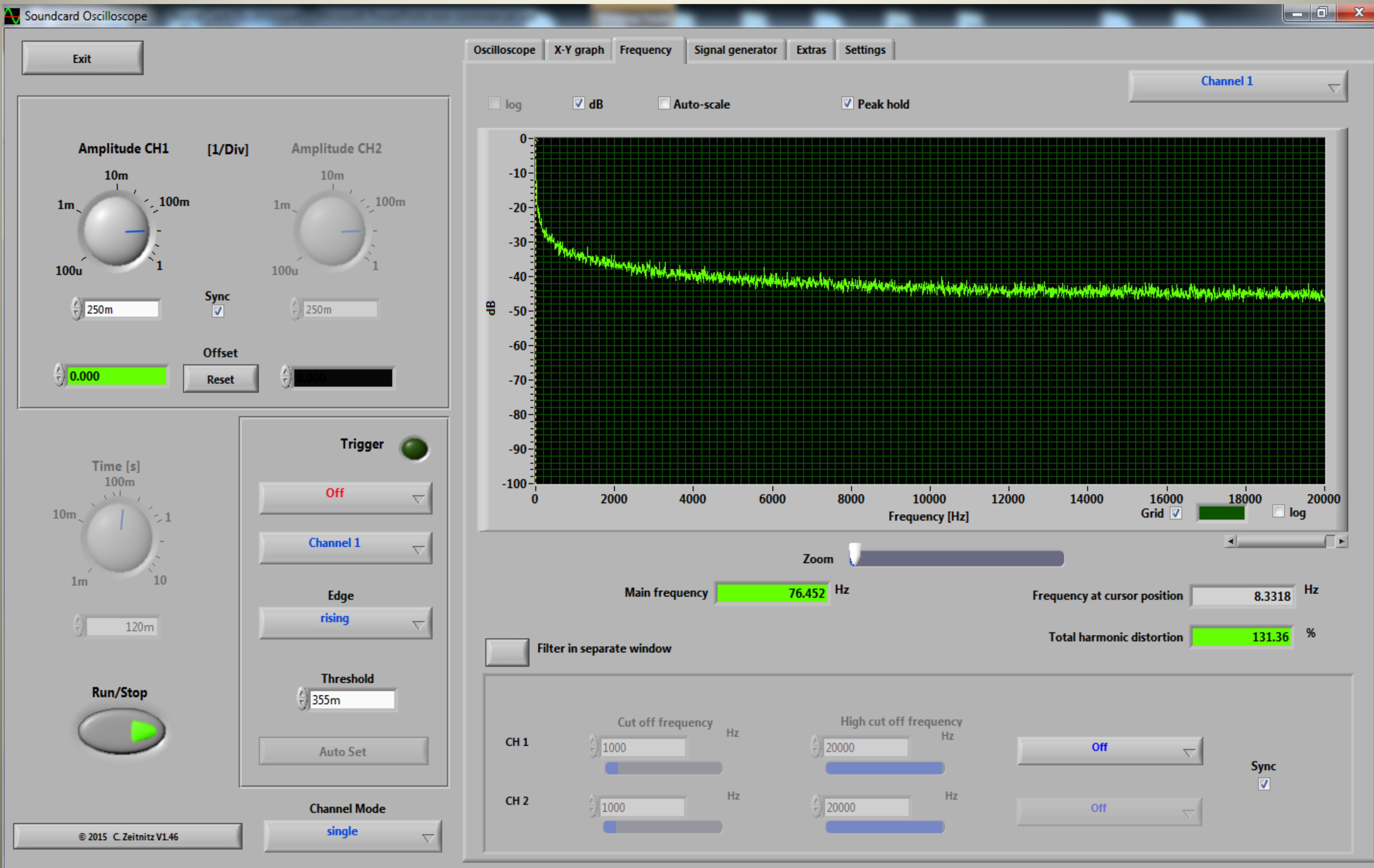
Oscilloscope View: "White Noise" has no periodicity, no noticeable pitch



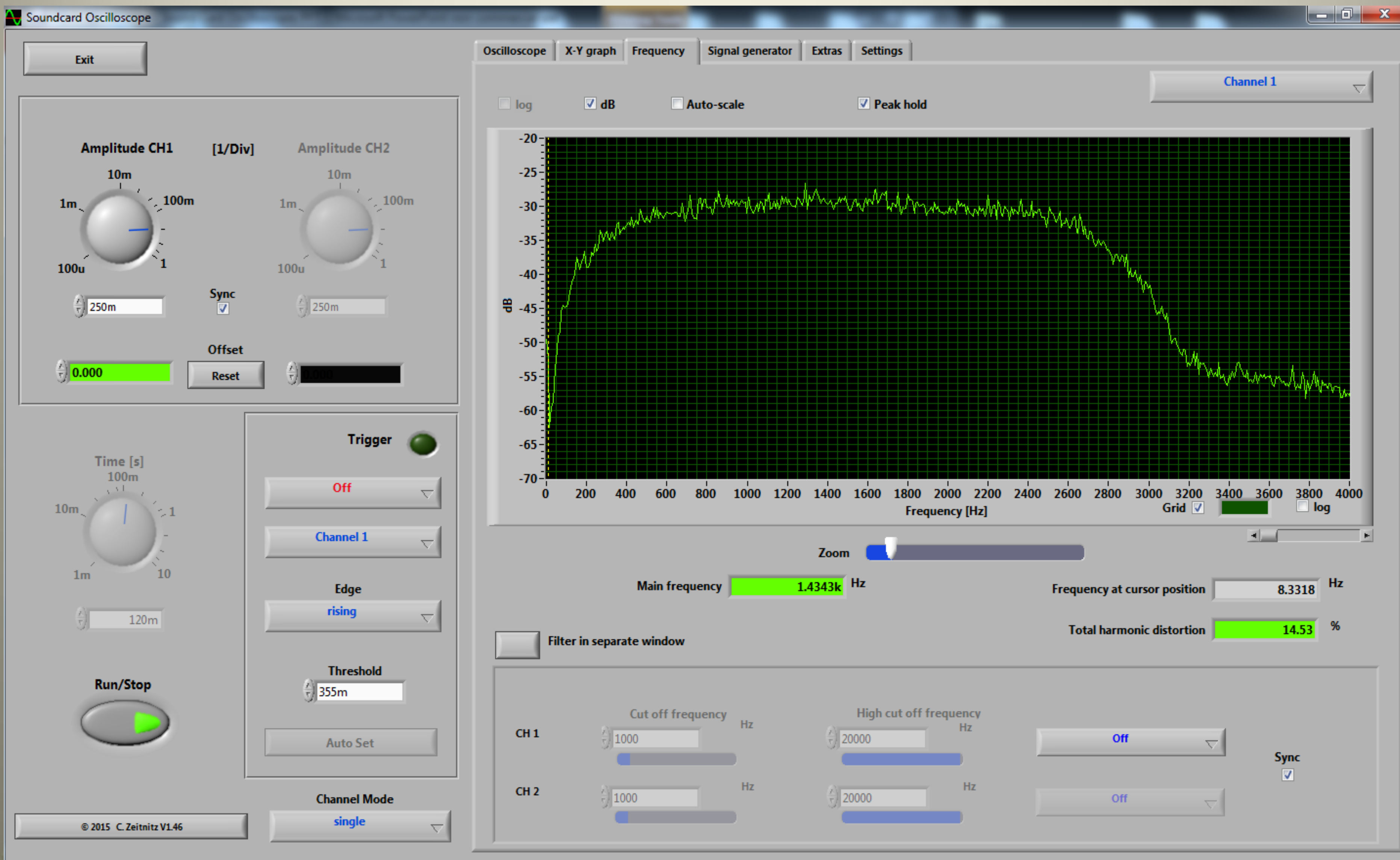
Frequency Distribution of White Noise
0 – 20 kHz (equal energy everywhere)



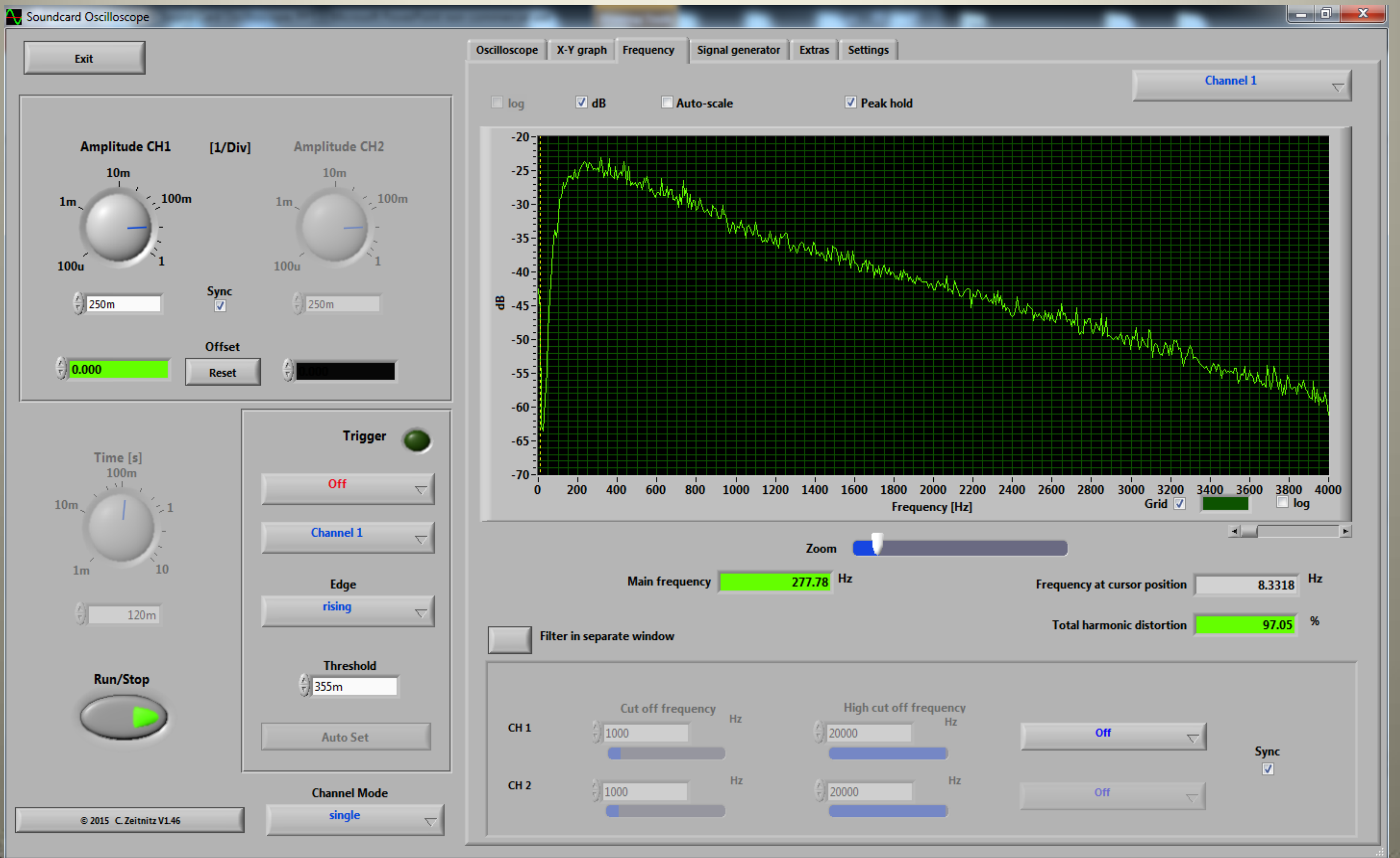
Frequency Distribution: Pink Noise
0 to 20 kHz



Bandpass of a typical SSB radio: Yaesu FT 1000 (1990) in USB mode (400 – 2600 Hz bandpass)



Bandpass of a typical FM radio 0 – 4000 Hz
Why the gradual decline of intensity with frequency?



What is the bandwidth of an RF carrier with no modulation?

(often called a "dead" carrier)

Modulation: adding information to a carrier

3 ways to modulate a carrier

1) amplitude changes (AM)
2) frequency or angle changes (FM)
3) phase changes (PM)

What MODE is

on/off

amplitude-shift-keying?

CW of course

In CW a "carrier" (EM wave) is keyed on/off producing in a receiver equipped with a bfo the sounds we call "dit and dah" → Morse Code

So CW is a digital mode in the sense that a machine can interpret the ON/OFF sounds as 0's and 1's

Spaces (no sound) = 0's tone on = 1

000 between letters, 0000000 between words

1 dah = 3 dits (3:1 typical ratio)

	letter		binary equivalent
Dit	e	=	10
Dah	t	=	1110
Letter	i	=	1010
Letter	m	=	11101110
Letter	o	=	111011101110

Why is CW still such a popular mode of operation especially for DX?

Advantages of CW

A good CW operator can copy CW when
the signal to noise ratio (S/N) is only 0 dB

The human ear/brain can detect and filter out the pitch you want in a qrm situation (pile up)

CW receive filters can be very narrow bandwidth (100 Hz) and hence, improve the S/N and eliminate unwanted signals

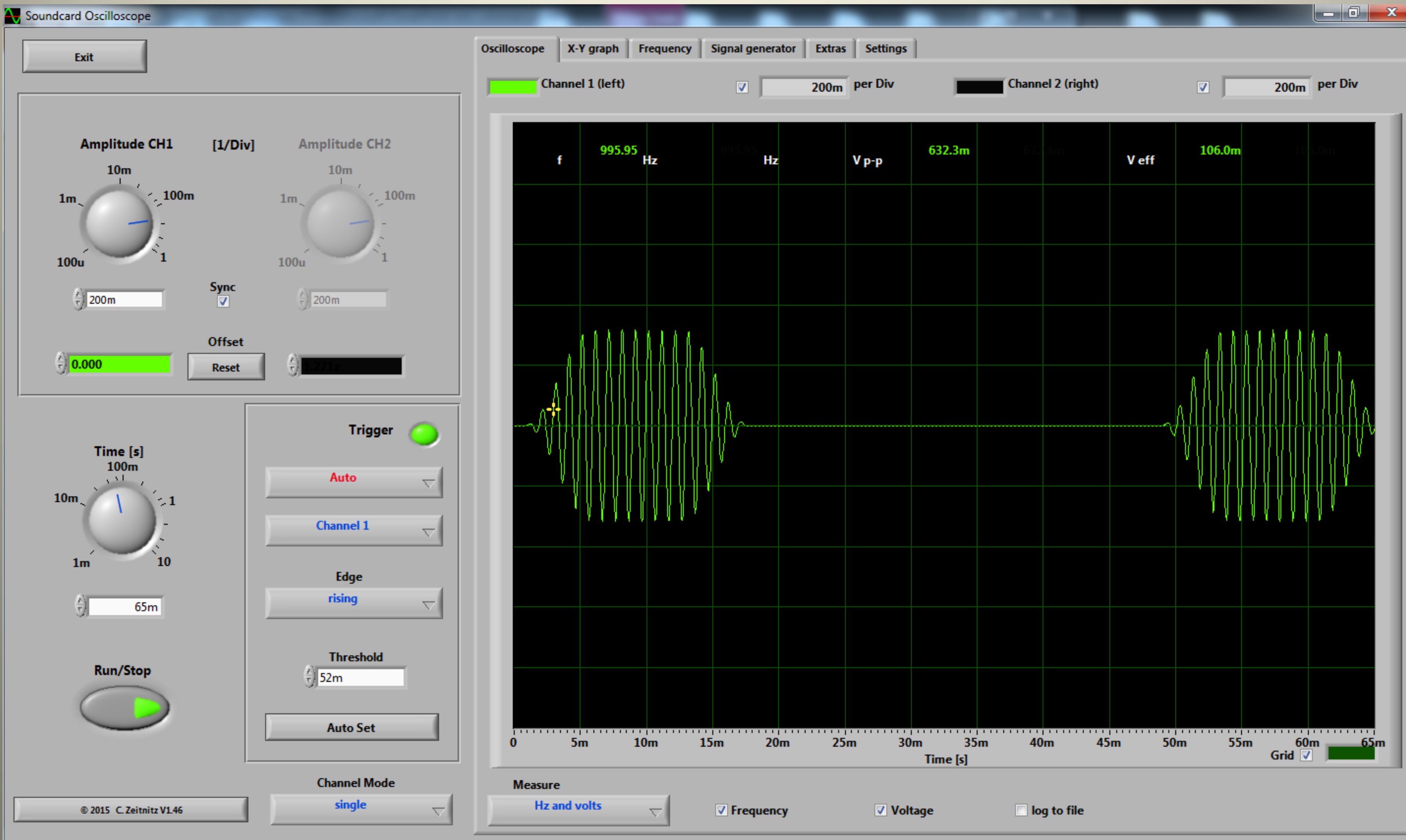
*** do not use noise "blankers" or noise "clippers" ***

What is the minimum “bandwidth” of a CW signal operating at 30 wpm

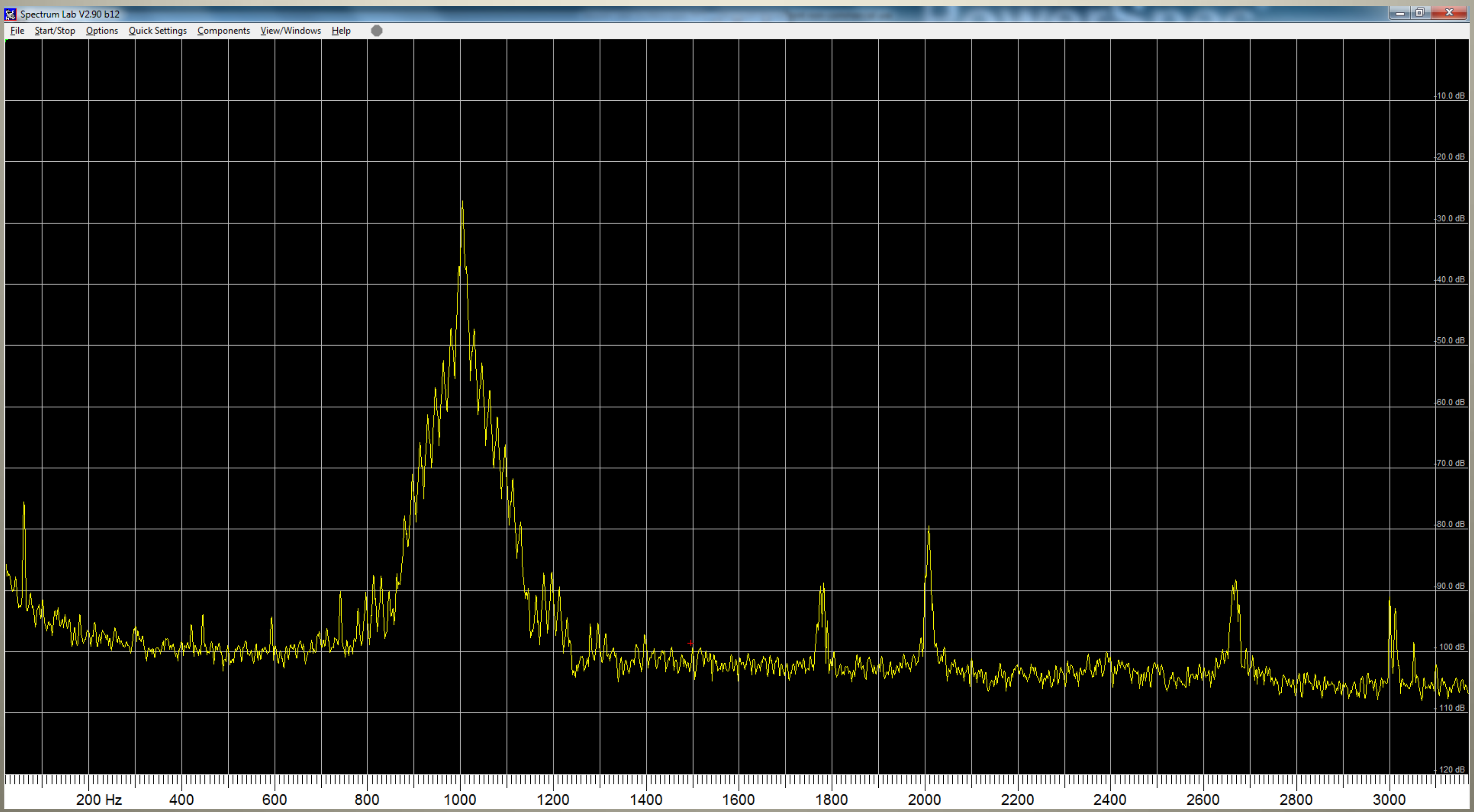
What factors determine the “bandwidth” of a CW signal?

How might an oscilloscope help you transmit a cleaner CW signal ?

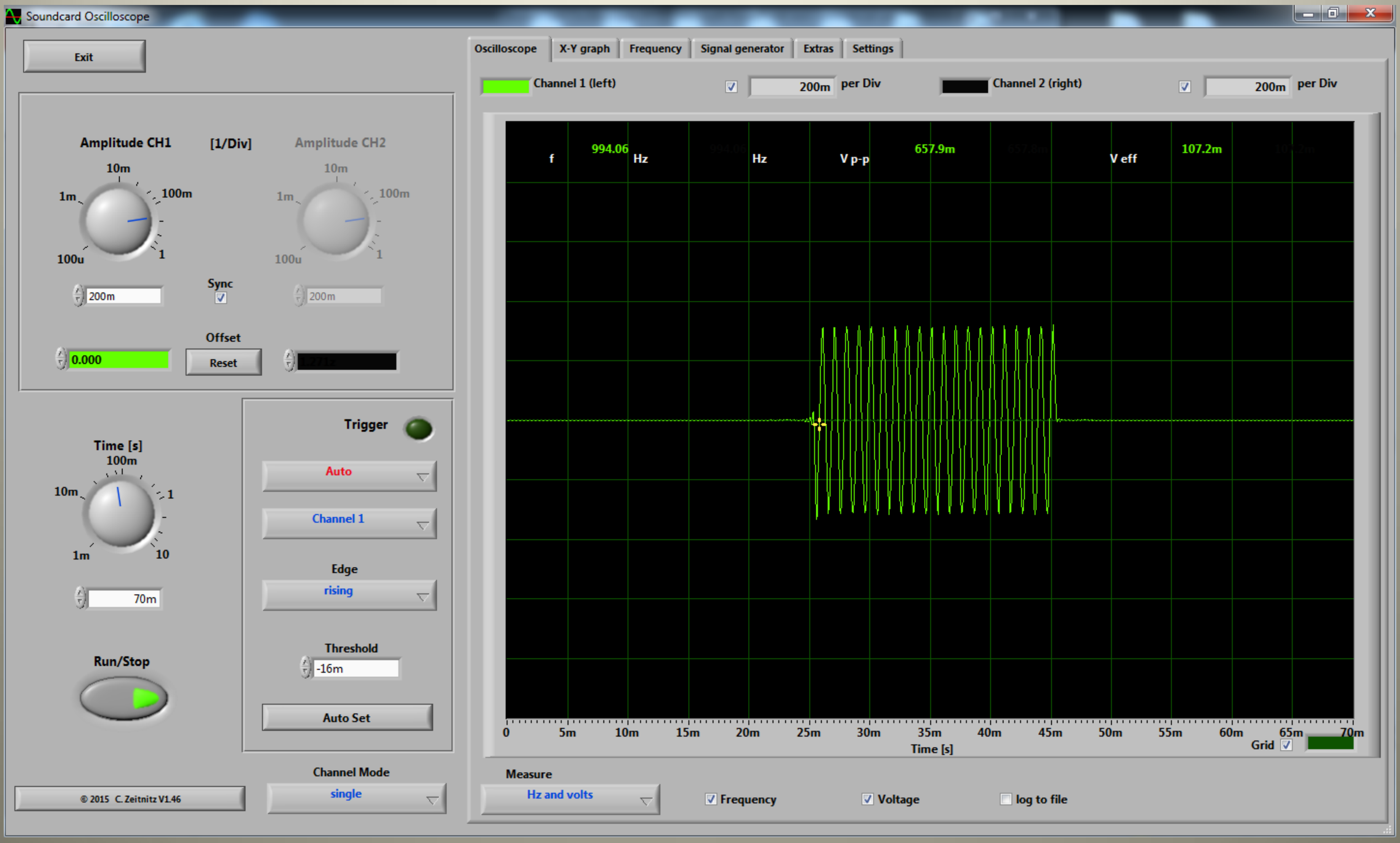
CW: dits (e) at 30 wpm
note the 4 millisecond "rise/fall times"



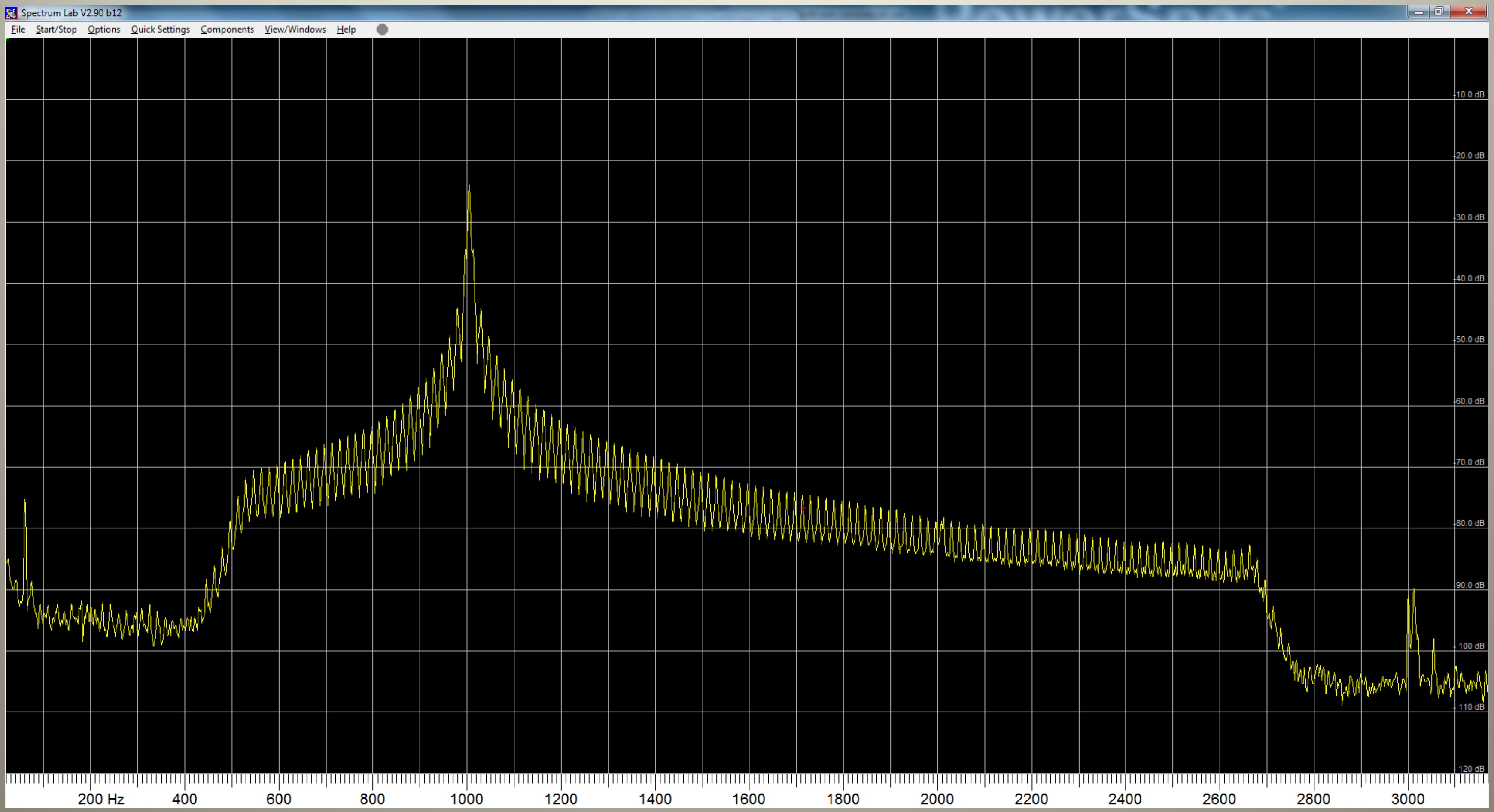
Spectrum of a "clean" CW TX at 20 wpm
center 1000 Hz 6 ms rise/decay times
bandwidth 200 Hz @ -50 dB



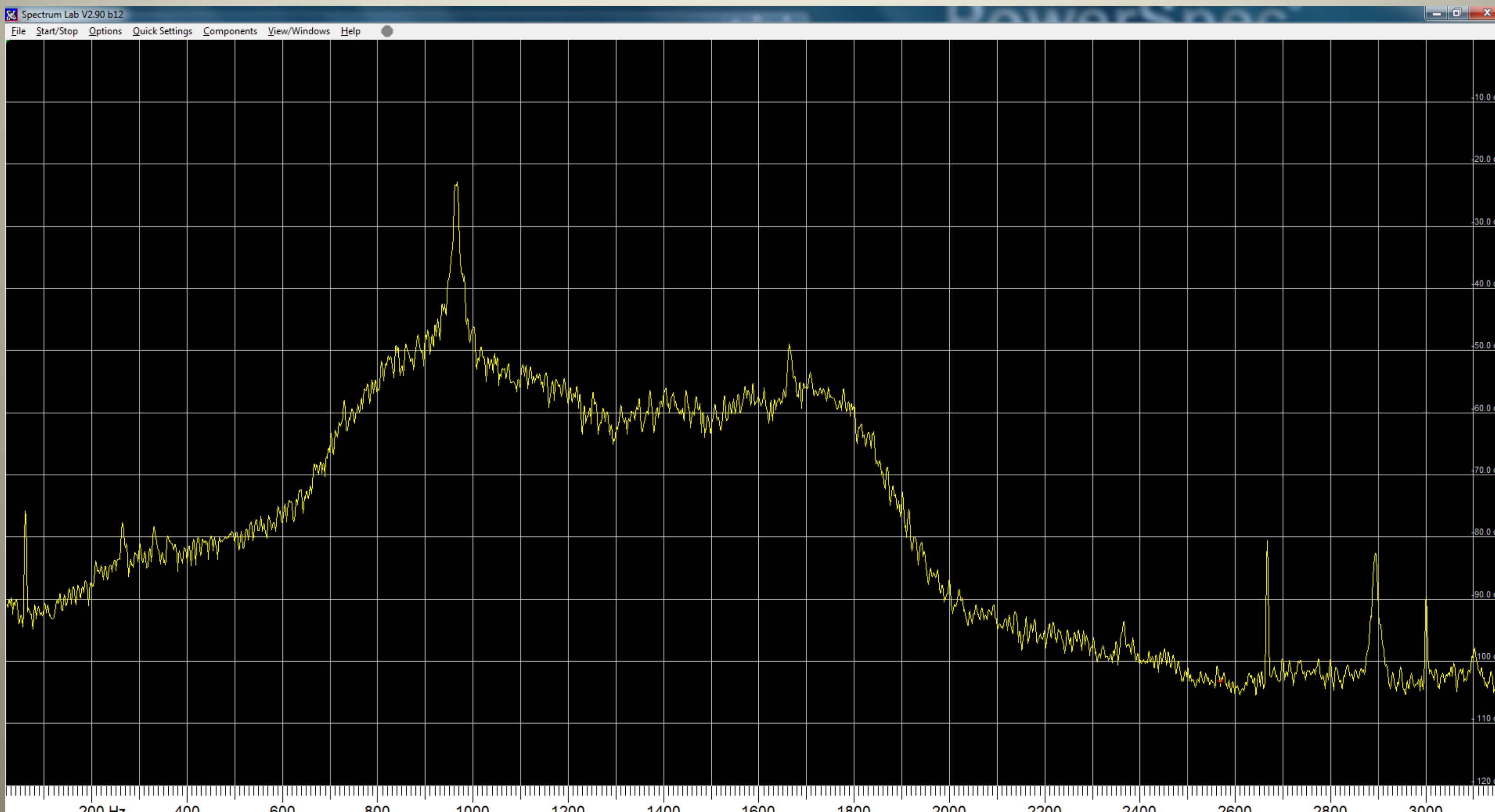
Turning the RF on/off too quickly produces harmonics called "key clicks"



Spectrum of CW TX 20 wpm with "hard keying"
1 ms rise/decay times - increased bandwidth
many sidebands - "key clicks"



“clean” CW received on 40 meters from K4DAL (Va)
He was sending @20 wpm with a keyer and TenTec Jupiter
my RX IF bandwidth set for about 1 kHz



RTTY: radio teletype

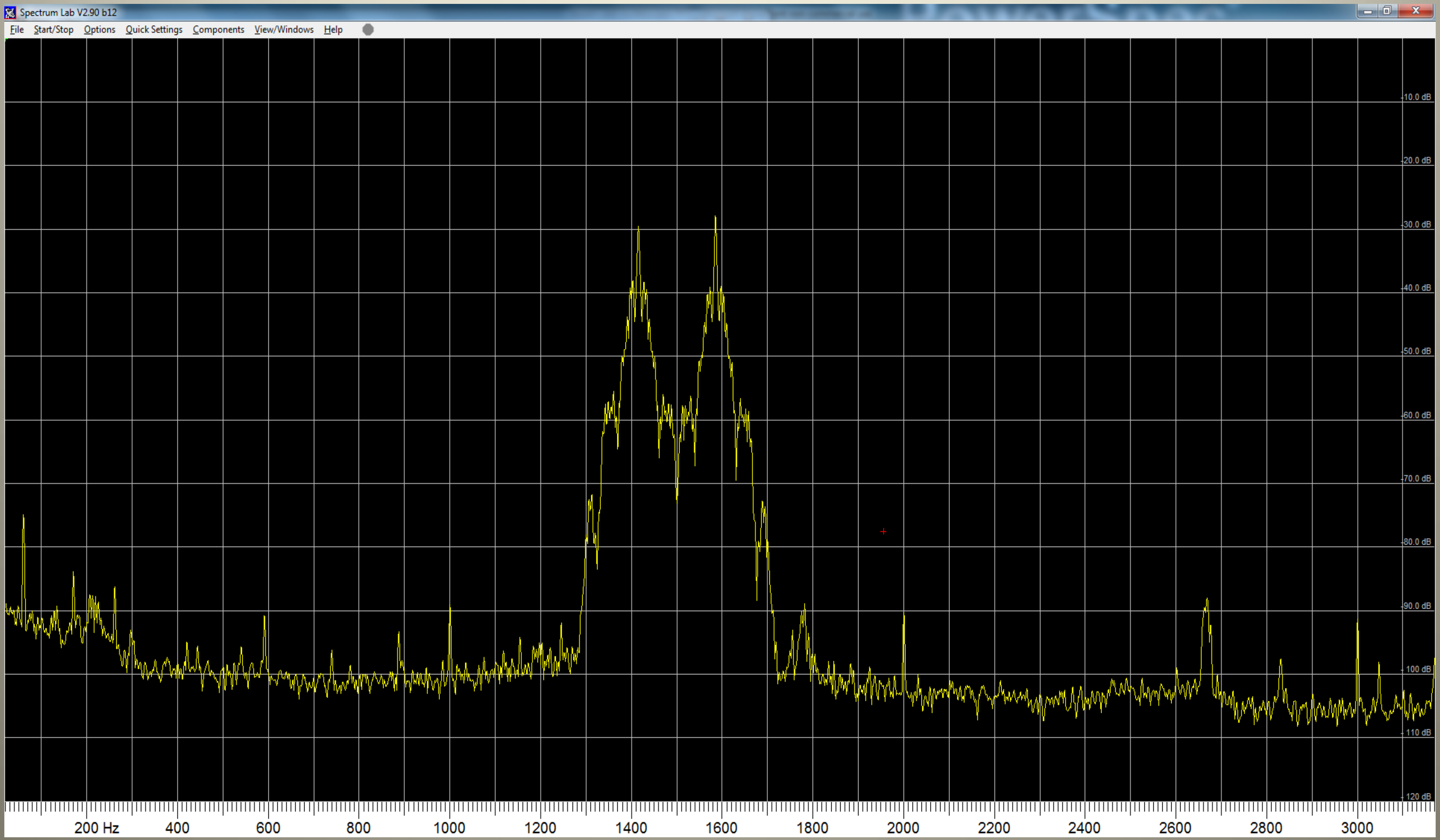
Rather than ON/OFF keying, like CW, why not just switch the carrier between two different radio frequencies (mark/space) to send the 0's and 1's

Pros: no time for "noise"
easy, fast, reliable, good for contests
FM rather than AM modulation
constant amplitude signals (linear amp not needed)

Cons: hard on finals ==> continuous duty cycle
takes more bandwidth than CW

Common RTTY: 45 baud (22 millisecond per symbol)
170 Hz shift, 60 wpm, 350 Hz bandwidth

Conventional two-tone RTTY
45 baud, 60 wpm, 400 Hz wide @ -60 dB



Problems with RTTY 45 on HF

Fading and phase delays due to changing ionospheric refraction (not reflection) of the EM wave

Poor on “long path” contacts around the world when you get “echo-like” signals

5 bit Baudot code ==> same time to send any character and no lower case, only UPPER CASE and numbers

No FEC or any kind of error detection

Data Rate vs. Symbol Rate

What if instead of binary modulation
on/off CW (0/1)
or mark/space RTTY (0/1)

You use 4, 8, 16, or 32 different audio tones in each “symbol”?

Then each “symbol” could carry more information, but needs more bandwidth, hence we have

MFSK, Olivia, Domino, THOR modes

Multi Frequency Modes

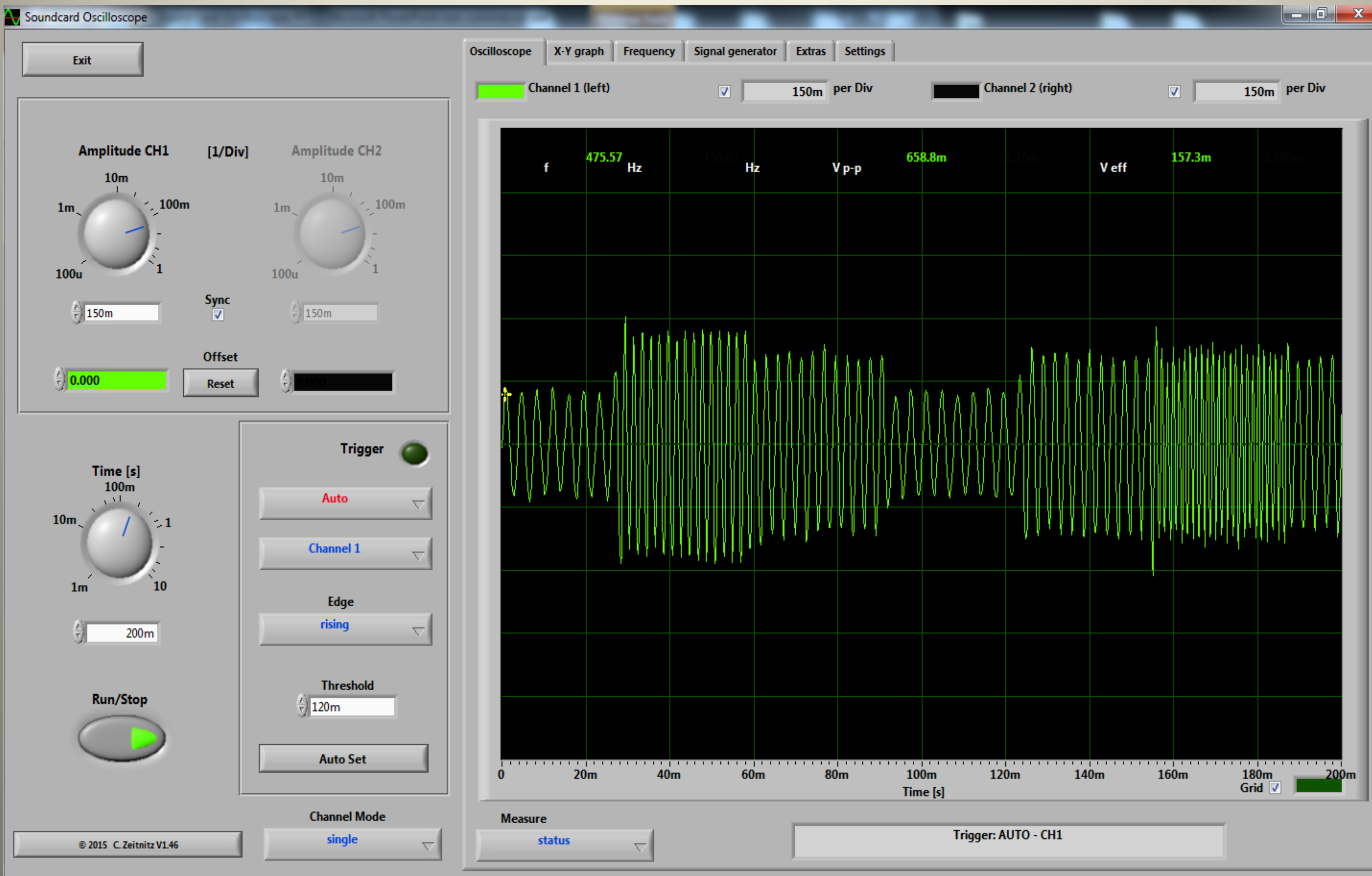
Each tone (sent one at a time) represents more data

MFSK 8/16/32/64/128 (3bit,4bit,5bit,6bit,7bit)

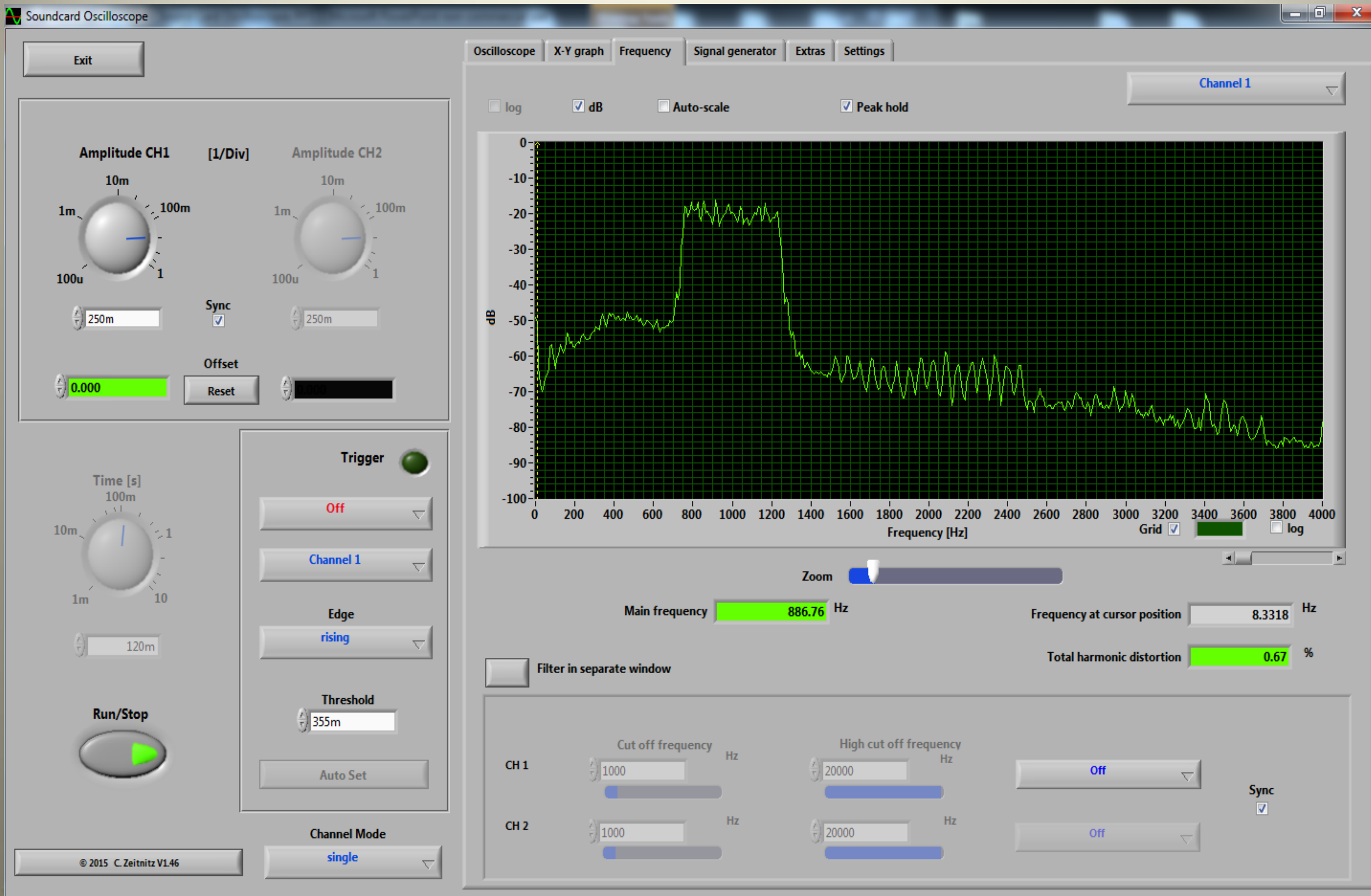
In F1B modes (FM) the amplitude shifts are ignored and we find noise (qrn) is mostly amplitude shifts

MFSK is a very sensitive mode on HF bands like 80/40/20 meters, works well with low power and simple antennas

MFSK   Oscilloscope View: energy vs. time
nearly constant amplitude with frequency changes



MFSK32 Spectrum View: 500 Hz wide



Problems with MFSK

The sound card/processor must be able to distinguish one tone from its adjacent tone in the presence of HF "noise" and "phase distortion" in the ionosphere.

Hence, there is a minimum spacing between tones.

Switching tones too quickly (high baud) causes errors due to phase and time distortions produced by ionosphere

Popular HF MFSK modes

MFSK 8 (32 tones, 36 wpm, 316 Hz bandwidth)

MFSK 16 (16 tones, 58 wpm, 316 Hz bandwidth)

MFSK 32 (16 tones, 120 wpm, 630 Hz bandwidth)

Olivia

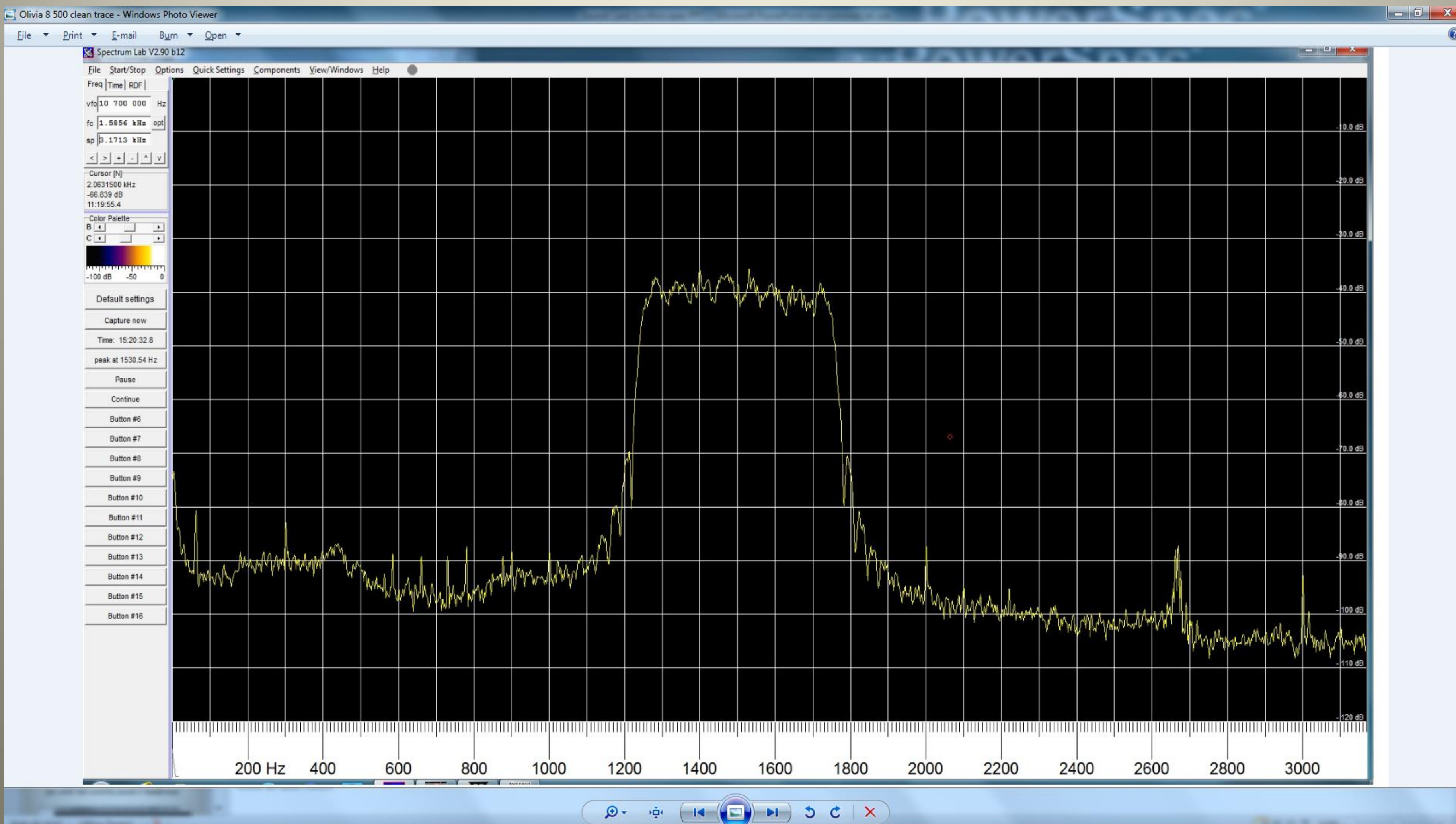
(named after the author's daughter)

Designed for copy under marginal S/N (-10 dB)
Has FEC (forward error correction)
Upper and Lower case
Resistant to qrn, qrm, qsb, frequency drift
Sounds like a calliope at a carnival

Speed, Tones and Bandwidth vary

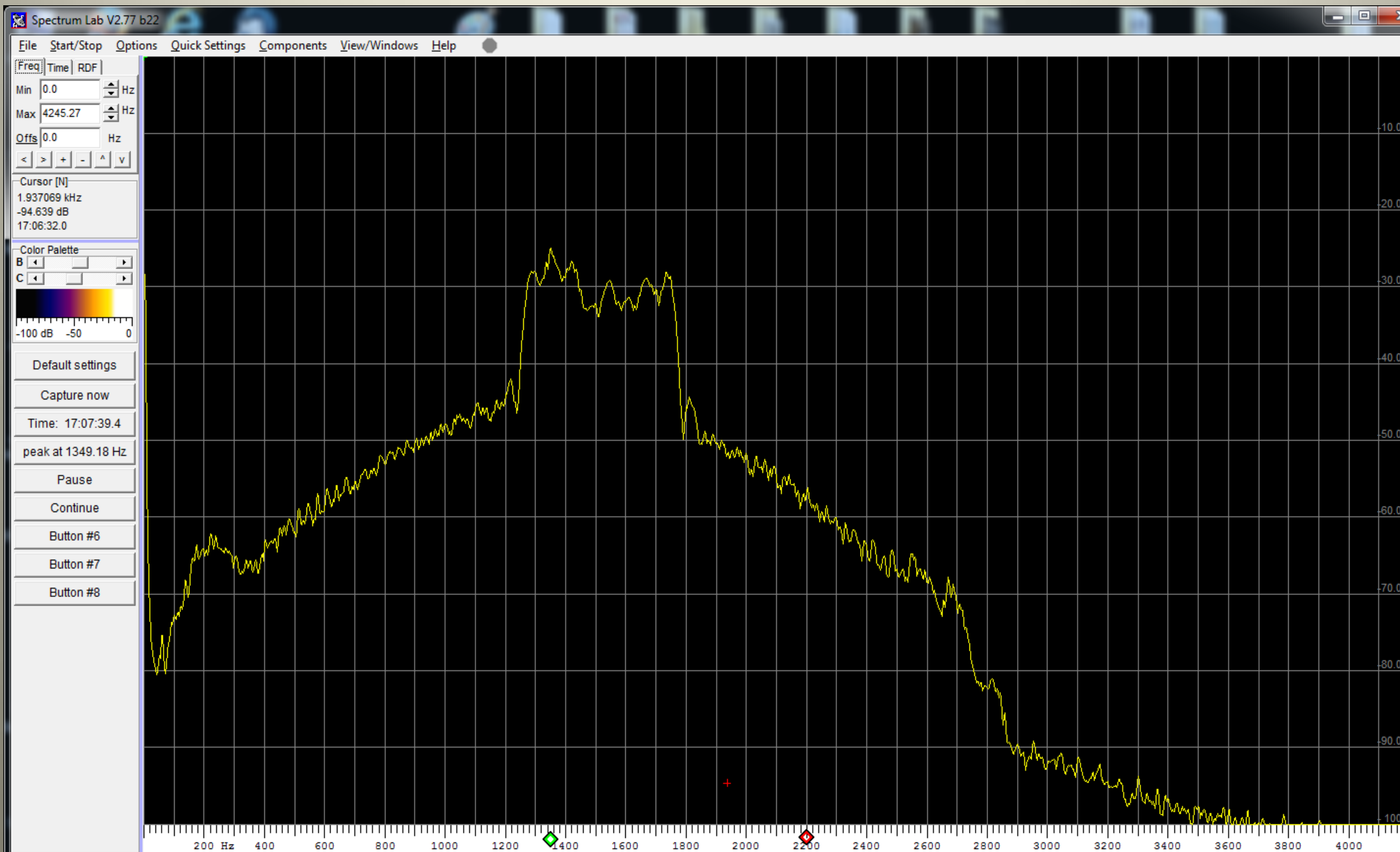
Olivia 4/8/16/32/64/128 number of tones (one at a time)
Olivia 125/250/500/1000/2000 Hz bandwidth
Olivia modes are 31 baud, 63 baud, or 125 baud

Olivia 8/500 Spectrum:
8 tones, 500 Hz bandwidth, 63 baud, 30 wpm
signal is 50 dB above baseline noise
This is what a "clean" Olivia 8/500 signal should look like



Olivia 8/500 TX signal "over-driven" into ALC action

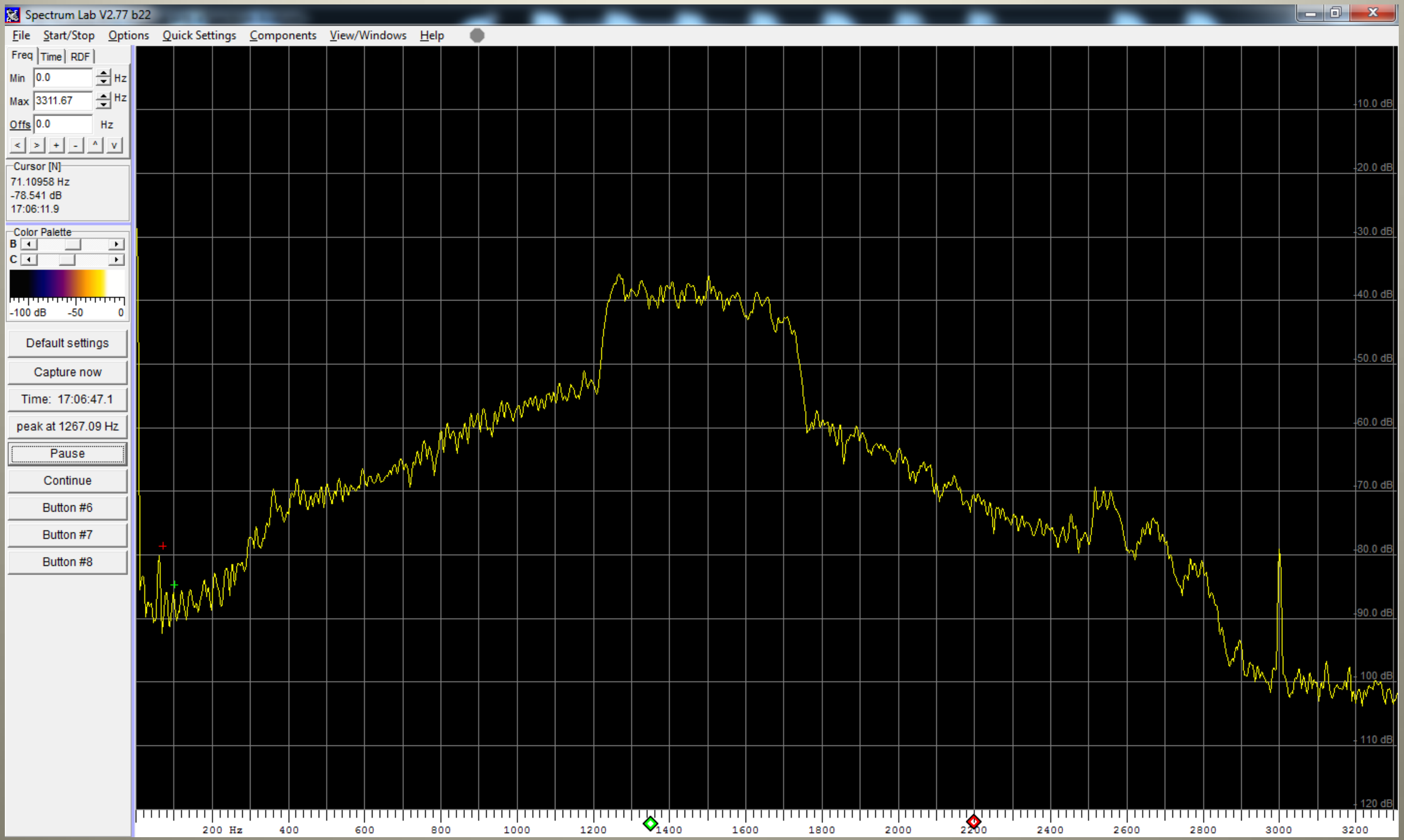
bandwidth 1700 Hz @ -30 dB causes "splatter"



Distorted Olivia 8/500 signal

received on 40 meters PA-NBEMS net

(you could hear scratchy sounds in headphones)



THOR

Uses a type of modulation called "incremental frequency shift"

18 tones are sent one at a time at constant amplitude (F1B)
but the CHANGE IN PITCH from one tone to the next tone is what determines the symbol, not the actual pitch of the tone (MFSK, Olivia)

THOR is very tolerant of drift in your radio's vfo or drift in your sound card's oscillator (+/- 100 Hz is ok)

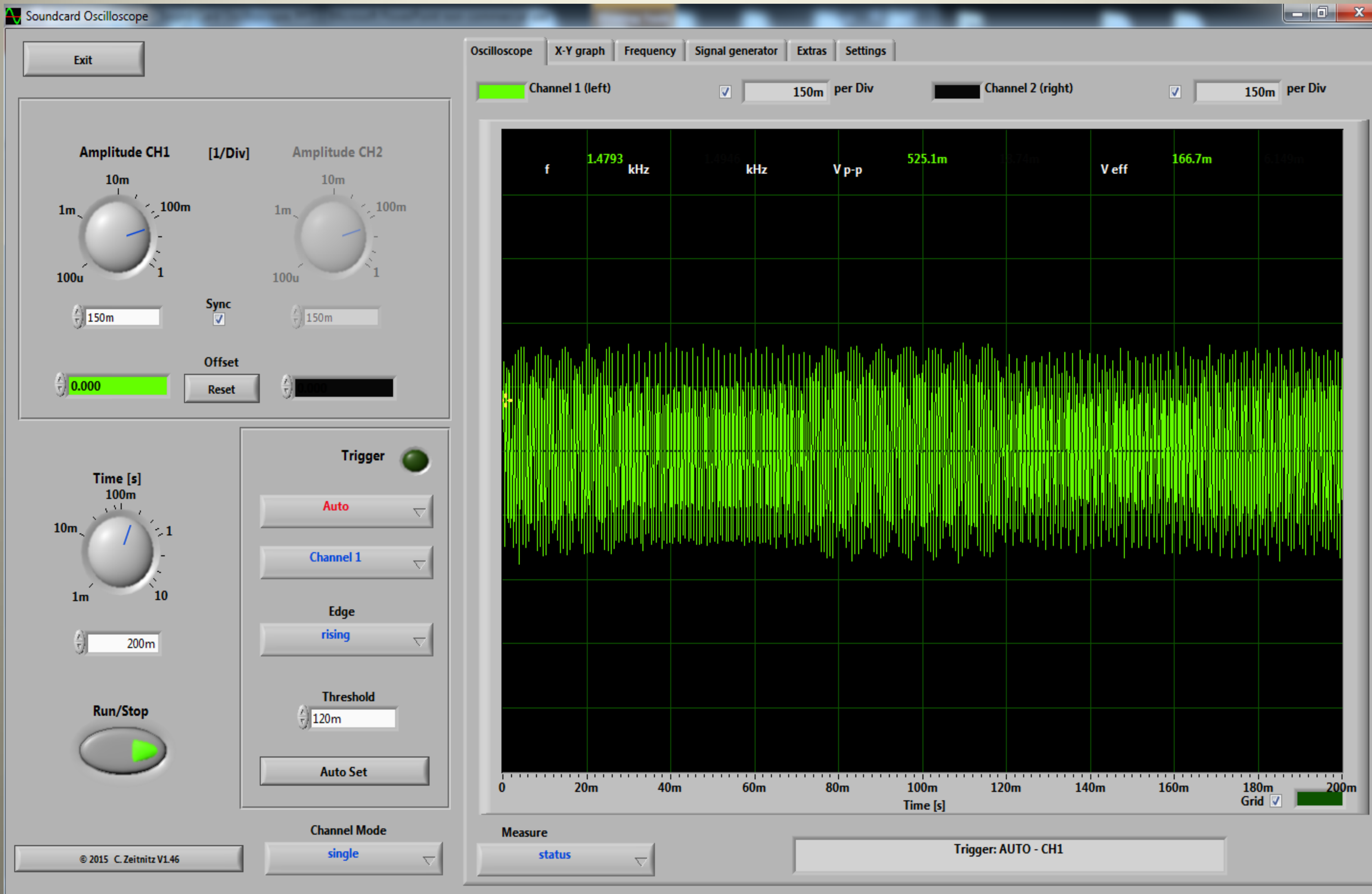
MODES: Thor 4,5,8,11,22,50,100 baud

Speed from 14 to 350 wpm

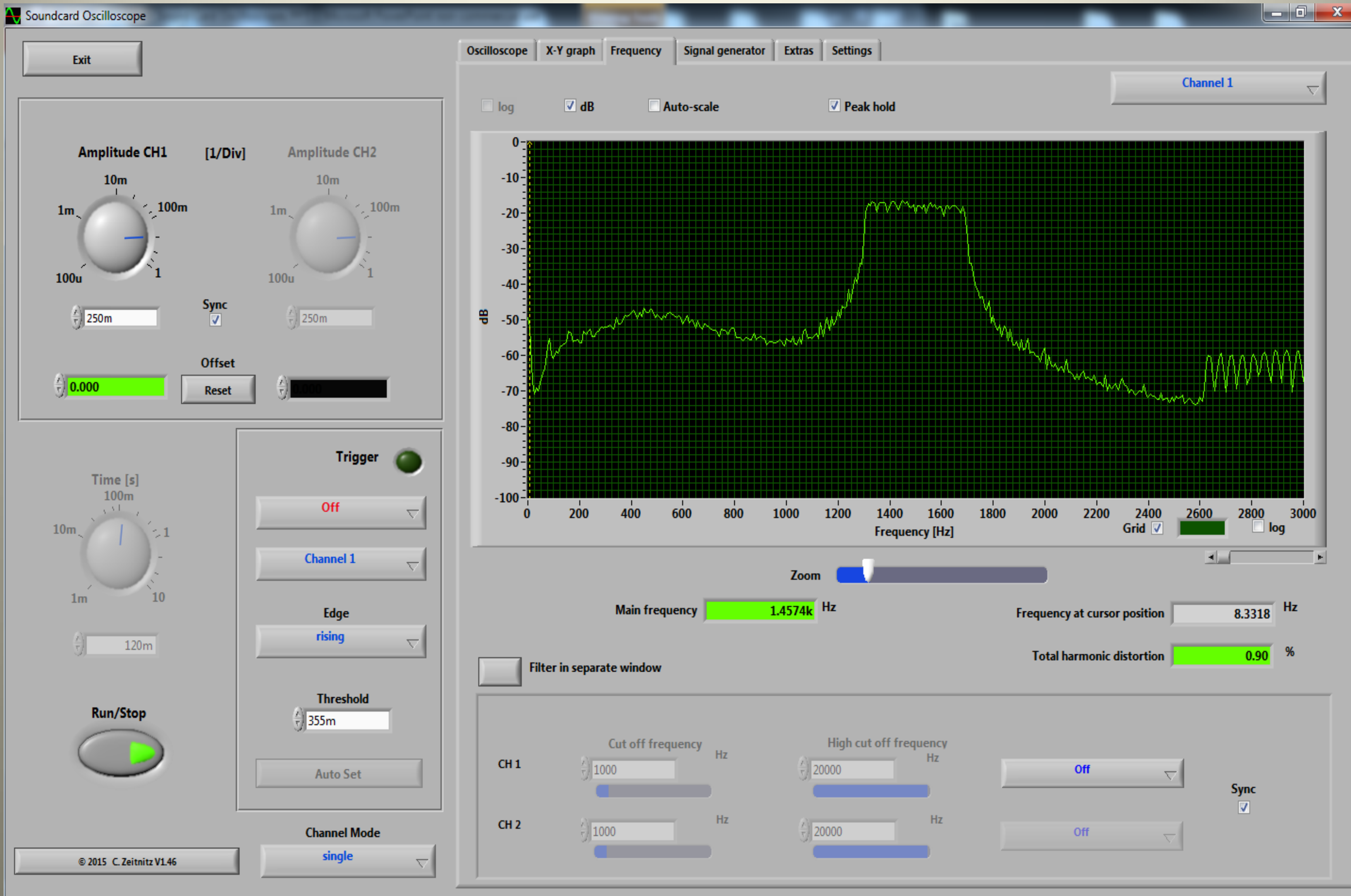
Secondary Channel: call, grid, etc.

THOR 22 Oscilloscope View

nearly constant amplitude, 22 baud, 78 wpm, 524 Hz wide

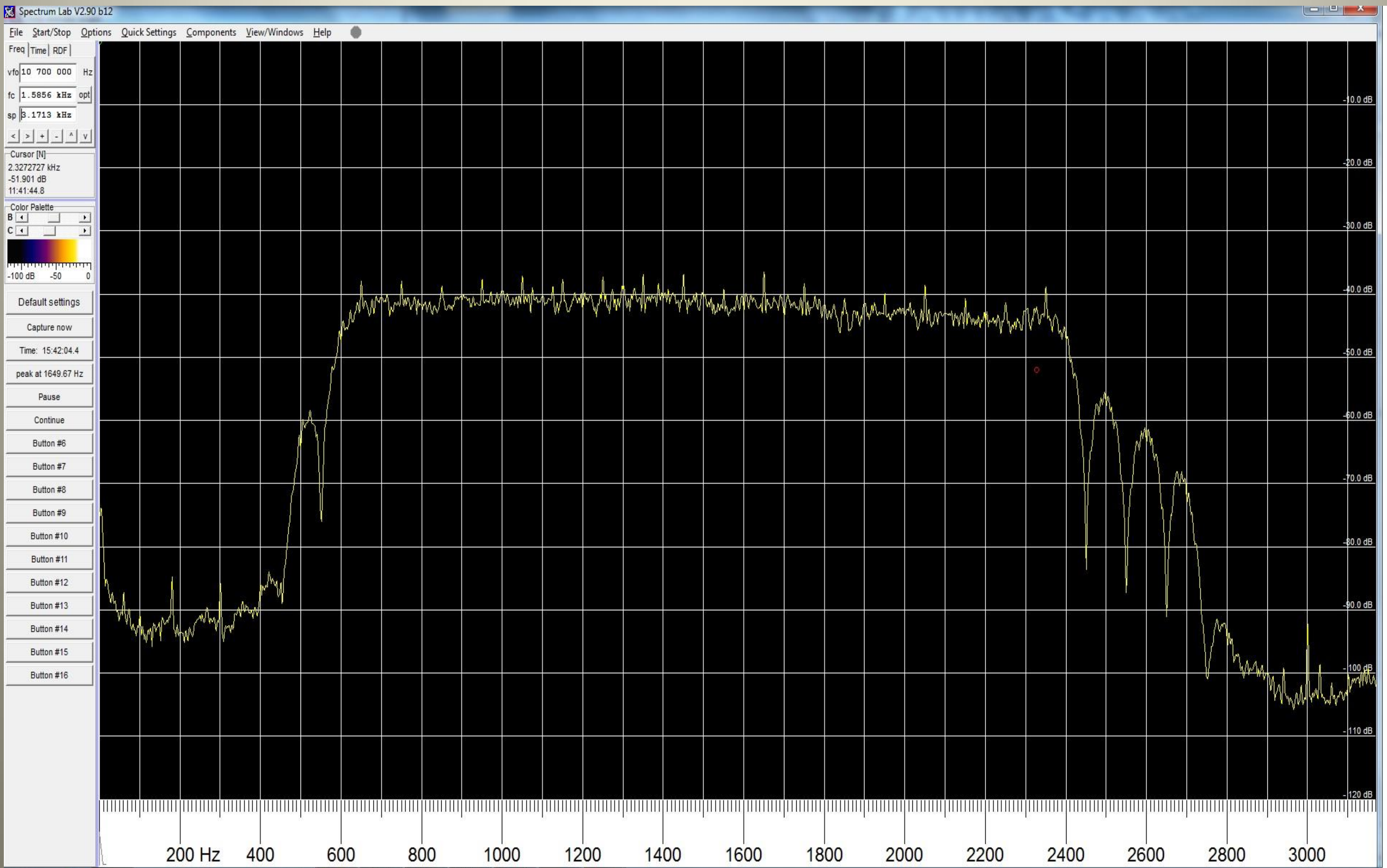


THOR 22: Spectrum View



THOR 100

97 baud, 352 wpm, 1800 Hz bandwidth



BPSK modes

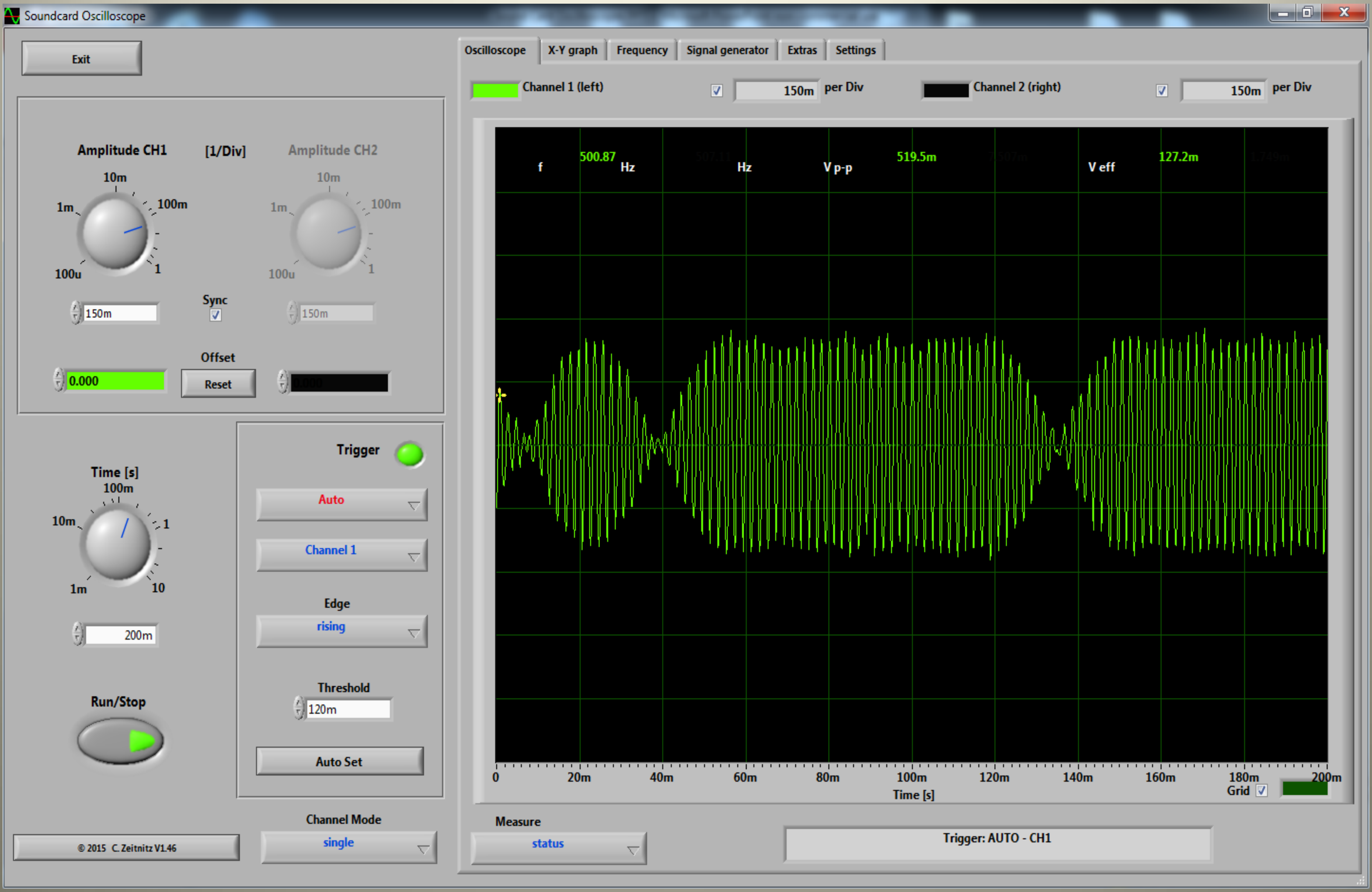
Advantages of Phase-Shift Keying (PSK)
over amplitude keying? (CW)
over frequency keying? (RTTY, MFSK, Olivia, Thor)

BPSK31 about 60 Hz bandwidth, 50 wpm, no FEC

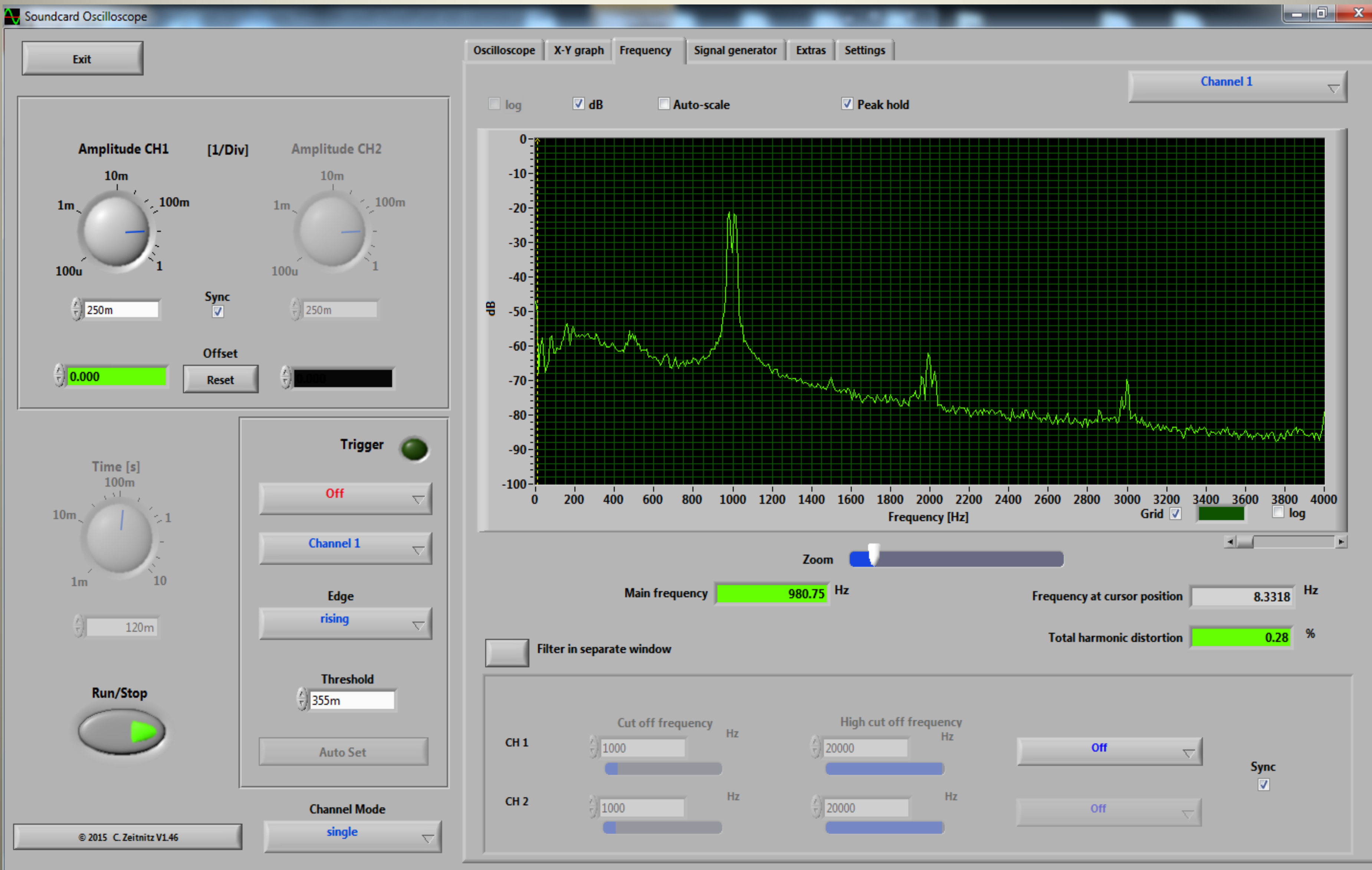
Pros: upper / lower case
superbrowser capability: translate multiple signals
efficient use of limited RF spectrum
no need for high power

Cons: needs a linear amplifier
no FEC (no error detection/correction)

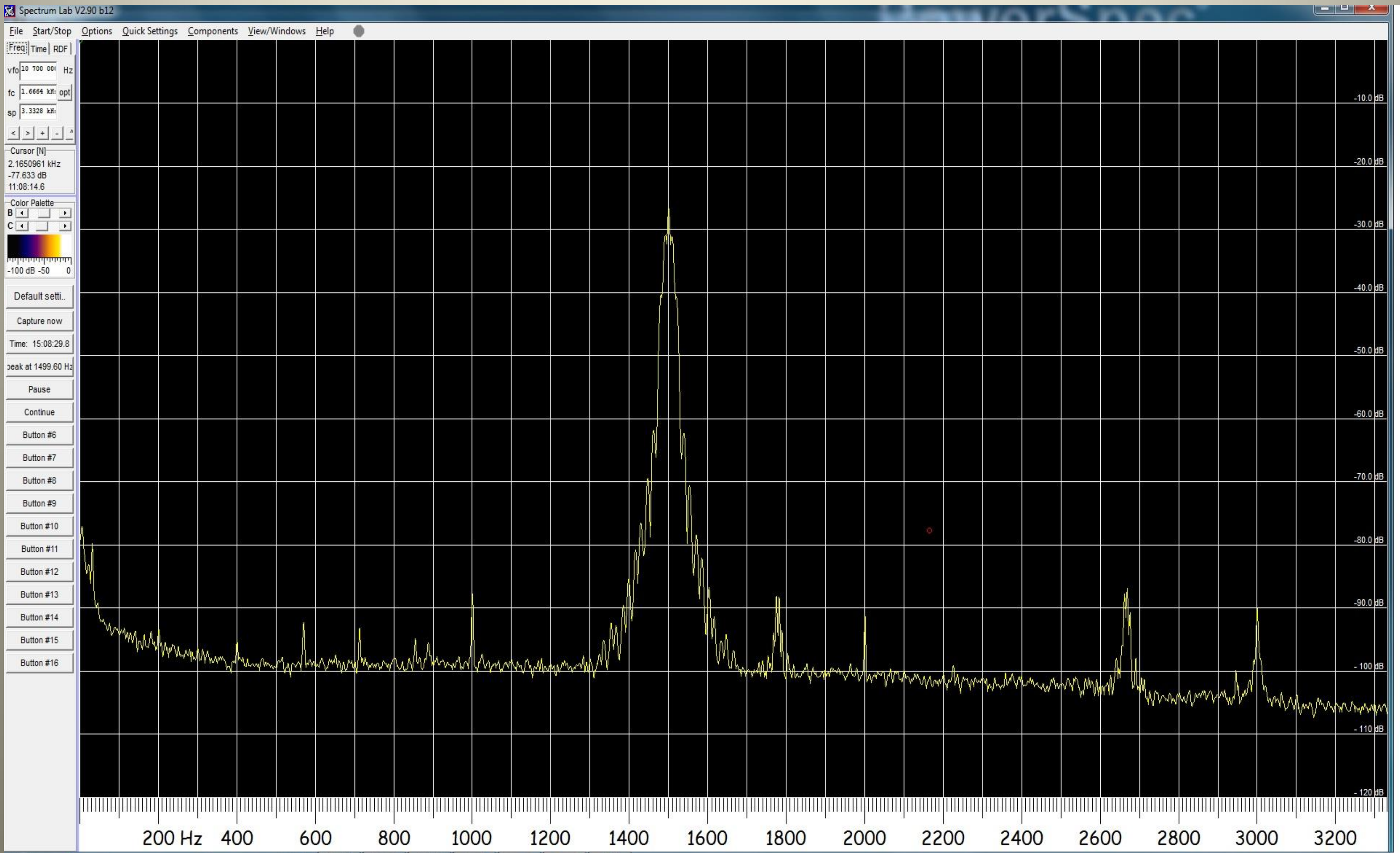
PSK31 Oscilloscope view: 32 ms per "symbol"
0 = phase shift 1=no phase shift



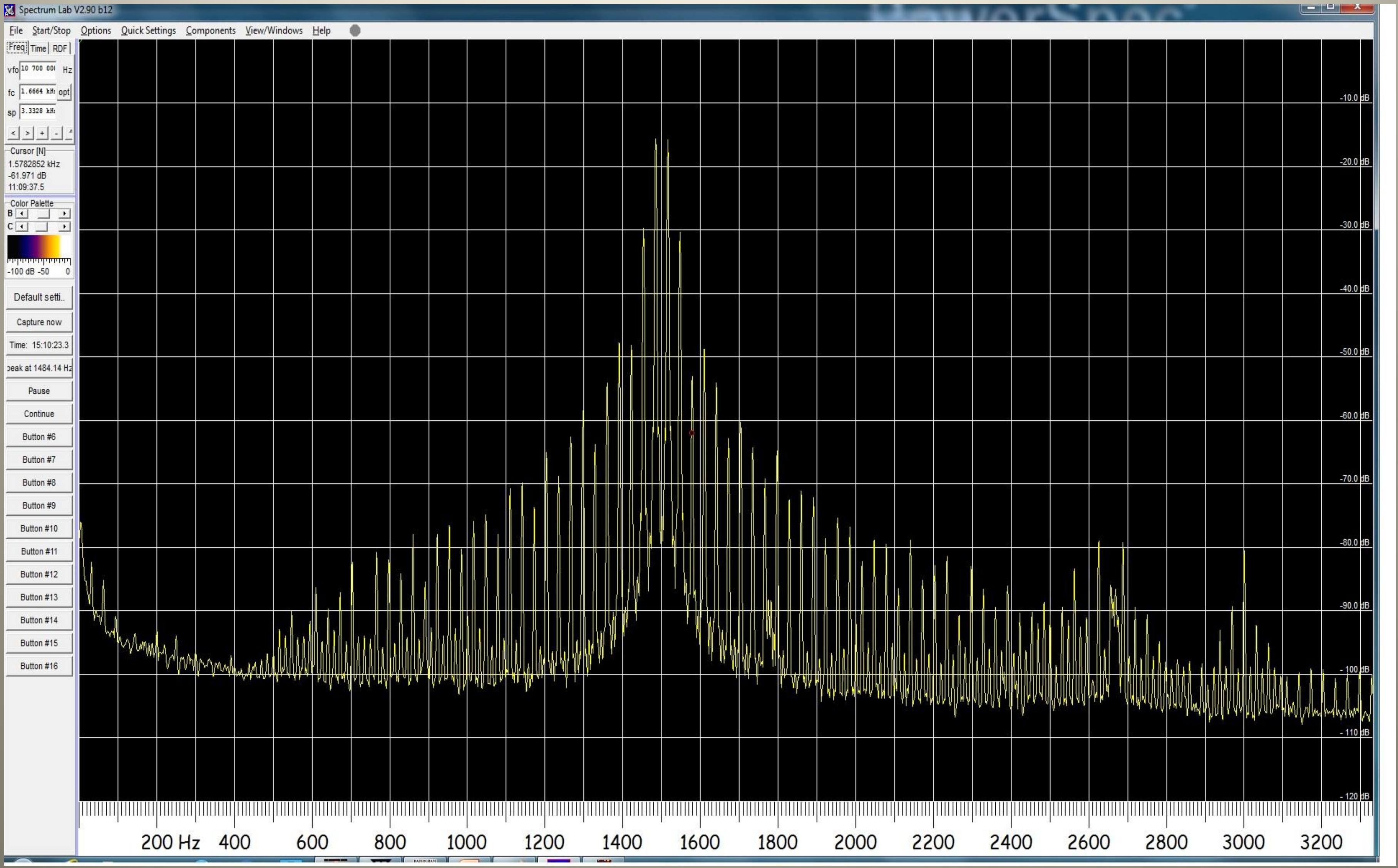
BPSK31 Spectrum View: bandwidth <100 Hz
note slight 2nd and 3rd harmonic (down >30 dB)



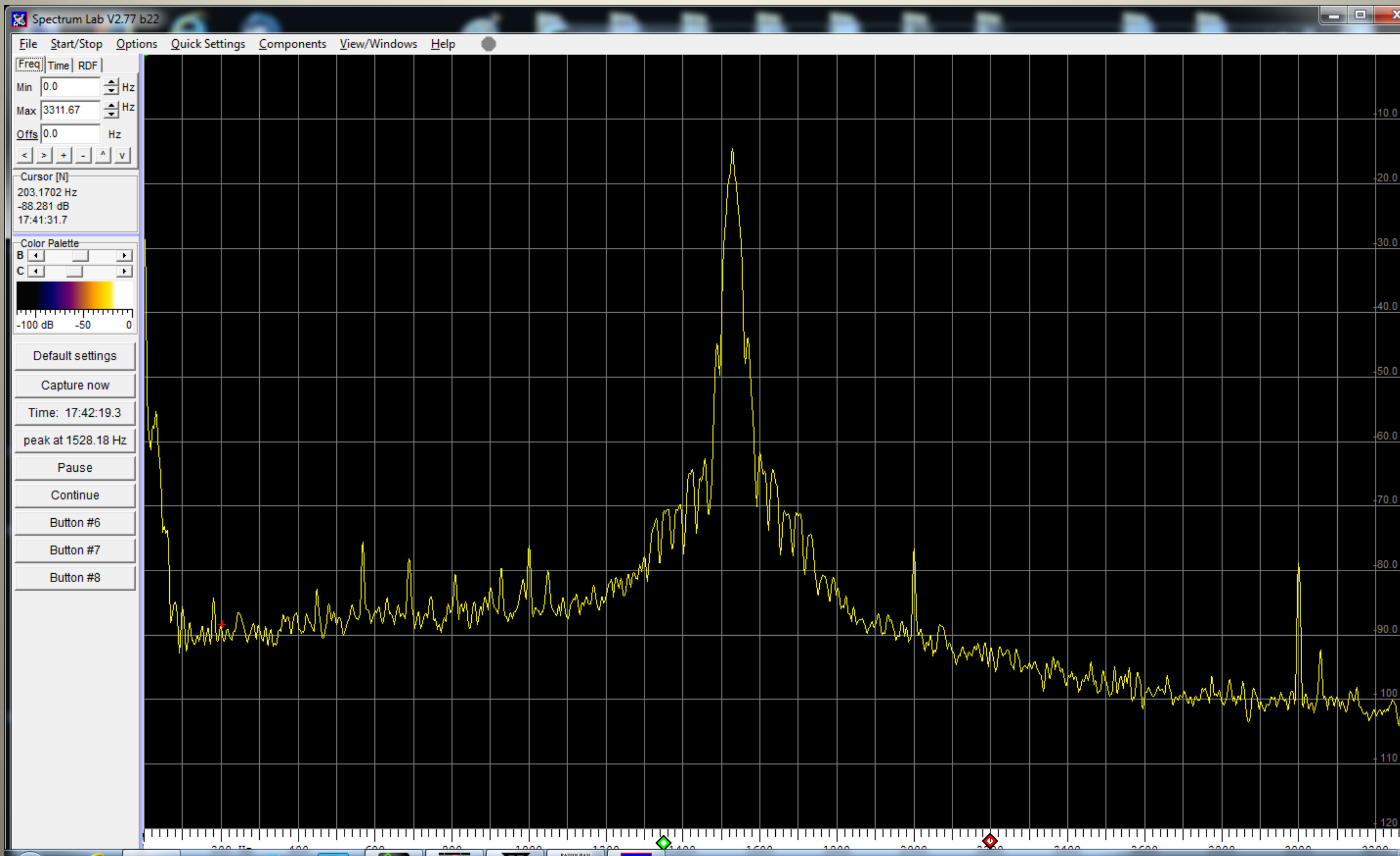
"clean" BPSK31 TX with no ALC
TX bandwidth 150 Hz @ -50 dB



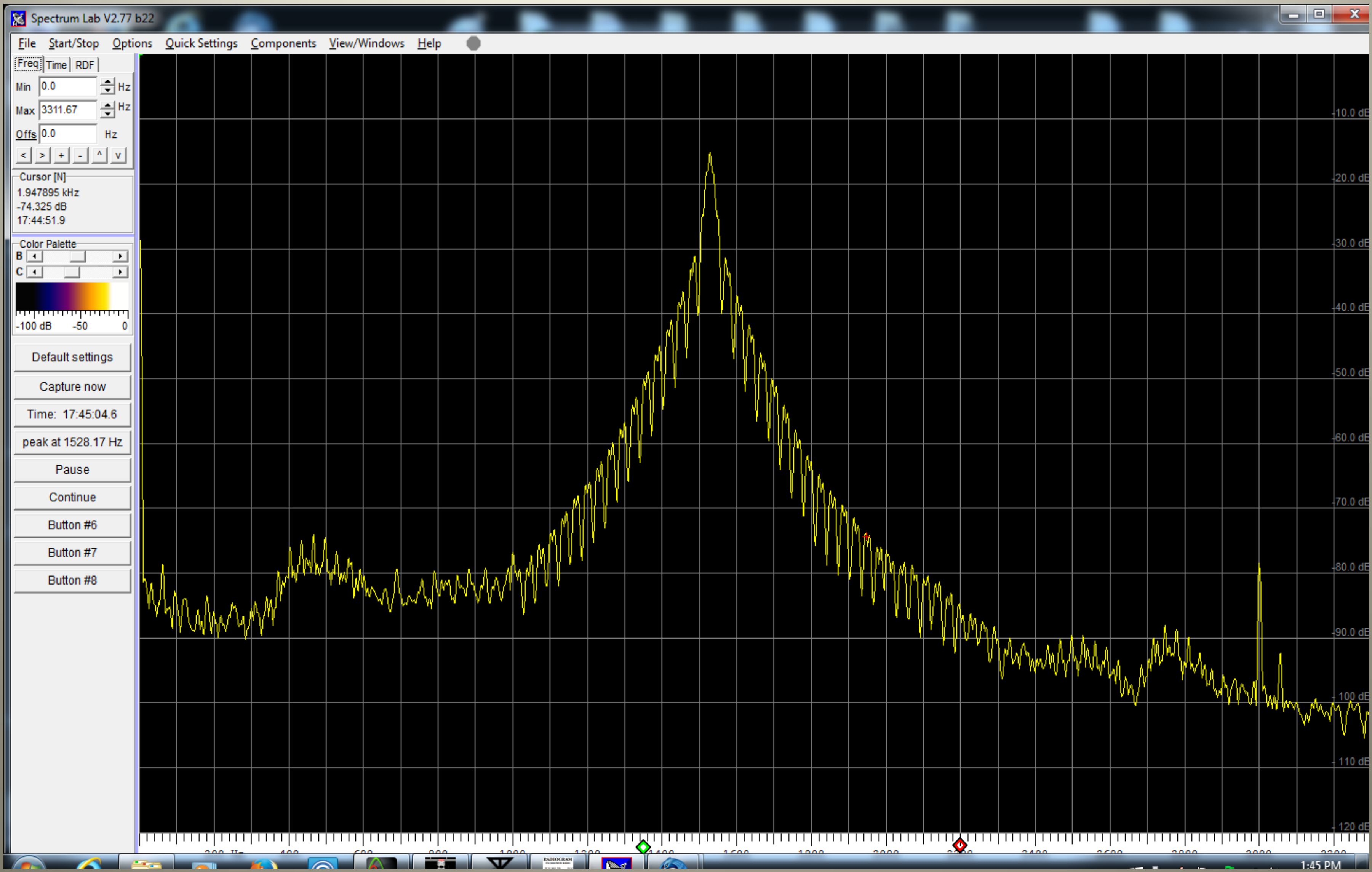
Wide BPSK31 - TX driven into excessive ALC
TX bandwidth 600 Hz @ -50 dB



Example of a CLEAN BPSK31 signal received on 20 meters



Example of a distorted BPSK31 signal received on 20 meters



8PSK modes

Remember: BPSK is a two-state system (shift/no shift)

8 PSK modes employ shifts of
0, 45, 90, 135, 180, 225, 270, 315 degrees

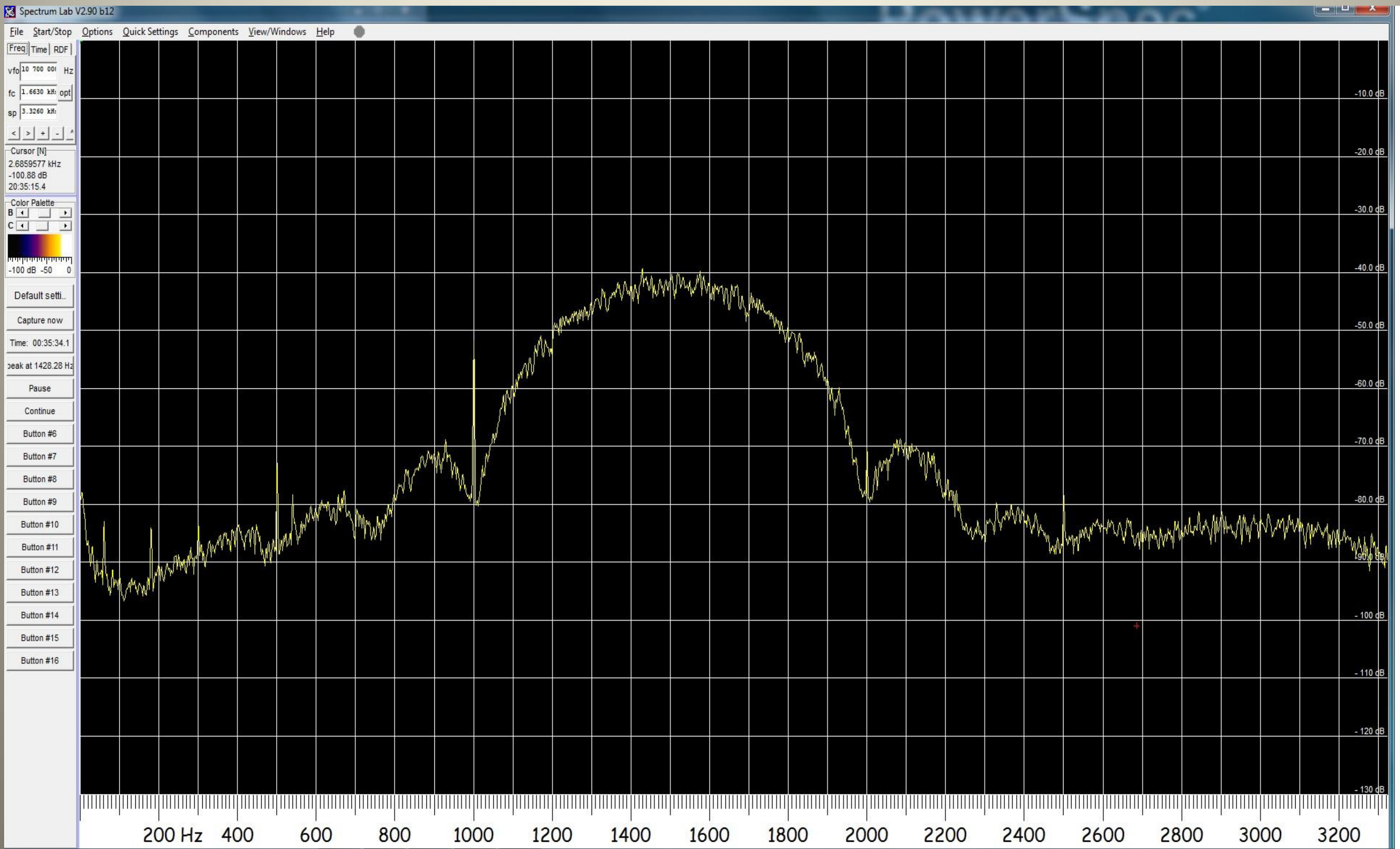
Each "symbol" contains more information: 8 "states" (3 bit)

8PSK1200F is almost 4000 words per minute
Ideal on VHF/UHF FM to send long FLAMP files
Ideal for ARES/RACES traffic

Con: takes more bandwidth

8PSK500F Spectrum View

note sidebands and “pilot tone” at 1000 Hz



Safety in Numbers?

BPSK31 is one carrier modulated at 31.25 baud ➔ 50 wpm

Why not send multiple simultaneous carriers each modulated with a psk information?

MT63 is born

64 carriers, each carrying an independent PSK signal

Choice of 5, 10, 20 baud (500, 1000, 1500 Hz wide)

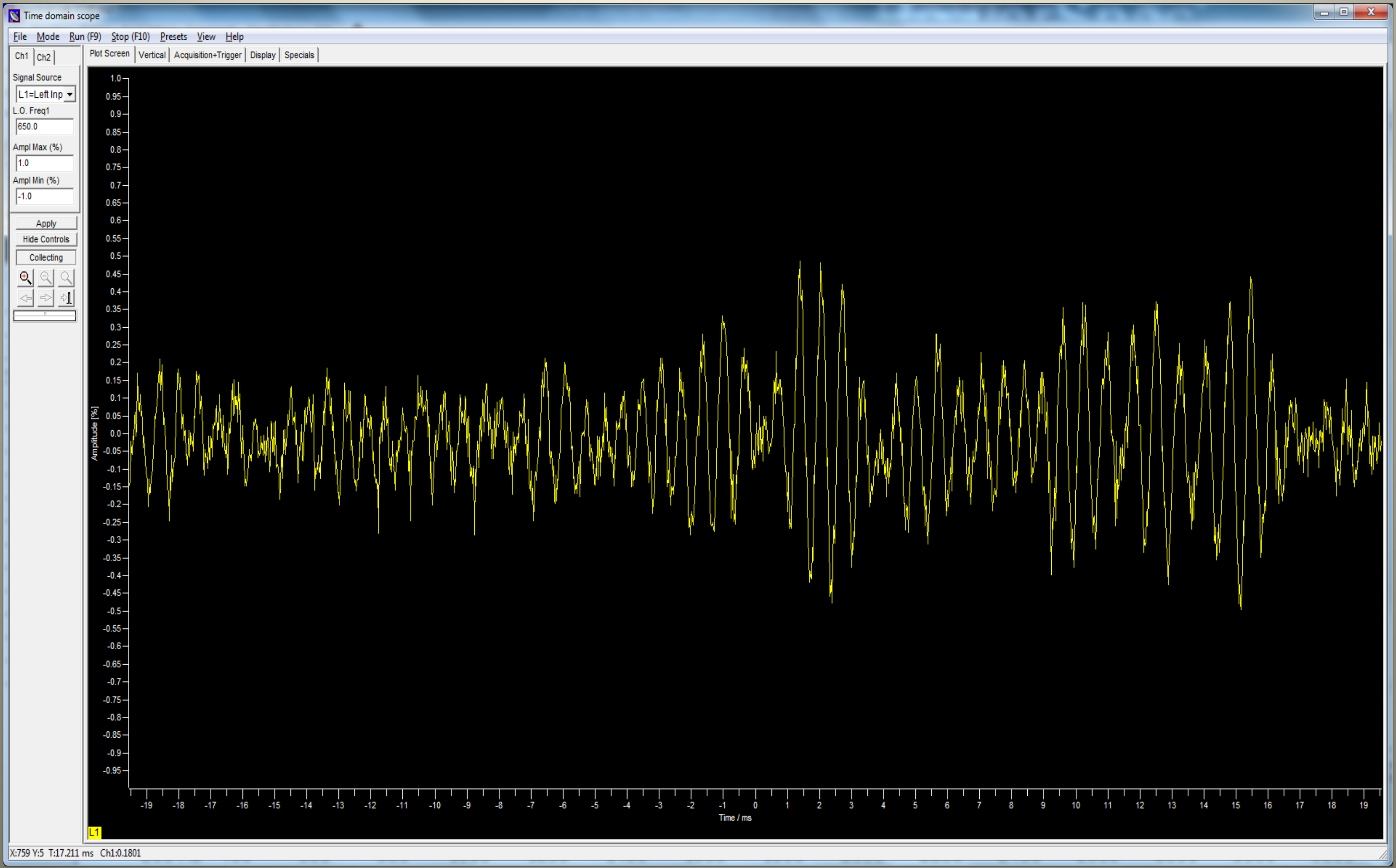
Speeds of 50, 100, 200 wpm

Pros: Highly immune to noise

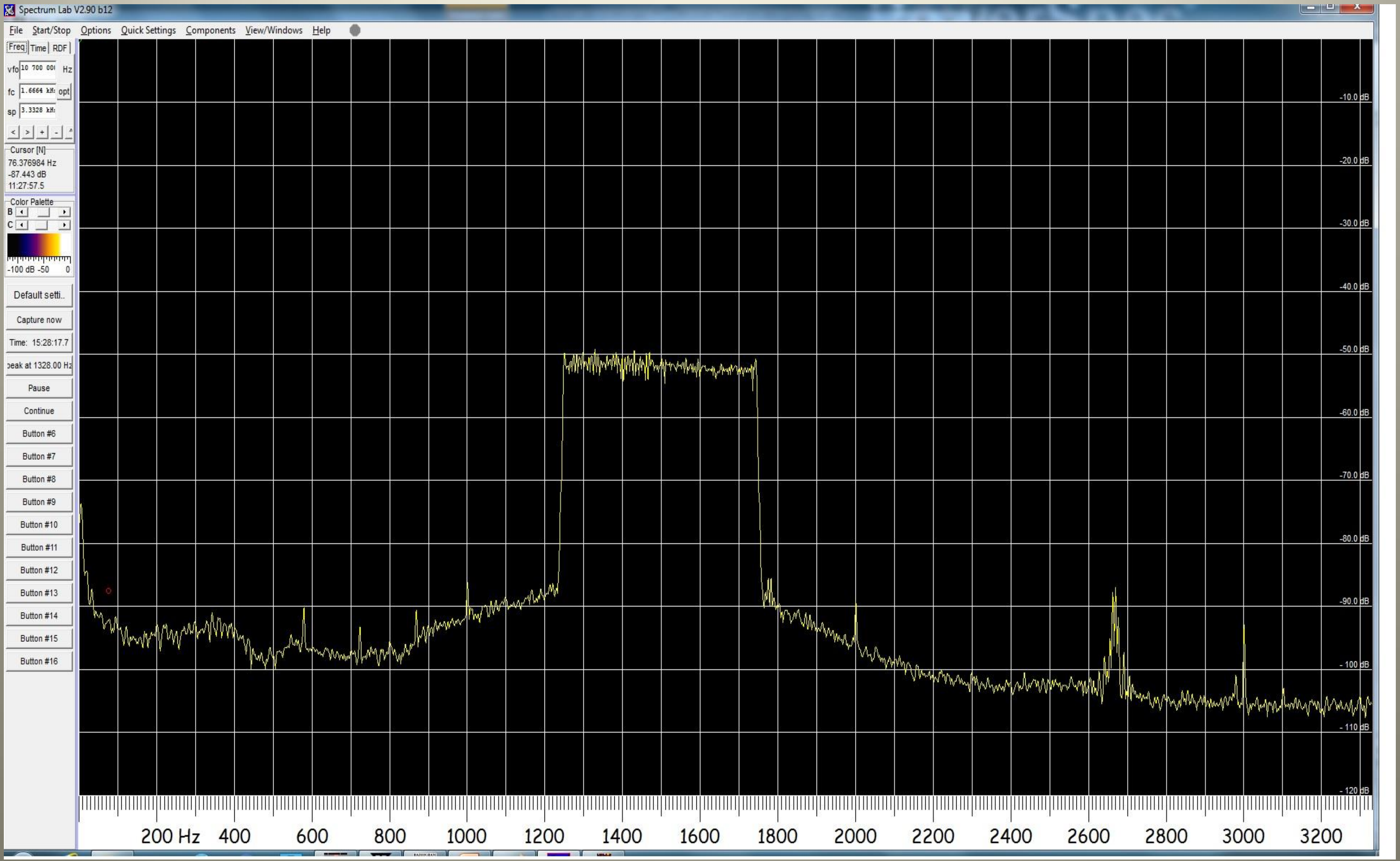
Works wonders on an FM repeater for ARES/RACES drills

Works on FM radios with "acoustic coupling"

MT63 - 500 in Oscilloscope View
note the high peak to average rates



MT63 - 500 Spectrum
64 carriers, 5 baud, 50 wpm



Speed vs. Sensitivity

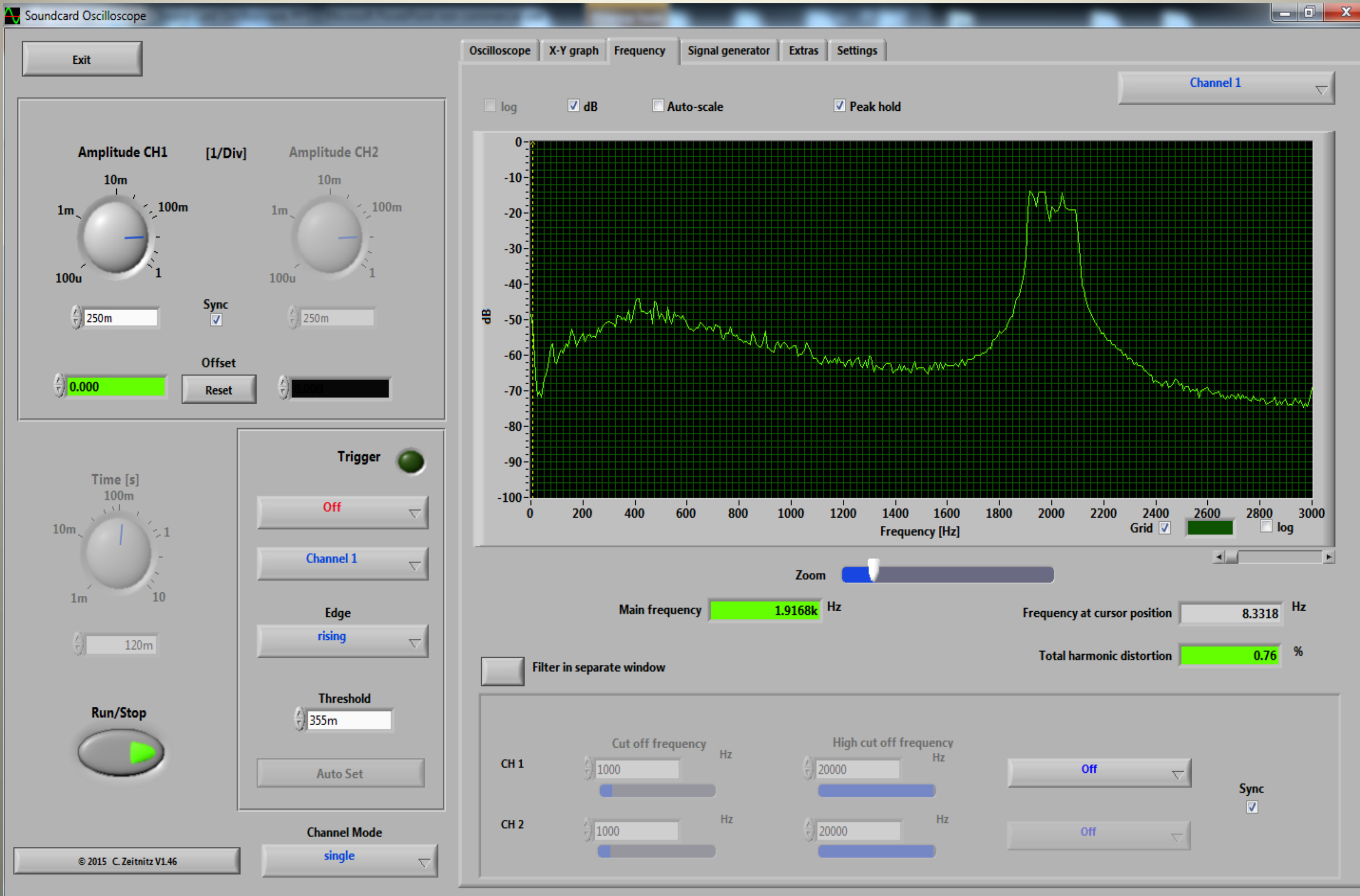
Highest sensitivity modes take more time to detect the signal from the "noise"

JT modes: JT65, JT9

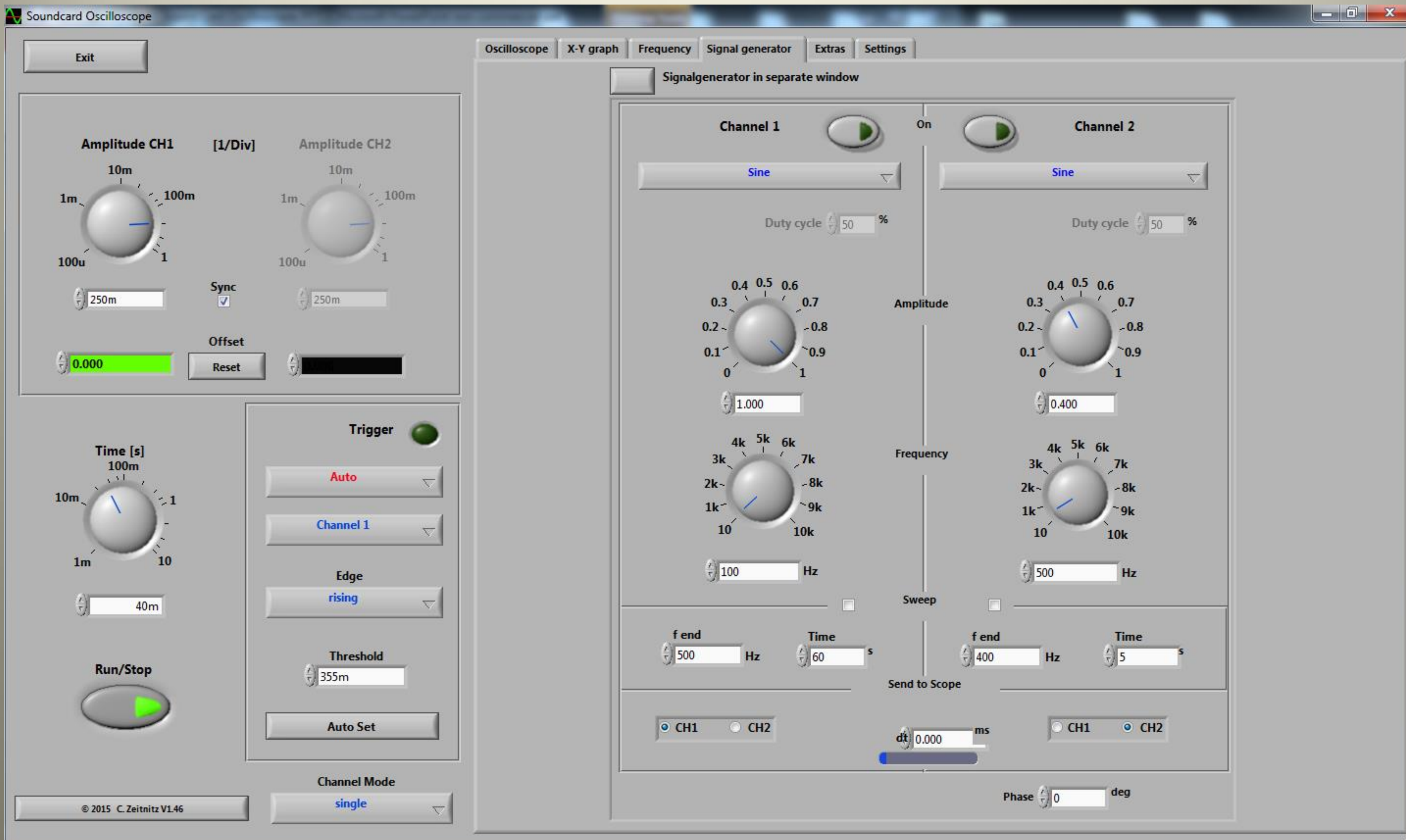
Use special coding for the message but can work at S/N ratios of -24 dB but at only 3 wpm

(you can work the world with 1 watt and a dipole)

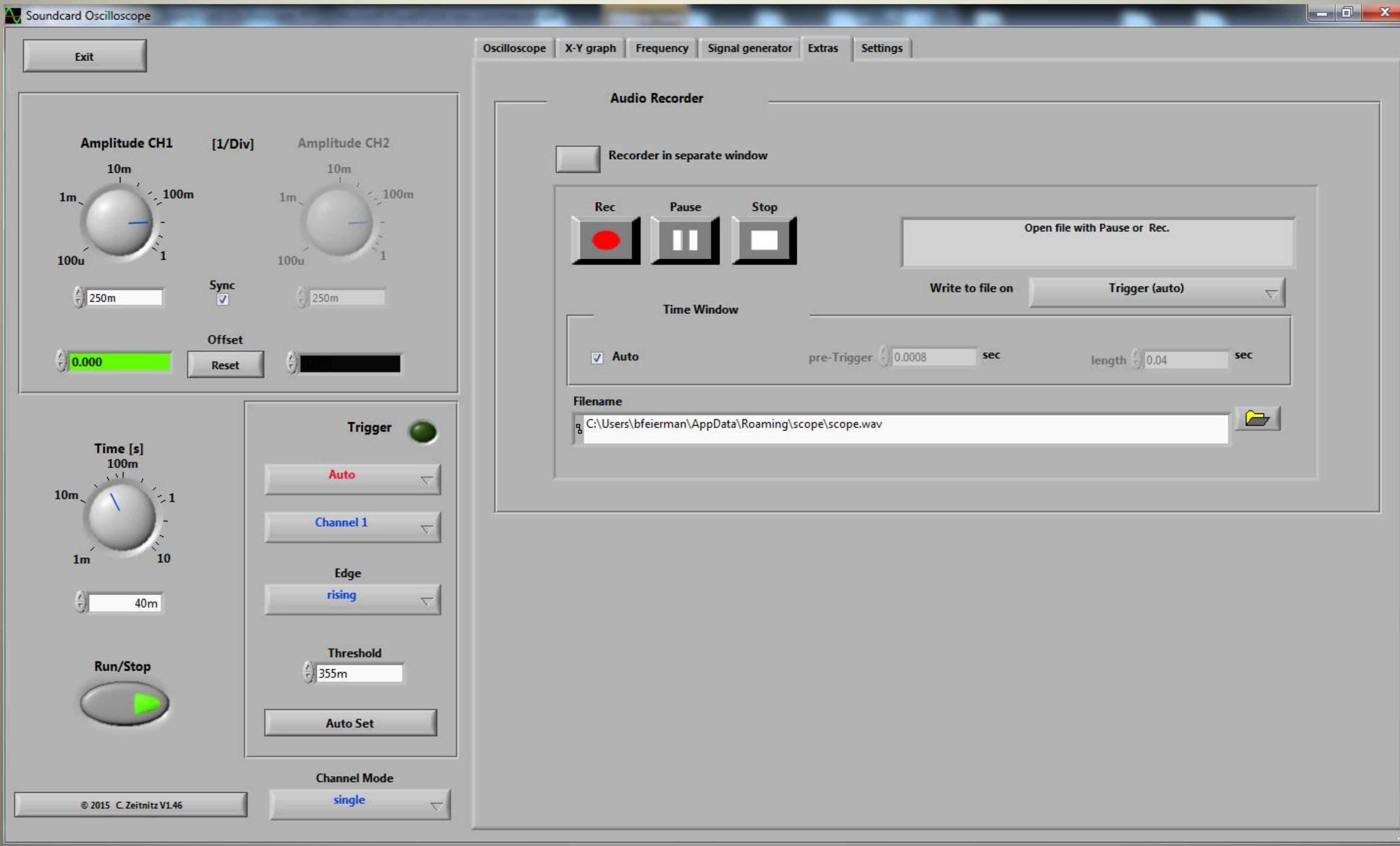
JT 65 Spectrum View
3 wpm but can be copied at -24 dB S/N



Other uses for C.Zeitnitz's Sound Card Scope
Two Channel Signal Generator
(sine, triangle, square waves, white noise)



Audio Recorder / Playback



Useful References

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Sound Card Oscilloscopes QST Feb 2016
ARRL Handbook
HF Digital Handbook, 4th edition, Steve Ford, WB8IMY (ARRL)
Get on the Air with HF Digital, Steve Ford, WB8IMY (ARRL)
Work the World with JT65 and JT9, Steve Ford, WB8IMY (ARRL)