March 2021 SLAARC

Transceiver Performance for the HF DX & Contest Operator

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NCØB

RX performance is now so good,
TX limitations dominate today.

Don’t focus just on RX performance

- I started testing receivers in 1976.
- Receiver performance was mediocre.
- Receivers today have vastly improved.
- Transmitters have gotten worse!

HF Sensitivity specifications are a non-issue

- I keep getting asked to sort my web table by sensitivity.
- SSB Sensitivity rating in microvolts goes back decades.
- R-390A from 1954 is 0.2 microvolts
- Drake R-4C 0.2 microvolts
- K3S with preamp #1 is also 0.2 microvolts.

At HF local noise is often the limit

Urban noise a major issue today.

1969 to 2019 urban noise increased 3 dB per decade.

Sources of noise:
Line noise
Wall warts
Switching power supplies (computers)
Household appliances with microprocessors
LED light bulbs, some worse than others
VDSL leakage
Pot Grow lights

Why isn’t great RX alone adequate ?

If a wide signal is in RX passband, reception can be degraded or blocked.

A wide signal can be:
SSB splatter
Excessive CW key clicks
Broad transmit composite noise

What has improved in recent years?

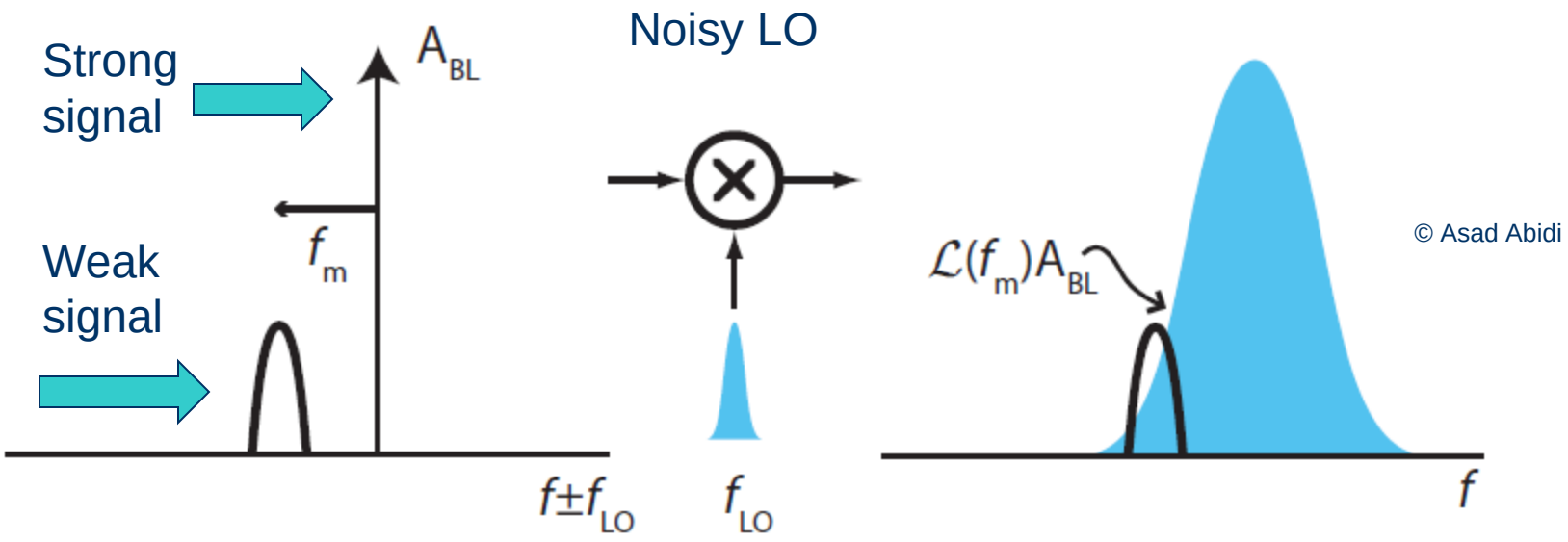
- As Reciprocal Mixing Dynamic Range has improved, transmit composite noise is better on certain models.
- Examples: K3S, IC-7851, FTdx-101D, FTdx10
- At wider signal spacings: TS-890S, IC-7610
- This is a first for Yaesu to offer improved transmit composite noise.

What Numbers are Most Important in a multi-signal environment ?

- Close-in Dynamic Range (DR3) on CW or RTTY
- Reciprocal Mixing Dynamic Range (RMDR)
- Transmitted broadband composite noise
- Transmit IMD splatter limits RX performance.
- Key clicks limit close-in CW reception.

Hopefully the noise improves with offset.

A noisy LO or Clock Oscillator affects TX and RX



Noisy local oscillator (LO) transfers its noise to the strong out-of-passband signal and on top of the weak signal we are trying to copy.

The devil is in the details !

A caution about the latest QST Product Reviews

March 2020 QST review of the Xiegu G90 transceiver has mediocre RMDR and transmit composite noise issues.

Bob's sidebar also pointed out:

CW sidebands higher than average (key clicks)
Transmit IMD (splatter) higher than we would like to see
Transmit noise close-in higher than we would like to see.

Bob said We do not recommend using an amp with this transceiver.

We all need to be good neighbors and not pollute the airwaves with poor quality signals that makes QRM worse.

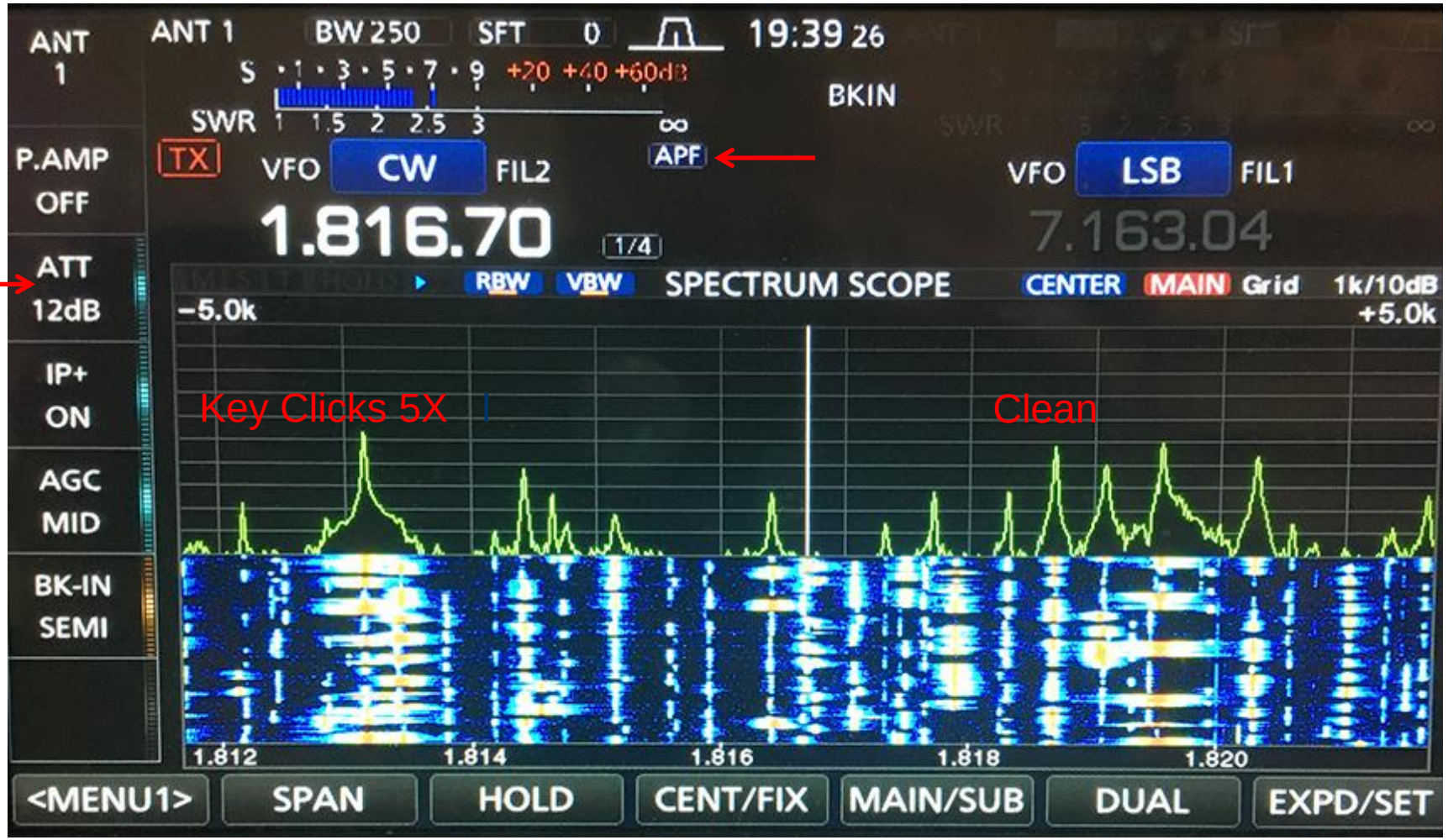
December 2018

Over 30 stations in 10 kHz IC-7610

ARRL 160m CW Friday 7:40 PM

Note

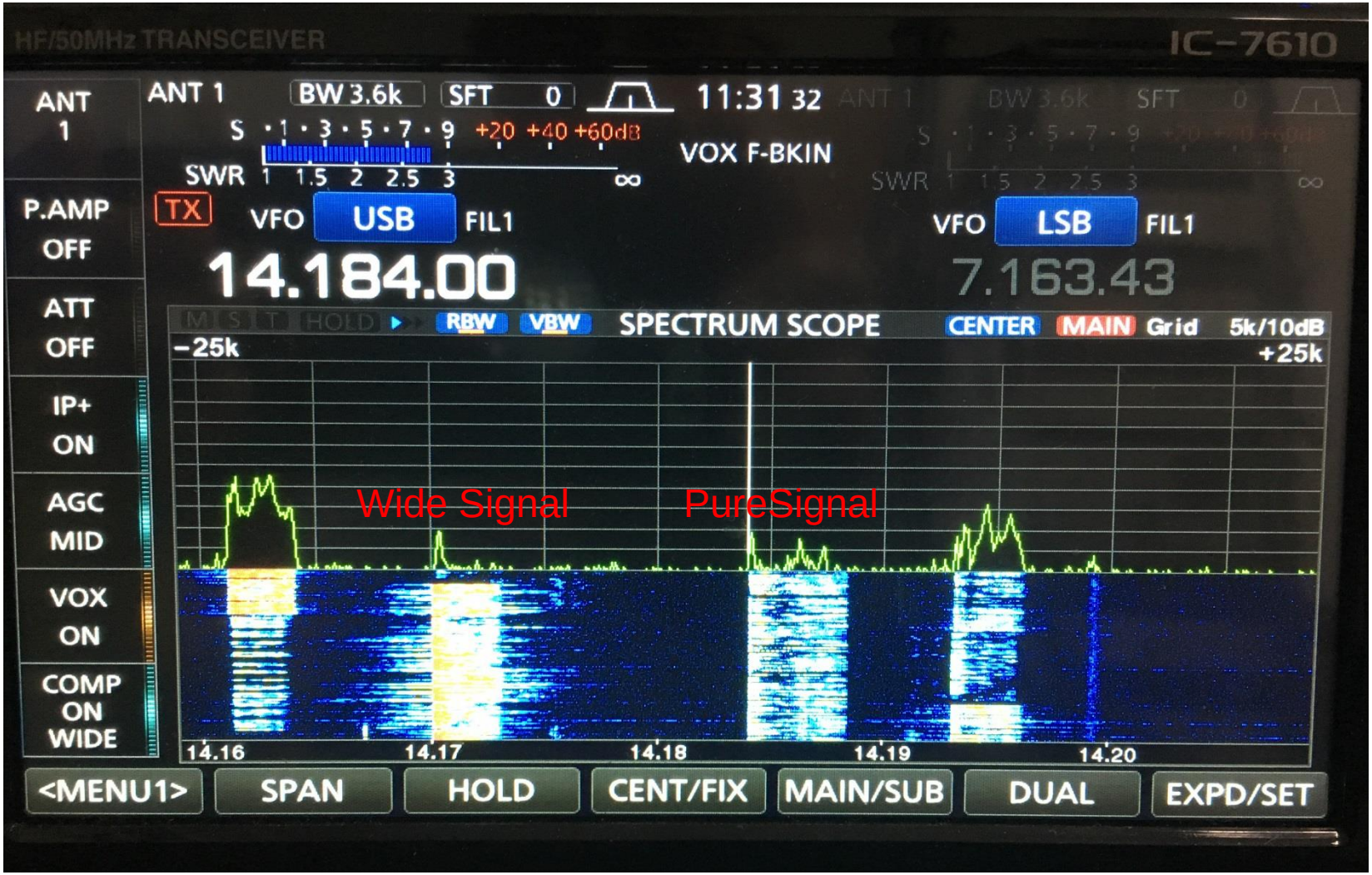
ATT



PureSignal TX BW 4.6 kHz not a good choice!

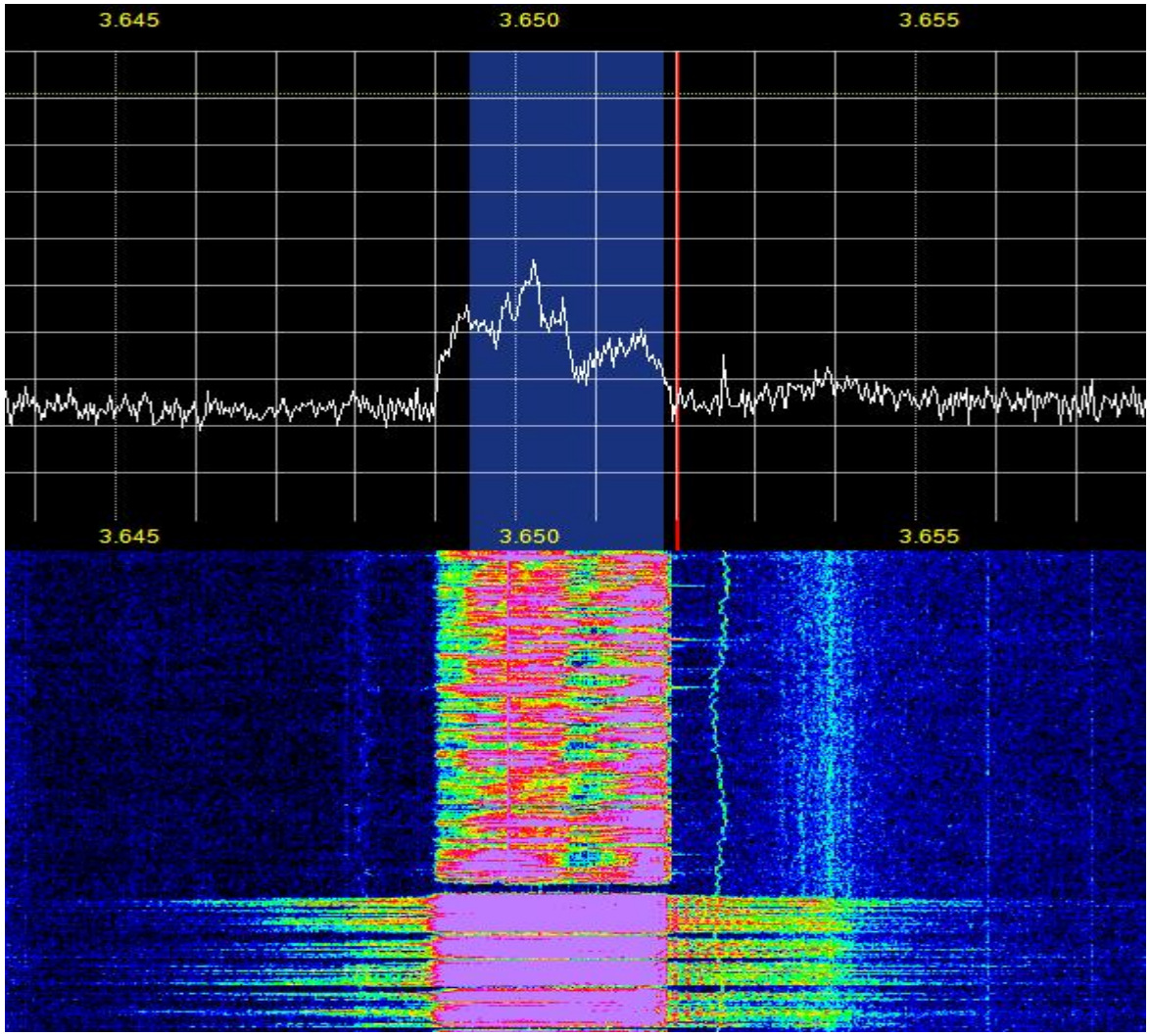
Pre-distortion example on 20m June 2019

Currently only Apache offers pre-distortion



Both stations running legal limit amplifiers

Typical SSB Splatter vs. PureSignal Adaptive Pre-distortion



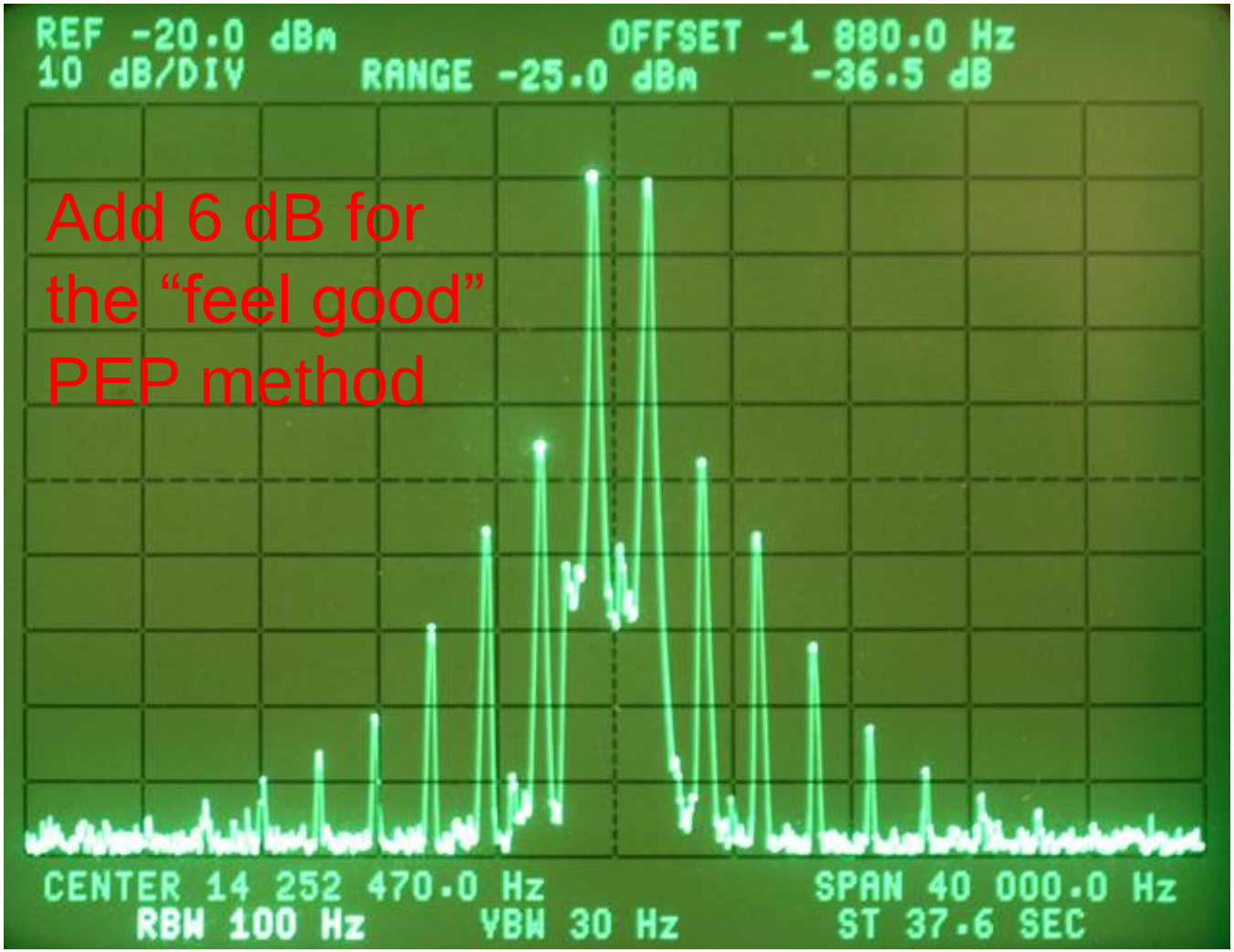
Apache with PureSignal

Kenwood

The cleanest transmitter I have ever owned.

-36 dBc 3rd Order, -47 dBc 5th Order

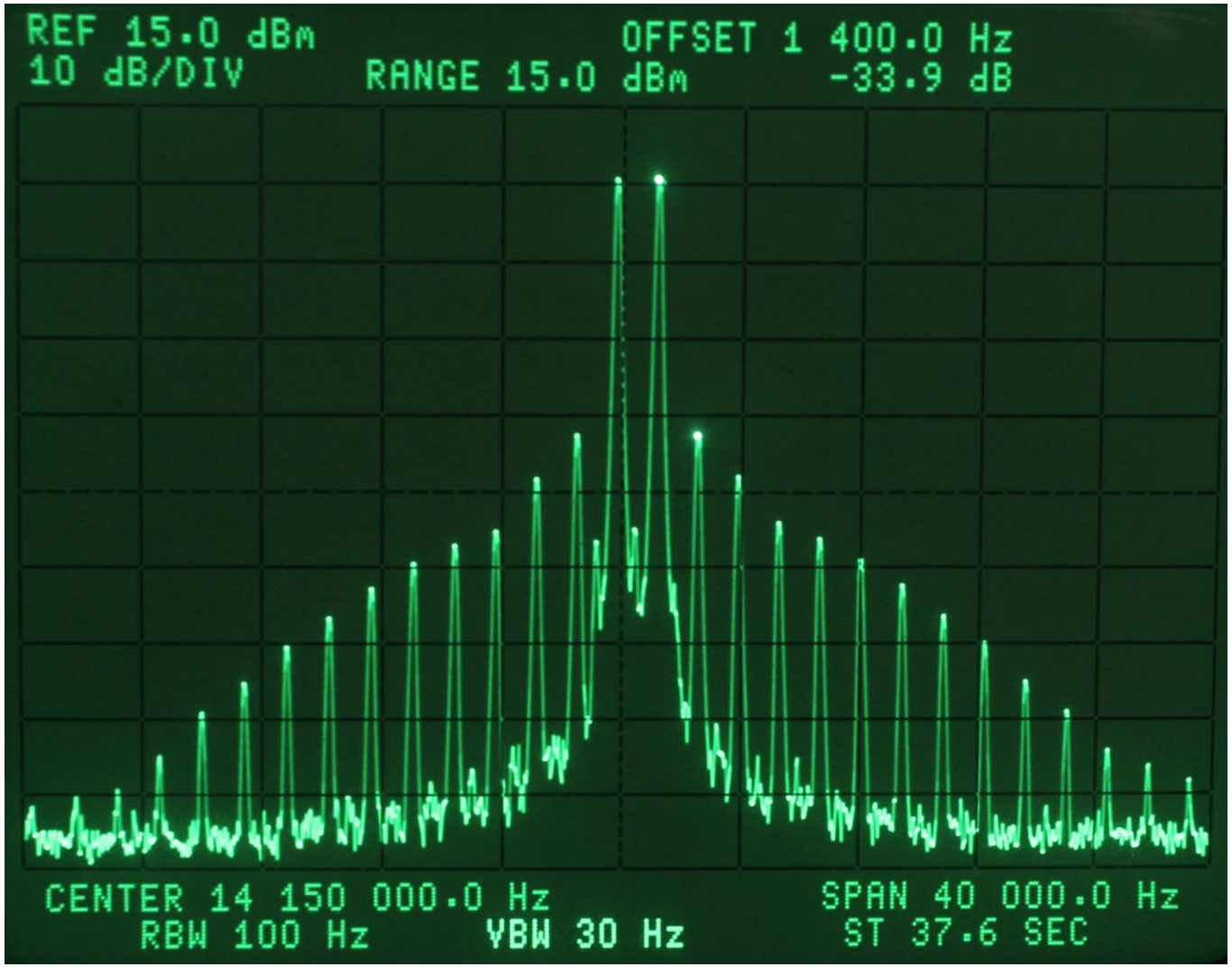
Collins 32S-3 on 20m at 100 watts



My 2nd cleanest

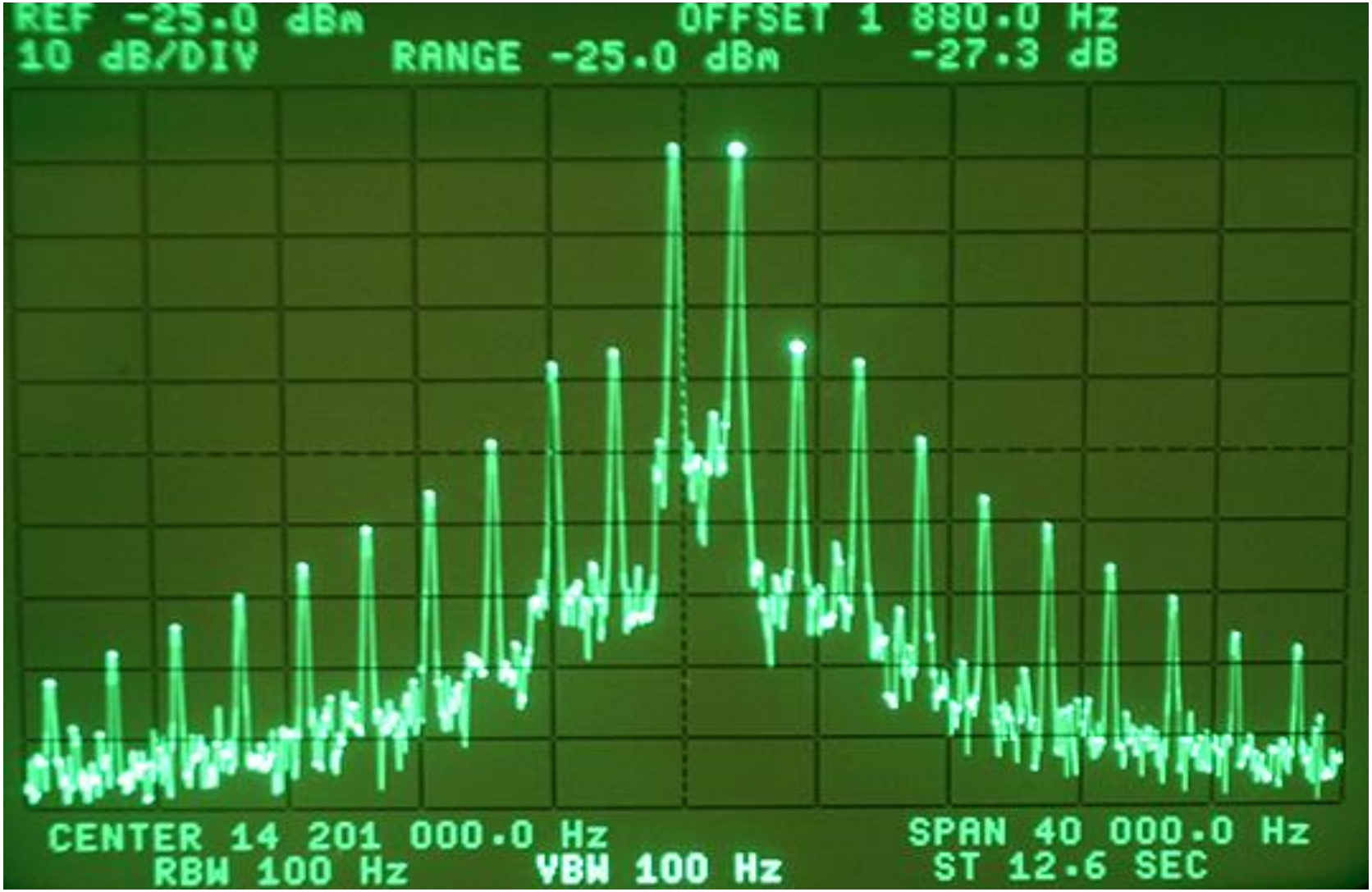
Kenwood TS-990S: -34 dBc 3rd order

A 50 volt PA can be cleaner



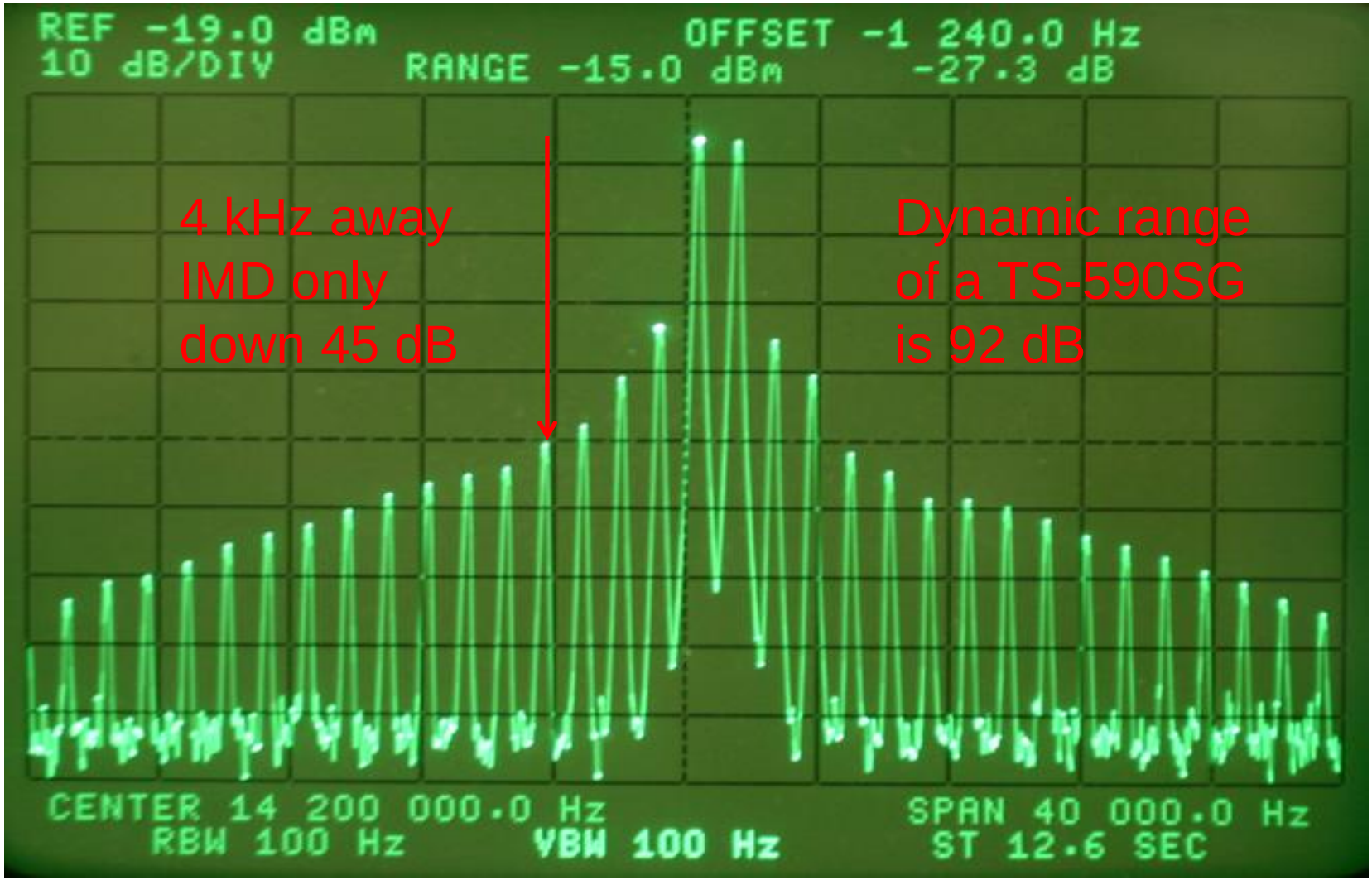
-27 dB 3rd order, -40 dB 7th order

Icom 756 Pro III on 20 meters @ 70 W



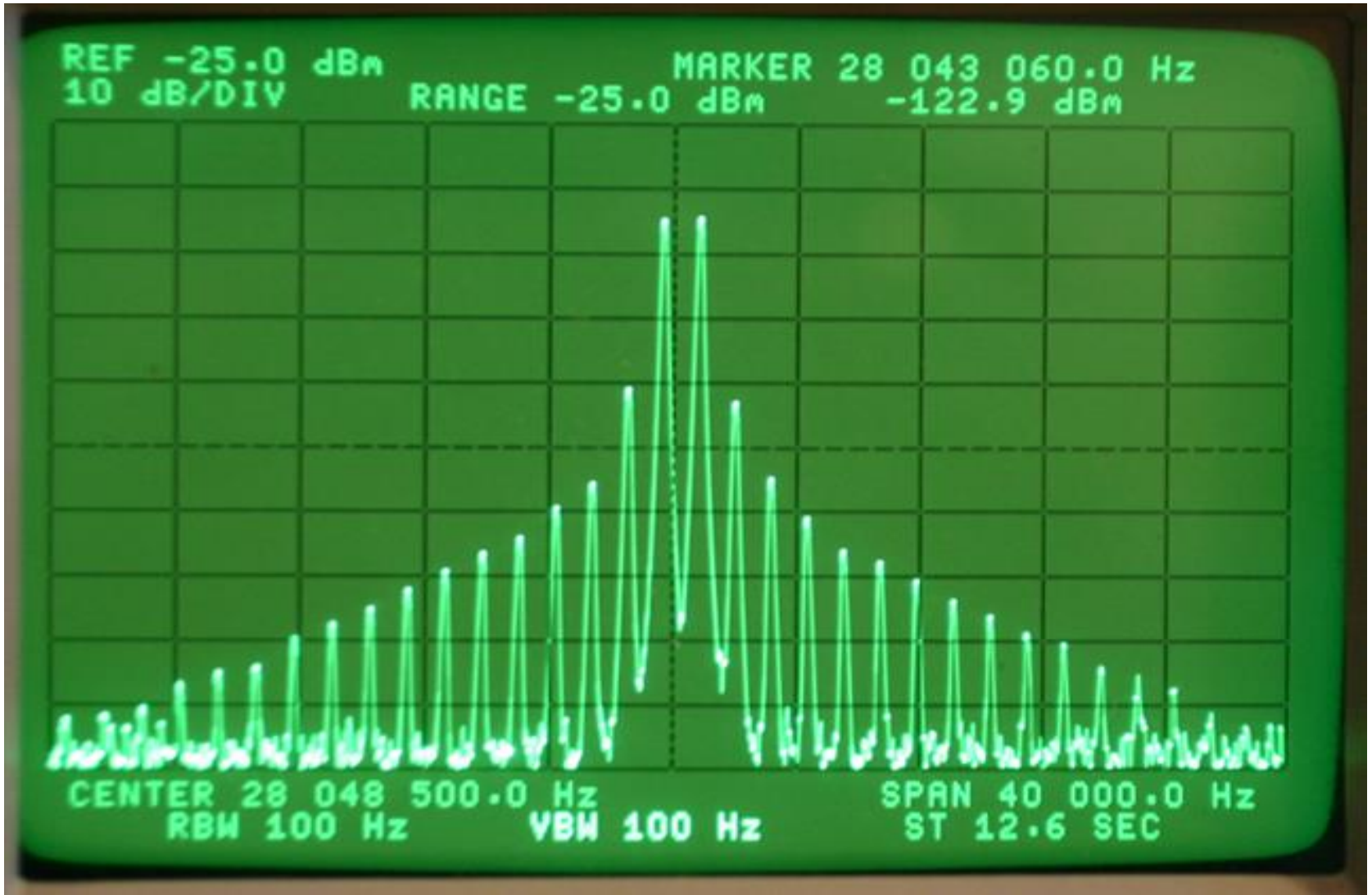
-27 dBc 3rd order, -34 dBc 5th order

K3 Transceiver on 20 meters @ 100 W



-27 dB 3rd order, -40 dB 5th order

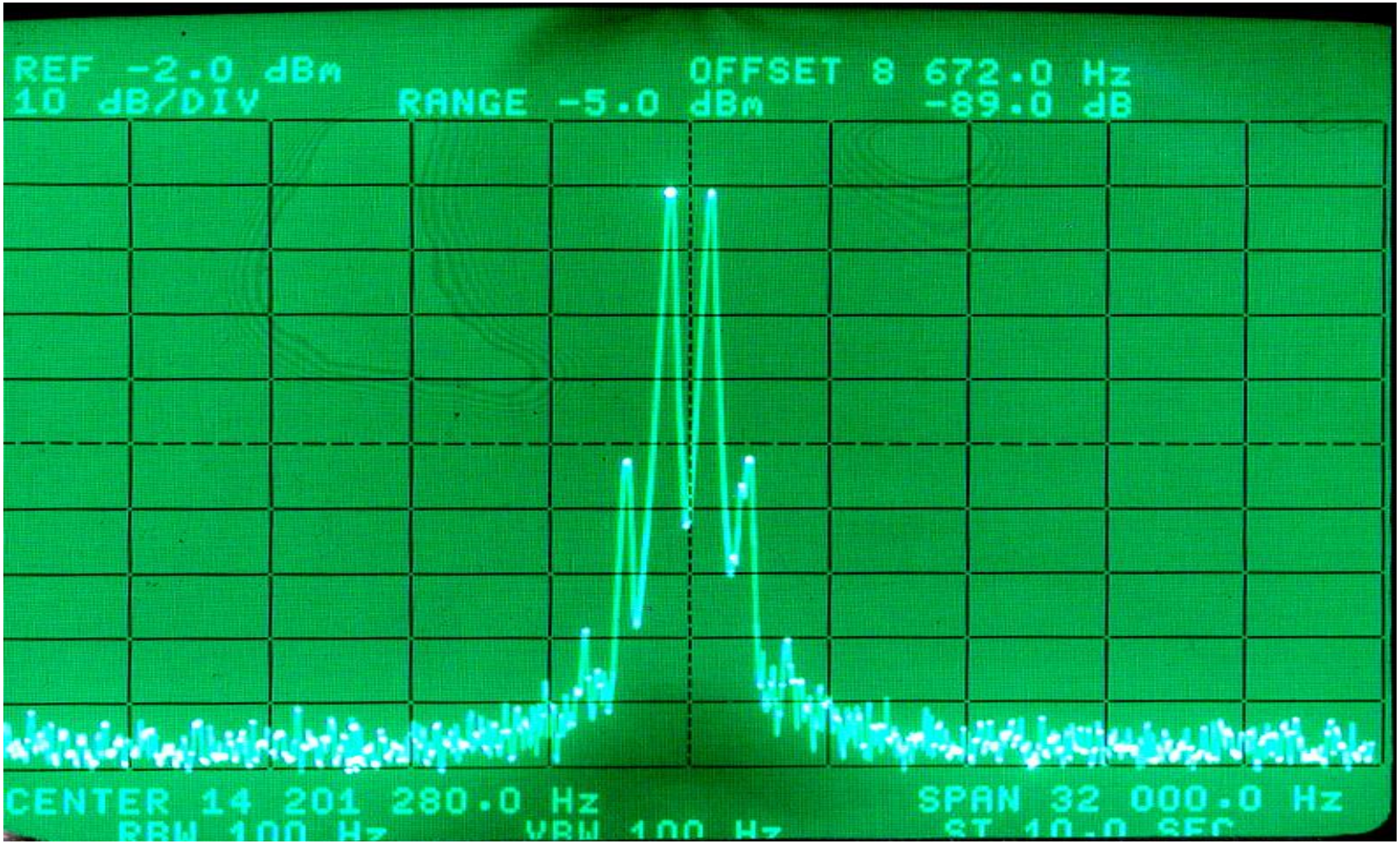
K3 Transceiver on 20 meters @ 50 W



-42 dB 3rd Order, -70 dB 5th Order

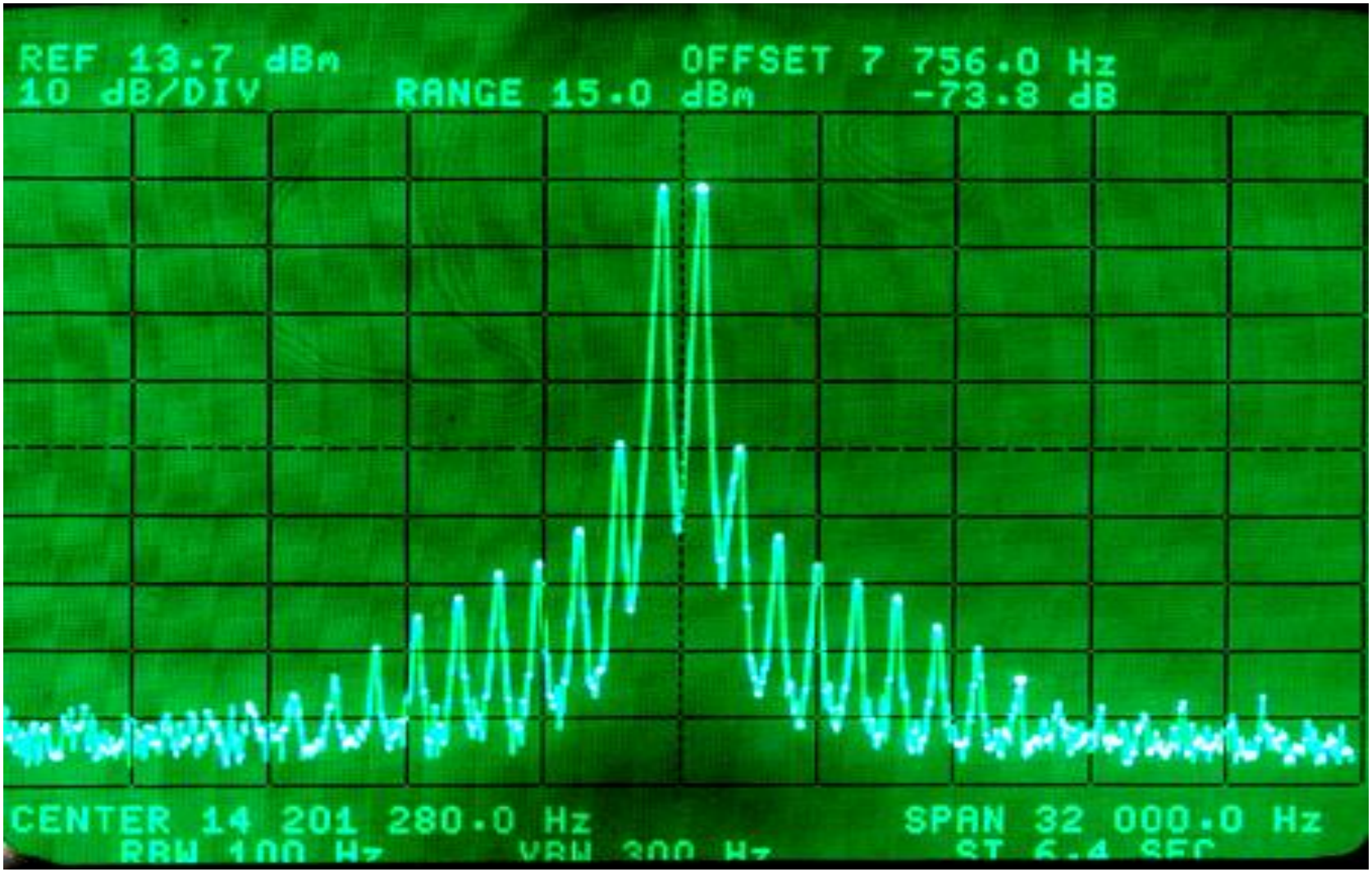
Yaesu FT-1000 Mk V, 20 M, Class A @ 75 W

Provided by Pete, W6XX

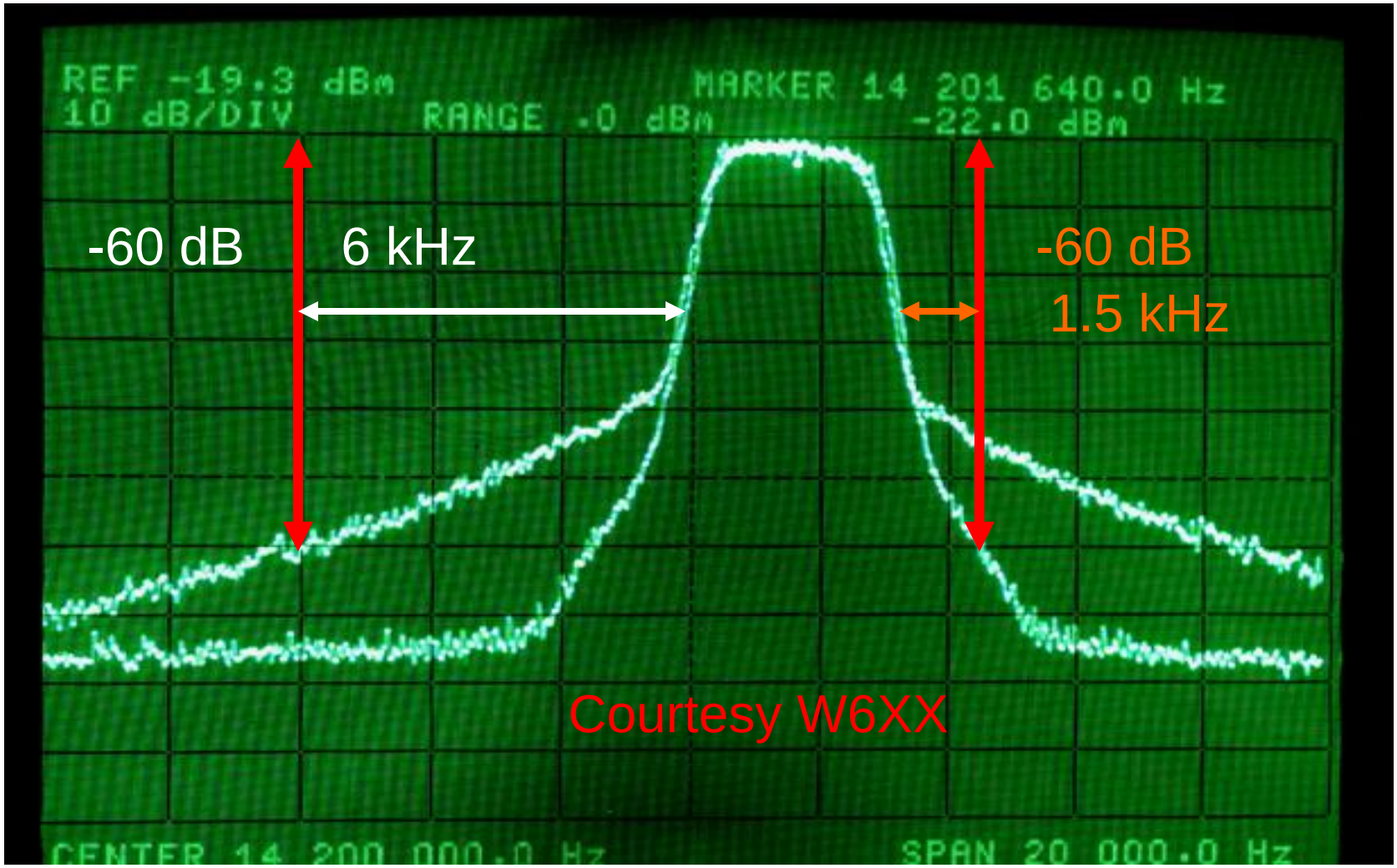


-40 dB 3rd Order, -52 dB 5th Order

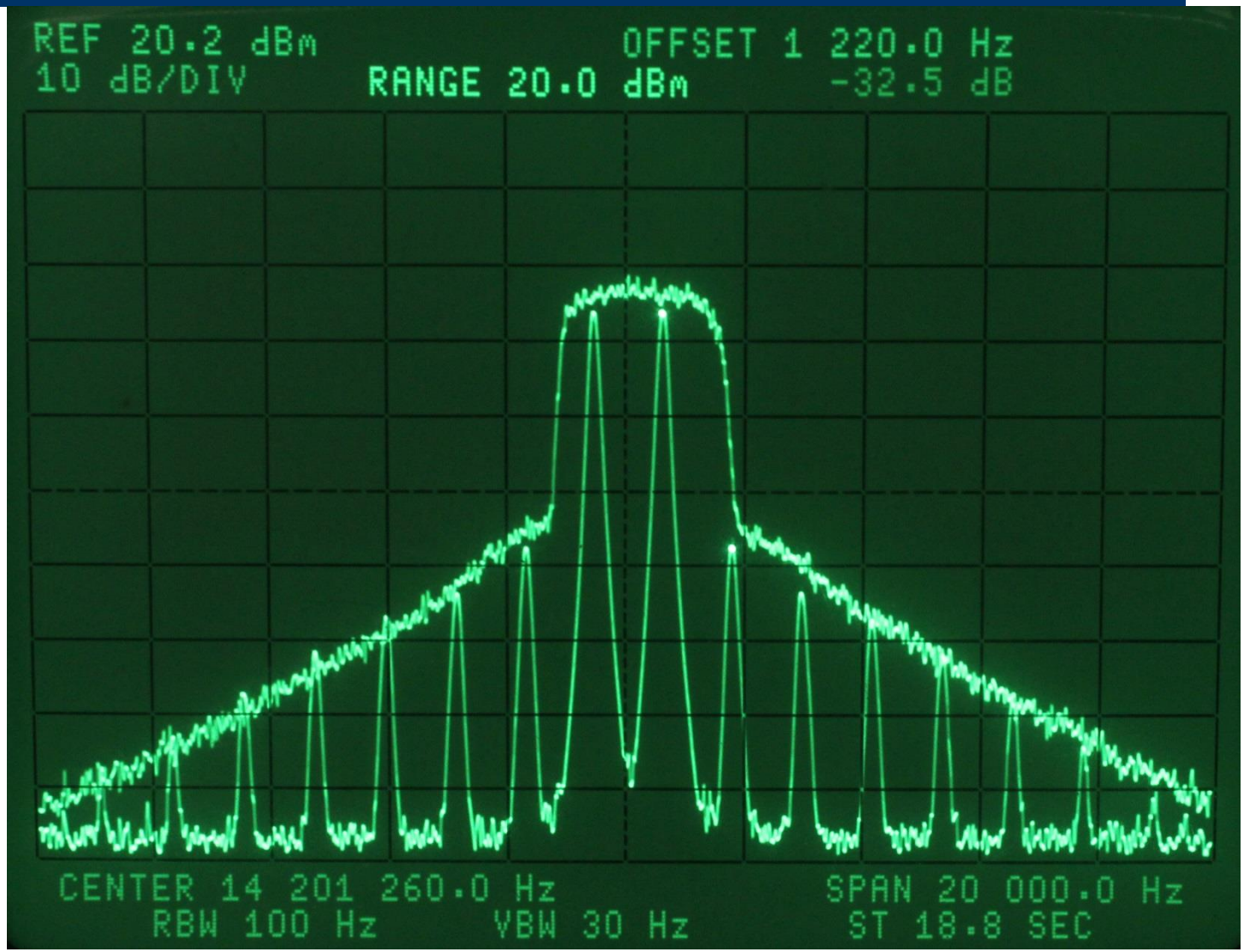
Mk V Class A + 8877, 20 meters @ 1.5 kW



White Noise Mk V Class A vs. K3 Class B @ 75 Watts



2-Tone compared to noise spectra



What is the Bandwidth of CW Signal?

On channel signal = S9 + 40 dB (-33 dBm)
Receiver = K3, 400 Hz 8-pole roofing + 400 Hz DSP Filter
Transmitter = Omni-VII with adjustable rise time
Undesired signal 700 Hz away, continuous “dits” at 30 wpm

Rise time of Omni-VII	Strength of CW sidebands		
Signal	S9 + 40	-33 dBm	Ref
3 msec	S7	-83 dBm	-50 dB
4 msec	S6	-88 dBm	
5 msec	S6	-88 dBm	
6 msec	S5	-93 dBm	22 dB !
7 msec	S4	-99 dBm	
8 msec	S4	-99 dBm	
9 msec	S4	-99 dBm	
10 msec	S3	-105 dBm	-72 dB

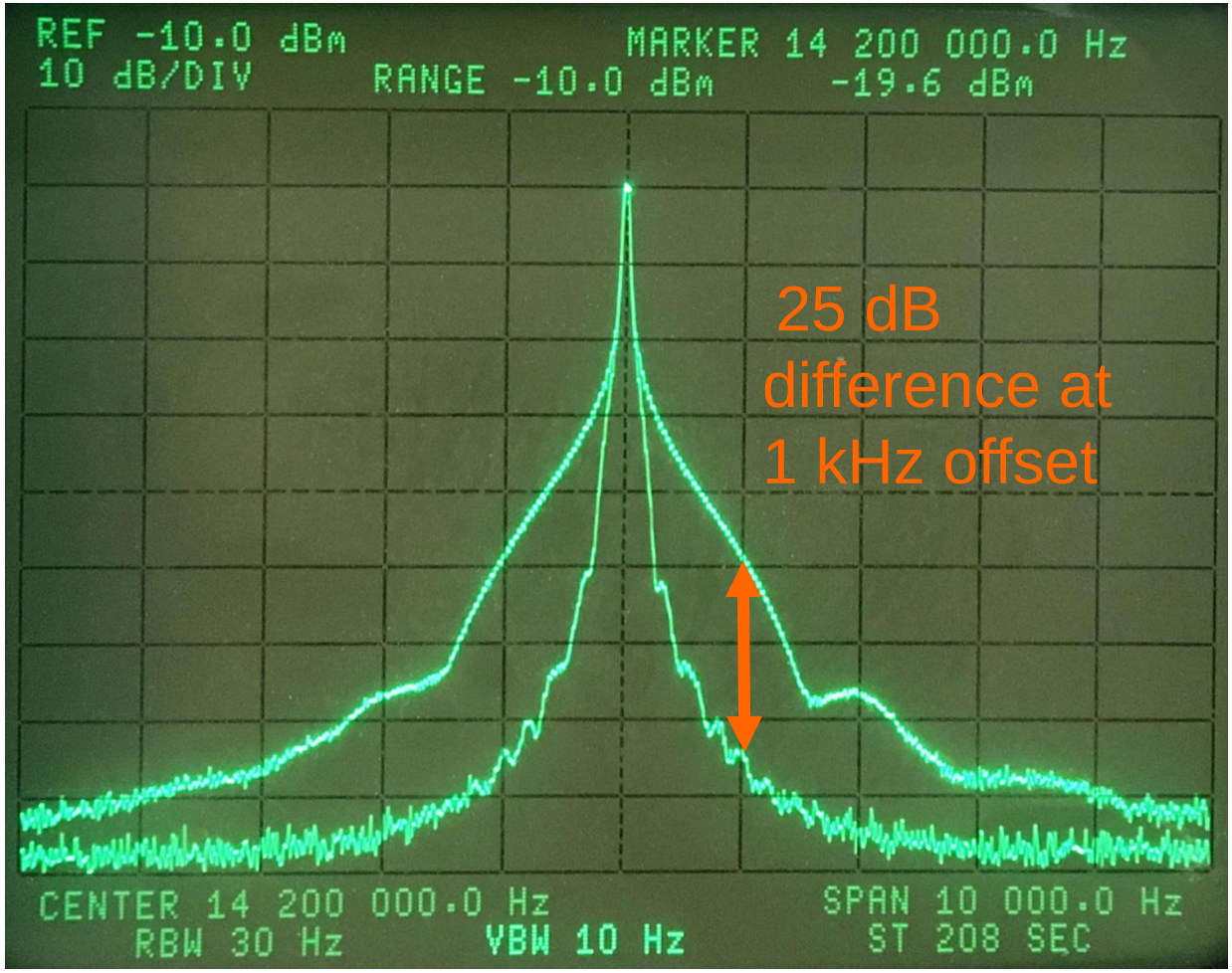
Measurement with Spectrum Analyzer

- The Ten-Tec had a 22 dB difference in key clicks going from 3ms to 10ms.
- Today the rise time menu options are often 1ms to 6ms, which is even worse.

You can select 1 msec on many rigs !!!!

Spectrum of CW Signal on HP 3585A Analyzer

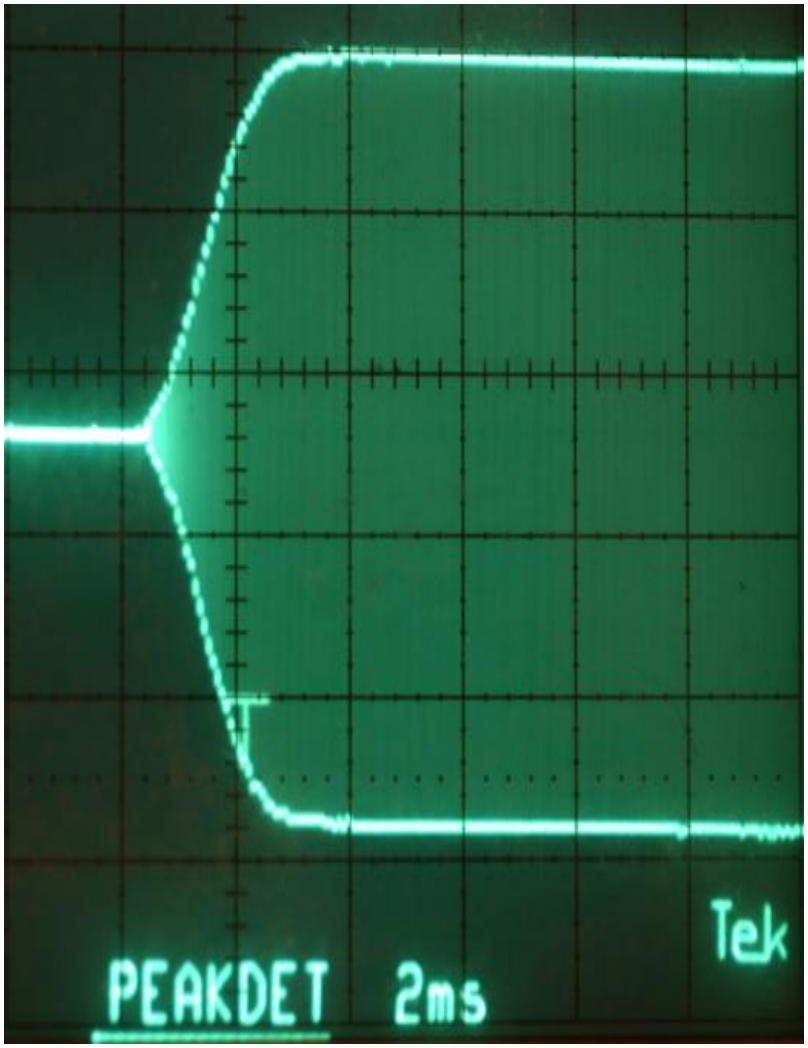
Comparison of 1 msec vs 6 msec rise time

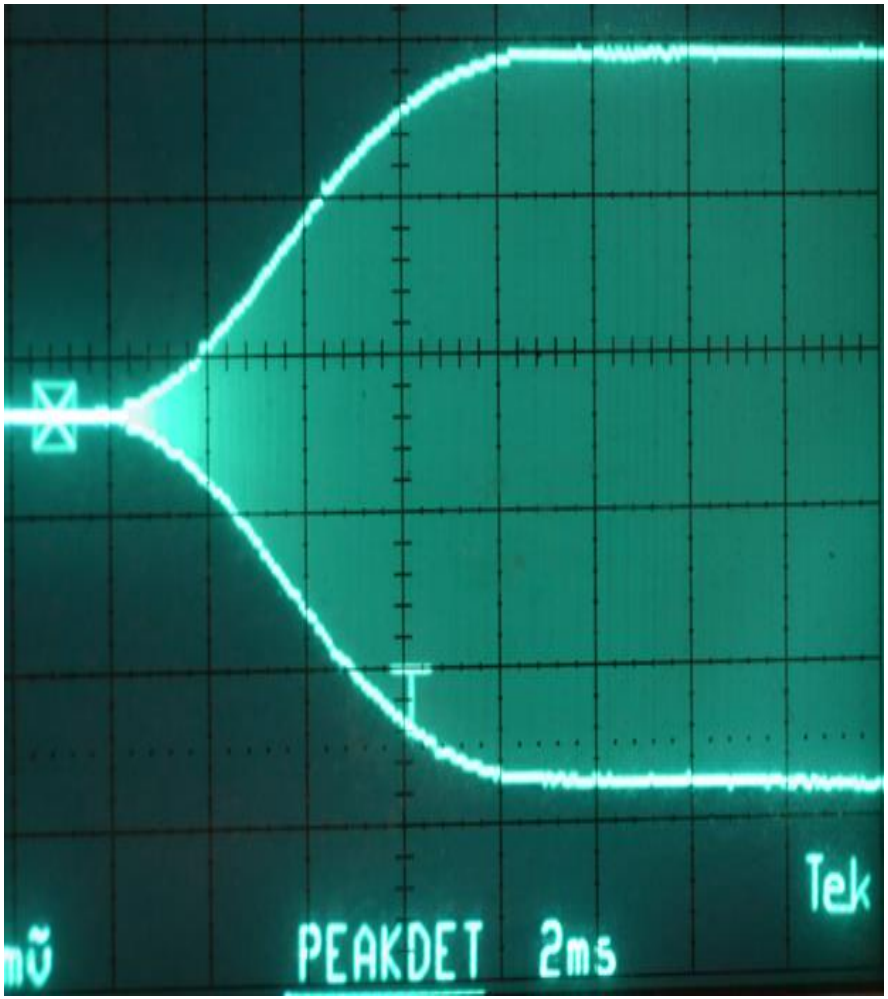


1 or 2 ms should be labeled "Turn Key Clicks ON"

This screen capture is in the time domain

Leading edge of “dit” 3 & 10 msec





Another source of transmitted interference

Transmit Composite Noise

Elecraft K3S, Icom IC-7610 & Yaesu FTdx-3000 on 20m in dBc/Hz

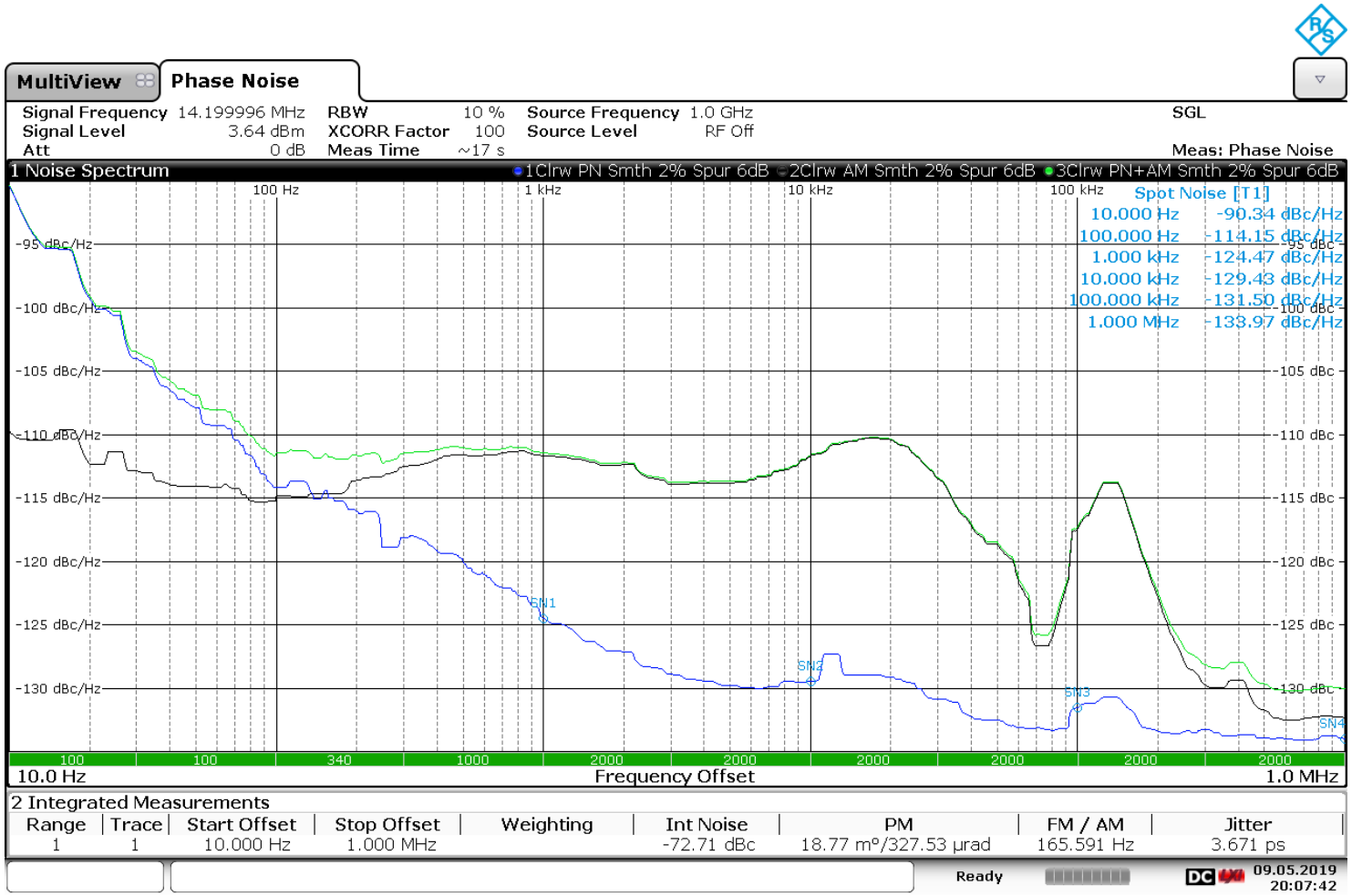
Offset kHz	K3S	Icom	Yaesu
10 kHz	-141	-128	-120
100 kHz	-143	-142	-121

When the transmit noise doesn't fall off at 100 kHz, that rig would be a terrible choice for Field Day.

Same problem with another ham close to your location

Note: Give Boulder FT-1000MP vs. FTdx-3000 example.

IC-7300 30 watts AM Noise Dominates



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Did you read my article in November 2019 QST ?

"It's Time to Clean Up our Transmitters"

A "tip of the hat" to the League for emphasizing it is time for the OEMs to do better on the transmit side.

Note: In the same issue, the review of the SPE Expert 1.5K-FA
Normal IMD -30 dB PEP
PureSignal* -47 dB PEP, a 17 dB improvement
* Predistortion

Solid-state Linear Amps not so Linear

The ARRL published a compendium of tube-type linear-amplifier odd-order distortion performance, copyright 1997.

All the amps had third-order IMD down between -40 and -50 dB PEP.

QST review Elecraft KPA1500 amp listed third-order IMD at -30 dB PEP.

Flex PowerGenius XL -30 dB on 20m, -27 dB PEP on 10 & 6 meters.

SPE Expert 1.5K-FA ARRL measured -30 dB PEP on 20 meters.

-30 dB is 6 to 10 dB worse than the cleaner transceivers in use today.

TS-990S has 3rd order IMD down -40 dB PEP !

Transmitters have gotten worse, and now solid-state amps are worse.

The I/O IMD curve is important !

The I/O Data should be a straight line

Note: Elecraft KPA1500 curve much more linear than Acom 1200S

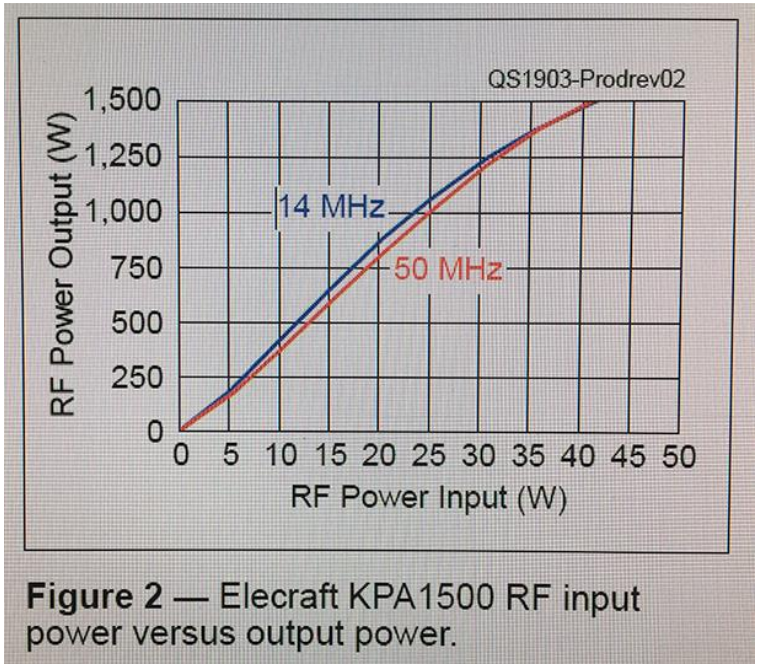

Figure 2 — Elecraft KPA1500 RF input power versus output power.

Graph QST March 2019

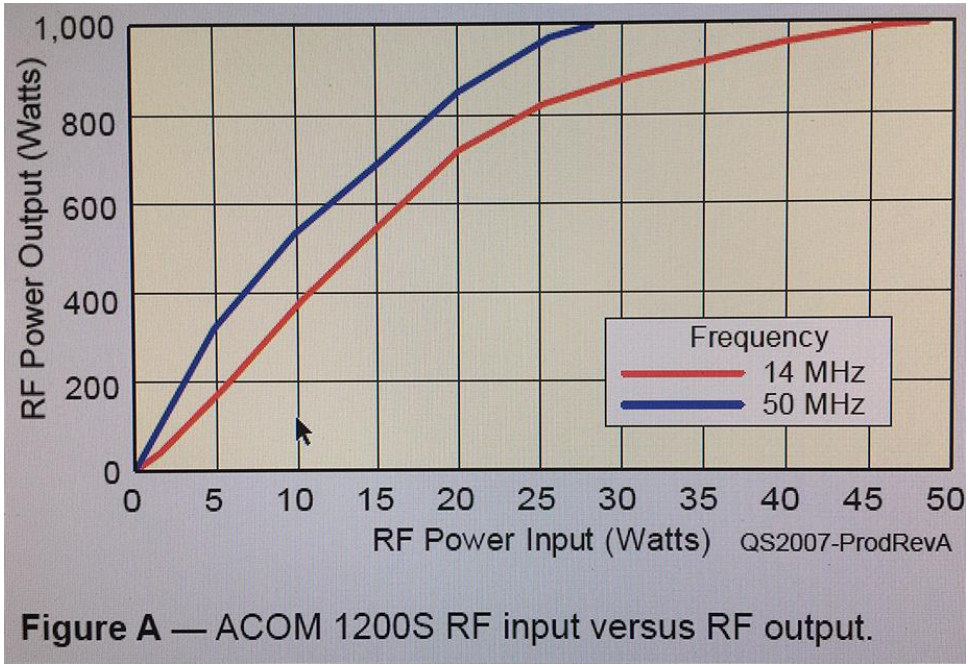

Figure A — ACOM 1200S RF input versus RF output.

Graph QST July 2020

3rd order IMD better than 5th order is a red flag !

While the Acom 1200S is advertised as a 1000 watt “linear” amplifier, it should be run no higher than 600 watts to be relatively clean.

Model	3rd order	5th order	7th order	9th order	Power
1200S	-34	-33	-47	-64	1 KW
1200S	-33	-41	-54	-62	500 W
SPE	-30	-38	-42	-53	1.5 KW
KPA	-30	-40	-48	-59	1.5 KW
PG XL	-31	-40	-51	-53	1.5 KW

Look at 5th order as a more valid method of comparison.

Bottom Line Today

- Receiver performance from all six major brands is excellent.
- The limit today in a pile-up is likely to be the broadband “noise” of the adjacent QRM.
- SSB Splatter “noise”,
- CW Key Clicks “noise”
- Broadband Composite “noise”.

The challenge for us the consumer

- Unless we demand cleaner transmitters it likely won't happen.
- Competition drove RX dynamic range from the mid 70s 15 to 20 years ago, to today when 100 dB is the middle of the pack.
- OEMs finally learned how to design clean synthesizers.
- The technology is there to improve transmitters if we vote with our pocketbook.

http://www.NC0B.com

Sherwood Engineering

Questions after the fact, or a PDF of this presentation.

Email: rob@nc0b.com