Contest & DX Performance A Complex Subject Today

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Great RX Performance – TX Limitations

Don’t focus on just a few transceivers

- I started testing receivers in 1976.
- Our choices today are amazing.
- We also have several new challenges.
- What are they?
- Let’s look at the issues.

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.
- K3S with preamp #1 is also 0.2 microvolts.
- Reception limits today are often urban noise (RFI).

What is Sensitivity & Noise Floor?

- For SSB it means a 10 dB S+N/N ratio in a 2400 Hz bandwidth (BW).
- Reviews today emphasize noise floor. (500 Hz BW)
- Noise floor is similar, but it is a 3 dB S+N/N ratio.
- R-390A noise floor -137 dBm
- K3S noise floor -138 dBm

How much has local noise increased ?

Urban noise a major issue today.

From 1969 to 2019 I would estimate 3 dB per decade.

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

The other main performance value

Dynamic Range

The search for the “magic” 100 dB radio

Not uncommon today

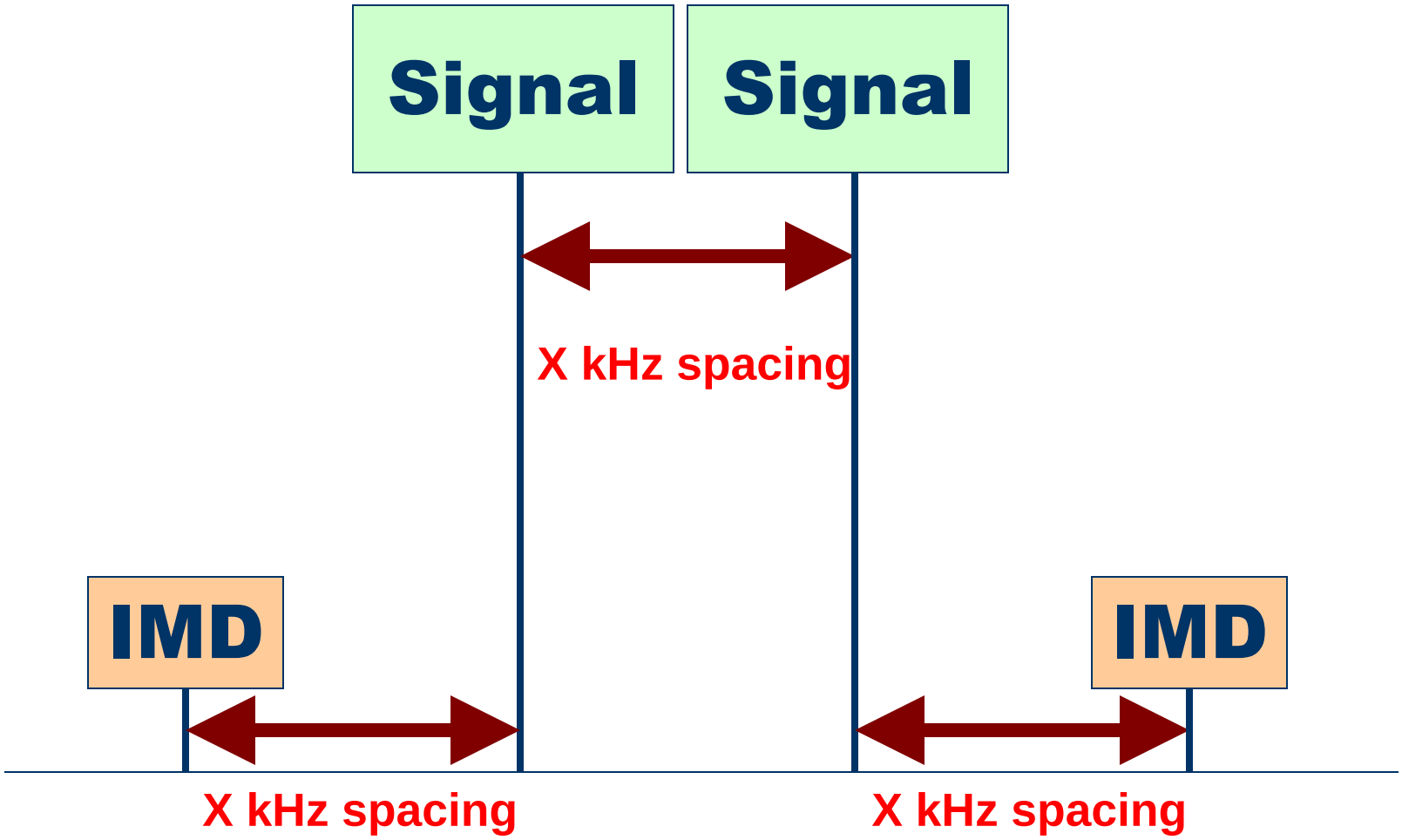
Often not required

Defined in QST and *hr magazine* in 1975

What does dynamic range mean?

- Two equal signals are fed into the receiver.
- Third-order IMD is dominant.
- Level adjusted until distortion = noise floor
- This level vs. the noise floor = dynamic range
- Example:
- Noise floor = -128 dBm, test signals = -28 dBm
- -128 dBm minus -28 dBm = 100 dB
- Dynamic Range (DR3) = 100 dB

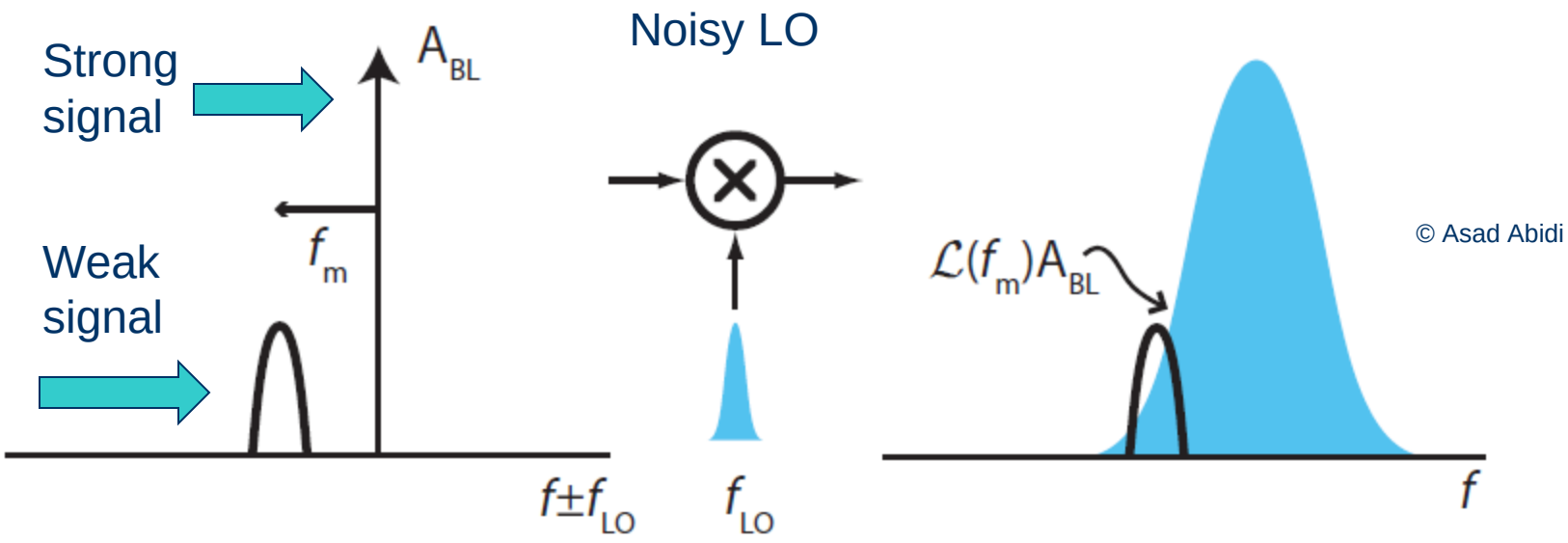
Third Order IMD to Measure Dynamic Range



State-of-the-Art in RX Dynamic Range today

- Close-in dynamic range (DR3) > 95 dB
- Brands with great performance:
- Each brand has a model this good or better.
- Apache (Alphabetical order)
- Elecraft
- Flex
- Icom
- Kenwood
- Yaesu

Reciprocal mixing puts LO noise on top of weak signal



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

Reciprocal Mixing Dynamic Range (RMDR) has been explained by Bob Allison in QST sidebars in April 2012 and May 2016.

RMDR can dominate over the more obvious dynamic range (DR3) values.

A 2013 FTdx-3000 Product Review quoted DR3 = 100 dB.
At the same time QST quoted RMDR = 82 dB.
The 100 dB value is meaningless since 82 dB dominates.

March 2020 QST review of the Xiegu G90 transceiver has the same issue.
DR3 = 91 dB while RMDR = 84 dB. Ignore the 91 dB value!

Bob's sidebar also pointed out mediocre CW keying sidebands, SSB IMD splatter performance, and transmit phase noise. Bob said Don't use an amp!

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

There are two basic types of transceivers today

- Superheterodyne, hybrid or not, and Direct Sampling
- They both work, and each has its strengths and weaknesses.
- Superhet is likely a better choice for Field Day.
- All Direct Sampling radios have a band scope.
- For contesting, I find a band scope very helpful.

Possible concerns for Direct Sampling

- Field Day or a ham 1 mile away
- Front-end L/C filter is likely a half octave filter, 11 to 15 MHz for the Icom 7300 or 7610.
- A superhet with a crystal roofing filter has an advantage in these difficult RF environments.
- 99% of the time this is a non-issue.

Some are only CW oriented *

Features desirable today

- QSK, or at least click-free semi-break-in *
- APF to reduce band noise and fatigue *
- Band scope & waterfall display for contesting, for multipliers, & watch the pile-up
- Efficient User Interface
- Rock solid connection to logging program
- Tuning knob for computer-controlled direct sampling transceivers

Time for the numbers

- What do performance numbers in QST mean?
- Do you need the absolute best numbers? NO !
- You can optimize the performance of whatever transceiver you own.
- Lots of transceivers can be perfectly adequate.

Close-in 2-kHz Test @ 500 Hz BW

Dynamic Range of Top 18 Transceivers

• Yaesu FTdx-101D	110 dB	
• Elecraft K3S	106 dB	
• Icom 7851	105 dB	
• Kenwood TS-890S	105 dB	
• Hilberling PT-8000A	105 dB	
• Elecraft KX3	104 dB	
• Apache 7000DLE	103 dB	
• Yaesu FTdx-5000D	101 dB	
• Flex 6400	100 dB	
• Flex 6600	99 dB	(16 dB preamp ON)
• Flex 6700 (2017)	99 dB	(Preamp OFF)
• Icom 7610	98 dB	
• Icom 7300	97 dB	(IP+ ON, high serial number)
• Flex 5000	96 dB	
• Ten-Tec Orion II	95 dB	
• Ten-Tec Orion I	93 dB	
• Kenwood TS-590SG	92 dB	
• Ten-Tec Eagle	90 dB	

You can effectively work DX and Contests with any of these fine transceivers.

New price range $1000 to $12,000+

Used market price even lower

I have run contests with 12 of the 18
N2IC uses two TS-590 models.

Where will the K4 fit in this table?

- We don’t yet know, since it hasn’t shipped, but we do know the architecture.
- A basic Elecraft K4 will be much like an Icom IC-7610. Direct sampling & 2 receivers
- The K4HD (with the superhet module and roofing filters) will have an architecture similar to the Yaesu FTdx-101D or MP.

New and used price bargains today

- A new IC-7300 sells for as little as $899.
- A used TS-590S sells for $600 or less.

- I prefer a radio with a built-in band scope but LP-PAN and SDR “dongles” provide viable options.

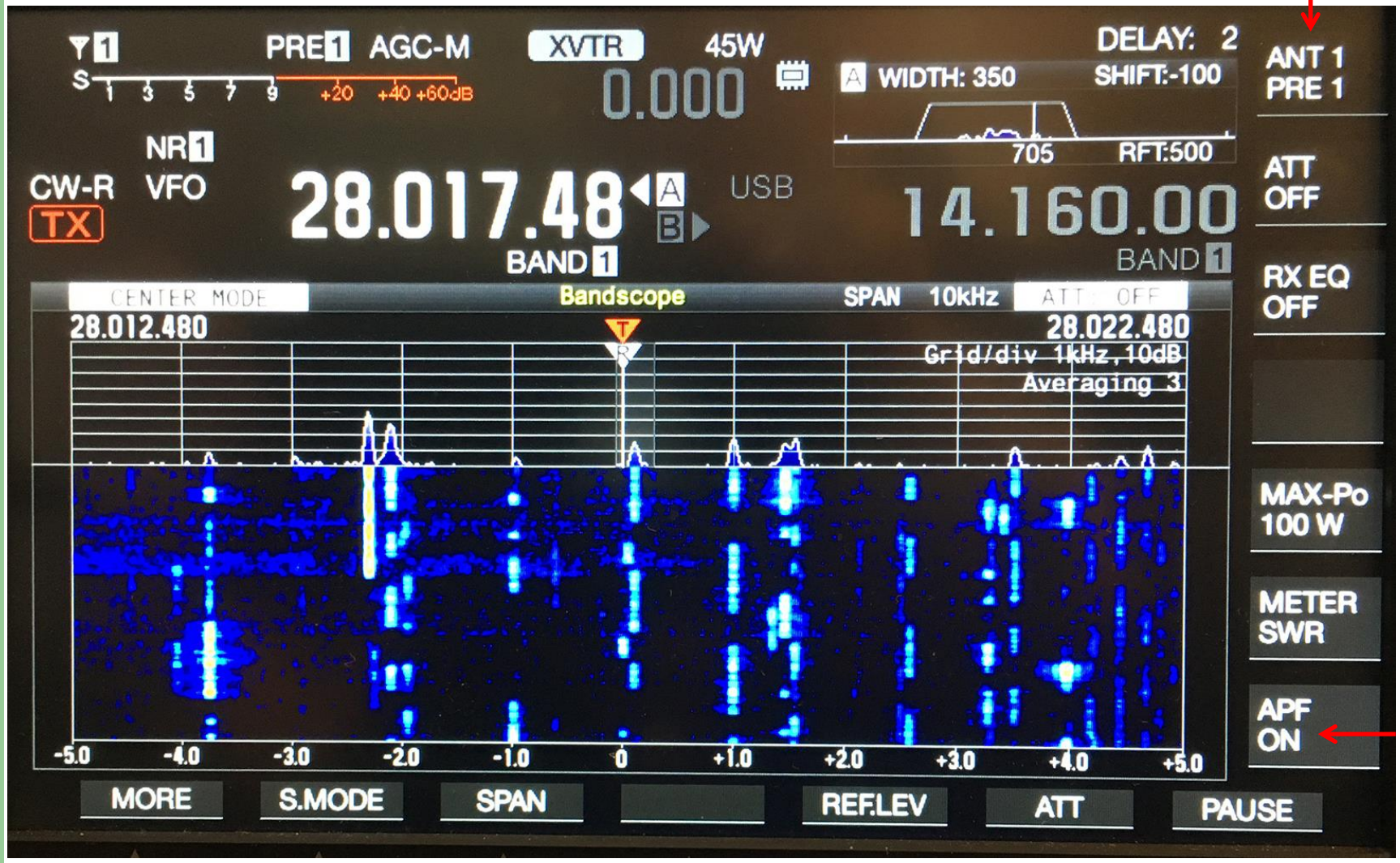
- What does a band scope offer?

December 2018

Over 20 stations in 10 kHz TS-890S

ARRL 10m Saturday afternoon

Note preamp



Pay attention to NET GAIN

- The 10m slide, and a following 160m slide, emphasizes using common sense on preamp and attenuator settings.

- On 40m and below, use your attenuator.
- On 15m and above, a preamp is useful if you are in a quiet location.
- Urban noise may make a preamp useless.

- A preamp at night on 40m is crazy!

What else can a band scope show?

- Not only can we look for contest multipliers, a clear frequency, or DX, the scope and waterfall also show other causes for QRM.

- Your receiver filters cannot eliminate in-passband QRM such as Key Clicks, SSB Splatter, or Transmit Composite Noise.

December 2018

Over 30 stations in 10 kHz IC-7610

ARRL 160m CW Friday 7:40 PM

Note

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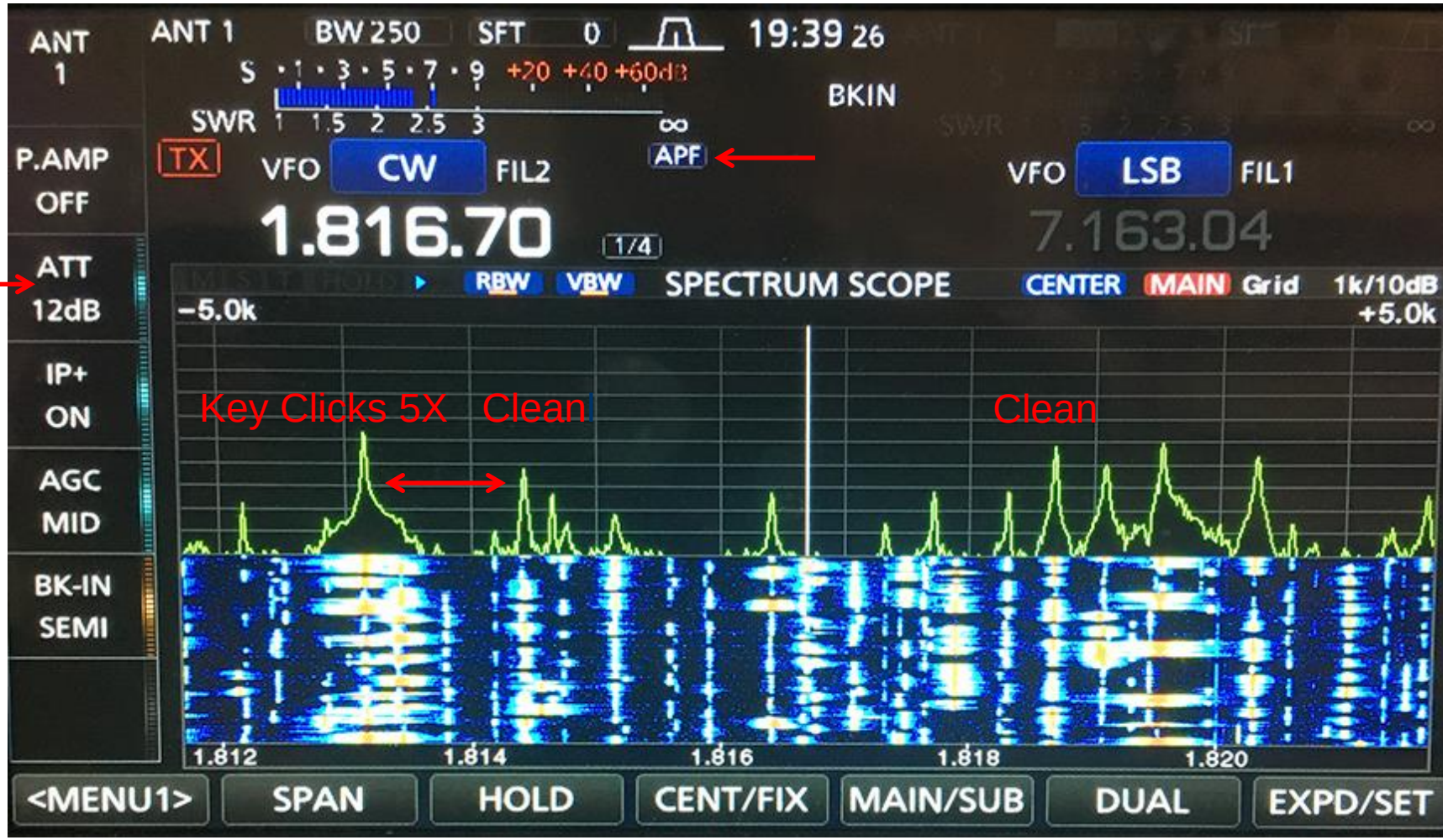
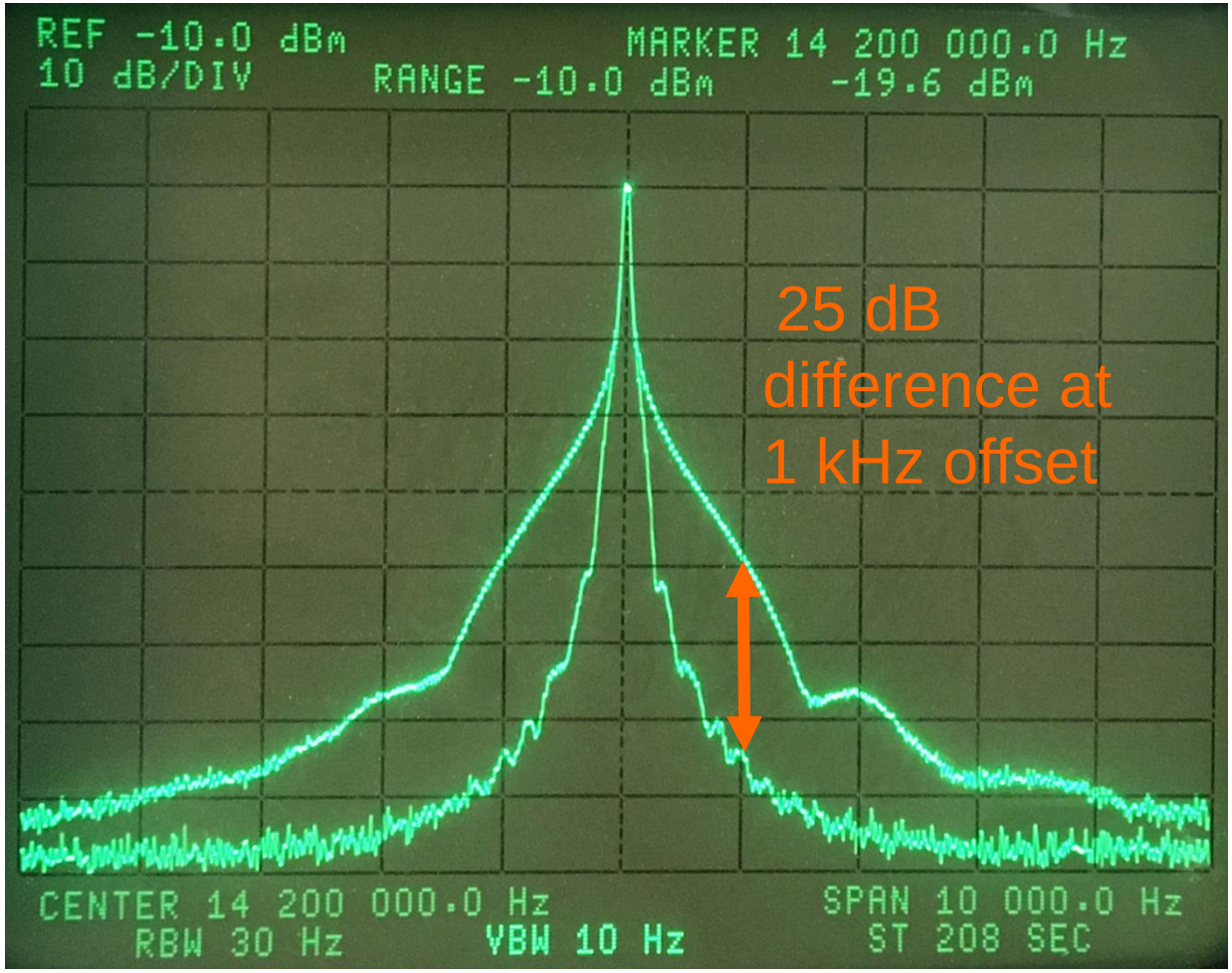


You can select 1 msec on many rigs !!!!

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"

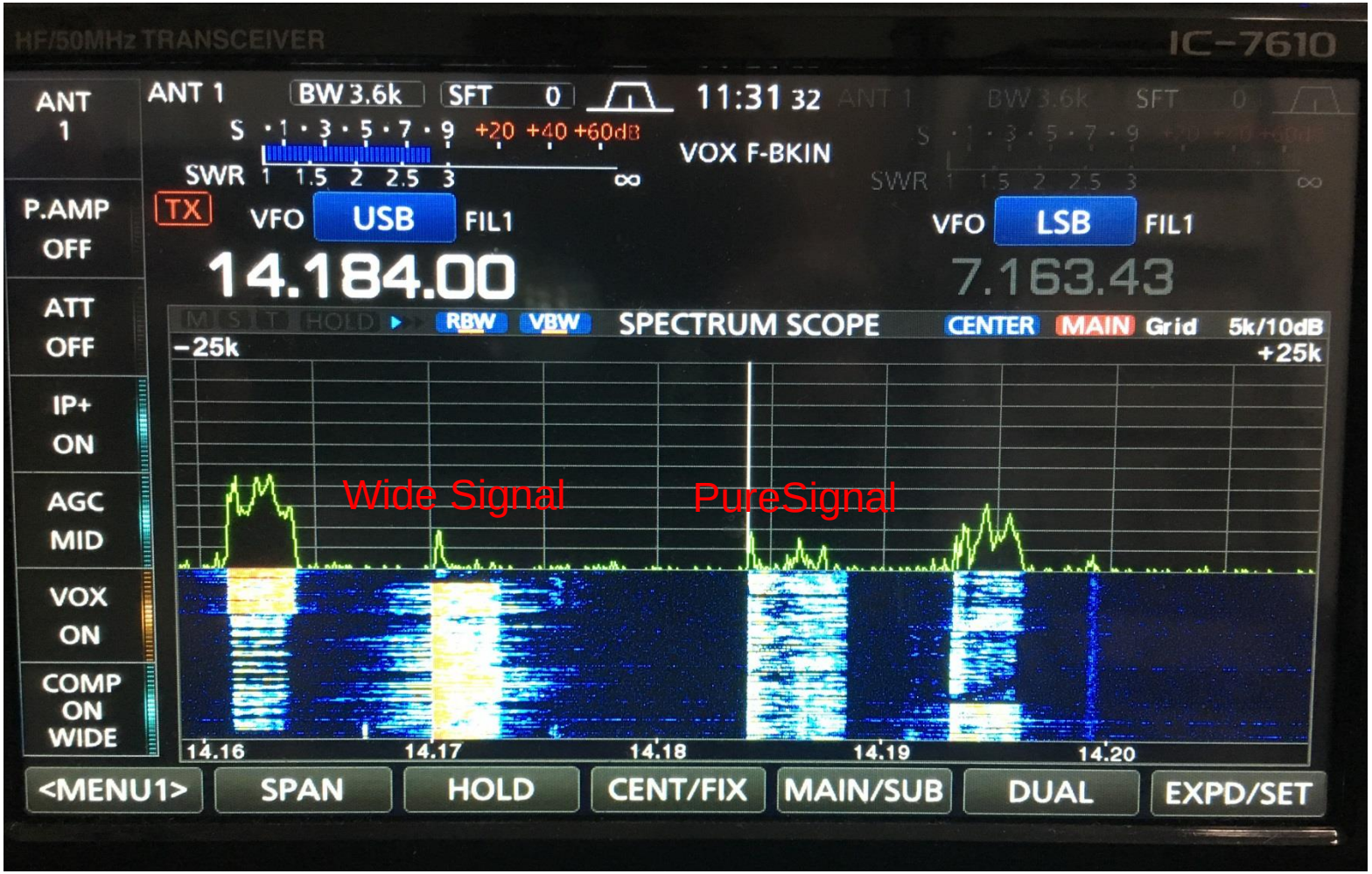
How wide is your SSB signal?

- A typical SSB signal today from a 13.8 volt PA is over 10 kHz wide at -60 dB.
- Copying an S3 signal next to an S9+30 signal
- Splatter from a station 3 to 5 kHz away will dominate over a receiver's dynamic range.
- Examples of transmitter odd-order distortion.

KA0KA chose 4.6 kHz transmit bandwidth

Observe the waterfall differences

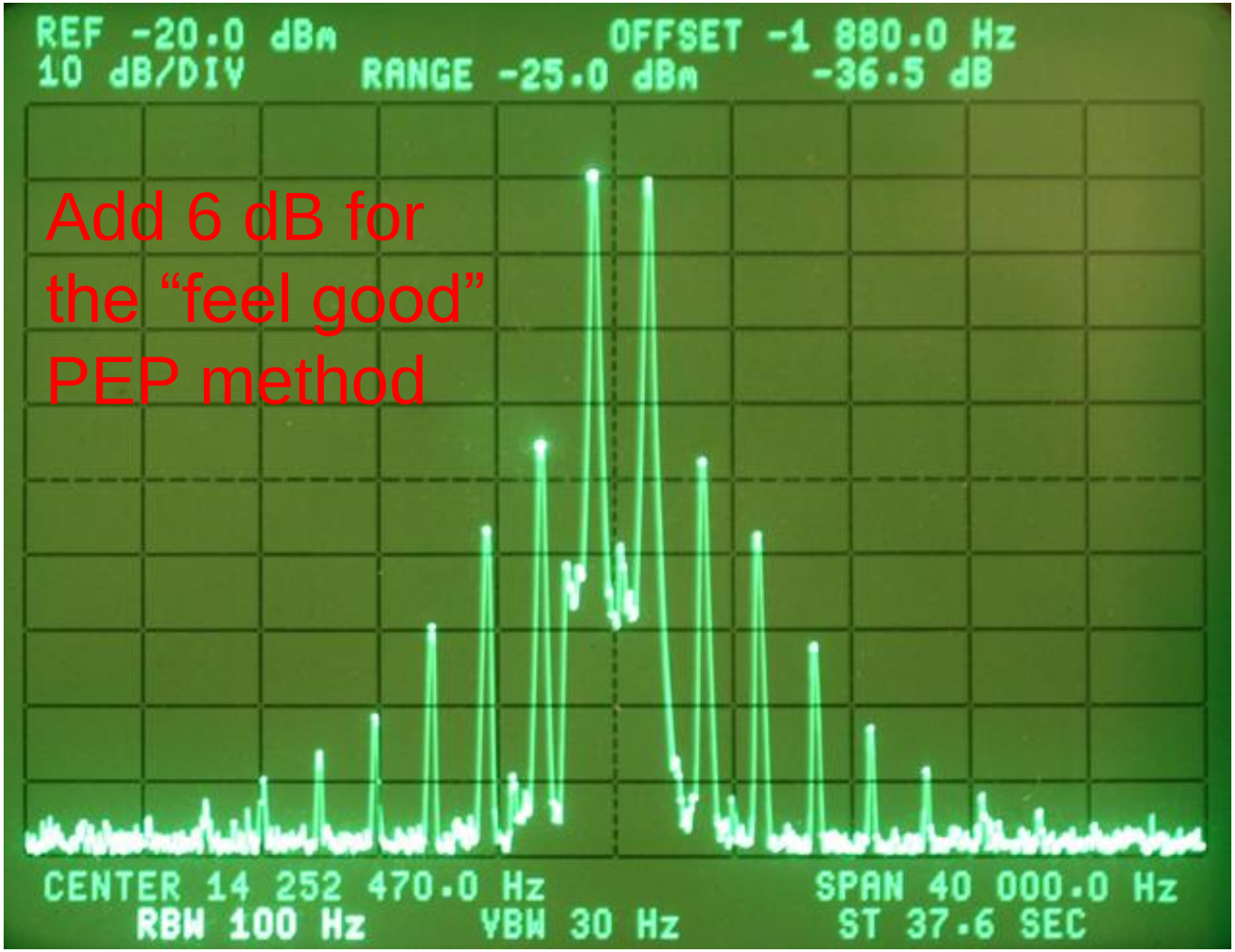
On air example of PureSignal



The cleanest transmitter I have ever owned.

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

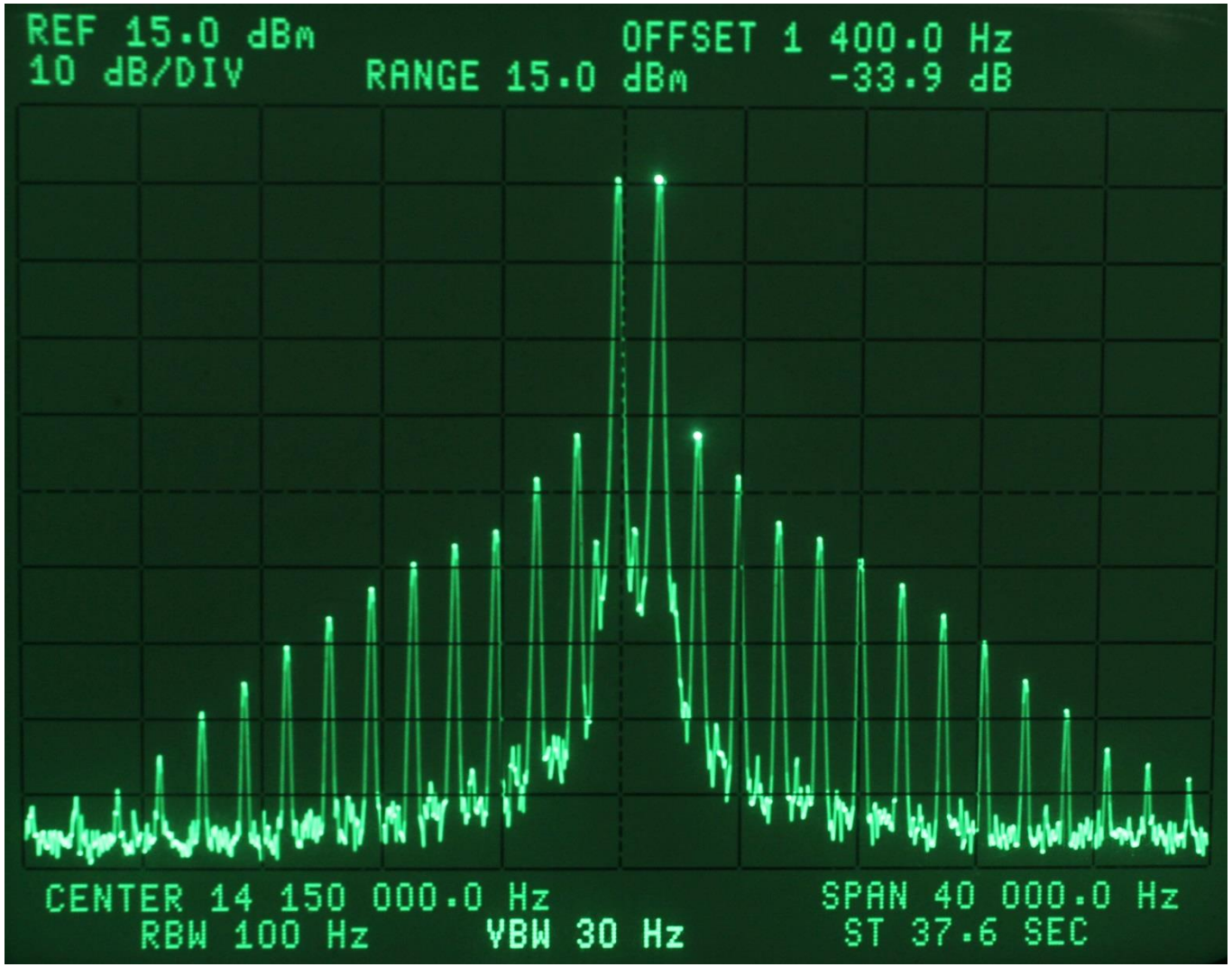
Collins 32S-3 on 20m at 100 watts



My 2nd cleanest

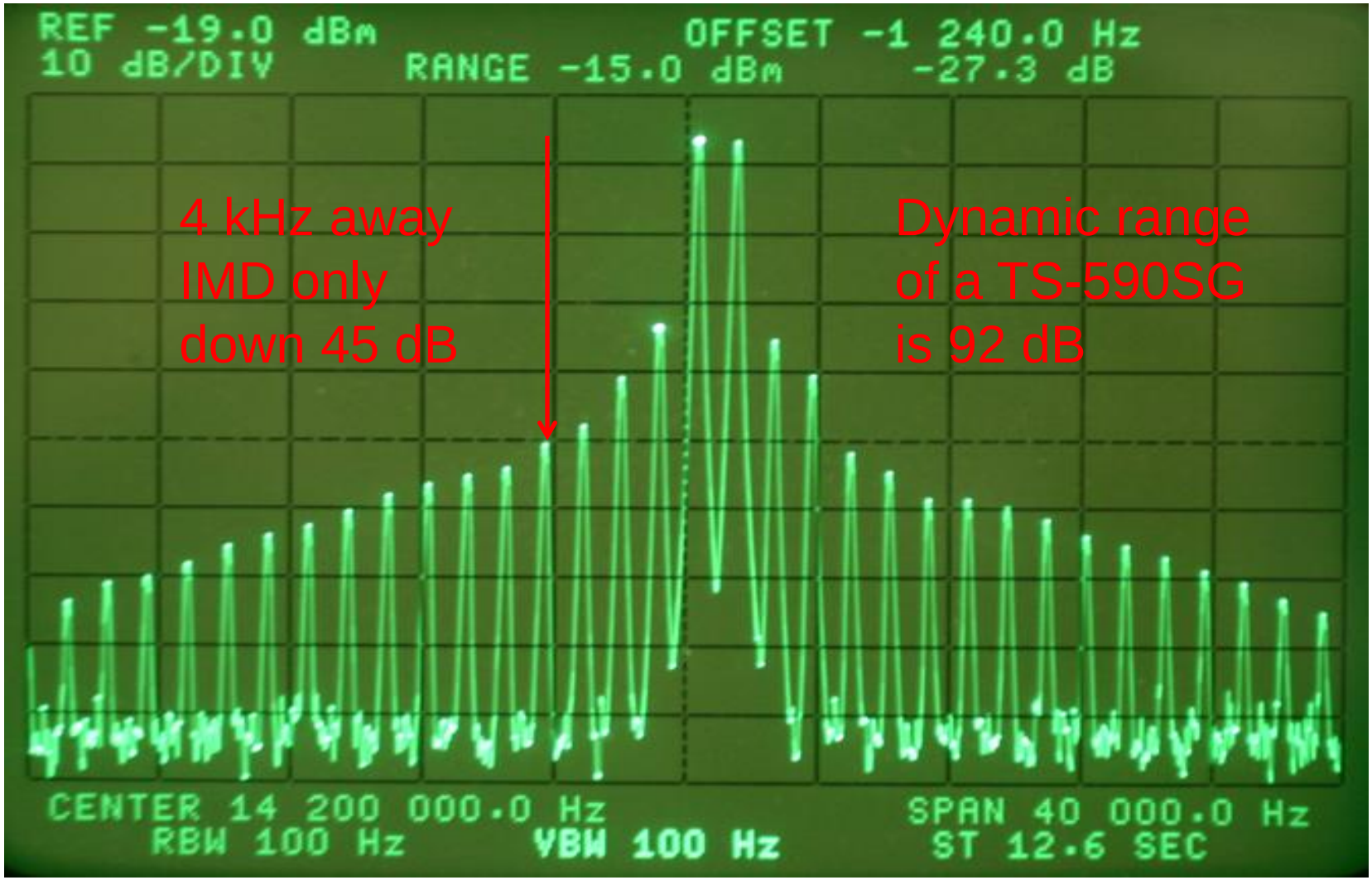
Kenwood TS-990S: -34 dBc 3rd order

A 50 volt PA can be cleaner



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

K3 Transceiver on 20 meters @ 100 W



What is often the limit today?

- Receivers have drastically improved in the past 10+ years.
- Transmitter cleanliness: No Improvement except for Apache PureSignal on SSB.
- Transmitted IMD splatter, CW key clicks, and transmitted broadband noise, are often the limit today.

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 -28 dB PEP
PureSignal* -47 dB PEP, a 19 dB improvement
* Predistortion

3 kinds of Transmitted “noise”

- We have 3rd order IMD splatter “noise”.
- Rigs where you can “turn on” key click “noise”.
  (Rise time can be set to 1 or 2 milliseconds!)
- I recommend no faster than 6 milliseconds.
- Rarely mentioned “transmitted broadband noise”.
- There are no listing for transmitted broadband noise in OEM spec sheets.
- Some models are absolutely terrible.
- We need to be a good neighbor.

QST November 2019

Many hams commented on my article

- Unfortunately not one OEM said a word.
- Apache currently has monopoly on predistortion
- Elecraft says in the future the K4 will offer it.
- Flex has it very low on their future feature list.
- All the new amps have a sampler output.
- Unless competition forces the issue, and affects sales, likely nothing will improve.
- Do most hams even care that their SSB signal is 10 kHz wide or wider at -60 dB?

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 -28 dB PEP on 20 meters.

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

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

We have wonderful receiver performance today, not so much our transmitted signal. This problem adds to QRM.

ARRL DX SSB 15 meters March 2020

I chose a single band effort this year.
Signal to noise excellent on 15m at my QTH.
Splattering signals were unfortunately common.
Audibly splatter was annoying.
The band scope and waterfall visually demonstrated the bad actors.
Most rigs are not this terrible.
Overdriven “linear amplifiers” likely the culprit.
A monitor scope is really helpful.
How many regularly use a scope?

Don’t be a slave to one number !

- Let me emphasize there are great products now from all six major OEMs.
- Note the 18 models listed earlier with a dynamic range of 90 dB or greater at 2 kHz.
- Pick your personal desired performance level and price, then look at the whole picture.
- Examples: good ergonomics, reliability, factory service, clean RX & TX audio, NR & NB, spectrum display, timely firmware upgrades.
- Long term cost of ownership!

How can we improve reception?

- Add a better antenna.
- Directivity always helps.
- Consider an RX antenna or different polarization.
- This might be RX with an antenna for another band.
- TX vertical 160m, RX 80m dipole. See what helps.
- A local noise canceling antenna and accessory
- A 3 element Yagi at 40 feet will do wonders compared to a vertical or G5RV.
- Your don’t have to go as far as I did in creating my “antenna farm”.

You can see my emphasis on antennas

Sherwood Engineering

Videos from past CTU presentations

CTU 2013 through 2019 (Select desired year)

http://www.contestuniversity.com/videos

Sherwood Shootouts (Contest Comparisons) published by DJ0IP

http://www.dj0ip.de/sherwood-forest/sherwood-s-shootouts/

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