2014 / 2015 Rig Contest Results
+
Which Specs Really Matter?

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NCØB

Is my rig good enough?

- **What is important in a contest or DX pile-up environment remains constant.**
- We need Good Dynamic Range to hear weak signals in the presence of near-by strong signals.
- You need a better receiver for CW than for SSB.
- 2014 / 2015 Contest performance observations
- **How does published test data relate to reception of weak signals?**

Rigs used at NC0B this past season

Flex 6700 series @ $7,500

Kenwood TS-990S @ $7,400

Apache ANAN 200D @ $4,250

Elecraft KX3 with KXPA100 amp @ $2,260

Kenwood TS-590SG @ $1,710

Rig experience in 2014 / 2015

Kenwood TS-990: CQWW SSB October 2014

Flex 6700: ARRL 160 CW & ARRL 10 meter contests December 2014

ANAN-200D: Stew Perry W1BB 160 CW end of December 2014

Elecraft KX3 + KXPA100: CQWW 160 CW contest January 2015

Kenwood TS-590SG: CQWW 160 SSB contest February 2015

(All rigs drove an Alpha 89 PIN Diode QSK legal limit amplifier)

Details – Kenwood TS-990S

- Main receiver down conversion all bands
- Third-order transmit IMD excellent at -40 dB
- Has a cleaner 50 volt PA
- Band scope very effective
- Excellent low-fatigue receive audio
- RMDR is its weakest point, but should rarely be an issue in most environments.
- Needs NB and NR firmware improvements

Details – Flex 6700

Fantastic band scope with amazing resolution

Clean audio, very low fatigue, minimal ringing

Tuned receiver with FlexControl

V1.38 software was a significant improvement.

I used two separate computers, one for N1MM and SmartCAT for band data, plus second computer to actually run SmartSDR.

With V. 1.40 software, three logging programs support focus recovery after user adjustable time. (2 seconds default)

Apache ANAN-200D

- Initially CW selectivity was terrible
- Consultation with NR0V resolved the issue
- Tuning was done with a FlexControl
- Bandscope was good, though not as good as a Flex 6700 with the default settings.
- Could not view signals too weak to copy
- I could have fixed this if I had known how.
- Focus was a major shortcoming
- Many contacts were lost due to loss of focus
- Planned fix for N1MM+ by May 15th.

ANAN-200D continued

- CW selectivity fixed with buffer & filter change
- Initial shape factor @ 200 Hz was 4:1 !
- Buffer & filter change shape factor = 1.6:1
- Dual 19-inch monitors, N1MM + PowerSDR
- Loss of focus was a rate killer.
- Improper keystrokes = shifts to BC band, 3 MHz, Shortwave bands, etc.
- APF excellent once selectivity corrected
- Software is open source, written in C & C#
- New NR code shipped in March

A Note on CW Selectivity

- Shape factor at 500 or 250 Hz = 2:1 minimum with any modern rig
- Most DSP rigs will have a shape factor 1.5:1
- If you are tuned 1 filter bandwidth away from a strong CW signal, you should only hear key clicks, not a CW signal.
- That was the tip-off that something was wrong with the 200D until the buffer setting and filter type was set properly.

Details – Elecraft KX3

- Operated as CE0Y/NC0B Easter Island
- Performed well in 2015 CQWW 160 CW
- QSK improved, but still had keying artifacts
- DSP provides excellent bandwidth control
- KXPA100 drove Alpha 89 to 1.5 kW
- Opposite sideband rejection is its performance limit, being around 60 dB.
- Would be my first choice for QRP operation compared to IC-703+ or Argonaut VI

KX3 continued

The only problem operationally I had was large QSYs on 160 with a narrow-band antenna.

Had to drop power to 10 watts to disable 100 watt PA

Then retune L-network to low SWR

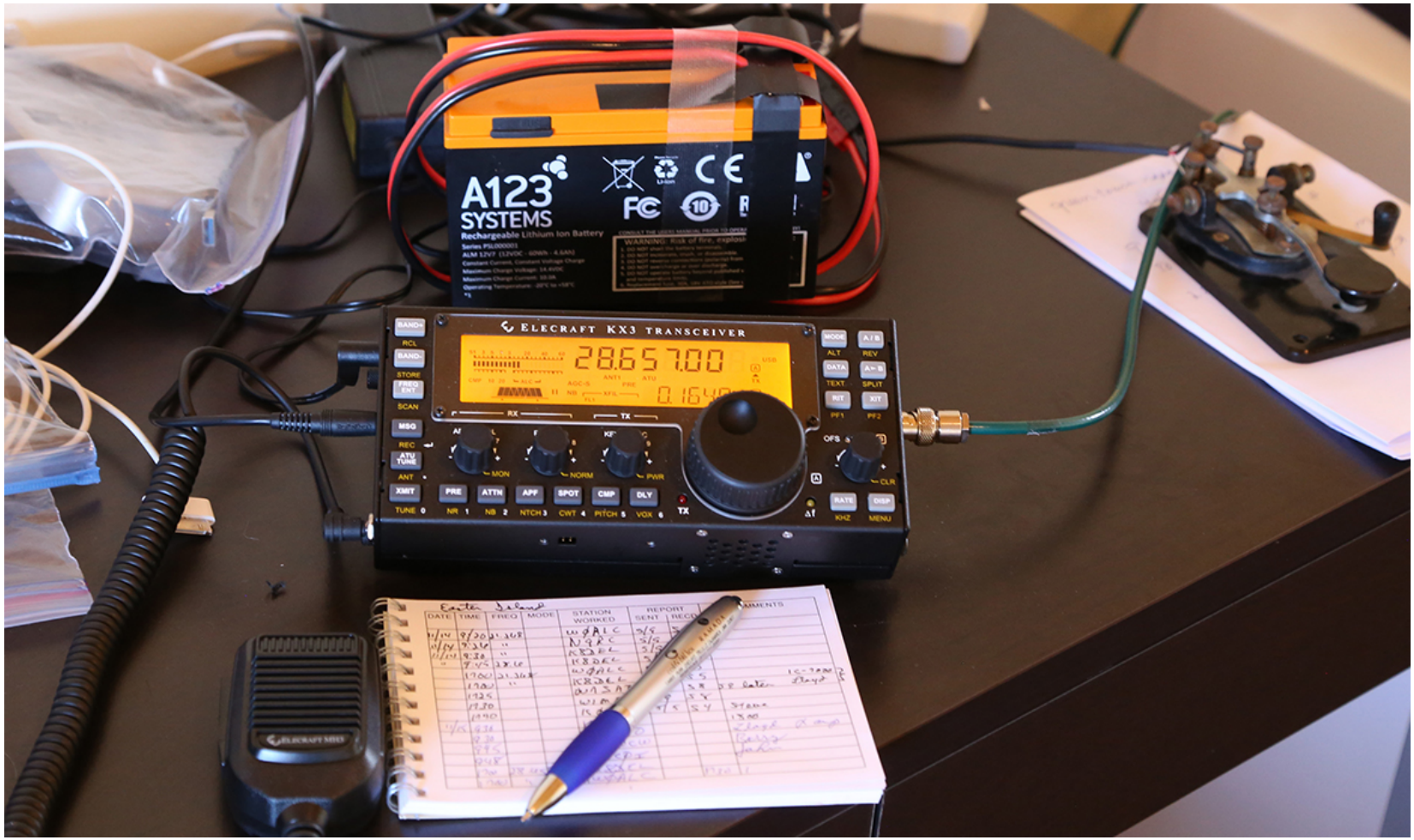
Otherwise if I put Alpha 89 in standby, the KXPA100 would lockup on a high SWR.

10 dB preamp used during daylight hours 160, which should be considered normal.

(Battery and charger details available on request)

Operated SSB and CW on 10 & 15 meters

Shack on Easter Island - Great Fun !



Kenwood TS-590SG

- The 590S was improved as the 590SG
- The radio is now in the top 10 on my chart
- N2IC, a top contester, has a pair of the older TS-590S models.
- I don’t know a better bang for the buck than this Kenwood transceiver.
- DSP selectivity is excellent and easy to use with Hi / Low adjustments on SSB or width on CW.
- Ergonomics are user friendly

What is the least understood Spec ?

When is the spec for noise floor significant?

Why does it rarely matter on most bands?

What is often not understood ?

Noise Floor is usually significantly lower than Band Noise.

An ITU graph published in the ARRL Handbook gives us a starting point to relate band noise to noise floor.

This ITU data is in a 500-Hz bandwidth, just like typical noise floor data.

(Note: Noise floor is bandwidth dependent, unlike Noise Figure)

Band Noise vs. Frequency from ARRL Handbook

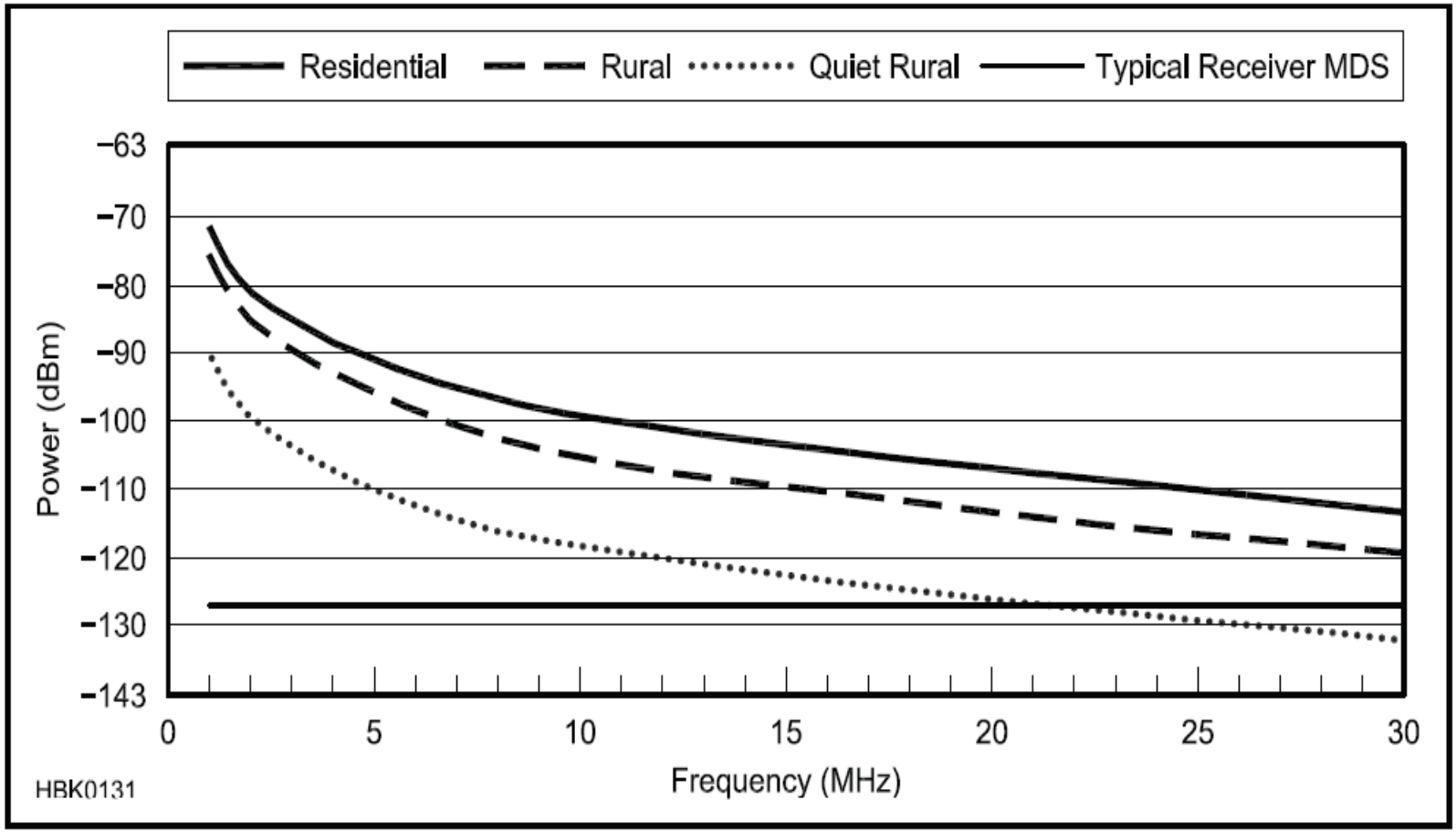


Fig 1 — Typical noise levels versus frequency for various environments. (Man-made noise in a 500-Hz bandwidth, from Rec. ITU-R P.372.7, *Radio Noise*)

Most Radios are designed for 10 meters

It is easy to assume that a -140 dBm noise floor is better than a -130 dBm noise floor.

If band noise on 20 meters is typically -110 dBm, of what value is a receiver noise floor that is 20 to 30 dB lower than band noise?

Use your 6 or 10 dB attenuator on the lower bands

Band noise easily changes 10 dB depending on beam heading.

Optimally receiver noise should be 8 to 10 dB lower than band noise to have minimal effect on receiving weak signals.

How does band noise vary by band?

If we take the ITU rural data as a starting point, what is typical?

160 meters:	-87 dBm
80 meters:	-93 dBm
40 meters:	-101 dBm
20 meters:	-109 dBm
15 meters:	-114 dBm
10 meters:	-119 dBm

That’s a 30+ dB difference in band noise

Measured band noise at NC0B

160 meters 8:00 AM MST:	-105 dBm	January 2014
160 meters 4:00 PM MST:	-101 dBm	160 meter CQ
160 meters 6:30 PM MST:	-91 dBm	CW Contest

ITU rural nominal value:	-87 dBm

Beam Heading, October 2013	15 meters	10 meters
0 degrees beam heading:	-124 dBm	-129 dBm
30 degrees:	-124 dBm	-123 dBm
60 degrees:	-118 dBm	-120 dBm
90 degrees:	-114 dBm	-120 dBm
120 degrees:	-113 dBm	-122 dBm
150 degrees:	-114 dBm	-122 dBm
ITU rural nominal value:	-114 dBm	-119 dBm

ITU / ARRL Data is generally correct

- Those numbers = starting point for a rural QTH
- On a give day can be +/- 10 dB differences
- CQWW SSB 2014 my 10 meter noise floor was 10 dB lower than the ITU value, pointed West between 3 and 5 PM local time while working ZL, VK & JAs.
- (5 element monoband yagi @ 65 feet)
- 80 M mid-day band noise measured -120 dBm
- Urban QTH with RFI noise, all bets are off.
- How's your neighbor's Plasma TV ?

Typical receiver noise floor values

Rig	Preamp OFF	Preamp ON
Pro III	-132 dBm	-140 dBm
TS-990	-127 dBm	-138 dBm
K3	-130 dBm	-138 dBm

- ITU night-time band noise on 40 meters is around -100 dBm, while typical receiver noise floor is -130 dBm, or 30 dB lower with the preamp OFF !

What does all this imply?

- For most radios: Up-conversion / down-conversion
- On the lower bands at night, attenuation is often appropriate.
- There is no point in band noise reading upscale on your S meter.
- A preamp is usually NOT needed on 20 meters.
- A preamp would never be needed on 40 meters and below, assuming the transmit antenna is used on receive.

Preamp on 160 or 80 meters OK?

- Many rigs today have an RX input for a receive only antenna.
- A Beverage or a small loop would usually have a head amp, at least for impedance matching. (Maybe just a transformer)
- A preamp for a receive-only antenna may well be appropriate on the low bands.
- Use common sense for special cases.

Where do these examples not apply?

- Direct sampling radios are very different
- Examples of direct sampling radios:

- Perseus receiver (CW Skimmer)
- Apache ANAN-100D & ANAN-200D
- Flex 6300, 6500 or 6700

- The overload point of the Flex is much higher, and the noise floor is also much higher, with the preamp OFF.

- Apache is different in that it has a preamp in the circuit all the time, plus a variable attenuator.

Some comparison data

Rig	Noise Floor Preamp Off / On	Noise Figure Preamp Off / On
Icom Pro III	-132 dBm / -140 dBm	12 dB / 4 dB
Elecraft K3	-130 dBm / -138 dBm	14 dB / 6 dB
Kenwood 990S	-127 dBm / -138 dBm	17 dB / 6 dB
Flex 6700	-118 dBm / -132 dBm	26 dB / 12 dB

For classic radios with normal mixers (up-conversion or down-conversion) attenuation is often helpful in potential overload conditions (contests / DX pile-ups) on 40 meters and below. Possibly even on 20 meters.

For direct sampling radios, particularly the Flex 6000 series, attenuation would rarely be needed, but a preamp would be useful on 15 meters and up.

How do we chose a new transceiver?

- On most bands receivers are too sensitive.
- Make the most of the radio's dynamic range by properly using the attenuator and using the preamp only when necessary.
- Published dynamic range can be misleading, depending on how it is measured. Read the fine print, as I discussed in past years.
- Look at RMDR, as this typically dominates.
- (RMDR* = Reciprocal Mixing Dynamic Range)
- [*QST April 2012 for sidebar – Bob Allison]
- It is a numbers game today!
- Evaluation in contest conditions is critical.
- A lab setup can never approximate CQ WW !

Speaking of RMDR - It means what ?

- Most of the time phase noise (reciprocal mixing dynamic range) isn't a problem.
- Poor RMDR likely implies bad transmitted broadband noise, too.
- When does it likely really matter?
- Field Day
- Multi-Multi contest stations
- You have a nearby neighboring ham within a few miles of you.

Example of transmitted phase noise hell

- There are two hams in Boulder, CO that are 5 miles apart.
- Ham A never bothered Ham B with his Yaesu FT-1000 MP
- New FTdx-3000, Ham A wipes out the whole 15 meter band with S9 broadband noise at Ham B's QTH
- We need to be a good neighbor, be it from a wide SSB signal, terrible key clicks on CW or poor transmitted phase noise.

RMDR can be the limit instead of DR3

- My web site's the top 4 radios are outstanding from an RMDR standpoint.
- Flex 6700, Elecraft K3 & KX3, PT-8000A
- The new Elecraft K3 synthesizer board can upgrade any K3 to outstanding phase noise / RMDR performance
- For under $200 you can be state-of-the-art
- (Part # KSYN3A)

Passive IMD in Roofing Filters

- While testing the K3's new synthesizer, six roofing filters were tested for their effect on dynamic range.
- Some variation is expected, but there was significant variation with the 5-pole filters.
- This warrants further investigation.
- Roofing filter passive IMD has been observed with all "Down Conversion Radios".
- This has become the limit in the numbers race.

How to cope on noisy bands

- Set the RF GAIN so punching in 6 dB attenuation definitely drops the band noise.
- If the band noise between words is as loud as a weak but Q5 signal, this adds to fatigue.
- If your receiver has hiss or hum in your phones, consider plugging your phones into a speaker that has high-pass and low-pass filters.
- Examples: Icom SP-20, SP-23 or SP-34
- Yaesu SP-2000 or Kenwood SP-990

Transmit IMD Needs to be improved

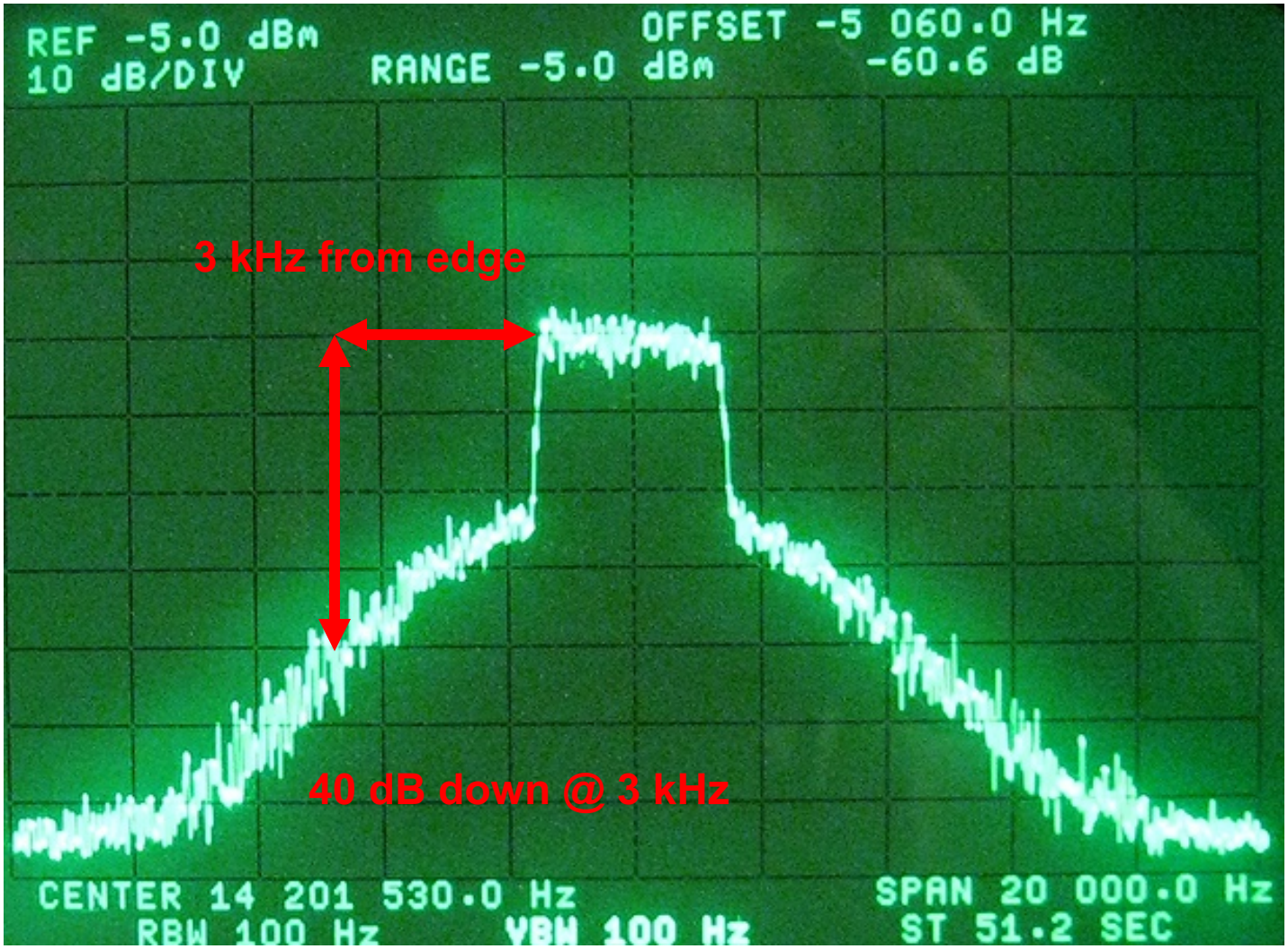
- Receivers have improved dramatically over the past 10 years, but rarely so transmitters.
- AI0L had complaints of being broad.
- Comparing rig A & amp A to rig B and amp B
- Desired sideband was S9 +15 dB
- Opposite sideband with “A” combo = S8
- Opposite sideband with “B” combo = S2
- “A” combo is current rig & solid-state amp
- “B” combo is 30 year old rig & 2x3CX800A7s

Transmit Intermodulation IC-7410

- White noise fed into mic jack to approximate speech using IC-7410.
- (This is a typical example, not just this rig.)
- Look at the “shoulders” of IMD close-in to the transmit passband.
- If this station is 3 kHz away and is strong, hearing a weak signal will be difficult.

Noise source = GR 1381, 5-kHz -3 dB BW

Icom IC-7410 Class AB, White Noise



Reception limits on SSB may be the other guy

On SSB, adjacent-channel splatter is usually worse than the dynamic range of the receiver.

Today's 13.8 volt PAs are significantly worse from a transmitted IMD standpoint than tube PA circa 1962 (Collins 32S-3).

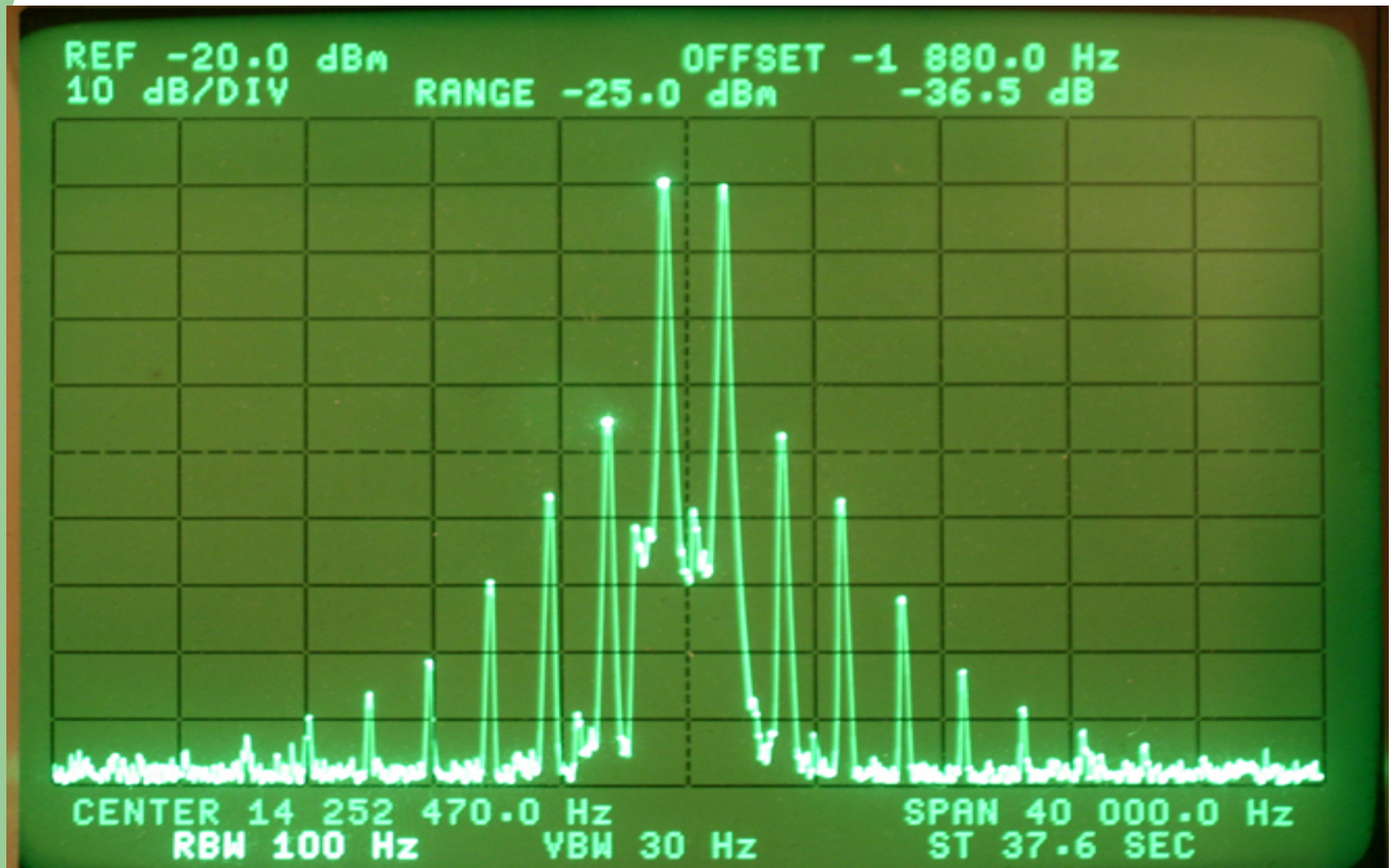
Why are rigs today, that will never be used mobile, still running on 13.8 volts?

With today's LDMOS FETs, 50 volt PA s should be the norm.

My cleanest transmitter

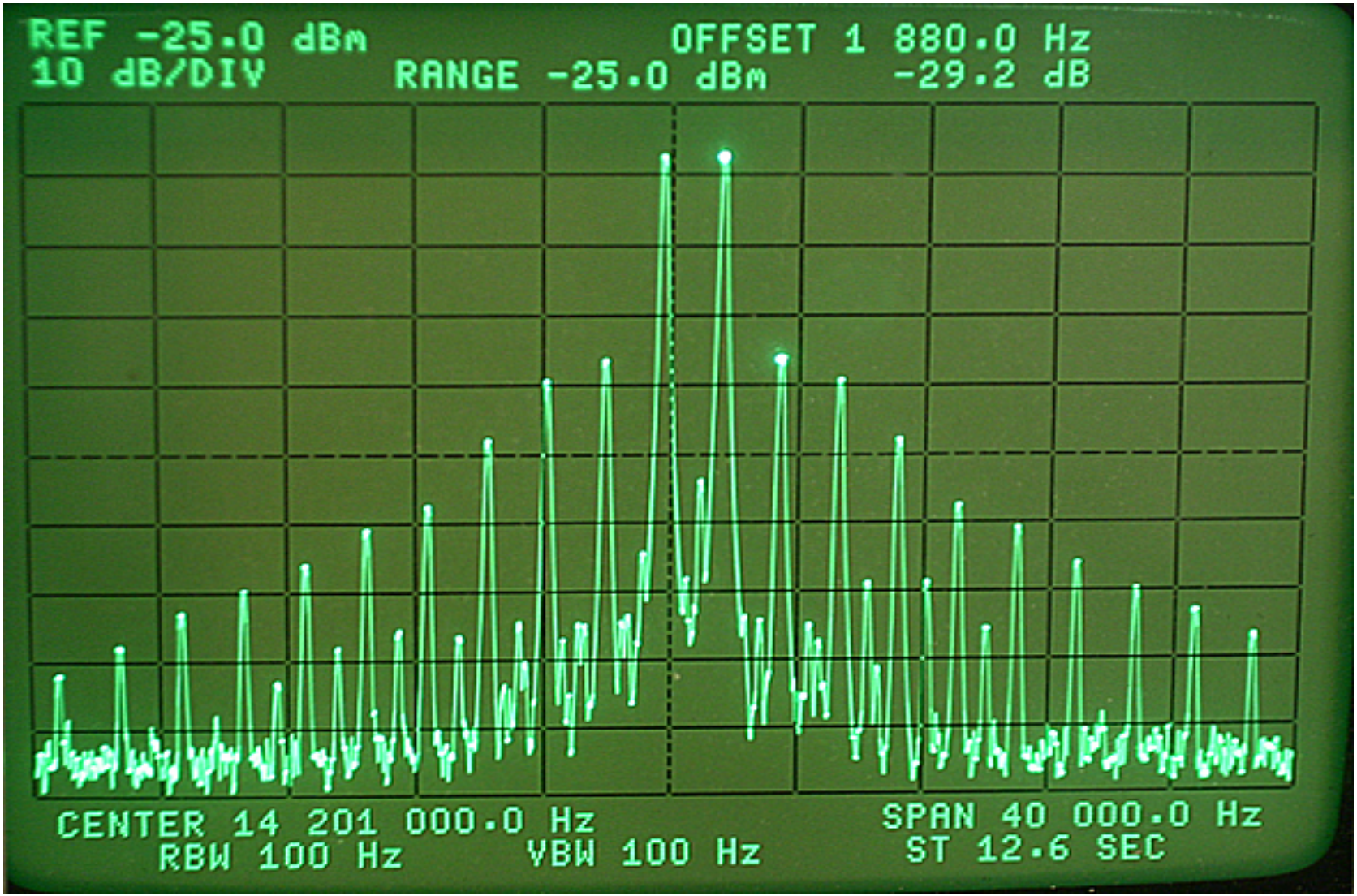
-36 dB 3rd Order, -60 dB 7th Order

Collins 32S-3 on 20 meters @ 100 W



-29 dB 3rd order, -41 dB 7th order

Flex 5000A on 20 meters @ 70 Watts



Will you pay more for a cleaner signal ?

We need help from our OEMs to clean up the bands

Will you spend $100 to $200 more for a cleaner SSB signal?

Pre-distortion could help even a 13.8 volt PA

Apache offers that now, though setup is complex

A cleaner rig is only useful if the operator doesn't over drive his linear into clipping. Who me splatter?

Every ham should have a scope or a real peak reading wattmeter if you run a linear amplifier.

PURESIGNAL RESULTS

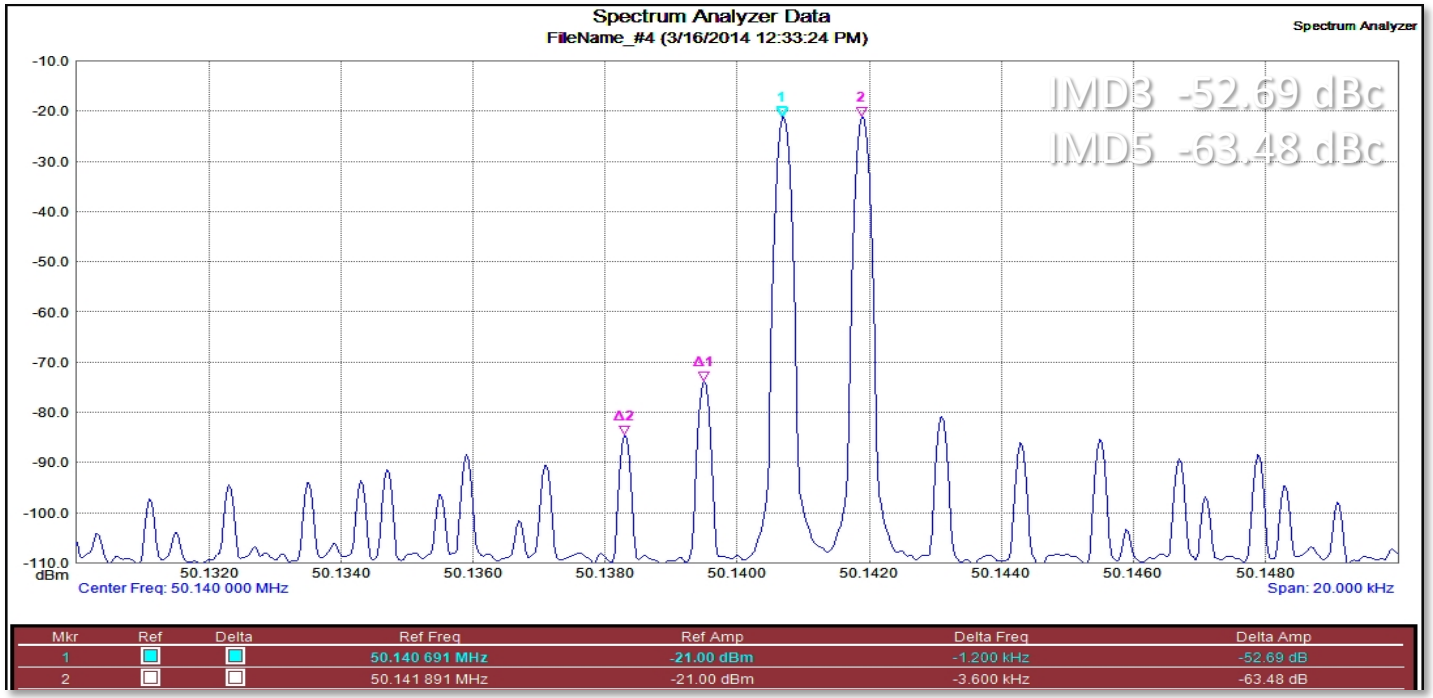
Mike, N1JEZ

Pre-Distortion results with RF sampler at output of Acom linear amp

ANAN-100

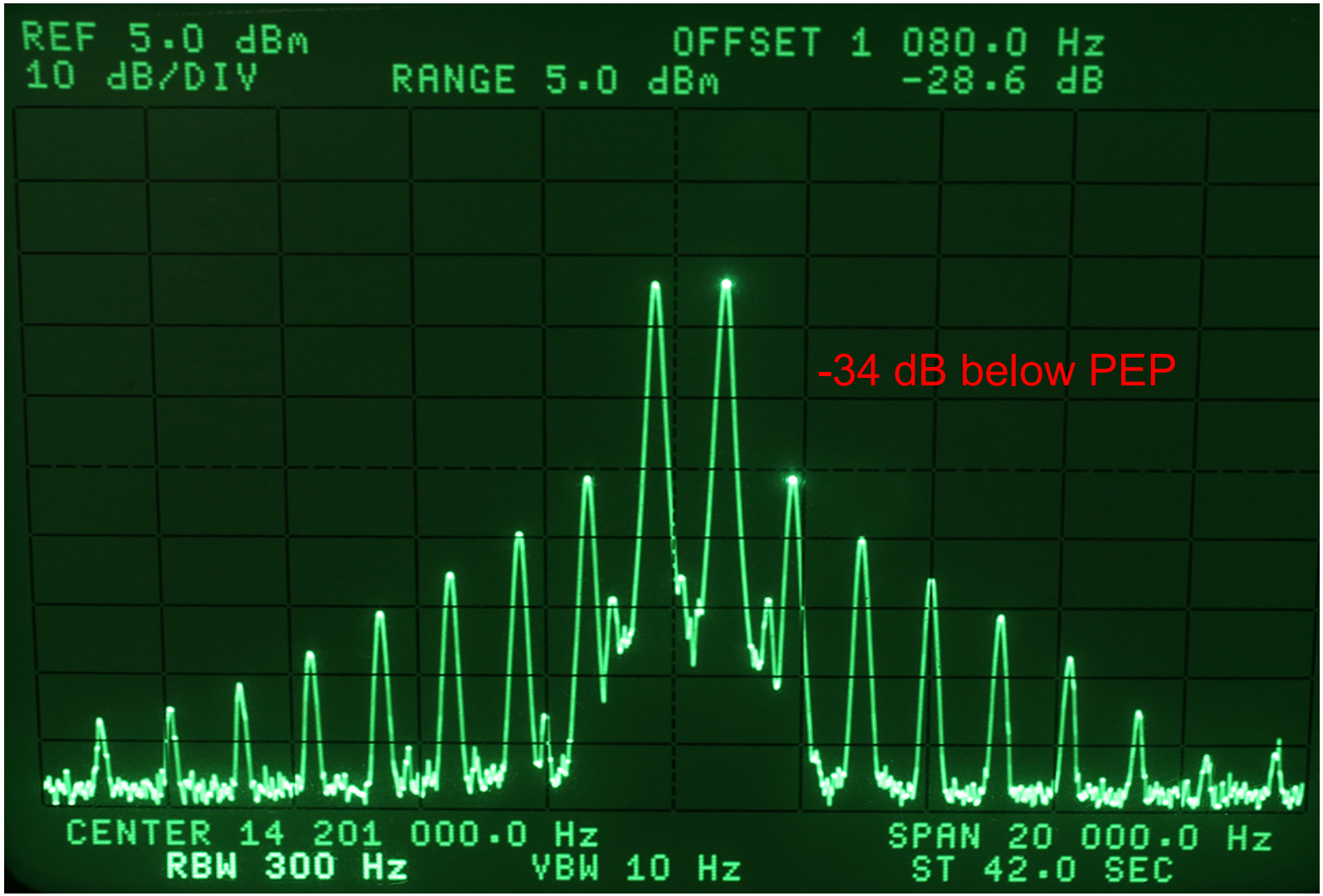
ACOM-1006

3rd order -52 dBc
5th order -63 dBc



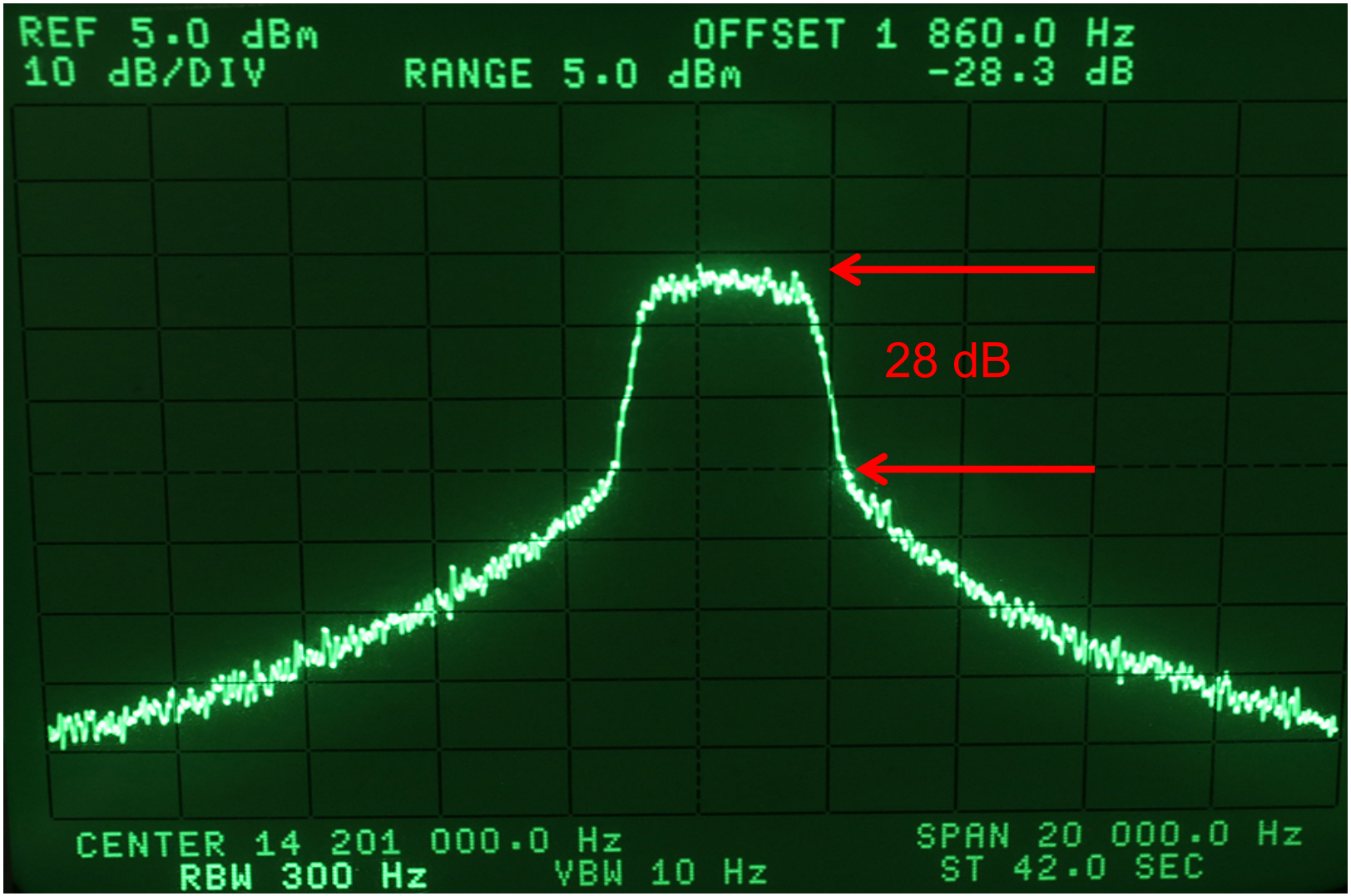
Tones are 700 Hz and 1800 Hz

Icom IC-781 Classic 2-Tone Test 3rd order -28 dB



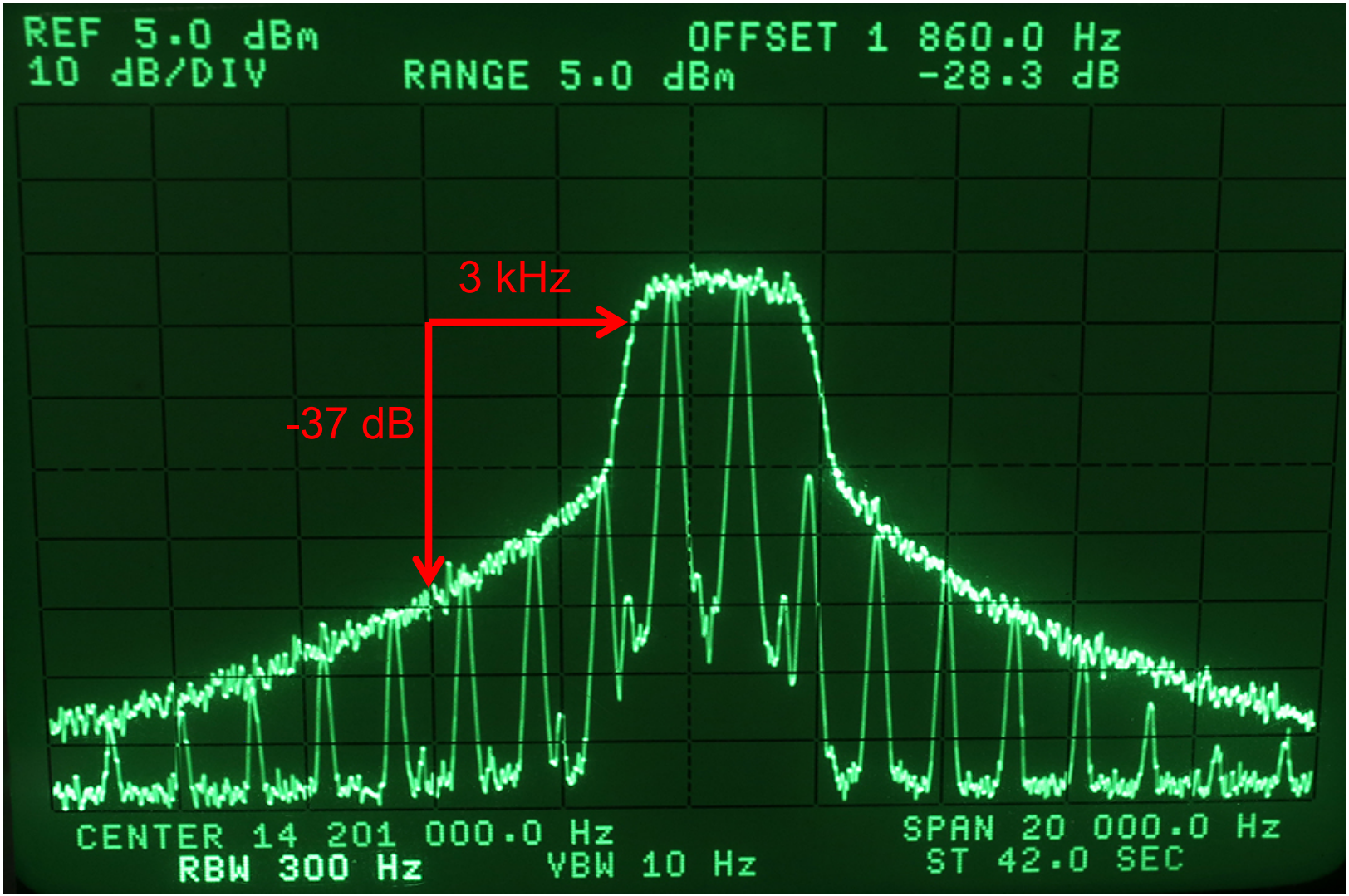
GR 1381 BW = 5 kHz @ -3 dB

IC-781 White Noise Intermodulation Occupied Bandwidth



How Wide Is Your Signal ?

Comparison 2-Tone vs. Noise Intermodulation Bandwidth



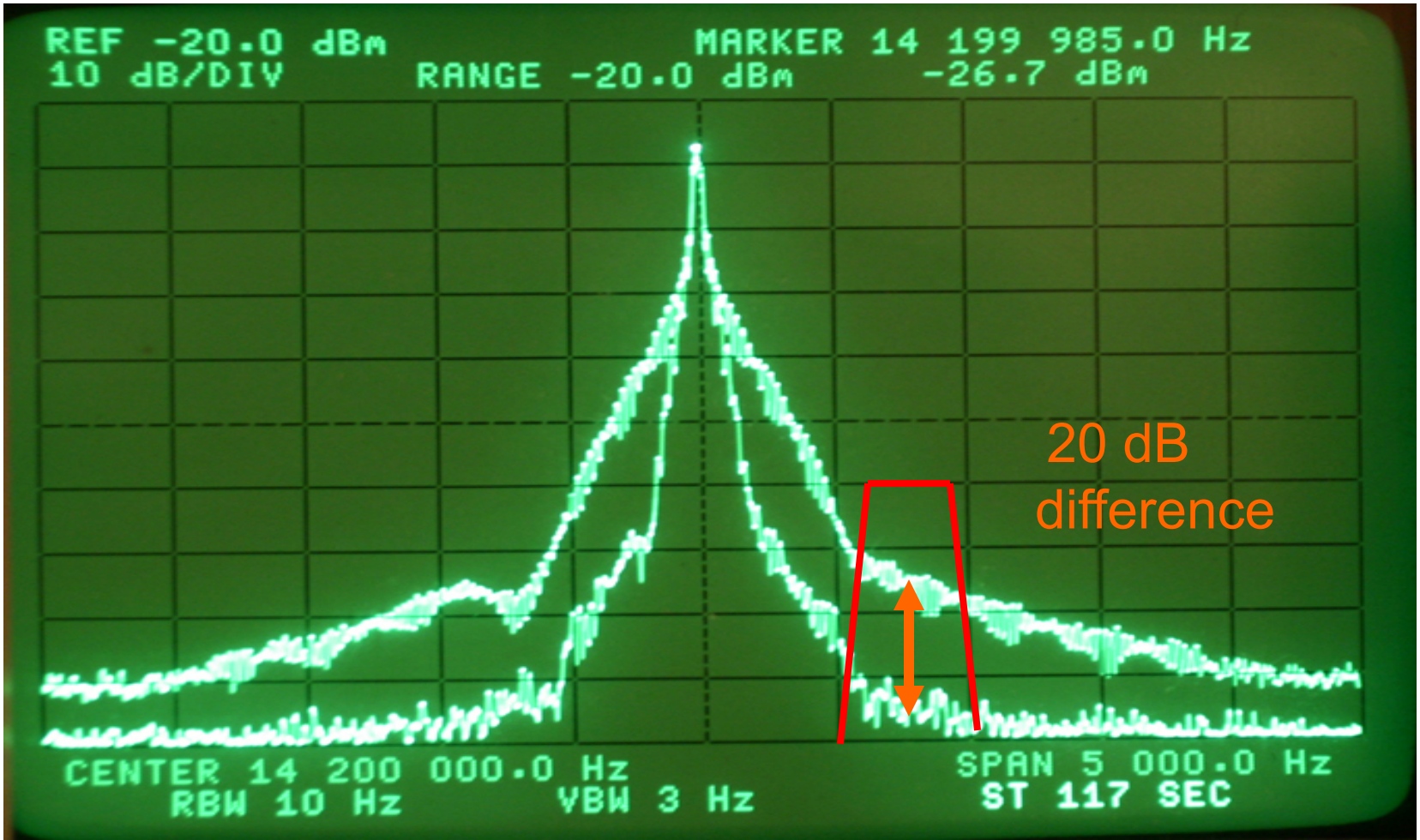
Broad signals Also Exist on CW

- The following slide shows the difference between a rise time of 3 milliseconds vs. 10 milliseconds.
- There is a 20 dB difference in the strength of the key clicks 700 Hz removed from the transmitting station.
- (Transmitter was a Ten-Tec Omni-VII that has a menu to adjust the rise time.)

Many rigs are much faster than 3 msec

Spectrum of CW Signal on HP 3585A Analyzer

Comparison of 3 msec vs 10 msec rise time



Bad choices in the menus of many rigs

Many rigs today offer user adjustable rise times for CW operation.

The choices are often way too fast.

Typical choices: 1, 2, 4 & 6 milliseconds

I tested a $7000+ rig with a 1.5 millisecond rise time that was 4.8 kHz wide at -60 dB.

Anything faster than 4 milliseconds will to too broad.

Again: Be A Good Neighbor !

Choices today on rig selection

- We have rigs from $1000 to $14,500 for sale.
- Many do well in contest conditions.
- It is hard to evaluate on-air performance from some of the published data.
- Many aspects of a radio affect contest scores
- In the end, hopefully you enjoy using your rig on the air !

Sherwood Engineering

Videos from past CTU presentations

CTU 2013 & 2014 (Select desired year)
http://www.contestuniversity.com/main/page_videos.html

CTU 2011
http://www.pvrc.org/webinar/radioperformance.wmv