New Offerings 2013
Since Dayton 2012

Rob Sherwood
NCØB

New strides plus some disappointments

- **What is important in a contest or DX pile-up environment is still the same in 2013.**
- 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.
- There are some new top performers.
- **Design problems get into production.**

What New Rigs have Shipped?

Announced Dayton 2012:

Hilberling PT-8000A @ $18,000

Kenwood TS-990S @ $8,000

Flex 6000 @ $4,300 to $7,500

Yaesu FTdx-3000 @ $2,700

Elecraft KX3 with 100 watt PA option around $1,700

What is unusual about new rigs?

Hilberling may be the last virtually pure analog rig to be designed.

(Also has excellent phase noise, 10-25 dB better than FTdx-5000)

Kenwood TS-990 is 5X the cost of the effective TS-590S

Flex is advertising a very flexible system that is now shipping.

Yaesu 3000 has a disappointing synthesizer compared to 5000

(Significant performance drop at half the price of FTdx-5000)

(Also FTdx-3000 has some serious ergonomic issues)

Elecraft KX3 has phase noise nearly as good as the Hilberling

(Due to direct conversion, close-in CW performance limited)

(KX3 QSK not competitive with K3 QSK)

Are there any Deal Changers this year?

- The Hilberling has required many hardware updates after I tested it and used it in two contests.
- At $18K+, it will be a niche product.
- The 990 vs. 590 leave a significant pricing hole.
- Flex 6000 series: is Mouse Control OK for contests?
- Yaesu continues to do processing in their ALC.
- The advantages of Class A PA are negated by Yaesu ALC design.
- Unlikely the KX3 will appeal to serious contesters due to its size.
- That said, it worked really well in W1BB CW contest

Details - Hilberling PT-8000A

- Covers 160 – 2 meters
- Is the added complexity worth added value?
- 600 watt PA derated to 200 watts; quite clean
- 2012 units needed major hardware updates
- 30% THD due to product detector overload
- Audio was rolled off 15 dB at 3 kHz
- Minor synthesizer noise bump at 30 kHz caused by improper power supply bypassing

More Details - Hilberling PT-8000A

- 500-Hz 16-Pole crystal filter inadequate
- Audio-derived AGC using audio DSP for narrower bandwidths was a disaster
- (AGC attack caused rail to rail clipping)
- Had XYL listen: “Is it supposed to do that?”
- Adding 250 Hz crystal CW filter selection was mandatory for good CW performance
- Note: BW is at -3 dB, @ -6 dB 600 & 300 Hz
- Price a significant issue
- Requires computer for band scope

Details – Kenwood TS-990S

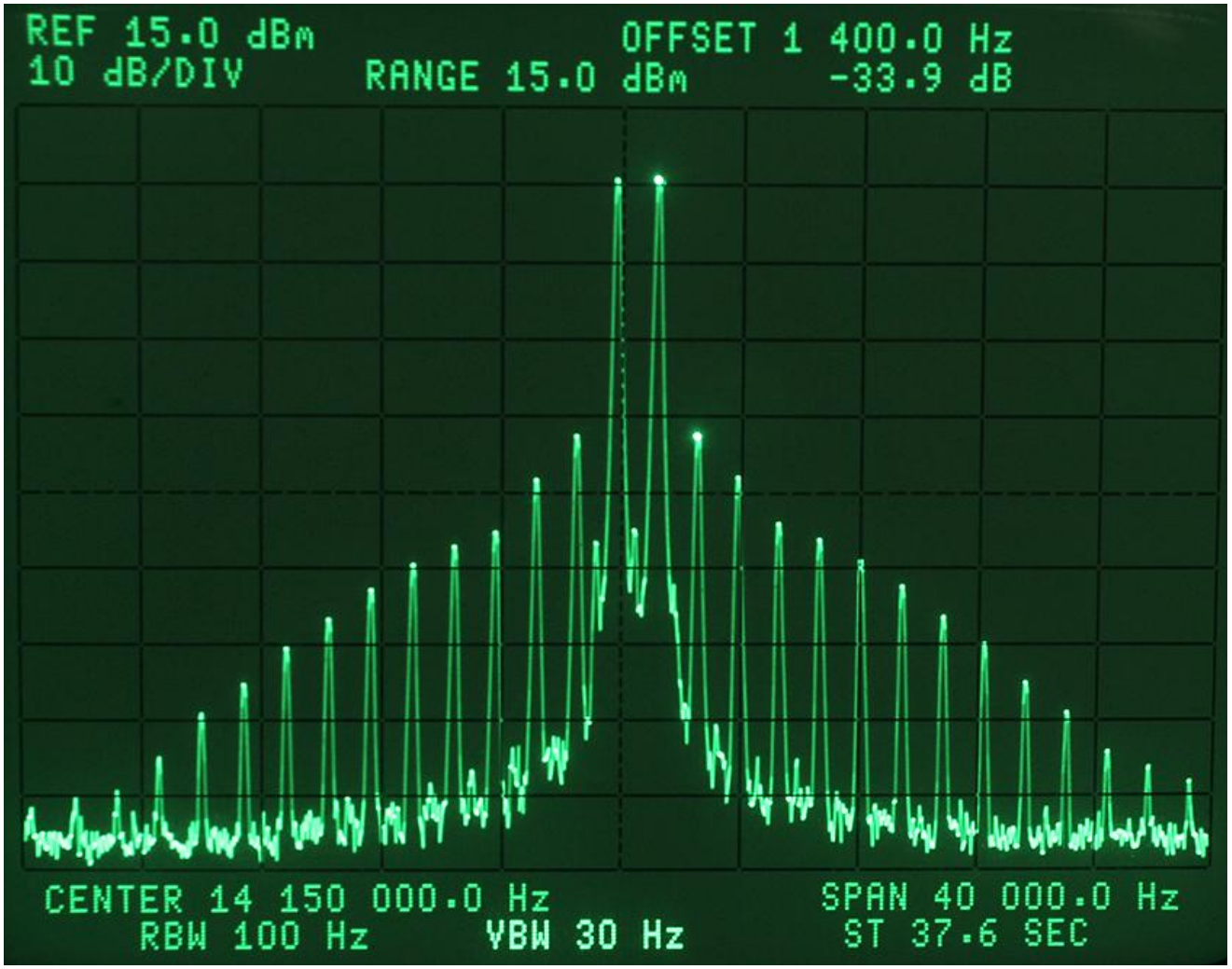
- Main receiver down conversion all bands
- CW limitations of 590S main receiver not present on 990S main receiver for 10, 6 & WARC
- Sub receiver same as TS-590S
- 50 V. FET PA, excellent transmit IMD
- Built-in band scope
- Price competitive with flagship products of other OEMs
- Passive IMD with 500 Hz filter

More Details – Kenwood TS-990S

- At 20 kHz I measured a DR3 = 111 dB
- (Highest I have ever measured)
- A value nearly this high will likely hold close in, which may produced a 2-kHz DR3 using ARRL 1-Hz filtering of greater than 107 dB
- However with a 500-Hz filter, the measured RMDR on 20, 15 and 12 meters is 87 dB, a significant difference. *

* (RMDR Varies by band from from a low of 85 dB on 17 meters to a high of 98 dB on 30 meters)

TS-990s Excellent transmit IMD



3rd Order IMD down 34 dB reference test tones

Reference PEP = IMD down 40 dB

Note: ARRL and OEMs use the PEP method

Details – Flex 6000 series

Fantastic band scope with amazing resolution

Only used a prototype for 2 days in May

(One day in the lab, and one day at Ault)

First time Gerald had heard it in a quiet location

Can have multiple receivers and / or bandscopes

Only 1 knob & 3 buttons with external Pod

Is a computer interface the reason Flex only holds 2% market share for contesters?

More Details – Flex 6000 series

Preamp selections seem odd to me.

Has one or two 20-dB preamps.

To get 10 adds 10 dB pad before the preamp.

Going from 0 dB preamp to 10 dB only improves noise figure 4 dB because of the attenuator.

Handles strong BC signals from 160 antenna well

Have not yet tested 13.8 volt transmit IMD

Why didn’t Flex use a 50 V. PA?

IMD without Dither or “Magic”

Perseus IMD varies from 77, 87 to 96 dB down with no Dither
Depending on level S9 +30, S9+40 or S9+50. (-43, -33 or -23 dBm)

Apache is < -50 dBm without Dither at S9+30 (-43 dBm)
Apache is < 75 with Dither
Apache is < 85 with Dither and Random

The Flex 6700 without “Magic” was similar to Apache
“Magic” didn’t work very well in May

“Magic” optimization with ATE takes 48 hours !

With “magic”, Flex is measuring a DR3 over 105 dB

If the IMD is smeared away with digial “diddling”, does this really work in CQ WW CW contest?

Does anyone really know?

Details – Yaesu FTdx-3000

- Ergonomics a significant disappointment
- Band scope is close to useless
- Adjusting power to drive linear can take 4 or more operations of the menu / buttons / knobs on SSB!
- Has typical poor AGC impulse noise problem
- Processing is mostly in ALC, same as with the FTdx-5000 and FT-950.
- (No point in Class A with Yaesu ALC system)
- Why won’t they fix the speech processor?

Details – Elecraft KX3

- Amazing tiny radio that performs well
- Performed well in Stew Perry CW contest
- QSK a big disappointment with lots of clicks on receive audio
- Audio level inadequate for 30 ohm phones
- Had to use powered computer speakers to drive my Sony headphones
- DSP provides good bandwidth control
- Needs KXPA100 to drive any linear 1.5 kW
- Ergonomics OK for such a small rig

A few more comments on KX3

Limitations for CW are the opposite sideband rejection.

While the 2-kHz dynamic range is excellent, this doesn't tell the whole story. A signal on the opposite sideband is down only 60 to 70 dB. This is a limitation of direct conversion.

Excellent phase noise is possible in a $1000 radio.

Frequency wanders around 5 to 10 Hz due to the LO design. Would be an issue in some weak signal transmission systems such as WSJT.

AGC handles impulse noise well, just like K3

Wide-spaced vs. Narrow-spaced DR3

- In 1976 I found that wide roofing filters were a problem. Caused overload in CW pile-up.
- 20-kHz testing not adequate for DR3
- 2-kHz DR3 test gave drastically lower values
- Better approximated on-air results
- From 1975-2001 QST only published 20 kHz
- 2002 QST added 5 kHz DR3 data
- 2006 QST added 2 kHz DR3 data
- Usually 20 to 30 dB lower than 20 kHz value

What value is adequate?

Close-in DR3 of 75 dB OK on SSB.

Why?

Transmitted splatter 3 kHz away usually worse than the dynamic range of the receiver.

On CW, due to much narrower transmit bandwidth signal, 85 dB or better is a desirable number.

ARRL / Sherwood Testing Compromise

From 1976 through 2006 the ARRL and I tested radios in a 500 Hz bandwidth. Worst case data was published whether a radio was Intermod Dynamic Range Limited (DR3) or Phase Noise limited. (Now called reciprocal mixing dynamic range limited - RMDR *)

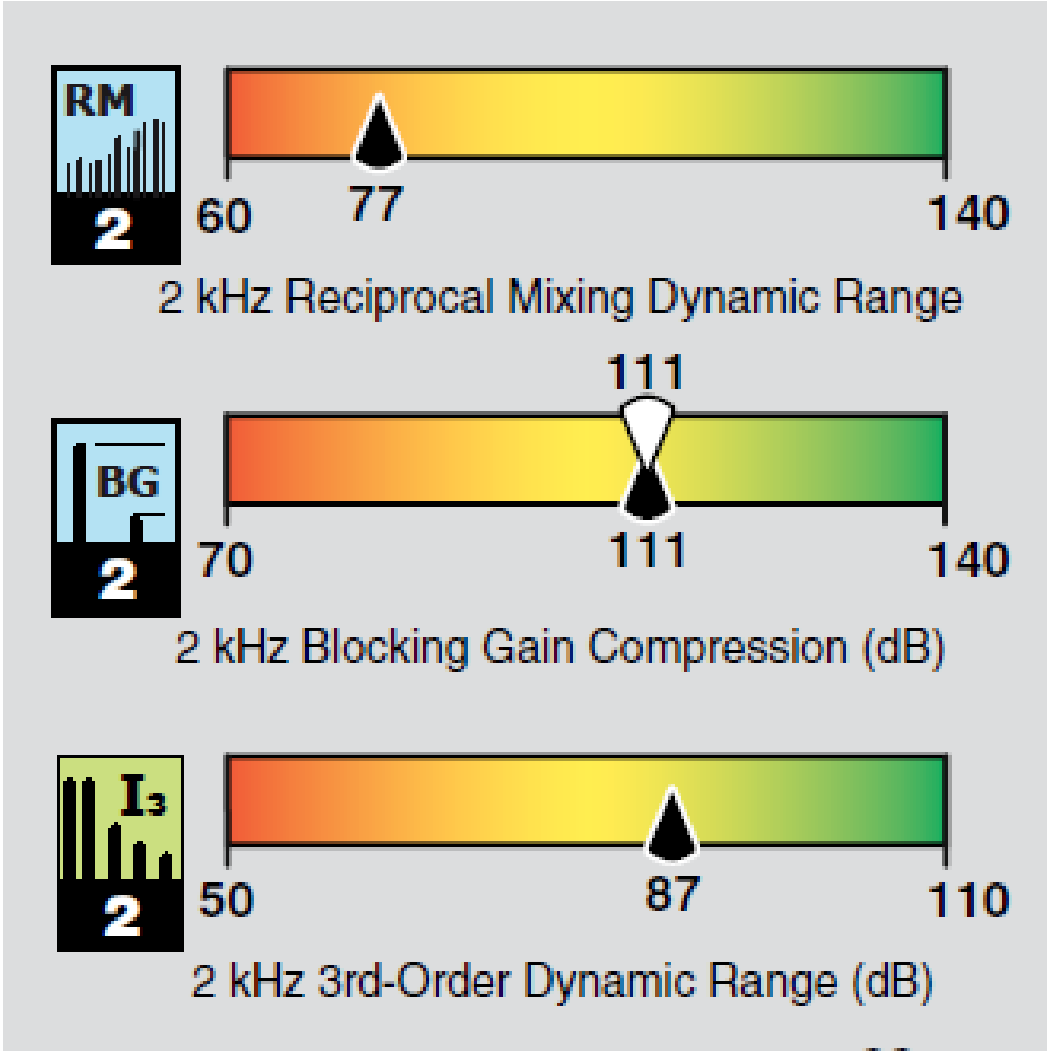
Between 2007 – 2011 the League virtually took the effect of synthesizer phase noise out of the picture by making dynamic range measurements with an FFT analyzer and a 1 Hz filter bandwidth.

While this measurement is technically accurate, the data usually had little correlation to how the radio performed on the air. It also eliminated the incentive for the OEMs to improve their synthesizers.

In the Fall of 2011, with the help of Adam Farson, VA7OJ, the League agreed to emphasize Reciprocal Mixing Dynamic Range (RMDR *).

* (As defined by the ARRL, April QST 2012)

New Graphic for RMDR, IC-9100 Review



QST April

2012 P. 54

From a practical stand point, the 77 dB value is the limit on the air, not the 87 dB value.

IC-9100 RMDR Table Data QST 4/2012

Reciprocal mixing dynamic range,
500 Hz bandwidth, 3 kHz roofing filter:
14 MHz, 20/5/2 kHz offset: 101/80/77 dB.

In a CW pile-up, the reciprocal mixing limitation is more of an issue (77 dB) than if the QRM was up or down the band 20 kHz (101 dB)

Bob clearly explains importance RMDR

Note how reciprocal mixing relates to the two-tone third order DR figures, especially at 5 and 2 kHz spacing. A single, strong adjacent signal 5 or 2 kHz from the desired signal with resulting reciprocal mixing has a greater impact on your ability to hear a desired weak signal than do two strong signals 5 and 10 kHz away (5 kHz spacing) or 2 and 4 kHz away (2 kHz spacing) with a resulting intermodulation distortion (IMD) product that covers up the desired signal. In many cases, reciprocal mixing dynamic range is the primary limiting factor of a receiver's performance.

-Bob Allison, WB1GCM, ARRL Laboratory Engineer

Elecraft KX3 December QST 2012

- For some reason, the next HF transceiver review lost the RMDR graphic, but the reciprocal mixing data was published.

Reciprocal mixing dynamic range (500 Hz BW):

14 MHz, 20/5/2 kHz offset:
120/119/114 dB.

Third order dynamic range at 5 kHz, QST = 103 dB
Note: Phase noise is 16 dB better than the third order dynamic range.
This is the best phase noise ever published in QST for an amateur transceiver !

FTdx-3000 QST Review April 2013

- Concerns:
- The RMDR Graphic is missing again.
- The table data is there, but not emphasized
- Third-Order Dynamic Range with 1 Hz testing:
- DR3 = 100 dB @ 2 kHz
- RMDR = 82 dB @ 2 kHz !

- Not discussed in the review that RMDR is 18 dB worse than the third order value of 100 dB!

- The 100 dB number is meaningless on the air.

Web data even more exaggerated

- From Yaesu web site – FTdx-3000:
- **With frequency separation of only 2 kHz between the desired signal and an interfering signal, the dynamic range measures 106 dB and IP3 +33 dBm.**
- **Even the Leagued didn't measure 106 dB DR3**
- The 82 dB RMDR value is the real limit, not 106 dB !

How to measure IMD in 24 dB noise

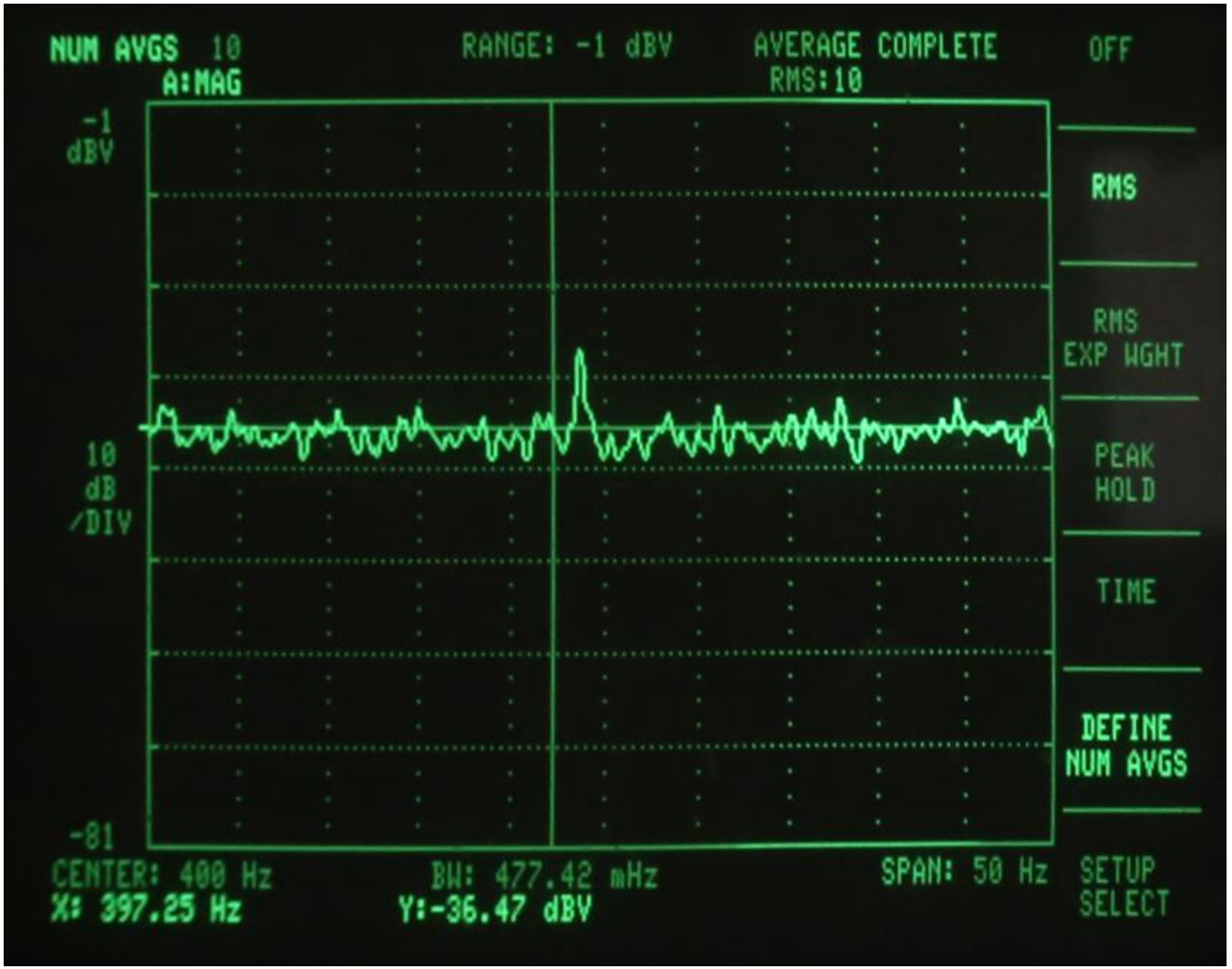
The elephant in the room is how to measure the TS-990S.

On 20 meters the RMDR is more than 20 dB lower than the DR-3 measured with 1-Hz FFT analyzer.

What does it take to “see” a signal buried in that much noise?

Test on TS-990S 20 meters

FFT 0.5 Hz BW to measure IMD in 24 dB Noise



If 1/1000th the bandwidth of a normal CW filter is needed to measure DR3, what does this prove when we are on the air?

How to sort the wheat from the chaff

- The problem for the less technical amateur is how to sort out the data if one is considering advertised or ARRL lab values in making a purchasing choice.
- Bob Allison (ARRL Lab Engineer) clearly stated that RMDR is often "the primary limiting factor in receiver performance".
- Since the RMDR graphic in QST was published only once in 2012, this data is easily overlooked.
- Argonaut VI review in August 2013 QST didn't even publish RMDR tabular data, let alone the graphic.

Some Amateurs Upset

- Many hams have contacted me after buying a radio to say they feel misled.
- If published data (magazine ads or ham publications reviews) emphasize performance that is 10 to 25 dB better than on-air performance, we have a problem.
- There was a flurry of chatter after I published the FTdx-3000 RMDR of 82 dB Dec 13, 2012.
- QST confirms the 82 dB value, but most hams are only seeing the 100 to 106 dB numbers !

E-mail quote from Bob Allison to Rick Stealey, K2XT

- “If one is serious about performance, that person will have a very large antenna array on a tall tower. After spending 10's of thousands of dollars on an antenna farm, one would hopefully choose a transceiver with the highest dynamic ranges and would consider each dynamic range carefully.”
- “The point is moot with a dipole antenna or even a tribander; there's just not enough voltage at the antenna jack to notice RM or 3 IMD DR.”
- This second bullet is NOT TRUE !
- Nearby locals can certainly cause RM or DR3 limitations.

Examples of strong signals causing RM & DR3 IMD

- Locals, particularly 160 and 80 meters
- Dipole at 70 feet 80 m is a cloud warmer !
- Field Day, a very difficult environment
- Multiple transmitters in Multi-Multi or Milti-2
- Multiplier station in a contest
- DXpedition with more than one transmitter
- East Coast short skip on low bands

- A tri-band yagi at ½ wave height will pickup state side signals stronger than a tall stack !

How do we chose a new transceiver?

- We should look at lab data, but the numbers can be misleading.
- It is a numbers game today!
- Evaluation in contest conditions is critical.
- A lab setup can never approximate CQ WW !
- There are many factors that I have discussed at other forums over the past 5 years.

End of 2013 rig evaluations

- If there is time, here are some other issues:
- Other factors that effect copy, cause fatigue, may damage your linear or cause splatter, and generally make operating less enjoyable.

Important factors to consider

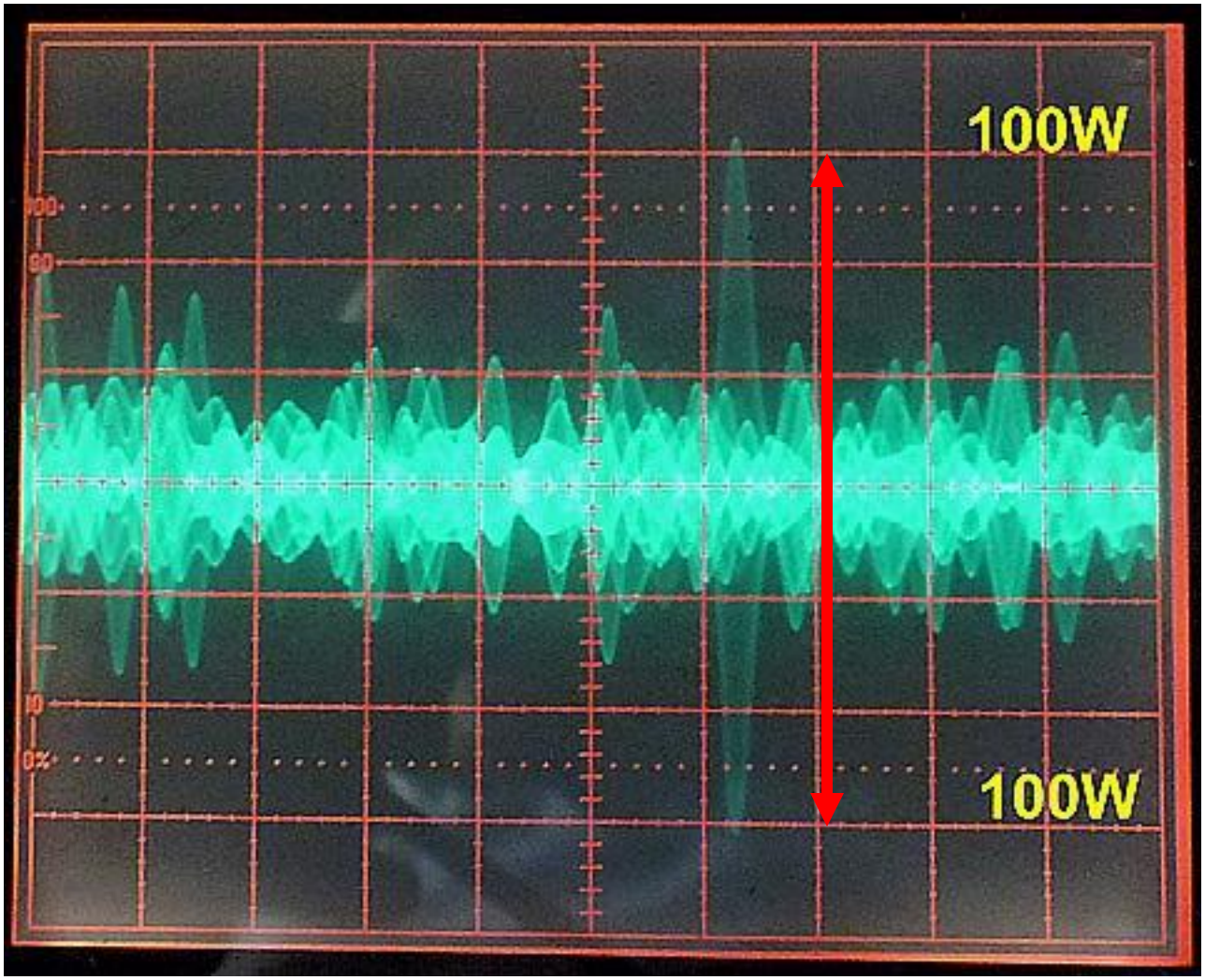
- Contest Fatigue is made worse by crappy receive audio and poor AGC performance.
- Bad ergonomics can drag down your score.
- Transmit IMD (splatter) is not improving.
- Is speech processor adequate?
- Is firmware regularly updated?
- Is warranty service done well and quickly?
- Is the radio supported with parts and service after it is out of production?
- Botton Line: Do you enjoy using your radio?

Examples of problems rarely discussed

- It is amazing what gets into production, isn't even mentioned in reviews, but degrades performance on receive and transmit.
- TS-590S has a 80 to 100 watt ALC spike on SSB when set to 50 watts to drive a low-drive linear. (Alpha 87A, 9500, Acom 1500, 2000)
- IC-7410 has the same problem that was mentioned in QST that causes splatter and can blow low-drive ceramic tubes.

Courtesy Adam Farson – VA7OJ

Set to 50 Watts Key Down - White Noise



IC-7410

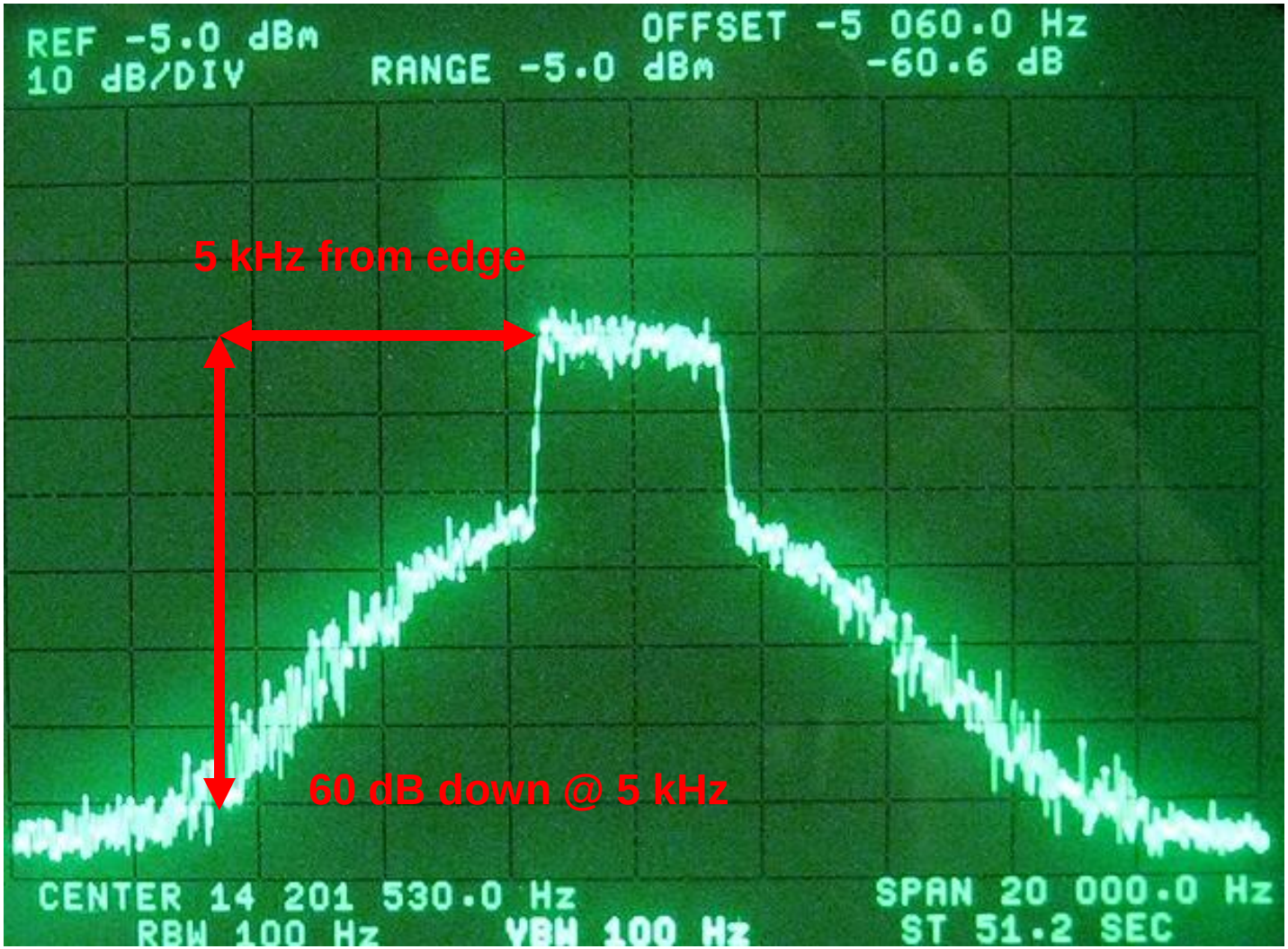
6 Div = 100 W PEP. Rig at half power, but spikes to 100 watts every 2 or 3 sec.

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

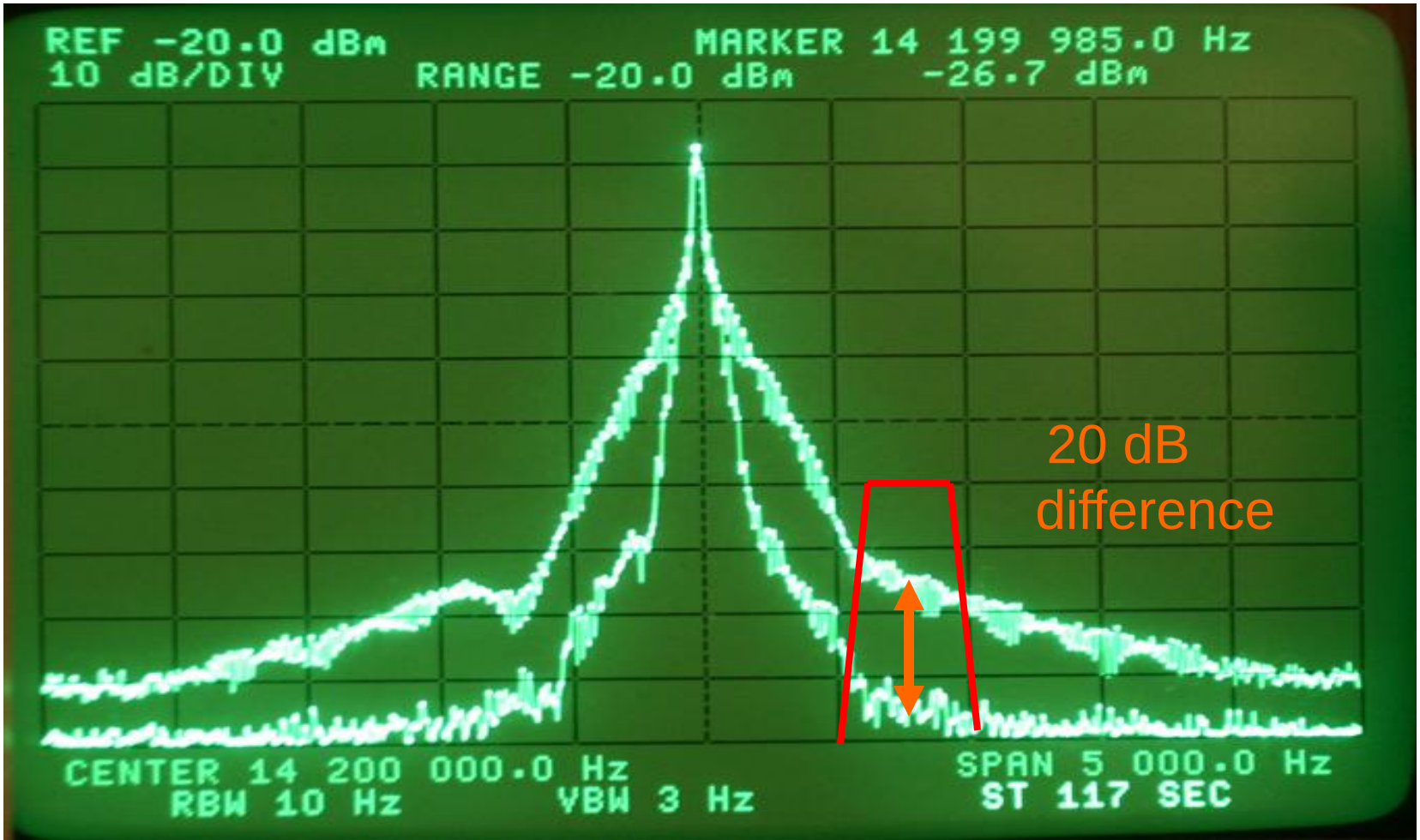


Broad signals Also Exist on CW

- 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 click 700 Hz removed from the transmitting station.
- (Transmitter was a Ten-Tec Omni-VII that has a menu to adjust the rise time.)

Spectrum of CW Signal on HP 3585A Analyzer

Comparison of 3 msec vs 10 msec rise time



AGC Impulse Noise Anomaly

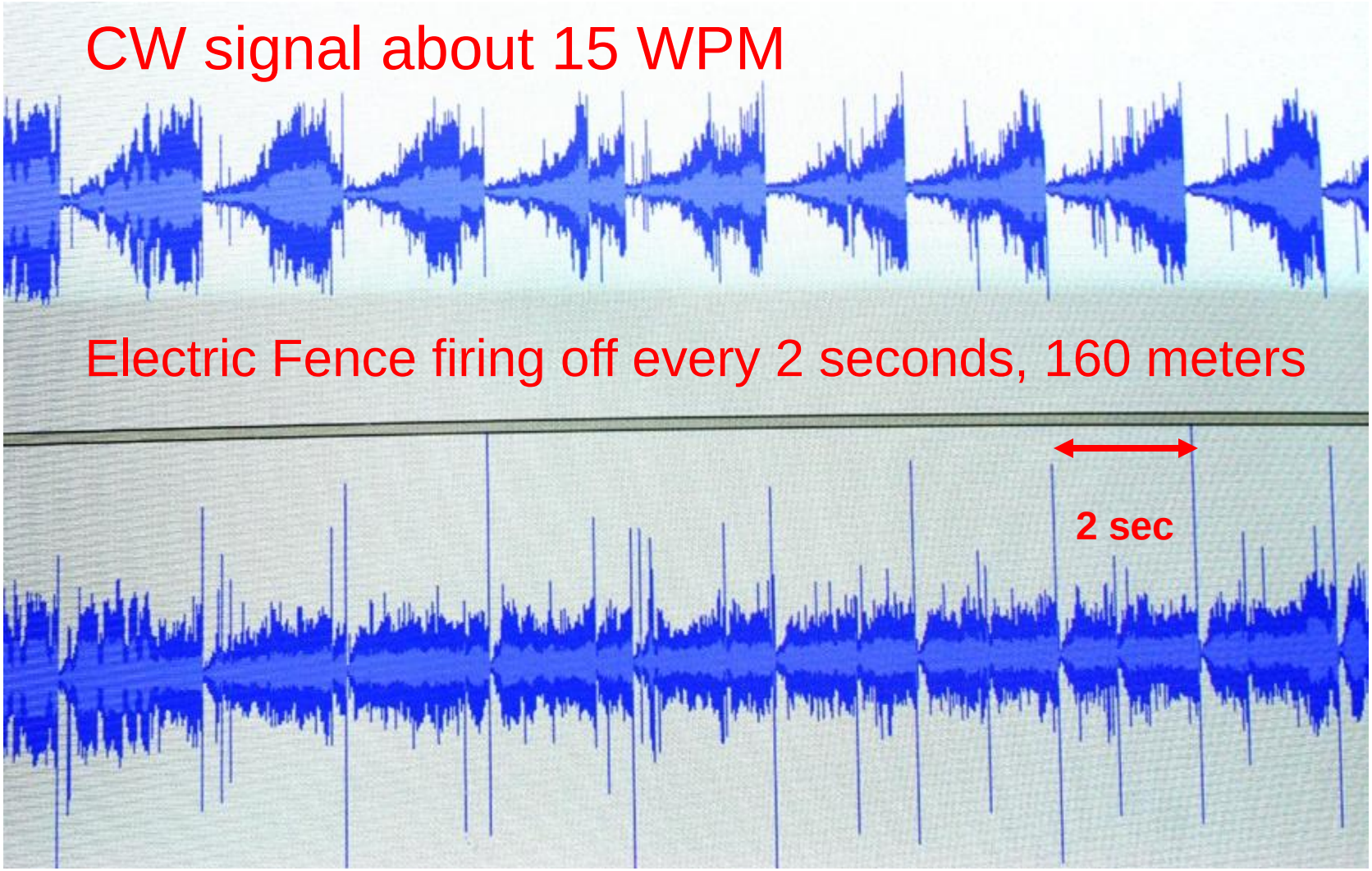
Most new radios since 2003 exaggerate impulse noise.

The exceptions: Elecraft, Flex & some newer Ten-Tec

Programmed DSP to ignore a tick, click or pop.

Elecraft calls it the Sherwood Test.

Omni-7 on Top - Pro III on Bottom



Listen to 30 second audio clip

- Audio Icom 756 Pro III
- 160 meters, 4 PM, Dec 13, 2008
- Electric fence & CW signals
- KV4FZ calling DX station
- Note volume level relatively constant

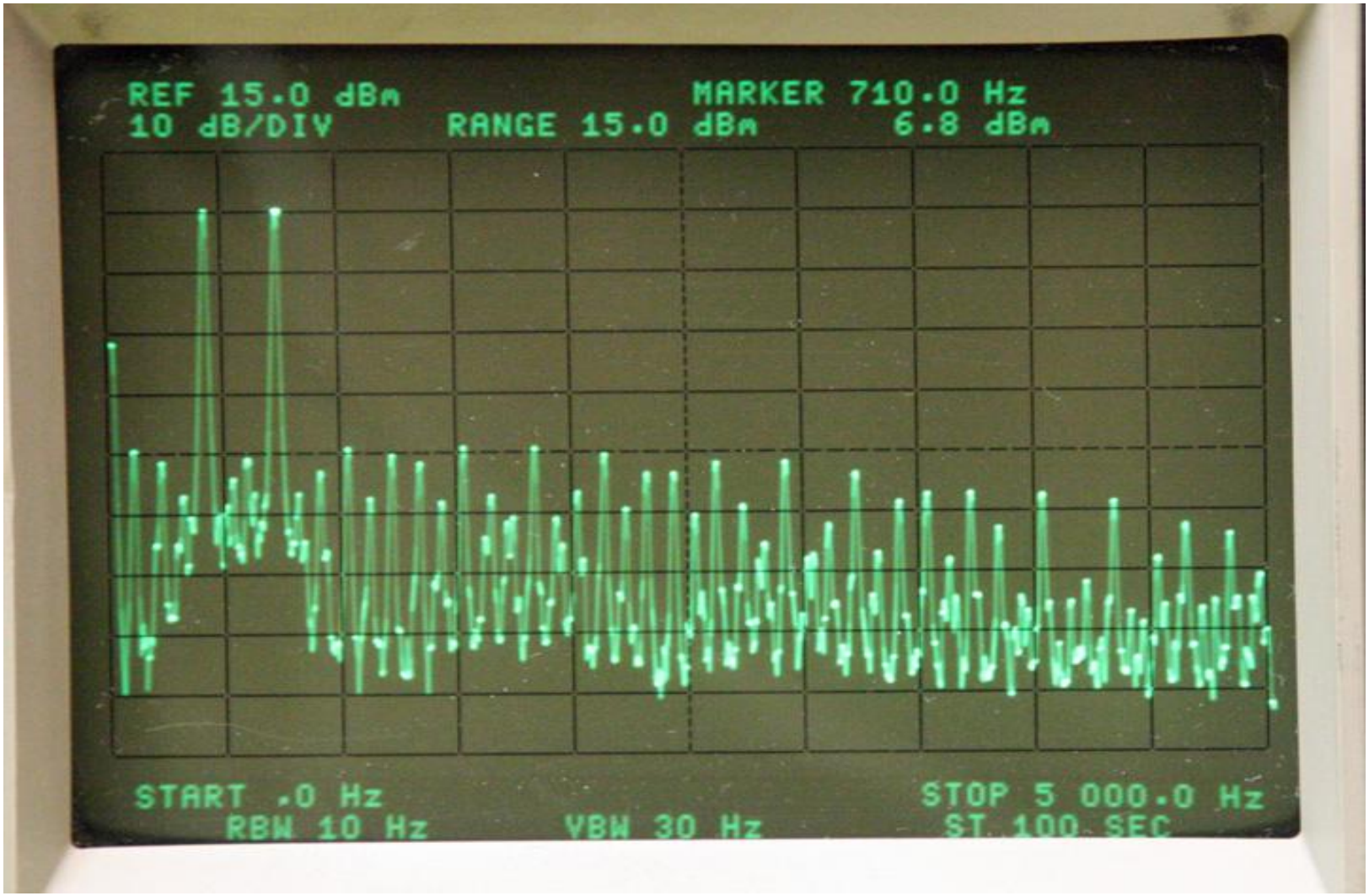
Audio clip with DSP AGC problem

- Audio Ten-Tec Omni-VII
- 160 meters, 4 PM, Dec 13, 2008
- Electric Fence & CW signals
- Exact same signals as with Pro III
- Note AGC being hammered by impulses
- Other rigs with the same AGC problem:
- IC-7800, IC-7700, IC-7600 & IC-7000
- FTdx-9000, FTdx-5000, FTdx-3000
- TS-990S
- Orion I & II

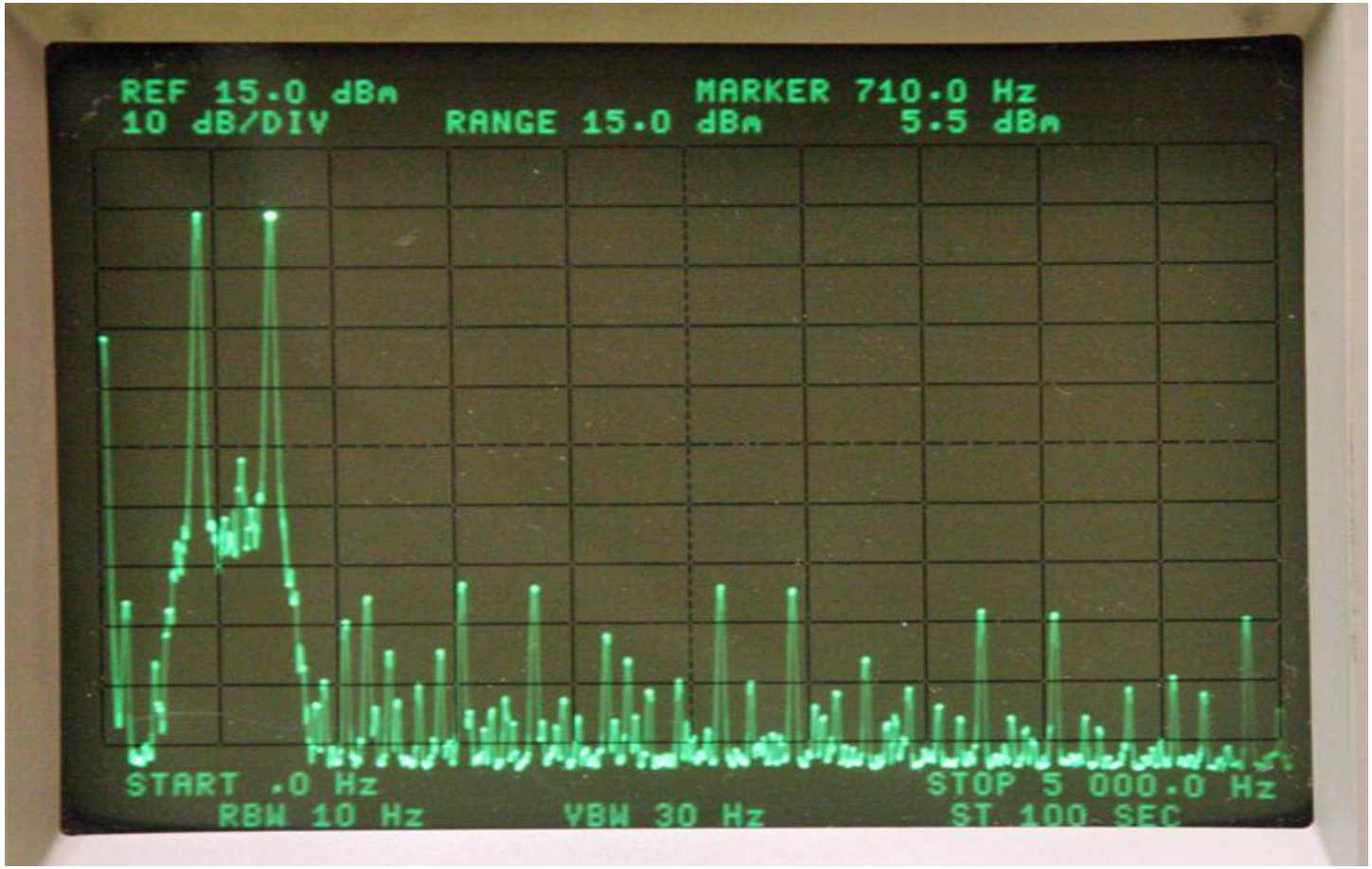
Contest Fatigue from audio artifacts

- In the “good old days”, a pair of 6V6s in push pull were common. Audio was smooth and pleasant.
- Often today receive audio is an after thought.
- The rig manufacturers need to be concerned about the noise and distortion beyond the 300 to 3000 Hz bandwidth. Our ears hear much more than 2700 Hz of bandwidth.

Screen shot from Elecraft Lab Fall 2008

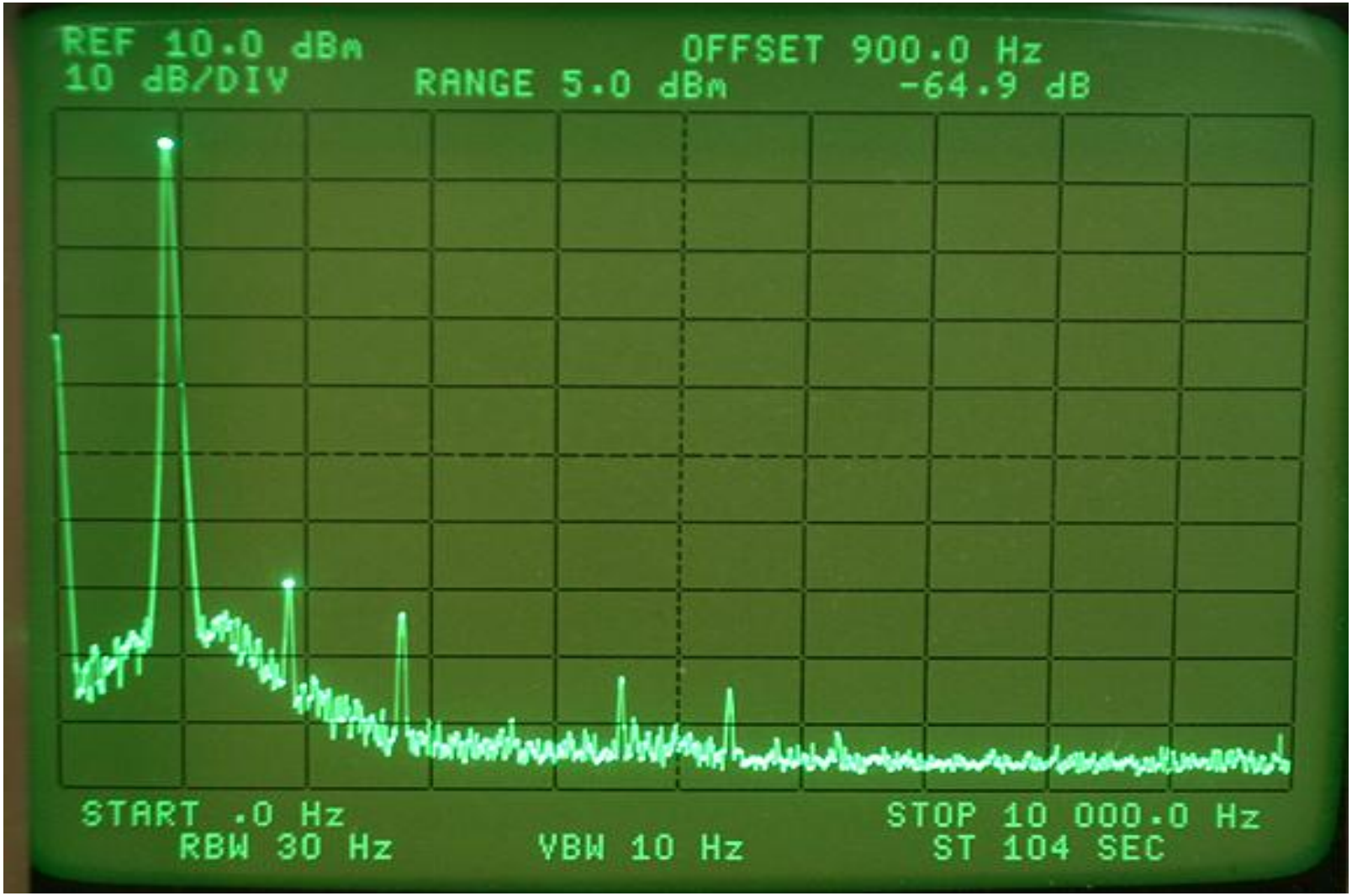


K3 After New Choke Installed



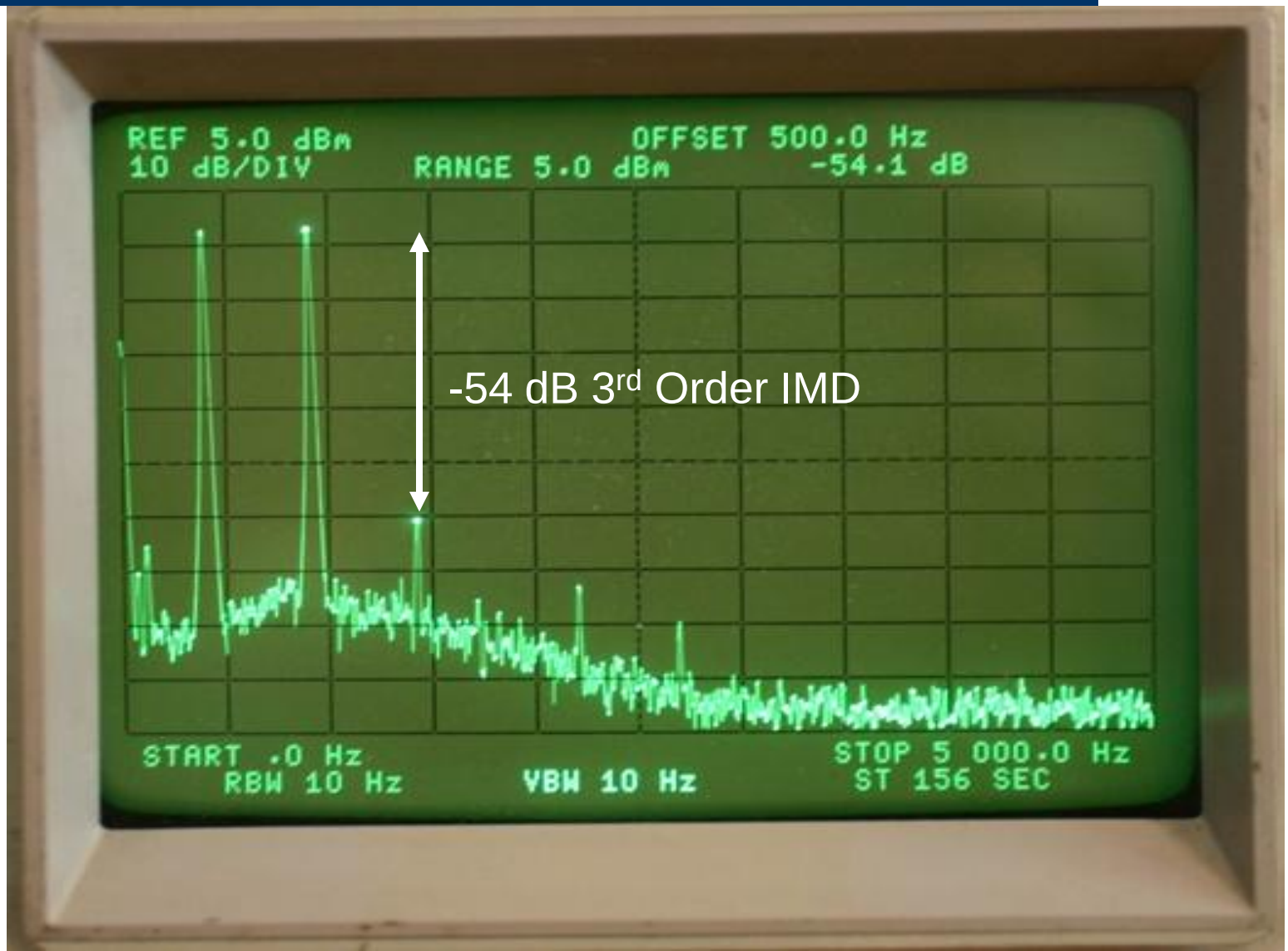
0.1 % distortion

Icom 756 Pro III Harmonic Distortion



< 0.3 % distortion

Icom 756 Pro III in-band IMD Distortion



Choices today on rig selection

- We have rigs from $1000 to $18,000 for sale.
- Many do well in contest conditions.
- It is hard 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

http://www.sherwood-engineering.com

http://www.NC0B.com