Disruptive Technologies

How they change our hobby

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Something new can be a game changer

- **Disruptive technology can do the following:**
- Create a new market that didn't exist
- Disrupt an existing market
- Drastically affect market share of existing companies
- Significantly improve performance
- Reduce costs

Three Examples disruptive technology

Tubes replaced by the transistor. Even microwave ovens are switching from magnetrons to LDMOS!

Digital Cameras vs. Kodak film

Kodak invented the digital camera and then lost the market to others. They didn't want to cannibalize their film market !

Apple & the iPhone changed the cell phone industry forever.

What are some amateur examples in our lifetime?

When I received my General class license in 1961, the Drake 1A had been out for 4 years and the KWM-2 for 2 years.

Of the two other hams in my village, one owned the KWM-2 and the other a 75A-4 and HT-32.

A lot of amateurs didn't like "slop bucket", but SSB was clearly winning out over AM by the late 1960s.

Computer Contest Logging – Major Change

- My first contest was a multi-2 160-meter contest. (1800-1825 & 1975-2000 kHz)
- Logging was on serialized file cards.
- Calls also recorded on a wall size piece of paper in hopes of minimizing dupes.
- Computer logging has phenomenally improved our contest productivity.

Is there a Hardware Change Occurring?

Superheterodyne architecture is what most of us have known since we were licensed. It was invented by Edwin Armstrong in 1918.

Two interesting products went through the Sherwood lab in early 2008:

Elecraft K3 and an obscure direct sampling receiver Perseus

ARRL reviewed Perseus December 2008

Perseus was completely different, a direct sampling receiver with a “clock” but no “local oscillators”.

Perseus is only a receiver, but it foreshadowed what was coming.

Direct-Sampling Transceiver

- Flex announces 6000 series May 2012
- I first used a 6700 CQWW 160 CW January 2014. v 1.1
- ARRL 160 CW contest December 2014 v. 1.30
- ARRL 10 meter contest December 2014 v. 1.38
- Software proprietary (Not open source)

Latency 163ms to 51ms, filter shape factor dependent

Analog radios typically 10ms or less on CW

Apache ANAN 100D & 200D

- Used 200D December 2014 & January 2016 CW contests on 160 meters.
- OEMed out of India (No software expenses!)
- Software open source by US hams
- New features and bug fixes can come within days.
- Latency now under 20ms, down from 130ms.

In early 2016 two parallel tracks

- Elecraft time-proven down-conversion
- Flex Radio or Apache direct sampling SDR

- Both architectures have their advantages.

- Quibbling over a few dB of dynamic range is pointless at this 100 dB level of performance.

(85 dB dynamic range is usually good enough.)

Need for 85 dB dynamic range is mostly a CW issue

The bandwidth of a clean CW signal is about 1 kHz @ -60 dB. We should be able to copy a weak signal 500 Hz to 1 kHz away from very strong QRM.

On SSB typical bandwidth is about 10 kHz @ -60 dB due to transmitted splatter (intermod products).

SSB splatter, rather than dynamic range, usually limits what we can copy if strong QRM is 3 kHz away.

We lived with up-conversion 70 dB dynamic range radios for about 20 years, a significant compromise in CW contests or Dxpeditions.

An alternate testing method from Flex Radio: IFSS

IFSS = Interference free signal strength

Third-order distortion products can be measured over a range of test signal levels, not just the one point where IMD level = noise floor.

If data is taken starting with distortion = noise floor, and then beyond that into significant overload, we can produce a graph of the overload characteristics.

Unlike superhet radios, direct sampling radios produce distortion products at much lower signal levels.

The concept of IFSS is to ignore distortion below BAND NOISE.

Of course band noise varies all over the map from “band to band” and for each location. It also varies from “day to day” to some extent.

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

* = nighttime # = daytime

Noise floors equal for both radios

An Interesting Comparison of IFSS *

I decided to compare the K3S and the 6700 by leveling the playing field.

The noise floors were set to be almost identical on 10 meters.

Normalized for -135 dBm noise floor K3S had an IFSS value 4 dB > than 6700

Normalized for -117 dBm noise floor 6700 had an IFSS value 4 dB > than K3S

* IFSS = Interference free signal strength

IFSS comparisons of well behaved radios

The K3S is an example of an excellent superheterodyne radio.

The Flex 6700 is an example of an excellent direct sampling radio.

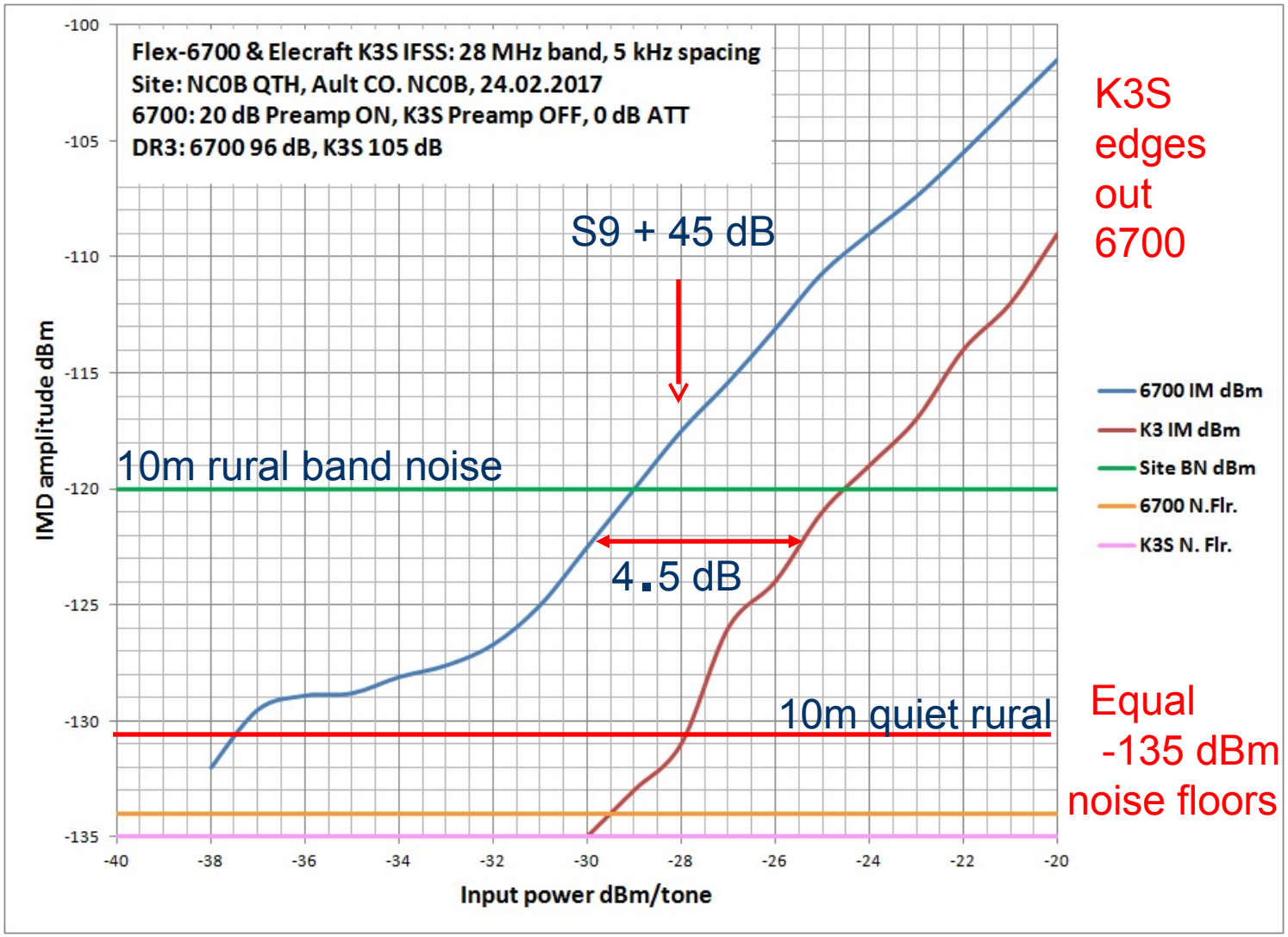
Both have excellent phase noise and dynamic range.

The following two slides show that two-tone input level vs. distortion products produce smooth graphs.

This indicates that these radios should not exhibit unexpected overload characteristics.

Data by NC0B Graph by VA7OJ

IFSS Chart: Elecraft K3S vs. Flex 6700 10 meters



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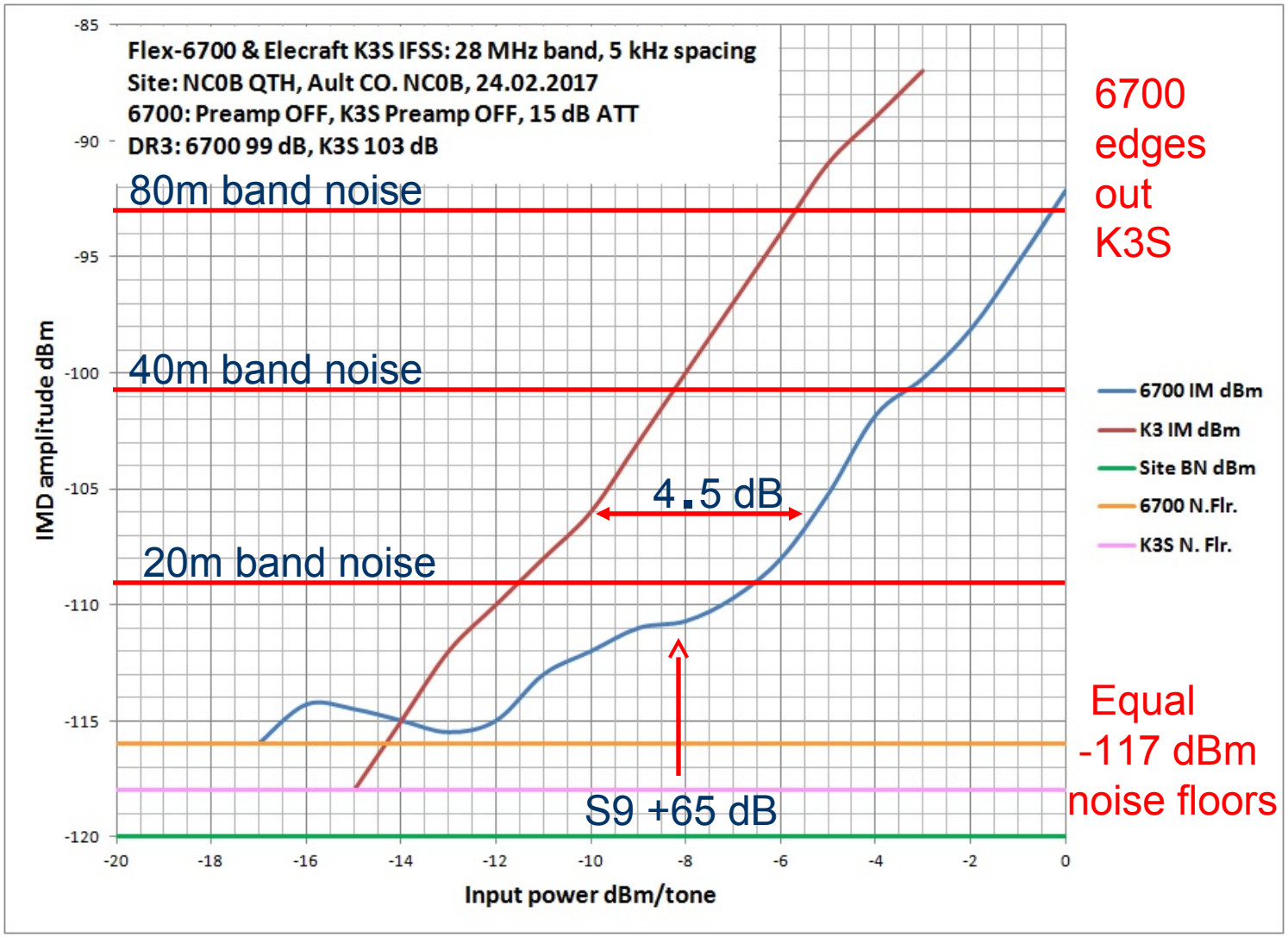
IFSS Chart: Flex 6700 vs. Elecraft K3S



Not all direct-sampling radios are this well behaved

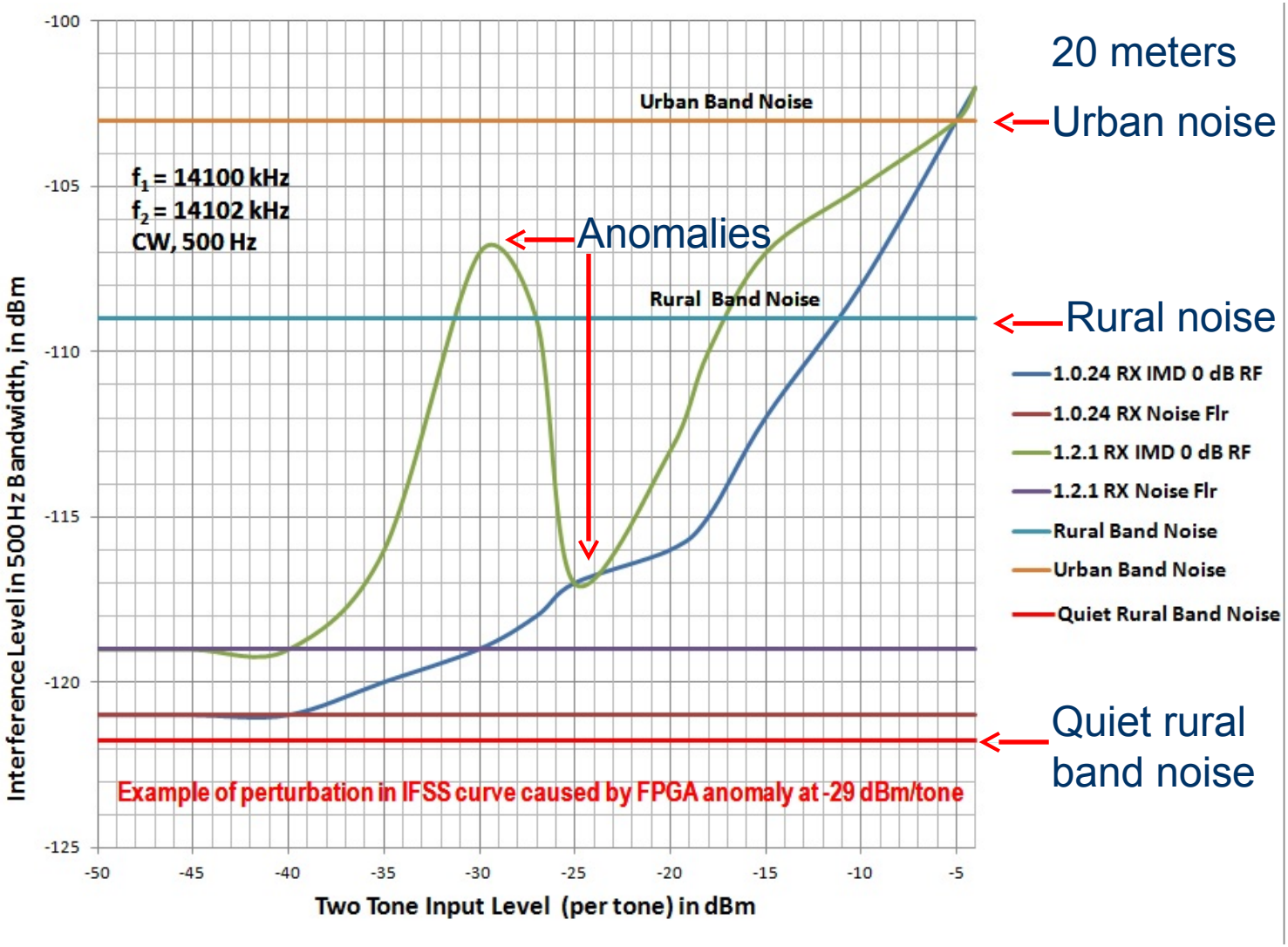
The following two graphs demonstrate direct-sampling IFSS distortion curves that are not as “well behaved” as the Flex 6700.

“Well behaved” means it should have a monotonic curve, i.e. smooth and does not reverse directions.

Note: The IFSS curve of a superhet radio is virtually guaranteed to be monotonic and not reverse directions.

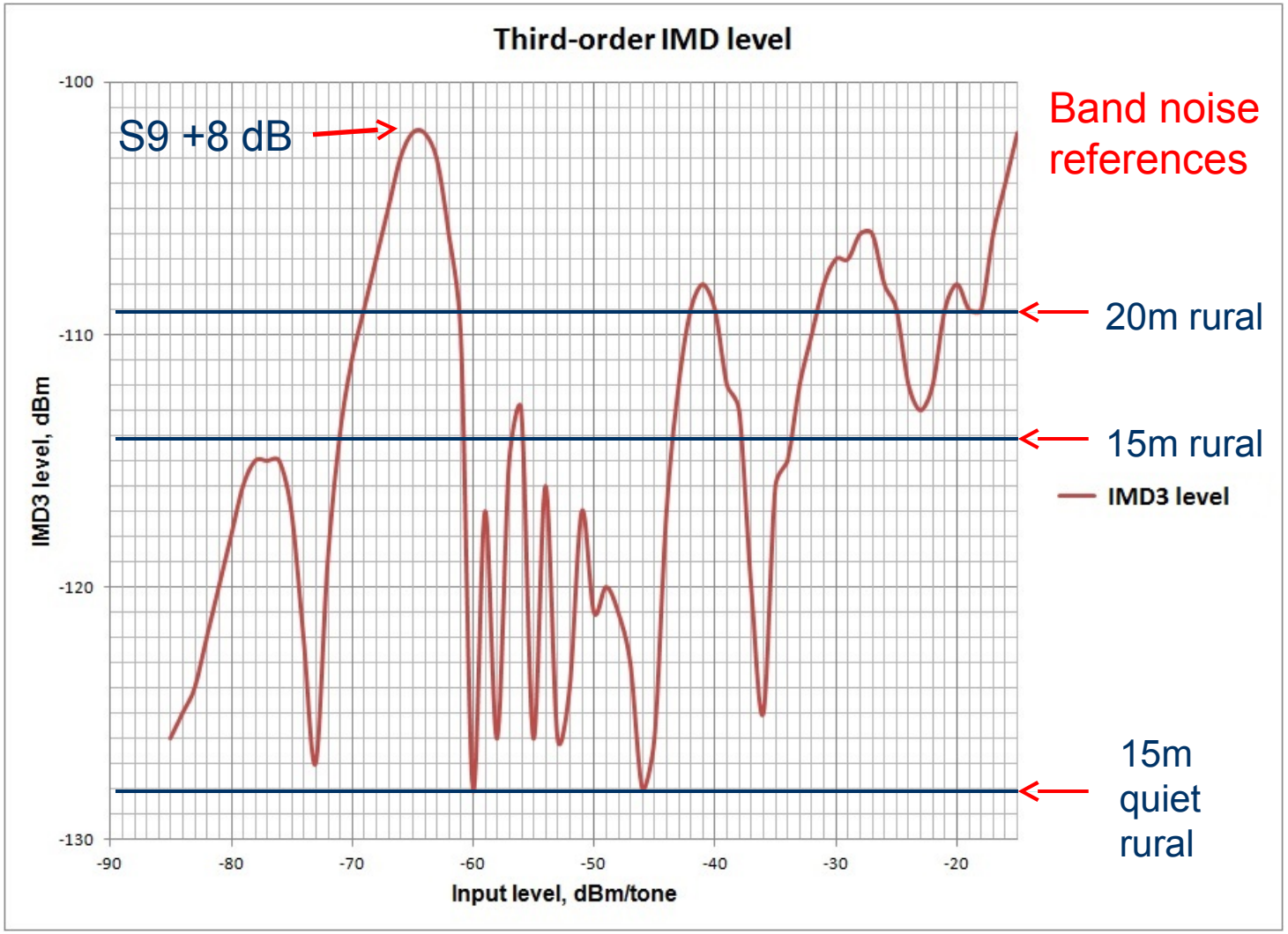
Data by VA7OJ Graph by VA7OJ

IFSS curve with non-monotonic distortion pattern



Data by NC0B Graph by VA7OJ

Worst case IFSS data I have measured



Disruption began in April 2016

- First quarter 2016 we had about 18 very good superhet transceivers choices, and a couple of excellent direct sampling SDR radio types that used a computer interface.
- Icom dropped a grenade into the status quo.
- The IC-7300 hit the market at $1495 as a direct-sampling radio with knobs.

Sales of the IC-7300 went through the roof

No dealer could keep the 7300 in stock in April or May.

A mini price war occurred, offering a slightly lower price with possible delivery sometime in June.

Icom delivered 1000 units to their dealers at the Dayton Hamvention, all of which sold out by the end of the show.

Two things are apparent:

Many hams still like radios with knobs.

By summer or fall, at a price point of around $1300, the decision to try the new product was easy for 1000s of hams. World-wide sales continued at a stunning pace.

How did it perform?

An entry-level radio plays well

- Lab numbers were good, with some limitations on operating environments.
- Multi-transmitter Field Day would stress the radio, particularly without bandpass filters.
- Front end 7300 on 20 meters only down 10 dB on 40 and 17 meters.
- Contest evaluation would have to wait until the fall of 2016.

IC-7300 during 2016/2017 contest season at NC0B

CQWW SSB October 2016 (10 meters only)

ARRL 160 meters CW December 2016

ARRL 10 meters CW & SSB December 2016

Stew Perry W1BB 160 meter CW December 2016

CQWW 160 meter CW, 6 hours Sunday January 2017

10-10 Winter QSO Party

ARRL DX SSB March (10 meters only)

How did the 7300 perform in 7 major contests?

In a nut shell, I was stunned how Icom's "Entry Level" Radio performed on both CW and SSB.

160 meter CW contest congestion is severe. For an S&P operator like myself, it can take 2 to 3 hours to tune in each signal and work every new station between 1800 & 1880 for each pass through the band.

At the other extreme, weak signal conditions were the norm for the December ARRL 10-meter contest. Except for a major E Skip opening to the pacific northwest on SSB, much of the time was spent working very weak signals on CW.

101 Qs CW all S&P & 176 Qs SSB

On Saturday afternoon I ran 94 SSB stations in 45 minutes before the sporadic E opening fizzled.

Which 7300 features worked ?

Selectivity is excellent on CW and SSB. Filter defaults adjustable

Used semi break-in at 26 WPM. 2 relays limit QSK speeds.

All logging with N1MM+

Receive audio very clean and low fatigue

Noise reduction the best I have used to take the edge off of band noise.

¼ tuning speed perfect for CW

Latency under 10ms, like analog radios

Small spectrum scope and waterfall never let me down.

Drove an Alpha 89 or Acom 1000 in all 7 contests.

Does this define “Disruptive Technology” ?

Some sales number comparisons

From April 2016 through January 2017, Icom sold over 10,000 IC-7300 transceivers worldwide.

Over 5000 of those were in the US and Canada, and over 3000 in Europe. As of 5/11/2017 8200+ sold US & Canada

To put this in perspective, Elecraft’s extremely successful K3 line took about 8 years to sell 10,000 radios.

Are we at the cusp of a major architecture change for the majority of ham transceivers?

We may not know for another year or two.

Icom had a demo IC-7610 at Dayton 2017.

Unofficial data on Icom sales and production

At Dayton 2017, an Icom staff member told a friend of mine that as of the Hamvention, Icom had manufactured 20,000 IC-7300 transceivers.

Some, of course, were still in inventory at dealers and at Icom.

At Friedrichshafen this July, a presenting dealer friend said he was told Icom had sold 25,000 radios (all models) in the past 13 or 14 months.

If these numbers are close to being accurate, I would say the sleeping giant has awakened and every other OEM must be taking note!

What has changed in last couple years?

- RMDR* has usually been the practical limit for superhet transceivers, except for the IC-7851 and the K3S.
- Direct Sampling SDR radios changed that.
- DS SDR front-end selectivity is all over the map.
- Field Day, nearby neighbor = significant issue
- * RMDR=reciprocal mixing dynamic range

What is coming down the pike?

IC-7610 announced to have a tracking preselector & identical dual receivers for easy split operation in contests and all DXpeditions.

Solid-state T/R switching expected for QSK operation at high speeds.

ANAN 8000DLE promises improved phase noise, 200 watts LDMOS with internal DC to DC converter. (13.8 to 50 volts for PA)

(No $900 custom 50-volt power supply like in TS-990S)

Third-order IMD measured > -70 dB below each tone on 20 meters
Typical 13.8 volt transceiver today is -30 dB below each tone.
(ARRL method, or OEM method, add 6 dB)

Integrated Pure Signal for transmit IMD better than Class A

Dual 16-bit ADCs for up to 7 receivers. (CW Skimmer 6 bands?)

Measurements 8000DLE Xmit IMD

The following have measured transmit IMD better than -70 dBc for the transceiver barefoot. (Internal Coupler)

NR0V Warren Pratt who wrote Pure Signal

W9AC Paul Christensen

N4LQ Steve Ellington

W2GOR Gordon Bahary -70 dBc with OM Power at 1.5 KW !

Note: The following new amps have a sampling coupler built-in: Elecraft KPA1500, Hilberling HPA-8000B, Flex PowerGenius XL
Implies what? Added just for Apache products? Not likely.

What happens long run?

Transceivers we have now:

- Superhets perform quite well
- (At least a 18 good choices from my website)
- DS SDR radios with Windows or iOS UI
- Flex and Apache 6 models total
- Apache 8000DLE is now shipping
- Flex Maestro is a Windows tablet in a box with buttons and knobs. Can replace Windows PC
- IC-7300 DS SDR standalone radio with knobs and a small but very sharp LCD display
- IC-7610 ships to the US later this year

How will this shake out in the long run?

- Major changes take time.
- Up-conversion-only radios are mostly gone.
- Most everyone wants a bandscope/waterfall.
- TS-590SG has a bandscope port for a dongle with lots of interest in that feature.
- In the long run preselectors went away because up-conversion was cheaper.
- In the long run up-conversion generally failed to keep up with performance demands.

Will DS SDR Prevail?

- There isn't anything inherently wrong with the superhet that has worked for 80+ years.
- K3S & IC-7851 are top performers.
- Cost may dictate DS SDR
- K3S $3K to $5.3K*, IC-7851 $13.5K !
- Will remote operation due to antenna covenant restrictions and urban noise favor the computer-run DS SDR?
- Will the majority of operators choose a DS SDR with knobs, like the 7300?
- * Including P3 panadapter

The next year will be very interesting

- Has the IC-7300 this past year been just a one-time anomaly or just the beginning of a tectonic shift?
- You can get amazing performance for a modest price today. (TS-590SG @ $1270)
- Top contester N2IC has a pair of TS-590
- There certainly has been disruption in the market price of used equipment.
- Used Pro III selling for about $1000
- Is it time to contest with something new or simply new to you? Enjoy.

Sherwood Engineering

Videos from past CTU presentations: 2013 - 2016

https://www.contestuniversity.com/videos/

CTU 2011, NC0B only, download wmv file

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