

Contest University 2022
Improve your antenna first !

Transceiver Performance for the HF Contest & DX Operator

For SSB transmit performance
issues watch my 2021 Zoom
video on CTU website

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RX performance is generally excellent
If you optimize your transceiver

Two Goals Today at CTU

- How to optimize operation of your current rig.
- **Net Receiver Gain settings very important !**
- When to use a preamp and when to use an attenuator

- Data on new rigs in the last 19 months
- Lab measurements are a starting point.
- On-air contest evaluation is also very necessary.

Sensitivity & Noise floor are a non-issue

- Sensitivity and noise floor consistent over 60 years.
- R-390A from 1954 is 0.2 microvolts & -137 dBm
- Drake R-4C sensitivity 0.2 microvolts & -138 dBm
- K3S with preamp #1 is 0.2 microvolts & -138 dBm
- **NOTE:** More recently a wide variation in gain structure for direct sampling transceivers.
- <https://foxmikehotel.com/sortable-sherwood-test-table/>
- (by Frank K4FMH)

You need to know your radio

Model	Noise floor no preamp	Dynamic Range
Elecraft K4	-121 dBm	101 dB
Flex 6600	-111 dBm	99 dB
Icom 7610	-132 dBm	98 dB

Gain structures are completely different, no preamp no attenuation.

With the Flex you likely need preamp gain 20m and up.

With the Icom you likely need attenuation on 40m and down.

The Elecraft K4 is in the middle.

None of the designs are right or wrong, but they are very different.

You need to know your band noise vs. receiver noise floor.

Residential Urban Noise is worse than in this graph

Band Noise vs. Frequency from ARRL Handbook

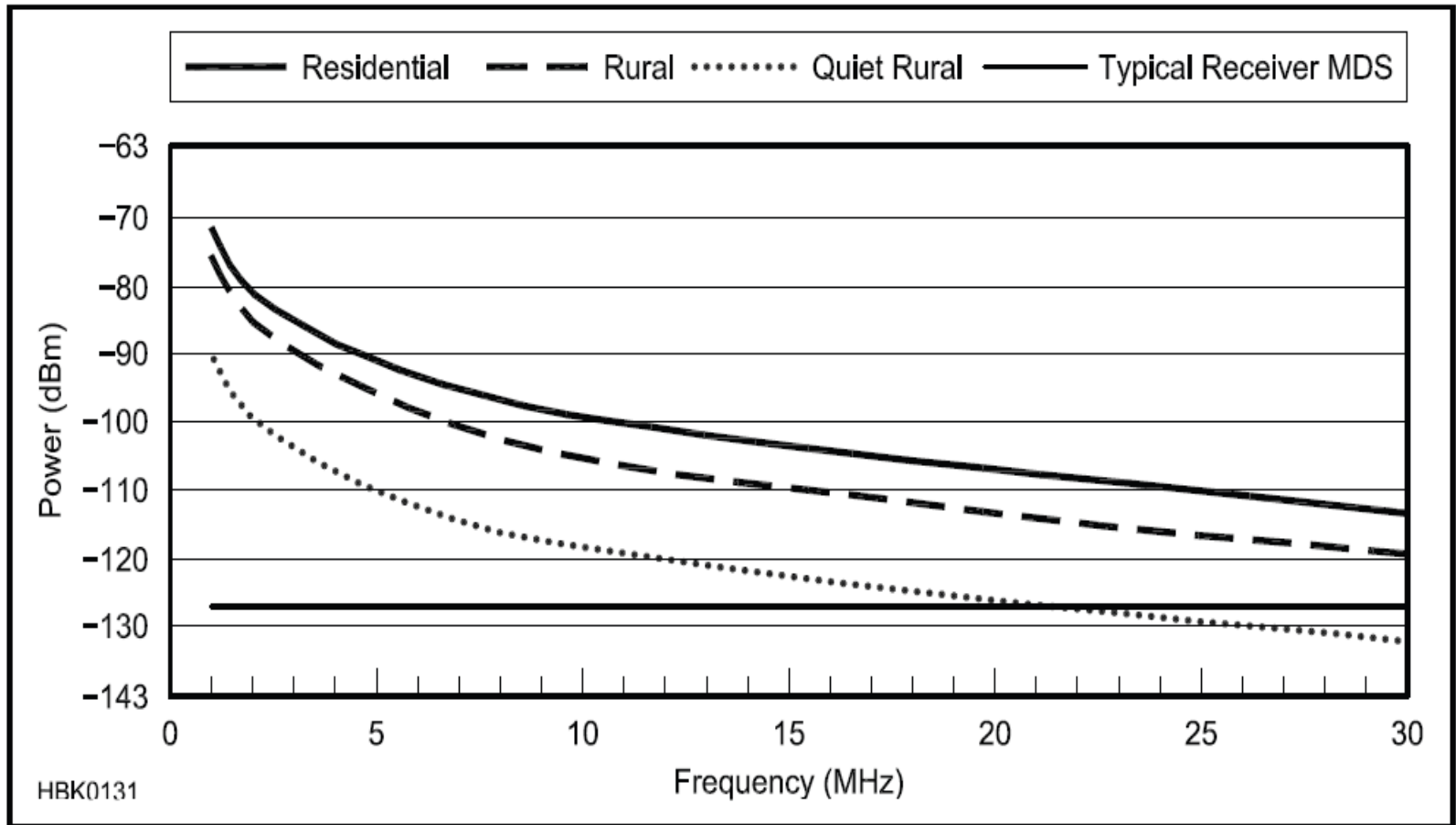


Fig 1 — Typical noise levels versus frequency for various environments. (Man-made noise in a 500-Hz bandwidth, from Rec. ITU-R P.372.7, *Radio Noise*)

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

Didn't I say your antenna is important?

Antennas to measure band noise



Measured band noise at NC0B

Band	20 meters	15 meters	10 meters
0 degrees:	-114 dBm	-124 dBm	-129 dBm
30 degrees:	-113 dBm	-124 dBm	-123 dBm
60 degrees:	-110 dBm	-118 dBm	-120 dBm
90 degrees:	-108 dBm	-114 dBm	-120 dBm
120 degrees:	-107 dBm	-113 dBm	-122 dBm
150 degrees:	-107 dBm	-114 dBm	-122 dBm
180 degrees:	-108 dBm	-114 dBm	-121 dBm
225 degrees:	-109 dBm	-120 dBm	-130 dBm
270 degrees:	-109 dBm	-120 dBm	-130 dBm
315 degrees:	-111 dBm	-122 dBm	-130 dBm
ITU rural value:	-109 dBm	-114 dBm	-119 dBm
Antenna	204BA	155CA	105CA
Height	70 feet	70 feet	65 feet

My assumption of a typical gain setting mistake

If in doubt turn the preamp ON ? No No No

If an attenuator is ON, you can't copy! No No No

AGC threshold should be above band noise.

You need to understand **antenna noise gain**.

RX noise floor should be 10 dB lower than band noise.

Examples to follow

You can measure this by ear

15, 10 & 6 meter antenna noise gain

Rig = Icom IC-756 Pro III

6 meter antenna = Ariane C5-50 @ 50 feet

10 meter antenna = Hy-gain 105CA @ 65 feet

15 meter antenna = Hy-gain 155CA @ 70 feet

Preamp	15m	10m	6m
None	4 dB	3 dB*	1 dB
Preamp 1	11.5 dB	9.5 dB	4.5 dB
Preamp 2	13.0 dB	11.0 dB	9.5 dB

* @ 3 dB, receiver noise = band noise = not OK

A Typical receiver noise floor value

- Rig Preamp OFF Preamp ON
- TS-990 -127 dBm -138 dBm

- ITU **nighttime** band noise on **40 meters** is around **-100 dBm!** 17 dB of gain to burn.

- On the low HF bands most receivers are way too sensitive at night.

- 40, 80 & 160m: 12 to 18 dB attenuator OK

Reducing Operator Fatigue

Optimize your AGC threshold

Set the AGC threshold about 6 dB above band noise.

Use attenuator, RF gain control or AGC threshold adjustment, if available.

(AGC-T 50 to 60 for Flex, Horizontal Line Apache)

You don't want the AGC to bring up band noise to equal the weakest signal.

Trade-off? Yes, occasionally you will have to advance the AF gain a small percentage of the time.

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.

Quickly lets define Dynamic Range

- We saw that sensitivity isn't an issue.
- Dynamic range is important and we have many choices today from which to choose.
- **>95 dB radios available from all major OEMs.**

What does dynamic range mean?

- When internally generated 3rd order distortion equals the noise floor of the receiver.
- Can be called “Spurious-free Dynamic Range”.
- Note: For years RMDR* was the practical limit.
- (Reciprocal Mixing Dynamic Range)
- FTdx-3000 ARRL DR3 vs RMDR example

Dynamic Range with 2 kHz tests

- Wide roofing filter DR3 **70 dB** is typical
- Narrow roofing filter (K3S, 890S, 101D) DR3 is typically **105 to 110 dB**
- Direct sampling (Apache, K4, Flex, Icom) no roofing filters, no difference 20 kHz vs 2 kHz
- Direct sampling **100 dB** +/- 3 dB any spacing

Superhet roofing filter advantage

- Big signals, line of sight, $S9+70$ to 85 dB superhet with a roofing filter has a **Blocking or overload advantage**
- This assumes the other transmitter is clean!
- K3s **150 dB** blocking value likely can't be realized
- Direct sampling ADC overload from **116 dB to 130 dB**

Close-in 2-kHz Test @ 500 Hz BW

Dynamic Range of Top 22 HF Transceivers

• Yaesu FTdx-101D	110 dB
• Yaesu FTdx10	107 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
• Elecraft K4	101 dB
• Yaesu FTdx-5000D	101 dB
• Flex 6400	100 dB
• Flex 6600	99 dB
• Flex 6700 (2017)	99 dB
• Icom 7610	98 dB
• Icom 7300	97 dB
• 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
• Flex 6300	89 dB
• Icom 705	88 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

(16 dB preamp ON)

(Preamp OFF)

(IP+ ON)

(IP+ ON, S/N around 10,000 and up)

I have run contests with 17 of the 22

N2IC uses two TS-590 models in SO2R.

(No IP+ ADC linearization)

Possible concerns for Direct Sampling

- Field Day or a ham 1 mile away
- Front-end L/C filter is often a half octave filter, 11 to 15 MHz for the Icom 7300 or 7610.
- A tracking pre-selector can help reduce out-of-ham band commercial signals.
- Available from Icom and Yaesu

A quick comment on Key Clicks !

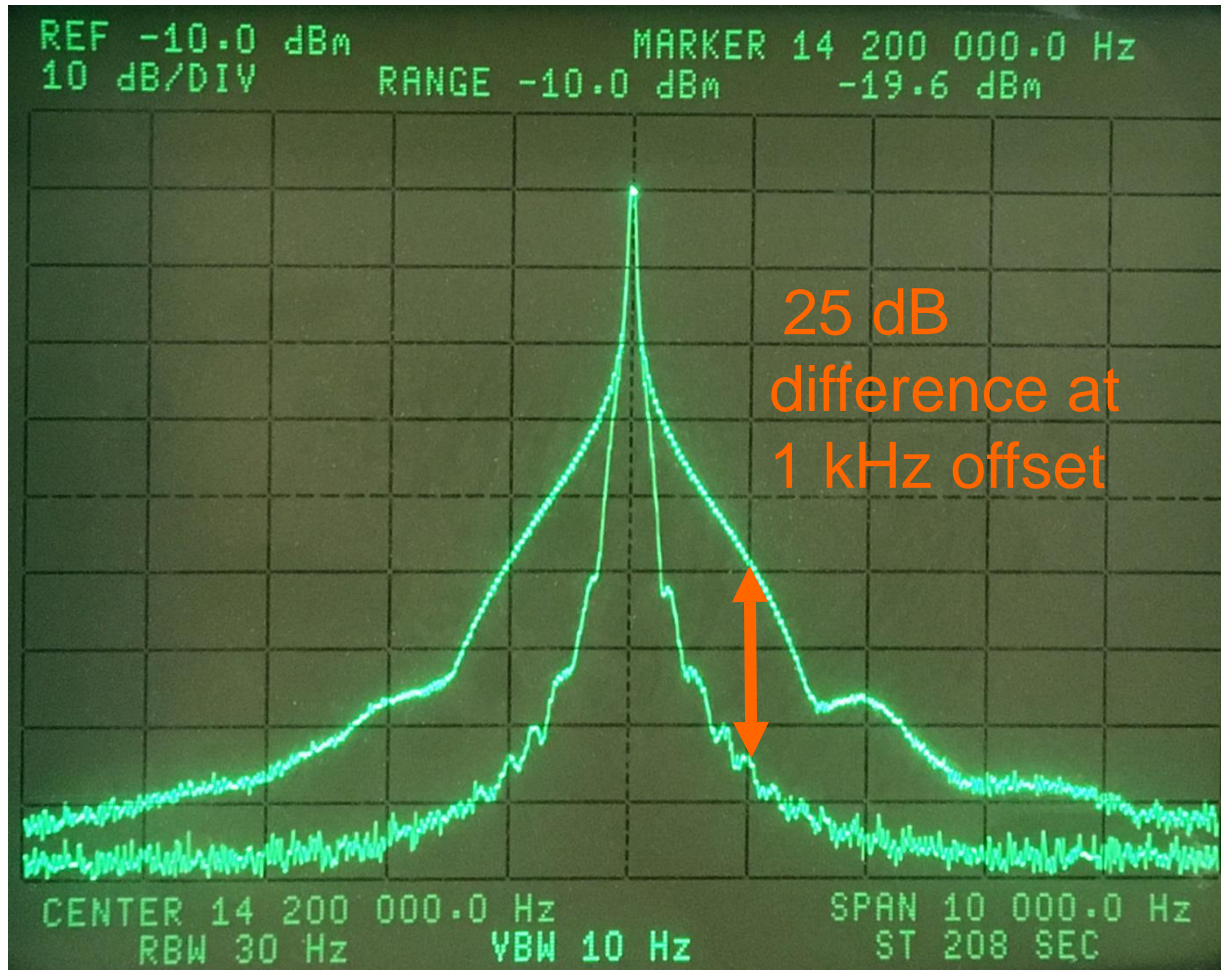
- Check your menu for Rise Time selection.
- You can turn ON key clicks inadvertently on Kenwood and Icom rigs.
- Please pick 6ms or 8ms setting.
- Rise time hard coded on Flex and Elecraft
- Yaesu menu no selection faster than 4ms
- Often the actual value is faster than displayed in the menu.

1 and 2 ms key click special

You can select 1 or 2 ms on some rigs !

Spectrum of CW Signal on HP 3585A Analyzer

Comparison of 1 msec vs 6 msec rise time

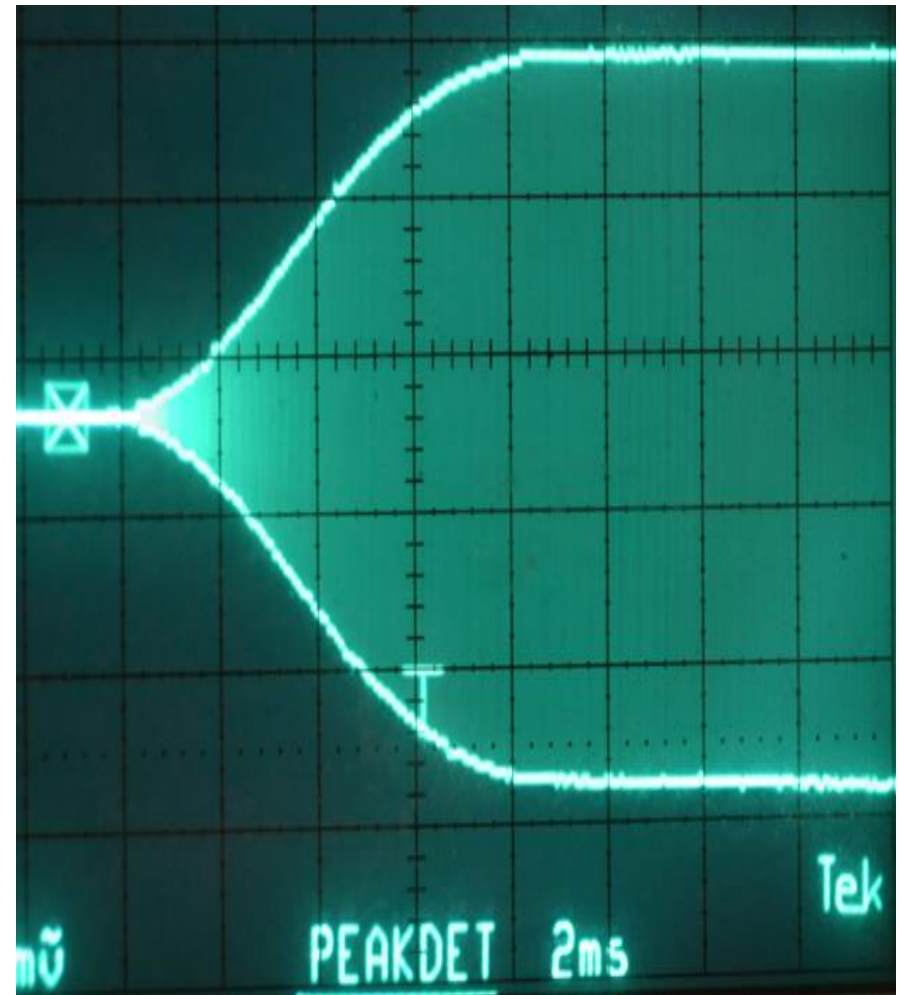
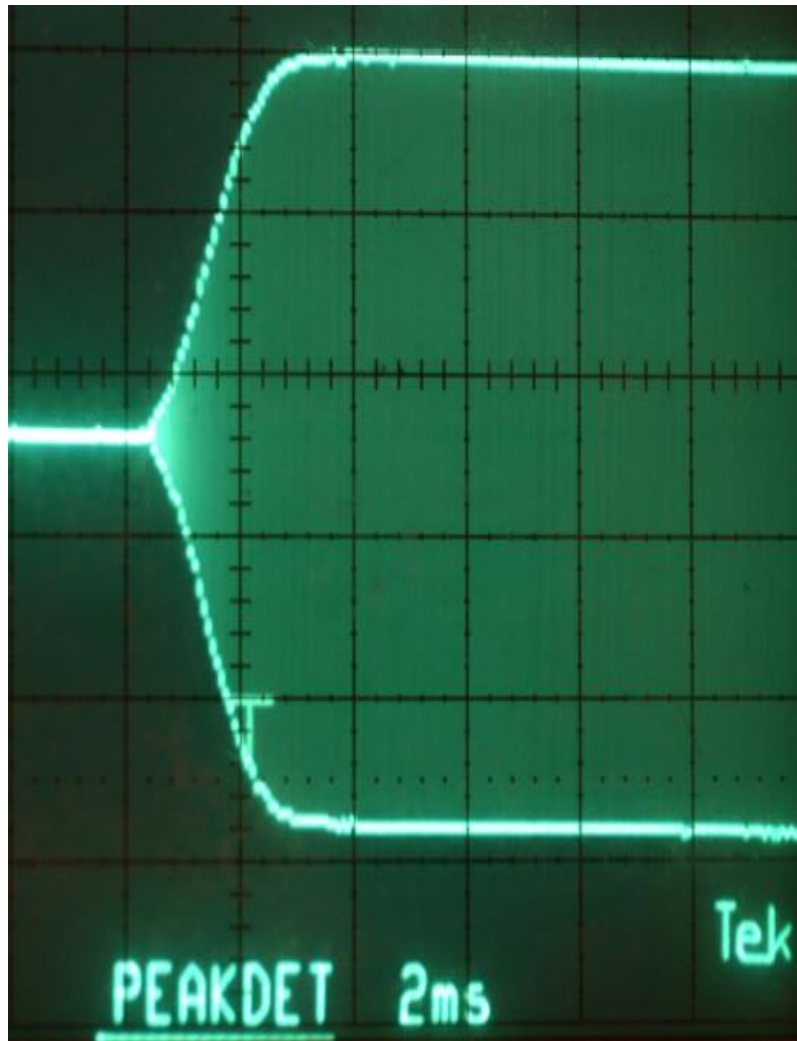


1 or 2 ms
should be
labeled
"Turn Key
Clicks ON"

Data from
TS-890S

This screen capture is in the time domain

Leading edge of “dit” 3 & 10 msec



101D/MP not operated in a contest at NC0B

Rig Price Comparisons

• Model	Price	New 2020 / 2021
• Elecraft K4D	\$5950 (tuner included)	Yes
• Yaesu FTdx10	\$1400	Yes
• Icom IC-705	\$1350	Yes
• Icom IC-7610	\$3200	For comparison
• FTdx-101D	\$3150	Prices as of 4/13/2022
• FTdx-101MP	\$4200	
• TS-890S	\$4080	
• Flex 6600	\$4400	

Data in 2021 on the new K4 !

- K4 Performance: Dynamic Range (DR3) 101 dB
- One receiver (no Sub receiver)
- Can be on 2 bands at once with L/C input filtering limitations.
- (Front end goes broadband, plus TX LPF in the circuit all the time)

- An Elecraft K4D is similar to an Icom IC-7610 in that it has:
- 2 independent receivers – Main & Sub
- Independent L/C front-end filters but with TX LPF in the circuit if a common antenna is selected for both Main and Sub receivers.
(A coax jumper cable from RX out to RX in is required)

- Weeks of testing at NC0B and N0QO resulted in finding many firmware bugs: AGC, CW timing, RX audio, TX audio, etc.
- Elecraft has been updating FW to address these issues.

The challenge for K4 development

- Kenwood and Yaesu are still superhet.
- Direct sampling history:
- Apache 100D: 9 years ago, including PureSignal
- Flex 6700: 7 years ago
- Icom 7300: 6 years ago
- Icom 7610: 5 years ago
- Elecraft K4: shipped 15 months ago
- R30 Beta shipped May 16, 2022
- Wayne seeking additional K4 field testers May 18th due to bugs not observed before R30 Beta release.
- Wayne: Regression testing may be tedious.

Firmware release history 2021 – May 2022

- Firmware R15 shipped around February 2021
- Firmware R17 lab tested May & June 2021
- Firmware Release R26 used for December contests
- Inadequate audio gain corrected with R28
- SSB TX EQ corrected R28
- Speech processor improved w/ R29 late March 2022
- CW DSP update R29 released late March 2022
- R29 Beta pulled in April
- R30 Beta has several issues as noted.

CW comparisons K4D & IC-7610

Measured Bandwidth/Attenuation

Attn. dB	KD4	IC-7610
	Filter: 100 Hz	Filter: 150 Hz
	BW (Hz)	BW (Hz)
-6	180	160
-20	300	185
-40	410	210
-60	475	240

After I posted these results, four operators said they noticed the same thing during the previous week's CQWW CW.

Contests operated with K4D 2021

- ARRL 160m CW (2021)
- ARRL 10m CW & SSB (2021)
- 160m 110 Qs, 44 mults operating + testing
- 10m 402 Qs, 60 mults, no stops for testing
- AGC, inadequate selectivity and low audio gain were the biggest issues for me.
- I found a mouse is very helpful.

Comments on the FTdx10

- Lab numbers almost at FTdx-101D/MP level
- Ergonomics & UI seem clumsy to me.
- April & May 2021 firmware were major updates.
- Key clicks are no longer a problem.
- All 3D waterfall history goes away the instant you transmit in any mode. Useless !
- 2D waterfall now ok with firmware update.
- However, waterfall runs too fast, 10 seconds.
- The 101D & MP have this same 3D limitation.
- December 2021 FW improved User Interface.
- April 2022 FW update fixed a minor bug.

Contest operated with FTdx10

- CQ WW 160m CW (2021)
- 212 Qs, S&P, 3 JAs, 45 sections
- 7+ hours on the air, limited weekend “on time”
- Selectivity and APF worked very well.
- Ergonomics & User Interface aside, it is an excellent performer at a low price.
- Jumpy band scope needs averaging.
- A mouse is helpful due to small buttons.
- Noisy T/R relay, slow noisy tuner relays

Comments on the IC-705

- 160m – 70cm, lab numbers = 7300 IP+ OFF
- IP+ (dither) helps lab numbers.
- Hard to tell on the air whether IP+ makes a difference.
- May be significant 10m near sun spot maximum.
- For HF, operates just like an IC-7300
- Lots of VHF features
- Excellent ergonomics and scope display
- Common user interface for all the Icom direct sampling transceivers: 7300, 7610, 9700 & now the 705
- **Great new scrolling feature** for these four Icom rigs.
- R8600 receiver also similar user interface

Contests operated with the Icom 705

- IC-705 **Note: I wasn't running QRP.**
- Sweepstakes, 100 Qs just for fun
- ARRL 160m CW, 392 contacts, S&P only, **2 JA Qs**, 80 sections, 16+ hours on air
- ARRL 10m CW and SSB, sensitivity fine
- Lack of a headset with VOX an issue

Comments on the IC-7610

- CW & SSB Selectivity excellent
- Easy to adjust filter bandwidth default values
- Good adjustable APF
- Easily adjustable AGC decay speeds
- Silent T/R switching & amp key line
- **Flaky Drive Gain adjustment varies by band**
- On S meter scale, ALC = 5 a good value.
- Need **\$300** RC-28 for easy Sub RX tuning

Recent contests operated with IC-7610

- A/B comparisons with K4D
- December 2021 ARRL 160m (Lots of QRM)
- ARRL 10m CW & SSB (Weak Signals)
- It is hard to evaluate a new rig (K4D) without instant access to another reference radio.
- I always have access to a reference radio since I have three operating positions.
- (Not implying reference radio is perfect!)
- If something seems odd, make A/B comparison

Don't select a new radio on one number !

Important factors to consider

- Operator fatigue is made worse by poor receive audio and poor AGC performance.
- Bad ergonomics slows you down in a contest.
- Is speech processor adequate?
- NB and NR very important for urban QTHs.
- 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?
- Bottom Line: Do you enjoy using your radio?

<http://www.NC0B.com>



Sherwood Engineering

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