

Transceiver Performance and Selection of a New Radio

Focus on your antenna !
Directivity is a big deal.

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Consider the overall picture.
It may be more than just a new rig.

Are you considering a new HF rig?

Goals to emphasize today

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

- New rigs that cost \$1600 or less
- IC-7300, FTdx10, FT-710, TS-590SG & IC-705

- Lab measurements to weed out poor choices.
- On-air evaluation is also very helpful.
- Are you locked into one brand?

* RMDR defined in 2012

Defined in QST and *hr magazine* in 1975

What does dynamic range mean?

- When internally generated 3rd order distortion products equal the noise floor of the receiver.
- Can be called “Spurious-free Dynamic Range”.
- Note: For years RMDR* was the practical limit.
- *Reciprocal Mixing (phase noise) 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 (Orion II, K3S, 890S, 101D) DR3 is typically **95 to 110 dB**
- Direct sampling (Apache, K4, Flex, Icom) no roofing filters, no difference 20 kHz vs 2 kHz
- Direct sampling **100 dB** +/- 5 dB any spacing

Close-in 2-kHz Test @ 500 Hz BW

Dynamic Range of Top 25 HF Transceivers

• Yaesu FTdx-101D	110 dB
• Yaesu FTdx10	107 dB
• Yaesu FT-710	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
• TS-990S	87 dB
• Elecraft KX2	86 dB

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

New price range \$1000 to \$12,560+

Used market price even lower !

100 dB radios unheard of 20 years ago !

(16 dB preamp ON)

(Preamp OFF)

(IP+ ON)

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

I have run contests with 20 of these 25

(No IP+ ADC linearization)

(RMDR limited close-in)

How do you select a new radio?

- Do you pick one of those top 25 models?
- Married to one brand? Pick \$ that fits your budget.
- Price range for new rigs \$1000 to \$12,560+
- Ergonomics and User Interface (UI) are important
- Quality of Noise Mitigation – NB and NR
- Antennas are more important than the rig model.
- Location, Antennas, Operator Skill, Radio Model

Every ADC needs preamp gain on upper HF bands

Direct Sampling Radio Examples

You need to know your radio

Model	Noise floor no preamp	Dynamic Range
Flex 6600	-111 dBm	99 dB
Elecraft K4	-121 dBm	101 dB
Yaesu FT-710	-127 dBm	106 dB
Apache 7000	-131 dBm	103 dB
Icom 7610	-132 dBm	98 dB
Icom 7300	-133 dBm	97 dB

Up to 22 dB gain differences with no preamp or attenuation.

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

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

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

You want receiver noise floor 10 dB lower than band noise.

More later when discussing **Antenna Noise Gain**.

Residential Urban Noise is worse than in this graph

Band Noise vs. Frequency from ARRL Handbook

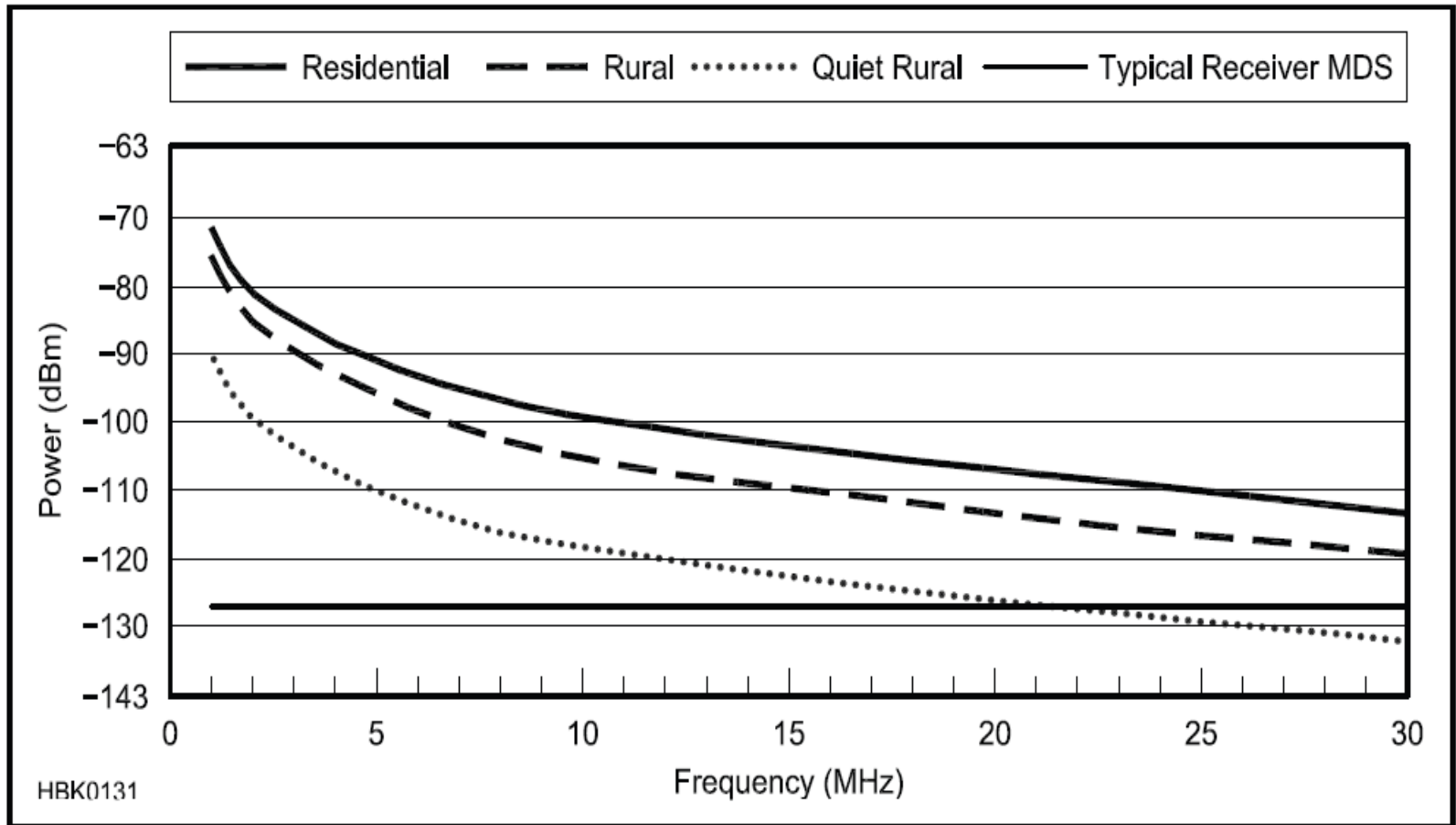


Fig 1 — Typical noise levels versus frequency for various environments. (Man-made noise in a 500-Hz bandwidth, from Rec. ITU-R P.372.7, *Radio Noise*)

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

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

Typical gain setting mistake

If in doubt turn the preamp ON ? **No**

Only use a preamp if necessary. (ARRL DX SSB example)

If an attenuator is ON, you can't copy! **Incorrect !**

Most radios are too sensitive on 40m and below.

Preamps and attenuators are “**tools**” to be used when needed, **not ON or OFF** all the time.

Attenuation may be your RF gain control. (IC-7300)

Misconceptions

If preamp 2 has the lowest noise floor, I should run it all the time.

That is completely incorrect. I'll discuss Antenna Noise Gain.

I purchased an SDR radio since it is digital and it has no noise !

That would be quite an invention, the noiseless radio.

Every radio, superhet, direct sampling or direct conversion has at least 150 dB of gain. It will be divided between analog gain and digital gain, but 150 dB of gain is required to go from -130 dBm to +20 dBm (100 mW of audio).

You can check this by ear but try a meter once.

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

Some Antenna Comments

- Height is very important
- 40 feet or higher vs. 25 feet is a big deal.
- At my QTH 70 feet vs. 40 feet on 20m = 1 to 2 S units.
- Sun spots improving. More DX 15, 12 & 10m
- Pick horizontal over vertical if at all possible.
- 6 dB ground gain from a horizontal antenna.
- Keep away from house if possible.
- RFI from equipment in your home is an issue.

A step up from a vertical

Optimize your antenna first

- A Yagi at 40 feet vs. a vertical is significant.
- Side and Rear rejection can be 20 dB or more.
- At my QTH 2 Yagis on the same band pointed in different directions sound like two different bands from a QRM standpoint.
- A center-fed 40-foot zepp fed with window ladder line and a DXE tuner balun is broadside on 20m through 10 meters. (Tuner required)
- **Know where your RF is pointed !**

Didn't I say your antenna is important?

Directive Antennas reduce QRM !



Main Architecture types

Also consider the User Interface (UI)

- Superhet or Direct Sampling architecture
- Most common UI today: Internal LCD or computer screen
- Flex runs on Windows or Apple OS
- Apache runs on Windows only
- Windows updates can “break” things !
- Complication – Computer OS not real-time operating system

- All others are stand-alone embedded operating system
- How you interface with your radio is very personal.
- Let’s look at some examples.

Some Rig Price Comparisons

• Model	Price	New 2020 / 2022
• Elecraft K4D	\$6480 (tuner included)	Yes
• Yaesu FTdx10	\$1400	Yes
• Icom IC-705	\$1350	Yes
• Yaesu FT-710	\$1050	Yes
• Icom IC-7300	\$1000	For comparison
• Icom IC-7610	\$3250	
• FTdx-101D	\$3700	Prices as of April 20 2023
• FTdx-101MP	\$4900	
• TS-890S	\$4200	
• Flex 6600	\$4600	

Comments on Flex

- Preoccupied with a military contract for 2+ years.
- That project is wrapping up soon.
- Focused last 5 years on remote and contesting
- Very few DSP improvements for years
- Some CW bugs have been around for a very long time.
- Very loyal customer base
- No schematics or documentation published
- Current models are starting to ship again.
- Maestro an interesting but expensive remote device still on backorder until late 2023 or even early 2024.

Comments on Apache

- Leading noise mitigation (NB and NR)
- The only brand with pre-distortion splatter reduction.
- A fiddlers delight
- Don't consider it "plug and play".
- Not recommended for your first HF transceiver.
- Buy a 100-watt standalone radio (no computer).
- Incomplete documentation on dozens of settings
- OEM makes the radio
- Open Source software runs the radio
- Consider a separate computer for just the radio.

Comments on the IC-7300

- A game changer that came out 7 years ago.
- More than 50,000 sold in just the USA and Canada !
- Good Dynamic Range
- 7300 operates much like more expensive IC-7610
- Excellent ergonomics and scope display
- Common user interface for all the Icom direct sampling transceivers: 7300, 7610, 9700 & 705
- **Added scrolling & re-center feature** for these Icom rigs.
- Last firmware update summer of 2021

Comments on the Yaesu FT-710

- Yaesu's first direct sampling transceiver
- Similar to IC-7300 but better lab numbers
- Price FT-710: \$1050
- Price 7300: \$1000
- Price FTdx10: \$1400
- User Interface and band scope could be improved.
- Multiple contest evaluations fall of 2022.
(CQ WW CW, ARRL 160 & 10m)

Comments on the Yaesu FTdx10

- Excellent Lab numbers
- Ergonomics different than the FT-710
- User Interface & band scope could be improved.
- Classic hybrid superhet with roofing filters.
- Both 710 and 10 have an Audio Peak Filter for CW.
- Multiple contest evaluations fall of 2022.
(ARRL 160 & 10m plus Stew Perry Top Band CW)

Yaesu FTdx10 vs. FT-710

- Sitting in front of both it is as if they were designed by different companies.
- Adjusting filter bandwidth easy on the 10 and not very flexible on the 710.
- The 10 has the volume control on the wrong side of the VFO for right handed people.
- The 710 has less crowded button placement
- Neither of the band scopes and waterfall displays automatically re-center when tuning.

Kenwood TS-590 series

- TS-590SG shipped late 2014
- Excellent overall performer
- **Lacks a band scope that is now typical.**
- (Can be added with an SDR dongle)
- TS-590S goes back to late 2010
- Reasonable used price option
- Easy User Interface
- I operated both S and SG 160m CW contests several years ago along with T-T Eagle.

Will Kenwood bring out a new rig in 2023?

- The TS-590SG came out in late 2014.
- The TS-890S came out in late 2018.
- **TS-890S has the best waterfall in my opinion.**
- The HF to UHF TS-2000 discontinued with no replacement.
- Hamvention only announced a new TH-D75A handheld.
- Planned competitor to 7300 & 9700 has never materialized.
- Every new radio in last 7 years has a band scope and waterfall.

10 watts and a battery

Summits and Parks on the air

- Does operating outdoors interests you?
- Consider the Icom IC-705
- 160 m through 70cm
- SSB, CW, FM, Digital FT8 (with laptop) \$1350
- Companion AH-705 single wire tuner \$360
- 23 foot single wire plus a radial 40m – 6m
- I worked a 705 POTA new year's day on 2 meters.
- S9 SSB signal on a mountain 100 miles away

Much smaller than 9.3 pound IC-7300

2.4 pound Icom IC-705



Comments on the IC-705

- For HF, operates much 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
- Display re-centers when tuning as with the other three.

Comments on the Elecraft K4

- Much of the K3 firmware was ported to the K4.
- Major firmware improvements in the last two years.
- Firmware and features still under development.
- New Beta releases often have new bugs.
- Regression analysis still needs improvement.
- The most expensive current mainstream rig. \$6480 with tuner
- Price increased 9% April 20, 2023.
- HD model and pre-distortion may be years down the road.
- Customer base is likely past K3 owners.
- Lots of brand loyalty and reflector support.
- Note: With a multi-band antenna Sub RX cannot be on a higher band than the main RX due to TX low pass filter in the circuit.

Comments on IC-7610 compared to 7300

- No noisy relays for T/R or amp key line
- Audio Peak Filter (APF) for CW
- Identical dual receivers, DX split or other band
- More physical buttons and larger LCD screen
- Buttons for each band
- Two transmit antenna ports
- One RX antenna port
- DVI-D port for external LCD monitor
- Quieter fan
- RC-28 tuning knob for Sub RX \$300
(Flex and Elecraft tuning knobs similarly priced)

Don't select a new radio just from one number !

Important factors to consider

- Operator fatigue is made worse by poor receive audio and poor AGC performance.
- NB and NR very important for urban QTHs.
- You might select a radio mainly due to its ability to do noise mitigation.
- Flex may be best for remote operation.
- Apache has PureSignal and great NR & NB.
- Both require an internal or external computer.

Don't select a new radio just from my chart !

More factors to consider

- Bad ergonomics are frustrating.
- Is speech processor adequate?
- Standalone or Computer Operated?
- 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?



Sherwood Engineering

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