

New 2025 Presentation

Performance Numbers

What do they mean?

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Interpreting the Sherwood Table

Have you looked at the Sherwood web page?

Wrong assumptions are often made about the data

Receiver Test Data

(Terms Explained: [PDE](#))

Sorted by Third-Order Dynamic Range Narrow Spaced - or- ARRL RMDR (Reciprocal Mixing Dynamic Range) if Phase Noise Limited

The term RMDR has only existed since 2012. To convert column LO Noise to RMDR, subtract 27 dB. Example: an LO Noise of 127 dB would be an RMDR value of 100 dB

Note: The term blocking only applies to a superhet radio. For a direct sampling radio the value in the blocking column is the ADC overload point reference receiver noise floor.

Updated 2 June 2025. Added Yaesu FTX-1 Optima

Device Under Test	Noise Floor (dBm)	AGC Thrshld (uV)	dB	100kHz Blocking (dB)	Sensitivity (uV)	LO Noise (dBc/Hz)	Spacing kHz	Front End Selectivity	Filter Ultimate (dB)	Dynamic Range Wide Spaced (dB)	kHz	Dynamic Range Narrow Spaced (dB)	kHz
LO Noise Corrected 05/10/19	-127	4.5			0.60								
Yaesu FTdx-101D/MP	-136 ^b -141 ⁶	1.6 ^b 0.58 ^{b1}	3	>147	0.20 ^b 0.12 ^{b1}	154 155	10 50	A Trk Presel	>115	110	20	110	2
Added 12/30/20	-126	4.2			0.63								
Yaesu FTdx10	-135 ^b -140 ⁶	1.46 ^b 0.54 ^{b1}	3	141	0.21 ^b 0.15 ^{b1}	152 153	10 50	B Half Octave & Bandpass	105	107	20	107	2
Added 10/01/22	-127	4.0			0.66								
Yaesu FT-710	-135 ^b -140 ⁶	1.40 ^b 0.38 ^{b1}	3	129	0.23 ^b 0.13 ^{b1}	150 154	10 30	B Bandpass	108	107	20	107	2
Added 02/11/18	-131	2.40			0.40								
Icom IC-R8600 Second sample S/N 02001177	-142 ^b -130 ^{ab}	0.67 ^b	3	125	0.12 ^b 0.49 ^{ab}	144 148	10 50	B Half Octave	>100	109 ^{ab} 88 ^{ac}	20	107 ^{ab} 88 ^{ac}	2
Added 11/10/15	-135	1.5			0.27								
Elecraft K3S	-138 ^b -145 ¹⁰	0.45 ^b	3	150	0.20 ^b 0.08 ¹⁰	144 146	10 50	B Band Pass	110	107 ^q	20	106 ^p 106 ^q	2
Added 3/17/17	-135	1.5			0.27								
Elecraft K3S 2nd Sample 10 meter data	-138 ^b -145 ¹⁰	0.45 ^b	3	150	0.20 ^b 0.08 ¹⁰	144 146	10 50	B Band Pass	110	106 ^{ah}	20	105 ^{ah}	2
Added 02/23/15	-136	1.0			0.27								
Elecraft K3 (RX Gain Recal) New Synthesizer	-139 ^{bq}	0.3 ^b	3	141	0.20 ^b	145 147	10 50	B Band Pass	108	105 ^q	20	107 ^p 104 ^q	2
Added 04/25/16	-123	8.5			0.65								
Icom IC-7851	-135 ^b -141 ^{b1}	1.85 ^b 1.16 ^{b1}	3	149	0.16 ^b 0.11 ^{b1}	148 153	10 50	A Trk Presel	100	110 ^{aa}	20	105 ^{aa}	2

Let's back up 51 years !

What data did we have 51 years ago?

Specs were typically quite limited.

Sensitivity in microvolts, still used today.

Selectivity and possibly shape factor

Cross modulation, an AM figure of merit.

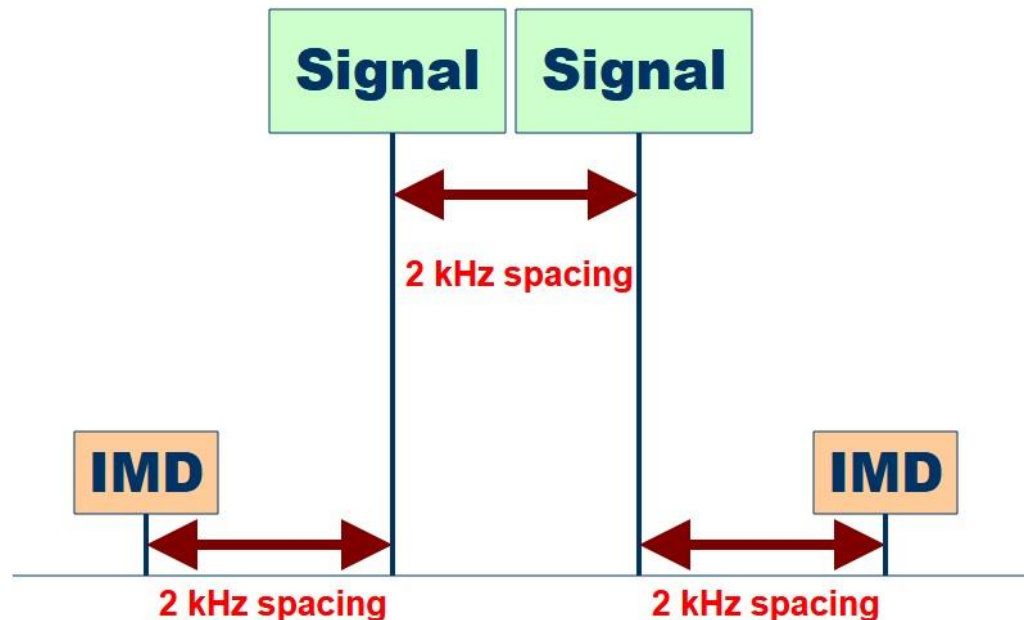
In 1975 it all changed due to articles in QST and *ham radio magazine*

What was new 50 years ago?

- **Noise floor** with a CW bandwidth – 500 Hz.
- **Dynamic Range also measured on CW.**
- Dynamic range (DR3) only measured at 20 kHz !
- This was already obsolete for the Drake R-4C.
- The first up-conversion radio was the Drake TR-7.

What is dynamic range?

- When two signals enter an amplifier (or mixer, or...) with nonlinearity, “new signals” come out
- Third-order intermodulation is the usually biggest problem – the “new signals” are at predictable frequencies
- Dynamic range is defined as the input signal level that causes these “new signals” to rise to be equal to the noise floor



What was the dynamic range problem?

- Topology of most superhet radios had changed.
- Wide first IF filter was above 10m or 6m.
- First IF filter, **lots of gain**, crystal filter at 2nd IF
(Typically between 4 and 11 MHz)
- In a CW contest or DXpedition the radios overloaded.
- 20-kHz test data didn't show the problem.
- 1977 Sherwood introduced the 2-kHz DR3 test.
- Typical 20-kHz data was 80 to 90 dB.
- Typical 2-kHz data was 65 to 75 dB.

Where are we today?

- Both QST and Sherwood publish 20 & 2-kHz data.
- Sherwood has 14 columns of data for 150 radios.
- All radios are only sorted (ranked) by the 2-kHz DR3 data column.
- Most hams only look at the 2-kHz data.
- A radio's position in the table is not an overall ranking!
- Other columns are not ranked top to bottom, but contain lab numbers for all the other measurements for that specific radio.

These were compared in a podcast

- FTX-1 Field DR3 91 dB, IC-705 DR3 88 dB
- The reviewer assumed due to the 2 kHz DR3 ranking, the FTX-1 Field was more sensitive than the IC-705.
- If you actually look at the data that was wrong.
- FTX-1 SSB sensitivity 0.9 μV
- IC-705 SSB sensitivity 0.67 μV

Do you see the problem?

- The only column of data that is sorted (ranked) is the 2-kHz dynamic range value.
- All the other data must be compared manually.
- If you want to compare noise floor values in dBm you have to look it up by each model.
- What else should you not do?

Don't choose a radio by one number

- Today there are more than 20 transceivers with a DR3 > 90 dB
- Other important issues, and it isn't noise floor or sensitivity.
- Compare:
- User Interface (knobs, buttons, display, computer or standalone)
- Ergonomics (Is the radio easy to use?)
- Menus, and is it necessary to access them regularly?
- If you can, try out a potential new radio at a friend's QTH.
- If you have a ham store near you, make use of it.

Great basic performance from all OEMs

- You can contest and DX with dozens of rigs.
- The magic “100 dB radio” is now common.
- Choices by brand, cost & size
- I operated multiple CW contests 4th quarter 2022 with \$1000 to \$1300 rigs with only user interface and ergonomics not optimized.

Dynamic Range of Top 26 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 7760	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
• Yaesu FTX-1	91 dB
• Ten-Tec Eagle	90 dB
• Flex 6300	89 dB
• Icom 705	88 dB
• TS-990S	87 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 !

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 rigs

(No IP+ ADC linearization)

(RMDR limited close-in)

How do you select a new radio?

- Do you pick one of those top models?
- That would be a good start.
- Married to one brand? **Pick price** that fits your budget.
- Price range for current **new** rigs today \$1000 to \$7,000+
- Size of the rig for DXpeditions, SOTA, POTA, etc.
- Let's look at lab numbers and what they mean.

Data from my website, left to right

- Noise Floor is rarely an issue due to urban noise.
- Rural noise is likely higher on 15m than RX noise.
- Noise floor may be important with a limited antenna such as SOTA, POTA or using an RX only antenna.
- Improving your antenna, if you can, is more important than buying a new radio with better lab numbers.

Comments on AGC threshold

- Band noise is often above the AGC threshold.
- Consider using attenuation or RF gain to raise the AGC threshold so it is 3 to 6 dB above band noise.
- This reduces operating fatigue.
- Band noise is then not as loud as a modest signal.

Blocking

- Superhet radios eventually block from an out-of-passband signal.
- Direct Sampling radios run out of ADC dynamic range
- Most of the time blocking/ADC overload isn't an issue.
- A blocking value of 125 dB is usually adequate.

SSB Sensitivity = 10 dB S+N/N Ratio

- As with Noise Floor, with today's manmade noise levels Sensitivity is rarely a performance issue.
- The same antenna limitations apply.
- 0.15 uV with preamp 1 enabled is a reasonable value.
- The same value applies to a legacy radio such as a Collins 75S-3C or a Drake tube radio.

Local Oscillator Noise and RMDR

- Legacy radios didn't have an LO noise issue.
- They had a PTO and band crystals.
- Early synthesized radios had poor LO noise.
- No radio introduced in the last 10 years has an LO or direct sampling clock noise issue.
- To convert LO noise to RMDR subtract 27 dB.

Front End Selectivity

- Most rigs have either a half-octave or ham band only L/C filters.
- A few offer a rather wide tracking L/C filter.
- (FTdx-101D/MP & high-end Icom rigs)
- On 40m the -10 dB bandwidths are 250 kHz to 500 kHz wide.
- Beware of claimed “magical” QRM and QRN reduction.
- The main improvement of a tracking preselector is reducing out-of-band commercial signals.
- Additional L/C bandpass filters are often needed for Field Day setups.

Finally we are back to Dynamic Range

- With 20+ transceivers with a close-in 2-kHz dynamic range over 90 dB, most hams don't have an overload issue.
- A radio with roofing filters has about a 20 dB advantage for the exceptional cases such as:
 - A line-of-sight local ham that is S9+60 dB
 - Field Day with CW, Digital and SSB stations on the same band.
 - A multi-multi contest station with both RUN and MULT stations.

When might a 99 dB IC-7760 overload?

- On 10m my band noise was -130 dBm, May 11, 2020 @ noon.
- The noise floor of the 7760 is -133 dBm
- $-130 \text{ dBm} + 99 \text{ dB} = -31 \text{ dBm} = \text{S9}+42 \text{ dB}$
- Theoretically DR3 products would be audible above band noise with multiple signals approximately $\text{S9}+45 \text{ dB}$.
- WRTC in Europe 40m at night, IC-7610 needed 9 dB attenuation or OVF was indicating ADC over-range.
- Typical nighttime band noise -100 dBm
- 7610 noise floor -132 dBm.
- **Noise floor of -132 dBm is counter productive on 40m at night.**
- 15 dB of attenuation would give the best dynamic range to cope with shortwave AM signals 7.20 to 7.45 MHz and the 49 meter band below 40m.

What mistake is most often made?

- A radio has to be sensitive enough for 10m let alone 6 meters which is a standard band today.
- Thus radios are too sensitive on 160, 80 & 40m.
- Using a preamp on these lower frequency bands at night is the opposite of what is appropriate.
- Use the attenuator or the RF gain control.
- The 12 dB attenuator would be a good starting point.

What has changed?

Up-conversion radios were replaced with down conversion

Once the Orion I and then the K3 came along, up-conversion radios with a high-frequency wide first IF filter went obsolete.

Both the Orion 1 and the K3 have a low frequency first IF.

A 70-dB 2-kHz up-conversion dynamic range radio couldn't compete with a 105 dB dynamic range down-conversion K3S.

The exception was the now discontinued Icom IC-7851 with its 1.2 kHz CW roofing filter at 64 MHz. (Also a 105 dB radio)

What about direct sampling rigs?

- Direct sampling transceivers currently on the market have a dynamic range between 97 dB and 107 dB with built-in linearizing dither.
- Even the IC-705 with no dither option has a dynamic range of 88 dB.
- Usually the DR3 of a direct sampling radio is the same at any test spacing including 20 kHz and 2 kHz.

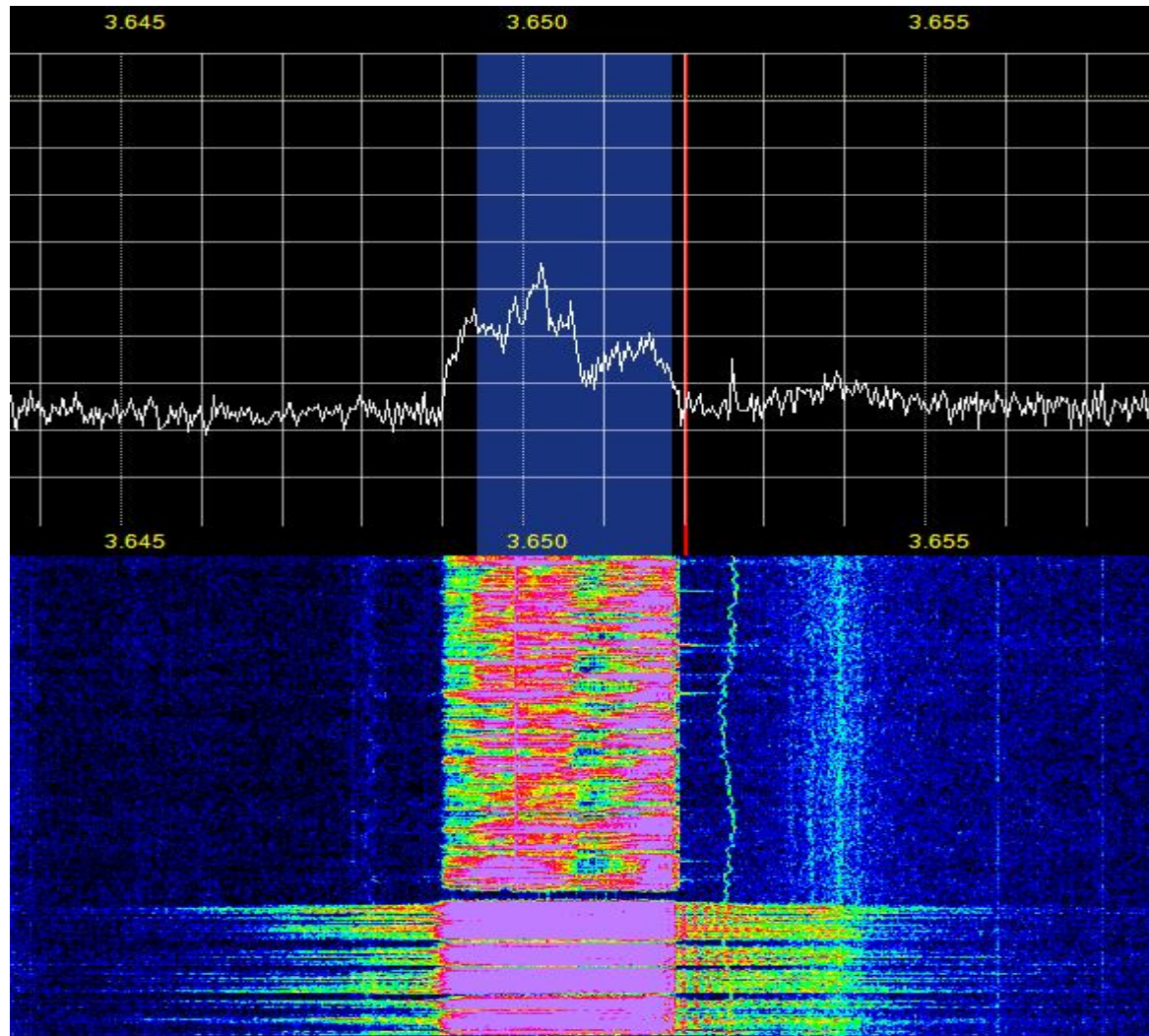
What rig should you own?

- I am often asked why I don't own the top Yaesu rigs on my webpage?
- I did own the FTdx10 and FT-710 for several years. They worked well but I prefer the User Interface, Ergonomics and Band Scope and Waterfall of the IC-7610.
- That is 100% subjective and should have no bearing on what rig works best for you.

Do transmit differences matter?

- We have only looked at RX issues until now.
- What is currently available to clean up our TX signal?
- The biggest difference is pre-distortion on SSB.
- 3 of the top 6 OEMs offer some kind of pre-distortion.
- Apache has had PureSignal for over 12 years.
- Icom has had DPD for over 1.5 years.
- Flex has SmartSignal currently in Beta.
- There are some other differences but let's look at some real signals with and without pre-distortion.

PureSignal adaptive pre-distortion vs. no pre-distortion SSB splatter



Class A is gone with current rigs

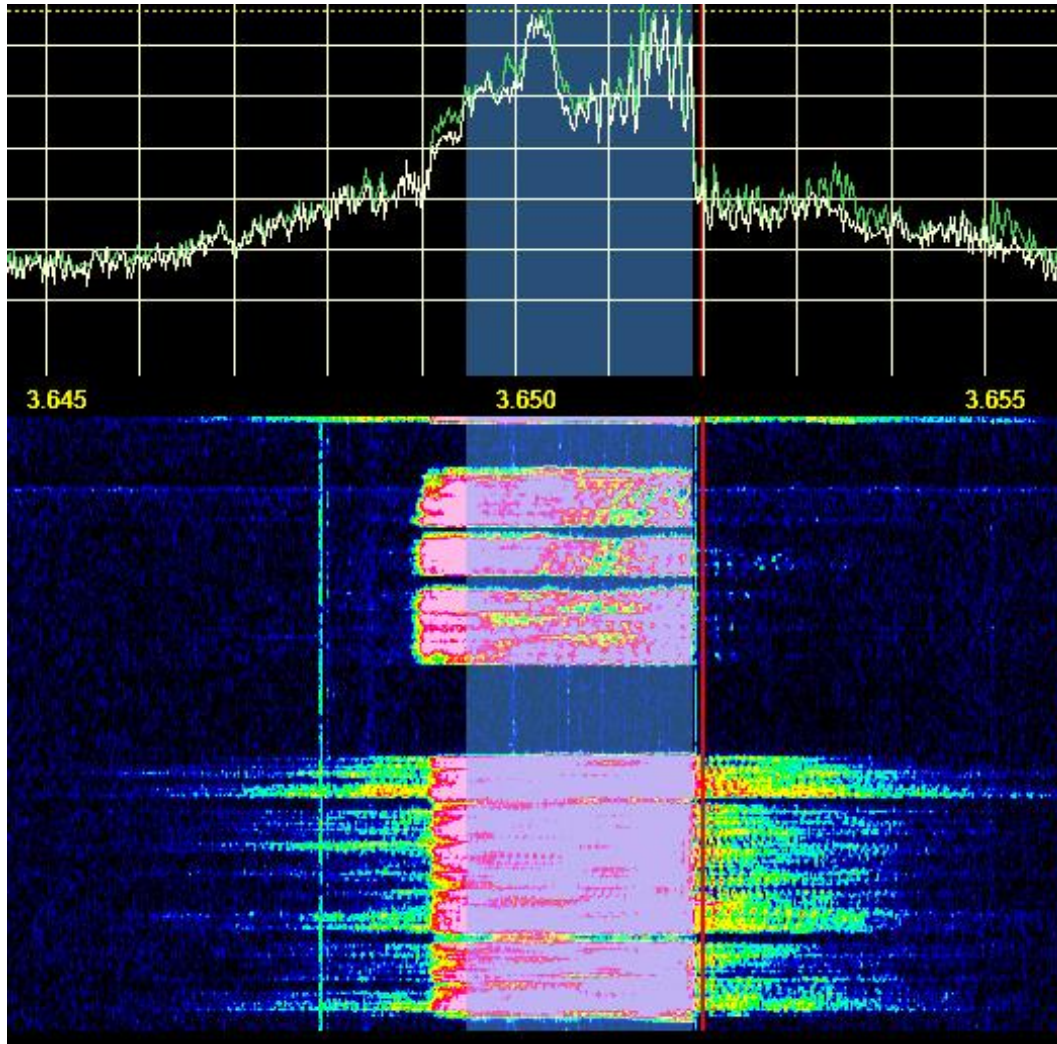
Icom now offers DPD predistortion

K4 ?

Apache 200D & PureSignal APD & Amp

Kenwood TS-890S & Alpha 89

Icom Digital Pre-Distortion (DPD) vs. no pre-distortion SSB Splatter



Display 10 kHz span
Apache 7000DLE RX

Blue shading is the
2.4 kHz RX bandwidth

Icom 7610 with DPD
driving an Acom 1000
Amp not in DPD loop
NC0B

Flex 6600M driving a
PowerGenius XL
W5AP

Apache PureSignal by Warren NR0V

- While all the pre-distortion solutions work barefoot, not all support any 3rd party amplifier in the distortion correction loop.
- PureSignal always has supported a 3rd party amplifier, and all that is needed is an internal or external RF sample port on the amplifier.
- PureSignal continually recalculates a distortion correction solution on the fly. No manual calibration is needed, and it **does not need to** recalibrate after a change in frequency or power level.

Comments on IC-7610 & IC-7760

- Both rigs offer pre-distortion (DPD) barefoot.
- Only PW2 offers DPD with the amp in the correction loop.
- (Neither PW1 nor 3rd party amps are supported with DPD)
- While the 200-watt 7760 barefoot has cleaner odd-order distortion than the 100-watt 7610 barefoot, the net PW2 distortion is the same regardless of which rig drives the amp.
- 7760 competes at 200 watts as with other flagship offerings.
(FTdx-101MP, TS-990S, Apache 8000)

Flex-Radio SmartSignal Pre-distortion

- Since SmartSignal as of July 2025 is still in Beta, it does not currently support an external amplifier. This is expected to change relatively soon.
- SmartSignal can calibrate on voice or a built-in 2-tone test. It only re-calibrates if a change in frequency exceeds 10 kHz, or if the called for power output changes.

Important factors to consider

- We have great rig choices today at reasonable prices.
- Try to operate a potential new radio if you can.
- Few hams have to contend with overload today with 90+ dB radios.
- We need Elecraft, Kenwood and Yaesu to offer pre-distortion for less QRM on the phone bands.
- Luckily pre-distortion with a cleaner tube type linear = big IMD improvement even outside the correction loop.
- Don't select a new radio by one single number !

Comments

- If you have questions about data on my webpage, please feel to contact me.
- It frustrates me when dynamic range ranking is assumed to apply to all the other test data.
- Please look at other column data when comparing rigs for some specific parameter.
- Bottom Line: Do you enjoy using your radio?



Sherwood Engineering

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Feel free to email questions !