Please check pa0q.nl for the summary of HF Power Amplifiers

QST Magazine Product Reviews - Key Measurements Summary - HF-Transceivers or Receivers (page 1/7)

		Receiver								Transmitter			
	Subject of measurement, band: 14 MHz	20 kHz reciprocal mixing dynamic range	2 kHz reciprocal mixing dynamic range	20 kHz blocking gain compression	2 kHz blocking gain compression	20 kHz 3rd-order dynamic range	**2 kHz 3rd-order dynamic range**	20 kHz 3rd-order intercept	2 kHz 3rd-order intercept	Transmit 3rd-order IMD typical	Transmit 9th-order IMD typical	5 kHz Transmit keying bandwidtch	10 kHz Transmit phase noise
	Min/max of scale	-60/-140 dB	-60/-140 dB	70/140 dB	70/140 dB	50/110 dB	**50/110 dB**	-40/+35 dBm	-40/+35 dBm	-20/-35 dB	-20/-70 dB	-55/-95 dB	-110/-150 dB
	Transceivers/receivers sorted by 2 kHz 3rd-order dynamic range and if equal by 20 kHz 3rd-order dynamic range												
1	**Yaesu FTdx5000D, December 2010**	N/M	N/M	136 dB *	136 dB *	114 dB **	114 dB **	+41 dBm **	+40 dBm **	-43 dB **	-72 dB **	N/M	N/M
2	**Yaesu FTdx101MP, December 2020**	-130 dB	-125 dB	>135 dB	>135 dB	112 dB **	110 dB	N/M	N/M	-38 dB **	-57 dB	-95 dB	-160 dB **
3	**Yaesu FTdx101d, November 2019**	-130 dB	-125 dB	>135 dB	>135 dB	111 dB	110 dB	N/M	N/M	-42 dB **	-58 dB	-95 dB	-152 dB **
4	**WiNRADIO WR-G31DDC, January 2012**	N/M	N/M	128 dB	128 dB	107 dB	107 dB	+32 dBm	+32dBm	N/A	N/A	N/A	N/A
5	**Kenwood TS-590SG, July 2015**	-118 dB	-94 dB	139 dB	130 dB	106 dB	106 dB	+29 dBm	+29 dBm	-42 dB **	-58 dB	N/M	N/M
6	**Icom IC-7851, July 2016**	-125 dB	-114 dB	131 dB	129 dB	110 dB	105 dB	N/M	N/M	-36 dB	-61 dB	-92 dB	-148 dB
7	**Kenwood TS-890S, June 2019**	-130 dB	-125 dB	>140 dB **	>140 dB **	106 dB	104 dB	N/M	N/M	-42 dB **	-62 dB	-95 dB	-123 dB
8	**FlexRadio FLEX-6600M, February 2020**	-122 dB	-118 dB	122 dB	122 dB	105 dB	104 dB			-45 dB **	-56 dB	-93 dB	-135 dB
9	**Elecraft K3S, November 2016**	-119 dB	-115 dB	145 dB **	136 dB	105 dB	104 dB	N/M	N/M	-35 dB	-62 dB	-95 dB	-142dB
10	**Elecraft K3, after Synthesizer Upgrade, November 2015**	-119 dB	-115 dB	143 dB **	143 dB **	106 dB	103 dB	N/M	N/M	N/M	N/M	N/M	N/M
11	**Elecraft K3, January 2009 with update, November 2015**	-115 dB	-93 dB	143 dB **	135 dB	106 dB	103 dB	+29 dBm	+28 dBm	-29 dB	-51 dB	N/M	N/M
12	**FlexRadio FLEX-6700, April 2015**	-124 dB	-116 dB	128 dB	128 dB	103 dB	103 dB	+46 dBm **	+46 dBm **	-41 dB **	-61 dB	N/M	N/M
13	**Elecraft K3, April 2008**	N/M	N/M	139 dB	139 dB	103 dB	102 dB	+26 dBm	+26 dBm	-27 dB	-53 dB	N/M	N/M
14	**Kenwood TS-990S, February 2014**	-117 dB	-87 dB	138 dB	133 dB	112 dB **	101 dB	+44 dBm **	+35 dBm	-39 dB **	-56 dB	N/M	N/M
15	**FlexRadio FLEX-6500, February 2017**	-122 dB	-115 dB	130 dB	129 dB	103 dB	101 dB	N/M	N/M	-39 dB **	-55 dB	-95 dB	-153 dB **
16	**Icom IC-7610, October 2018**	-127 dB	-113 dB	120 dB	120 dB	101 dB	101 dB	N/M	N/M	-41 dB **	-61 dB	-89 dB	-138 dB
17	**Yaesu FTdx3000, April 2013**	-106 dB	-82 dB	137 dB *	127 dB	110 dB	100 dB	+40 dBm **	+23 dBm	-27 dB	-52 dB	N/M	N/M
18	**SSB Electronic ZEUS ZS-1, June 2014**	-128 dB	-120 dB	129 dB	129 dB	105 dB	100 dB	+31 dBm	+31 dBm	-34 dB	-60 dB	N/M	N/M
19	**Hilberling PT-8000A, November 2014**	-118 dB	-111 dB	138 dB	138 dB	104 dB	100 dB	+35 dBm	+30 dBm	-35 dB	-59 dB	N/M	N/M
20	**Elecraft KX3, December 2012**	-120 dB	-114 dB	130 dB	128 dB	103 dB	100 dB	+34 dBm	+34 dBm	-30 dB	-55 dB	N/M	N/M
21	**Apache Labs ANAN-8000DLE, April and November 2018**	-115 dB	-110 dB	125 dB	125 dB	100 dB	100 dB	N/M	N/M	-54 dB & **	-60 dB &	-95 dB	-136 dB

QST Magazine Product Reviews - Key Measurements Summary - HF-Transceivers or Receivers (page 2/7)

			Receiver								Transmitter				
		Subject of measurement, band: 14 MHz	20 kHz reciprocal mixing dynamic range	2 kHz reciprocal mixing dynamic range	20 kHz blocking gain compression	2 kHz blocking gain compression	20 kHz 3rd-order dynamic range	**2 kHz 3rd-order dynamic range**	20 kHz 3rd-order intercept	2 kHz 3rd-order intercept	Transmit 3rd-order IMD typical	Transmit 9th-order IMD typical	5 kHz Transmit keying bandwidtch	10 kHz Transmit phase noise	
		Min/max of scale	-60/-140 dBc	-60/-140 dBc	70/140 dB	70/140 dB	50/110 dB	**50/110 dB**	-40/+35 dBm	-40/+35 dBm	-20/-35 dB	-20/-70 dB	-55/-99 dB	-110/-150 dB	
		Transceivers/receivers sorted by 2 kHz 3rd-order dynamic range and if equal by 20 kHz 3rd-order dynamic range													
	22	**Icom IC-R8600, November 2017**	-122 dB	-108 dB	115 dB	124 dB	103 dB	**99 dB**	N/M	N/M	N/A	N/A	N/A	N/A	
	23	**ELAD FDM-DUO, May 2016**	-108 dB	-104 dB	124 dB	106 dB	99 dB #	**99 dB #**	N/M	N/M	-39 dB **	-70 dB	-88 dB	-141 dB	
	24	**FlexRadio FLEX-5000A, July 2008**	N/M	N/M	123 dB	123 dB	99 dB	**99 dB**	+35 dBm	+30 dBm	-34 dB	-54 dB	N/M	N/M	
	25	**TenTec 599AT Eagle, August 2011**	N/M	N/M	136 dB	126 dB	98 dB	**98 dB**	+22 dBm	+22 dBm	-28 dB	-48 dB	N/M	N/M	
	26	**Kenwood TS-590S, May 2011**	N/M	N/M	**141 dB ****	121 dB	106 dB	**97 dB**	+26 dBm	+22 dBm	-29 dB	-52 dB	N/M	N/M	
	27	**Perseus SDR, December 2008**	N/M	N/M	129 dB	129 dB	100 dB	**97 dB**	+35 dBm	+35 dBm	N/A	N/A	N/A	N/A	
	28	**Apache Labs ANAN-100D, October 2015**	-117 dB	-105 dB	124 dB	122 dB	97 dB	**96 dB**	+22 dBm	+22 dBm	**-49 dB ****	-60 dB	N/M	N/M	
	29	**TEN-TEC 539 Argonaut VI, August 2013**	N/M	N/M	N/M	N/M	96 dB	**96 dB**	+20 dBm	+20 dBm	-30 dB	-51 dB	N/M	N/M	
	30	**Icom IC-7700, October 2008**	N/M	N/M	125 dB	102 dB	106 dB	**95 dB**	+35 dBm	+24 dBm	-28 dB	-53 dB	N/M	N/M	
	31	**Flex-3000, Oct/Nov 2009**	N/M	N/M	113 dB	113 dB	99 dB	**95 dB**	+28 dBm	+26 dBm	-30 dB	-45 dB	N/M	N/M	
	32	**Icom IC-7300, August 2016**	-114 dB	-102 dB	123 dB	123 dB	97 dB	**95 dB**	N/M	N/M	-30 dB	-58 dB	**-95 dB**	-139 dB	
	33	**TenTec Orion-II, September 2006**	N/M	N/M	136 dB	136 dB	92 dB	**95 dB**	+20 dBm	+21 dBm	-28 dB	-52 dB	N/M	N/M	
	34	**FlexRadio FLEX-6400M, February 2019**	-122 dB	-118 dB	123 dB	123 dB	95 dB	**94 dB**	N/M	N/M	**-41 dB ****	-55 dB	**-95 dB**	-129 dB	
	35	**FlexRadio FLEX-6300, April 2015**	-121 dB	-116 dB	127 dB	126 dB	92 dB	**92 dB**	**+43 dBm ****	**+43 dBm ****	**-41 dB ****	-54 dB	N/M	N/M	
NEW	36	**Icom IC-705, February 2021**	-114 dB	-110 dB	124 dB	124 dB	90 dB	**90 dB**	N/M	N/M	**-40 dB ****	-63 dB	**-93 dB**	-138 dB	**NEW**
	37	**Icom IC-7410, October 2011**	N/M	N/M	**143 dB ****	111 dB	106 dB	**88 dB**	+29 dBm	+5 dBm	-30 dB	-61 dB	N/M	N/M	
	38	**Icom IC-7600, November 2009**	N/M	N/M	122 dB	102 dB	106 dB	**88 dB**	+31 dBm	+13 dBm	-31 dB	-48 dB	N/M	N/M	
	39	**Icom IC-9100, April 2012**	-101 dB	-77 dB	**142 dB ****	111 dB	108 dB	**87 dB**	+29 dBm	+2 dBm	-29 dB	-64 dB	N/M	N/M	
	40	**Elecraft KX2, May 2017**	-99 dB	-102 dB	116 dB	112 dB	93 dB	**87 dB**	N/M	N/M	-36 dB	-58 dB	**-94 dB**	-128 dB	
	41	**Icom IC-7800 V2, March 2007**	N/M	N/M	**144 dB ****	117 dB	108 dB	**86 dB**	**+38 dBm ****	+22 dBm	-32 dB	-52 dB	N/M	N/M	
	42	**FlexRadio FLEX-1500, December 2011**	N/M	N/M	107 dB	107 dB	100 dB	**86 dB**	+31 dBm	+13 dBm	-22 dB	-48 dB	N/M	N/M	
	43	**Yaesu FTdx9000MP, July 2010**	N/M	N/M	137 dB	102 dB	99 dB	**85 dB**	+28 dBm	+7 dBm	-37 dB **	-75 dB **	N/M	N/M	

QST Magazine Product Reviews - Key Measurements Summary - HF-Transceivers or Receivers (page 3/7)

		Receiver								Transmitter			
	Subject of measurement, band: 14 MHz	20 kHz reciprocal mixing dynamic range	2 kHz reciprocal mixing dynamic range	20 kHz blocking gain compression	2 kHz blocking gain compression	20 kHz 3rd-order dynamic range	**2 kHz 3rd-order dynamic range**	20 kHz 3rd-order intercept	2 kHz 3rd-order intercept	Transmit 3rd-order IMD typical	Transmit 9th-order IMD typical	5 kHz Transmit keying bandwidtch	10 kHz Transmit phase noise
	Min/max of scale	-60/-140 dBc	-60/-140 dBc	70/140 dB	70/140 dB	50/110 dB	**50/110 dB**	-40/+35 dBm	-40/+35 dBm	-20/-35 dB	-20/-70 dB	-55/-99 dB	-110/-150 dB
	Transceivers/receivers sorted by 2 kHz 3rd-order dynamic range and if equal by 20 kHz 3rd-order dynamic range												
44	**TenTec R4020 QRP, February 2011**	N/M	N/M	N/M	N/M	84 dB	**84 dB**	+10 dBm	-10 dBm	N/M	N/M	N/M	N/M
45	**Yaesu FTdx1200, January 2014**	-104 dB	-81 dB	132 dB	123 dB	101 dB	**83 dB**	+31 dBm	+4 dBm	-32 dB	-50 dB	N/M	N/M
46	**Yaesu FT-991, November 2015**	-103 dB	-75 dB	134 dB	99 dB	100 dB	**82 dB**	+31 dBm	-1 dBm	-26 dB ~	-46 dB	N/M	N/M
47	**Yaesu FT-991A, May 2018**	-103 dB	-75 dB	133 dB	99 dB	99 dB	**82 dB**	N/M	N/M	-30 dB ~	-48 dB	-85 dB	-119 dB
48	**TenTec Omni-VII, July 2007**	N/M	N/M	137 dB	134 dB	91 dB	**82 dB**	+11 dBm	+6,5 dBm	-27 dB	-55 dB	N/M	N/M
49	**Icom IC-R9500, January 2008**	N/M	N/M	**144 dB ****	109 dB	5kHz/92 dB	**81 dB**	+32 dBm	-4dBm	N/A	N/A	N/A	N/A
50	**Yaesu FTdx9000C, March 2006**	N/M	N/M	128 dB	97 dB	101 dB	**78 dB**	+35 dBm	+1 dBm	**- 43 dB ****	**-80 dB ****	N/M	N/M
51	**Expert SunSDR2 Pro, October 2016**	-118 dB	-65 dB	129 dB	107 dB	78 dB	**78 dB**	N/M	N/M	-30 dB	-57 dB	**-95 dB**	-135 dB
52	**Yaesu FT-450D, November 2011**	N/M	N/M	134 dB	88 dB	97 dB	**76 dB**	+16 dBm	-21 dBm	-25 dB	-50 dB	N/M	N/M
53	**Yaesu FT-950, March 2008**	N/M	N/M	128 dB	98 dB	95 dB	**71 dB**	+21 dBm	-4 dBm	-35 dB	-56 dB	N/M	N/M
54	**Alinco DX-SR8T, June 2011**	N/M	N/M	100 dB	83 dB	94 dB	**70 dB**	+1 dB	-30 dBm	-28dB	-53 dB	N/M	N/M
55	**Yaesu FT-2000D, October 2007**	N/M	N/M	136 dB	87 dB	98 dB	**69 dB**	+26 dBm	-16 dBm	**-41 dB ****	-65 dB	N/M	N/M
56	**Icom IC-7100, July 2014**	-103 dB	-84 dB	120 dB	89 dB	95 dB	**68 dB**	+13 dBm	-25 dBm	-34 dB	-49 dB	N/M	N/M
57	**Yaesu FT-891, June 2017**	-98 dB	-72 dB	131 dB	123 dB	93 dB	**68 dB**	N/M	N/M	-30 dB	-49 dB	-85 dB	-116 dB
58	**Icom IC-7200, June 2009**	N/M	N/M	140 dB	83 dB	99 dB	**67 dB**	+23 dBm	-11 dBm	-32 dB	-58 dB	N/M	N/M
59	**Yaesu FT-450, December 2007**	N/M	N/M	134 dB	90 dB	97 dB	**67 dB**	+13 dBm	-31 dBm	-30 dB	-48 dB	N/M	N/M
60	**Yaesu FT-2000, February 2007**	N/M	N/M	126 dB	92 dB	95 dB	**64 dB**	+16 dBm	-22 dBm	-32 dB	-60 dB	N/M	N/M
61	**Icom IC-7000, May 2006**	N/M	N/M	112 dB	86 dB	89 dB	**63 dB**	+6 dBm	-27 dBm	-33 dB	-58 dB	N/M	N/M
62	**Yaesu FT-818ND, January 2019**	-99 dB	-71 dB	124 dB	93 dB	92 dB	**62 dB**	N/M	N/M	-31 dB	-60 dB	-81 dB	-117 dB
62	**Alinco DX-SR9T, October 2014**	-88 dB	-72 dB	114 dB	91 dB	87 dB	**60 dB**	+17 dBm	-25 dBm	-28dB	-47 dB	N/M	N/M

Notes (page 4/7)

= IMD
* = Blocking exceeded the levels indicated
** = Below/above measurable levels
% = Preamp off
@ = PEP
! = vs. carrier
& = After update QST November 2018, with Pure Signal ON, 200 Watt full power.
N/A = Not applicable
N/M = Not measured

Please take into account that there might be a difference in the numbers when comparing the older product reviews compared to the later product reviews, due to changes in the testing methodology, measurements filters, etcetera.

Dark green = awesome
Green = excellent
Light green = good
Yellow = average
Orange = moderate
Red = poor
Dark red = bad

Blocking gain compression:

When a very strong off channel signal appears at the input to a receiver it is often found that the sensitivity is reduced. The effect arises because the front end amplifiers run into compression as a result of the off channel signal. This often arises when a receiver and transmitter are run from the same site and the transmitter signal is exceedingly strong. When this occurs it has the effect of suppressing all the other signals trying to pass through the amplifier, giving the effect of a reduction in gain.

Blocking is generally specified as the level of the unwanted signal at a given offset (normally 20 kHz) which will give a 3 dB reduction in gain. A good receiver may be able to withstand signals of about ten milliwatts before this happens. The blocking specification is now more important than it was many years ago. With the increase in radio communications systems in use, it is quite likely that a radio transmitter will be operating in the close vicinity to a receiver. If the radio receiver is blocked by the neighbouring transmitter then it can seriously degrade the performance of the overall radio communications system.

Reciprocal mixing dynamic range:

ARRL Lab reports three dynamic range measurements that determine a transceiver's overall performance.
Along with blocking gain compression dynamic range and two tone third order dynamic range, we must consider RMDR while evaluating how well a receiver hears.
Which of these measurements is the most important factor in comparing receivers depends a lot on how you plan to use that receiver. For hearing weak signals at or near the receiver's noise floor, receiver noise typically is the limiting factor. For the reception of stronger signals under crowded band conditions, two tone third order DR is the most important number.
To assess a receiver's ability to perform well in the presence of a single, strong off-channel signal (common within geographical ham radio "clusters" or with another ham on the same block), blocking gain compression DR is usually the dominant factor. Reciprocal mixing is noise generated in a superheterodyne receiver when noise from the local oscillator (LO) mixes with strong, adjacent signals. All LOs generate some noise on each sideband, and some LOs produce more noise than others. This sideband noise mixes with the strong, adjacent off-channel signal, and this generates noise at the output of the mixer. This noise can degrade a receiver's sensitivity and is most notable when a strong signal is just outside the IF passband.
RMDR at 2 kHz spacing is almost always the worst of the dynamic range measurements at 2 kHz spacing that we report in the "Product Review" data table.

3rd order dynamic range:

The difference in decibels between the weakest signal the receiver can handle and the strongest signal the same receiver can handle simultaneously,
- without the need of using additional controls of the receiver, manually carried out by the operator - within 20 kHz (wide spaced) and 2 kHz (close in) within the receiver's passband.
For more information on this important item, written by Rob Sherwood NC0B, please use this link: http://www.sherweng.com/documents/Barc2008.pdf

Notes continued, Version and Disclaimer (page 5/7)

3rd order intercept:
This more or less theoretical point, gives a good indication of a receiver's overall strong signal performance. Third order intercept is related to two-tone third order IMD.
When receiver's response on desired and undesired signals (within the passband) were plotted in the same graph, the two lines would intersect at a point called the third-order intercept.
ARRL Product Review testing includes Two-Tone IMD results at several signal levels. Two-tone, Third-order Dynamic Range figures comparable to previous reviews are shown on the first line in each group.
Third order two-tone dynamic range values shown are best case. IMD DR depends on band activity and signal strengths. See text and February 2010 QST, page 52, for an explanation.
As from May 2016 you may notice ARRL is no longer publishing third-order intercept point data for receivers. Technology has changed, and most modern receivers do not have a 3:1 ratio between the IMD signal level and the IMD input level. This ratio can be significantly higher or lower than 3:1. Since the IP3 figure is mathematically based on a 3:1 ratio, publication of this data would be meaningless. Instead, pay attention to the three dynamic ranges — IMD, blocking, and reciprocal mixing. The lowest of these three dynamic ranges represents the limiting dynamic range of the receiver.

Transmit 3rd and 9th order IMD:
All measurements in dB are below PEP output, except note !.
Transmit two-tone intermodulation distortion, or two-tone IMD, is a measure of spurious output close to the desired audio of a transmitter being operated in SSB mode. This spurious output is often created in the audio stages of a transceiver, but any amplification stage can contribute**
If you have ever heard someone causing "splatter", the noisy audio that extends beyond a normal 3 kHz nominal SSB bandwidth, then you have heard the effects of transmit IMD.
Frequencies close to the transmit signal are affected the most, but depending on the amount of IMD, large portions of the band can suffer from one poor transmitter**
Pure Signal = Pre Distortion

Transmit phase noise
As from May 2016, ARRL introduces several changes to the Key Measurements Summary chart for HF transceivers. ARRL has added bars for transmitted phase noise, which are important parameters of transmission quality, in addition to transmitted intermodulation distortion (IMD) products on SSB.
Over the past decade, we have seen substantial improvements in receiver technology in terms of dynamic range — the ability to perform well in a band crowded with strong signals.
However, the best receiver cannot remove interference created by the poor transmission quality of an adjacent signal.
High levels of IMD products caused by poor transmitter design or improper adjustment causes SSB splatter on both sides of the intended transmitted spectrum, interfering with others on nearby frequencies. High levels of transmitted phase noise add to the background noise level, masking signals that would normally be audible.

Transmit keying bandwidtch
As from May 2016, ARRL introduces several changes to the Key Measurements Summary chart for HF transceivers. ARRL has added bars for transmitted CW keying sidebands, which are important parameters of transmission quality. The ranges for these new Key Measurements were determined from data of 30 transceivers tested from 2008 to the present.
The transmitter Key Measurements give an indication of the overall cleanliness of the transmitter. As with the receiver dynamic range measurements, more detailed information is available in the accompanying table of tests performed in the ARRL Lab. ARRL will also continue to publish the detailed plots showing keying waveform, keying sidebands, and transmitted phase noise.
Note that high keying sideband levels are mainly caused by little or no rise and/or fall time (≤1 millisecond) on the keying waveform.
A transmitter with a 1 millisecond of rise and/or fall time will create key clicks and keying sidebands that are 35 dB down and 500 Hz away from the carrier and will likely interfere with neighboring stations. The Lab tests transceivers with default settings, but some radios that are very clean at default settings can be adjusted for rise/fall times that increase the keying sidebands significantly. Strong keying CW sidebands from an adjacent transmitter can cause a thumping sound in the speaker, with or without key clicks.

For more information (including what the numbers really mean) please read ARRL's QST Magazine August 2004 and January 2006 very interesting articles and the ARRL Lab Test Procedures Manual, available at the ARRL website www.arrl.org.

Version December 29, 2020
Please send me an e-mail (to hans@pa0q.nl) if you have corrections, remarks, etc. Thank you!

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