Sherwood Engineering HF Test Results

Model Elecraft K4D Serial # 00122 & 00384 Lab Test Dates: 5/26-6/13/2021

Front End Selectivity (A – F)	Bandpass	B
Dynamic Range of radio with no preamp		
Dynamic Range 20 kHz	101	dB
Dynamic Range 10 kHz	101	dB
Dynamic Range 5 kHz	101	dB
Dynamic Range 2 kHz	101	dB
Dynamic Range of radio with preamps 1 or 2		
Dynamic Range 20 kHz	101	dB
Dynamic Range 10 kHz	101	dB
Dynamic Range 5 kHz	101	dB
Dynamic Range 2 kHz	101	dB
Blocking or ADC overload above noise floor		
1uV signal @ 50 kHz, AGC On,	128	dB

The RMDR Limit and the ADC overload point were the same.

Reciprocal Mixing Dynamic Range (RMDR)

Spacing kHz		
2.5	114	dB
5	118	dB
10	121	dB
15	123	dB
20	124	dB
50	128	dB

Phase noise (normalized) at 2.5 kHz spacing:	141	dBc/Hz
Phase noise (normalized) at 5 kHz spacing:	145	dBc/Hz
Phase noise (normalized) at 10 kHz spacing:	148	dBc/Hz
Phase noise (normalized) at 15 kHz spacing:	150	dBc/Hz
Phase noise (normalized) at 20 kHz spacing:	151	dBc/Hz
Phase noise (normalized) at 50 kHz spacing:	155	dBc/Hz

Noise floor, SSB bandwidth 14 MHz, no preamp		-113	dBm
Noise floor, SSB bandwidth 14 MHz, Preamp 1 On		-126	dBm
Noise floor, SSB bandwidth 14 MHz, Preamp 2 On		-130	dBm
Sensitivity SSB at 14 MHz, no preamp		1.5	uV
Sensitivity SSB at 14 MHz, Preamp 1 On		0.44	uV
Sensitivity SSB at 14 MHz, Preamp 2 On		0.24	uV
Noise floor, 500 Hz, 14.2 MHz, no preamp		-120	dBm
Noise floor, 500 Hz, 14.2 MHz, Preamp 1 On		-131	dBm
Noise floor, 500 Hz, 14.2 MHz, Preamp 2 On		-136	dBm
Noise floor, SSB, 50.125 MHz, no preamp		-107	dBm
Noise floor, SSB, 50.125 MHz, Preamp 1		-118	dBm
Noise floor, SSB, 50.125 MHz, Preamp 2		-127	dBm
Noise floor, SSB, 50.125 MHz, Preamp 3		-136	dBm
Sensitivity, SSB, 50.125 MHz, no preamp		3.2	uV
Sensitivity, SSB, 50.125 MHz, Preamp 1		0.9	uV
Sensitivity, SSB, 50.125 MHz, Preamp 2		0.3	uV
Sensitivity, SSB, 50.125 MHz, Preamp 3		0.11	uV
Noise floor, 500 Hz, 50.125 MHz, no preamp		-113	dBm
Noise floor, 500 Hz, 50.125 MHz, Preamp 1 On		-125	dBm
Noise floor, 500 Hz, 50.125 MHz, Preamp 2 On		-134	dBm
Noise floor, 500 Hz, 50.125 MHz, Preamp 3 On		-143	dBm
Signal for S9, no preamp	-73 dBm	50	uV
Signal for S9, Preamp 1	-73 dBm	50	uV
Signal for S9, Preamp 2	-73 dBm	50	uV
Note: Hysteresis +/- 3 dB			

Gain of preamps measured using ADC over load indicator

Preamp 1	11.6	dB
Preamp 2	17.8	dB
Preamp 3	32.3	dB
AGC threshold at -3 dB, no preamp	11	uV
AGC threshold at -3 dB, Preamp 1 ON	3	uV
AGC threshold at -3 dB, Preamp 2 ON	1.4	uV
AGC threshold at -3 dB, Preamp 3 ON	0.35	uV

Note: Preamp 3 is only accessible on 12, 10 and 6 meters.

The initial lab measurements were made with software revision R17 (Beta released May 27, 2021) Other tests in June were with firmware R19.

Comments are at a point in time in respect to beta firmware R17. Issues that need firmware updates have been reported to Elecraft. In December 2021 I borrowed a different K4D (S/N 0384) and noted several major issues with firmware R26. Many of the problems reported with R17 or R19 still have not been addressed with R26.

Data for the K4D was taken with the main receiver. Similar results were measured for the sub-receiver.

Dither and Random ADC linearization raises the noise floor about 1.5 dB. Dynamic range with dither and random OFF is in the low 70s. This dynamic range difference exists to a lesser extent with the Icom 7300, 7610 and R8600, denoted as IP+ ON or OFF. Noise floor degradation for the IC-7300, 7610 and R8600 from dither (IP+) is between 1 and 3 dB with these three different models. Dither degrades the Perseus SDR noise floor about 2 dB, and the Apache 7000DLE about 1 dB.

There is a significant 8 dB roll-off of high frequencies on SSB that degrades intelligibility. Due to this roll-off, the 10 dB S+N/N sensitivity measurement, for example, was made at a 1000 Hz beat note for consistency. If the audio passband were flat, there would be a minimal sensitivity measurement difference with beat note pitch.

The transmit passband does not have this roll-off slope, unlike receive.

Preamp gain was measured using the ADC overload indicator which is accurate within 0.1 dB. The bar-graph S meter granularity is around 3 dB or so.

The ADC overload indicator needs to be much more visible than the current + sign in front of the 60 dB above S9 indicator. In addition the indicator changing color to magenta goes back to normal if the overload signal is much above the nominal value. Those overload points for no preamp, preamp 1, preamp 2, and preamp 3 are +8.8 dBm, -2.8 dBm, -9 dBm and -23.5 dBm on 6 meters. Preamp 3 was not tested on 12 or 10m. Firmware R19 reportedly changed ADC overload to the letters OVF for better visibility.

Note: The enunciator for both having Dither and Random enabled, plus the overload indicator are nominally going to be updated in firmware release R27 or later.

Note: A discussion of ADC overload (over-range) for signals significantly outside the selected DSP passband is listed below.

As a comparison to the IC-7610, the Icom has a 20 dB ADC driver chip that is always in the circuit. The K4, on the other hand, has no analog gain ahead of the ADC chip with the preamp OFF.

If the 7610 is adjusted for 12 dB of attenuation, the noise floor of the 7610 will be the same as the K4. In this case the K4 will over-range the ADC at a level 6 dB higher than the Icom.

When the 7610 is operated with no preamp, and a K4 is operated with preamp 2, both the 7610 and the K4 will both over-range at -9 dBm. In this case the total gain ahead of the ADC chip will be the same for both rigs. Both the 7610 and K4 use the same ADC chip.

This gain design decision of the K4 is similar to the Flex 6000 series, which also has no active gain ahead of the ADC chip with the preamps turned OFF.

Transmit composite noise Elecraft K4 readings in dBc/Hz using a crystal bandpass filter

No listing closer than 5 kHz due to spurious signals generated by the K4D.

Offset kHz	100 watts	30 watts
5	-136	-134
10	-136	-135
20	-139	-138
50	-148	-143
100	-150	-143

Transmit IMD dBc (Add 6 dB for “feel good” PEP method)

Power 100 watts			Product	
Band	3rd	5th	7th	9th
6m	-24	-30	-34	-50
20m	-29	-32	-40	-54
80m	-28	-31	-40	-66

Power 50 watts			Product	
Band	3rd	5th	7th	9th
6m	-30	-34	-55	-52
20m	-31	-36	-47	-62
80m	-31	-38	-53	-62

Operational observations with firmware R17 were in May and R26 in December of 2021. In December both the ARRL 160 meter and 10 meter contests were used for on-air evaluation of the K4D using serial number 0384.

On 160m I ran into a case of two signals calling CQ 90 Hz apart that were not differentiated much by the K4 100Hz filter selectivity. I went back and forth between the K4 and a 7610, and the selectivity difference was dramatic, prompting me to make lab measurements during the contest. That data is below. Note the K4 was set to 100 Hz and the 7610 to 150 Hz.

Here is the K4 measured bandwidth of the nominal 100 Hz filter.

dB	BW Hz
-6	180
-20	300
-40	410
-60	475

Here is the 7610 measured bandwidth of the nominal 150 Hz filter.

dB	BW Hz
-6	160
-20	185
-40	210
-60	240

NOTE: This information has been sent to Elecraft.

SSB receive with firmware R17, transient voice sounds, such as the beginning of a word, randomly caused unpleasant distortion. This issue has been improved with firmware R26. The AGC did not handle modest QRN properly with R17 firmware. No QRN existed during the December contest time period. At times even with AGC on Slow, the gain will open up full for no obvious reason. The AGC on a station S9+20 over who is not on VOX will suddenly switch to full gain and make background noise as loud as the stations voice. Turning off the AGC Impulse option mitigates this specific issue.

While the AGC settings can be adjusted to the user's preferences, only Fast and Slow are available at a given time. I find three speeds a more convenient way to quickly optimize AGC decay times. Fast, Medium and Slow would be helpful.

Note: R19 reportedly extended the range of AGC decay when set on Slow.

The embedded operating manual, and PDF version C10, appear to be garbled as to describing settings for AGC Attack, Slope and Threshold. Due to this misdirection I mainly only adjusted the Threshold setting. It did, however, flatten the AGC curve. Personally I prefer a flatter AGC since strong signals aren't much louder than weak signals. Others may well prefer a much greater slope to the AGC.

As noted back in May, with the AF gain wide open, the audio chip in the K4 cannot be driven to rated 2 watts output. I measured the audio power of an S9 test signal with the AF gain wide open driving my 8-ohm Icom SP-20 speaker with three settings of the AGC Threshold.

Threshold Setting	Maximum Watts Output
6	0.78 watts
5	0.24 watts
4	0.076 watts

Only producing 76 milliwatts of audio with the volume full clockwise is unacceptable.

A very strange observation was made during the ARRL 10 meter contest when on SSB. With the volume control adjusted to a comfortable level at 1 o'clock with an S9 signal, when a station quit talking, band noise when not speaking was much louder than his speech. Band noise was around 6 dB louder than the speech level of an S5 to S9 signal. I made an A/B comparison during the 10m contest on the same DX signal comparing the K4D to the IC-7610. No such strange audio issue existed with the Icom transceiver.

On SSB transmit, the selected bandwidth is slightly less than the menu says. At 3000 Hz transmit bandwidth, the lower 100 to 200 hundred Hz audio is attenuated. Switching to ESSB mode set for 3.0 kHz (minimum bandwidth option) eliminates this issue.

Transmit EQ listed in dB on the parametric sliders are about one quarter the amount indicated. To reproduce my voice as with other rigs I own, the EQ sliders had to be set to extremes, such as -16 dB for the lower frequency sliders and +16 dB for the higher frequencies sliders. This indicated 32 dB of EQ slope does not actually exist.

NOTE: EQ issues were still not corrected with R26 firmware.

On CW for modest to stronger signals, the CW elements (dits and dahs) sound harder and are more fatiguing or jarring than some other transceivers. The sound is similar to an FTdx10 which I also found fatiguing. CW operation was evaluated June 5th, 2021 on 20m during a CW contest. Stations were predominately in Europe.

With a threshold setting of 4, the volume level on SSB is marginally adequate, on CW with weak signals the volume control often had to be operated wide open. While the audio specification is 2 watts with the default threshold setting of 6, the R26 audio gain cannot reach 1 watt in 8 ohms and is under 2 watts into 4 ohms.

On VOX operation, an annoying pop often occurs when switching back to receive.

A USB mouse is highly recommended to navigate all the soft buttons and menus.

Antenna noise gain is a method of determining whether a preamp is useful on a given band, typically above 20 meters. Preamp 3 in the K4 can be enabled on 12 through 6 meters, thus I compared the antenna noise gain of three rigs on 6 meters.

Preamp	K4D	7610	756 Pro III
None	0 dB	1 dB	1 dB
Preamp 1	0.5 dB	4 dB	4.5 dB
Preamp 2	1.5 dB	6 dB	9.5 dB
Preamp 3	4 dB	x	x

Note: There is no third preamp in the two Icom rigs. A 3 dB antenna noise gain means the receiver is contributing half the noise, with the other half band noise. At 10 dB antenna noise gain, the receiver's noise is a small fraction of total noise. I consider 6 dB the of antenna noise gain adequate but not ideal.

NOTE: Use of preamp 3 may only applicable in locations with very low band noise and very low local RFI interference.

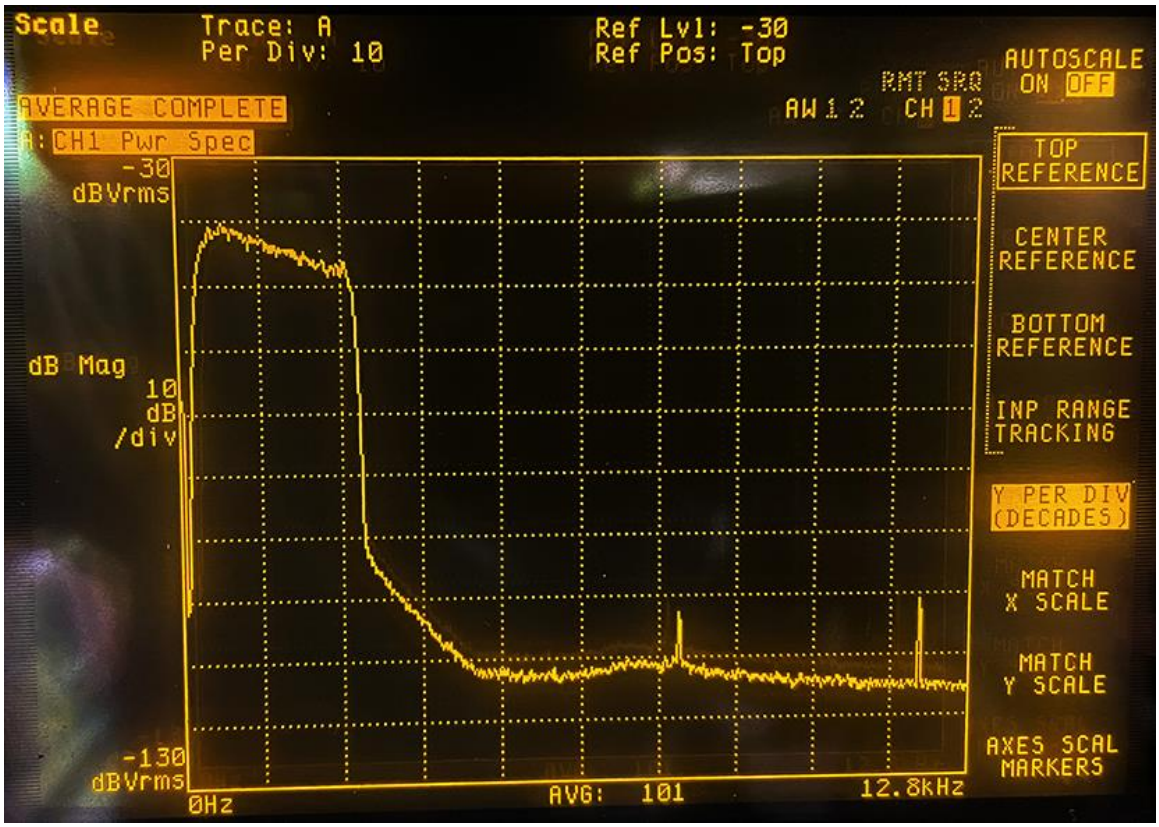
The power button should have a delay of at least 250ms before it shuts off the transceiver. It should be a push and hold so the rig isn't inadvertently turned off.

Receive latency 31.4 ms at 2.4 kHz and 500 Hz bandwidths.

Pulse suppression ON (default) reduces AGC impulse capture from S9 to not moving the S meter at all, which is excellent. Very few modern transceivers handle impulse noise properly, such as from an electric fence or spark from a switch open or closure. An antenna switch often causes an impulse that kicks the S meter up to S9 on Icom, Kenwood, Yaesu and possibly Flex products. Apache and Elecraft may be the only current brands that don't have this problem.

Screen capture of RX audio roll-off attached below.

Example of receiver 8-dB high-frequency audio roll-off on SSB.



Transmit composite noise, transmit IMD and the above RX plot data taken by Ken, N0QO. Extensive feedback to Elecraft provided by NC0B and N0QO.

Rev G2