Sixty Meter Operation with Modified Radios

The following pages document the results of 60-meter transmitter performance on a group of transceivers that have been modified to enable operation on the sixty-meter band.[1] This document was prepared to provide more information as to the issues that bear on proper 60-meter operation. It should be emphasized that it is the responsibility of each operator to ensure that his or her operating complies with the rules (for more information, refer to the "60-Meter FAQ" on the ARRL's web page at http://www.arrl.org/FandES/field/regulations/faq.html).

Note that while most of the group of transceivers tested here are Kenwoods, this is strictly due to the selection of radios that were available at the time of the test. The specific models tested were as follows:

ICOM IC-751	Kenwood TS-50	Kenwood TS-570
Kenwood TS-850	Kenwood TS-940	SGC SG-2020ADSP
Yaesu FT-897		

All transceivers were tested on 5.3305 MHz, in USB mode, with applied audio sufficient to produce 50 W PEP.[2] The tests performed on these transceivers were as follows:

Spectral Purity
Transmit Intermodulation Distortion
Transmit Frequency Response using a swept audio input
Transmit Frequency Response using pre-recorded female voices
Transmit Frequency Response using pre-recorded male voices
Miscellaneous Transmit Frequency tests

In addition to the tests mentioned above, the Lab's Kenwood TS-950 was tested for Transmit Frequency Response on a frequency of 3.9 MHz in USB mode.

Spectral Purity:

For the Spectral Purity test, a 1 kHz tone was supplied to the transceiver's microphone input, and the level of the audio was adjusted for 50 W PEP output.[2]

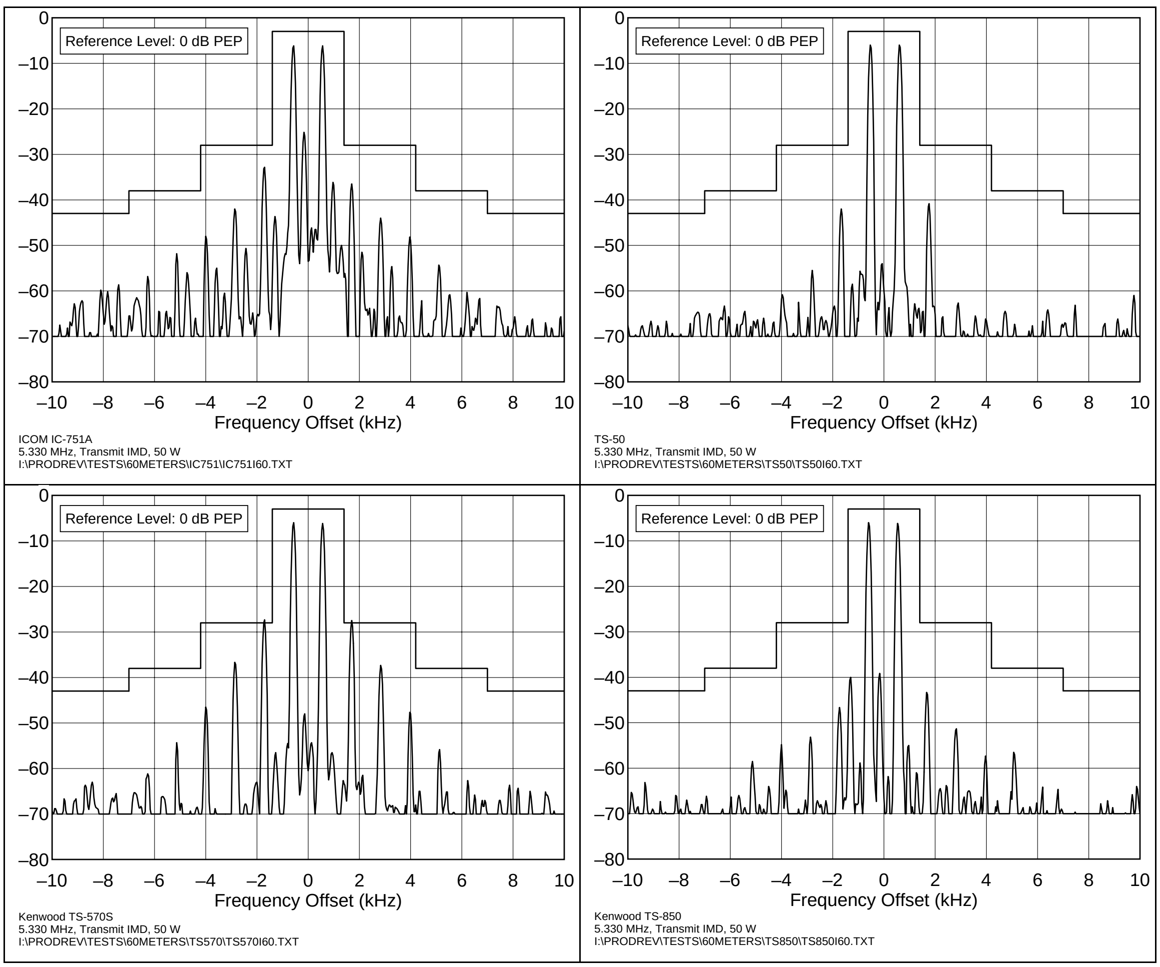
Spectral Purity Test Results:

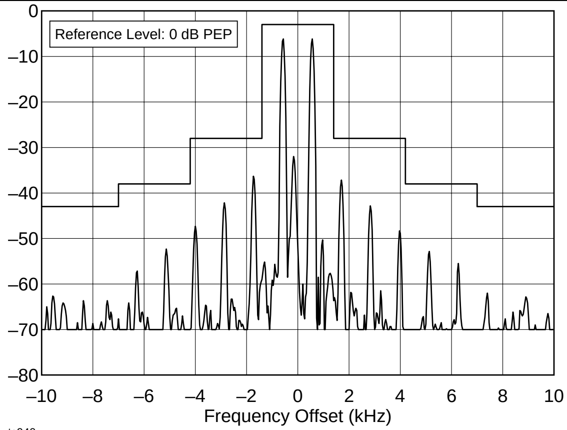
Transceiver	Worst-case spurious	Transceiver	Worst-case spurious
ICOM IC-751	–59 dBc	Kenwood TS-850	–56 dBc
Kenwood TS-50	–49 dBc	Kenwood TS-940	–45 dBc
Kenwood TS-570	–59 dBc	SGC SG-2020ADSP	–48 dBc
Yaesu FT-897	–63 dBc		

Transmit Intermodulation Distortion (IMD):

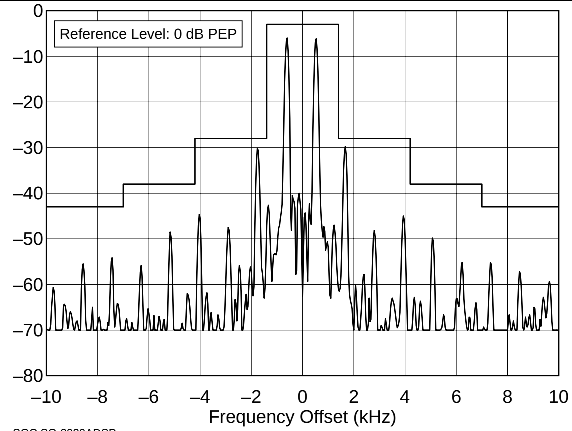
For the Transmit IMD Test, the Lab's Audio Two-Tone Generator was connected to the transceiver microphone input and the controls of the generator were adjusted to produce 50W PEP with equal power in both tones (tone frequencies are 700 and 1900 Hz). The spectral output is shown in the plots that follow.

The additional "step" line on the graphs is the emissions limit for transceivers that are subject to type acceptance on the HF bands (47 CFR Part 2). While these limits are not a requirement for Amateur Radio transceivers for HF (which are not subject to type acceptance), they indicate the type of restrictions imposed on other services using this spectrum, including the primary users of the allocation at 60 meters.

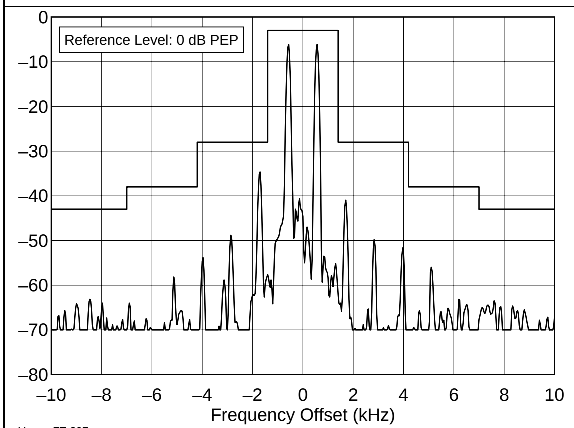




ts940
5.330 MHz, Transmit IMD, 50 W
I:\PRODREV\TESTS\60METERS\TS940\TS940I60.TXT



SGC SG-2020ADSP
5.330 MHz, Transmit IMD, 20 W
I:\PRODREV\TESTS\60METERS\SGC2020\SGC20I60.TXT



Yaesu FT-897
5.330 MHz, Transmit IMD, 50 W
I:\PRODREV\TESTS\60METERS\FT897\FT897I60.TXT

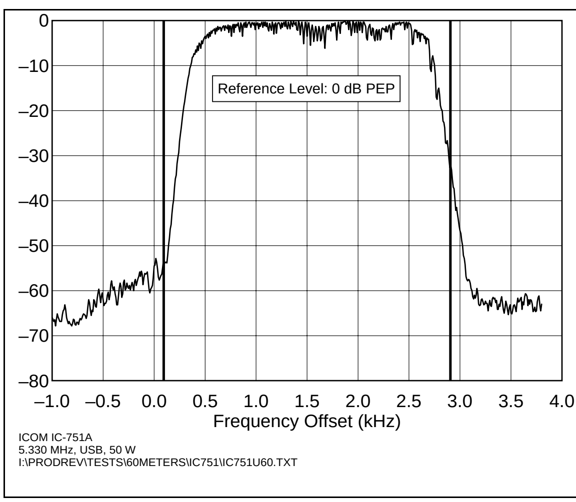
Transmit Frequency Response:

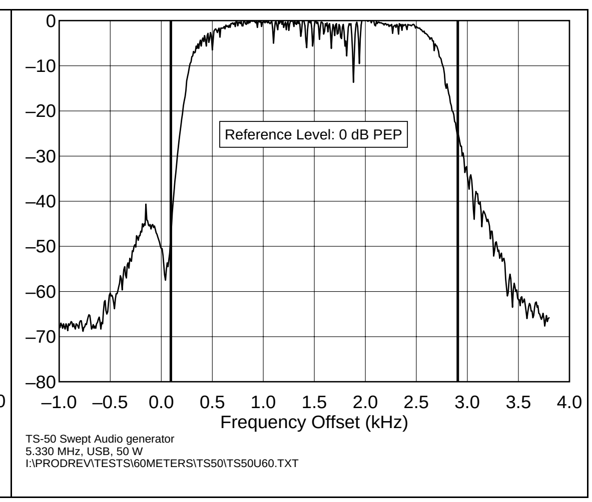
A. Using a swept audio input.

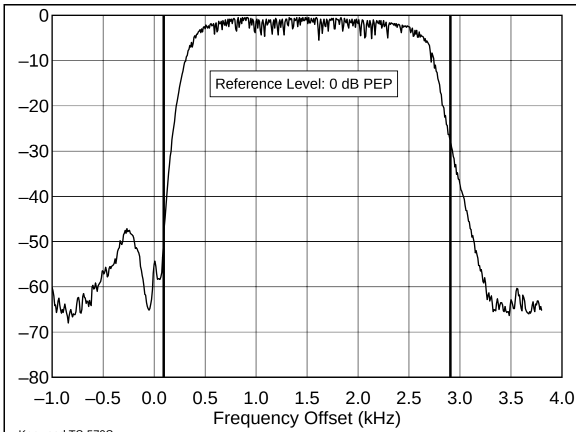
This test indicates the passband response of the transmitter under test. A constant level audio generator was connected to the transmitter's microphone input and the level was adjusted for 50W PEP at the point of maximum audio response. The attenuated transmitter output was connected to a spectrum analyzer, set to hold the RF peak for each frequency, accumulating the indicated response curve by repetitive spectral sweeps while manually changing the frequency of the audio generator.

The definition of bandwidth in the FCC Rules – Part 97.3(a)(8) – is "the width of a frequency band outside of which the mean power of the transmitted signal is attenuated at least 26 dB below the mean power of the transmitted signal within the band," but this does *not* mean that the bandwidth can be inferred from the points 26 dB below the peak response shown. For a discussion of this issue see Note 3, which was provided by Ed Hare, W1RFI.

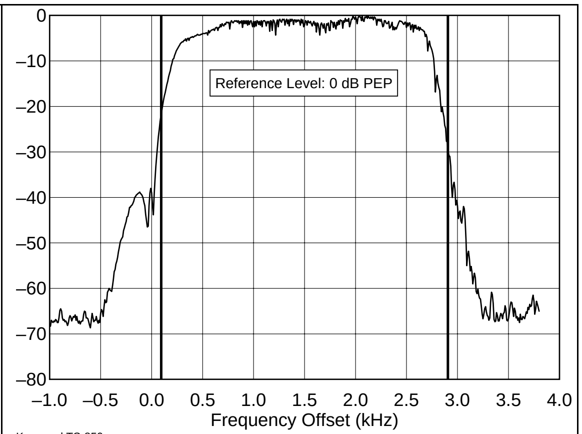
On the plots shown, the heavy vertical lines indicate the boundaries of each 2.8 kHz channel. The frequency offset shown is the offset relative to the suppressed carrier.



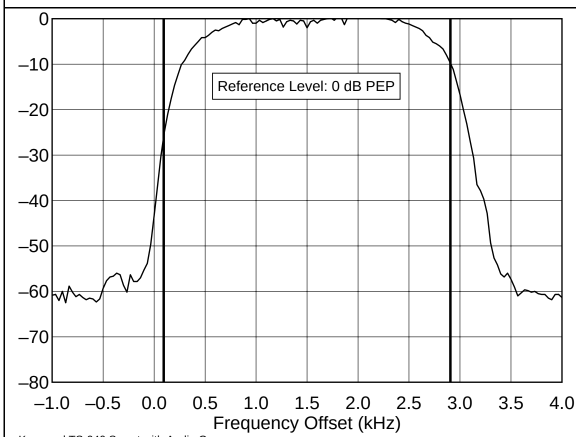




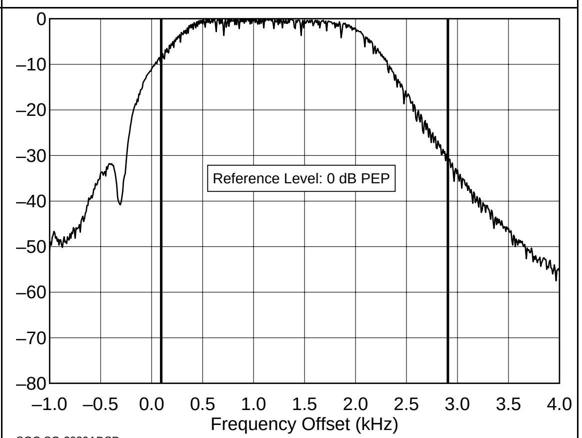
Kenwood TS-570S
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS570\TS570U60.TXT



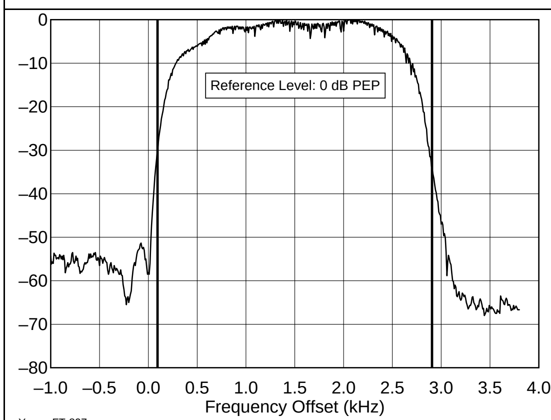
Kenwood TS-850
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS850\TS850U60.TXT



Kenwood TS-940 Swept with Audio Gen
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS940\TS940U60.TXT



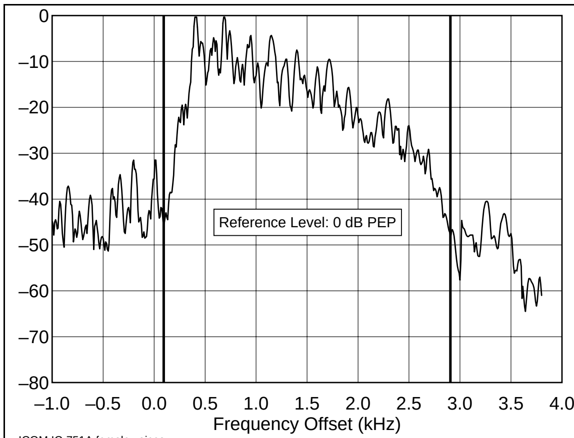
SGC SG-2020ADSP
5.330 MHz, USB, 20 W
I:\PRODREV\TESTS\60METERS\SGC2020\SGC20U60.TXT



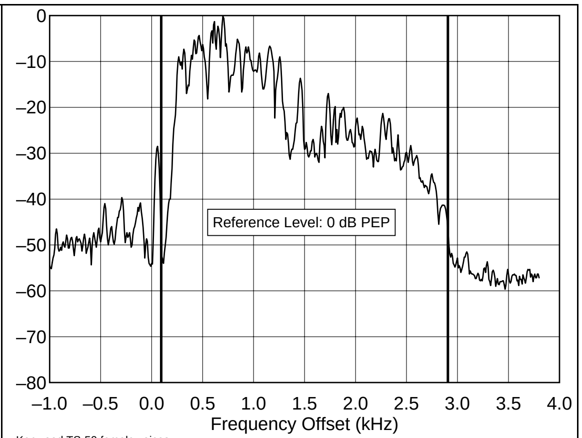
Yaesu FT-897
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\FT897\FT897U60.TXT

B. Transmit frequency response using pre-recorded female voices.

This test was performed with the same setup as with the audio response test shown above, except that the audio source was a recording of several female voices. The peak response shown in these graphs represents the effect of cumulative speech; see Note 3 for more information on how this relates to average speech power.



ICOM IC-751A female voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\IC751\IC751F60.TXT



Kenwood TS-50 female voices
5.330 MHz, USB, 50 W
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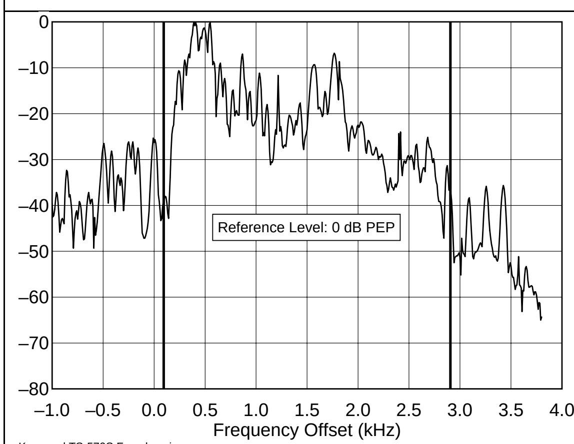
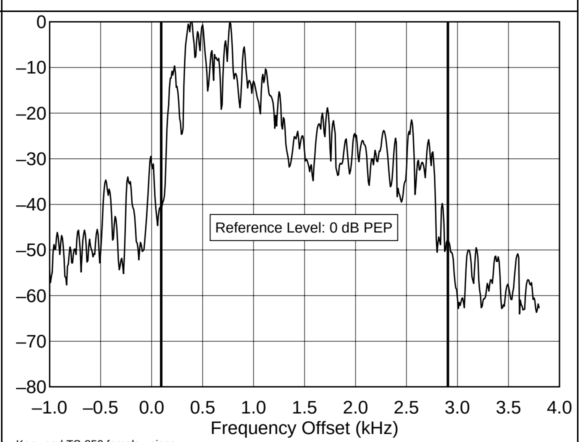
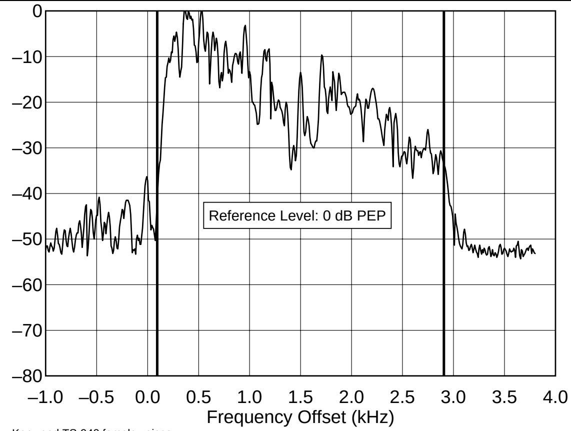


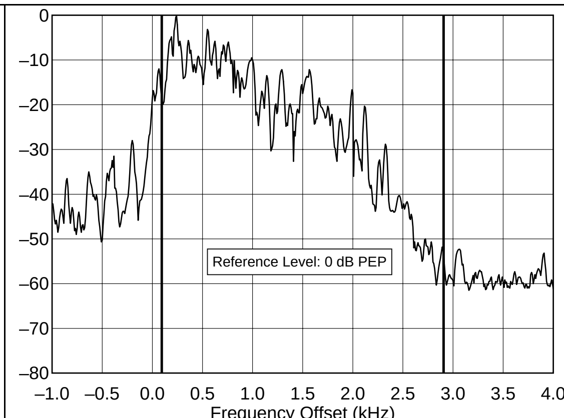
Kenwood TS-570S Female voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS570\TS570F60.TXT



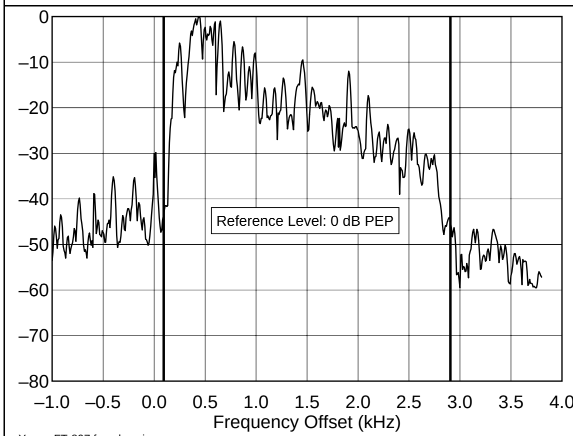
Kenwood TS-850 female voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS850\TS850F60.TXT



Kenwood TS-940 female voices
5.330 MHz, Transmit IMD, 50 W
I:\PRODREV\TESTS\60METERS\TS940\TS940F60.TXT



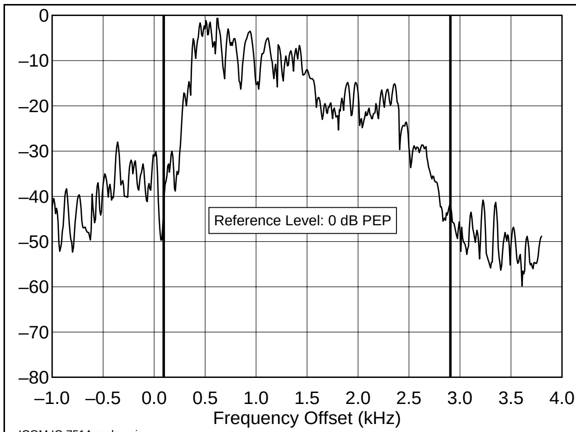
SGC SG-2020ADSP female voices
5.330 MHz, USB, 20 W
I:\PRODREV\TESTS\60METERS\SGC2020\SGC20F60.TXT



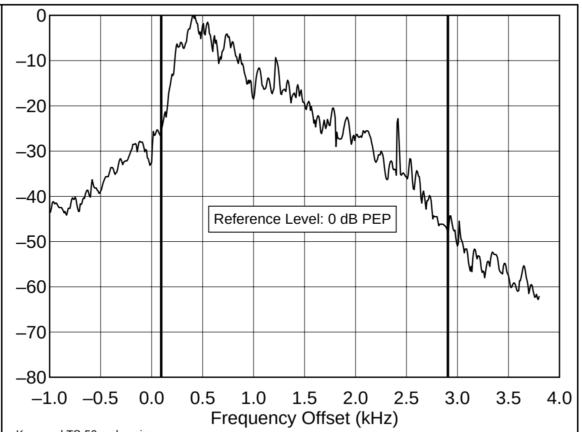
Yaesu FT-897 female voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\FT897\FT897F60.TXT

C. Transmit frequency response using pre-recorded male voices.

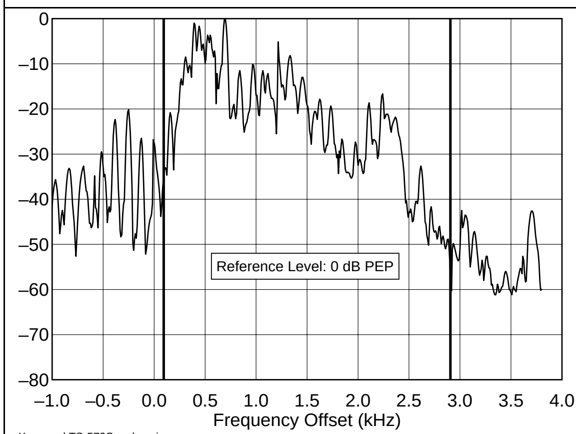
This test was performed with the same setup as with the audio response test shown above, except that the audio source was a recording of several male voices. The peak response shown in these graphs represents the effect of cumulative speech; see Note 3 for more information on how this relates to average speech power.



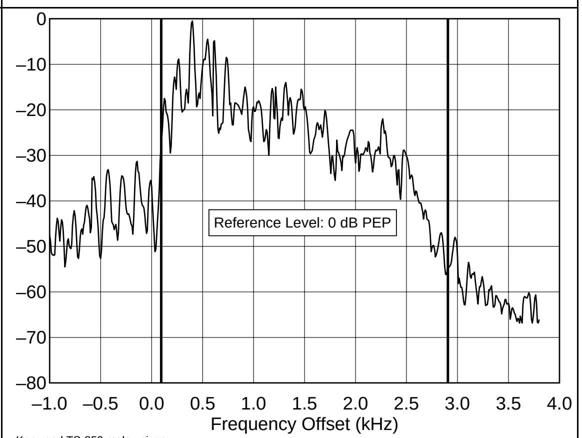
ICOM IC-751A male voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\IC751\IC751M60.TXT



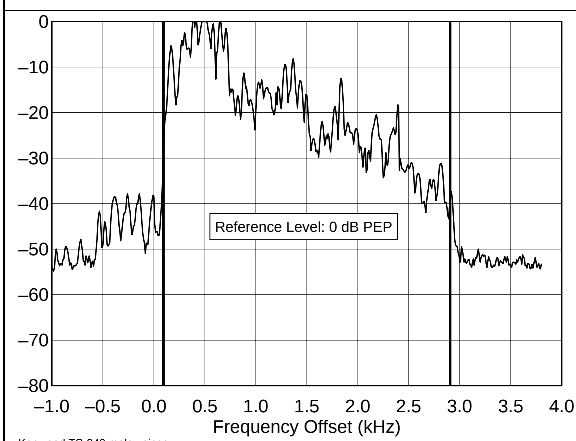
Kenwood TS-50 male voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS50\TS50M60.TXT



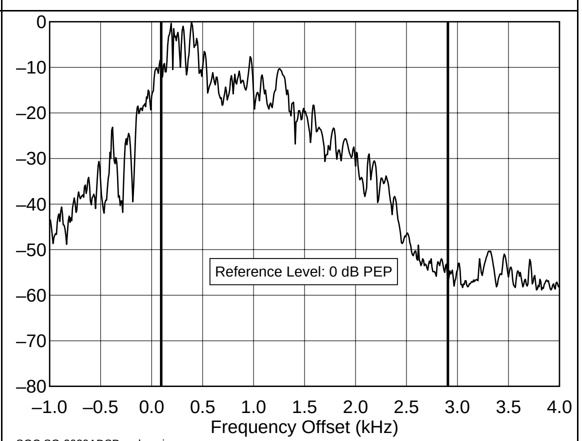
Kenwood TS-570S male voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS570\TS570M60.TXT



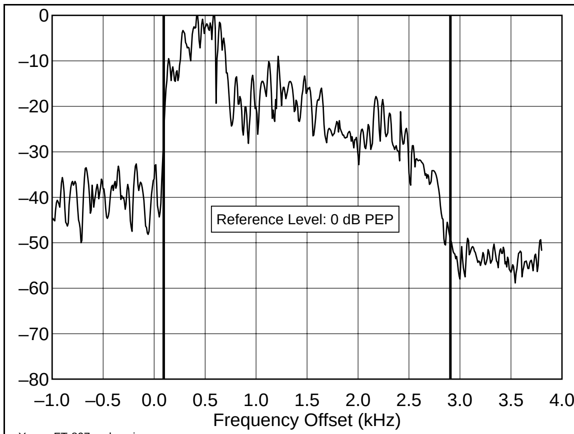
Kenwood TS-850 male voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS850\TS850M60.TXT



Kenwood TS-940 male voices
5.330 MHz, Transmit IMD, 50 W
I:\PRODREV\TESTS\60METERS\TS940\TS940M60.TXT



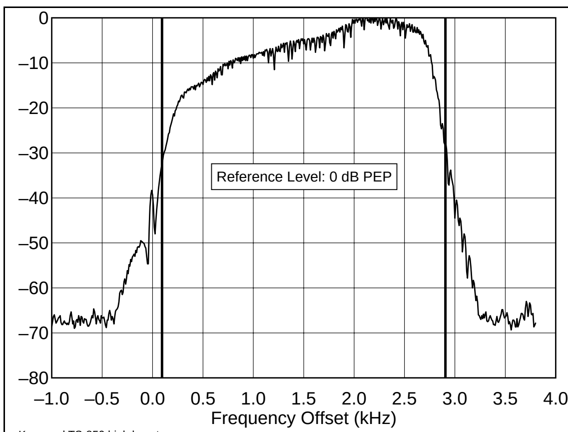
SGC SG-2020ADSP male voices
5.330 MHz, USB, 20 W
I:\PRODREV\TESTS\60METERS\SGC2020\SGC20M60.TXT



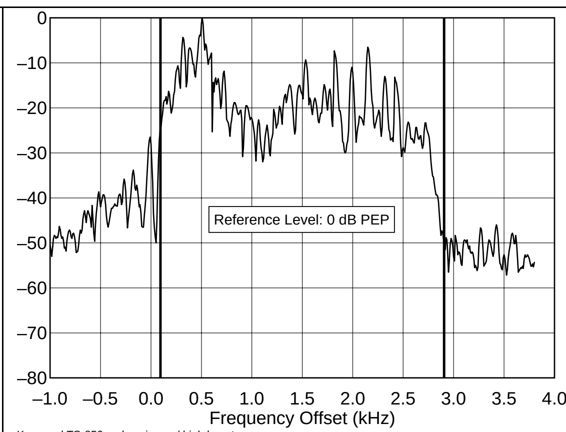
Yaesu FT-897 male voices
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\FT897\FT897M60.TXT

Miscellaneous Transmit Frequency Response Tests

In addition to the above swept-audio and voice response tests, a couple of the transceivers were tested for audio response with either the processor on, or some sort of audio enhancement enabled. Specifically, the effect of the "High Boost" feature of the Kenwood TS-850 was examined using a swept-audio input, and again using a voice input (in this case, the male voices recording was used).

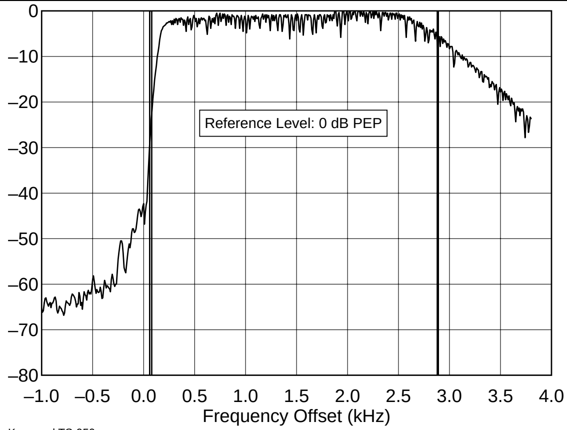


Kenwood TS-850 high boost
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS850\TS850H60.TXT

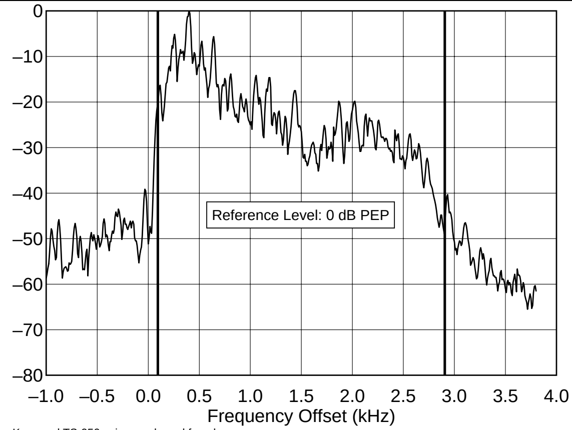


Kenwood TS-850 male voices w/ high boost
5.330 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS850\TS85MH60.TXT

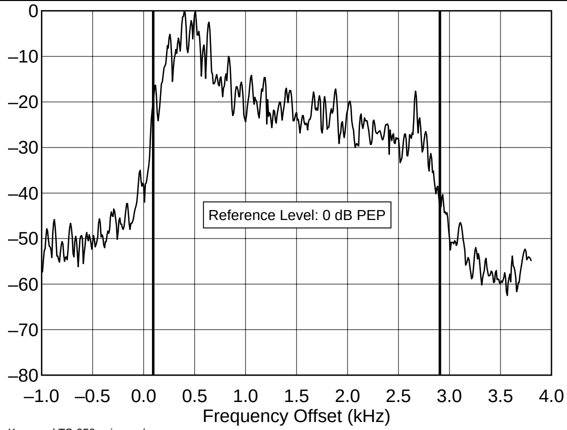
On the Kenwood TS-950 (an unmodified transceiver), several tests were performed on 3.9 MHz in USB (so as to match the filter shape that would be observed on 5.3 MHz). The first plot of this group is the swept audio response of the transceiver. The second plot is the response to voice input (both male and female voices were used for this test). The third plot is the response of a male voice with the processor enabled.



Kenwood TS-950
3.900 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS950\TS950U80.TXT



Kenwood TS-950 voices male and female
3.900 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS950\TS950V80.TXT



Kenwood TS-950 voices w/processor
3.900 MHz, USB, 50 W
I:\PRODREV\TESTS\60METERS\TS950\TS950P80.TXT

Notes:

1. These modifications are generally not endorsed by the transceiver manufacturers. Alinco, ICOM, Kenwood and Yaesu have all stated that they do not offer information on modifications to existing products to enable transmitting on the 60-meter band (apart from information supplied to MARS licensees).

SGC has published modification information for their SG-2020 model on their web page at http://www.sgcworld.com/Newsletter/Jul03/60MeterOps.html

2. The SGC SG-2020 was adjusted for an output of 20 W PEP for all tests.

3. The Part 97 rules define bandwidth as follows:

Sec. 97.3(a)(8) Bandwidth. The width of a frequency band outside of which the mean power of the transmitted signal is attenuated at least 26 dB below the mean power of the transmitted signal within the band.

However, this does not refer to the –26 dB points on a spectral graph! Bandwidth is the frequency range outside which all of the other energy transmitted has a total power that is 26 dB less than the signal transmitted inside that frequency range. So a whole bunch of intermodulation distortion that was –27 dB below the level inside the communications channel wouldn't be legal because all those –27 dB signals would add up to be more than –26 dB.

One also must consider "mean power." In a voice transmission, those "S" and "T" sounds with significant higher-frequency components may be fairly strong, but they don't occur very often, so their mean power is actually fairly low compared to the lower-frequency energy in the "main" passband of the communications channel. Observe the passband responses shown in this report, noting the differences in the swept audio response and the voice responses. If an analysis of the average power was done, it would indicate a bandwidth that was even less than that seen with the peak-hold function on the spectrum analyzer.

Last, but not least, in addition to the requirement to have our bandwidth <2800 Hz, centered on the channel, even our out-of-band emissions are below that limit, if they cause harmful interference to the adjacent-channel users, we have a responsibility to correct the harmful interference.