IC-9100 User Evaluation & Test Report

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Iss. 3, Sep. 9, 2015. (Typo corrected in Table 17, p. 20.)

Introduction: This report describes the evaluation of IC-9100 S/N 02001286 from a user perspective. ***Appendix 1*** presents results of an RF lab test suite performed on the radio. I was able to spend a number of days with the IC-9100 in my ham-shack, and thus had the opportunity to exercise the radio's principal features and evaluate its on-air behavior.

1. Physical "feel" of the IC-9100: Owners of current Icom IF-DSP transceivers should find the IC-9100 quite familiar, and will immediately feel comfortable with it. The front-panel layout is similar to that of the IC-7410, although the dual controls and additional keys for the Main and Sub receive sections dictate a somewhat different control placement. The learning curve will be minimal for IC-7410, IC-7600, IC-7700 or IC-7800 owners.

The main tuning knob has a knurled Neoprene ring similar to that of the IC-7410; it turns very smoothly without side-play. As in the IC-7600, the concentric major rotary controls are arranged in two vertical rows on either side of the screen and keypad.

The IC-9100 is solidly constructed and superbly finished. It conveys a tight, smooth, and precise overall feel (as do other Icom radios). The sheet-steel case is finished in an attractive black crinkle coating and fitted with a handle on the left side. The case retaining screws are located in recesses in the case covers. The sculpted front panel is similar to that of the IC-7410 and has a smooth, matte surface.

The IC-9100 is quite heavy (12 kg/26.5 lb with UX-9100 fitted). It uses the same die-cast, compartmented chassis as the IC-7410. The radio is fitted with the new 4-pin DC power socket. A USB "B" socket is provided on the rear panel, allowing direct CI-V and baseband connectivity to a PC via a standard USB cable. Both the case and the rear panel are well-ventilated. The front case feet are solid and extensible, allowing the front of the IC-9100 to be angled upwards.

2. Control knob/key functions and menus: Apart from some differences in placement, the IC-9100's control knobs will be very familiar to users of the IC-7410, IC-7600 and IC-746Pro.

The concentric NR/NOTCH controls and the dual concentric MIC GAIN/RF-SQL knobs for Main and Sub are in the left-hand row. Interestingly, the NR and NOTCH controls are multi-turn and detented; this makes for very fine adjustment of these functions.

The large monochrome LCD screen displays a very clear, crisp image, with excellent contrast and a paper-white backlight. MIC GAIN, CW PITCH and RF Power are now miniature rotary controls below the screen; NB threshold has been moved to the NB menu. The NR setting is displayed via a pop-up in the lower field of the screen.

The Twin PBT, MEM-CH/SUB DIAL and RIT/XIT knobs are in the right-hand row. Twin PBT, MEM-CH and SUB DIAL are detented. SUB DIAL serves as a tuning knob for the Sub VFO when activated via a key. The SUB key transfers function keys such as AGC, NB, NR, FILTER, PREAMP/ATT etc. etc. from the Main to the Sub receive section.

The menus are somewhat akin to those in the IC-7410, as the IC-9100's feature set is very similar to that of the IC-7410 but with the addition of menus for D-Star Digital Voice (DV) and GPS functions. . The menu presentation resembles that of the IC-7410; configurable settings are accommodated by item numbers selected via up/down softkeys e.g. the main menu, NB, RTTY, KEYER (in CW mode) and TCON (tone controls) menus. I found the set-up process fairly intuitive after consulting the relevant user-manual sections in cases of doubt.

Menus are selected by pressing the MENU key on the bottom left of the screen; this key also serves as an EXIT key. Menu selections with default values can be returned to default by pressing and holding their respective softkeys. For several menu items, the F-3 key serves this purpose even though it is not marked DEF.

The filter selection and adjustment procedure is similar to that on other Icom DSP radios. Press and hold the FILTER key for 1 sec. to adjust the filter bandwidth, select CW/SSB Sharp/Soft shape factors and match the desired roofing filter to each IF filter and mode. All IF filters are continuously adjustable.

The Time-Out Timer feature limits transmissions to a preset duration (3, 5, 10, 20 or 30 minutes, selectable by menu.) The PTT Lock function inhibits transmit. This feature is useful when receiving via active antennas or mast-mounted preamplifiers without T/R switching, or to avoid damaging test equipment when conducting receiver measurements. AFC and a frequency-error indicator for FM and DV are also provided. Note that the IC-9100 has no transverter function or interface.

Being a current IC-7700 owner and former 756Pro-series owner, and having recently tested the IC-7410, I found that the IC-9100's controls and menus fell readily to hand. A user familiar with a radio such as the IC-756Pro3 or IC-746Pro should find the IC-9100's learning curve manageable. The IC-9100's default settings are very usable, allowing the radio to be placed in service with minimal initial set-up. It is very easy to configure the IC-9100 for simultaneous dual receive with different frequency ranges on Main and Sub, e.g. HF/6m on Main and 2m on Sub. The Main and Sub audio will be heard in the left and right earpiece respectively, or in separate speakers if connected to the Main and Sub EXT SP jacks.

3. LCD display screen: The 13 cm (5 inch) diagonal monochrome LCD screen is 10 cm wide, 1 cm wider than the IC-746Pro screen. The display is very bright and crisp, and presents all radio parameters. The display layout is very similar to that of the IC-7410, except that both Main and Sub frequencies and settings are displayed when the SUB VFO is active. The IC-9100 offers a limited, non-real-time spectrum scope very similar to that of the 746Pro. The spectrum scope is initiated via menu and displays an approximate, qualitative histogram of band occupancy in the lower field of the screen. It mutes the receiver during its acquisition cycle. Scope span is configurable in the range 0.5 to 25 kHz.

The Notch (MN) and FILTER keys, and the Twin PBT controls, open pop-ups in the lower field of the screen. These can be used to select notch width and filter/PBT bandwidth respectively.

The SATELLITE key enables frequency tracking between the Main and Sub VFO's. The main tuning knob tunes Main and Sub simultaneously. There are two sub-mode: NORMAL (same-sense tracking) and REVERSE (inverse-sense tracking). The selected tuning step is the same on Main and Sub.

5. USB interfaces: The IC-9100 is equipped with a rear-panel USB "B" port. The radio can be directly connected via the "B" port to a laptop or other PC via a standard USB "A-B" cable. This is without doubt one of the IC-9100's strongest features. The USB port transports not only CI-V data, ***but also TX and RX PCM baseband*** between the IC-9100 and the computer. As a result, the USB cable is the only radio/PC connection required. Gone forever is the mess of cables, level converters and interface boxes! I believe that this feature will be standard on all future Icom HF radios. An Icom driver is required in the PC; this is downloadable from the Icom Japan World website. ***Note:*** On 3/13/2012, Icom Japan announced ***firmware upgrade*** capability via the USB "B" port.

6. Filter selections and Twin PBT: As do the other Icom DSP transceivers, the IC-9100 offers fully-configurable RX IF selectivity filters for all modes. Three default filter selections are available for each mode, with continuously variable bandwidth via the FILTER menu. In addition, there are selectable Sharp and Soft shape factors for SSB and CW. The IC-9100 comes fitted with a 15 kHz MCF roofing filter at the 64.455 MHz 1^{st} IF. Easily-installable plug-in 6 and 3 kHz roofing-filter modules (FL-430 and FL-431 respectively) are available as optional accessories. When these modules are fitted, the filter menu allows association of any one of the 3 roofing filters with each of the 3 IF filter selections.

The Twin PBT controls and PBT CLR key operate in exactly the same manner as on the IC-756Pro series, as does the BPF filter configuration feature (for filter bandwidths of 500 Hz or less.)

The TPF menu item in the RTTY menu selects the Twin Peak Filter (TPF) in RTTY mode. No CW APF (Audio Peak Filter) is provided. However, the CW RX LPF and HPF are a reasonable alternative to the "missing" APF; their ranges are 100 - 2000 and 500 - 2400 Hz respectively. The HPF and LPF can be set to "bracket" the received CW tone in a tight 100 Hz audio bandwidth. The F-3 softkey restores these filters to default (off).

7. BPF vs. non-BPF filters: As in other Icom IF-DSP radios, the IC-9100 allows the user to select two additional shapes for 500 Hz or narrower filters, in addition to SHARP and SOFT. These are BPF (steeper skirts) and non-BPF (softer skirts).

To configure a BPF filter, select a 500 Hz or narrower CW, RTTY or SSB-D filter with Twin PBT neutral. To set up a non-BPF filter, select a filter with BW > 500 Hz, and narrow the filter to 500 Hz or less by rotating the Twin PBT controls. Numerical and diagrammatic bandwidth displays and a "BPF Indicator" icon facilitate use of this feature. Examples of BPF and non-BPF filter passbands are illustrated in **Figs. 3 & 4** (Pages 11 – 12).

8. Notch Filters: The tunable manual notch filter (MN) is inside the AGC loop, and is extremely effective. The MN has 3 width settings (WIDE, MID and NAR); its stopband attenuation is at least 70 dB. The manual notch suppresses an interfering carrier before it can stimulate AGC action; it thus prevents swamping. The detented multi-turn NOTCH control allows precise MN adjustment.

The auto notch filter (AN) is post-AGC. It suppresses single and multiple tones, but strong undesired signals can still cause AGC action and swamp the receiver. MN and AN are mutually exclusive, and ANF is inoperative in CW mode. The NOTCH key toggles OFF – AN – MN. When MN is selected, a pop-up field is displayed at the bottom of the screen, allowing selection of WIDE, MID or NAR (narrow) notch by pressing and holding the key. Operation of the NOTCH key is identical to that in the IC-7410, IC-7700 or IC-7600.

10. NR (noise reduction): The DSP NR functionality is comparable to that of the IC-7700, and works very well. In SSB mode, the maximum noise reduction occurs at an NR control setting of 10. As NR level is increased, there is a slight loss of "highs" in the received audio; this is as expected. The measured SINAD increase in SSB mode was about 10 dB. The detented multi-turn NR control allows precise adjustment.

11. NB (noise blanker): The IF-level DSP-based noise blanker is arguably one of the IC-9100's strongest features. I found it to be extremely effective in suppressing fast-rising impulsive RF events before they can stimulate AGC action within the DSP algorithm. The NB completely blanks noise impulses which would otherwise cause AGC clamping. I found its performance comparable to that of the IC-7700's NB. The NB menu (threshold, depth and width) is accessed by pressing and holding the **NB** key. The NB works very effectively in conjunction with NR.

12. AGC system: The IC-9100 has dual AGC loops. The primary loop samples the digitized 36 kHz IF at the ADC output. This loop limits the IF signal power applied to the ADC input, thereby preventing ADC over-ranging even in the presence of extremely strong signals. The digital AGC detector for the secondary loop is within the DSP algorithm. Level indications from both detectors are processed in the DSP for AGC management. This architecture prevents strong adjacent signals from swamping the AGC, and allows full exploitation of the ADC's dynamic range.

The AGC menu is similar to that of the IC-7410 and IC-7600. The Slow, Mid and Fast AGC settings are customizable via menu for each mode, and AGC can be turned OFF via menu.

13. Receive and transmit audio menus: The IC-9100 TCON (Tone Control) menu offers the same generous selection of audio configuration parameters as that of the IC-7600 and IC-7700: TBW (low and high cutoff frequencies), RX and TX Bass/Treble EQ, RX HPF and LPF, transmit compression, etc. All audio settings are grouped under the M2/TCON softkey (F-4 in menu M2).

14. Metering: As in the IC-7410, on-screen bar-graphs replace the traditional moving-coil meter. Pressing and holding the ANT/METER key toggles between SWR, ALC and COMP. The S-meter and P_o scales are displayed at all times.

15. VFO/Memory management: The IC-9100 offers the same VFO and memory management features as other current Icom HF+ transceivers: VFO/memory toggle and transfer, memory write/clear, memo-pad, Split, VFO A/B swap and equalize, etc.

16. Brief "on-air" report: Prior to starting the test suite, I installed the IC-9100 in my shack and connected it to my solid-state 500W amplifier and multi-band vertical antenna. The interface was straightforward – RF drive, PTT and ALC. Once I had set up the ALC for 1 kW output, I was 100% QRV.

a) SSB: I made several 20m and 17m SSB QSO's with friends who are familiar with my voice and the sound of my signal. Distant stations reported that the audio quality of my transmissions was "excellent, clean and natural" when using the Heil PR-781 desk mic plugged into the radio's MIC socket. Two stations I worked on 20m SSB assisted me in optimizing transmit audio settings for the PR-781 and HM-36. It was observed that higher COMP settings caused slight distortion on voice peaks when using the HM-36. The radio showed no signs of excessive heating even after 2 hours' "rag-chew" SSB operation at 65 – 70W PEP output.)

The members of a 20m discussion group in which I regularly participate reported that the IC-9100's transmit audio was "excellent – articulate and smooth".

The following are the settings I used in the SSB trials:

Table 1: Transmit Audio Settings.

Mic	Band	Conditions	Mic Gain	TBW	COMP	Bass	Treble
PR-781	20m	S9+	60%	WIDE	OFF	-2	+3
HM-36	20m	S9+	60%	WIDE	≈ 6 dB	-2	+4
PR-781	17m	S5, QSB	60%	MID	6 dB	-2	+3

As in the IC-7410, the DSP-based noise blanker is superb. It does not distort the signal at all, and can be left on at all times; it is every bit as good as the IC-7700 or IC-7600 blanker. It suppressed fast-rising noise spikes and almost completely eliminated locally-generated electrical noise.

As discussed in Section 10 above, I found the NR very effective on SSB. Even at 10, NR did not attenuate "highs" excessively. NR is very effective in conjunction with NB.

Preamps 1 and 2 (10 and 16 dB gain, respectively) brought weak stations up to very comfortable copy without S/N degradation. The SSB filters and Twin PBT were excellent, as we have come to expect from other Icom DSP radios. MN and AN were extremely helpful. I was able to notch out single tones with MN; also, AN reduced the levels of multiple tones, suppressing the higher-pitched tone and reducing the level of the lower-pitched tone by about 20 dB.

Regrettably, I was unable to try out on-air 2m, 70cm or 23cm SSB or CW operating as I do not have suitable antenna systems at my station.

Overall, the IC-9100 receiver seemed a little noisier than my IC-7700 in the sense that band noise was more obtrusive. NR seemed slightly more effective on the 7700 than on the IC-9100, doubtless due to the IC-7700's more powerful DSP. Still, SSB operation on the 20 and 17m bands with a mix of strong and weak signals was very comfortable and pleasant. Receive audio quality was crisp and smooth throughout.

b) CW: Due to time constraints, I did not operate the IC-9100 on CW, but listened to CW signals on 20m. With 500 and 250 Hz CW filters (Sharp, BPF) and NR/NB on, ringing was minimal with Preamp off. I then set up a 250 Hz filter (Soft, non-BPF) with NR on and Preamp off. Again, there was virtually no audible ringing, and the received CW note was very smooth. Activating Preamp 1 or 2 raised the noise level, causing slight ringing which was more noticeable in the absence of signals.

In a brief test of full-break-in operation at ≈ 15 wpm, I found this mode very smooth and pleasant, with virtually instantaneous receiver recovery. No keying artifacts were audible in the headphones. (***Note:*** See 19.2 below.)

c) AM: In a quick check of AM reception, I listened to various MF and HF broadcast stations. A local station on 690 kHz and a music broadcast on 6910 kHz sounded good on the IC-9100's internal speaker, but much clearer (as one would expect) on my external speaker or on the headset.

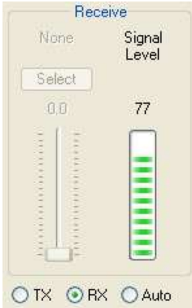
The 9 kHz AM filter offered the best frequency response, but the 6 kHz setting sounded somewhat "smoother" and 3 kHz cut the "highs" excessively. The IC-9100's Twin PBT is fully functional in this mode. Mid AGC was best for average to good signal conditions, but Fast AGC handled rapid selective fading more effectively. NR was quite effective in improving the S/N ratio of weak AM signals. (***Note:*** See 19.3, below.)

The NR did not distort the recovered audio even at its maximum setting (15). Above 10, the NR control had no further effect. (Note that the AM bass and treble EQ settings were both 0 dB, with HPF off.)

AN was effective in suppressing interfering tones and heterodynes, but MN caused some distortion when tuned across the signal. The reason for this is that MN suppresses the carrier in a manner similar to selective fading.

d) RTTY: I did not operate RTTY during the on-air test period, but monitored some 20m RTTY signals. I found that I was able to tune accurately using the center tuning indicator; the RTTY decoder in the lower field of the screen displayed the received text accurately. The squelch can be set to mute the audio in the absence of a received signal; this is convenient when using the Twin Peak Filter (TPF).

e) FM: A brief QSO on our local repeater yielded very favorable audio reports from distant stations. Listening to 20m SSB signals in the left ear and to the repeater in the right ear was very pleasant. The received audio quality on both sides was excellent, and there was no trace of spill-over or crosstalk between Main and Sub.



17. Test for EMC and Baseband Levels: No **EMC issues** of any sort were observed when using a headset plugged into the IC-9100's PHONES jack or an external speaker connected to the radio's EXT-SP jack. Tests were conducted at 1 kW on 40, 20, 17, 15, 12 and 10m and at 500W on 6m.

I measured the **RX baseband output** levels at the USB port using DM780*, and at ACC Pin 12 (AF) with a true RMS DVM. With a 14.100 MHz, S9 + 10 dB test signal offset 1 kHz to yield a 1 kHz test tone, DM780 read 77% of full scale and the level at ACC Pin 12 was 269 mV RMS (well within the 100 – 300 mV spec.)

18. Interfacing with Ham Radio Deluxe (HRD): I installed the Ver. 1.1 Icom USB drivers (downloadable from the Icom Japan world-wide support site) and HRD Ver. 5 Beta on my laptop, and connected the computer to the IC-9100 with a standard USB cable. The IC-9100 showed up in the computer as "USB Audio Codec". Once I had set the levels correctly, HRD started working, and was displaying PSK31 and RTTY traffic and waterfalls. **DM780 is a component of HRD.*

19. Concerns: The following issues were observed in the course of lab testing:

1. An ALC overshoot of up to 6 dB occurs on SSB (but not on any other mode) when a white noise baseband is applied to the USB port, with USB MOD level at 50%. This overshoot can be reduced to 1.5 dB by careful adjustment of baseband level and Compression. This adjustment requires observation of the RF envelope with an oscilloscope, and is quite critical. The overshoot can damage amplifiers driven by the IC-9100. ***Note:*** *This phenomenon was not observed at all on my IC-7700.* This issue has been reported on the IC-9100 Yahoo! Group. (See **Test 25**, ALC Overshoot, in Appendix 1C, Transmitter Tests.)

2. CW QSK (full break-in) does not work well when using the internal keyer at speeds > 12 wpm. If a string of dits is transmitted at speeds > 12 wpm, the receiver does not recover between dits. This issue has been reported on the IC-9100 Yahoo! Group. (See **Test 22b**, QSK Recovery, in Appendix 1B, Transmitter Tests.)

3. A disturbing high-frequency hiss is heard on AM when receiving a weak signal. (< -100 dBm). The hiss is especially noticeable at less than 30% modulation. NR and/or a narrower IF filter reduces or eliminates the hiss. If the modulation percentage is increased to 80%, and/or if signal power is -85 dBm or higher, the receiver quiets fully. (See **Test 1a**, AM Sensitivity, in Receiver Test section.)

4. Close-in reciprocal mixing noise is a few dB worse than on the IC-7600. This will affect the reception of weak SSB/CW signals in the presence of strong adjacent out-of-band signals. (See **Test 2**, Reciprocal Mixing, in Receiver Test section.)

5. Transmitted composite noise in the 1.2 GHz range is excessive. See plot in Test 24.

20. Conclusion: After a few days' "cockpit time" on the IC-9100, I am very favorably impressed by its solid, refined construction, clear and informative display, easy familiarization experience, smooth operating "feel", impressive array of frequency ranges and features and excellent on-air performance (taking into account the concerns listed above). This radio is unique in that it offers comprehensive all-band, all-mode capability in an attractive compact package. Icom are once again right on the mark with the straightforward USB computer interface.

21. Acknowledgements: I would like to thank Ray Novak N9JA at Icom America, and Paul Veel VE7PVL and Jim Backeland VE7JMB at Icom Canada for making an IC-7410 and an IC-9100 available to me for testing and evaluation.

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Appendix 1: Performance Tests on IC-9100 S/N 02001066

As performed in my home RF lab, June 5 - 10, July 8 – 11 and August 4 – 9, 2011.

A. HF/6m Receiver Tests

1: MDS (Minimum Discernible Signal) is a measure of ultimate receiver sensitivity. In this test, MDS is defined as the RF input power which yields a 3 dB increase in the receiver noise floor, as measured at the audio output.

Test Conditions: ATT off, NR off, NB off, Notch off. AGC-M. SHARP, 15 kHz roofing filter. Levels in dBm.

Table 2: MDS (HF, 6m).

	3.6 MHz		14.1 MHz		50.1 MHz	
Preamp	SSB 2.4 kHz	CW 500 Hz	SSB 2.4 kHz	CW 500 Hz	SSB 2.4 kHz	CW 500 Hz
Off	-129	-137	-128	-135	-127	-131
1	-137	-140	-136	-142	-137	-140
2	-139	-143	-137	-143	-138	-143

1a: AM Sensitivity. Here, an AM test signal with 30% modulation at 1 kHz is applied to the RF input. The RF input power which yields 10 dB (S+N)/N is recorded (Table 3).

Test Conditions: ATT off, NR off, NB off, Notch off. AGC-M. Wide (9 kHz) AM filter. 15 kHz roofing filter. Levels in dBm.

Table 3: AM Sensitivity..

Preamp	0.9 MHz	3.9 MHz	14.1 MHz
Off	-109	-110	-108
1	-116	-117	-116
2	-117	-118	-117
Note: *No degradation in 0.5 – 1.6 MHz range.*			

Notes:

1. Sensitivity is not degraded in the 0.5 – 1.6 MHz range.

2. The high-frequency hiss observed when receiving a weak AM signal (< -100 dBm) with the 9 kHz IF filter selected. The hiss is especially noticeable at less than 30% modulation, or when the received carrier is unmodulated. It was quite disturbing on an unmodulated carrier at -110 dBm. NR and/or the 6 or 3 kHz DSP IF filter reduce or eliminate the hiss. If the modulation percentage is increased to 80%, and/or if signal power is -85 dBm or higher, the receiver quiets fully.

1b. 12 dB SINAD FM sensitivity: In this test, a distortion meter is connected to the external speaker jack, and an FM signal modulated by a 1 kHz tone with 3 kHz peak deviation is applied to the RF input. The input signal power for 12 dB SINAD is recorded (Table 4).

Table 4: FM 12 dB SINAD Sensitivity in dBm.

Preamp	29.5 MHz	52.525 MHz
off	-112	-110
1	-121	-119
2	-123	-122

2: Reciprocal Mixing Noise occurs in a superheterodyne receiver when the noise sidebands of the local oscillator (LO) mix with strong signals close in frequency to the wanted signal, producing unwanted noise products at the IF and degrading the receiver sensitivity. Reciprocal mixing noise is a measure of LO spectral purity**.**

In this test, a strong "undesired" signal is injected into the receiver's RF input at a fixed offset from the operating frequency. The RF input power is increased until the receiver noise floor increases by 3 dB, as measured at the audio output. Reciprocal mixing noise, expressed as a figure of merit, is the difference between this RF input power and measured MDS. The test is run with preamp off. The higher the value, the better.

Test Conditions: SSB mode, 2.4 kHz filter, preamp off, ATT off, NR off, NB off, negative offset. Reciprocal mixing *in dB* = input power – MDS *(both in dBm).*

Table 5: Reciprocal Mixing Noise (HF/6m).

Offset kHz	3.6 MHz LSB			14.1 MHz USB			50.1 MHz USB		
Roof Fltr	15	6	3	15	6	3	15	6	3
2	70	70	70	68	68	68	68	67	68
3	72	71	72	70	69	71	70	70	70
5	80	82	83	79	80	82	80	80	82
10	91	92	93	90	91	91	90	90	91
20	96	98	98	96	96	98	96	96	97

3: IF filter shape factor (-6/-60 dB). This is the ratio of the -60 dB bandwidth to the -6 dB bandwidth, which is a figure of merit for the filter's adjacent-channel's rejection. The lower the shape factor, the "tighter" the filter.

In this test, an approximate method is used. An RF test signal is applied at a power level approx. 60 dB above the level where the S-meter just drops from S1 to S0. The bandwidths at -6 and -60 dB relative to the input power are determined by tuning the signal generator across the passband and observing the S-meter. Reciprocal mixing noise limits the level range to 60 dB or less.

Test Conditions: 10.000 MHz, SSB/CW modes, preamp off, AGC MID, ATT off, NR off, NB off.

Table 6: IF Filter Shape Factors.

Filter	Sharp	Soft
2.4 kHz SSB	1.39	1.43
500 Hz CW	1.34	1.51
250 Hz CW	1.42	2.19

4: AGC threshold & SSB filter roll-off. An RF test signal is applied at a level 6 dB below AGC threshold, with AGC off. The signal is offset 1 kHz from the receive frequency to produce a test tone. While tuning the signal generator across the IF passband, the frequency and audio level are noted at several points on the filter flank.

Test Conditions: 10.000 MHz LSB, 2.4 kHz filter, 15 kHz roofing filter, preamp off, AGC M, then off, ATT off, NR off, NB off. Input signal level -103 dBm *(6 dB below measured -97 dBm AGC threshold.)*

4a. AGC threshold: With AGC-M, increase RF input power until baseband level increases < 1 dB for a 1 dB increase in input level. Measured value = -97 dBm.

4b. Roll-off: With AGC off, reduce RF input power to 6 dB below AGC threshold = -103 dBm. Test data in Table 7 (roll-off in dB).

Table 7: IF Filter Roll-off.

Offset Hz	Sharp	Soft
250	-4	-9
300	-1	-6.5
400	-0.9	-5
500	-0.5	-4
750	-0.2	-1.1
1000	0	0
2000	-1	-1
2500	-1.7	-5
2700	-2.3	-8
2800	-15	-18

4c. Typical IF filter passband curves: The examples illustrated below depict typical filter passbands. Due to the limited dynamic range of the measurement method, the accuracy of the amplitude scale is limited.

In this test, a flat noise spectrum (band-limited to 30 MHz) from an RF noise source is applied to the antenna input, and the filter passband curve is captured by a baseband spectrum-analysis program running in a PC connected to the IC-9100 via the USB port.

Test Conditions: Noise loading (PSD) = -142 dBm/Hz. IC-9100 tuned to 14.100 MHz. AGC slow, NR/NB/preamp/ATT off, Twin PBT neutral.

Figs. 1 – 6 are the measured passband curves for various filter configurations.

Fig. 1: 2.4 kHz SSB filter (Sharp)

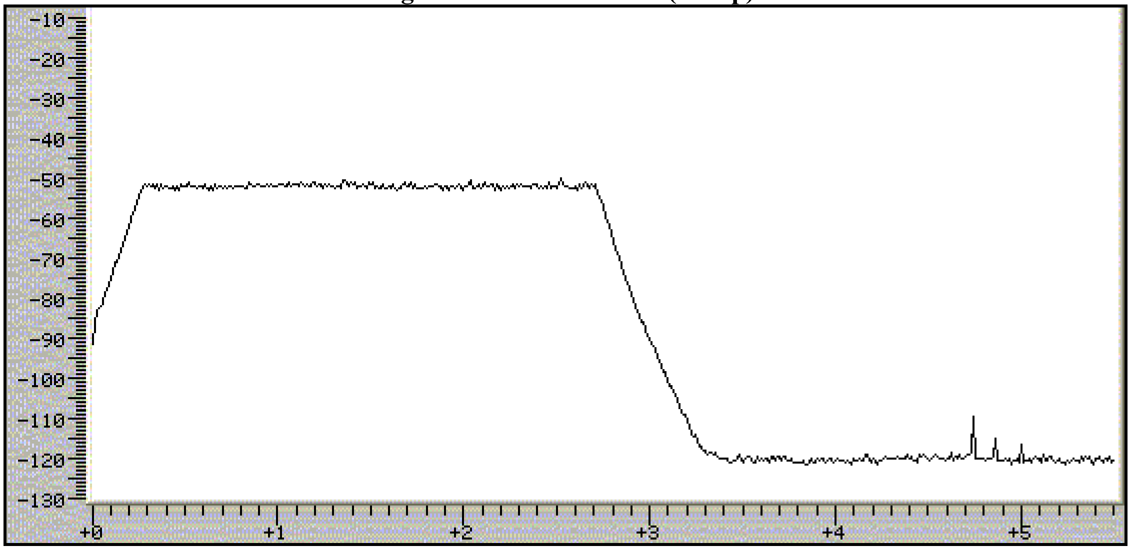


Fig. 2: 2.4 kHz SSB filter (Soft)

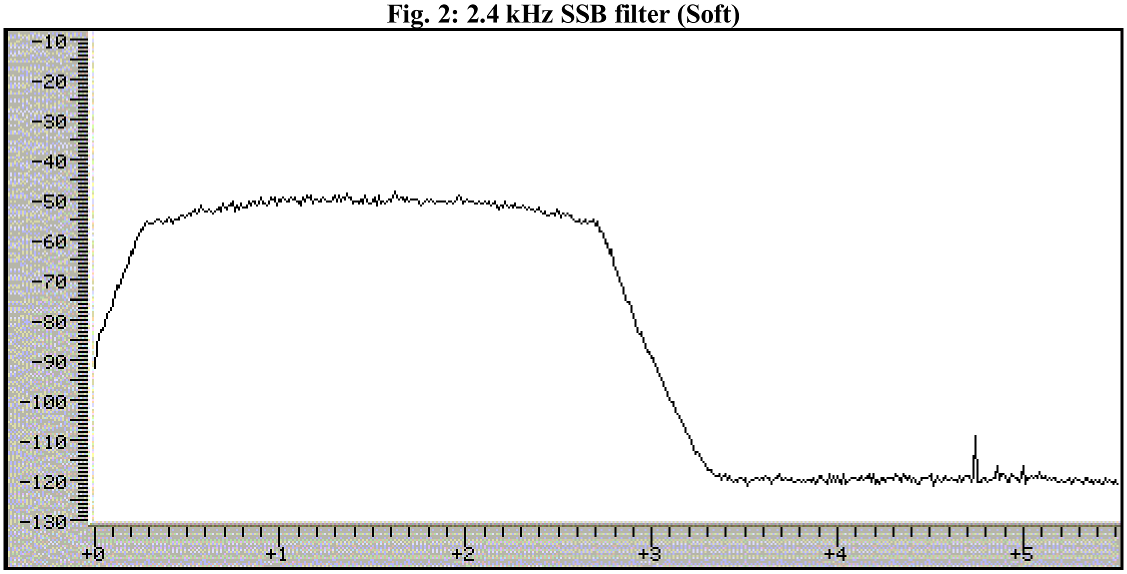


Figure 3: 500 Hz CW filter (Sharp, BPF)

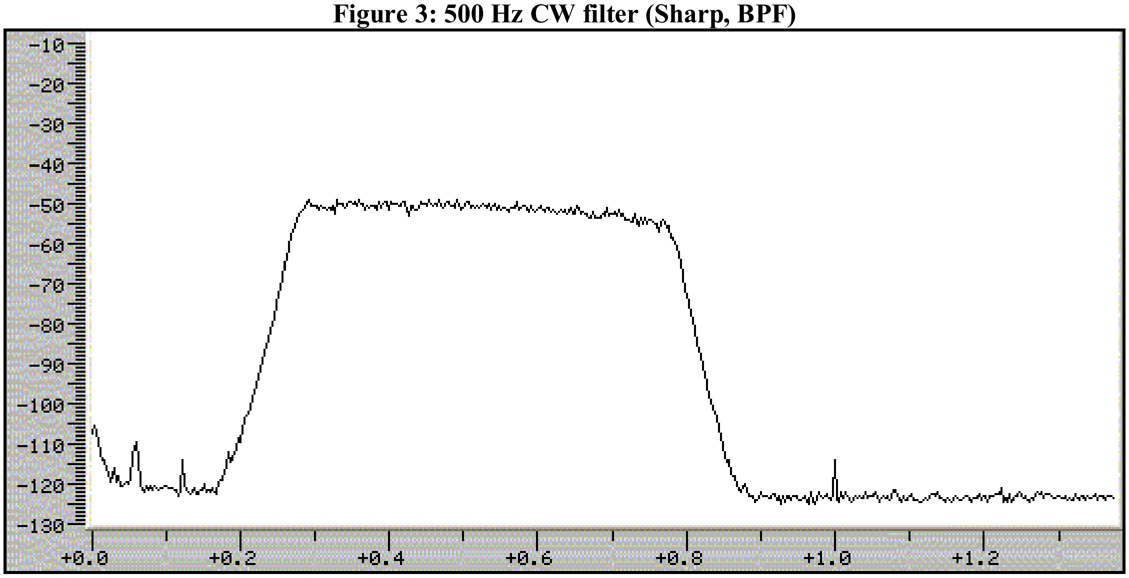


Fig. 4: 500 Hz CW filter (Sharp, non-BPF)

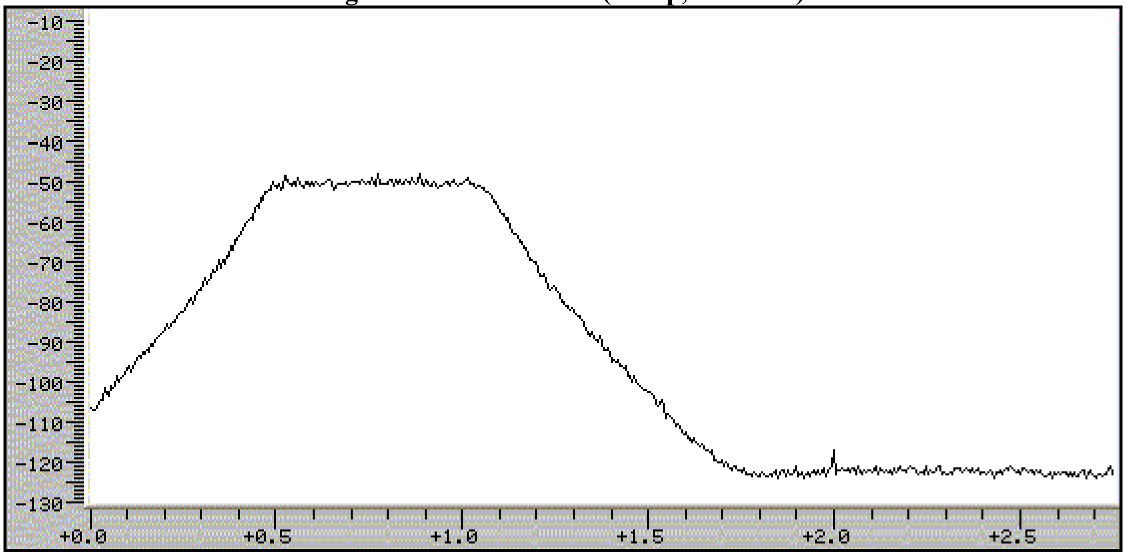


Figure 5: 500 Hz CW filter (Soft)

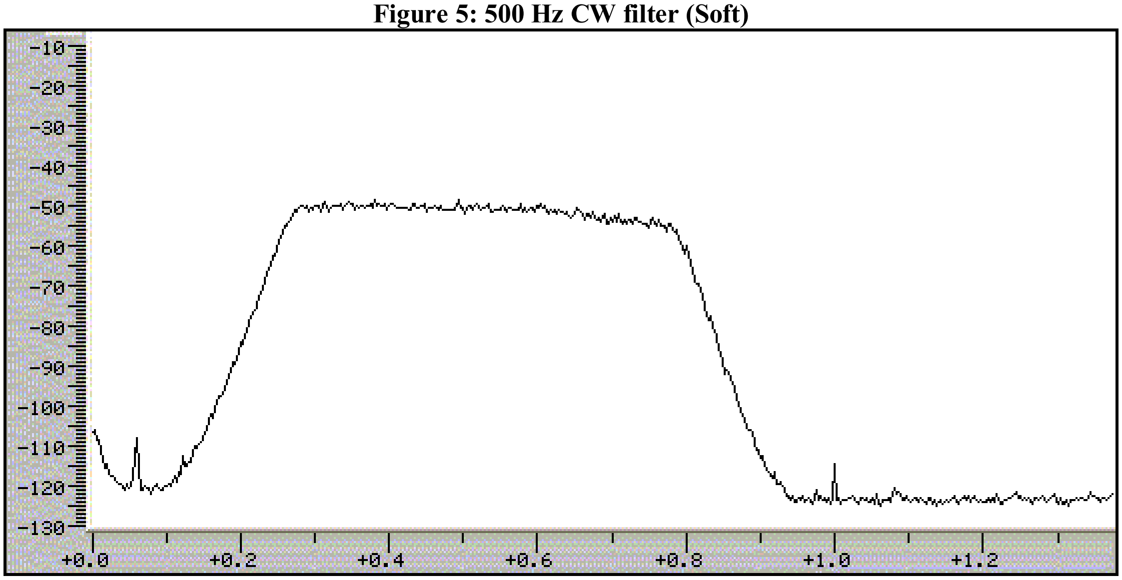
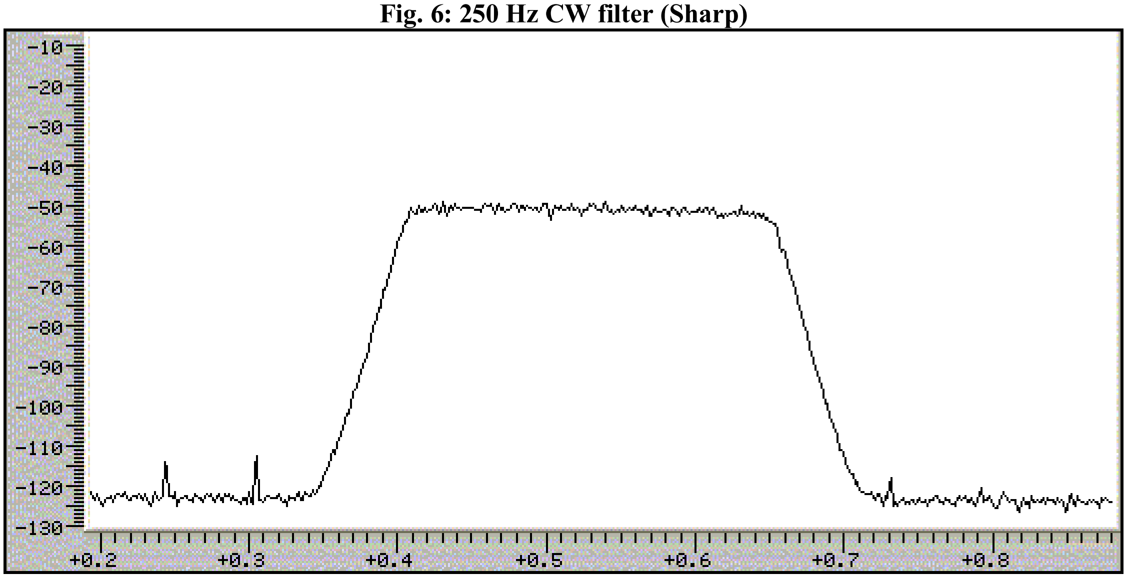


Fig. 6: 250 Hz CW filter (Sharp)



5: NR noise reduction, measured as SINAD. This test is intended to measure noise reduction on SSB signals close to the noise level.

The test signal is offset 1 kHz from the receive frequency to produce a test tone, and RF input power is adjusted for a 6 dB SINAD reading (-120 dBm). NR is then turned on, and SINAD read at 30%, 50% and 60% (max.) NR settings.

Test Conditions: 10.000 MHz LSB, 2.4 kHz Sharp, AGC MID, preamp off, ATT off, NR off, NB off, Twin PBT neutral.

Table 9: NR SINAD.

NR %	SINAD dB
0	6
3	8
5	10
6	12
8	13
9	13 (max)

This shows an S/N improvement of 7 dB with NR at maximum for an SSB signal roughly 4 dB above the noise floor. This is an approximate measurement, as the amount of noise reduction is dependent on the original signal-to-noise ratio.

Figures 7 and 8 are spectrograms of a single-tone RF signal at -120 dBm with NR off and at maximum, respectively.

Figure 7: SSB 2.4 kHz. -120 dBm RF signal, NR off.

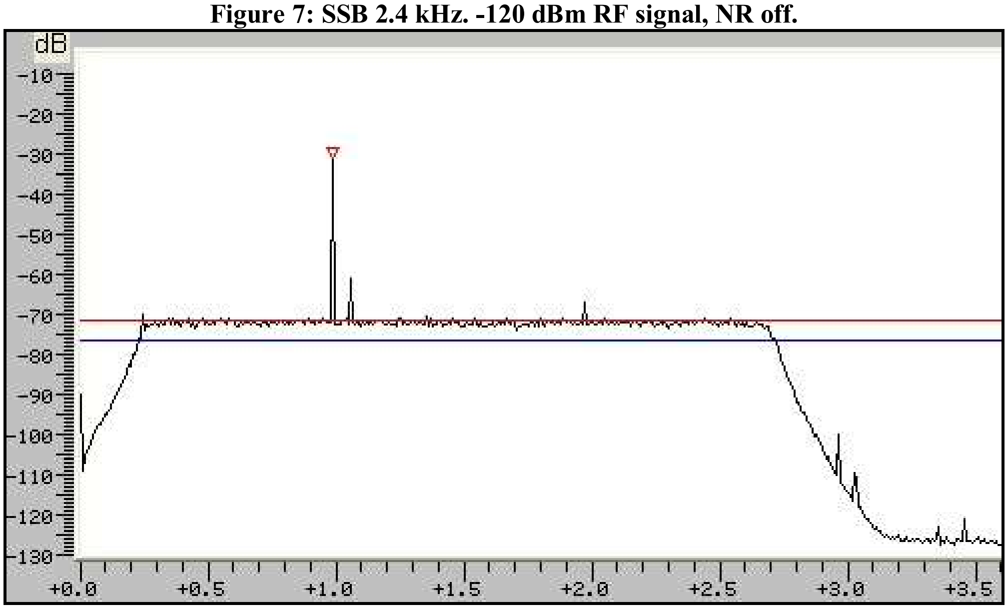
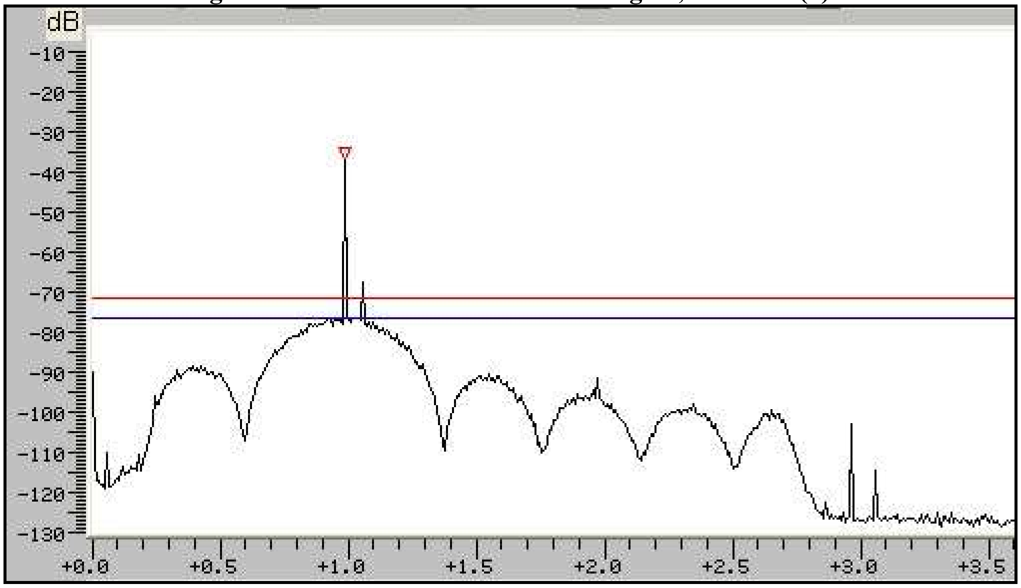


Figure 8: SSB 2.4 kHz. -120 dBm RF signal, max. NR (9).



6: Manual Notch Filter (MNF) stopband attenuation and bandwidth. In this test, an RF signal is applied at a level ≈ 70 dB above MDS. The test signal is offset 1 kHz from the receive frequency to produce a test tone. The MNF is carefully tuned to null out the tone completely at the receiver audio output. The test signal level is adjusted to raise the baseband level 3 dB above noise floor. The stopband attenuation is equal to the difference between test signal power and MDS.

Test Conditions: 14.100 MHz USB at -72 dBm (S9), 2.4 kHz Sharp, AGC MID, preamp off, ATT = 0 dB, NR off, NB off, MNF on, Twin PBT neutral.

Results: MNF nulls out signal completely. Measured MDS was -128 dBm per Test 1. A -58 dBm test signal was applied.

Thus, **stopband attenuation** ≈ 71dB (= -129 - {-58})

The receive frequency is now offset on either side of the null. The frequencies at which the audio output rises by 6 dB are noted. The **-6 dB bandwidth** is the difference between these two frequencies.

Table 10: MNF BW.

MNF -6 dB BW Hz	
Wide	167
Mid	119
Narrow	78

The figures below depict the Manual Notch Filter stopband for **W**ide, **M**id and **N**arrow settings. Due to the limited dynamic range of the measurement method, the accuracy of the amplitude scale is limited.

Fig. 7: Manual Notch Filter (WIDE).

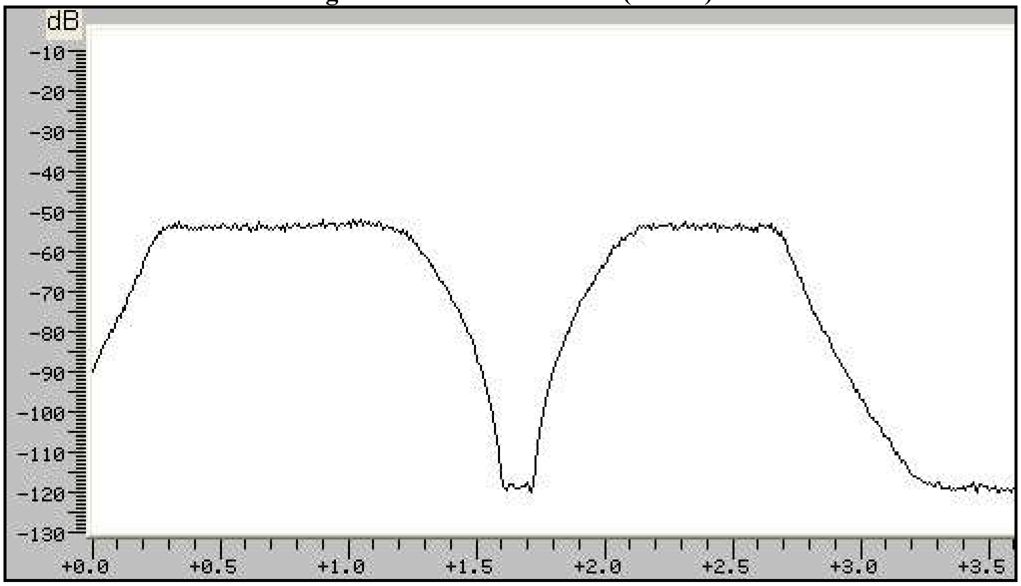


Fig. 8: Manual Notch Filter (MID).

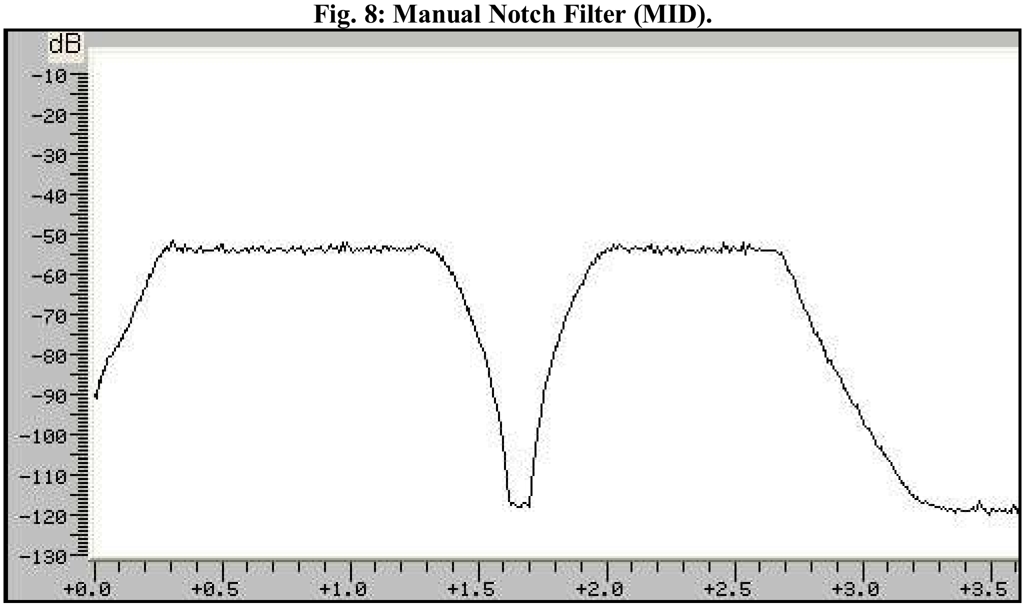
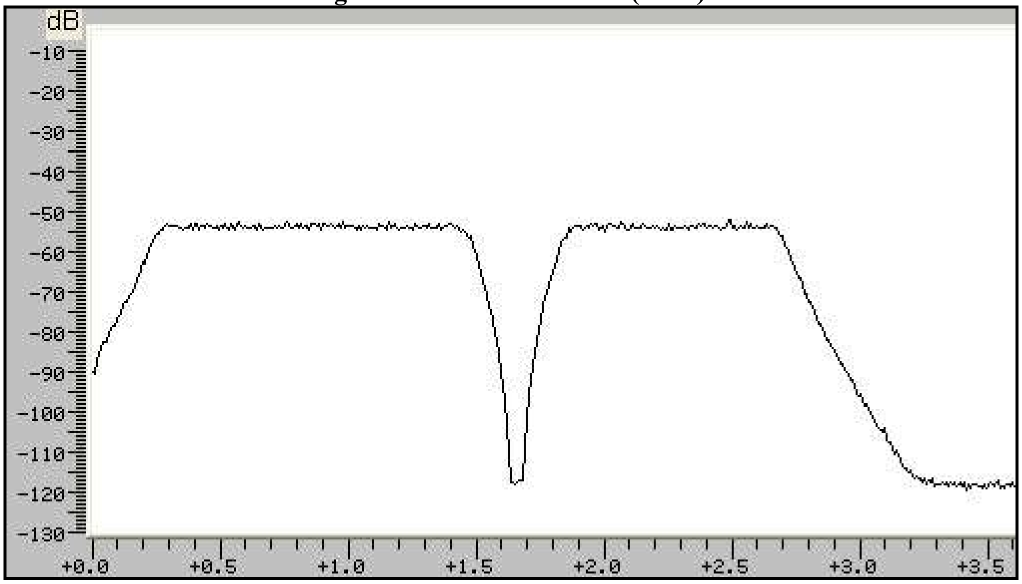


Fig. 9: Manual Notch Filter (NAR).



7: AGC impulse response. The purpose of this test is to determine the IC-9100's AGC response in the presence of fast-rising impulsive RF events. Pulse trains with short rise times are applied to the receiver input.

Test Conditions: 10.000 MHz LSB, 2.4 kHz SSB filter (Sharp), NR off, NB off/on, Preamp off/2, AGC Fast, with decay time set to 0.1 sec.

Test with pulse trains. Here, the pulse generator is coupled to the IC-9100 RF input via the pick-off port of a line sampler. The sampler's main port is terminated in 50Ω. The IC-9100 is tuned to 10 MHz, as the RF spectral distribution of the test pulse train has a strong peak in that band. AGC Fast (0.1 sec) and Preamp 2 are selected.

The pulse rise time (to 70% of peak amplitude) is 10 ns. Three pulse durations are used: 30, 50 and 100 ns. In all cases, pulse period is 600 ms. Pulse amplitude is $16V_{pk}$ (e.m.f.)

The AGC recovers completely; there is no evidence of clamping.

Table 11: AGC impulse response.

Pulse duration ns	AGC recovery ms	S: Pre off	S: Pre 2
30	≈ 100 (no clamping)	S2	S7
50	≈ 100 (no clamping)	S2	S8
100	≈ 100 (no clamping)	S4	S9

8: Noise blanker (NB) impulse response. As the IC-9100's noise blanker is a DSP process "upstream" of the AGC derivation point, the NB should be very effective in suppressing impulsive RF events before they can stimulate the AGC. To verify this, the NB is turned on during Test 7b (above). NB Level is adjusted for best suppression of the test pulses.

At 30 nS pulse duration, the S-meter deflection is *completely suppressed* (with Preamp off, 1 and 2) showing that the impulsive events never reach the AGC derivation point. At NB Level = 25%, Depth 8*, Width 85, occasional faint ticks are heard. At Level = 25%, Width 100, Depth 8, the pulse ticks are almost inaudible with Preamp off; with Preamp 2, a very faint “chuff” sound is heard for each pulse. Signals and/or band noise would mask these artifacts completely.

Next, NR is activated. With NR at 9 to 10 and NB on, the ticks are *completely inaudible.* As in other Icom IF-DSP radios, the NB mitigates AGC response to fast-rising RF events.

**default value*

9: S-meter tracking & AGC threshold. This is a quick check of S-meter signal level tracking.

Test Conditions: 2.4 kHz USB, Preamp off, ATT off, AGC MID.

A 14.100 MHz test signal at MDS is applied to the RF input. The signal power is increased, and the level corresponding to each S-meter reading is noted. (S9 readings are taken with Preamp off, Preamp 1 and Preamp 2 in turn.)

Table 12: S-Meter Tracking.

S	S0	S1	S2	S3	S4	S5	S6	S7	S8	S9	S9+10	S9+20	S9+30	S9+40	S9+50	S9+60
dBm	-96	-94	-92	-89	-86	-83	-81	-78	-75	-72	-62	-52	-43	-34	-24	-15
Preamp 1 on: S9 = -79 dBm. Preamp 2 on: S9 = -87 dBm.																
Measured AGC threshold (preamp OFF): -97 dBm (from Test 4)																

9a: Attenuator tracking. This is a quick verification of attenuator accuracy.

Table 13: ATT Value.

ATT	Value dB
OFF	0
ON	18

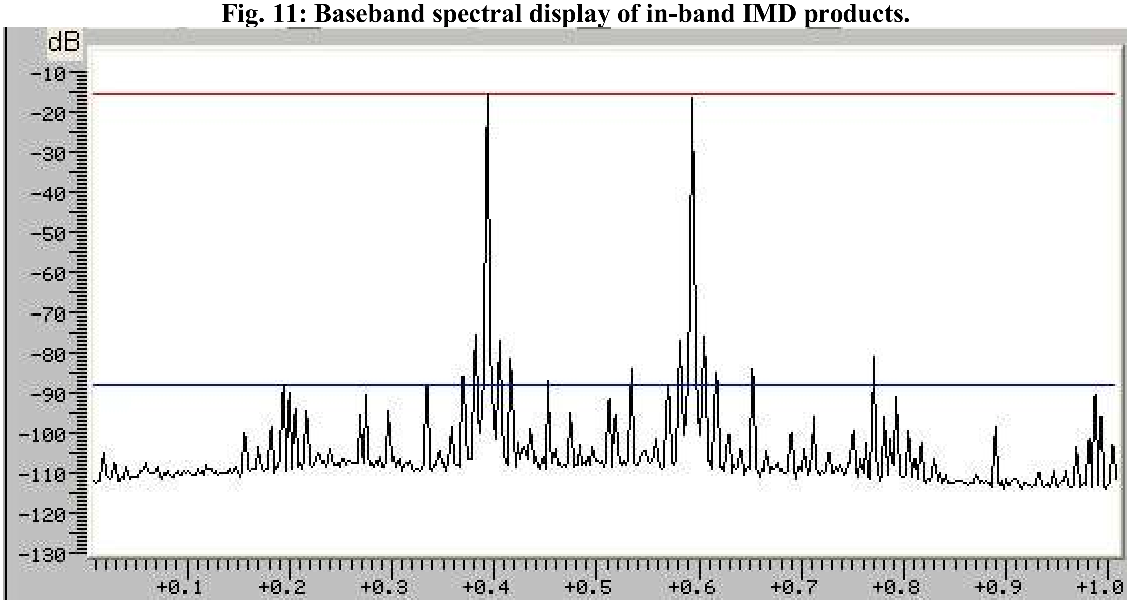
10. In-Band IMD test. The purpose of the In-Band IMD Test is to measure the intermodulation (IMD) products present in the audio output of the receiver when two closely-spaced signals (both falling within the IF passband) are applied to the RF input.

In this test, two signals f_1 and f_2 of equal amplitude and separated by 200 Hz offset are injected into the receiver input. f_1 = 10000.0 and f_2 = 10000.2 kHz. The 3rd-order IMD products are at 9999.8 and 10000.4 kHz respectively.

The two test signals are combined in a passive hybrid combiner and applied to the receiver input via a step attenuator. A baseband spectrum analyzer (here a PC running a FFT spectral-analysis program) is connected to the IC-9100's rear-panel USB port.

Test Conditions: IC-9100 tuned to 9999.6 kHz, 3.6 kHz USB, NR off, NB off, Preamp off, ATT off, AGC-F. RF input power -57 dBm composite (each test signal -63 dBm). Baseband spectrum analyzer reference level adjusted to place test signals at -10 dB line. **Fig. 11** illustrates the test signals and 3rd-order IMD products.

Fig. 11: Baseband spectral display of in-band IMD products.



On the X-axis, +0.0 kHz ^ 9999.6 kHz (virtual carrier). f_1 is at +0.4 kHz, f_2 at +0.6 kHz. The 3rd-order IMD products are at +0.2 and +0.8 kHz respectively.

Test Result: In-band IMD = -16 – (-88) = **-72 dB.**

11. Two-Tone 3rd-Order Dynamic Range (DR_3) & Third-Order Intercept (IP_3). The purpose of this test is to determine the range of signals which the receiver can tolerate while essentially generating no spurious responses.

In this test, two signals of equal amplitude P_i and separated by a known offset Δf are injected into the receiver input. If the test signal frequencies are f_1 and f_2, the offset $\Delta f = f_2 - f_1$ and the 3rd-order intermodulation products appear at $(2 f_2 - f_1)$ and $(2 f_1 - f_2)$.

The two test signals are combined in a passive hybrid combiner and applied to the receiver input via a step attenuator. The receiver is tuned to the upper and lower 3rd-order IMD products ($2 f_2 - f_1$ and $2 f_1 - f_2$ respectively) which appear as a 600 Hz tone in the speaker. The per-signal input power level P_i is adjusted to raise the noise floor by 3 dB, i.e. IMD products at MDS. The Pi values for the upper and lower products are recorded and averaged.

Note: *If the audio output drops by less than 3 dB when one of the test signals is removed, the measurement is noise-limited (indicated by NL in the table.)*

$DR_3 = P_i$ - MDS. Calculated $IP_3 = (1.5 * DR_3) +$ MDS.

Test Conditions: 14.1 MHz, CW mode, 500 Hz filter, AGC off, ATT off, NR off, NB off, CW Pitch = 12 o'clock. DR_3 in dB; IP_3 in dBm. NL = noise limited.

Table 14: DR_3 and IP_3 at 14.1 MHz. Δf in kHz, DR_3 in dB, IP_3 in dBm.

	Preamp off						Preamp 1						Preamp 2					
Roof	15		6		3		15		6		3		15		6		3	
Δf	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3	DR3	IP3
3	72NL		72NL		73NL		71NL		71NL		72NL		71NL		73NL		72NL	
5	78	-18	81	-14	82	-12	74NL		81NL		81NL		74	-32	82	-16	81	-20
7	82	-6	89	-2	90	0	79	-24	86	-13	88	-10	78	-26	88	-11	89	-10
10	86	0	94	12	96	13	95	1	93	-3	94	-1	88	-11	92	-5	94	-2
20	99	14	100	15	101	17	97	4	97	4	98	5	97	3	98	4	98	4
30	101	17	101	17	102	18	98	5	98	5	98	5	97	3	99	6	99	6
50	100	15	101	17	101	17	99	7	100	8	101	10	100	7	99	7	99	7

11. Two-Tone 2nd-Order Dynamic Range (DR_2) & Second-Order Intercept (IP_2). The purpose of this test is to determine the range of signals far removed from an amateur band which the receiver can tolerate while essentially generating no spurious responses within the amateur band.

In this test, two widely-separated signals of equal amplitude P_i are injected into the receiver input. If the signal frequencies are f_1 and f_2, the 2nd-order intermodulation product appears at $(f_1 + f_2)$. The test signals are chosen such that $(f_1 + f_2)$ falls within an amateur band.

The two test signals are combined in a passive hybrid combiner and applied to the receiver input via a step attenuator. The receiver is tuned to the IMD product ($f_1 + f_2$) which appears as a 600 Hz tone in the speaker. The per-signal input power level P_i is adjusted to raise the noise floor by 3 dB, i.e. IMD product at MDS. The P_i value is then recorded.

$DR_2 = P_i$ - MDS. Calculated $IP_2 = (2 * DR_2) + MDS$.

Test Conditions: f_1 = 6.1 MHz, f_2 = 8.1 MHz, CW mode, 500 Hz filter, AGC off, ATT off, NR off, NB off, CW Pitch = 12 o'clock. DR_2 in dB; IP_2 in dBm.

Table 14: MDS in dBm, DR_2 in dB, IP_2 in dBm.

Preamp	MDS, 14.2 MHz	DR_2	IP_2
off	-136	99	62
1	-142	104	64

12. Roofing-filter bandwidth (approximate): This is a non-invasive test, in which the widest available DSP-IF filter (10 kHz AM) is selected. A CW test signal is applied at the S9 level (-72 dBm). The receiver is then de-tuned above and below the center frequency for a 1 S-unit (≈ 3 dB) drop in S-meter reading, and the frequency offsets Δf and - Δf recorded. The 3 dB bandwidth $B_{3dB} = 2\Delta f$.

This procedure is useful for checking the 6 and 3 kHz roofing filters, but not the 15 kHz filter. This restriction is imposed by the 10 kHz maximum DSP-IF filter bandwidth.

Test Conditions: 10 MHz, AM mode, 10 kHz IF filter, AGC-M, ATT off, NR off, NB off, Preamp off.

Table 15: Roofing Filter BW in kHz

Nominal BW	Meas. 3 dB BW
6	≈ 10*
3	≈ 7.2

** 10 kHz is the limiting case due to the DSP IF filter bandwidth of 10 kHz. It is possible that the actual bandwidth of the 6 kHz roofing filter exceeds 10 kHz.*

13. AGC action due to signal within roofing-filter passband but outside the DSP IF channel: The purpose of this test is to determine the input power level at which an unwanted signal falling within the roofing-filter window, but outside the DSP IF passband, starts stimulating the AGC.

Test Conditions: 10 MHz, CW, 250 Hz IF filter, 3 kHz roofing filter, AGC-M, ATT off, NR off, NB off, Preamp off. Offset tuning by +500 Hz.

AGC action (S-meter indication) starts at **-20 dBm** test signal power, due to effect of reciprocal mixing noise. When offset is increased to +1 kHz, S-meter indication starts at **-21 dBm**.

14. 1st-IF image rejection: In this test, the IC-9100 is tuned to a mid-band frequency f_0, and a test signal at f_0 + twice the 1st IF is applied to the antenna port. The test signal power is increased sufficiently to raise the noise floor by 3 dB.

Test Conditions: f_0 = 15 MHz, CW, 500 Hz IF filter, 15 kHz roofing filter, AGC-M, ATT off, NR off, NB off, Preamp off. Set main tuning to 15.000 MHz.

Test signal freq. = (2 * 64.455) + 15 = 143.91 MHz.

Measured MDS = -135 dBm. Test signal power for 3 dB noise floor increase = -21 dBm. Thus, image rejection = -21 - (-135) = 114 dB.

14a. 1st-IF rejection: In this test, the IC-9100 is tuned to a mid-band frequency f_0, and a test signal at the 64.455 MHz 1st IF is applied to the antenna port. The test signal power is increased sufficiently to raise the noise floor by 3 dB.

Test Conditions: f_0 = 15 MHz, CW, 500 Hz IF filter, 15 kHz roofing filter, AGC-M, ATT off, NR off, NB off, Preamp off. Set main tuning to 15.000 MHz. Test signal freq. = 64.455 MHz.

Measured MDS = -135 dBm. Test signal power for 3 dB noise floor increase = -26 dBm. Thus, 1st-IF rejection = -26 - (-135) = 109 dB.

15. Audio THD: In this test, an audio distortion analyzer is connected to the external speaker output. An 8Ω resistive load is connected across the analyzer input. An S7 to S9 RF test signal is applied to the antenna input, and the main tuning is offset by 1 kHz to produce a test tone. The audio voltage corresponding to 10% THD is then measured, and the audio output power calculated.

Test Conditions: 10 MHz, USB, 3 kHz IF filter, 15 kHz roofing filter, AGC-F, ATT off, NR off, NB off, Preamp off. Offset tuning by -1 kHz.

Measured audio output voltage = 3.9V rms. Thus, audio power output = $\sqrt{[(3.9)^2/8]}$ = **1.9W in 8Ω**. (Spec. is 2W).

B. 2m/70cm/23cm Receiver Tests

16: MDS (Minimum Discernible Signal) is a measure of ultimate receiver sensitivity. In this test, MDS is defined as the RF input power which yields a 3 dB increase in the receiver noise floor, as measured at the audio output.

Note: Always terminate the antenna port in 50Ω when setting the 0 dBr baseband reference for these tests.

Test Conditions: ATT off, NR off, NB off, Notch off. AGC-M. SHARP. Levels in dBm.

Table 16: MDS (2m/70cm/23cm) in dBm.

144.1 MHz		432.1 MHz		1.24 GHz	
SSB 2.4 kHz	CW 500 Hz	SSB 2.4 kHz	CW 500 Hz	SSB 2.4 kHz	CW 500 Hz
-137	-142	-138	-143	-139	-144

16a. 12 dB SINAD FM sensitivity: In this test, a distortion meter is connected to the external speaker jack, and an FM signal modulated by a 1 kHz tone with 3 kHz peak deviation is applied to the RF input. The input signal power for 12 dB SINAD is recorded (Table 17).

Table 17: FM 12 dB SINAD Sensitivity in dBm.

146.52 MHz	446 MHz	1271 MHz
-123	-124	-125

17. Noise Figure: In this test, a calibrated noise source is connected to the antenna port via a precision DC - 2 GHz step attenuator. First, the antenna port is terminated in 50Ω and a 0 dBr baseband reference set. Then, the noise source is connected and the noise loading adjusted for a +3 dBr baseband level. The attenuator setting is noted.

As the noise source is calibrated, its noise power density PSD (in dBm/Hz) is known. Noise figure NF is derived as follows:

$NF \approx PSD - ATT + 174$ where ATT = attenuator setting in dB.

Test Conditions: 500 Hz CW, AGC Mid, ATT off, NR off, NB off.

Table 18. Noise figure in dB.

	144.1 MHz	432.1 MHz	1271 MHz
Measured	5.4	5.4	3.8
Calc. from MDS	5.0	4.0	3.0

End of Receiver Tests

C. Transmitter Tests

23: CW Power Output. In this test, the RF power output into a 50Ω load is measured at 3.6, 14.1, 50.1, 144.1, 432.1 and 1241 MHz in CW or RTTY mode, at a primary DC supply voltage of +13.8V.

Table 22: CW Power Output.

RF Power %	P_o Meter %	Power Output W					
	Freq. MHz	3.6	14.1	50.1	144.1	432.1	1241
70	70	82	74	73	69	54	5
100	100	116	113	106	104	76	10

23a: Autotuner (ATU) insertion loss. In this test, the transmitter is set for 100W (+50 dBm) output (P_1) on various bands. On each band, the ATU is activated and tuned, and the output (P_2) measured and noted. ATU insertion loss = (P_2 - P_1).

Test Conditions: RTTY mode, 3.6, 14.1 and 50.1 MHz successively, P_1 = +50 dBm, RF power meter and 50Ω resistive load connected to ANT1.

Table 23: ATU Insertion Loss.

Freq. MHz	P_1 (ATU in) dBm	P_2 (ATU out) dBm	ATU insertion loss dB
3.6	+50.7	+50.3	0.4
14.1	+50.5	+49.9	0.6
50.1	+50.3	+49.5	0.8

23b: Autotuner "hunting" check. In this test, the ATU is activated and tuned at 100W output on all bands supporting the ATU. On each band, a brief SSB transmission is made, during which the tester checks aurally for ATU sounds and visually for random SWR "flutter" above 1:1.

Test Conditions: *1*: RTTY mode, midband frequency on 3.6, 14.1 and 50.1 MHz in turn, P_o = 100W, RF power meter and 50Ω resistive load connected to ANT1. *2*: Brief voice transmission in SSB mode.

No audible or visible evidence of ATU "hunting" was observed on any band.

23c: SWR scale accuracy. The SWR scale is read with 50Ω and 100Ω resistive loads connected in turn to ANT1. To minimize the effect of line lengths on measurement accuracy, this test is run at 1.8 MHz. The RF POWER setting remains unchanged when switching loads.

Test Conditions: 1.81 MHz RTTY. P_o = 10W into 50Ω load.

Table 18: SWR Scale Accuracy.

Nominal Load	DC Resistance	SWR Reading
50Ω	50.1Ω	1:1
100Ω	100.9Ω	2.5:1

Note that with the 100Ω load, the SWR reading is somewhat dependent on P_o.

24: SSB Peak Envelope Power (PEP). Here, an oscilloscope is terminated in 50Ω and connected to the IC-9100 RF output via a 50 dB high-power attenuator. At 100W CW, the scope vertical gain is adjusted for a peak-to-peak vertical deflection of 6 divisions.

Test Conditions: USB mode, HM-36 mic connected, Mic Gain 45%, COMP OFF/ON, TBW = MID, COMP set at ≈ 30% (6 dB compression on voice peaks), SSB TX Bass/Treble set at 0 dB (default), supply voltage +13.8V.

Speak loudly into the microphone for full-scale ALC reading. **Figs. 12 & 13** show the envelope for 100W PEP, without and with compression respectively.

Fig. 12: 100W PEP speech envelope, no compression

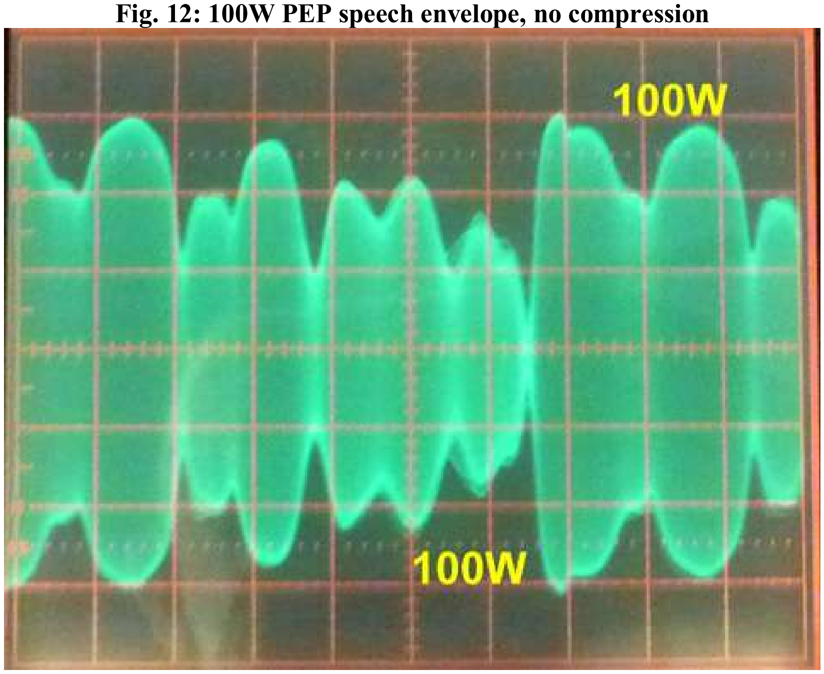
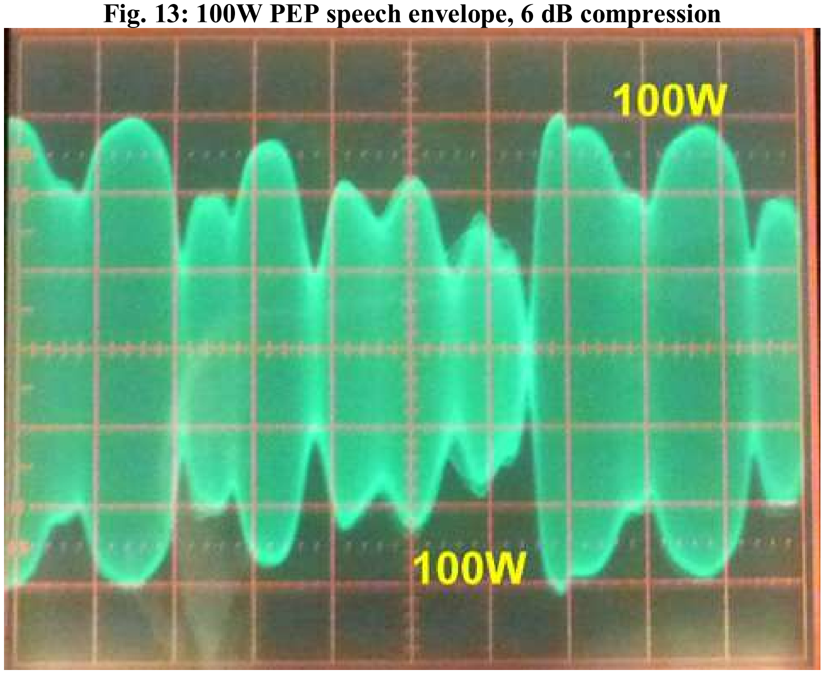


Fig. 13: 100W PEP speech envelope, 6 dB compression



25: SSB ALC overshoot: Reports of ALC overshoot in the IC-9100 Yahoo! Group led to an investigation of this issue. A test was performed in which white noise was applied via the USB port, and the RF envelope observed on an oscilloscope terminated in 50Ω and connected to the IC-9100 RF output via a 50 dB high-power attenuator**.**

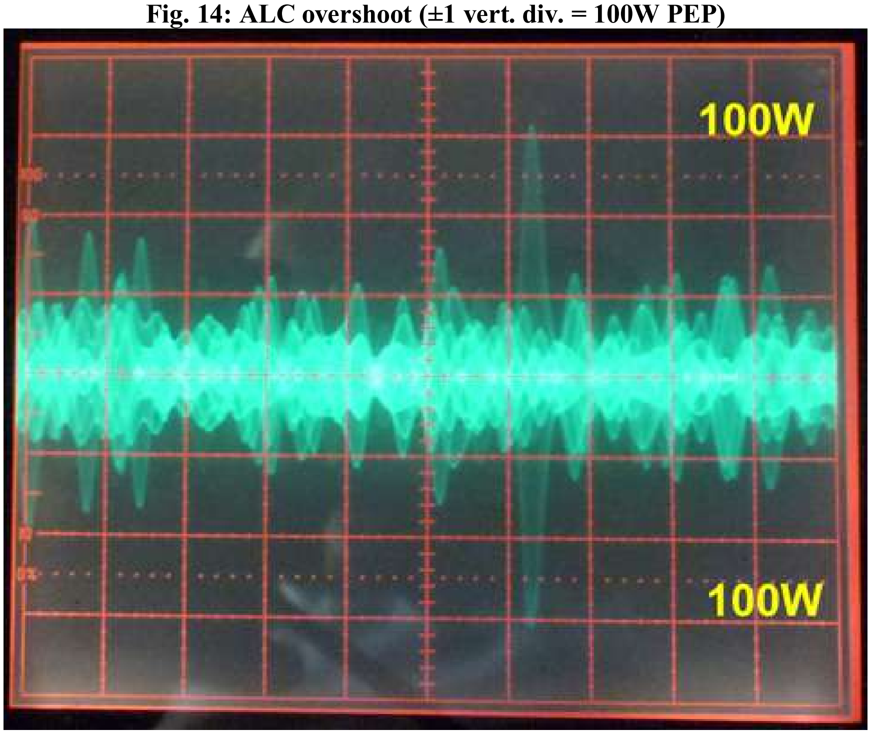
Test Conditions: 14100 kHz USB, COMP off, DATA OFF MOD = USB, USB MOD Level = 50% (default). Test signal: white noise. WIDE TBW (default value) selected. Supply voltage +13.8V.

Set P_o = 50W in RTTY mode. Select USB, then adjust USB Audio Codec device volume on computer for 50% ALC reading.

At 50W PEP, a leading-edge overshoot spike was observed about every two seconds, even with P_o set to 50W. The spike amplitude was +3 dB (100W). These overshoot levels are sufficiently high to fault out or even damage many amplifiers. The amplifier's ALC loop (if fitted) will not suppress the overshoot.

The ALC overshoot can be reduced to 1.5 dB by careful adjustment of baseband level (Mic Gain or USB MOD Level as appropriate) and Compression. This adjustment requires observation of the RF envelope with an oscilloscope, and is quite critical. PEP output drops sharply as the overshoot is reduced. **Fig. 14** shows a typical overshoot spike with baseband level set for 50W PEP.

Fig. 14: ALC overshoot (±1 vert. div. = 100W PEP)



26: Transmitter 2-tone IMD test. In this test, a 2-tone test signal is applied to the USB port from a tone-generator program running on a laptop computer. A spectrum analyzer is connected to the IC-9100 RF output via a 50 dB high-power attenuator. RF Power is adjusted for rated CW output on each band in turn.

Test Conditions: DC supply 13.8V, measured at DC power socket. 14.1, 50.1, 144.1, 432.1 and 1241 MHz USB, DATA OFF MOD = USB, USB Level = 50% (default). Test tones: 700 and 1700 Hz, at equal amplitudes. The 0 dBm reference level RL equates to 100W (except for 1241 MHz, where -10 dBm RL equates to 10W.)

On computer, adjust USB Audio Codec device volume for 100W PEP (each tone at -6 dBc). **Figs. 15** through **19** show the two test tones and the associated IMD products.

Fig. 15: Spectral display of 2-tone IMD at 14.1 MHz, 100W PEP.

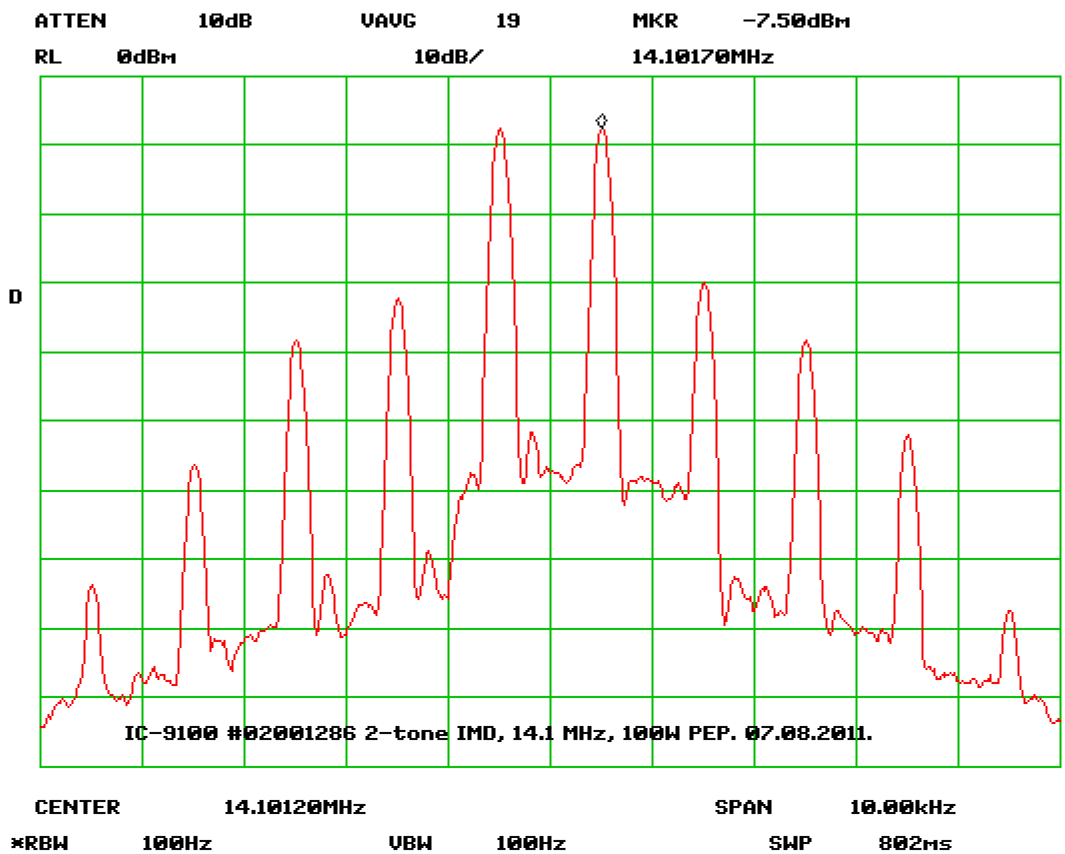


Fig. 16: Spectral display of 2-tone IMD at 50.1 MHz, 100W PEP.

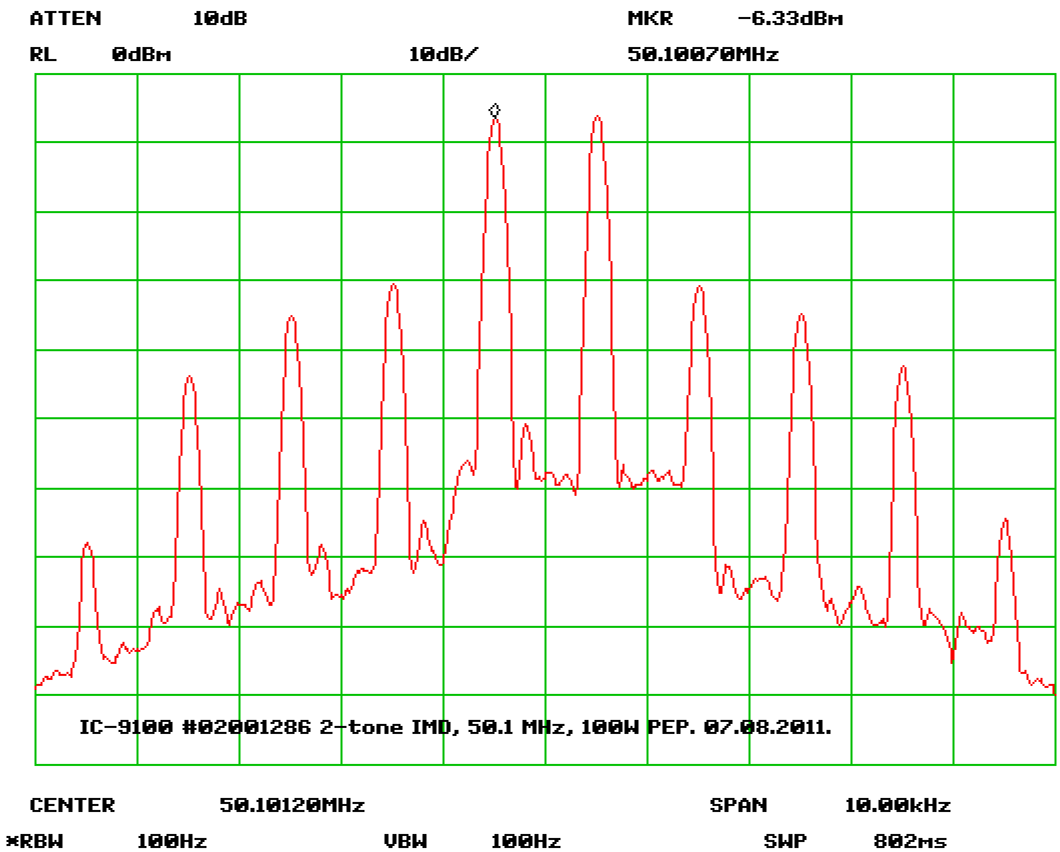


Fig. 17: Spectral display of 2-tone IMD at 144.1 MHz, 100W PEP.

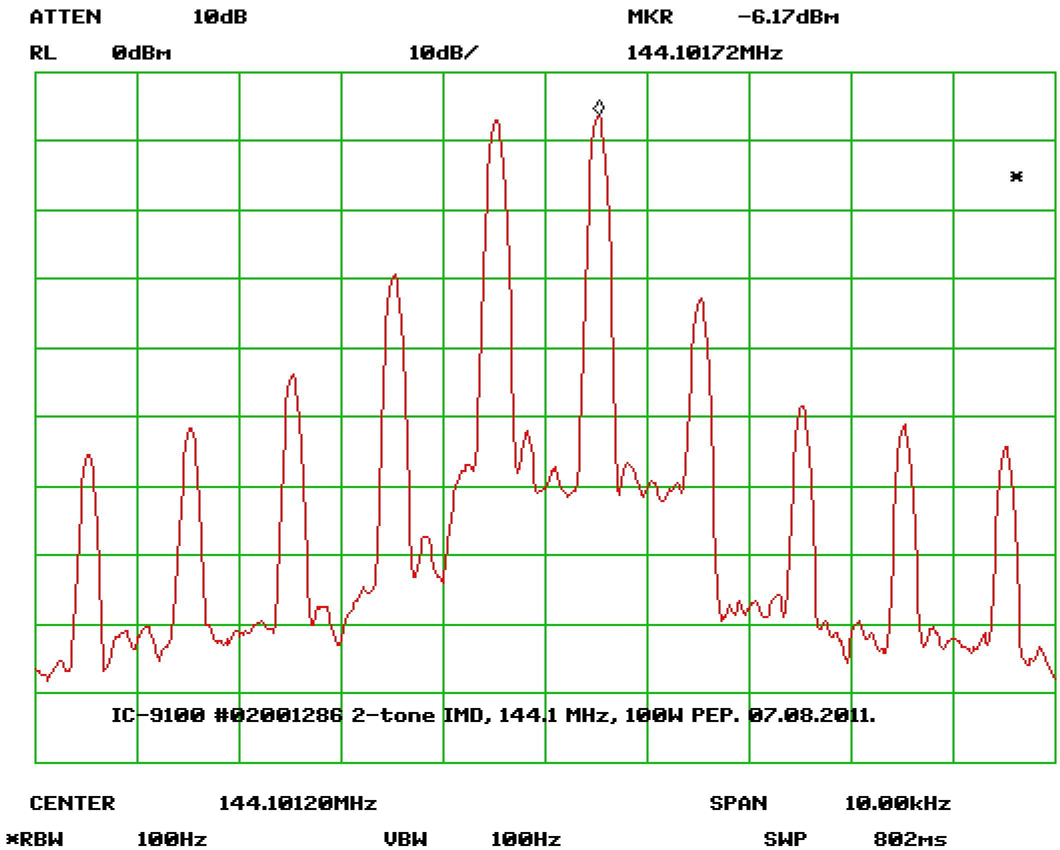


Fig. 18: Spectral display of 2-tone IMD at 432.1 MHz, 75W PEP.

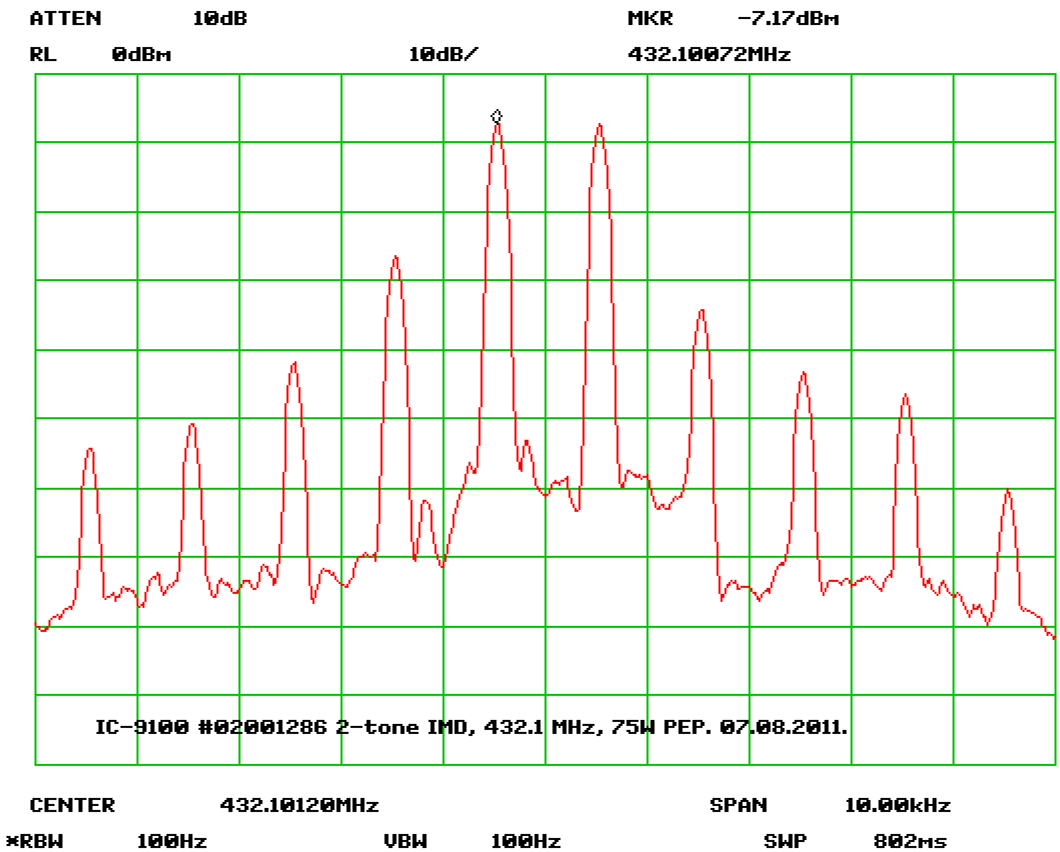


Fig. 19: Spectral display of 2-tone IMD at 1.241 GHz, 10W PEP.

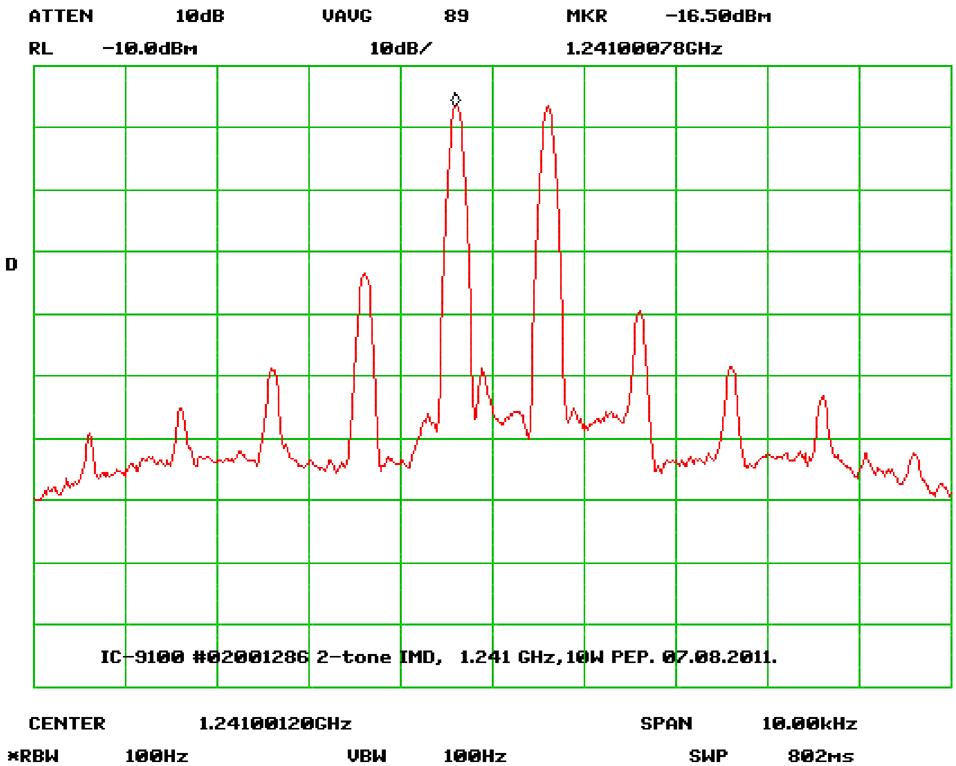


Table 19.

2-tone TX IMD Products at Rated P_o					
IMD Products	Rel. Level dBc (0 dBc = PEP)				
Freq. MHz	14.1	50.1	144.1	432.1	1241
IMD3 (3rd-order)	-30	-30	-31	-29	-35
IMD5 (5th-order)	-36	-35	-46	-41	-48
IMD7 (7th-order)	-53	-43	-51	-47	-54
IMD9 (9th-order)	-75	-66	-54	-58	-62

27: AM sidebands and THD with single-tone modulation. As in Test 18 above, the spectrum analyzer is connected to the IC-9100 RF output via a 50 dB high-power attenuator. On the IC-9100, RF Power is adjusted for 25W resting carrier. A 1 kHz test tone is applied to the USB port from the tone-generator program running on the laptop computer. The spectrum analyzer records the carrier and sideband parameters.

Test Conditions: 14100 kHz AM, 25W carrier output, DATA OFF MOD = USB, USB Level = 50% (default).

On computer, adjust USB Codec device volume for -7 dBc test tone level (90% modulation.) **Fig. 20** shows the carrier and sideband levels. Calculated THD ≈ **1.5%**.

Fig. 20: AM Sidebands for 90% Modulation.

IC-9100 #02001286, 14.1 MHz, 25W, AM sidebands & THD, 90% mod, 1 kHz mod. freq. 07.08.2011

DISCRETE SIDEBAND SEARCH RESULTS

CARRIER FREQ: 14.10 MHz

CARRIER POWER: -4.3 dBm

OFFSET FREQ		- OFFSET dBc	+ OFFSET dBc
.998	kHz	-7.0	-7.0
1.997	kHz	-27.0	-29.2
2.996	kHz	-29.5	-31.8
4.004	kHz	-44.8	-40.3
5.003	kHz	-51.3	-50.0

FOUND: 5 SETS OF SIDEBANDS

28: Transmitter harmonics & spectral purity. Once again, the spectrum analyzer is connected to the IC-9100 RF output via a 50 dB high-power attenuator. RF Power is adjusted for rated CW output on each band in turn. The 0 dBm reference level equates to 100W. The spectrum analyzer's harmonic capture utility is started.

Test Conditions: 14.1, 50.1, 144.1, 432.1, 1241 MHz RTTY, rated output to 50Ω load. Utility start and stop frequencies are configured as shown in **Figs. 18b, 19b and 20b.**

Fig. 21a

IC-9100 #02001286, 14.1 MHz, 100W CW, harmonics. 07.08.2011

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 14.10 MHz
.2 dBm

HARMONIC	LEVEL dBc		FREQUENCY	
2	-74.0		28.20	MHz
3	-66.7		42.30	MHz
4	-82.7		56.40	MHz
5	-90.7		70.50	MHz
6	-102.0		84.60	MHz
7	-99.5		98.70	MHz
8	-116.7	*	112.8	MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION = .1 %
(OF HARMONICS MEASURED)

Fig. 20b.

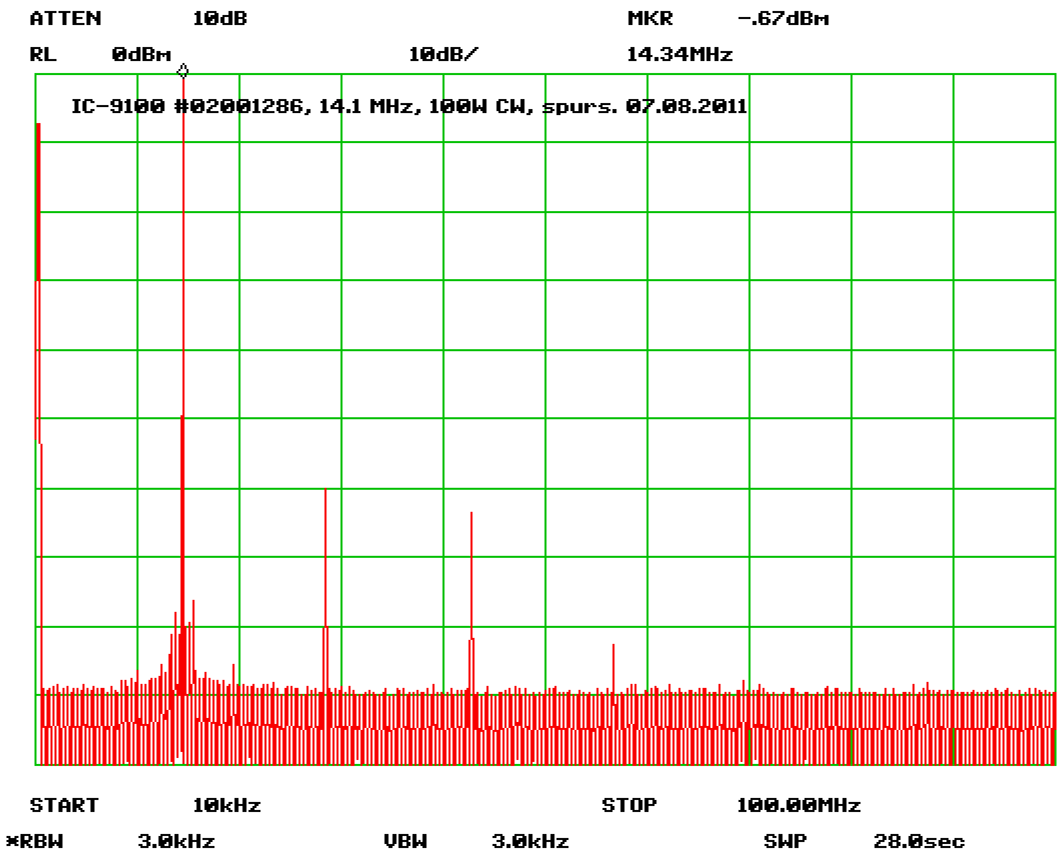

ATTEN 10dB
MKR -.67dBm
RL 0dBm
10dB/
14.34MHz
IC-9100 #02001286, 14.1 MHz, 100W CW, spurs. 07.08.2011
START 10kHz
STOP 100.00MHz
*RBW 3.0kHz
VBW 3.0kHz
SWP 28.0sec

Fig. 21a.

IC-9100 #02001286, 50.1 MHz, 100W CW, harmonics. 07.08.2011

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 50.10 MHz
.5 dBm

HARMONIC	LEVEL	dBc	FREQUENCY	
2	-78.2		100.2	MHz
3	-78.3		150.3	MHz
4	-87.2		200.4	MHz
5	-87.0		250.5	MHz
6	-113.0	*	300.6	MHz
7	-104.5		350.7	MHz
8	-116.7	*	400.8	MHz

* MEASURED LEVEL MAY BE
NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION = 0 %
(OF HARMONICS MEASURED)

Fig. 21b.

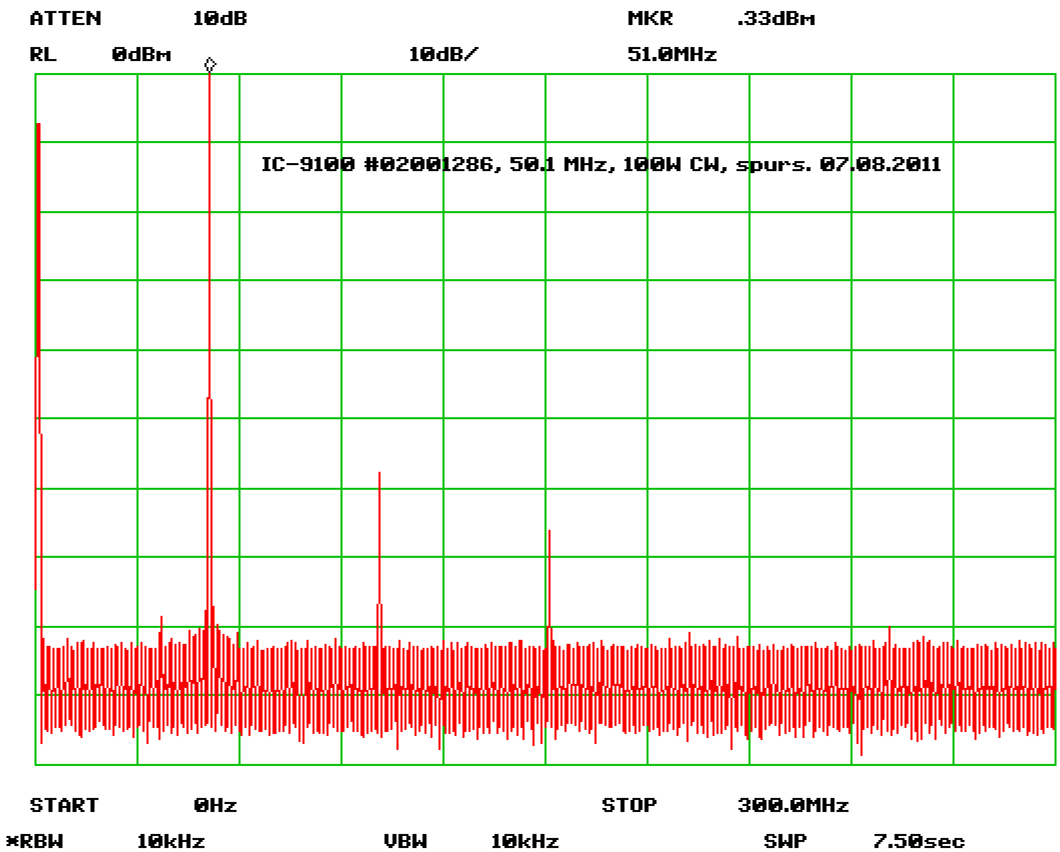

ATTEN 10dB
MKR .33dBm
RL 0dBm
10dB/
51.0MHz
IC-9100 #02001286, 50.1 MHz, 100W CW, spurs. 07.08.2011
START 0Hz
STOP 300.0MHz
*RBW 10kHz
VBW 10kHz
SWP 7.50sec

Fig. 12a.

IC-9100 #02001286, 432.1 MHz, 75W CW, harmonics. 07.08.2011

HARMONIC	MEASUREMENT	RESULTS	
FUNDAMENTAL	SIGNAL:	432.1	MHz
		-1.3	dBm

HARMONIC	LEVEL dBc	FREQUENCY	
2	-80.8	864.2	MHz
3	-81.0	1.296	GHz
4	-84.3	1.728	GHz
5	-87.3	2.161	GHz
6	-93.2	2.593	GHz
7	-77.8	3.025	GHz
8	-81.3	3.457	GHz

TOTAL HARMONIC DISTORTION = 0 %
(OF HARMONICS MEASURED)

Fig. 22b.

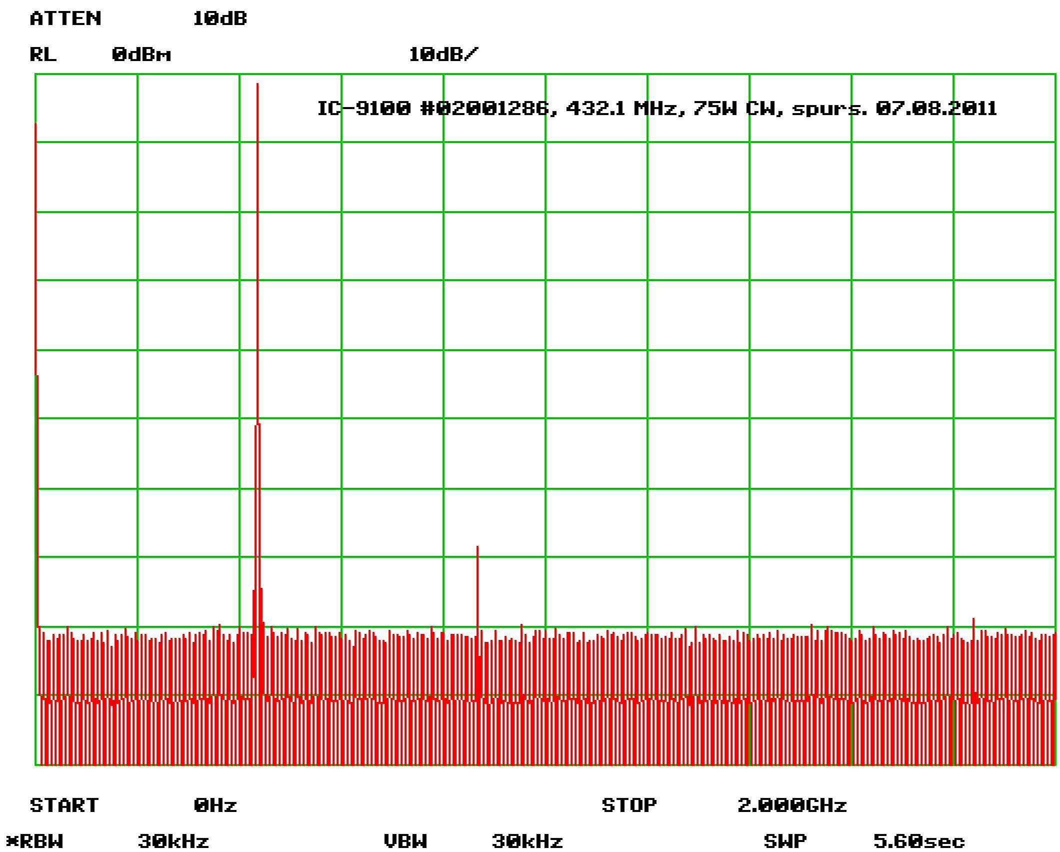

ATTEN 10dB
RL 0dBm 10dB/
IC-9100 #02001286, 432.1 MHz, 75W CW, spurs. 07.08.2011
START 0Hz STOP 2.000GHz
*RBW 30kHz VBW 30kHz SWP 5.60sec

Fig. 23a.

IC-9100 #02001286, 1.241 GHz, 10W CW, harmonics. 07.08.2011

HARMONIC MEASUREMENT RESULTS

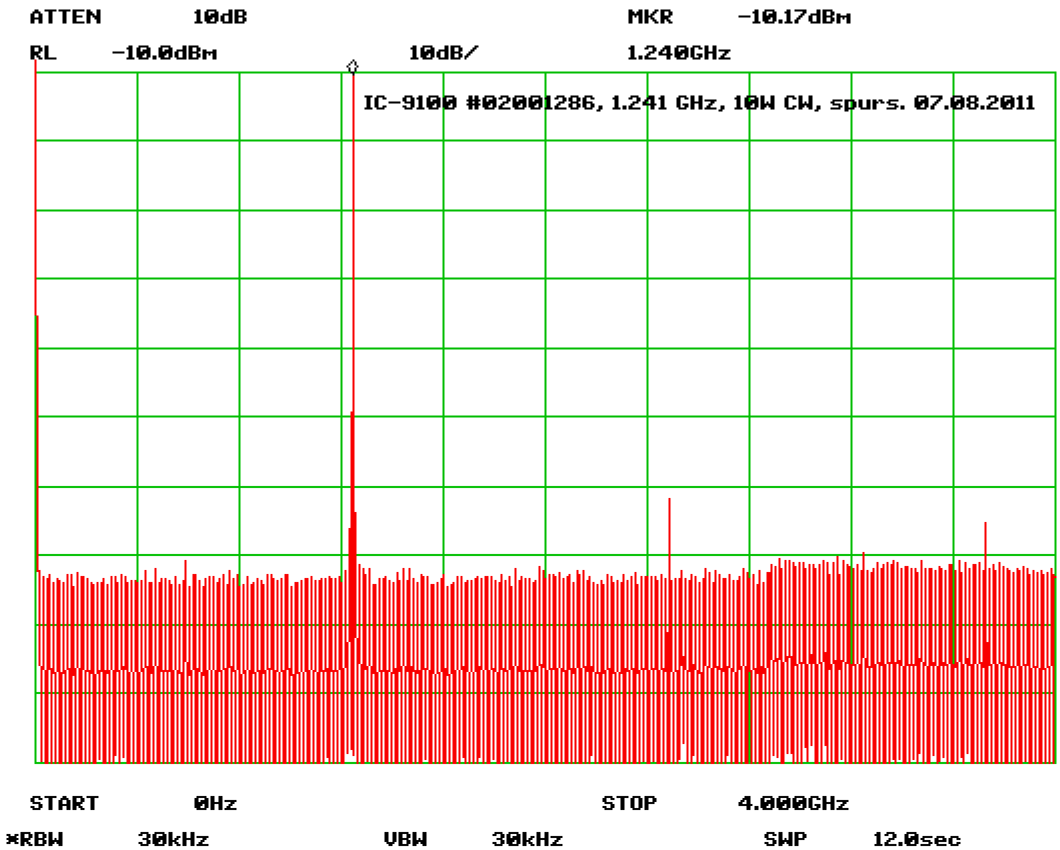
FUNDAMENTAL SIGNAL: 1.241 GHz
-10.2 dBm

HARMONIC	LEVEL dBc		FREQUENCY	
2	-59.7		2.482	GHz
3	-66.7		3.723	GHz
4	-76.7		4.964	GHz
5	-77.0		6.205	GHz
6	-100.7	*	7.446	GHz
7	-95.3	*	8.687	GHz
8	-99.0	*	9.928	GHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION = .1 %
(OF HARMONICS MEASURED)

Fig. 23b.


ATTEN 10dB
MKR -10.17dBm
RL -10.0dBm
10dB/
1.240GHz
IC-9100 #02001286, 1.241 GHz, 10W CW, spurs. 07.08.2011
START 0Hz
STOP 4.000GHz
*RBW 30kHz
VBW 30kHz
SWP 12.0sec

29: Transmitted composite noise. The spectrum analyzer is connected to the IC-9100 RF output via a 60 dB high-power attenuator. The spectrum analyzer's phase-noise utility is started. **Figs. 24a** through **24f** are the resulting composite-noise plots.

Test Conditions: 3.6, 14.1, 50.1. 144.1, 432.1 and 1241 MHz RTTY, rated output to 50Ω load. Utility minimum/maximum offset and spot frequencies configured as shown in **Figs. 24a** through **23f**. (***Note:*** The limitation of this measurement method is that the measured noise power is close to the spectrum analyzer's own noise floor.)

Fig. 24a: Composite noise at 3.6 MHz, 100W.

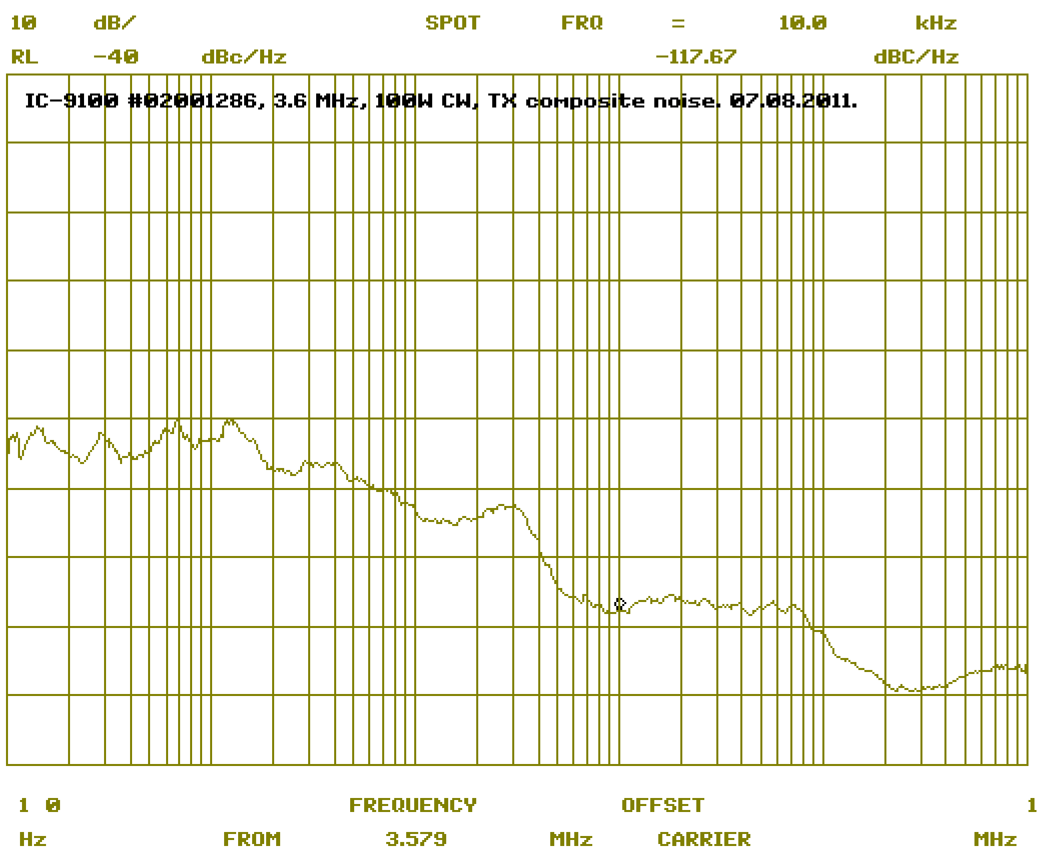


Fig. 24b: Composite noise at 14.1 MHz, 100W.

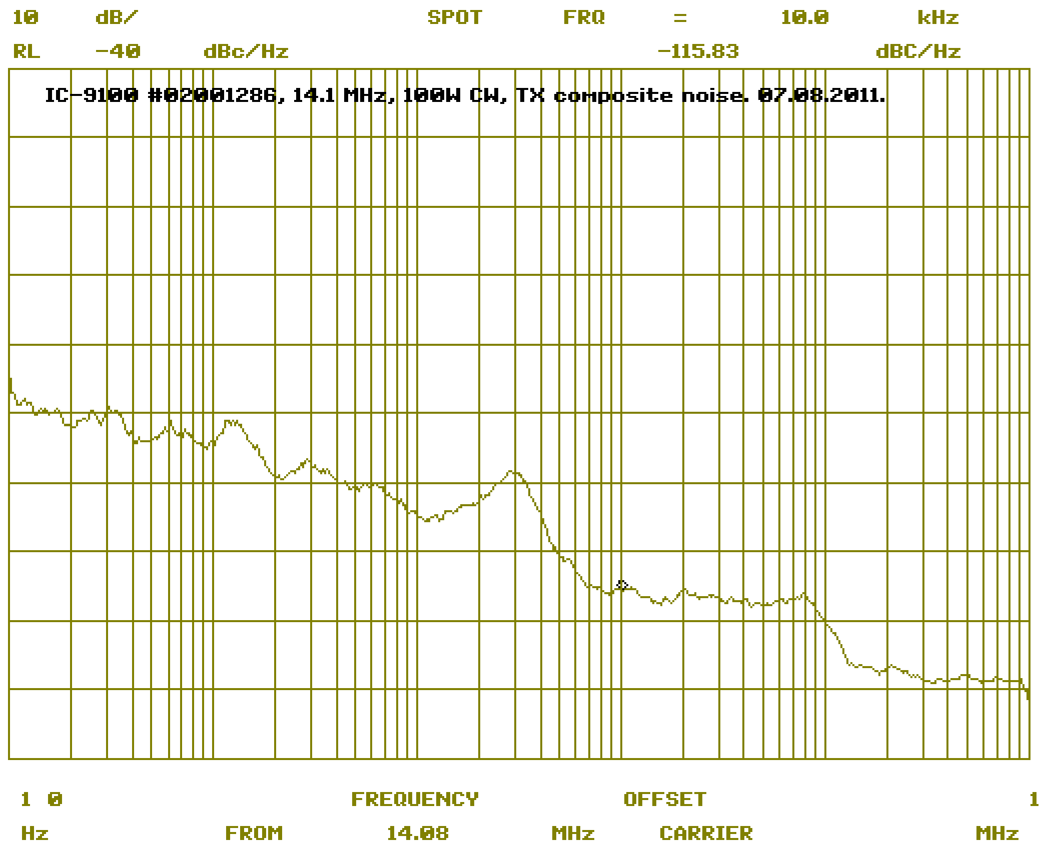


Fig. 24c: Composite noise at 50.1 MHz, 100W.

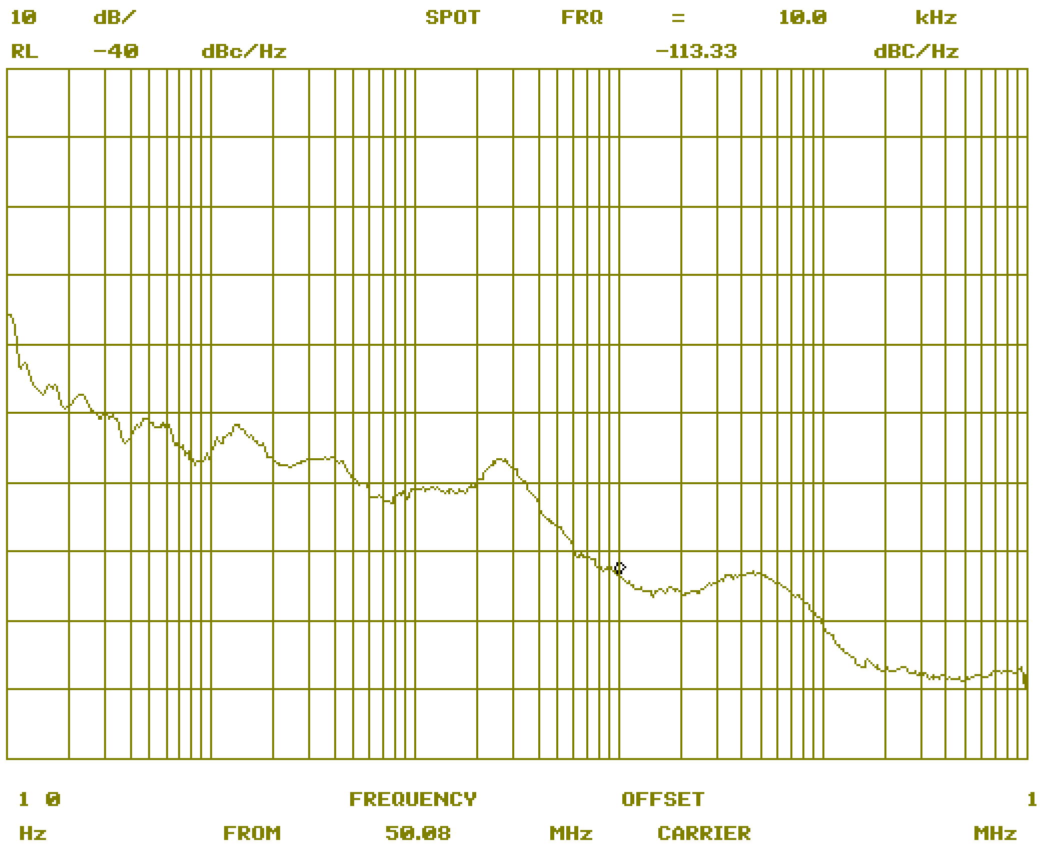


Fig. 24d: Composite noise at 144.1 MHz, 100W.

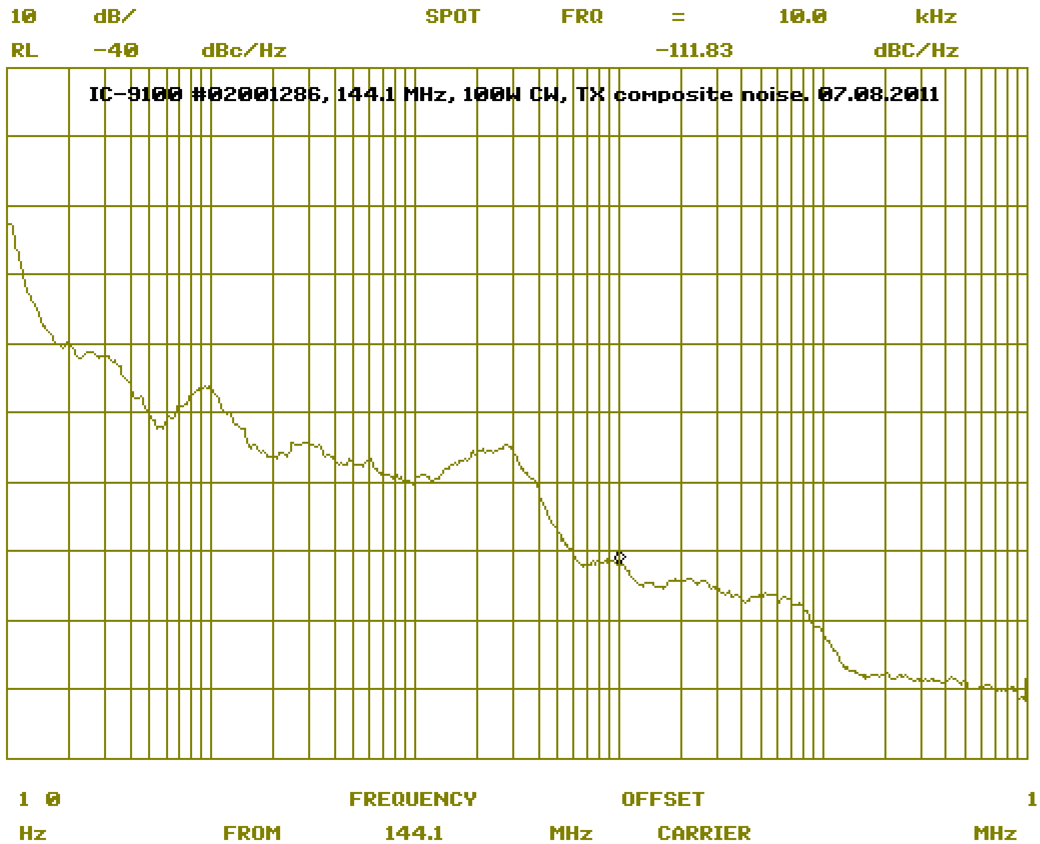


Fig. 24e: Composite noise at 432.1 MHz, 75W.

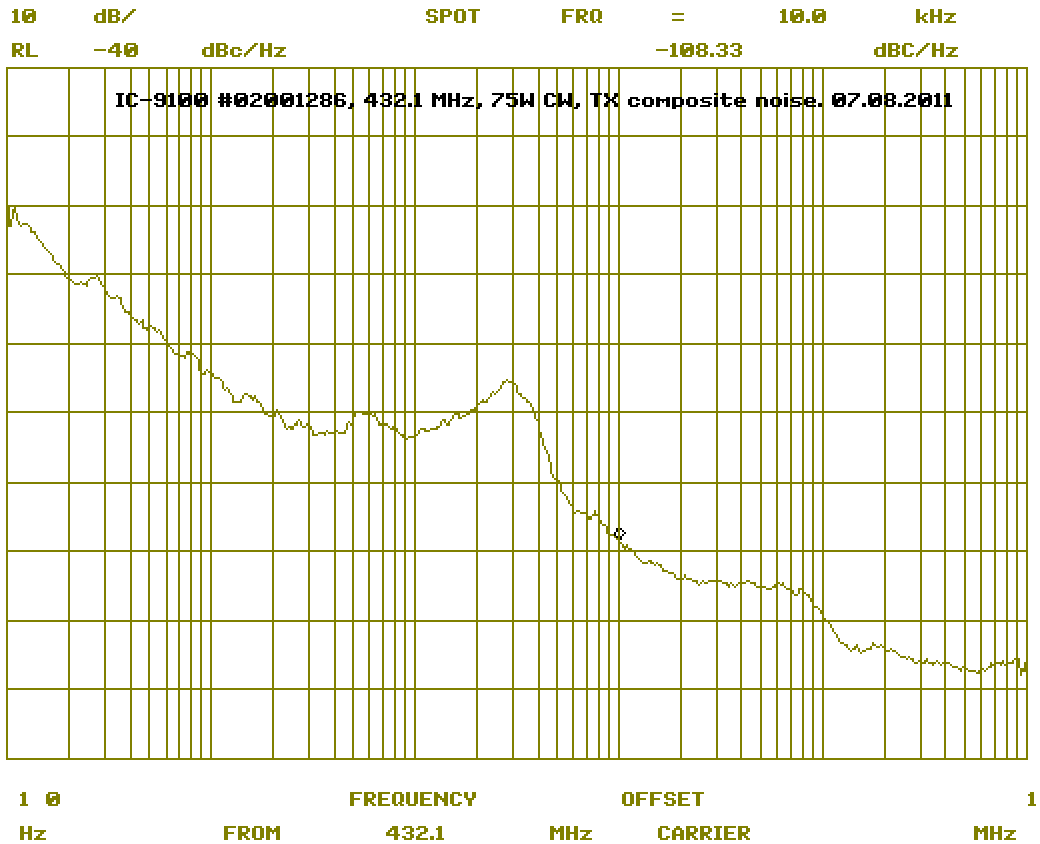


Fig. 24f: Composite noise at 1.241 GHz, 10W.

30: Spectral display of CW keying sidebands. The spectrum analyzer is connected to the IC-9100 RF output via a 60 dB high-power attenuator. The -10 dBm reference level equates to 100W. A series of dits is transmitted at the highest keying speed.

Test Conditions: 14.1 MHz CW, 100W output to 50Ω load. Equivalent keying speed ≈ 50 wpm (KEY SPEED max.) using internal keyer. CW rise time = 4 ms (default). Spectrum analyzer RBW is 10 Hz, video-averaged; sweep time < 4 sec. **Figs. 25a** and **25b** show the transmitter output ±5 kHz from the carrier.

Note the "comebacks" at ±4 kHz; these increase in amplitude as keying rate is increased and decrease at longer rise-time values. They are at < -70 dBc, so they should not normally create an on-air issue

Fig. 25a: Keying sidebands at ≈ 50 wpm, 4 ms rise-time 14.1 MHz, 100W.

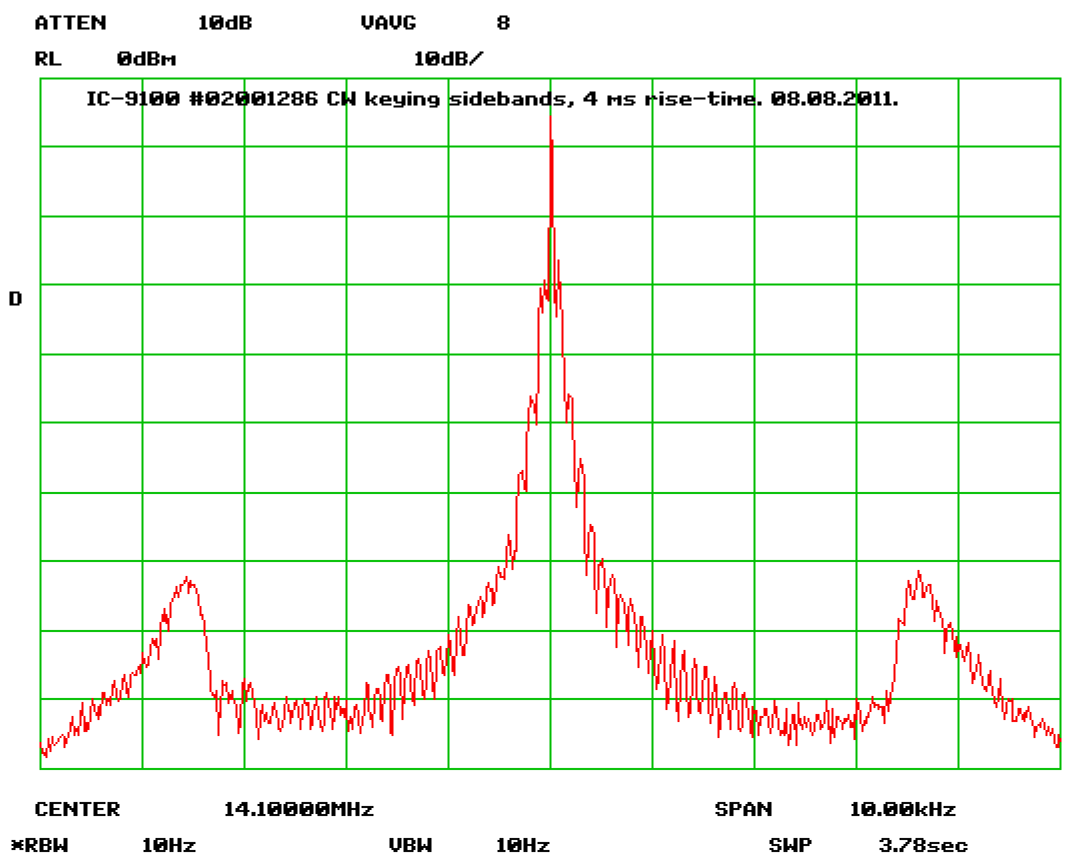
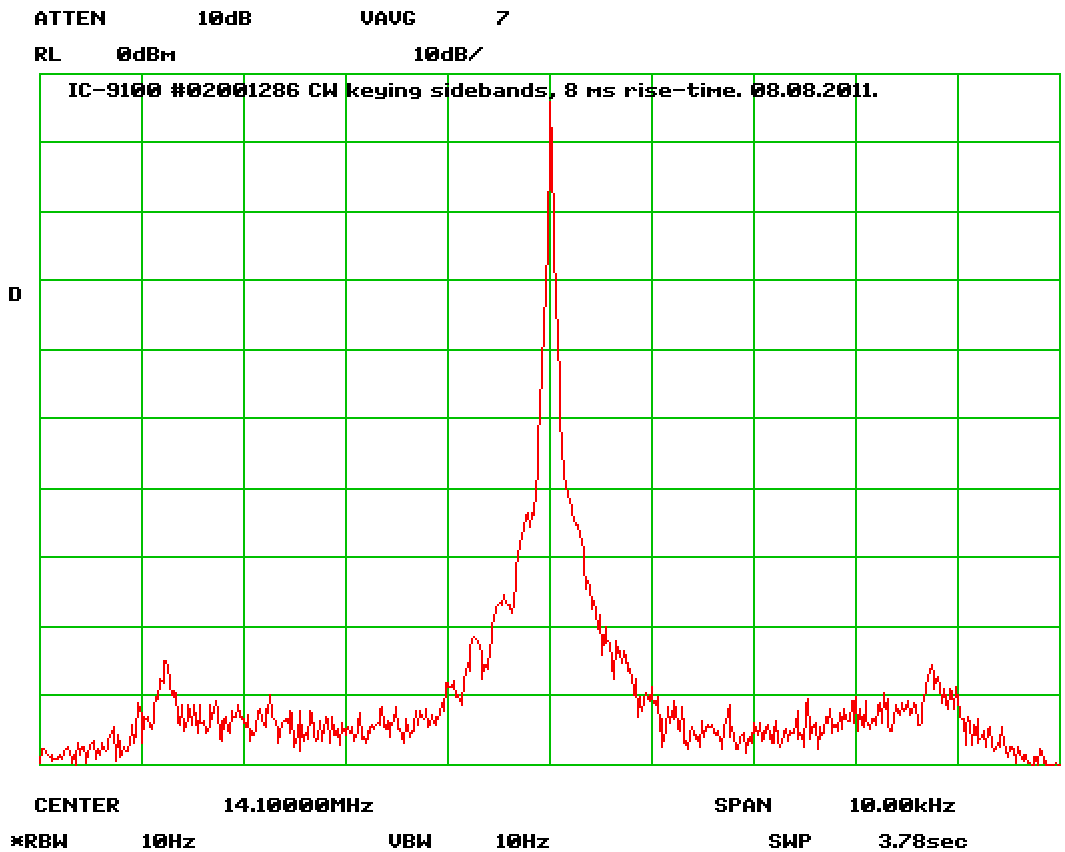


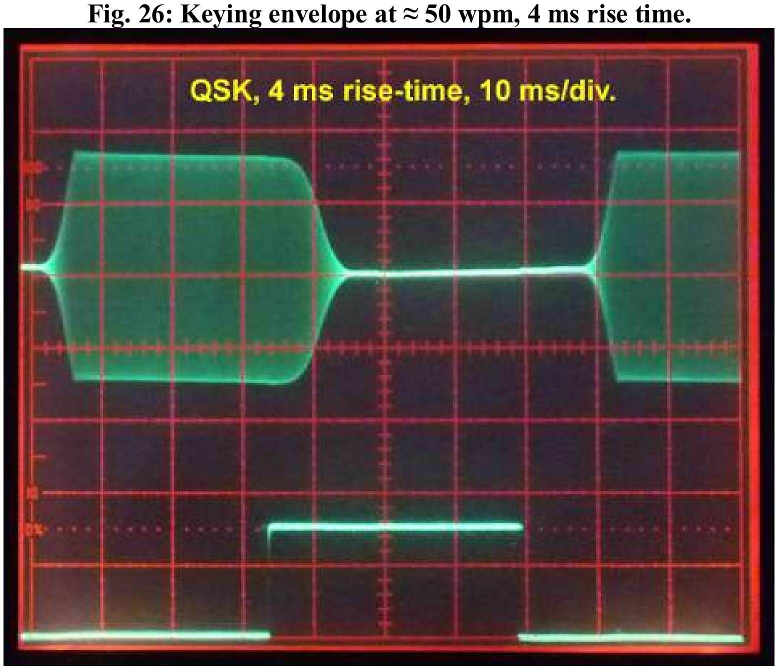
Fig. 25b: Keying sidebands at ≈ 50 wpm, 8 ms rise-time 14.1 MHz, 100W.



31a. CW keying envelope: The oscilloscope is terminated in 50Ω and connected to the IC-9100 RF output via a 60 dB high-power attenuator. A series of dits is transmitted from the internal keyer at the highest keying speed (≈ 50 wpm) in QSK mode (F-BK).

Test Conditions: 14.1MHz CW, 100W output to 50Ω load. CW rise time = 4 ms (default)

Fig. 26: Keying envelope at ≈ 50 wpm, 4 ms rise time.



31b. CW QSK recovery test: This test was devised to address Yahoo! Group reports that CW QSK (full break-in) does not work well when using the internal keyer at speeds > 12 wpm. If a string of dits is transmitted at speeds > 12 wpm, the receiver does not recover between dits.

The IC-9100 is terminated in a 50Ω 100W load via an RF power meter. A test signal is injected into the signal path between the radio's antenna port and the power meter via a line sampler; a 20 dB attenuator at the sampling port protects the signal generator from reverse power. Test signal level is adjusted for S3…S5 at the receiver.

Test Conditions: 14.010 MHz CW, 500 Hz IF filter, preamp off, ATT off, NR off, NB off, F-BK on, rise time = 4 ms, KEY SPEED at max., CW Pitch at 12 o'clock. Test signal at 14.0101 MHz. Sidetone = 600 Hz, received tone = 500 Hz.

Starting at minimum KEY SPEED, transmit a continuous string of dits and increase KEY SPEED until the received tone can no longer be heard in the spaces between dits. In the test run performed on August 7, 2011, the received tone could just be heard at **12 wpm**, but was no longer audible above this speed.

32: ACC Pin 11 (MOD, analog baseband input) level for 100W output.) A 1 kHz test tone is injected into ACC Pin 11, and the input voltage required for 100W RF output is noted.

Test Conditions: 14100 kHz USB, DATA OFF MOD = ACC, DATA-1 MOD = ACC, TBW = WIDE/MID/NAR (default values), Bass/Treble = 0 dB (default), test tone 1 kHz.

Adjust test tone level for ≈ 100W output in USB and USB-D1 modes. The required input levels were **15 mV rms** for 99W output in USB, and **73mV rms** for 96W output (max. obtainable) in USB-D1.

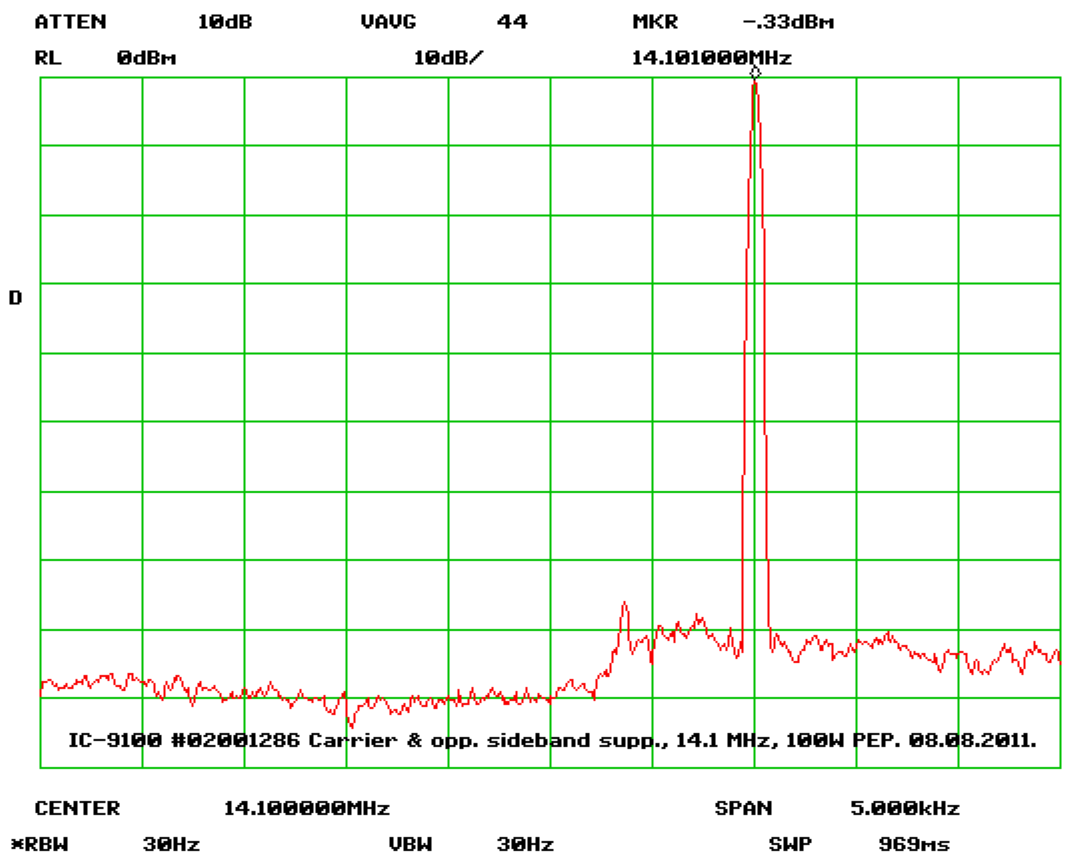
32a: Carrier and opposite-sideband suppression. A 1 kHz test tone is applied to ACC Pin 1, or via the USB port. Carrier and opposite-sideband suppression are checked on the spectrum analyzer at 100W RF output.

Test Conditions: 14100 kHz USB, DATA OFF MOD = ACC, DATA-1 MOD = ACC, TBW = WIDE (default), test tone 1 kHz.

Adjust test tone level for 100W output in USB mode. Read carrier amplitude at 14100 kHz, and opposite-sideband amplitude at 14099 kHz.

Result: Carrier and opposite sideband both < -90 dBc (at or below the spectrum analyzer's noise floor). **See Fig. 27.**

Fig. 27: Carrier & opposite-sideband suppression at 14.1 MHz.



32b: SSB transmit audio-frequency response via USB port. In this test, a white-noise baseband is applied to the USB port from a tone-generator program running on a laptop computer. The spectrum analyzer is connected to the IC-9100 RF output via a 60 dB high-power attenuator. The -10 dBm reference level equates to 100W.

Test Conditions: 14100 kHz USB, DATA OFF MOD = USB, USB Level = 50% (default). Test signal: white noise. WIDE, MID and NAR TBW are at default values.

On computer, adjust USB Audio Codec device volume for 45% ALC reading. Using Marker on spectrum analyzer, measure frequency and relative amplitude at lower passband edge. Move marker "down" 6 dB and record frequency. Move marker "down" a further 14 dB and record frequency again. Repeat procedure for upper passband edge. The test data are shown in **Table 20**.

Table 20: Measured SSB TX lower and upper cutoff frequencies (via USB input).

TBW	Lower (Hz)		Upper (Hz)	
1 kHz = 0 dB ref.	-20 dB	-6 dB	-6 dB	-20 dB
WIDE	50	75	2958	3058
MID	135	280	2702	2820
NAR	380	485	2525	2600

32c: SSB transmit audio-frequency response via MIC socket. To address a user enquiry concerning MIC socket frequency response, a swept measurement was performed manually with DATA OFF MOD = MIC, TBW = WIDE and a 3 mV rms test tone level. **Fig. 28** shows that the MIC input is essentially flat in the range 300 Hz…3 kHz.

Fig. 28.