EVALUATION OF ICOM IC-PCR1000

(with useful data on the WinRadio WR1500 and AOR AR-5000)

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(photo from Icom website)

INTRODUCTION

In this article, the ICOM IC-PCR1000 is evaluated in detail. The IC-PCR1000 is a small, "black box" receiver controlled from a PC via serial port, and widely available for under $400. Because it tunes from 0.5-1300 MHz, it could potentially be used for any form of VHF/UHF DX'ing (TV, FM, PSB, Weatheradio, etc.). The Windows control software provides many useful functions such as a spectrum display and extensive station presetting. A resourceful experimenter could readily use the radio for neat applications like auto-logging, recording ID's with a sound card, locating the receiver at a remote antenna site, etc. One could even program a PC to tune it to specific frequencies and monitor band conditions, and call you at work to let you know there is skip on channel 2!

This article is unique for two reasons. One, it is the first published review intended specifically for VHF/UHF DX'ers, and two, it is the first published source of detailed RF performance test data (not just restating the instruction manual). Note there are many web pages that cover this radio, and many of those go into extreme detail about tuning around the ham bands, using the software, and even hacks to modify its operation. One example is this page, which has a lot of PCR1000 links: http://www.gcn.ou.edu/~jahern/home/pcr1000/. An extensive review written by a ham, focusing on usability and software control, can be found at: http://www.strongsignals.net/htm/revpcr.htm. Icom's website is at http://www.icomamerica.com/receivers/pc/. Check out those links if you're interested in the receiver.

BASIC SPECS (from manufacturer)

Tuning range: 500 kHz to 1300 MHz (cell blocked from 824-849, 869-894 MHz), 1 Hz steps

Demodulator modes: AM, FM, Wideband FM, CW, USB, LSB

Size: 5.0" W x 1.2" H x 7.9" D, 2.2 lbs.

Power: 13.8 VDC +/-15%; uses 700mA maximum

Connectors: BNC jack (50 ohms) antenna, DB-9F for RS232C, 6mm coaxial DC power,

Audio: tiny, built-in speaker or via 3.5mm mini jack for headphones; 200mW

Conversion Scheme: 1st IF 266.7 MHz; 2nd IF 10.7 MHz; 3rd IF 450kHz

(note 3rd IF not used for wideband FM)

Selectivity (-6dB): 2.8 / 6 / 15 / 50 / 230 kHz

Sensitivity (SSB & CW mode, 10dB S/N, 2.8kHz filter):

0.56µV below 1.8MHz; 0.28µV @ 1.8-30MHz; 0.2µV @ 50-700MHz

Sensitivity (AM mode, 10dB S/N, 6kHz filter):

2.5µV below 1.8MHz; 1.4µV @ 1.8-30MHz; 1.0-1.8µV above 30MHz

Sensitivity (FM mode, 12dB SINAD, 15kHz filter):

0.5µV from 28-50MHz; 0.32µV from 50-700MHz; 0.4µV above 700MHz.

Sensitivity (WFM mode, 12dB SINAD, 230kHz filter):

0.79µV from 50-700MHz; 1.0µV above 700MHz.

CONTROL SOFTWARE

A supplied Windows application allows control of all functions. Tuning is supported by direct entry, up/down in user-selectable increments, a virtual knob, scanning, memories, etc. The S-meter is calibrated in ham-radio "S units" (I provide a calibration chart below). The most interesting feature is a "Band Scope" spectral display centered on the tuned frequency, with 4 preset span widths, fixed resolution, and start/stop updates. Software screen shots and downloads are available at the Icom website; I won't take time to describe it here.

CELL BLOCKING

Naturally, the mods to unblock the cellular frequencies are readily found on the 'net. This three step procedure requires removal of one resistor, replacement of another resistor with a zero ohm resistor (jumper), and shorting of a pair of pins.

NARROWBAND FM TEST

Sensitivity at 50MHz, using 15kHz filter: 0.12uV (-126dBm)

I tested the narrowband FM sensitivity using an HP8640B signal generator, coupled directly into the antenna jack. The test signal was a 1kHz sine FM modulated with a deviation of 5kHz, and an RF of 50MHz. The Icom's AGC was enabled, ATTenuator off. For S /N=10dB measured at speaker terminal, the required RF was 0.12uV rms.

Audio response (-6dB) is limited to approx. 250Hz to 2kHz (using 6, 15, or 50kHz IF filter)

WIDEBAND FM TESTS

Sensitivity at 100MHz, using 230kHz filter: 0.7uV rms (-120dBm) for 10dB S/N

2.2uV rms (-100dBm) for full quieting

I set up an HP8640B signal generator, coupled directly into the antenna jack. The test signal was a 400Hz sine FM modulated with a deviation of 75kHz peak-to-peak, RF of 100MHz. The Icom was set with AGC on, ATT off. For S/N=10dB measured at speaker terminal, the required RF was -120dBm (.71uV rms). For full quieting (determined by listening and viewing audio waveform on an o'scope), the required RF was -100dBm (2.25uV rms). The sensitivity did not appear to vary by more than 1dB across 88-108 (just a few points were taken to check this). One will find this radio to be as sensitive as most hi-fi FM tuners, and more sensitive than most TV's and VCR's.

Audio response (-6dB) approx. 80 Hz to 12kHz

Measured capture ratio: 1.5dB approx.

Tested using one 100MHz RF with a 1kHz FM tone; the other RF with a 2kHz FM tone; both RF's summed and applied to antenna. Watch oscilloscope while adjusting relative power level of two RF's to determine when one tone or the other dominates.)

Adjacent Channel Selectivity (+/- 200kHz offset): 28dB

Defined as attenuation measured at center of adjacent channel, i.e. 200kHz RF offset. This radio will have difficulty separating adjacent signals, especially if a high-gain antenna is used.

IF selectivity, 230kHz filter:

280kHz at –7dB down

370kHz at –20dB down

430kHz at –30dB down

This was measured internally, directly at the output of FI3. Wideband selectivity is in a single MuRata ceramic filter, in a standard 3-pin through-hole package (one of the few parts that aren't surface mount) which could be easily replaced with a better unit. I would highly recommend replacing the stock filter.

IF selectivity, 50kHz filter:

50kHz at –3dB

80kHz at –10dB

105kHz at –20dB

160kHz at –40dB

IMAGE REJECTION

Better than 78dB in the FM broadcast band.

An HP8640 signal generator was set to 100MHz, FM, 1kHz sine with 1kHz deviation. The Icom was set for a 6kHz filter, AGC on and ATT off. To get 15dB SINAD at the audio output required an input power of –126dBm. Then the signal generator was set to 121.4MHz and output power increased until the same SINAD is seen; this occurred at a power level of –48dBm. Therefore, image rejection is 78dB. The test was repeated for a test signal RF of 533.4 (to test the 1st IF), and both tests were repeated for a tuned frequency of 450MHz.

INTERCEPT POINT

IIP3 @ 20MHz = -14 dBm

IIP3 @ 100MHz = -28 dBm

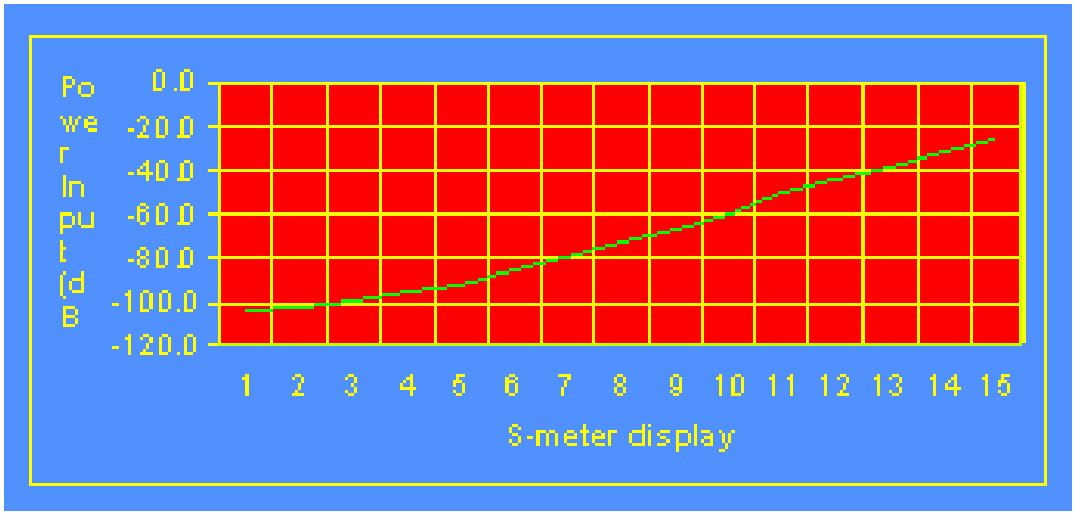
IIP3 @ 450MHz = +20 dBm

To measure 3rd order input intercept point, I used two HP8640 RF signal generators summed in a Mini Circuits ZSC-2-2B "splitter," and monitored the audio output on a spectrum analyzer. I used FM signals, having a 1kHz tone modulated with a deviation of 1kHz. The PCR1000 was tuned to 20MHz, AGC off, AFC off, ATT off, FM detector enabled, 6kHz filter bandwidth. I found the input level required for 15dB SINAD to be –118dBm; this is the reference. Then, with the two generators set at 20.2 and 20.4MHz (i.

*e. **200kHz spacing**), increased the input power simultaneously until I saw the same SINAD at 20.0MHz. This level was –52dBm. Therefore, the IIP3 = -14dBm. (-52+((118-52)/2)) The test was repeated at 100 and 450MHz. These values are low and the user will find the radio compresses easily in the presence of strong signals.*

S-METER CALIBRATION

Input Power (dBm/uV RMS)	S-meter display	Band Scope
-110/0.710	no indication	nothing
-100/2.25	4.0	5% of full scale
- 90/7.1	6.2	13%
- 80/22.5	7.8	20%
- 70/71	9.1	30%
- 60/225	15dB over S-9	45%
- 50/707	30dB over S-9	55%
- 40/2250	45dB over S-9	65%
- 30/7071	58dB over S-9	75%
- 20/22.5mV	pegged	85%
- 10/71mV	pegged	100%



Test was done by simply noting the power level input at the antenna jack. S-meter readings don't change with modulation type or varying deviation.

POTENTIAL FOR WIDEBAND USE (e.g. TV)

The IC-PCR1000 can tune in TV audio of course, but no provision is made for a video output. I looked around inside and found a point labeled "HFI8" where a wideband IF signal at 10.7MHz is available. It is spectrally upright and appears to have a 3dB bandwidth about 5MHz. This might not be the best point in the receiver to install a TV demod, but it demonstrates that sufficient bandwidth may be available. It would be neat to see Icom offer a TV demod module, with composite video out.

USE TESTS: FM & TV RECEPTION

The test unit was used at a location about 40 miles W of Washington, DC. Using an outdoor random wire, 150' long, 20' above ground, strung between trees and unmatched to unit, I could tune in 50 FM stations clearly.

Using a CM3025 (a 9-element, outdoor FM antenna) pointed south, I could tune in 38 FM stations clearly, and 5 more so distorted as to be unlistenable. Three local stations (WPER-89.9, WPLC-94.3, and WTOP-107.7), all within 10 miles, were the strongest signals. The noise floor with the CM3025 connected was at –80 dBm (S-7.0 on the S meter) from 84 to 114MHz, thus rendering the unit unusable for weak signal detection. (And that with the 20dB attenuator engaged.) With a compression point of –15dBm, the dynamic range is 65dB.

With a Radio Shack VHF/UHF antenna mounted in the attic and pointed to maximize Washington TV channels (4/5/7/9), all local TV signals could be tuned in but the PCR1000 was severely overloaded. For example, the RF's of channels 3, 6, 15, 16, 17, 18, 19 (where there are no broadcasters within 100 miles), were occupied with strong images, making them useless for DX'ing. Even with the 20dB attenuator engaged, the noise floor was still at –80dBm, way too high for DX.

Are these fair tests? Well, maybe. ICOM doesn't say in its instruction manual what the intended use of its radio is. It is supplied with a 24" telescoping whip on a self-adhesive plastic mount that can be attached to a window. ICOM recommends their AH-7000 "wide-band base station antenna" which is actually a discone. I believe Icom is right to do so. I tried connecting the unit to a similar discone, with 150' of coax, and had reasonably good results. ("Reasonably good" means the unit doesn't overload or desense, and lets you enjoy tuning around anywhere you want from LF to UHF without frustrating images and noise.) This is great for scanner enthusiasts, but of course a discone may be of little value to a DX'er except to monitor general band conditions. At least one reviewer agrees that a wideband discone is the best antenna for this; he used a Radio Shack model and had excellent results.

COMPARISON WITH OTHER EQUIPMENT

OKAY, are there other PC-controlled radios out there that might be suitable for a VHF/UHF DX'er? There is one on the market that might be worthy of serious consideration. The Rosetta Labs WiNRADiO model WR-1500 is comparable to the Icom in general capability and price, and can be purchased in a small black box (just like the IC-PCR1000) or as an ISA card that goes *inside* the PC. The ISA version is the WR-1500i; the external box is the WR-1500e. (Please note in this article we will test the WR-1500i; the manufacturer has updated this radio and now offers the WR-1550i, which they claim incorporates some performance improvements, at the same price. I don't believe the RF performance is claimed to be much different, however.) The manufacturer has a good website: http://www.winradio.com/home/1500i.htm.

These Australians have made probably the best attempt to put a wideband receiver into a PC. At $550 list price, the WiNRADiO costs a bit more than the PCR-1000, but it tucks right inside your desktop via a full-length ISA slot. In addition, the company sells software packages that help to make the most of a PC controlled radio. The $100 "Digital Suite" software has very good spectrum analyzer and time domain displays, audio recorder, an application that recognizes the different types of signals (voice or data, versus a spur or noise peak), and modules that decode some HF Fax and amateur packet transmissions. Another $100 suite processes trunked systems. And a third, optional, $100 suite is a sophisticated logger/ database for keeping track of all the signals you can listen to on this.

If you have $2000 to spend on a computer-controlled receiver, you could also buy the desktop AOR AR5000. Since we had one available, we tested it at the same time. It tunes 10kHz to 2600MHz. (A nice round-up of internal photos, block diagrams, technical specs, and reviews on the AR5000 can be found at this site - http://www.aoruk.com/ar5000.htm.) The AR5000 has a tunable preselector built in (much of the reason for the expense!) so I figured it would be fun to look at, as well. Perhaps, at 5 times the price, it would "blow away" the IC-PCR1000?

DYNAMIC RANGE COMPARISON

Since the testing methods were described in detail earlier, I'll just go right to the results here. Table 1 shows the measured sensitivity (using the available wideband IF filter, no attenuator, FM demod, and for 13dB SINAD) at several frequencies of particular interest to FM/TV DX'ing. Table 2 shows the 3rd order input intercept point.

Test frequency	Icom IC-PCR1000	WinRadio WR-1500i	AOR model AR-5000
70 MHz (TV-4)	-126 dBm	-108 dBm	-118 dBm
100 MHz (FM)	-126	-106	-118.5
221 MHz (TV-13)	-120	-108	-118

500 MHz (TV-18)	-126	-113	-117.5
650 MHz (TV-43)	-124	-112	-118.5
800 MHz (TV-69)	-121	-111	-119

Table 1. FM Sensitivity (dBm) for 13dB SINAD

Test frequency	Icom IC-PCR1000	WinRadio WR-1500i	AOR model AR-5000
70 MHz (TV-4)	-14 dBm	-41.3 dBm	-11.5 dBm
100 MHz (FM)	-28	-40.0	-13.5
221 MHz (TV-13)	not tested	-39.0	-13.8
500 MHz (TV-18)	-20	-30.5	-14.0
650 MHz (TV-43)	not tested	-48.3	-18.8
800 MHz (TV-69)	not tested	-38.3	-16.3

Table 2. 3rd Order Input Intercept Point (200kHz separation)

The Icom is the most sensitive unit of the three (even more sensitive in the FM band than my dedicated FM tuners at home, which run about -115dBm on a similar measurement).

For benefit of those not familiar with "3rd Order Intercept Point," this is one, standard way to evaluate how well a receiver can handle strong signals. The higher the number (algebraically), the better. If a receiver doesn't have 0 or above "3IIP" you can pretty much expect it to overload when connected to an antenna with gain (as evidenced by desensing, and/or ghost copies of strong radio stations showing up on the dial). Running this test involves increasing the power of the two signals (F1 and F2) until the mixing products (2F2-F1) reach the 13dB SINAD sensitivity power level, then calculating the "intercept" point from this. For my tests, I used two wideband FM signals spaced 200kHz apart, to simulate realistic broadcast band conditions faced by US DX'ers. Also, 200kHz spacing makes both test signals fall within the passbands of the receiver. (Testing with one of the signals outside the IF filter bandwidths make the receiver look better than it really is since the IF filter will attenuate it!)

None of the units tested show good 3IIP. With such low 3IIP, you can rest assured that the radios will be unusable with any large, high-gain antenna connected to them. (For comparison, my Kenwood KT-990D FM tuner has about 0 dBm for its 3IIP; a Carver TX-11 would be up about +10dBm or more; an average, sub-$200 hi-fi tuner will typically run about -20dBm on this

test. Of course, an FM tuner is designed for a much narrower range of frequencies, so it has an automatic advantage over these wideband radios we're discussing.) The AOR receiver actually did not perform as well as the Icom, and the WinRadio was the worst of the three. For the FM/TV DX'er, there is little about any of these three products to be recommended, but for the money the Icom unit is the best choice.

In the IC-PCR1000, I was unable to determine what, if any, preselection is used...the performance and price would imply there is none! I would have hoped for a preselector, since that would open up the possibility for some really interesting applications (like remote control). But keep in mind the unit only costs $400, and gives 1.3GHz of coverage! It's impressive in that sense, but I would like to see Icom offer a "premium" version with a tunable preselector and improved strong signal performance. Such a version would cost a lot more, but I believe many would be willing to pay, and it would make the product more "unique." (Rosetta sells a high-performance/professional version of the WinRadio, the WR-3100, that has 20dB better dynamic range--still not really enough for a high gain antenna--and it costs $2100.)

CLOSING COMMENTS

The IC-PCR1000 is very well constructed in a steel box, with a quality circuit board that has silk screen, solder resist, and no "white wires." It looks clean and professional on casual observation. Conceptually it works well, i.e. a "black box" receiver controlled by a PC which can provide truly useful scanning, logging, and memory features. Functionally the unit performs well. I had zero problems with the software, hooking it up, and using it in my office for several weeks. However, it is like a scanner in the sense that it cannot be connected to a high-gain antenna or used for serious DX. It works well with a whip, discone, or other modest antenna for casual listening, but it cannot handle the types of antennas DX'ers would want to use. A serious FM/TV DX'er would do better to take the $400 or so and find a used IC-R7000 on e-Bay.

Disclaimer: these tests are intended to demonstrate the utility of these radios for FM and TV broadcast DX'ing only. No claim is made or implied about how the radios will work for other modes and uses. Also note I only tested one sample of each model. All three were purchased in open retail channels (from Universal Radio).

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