IC-9700 VHF UHF all mode transceiver

Peter Freeman VK3PF

Photo 1: The non-identical twins: the IC-9700 and the IC-7300.

Those interested in the world of VHF, UHF and microwave communications have been discussing the newest offering from Icom since a sample was displayed at the Tokyo Ham Fair in August 2017. Promised as the first transceiver using Software Defined Radio (SDR) architecture covering the 2 m, 70 cm and 23 cm bands, amateurs around the world have been speculating on the features and likely performance of the IC-9700. Of recent weeks, the speculation was primarily about the selling price in various markets and then the likely delivery dates of the first units into the amateur markets in various continents.

At first glance, the IC-9700 looks very much like the first SDR offering from Icom: the IC-7300 HF and 50 MHz transceiver. The IC-7300 was the first offering from one of the major amateur transceiver manufacturers to deliver a Direct Digital Sampling and Direct Digital Synthesis transceiver. Other offerings were available in the market place from other manufacturers, but at the time they required a separate computer to drive the transceiver. The IC-7300 delivered a SDR but with a familiar user interface built in: VFO knob, a colour display and several familiar control buttons. It also introduced a very detailed set of optional features and settings available via the touch screen display and associated menu system.

The new IC-9700 delivers many of the features of the IC-7300 but in a VHF/UHF transceiver. In addition to the colour touch screen display and comprehensive settings menus, the transceiver gives a real-time spectrum scope and a waterfall display. In addition to the 2 m and 70 cm bands, the IC-9700 has the 23 cm band built in as a stock item. In the predecessor transceivers (IC-910 and IC-9100), the 23 cm band was a relatively expensive optional module. The IC-9100 could also have an optional module added to give access to D-STAR (Digital Smart Technology for Amateur Radio) Digital Voice (DV) mode, with an associated low-speed digital data capability.

The IC-9700 delivers D-STAR built in to the unit, with the higher speed Digital Data (DD) mode available on 23 cm. It also includes Satellite mode, using any combination of two of the three bands. The transceiver comes with three antenna connectors: an SO239 socket for 2 m socket, and separate N type connectors for the 70 cm and 23 cm bands.

System architecture

Similar to its HF relatives, the IC-7300 and IC-7610, the antenna connector for either the 2 m or 70 cm band connects to a band-specific preamplifier/attenuator module before passing to a band pass filter (BPF). The signal path then passes through an RF switch before going to an analogue-digital convertor (ADC) to be digitised. The digital signals from the ADC then pass to a Field Programmable Gate Array (FPGA) IC for processing. The FPGA has several outputs: recovered audio to a Digital to Analogue Converter (DAC) to pass to the speaker or headphones, to the CPU for processing and to produce the scope displays, or to a DSP unit for processing DV signals. In the case of the 23 cm band, the incoming signal passes
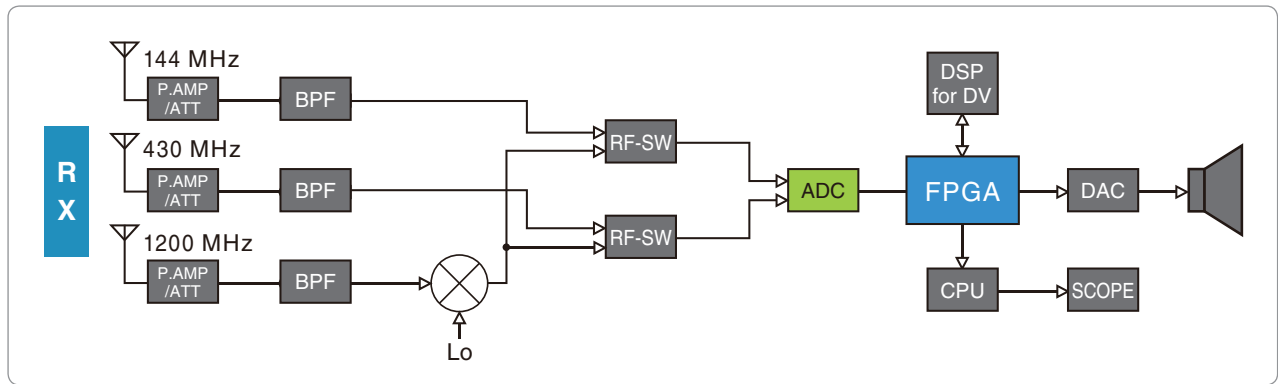
Figure 1: IC-9700 functional block diagram.

from the BPF to a mixer for a single conversion stage to an IF frequency (311 – 371 MHz) and thence to the RF switch and into the ADC for sampling. See Figure 1.

The process for transmit is similar, but in the reverse direction: Audio frequencies are sampled by an ADC; the digitised audio is processed in the FPGA and then produced as an RF signal at the required frequency by a DAC. The RF signal will then be processed with appropriate filtering and amplification on its way to the RF connector.

Control of the transceiver is via a number of typical switches and knobs, with additional controls accessible via the touch screen display. The first Menu level gives quick access to the more commonly used options. Settings which are typically rarely changed after they are first configured are in lower level menus, notably through the SET menu on the first level Menu screen.

The IC-9700 can receive on two bands at the same time, with two independent receivers. The bands must be different, but any mode can be in operation on each receiver. The radio can operate full duplex, so you can transmit on one band whilst still receiving on the second band.

Unpacking

The box is of different form factor to that for the IC-7300. On opening the box, you will see the Basic Manual in a plastic bag resting on a cardboard divider. Removing the divider reveals the next layer, with the HM-219 hand microphone, DC power cable and supplied accessories sitting in the middle section. Supplied items include two 25 A fuses, one 5 A fuse and a 3.5 mm (1/8") stereo plug for use for connecting a CW key or paddle. Lifting out this layer leads to the radio sitting in its foam plastic bag. The radio comes with a protective plastic film across the colour TFT display. Most users will wish to remove the film to enable easier access to the soft control buttons displayed on the menu system. Screen protector films are available on the market for the IC-7300 and should fit the IC-9700. A web search should bring up several options.

The 96-page Basic Manual is also available for download on the Icom Australia website, as is a brochure. Readers considering purchasing the radio might consider reading both the brochure and the Basic Manual to assist in your deliberations. Also available for download from the Icom global site are an Advanced Manual (173 pages), a CI-V Reference Guide (27 pages) and an instruction sheet and the installation package for the CS-9700 software. At the time of receipt of the radio, it appears that at least one page (page 2-2) was missing from the Basic Manual, both the hard copy supplied with the radio and the downloadable version. The Japanese language Basic Manual has pages 2-1 to 2-3. Icom

was alerted to the issue and have released a revised manual available for download. The pages concerned cover some of the basic connection features to the rear connectors, including USB and the accessory (ACC) connectors. If needed, download the revised Basic Manual from the Icom Australia website.

Connectivity

In addition to the three RF connectors and the DC power connector, there are several other connections available on the radio.

The front panel has the usual 8-pin microphone connector in the lower left corner, with a 3.5 mm stereo headphone jack located above the microphone connector. The front panel also has an SD card slot on the lower right edge.

The rear panel has the three antenna connectors and the DC power connector running across the upper portion. To the left there are two connectors below the 144 MHz antenna socket: an Ethernet connector (LAN) and an SMA socket for inputting a 10 MHz reference signal (REF). To the right hand side of the cooling fan, you will find the remaining connectors: an eight pin DIN Accessory (ACC) socket, a 2.5 mm stereo Data jack (DATA), an USB Type B port (USB) for connection to a PC, a 3.5 mm stereo jack (KEY) for a straight key or paddles, a CI-V remote control jack (REMOTE), two 3.5 mm mono external speaker jacks (EXT-SP SUB and EXT-SP MAIN), and a Ground terminal (GND).

The USB connector is flexible, with similar functions to those on the IC-7300 and IC-7610. It installs on a PC as both a communication port and as a sound card. The radio can output decoded RTTY data, demodulated audio signals or a 12 kHz IF signal, accept AF modulation input, interface for CI-V commands, clone the settings data using the CS-9700 software or remote control using the optional RS-BA1 version 2 software. It should be noted that the version 2 of RS-BA1 software must be purchased.

The LAN port can also be used for several functions: time synchronisation via an NTP server, outputting the demodulated AF signal or a 12 kHz IF signal, remote control using the optional RS-BA1 software, D-STAR Gateway communication or data communication for D-STAR DD mode.

For amateurs attempting weak signal communications, the radio can be set to support external low noise preamplifiers supplied by the user. This includes the older Icom preamplifiers which are no longer in production.

Getting on air

Connecting up the radio to a power supply, antennas and connecting the microphone was simple: the labelling on the rear of the radio gives a clear indication of each connection. The loan unit came supplied with firmware version 1.04. The main batch of radios arrived a couple of weeks later, with firmware version 1.05 installed.

I soon had a screen displaying odd ball (for local usage) frequencies in 2 m and 70 cm – the unit supplied was one of the USA variants, so the default frequency fit with USA band plans. It was simple to tune to the local repeater for 2

m and I soon also had the local 70 cm repeater output on screen. All of this without looking at the Manual – many features are similar to those on the IC-7300. I soon figured out how to switch between the Main and Sub bands: a long press of the MAIN: AF / RF/SQL centre button. Looking at the labels reveals that a long press on the centre button of the SUB: AF / RF/SQL centre button switches off the SUB band, leaving only one band active.

I soon had the basic Menu settings correct to set both the Duplex and the CTCSS Tone and had my first contacts on the 70 cm repeater. I had not adjusted any of the other controls, such as microphone gain or any of the Tone controls. I received comments that I sounded slightly different to normal, but I am sure that I could adjust settings to fix that difference: something to explore when I had more time to explore the radio.

I next dialled up the local 2 m and 70 cm beacons and immediately had signals from both, right on frequency when in CW mode. I could not yet check the 23 cm beacon as I had no antenna connected.

As with the IC-7300, the received audio quality sounds clean and crisp, being very pleasant for listening. Reports on the transmitted audio were also good.

I then started exploring the radio further, this time in conjunction with reading the manual. As with any SDR, there are many settings to configure. The basic configurations are covered in the Basic Manual. The first step should be to examine Section 1 of the Basic Manual, which describes the Panel features, including the various screens displayed on the touch screen display, together with lists of the available options on several of the screens. Section 2 covers the

basic installation and connections with references to some additional information later in the manual.

Section 3 covers basic operation, describing the fundamentals of changing frequency, band, mode, the dual watch feature, selecting Main and Sub bands, and several other basic options. These include setting microphone gain, an important setting if you are to not upset other amateurs when transmitting.

Section 4 examines most of the functions and controls required for Receiving and Transmitting, including several key controls.

Section 5 covers the controls for the Spectrum Scope and Audio Scope displays.

Section 6 describes the various tasks that make use of the optional SD card, including saving current settings and importing and exporting data.

Section 7 describes the Satellite

Communications settings.

Section 8 gives an outline of each of the options under the SET mode menus.

Section 9 describes the Clock settings and the operation of the NTP time synchronisation function.

Section 10 covers basic maintenance operations, cloning, rest and troubleshooting.

Section 11 lists the Specifications, whilst section 12 lists the available Options.

Section 13 gives details of the various Connectors.

More detailed settings and operational requirements are included in the Advanced Manual.

The "new" digital modes

Most amateurs are aware of the explosion of activity on the HF bands of the "new" digital mode FT8, which is included in the WSJT-X software suite. Many amateurs on VHF, UHF and

microwaves have been using other WSJT modes for many years. Readers of the *VHF/UHF - An Expanding World* column would be aware that WSJT modes have transformed operations on the weak signal segments of the VHF, UHF and microwave bands. Some of those modes require excellent frequency stability and accuracy to yield the best weak signal performance. Many keen operators were expecting that the inclusion of a 10 MHz Reference port on the IC-9700 meant that they would be able to reference lock the radio with a good quality 10 MHz frequency source – many operators currently use GPS-locked 10 MHz frequency sources to lock their radio master oscillators to the correct frequency, thus giving accurate frequency readout without any associated frequency drift.

As currently configured, the IC-9700 only has the capability of performing a "REF adjustment", allowing a "rough frequency calibration using the external reference frequency signal". This option is several layers deep in the SET menus. Once performed, the reference frequency is set close to the external reference. On exiting the function, the reference oscillator continues to behave as it would normally. See the comments in the break out box on digital modes regarding frequency stability.

At the time of writing, most of the software packages have not yet added the IC-9700 to the list of supported radios. This situation is changing rapidly as software authors are approached by users to add the new radio. As an interim measure, operators have been changing the CI-V address setting to that of another of the Icom transceivers, typically the IC-7300 or the IC-9100.

Operating any of the new or more established soundcard digital modes should be simple, once you have the radio and computer set up correctly. Once all the settings are correctly configured, CAT control and bidirectional audio between the radio and the computer can occur using only the USB cable, in a similar fashion to the operation of the IC-7300 and IC-7610.

Filter bandwidth can be set to as wide as 3.6 kHz with "Sharp" shoulders, giving increased bandwidth available for the modes such as FT8, MSK441, ISCAT-B and QRA64-E. See the break out box on digital modes for further comments.

A number of advanced features are available for operating CW and RTTY. The user can store up to eight (8) memories for each of CW, RTTY and Voice. The radio will decode RTTY signals. It is simple to access the required control and display screens, with detailed explanations available in the Advanced Manual. The Advanced Manual also explains how to record audio made whilst in a contact and recording Voice TX memories.

There are many other functions to explore, such as Tone and DTMF, Memory operation, setting Scans, interfacing and using an external GPS receiver. There are detailed descriptions on using D-STAR DV and DD modes. D-STAR users will find the GPS functions useful if using the radio portable or mobile, where the position data can assist in locating the nearest repeater.

CS-9700 Programming Software

About a week after the loan radio was acquired, the free CS-9700 Cloning/Programming software became available on the Icom Global site. The software runs on Windows 7 and above. Initially, read the instructions document, then download and install the package. Connecting to the radio is simple via the USB port. I started with the USB cable plugged into the radio with the radio turned on. After installing the CS-9700 software package, I plugged the USB cable into the computer. Provided that the required driver software is already installed, the software will open and should auto-detect the radio COM port. If this does not occur, try clicking the Search button.

The programming software can also be used to read and save information via an SD Card.

The radio has 99 memory channels per band, which should be sufficient for most users. To import a repeater list, you need to create a CSV file, as cut/copy and paste from another application is not available. The programming software instructions are good at explaining how to setup the PC and radio for import / export but do not explain the CSV input format required. To determine the format, I created a couple of memory channels, saved them to the radio, exported the CSV file and inspected its contents. One can then create a CSV file in the right format to load into the radio.

Switching between memories and VFO is a single button (V/M), scanning the memories is easy; as is repeater operation once the memory channels have been programmed. You can select memories by number or rotate the MULTI knob to manually select them. Switching between bands is easy via the touch screen or by pressing the AF knob to switch between A and B. The radio can only dual watch two different bands i.e., you cannot monitor two channels on the same band.

The SD card can also be used to transport firmware upgrades. Note that it is recommended that the user save the existing radio settings to an SD card prior to performing a firmware upgrade.

RS-BA1 software

Icom also have for sale the RS-BA1 IP Remote Control software package. The software is now in Version 2, which adds additional functionality for the transceivers with dual receivers. The user must purchase version 2 or above to support this radio. The software allows most functions of the transceiver to be controlled from a local PC connected to the radio, or over the internet. The software

can also be used with several other Icom radios.

The software has not been included in this review.

Operational tests

In general, the radio is easy to use. Received audio is excellent. Reports of transmitted audio have been positive. Some users have reported noticeable frequency drift when using the radio on SSB on 70 cm and 23 cm.

Satellite operators have been reporting excellent performance, once they have software settings correctly configured for the radio.

Once configured, the radio is easy to use in D-STAR modes.

A number of tests were conducted to assess performance parameters. Some quick tests were undertaken on the unit supplied for review, with more detailed tests

conducted on a retail purchased transceiver. We were impressed with the performance figures obtained, with the receiver performance easily better than the specifications in the Icom documentation. Transmitter performance was as specified.

Frequency stability was checked on the 23 cm band after allowing the test unit to warm up for at least two hours. The test signal was a GPS locked signal generator operating at 648 MHz, with a clear stable second harmonic audible in the receiver. The received signal was within 5 Hz of the expected frequency. The test transceiver had been updated to Firmware version 1.06, which was released 19 April 2019. The firmware update improved the performance of the Reference Auto-Calibration routine.

A test of transmitter frequency stability showed a drift of 2 Hz over

a 2-minute transmit period using WSPR mode, which is considered acceptable. Several users have reported unacceptable levels of frequency drift. It seems that there is some variability between individual radios.

Tests on two units failed to observe any power spike upon commencing transmitting. The observations were made using a spectrum analyser with a peak-hold function, and with a suitable fast oscilloscope. Some users on the IC-9700 Group at groups.io reported tripping of protection circuits in attached amplifiers. These issues were resolved by changing the TX Delay setting from the default OFF to a value such as 15 or 30 ms. The setting can be found via: MENU, Function, Tx Delay. Some users have expressed opinions that longer delays may be

desirable, especially where the user is driving a microwave transverter with the IC-9700. It is possible that such longer delays might be introduced via a firmware update in the future, but other interfacing solutions are possible, such that the longer delay occurs via an outboard sequencer unit which only activates the transceiver after the transverter has reached the desired state before RF is sent.

One US amateur is well regarded for his independent tests of transceivers and receivers: Rob Sherwood NC0B. Rob has given permission for us to reproduce the results from testing his IC-9700 on the 2 m band, as well as comparative test results from the IC-9100, IC-275H and FT-736. See Table 1. For those interested in more detailed test results, Rob's findings will be available for download from the WIA website page for this issue. Readers can also visit Rob's website: *http://www.sherweng.com/table.html*

Most of the data on the Receiver Test Data page relates to HF transceivers and receivers. Table 1 shows a selection of VHF capable transceivers and receivers measured on the 2 m band extracted from Rob's data. The noise floor and sensitivity measures for the IC-9700 are at the head of the pack. The filter rejection measure is exceptional, at 100 dB.

Issues to consider

There appear to be some issues if the amateur wishes to work at the extremes of performance and thus require a truly stable frequency source. The author considers the implementation of the use of the external 10 MHz reference in the current manner to be a significant disappointment – many possible purchasers were expecting that the presence of the input port indicated that a quality external reference would be able to lock the master oscillator, as seen in the IC-7610 and IC-R8500. Depending upon the detailed architecture used, it might be possible for the Icom engineers to develop a firmware solution which overcomes the frequency drift observed by several users.

For the amateur interested in exploring the weak signal segments of the bands, there will be another challenge to solve. The IC-9700 will only transmit on one band at a time. Accordingly, only a single PTT line is available on the 8-pin DIN interface connector on the rear of the transceiver. Anyone wishing to interface the transceiver to external power amplifiers will need to consider their switching options. It might be possible to set the transceiver to use an external preamplifier and thus use the DC signal available on the individual band coaxial line for switching. Another option would be the use a PIC or other microcontroller (Arduino, RaspberryPi, etc.) together with suitable sequencing (software and/or hardware) to control the radio's PTT line in conjunction with a main PTT switch, using the band data available from the CI-V signals (either via the USB port or the CI-V port), to ensure that all receive preamplifiers are protected and power amplifiers and radio are only activated after all devices are in the required transmit configuration.

To be fair to the manufacturer, some of these issues represent challenges that the amateur wishing to work at the limits would expect to have to solve.

Table 1: Receiver test data from Rob Sherwood NC0B.

Device Under Test	Noise Floor (dBm)	AGC Thrshld (uV)	dB	100kHz Blocking (dB)	Sensitivity (uV)	LO Noise (dBc/Hz)	Spacing kHz	Front End Selectivity	Filter Ultimate (dB)	Dynamic Range Wide Spaced (dB)	kHz	Dynamic Range Narrow Spaced (dB)	kHz
Icom IC-9700	-131 -145 [2]	0.7 0.18 [b]	3	111	0.35 0.082 [b]	130 138	10 50	B Bandpass	100	74	20	74	2
Icom IC-9100	-133 -141 [b] -141 [2]	2.4 1.0 [b] 0.39 [b1]	3	N.A.	0.36 0.15 [b] 0.130 [2]	119 136	10 50	B Bandpass	N.A.	101 [f]	20	71 [f] 60 [70]	2
Icom IC-275H 2 metres	-136 [a]	0.25	3	122	0.11	124 141	10 50	B Bandpass	75	85	20	63	2
Yaesu FT-736R 2 metres	-141	1.3	3	125	0.11	128 143	10 50	C Bandpass	80	88	20	66	2
Icom IC-R8600 Second sample S/N 02001177	-131 -142 [b] -130 [ab]	2.40 0.67 [b]	3	125	0.40 0.12 [b] 0.49 [ab]	144 148	10 50	B Half Octave	>100	109 [ab] 88 [ac]	20	107 [ab] 88 [ac]	2
Icom R9500	-127 -130 [b] -135 [b1]	1.1 0.25 [b] 0.16 [b1]	3	119	0.7 0.2 [b] 0.11 [b1]	134	10	B Bandpass	80	110 [f]	20	85 [f]	2

The data in the above table are reproduced with permission. The original data are published at the Sherwood Engineering Inc. web site: http://www.sherweng.com/table.html
The site includes explanatory notes and a key to annotations.

Overall impressions

The reviewer and several other local amateurs interested in VHF/UHF weak signal communications have been truly impressed with the performance of the IC-9700. It will be a very useful addition to the radio shack of anyone interested in operating on the bands covered by the transceiver.

All other users will find the IC-9700 covers most operational requirements in a visually attractive package with an excellent user interface. As one would expect with a transceiver with the capabilities of the IC-9700, the user will need to commit some time to reading the manuals and exploring the menu system to utilise the radio at its best.

Acknowledgements

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We thank Icom Australia for the loan of the transceiver for evaluation.

Recommended Retail Price is $3575.00 including GST. At the time of writing, local retailers are displaying prices of $2399.00 to $2495.00 including GST.

Use of the IC-9700 on Weak Signal Digital Modes

Rex Moncur VK7MO

The IC-9700 brochure describes an SMA socket marked "10 MHz Reference Signal Input". If you are like me, you might have assumed that this meant that the radio is capable of being locked to a 10 MHz reference, such as derives from a GPS disciplined oscillator. Unfortunately, this is not what it seems and not like the IC-7610 HF radio which allows the radio to be locked to a 10 MHz reference.

The purpose of the SMA socket on the IC-9700 is solely to allow you to calibrate the radio to an external reference. But after this is done and even if you continue to apply the 10 MHz external reference, the radio is free to drift until you calibrate it again. The main source of the drift results from the fan turning on and off. This produces drift of up to 30 Hz at 2 metres and 300 Hz at 23 cm over four minutes. As a result of this drift the radio is unsuitable for weak signal digital modes such as WSPR, JT65 and QRA64 with the sub-modes normally used on the bands for which the radio is designed. In this respect it is not as stable as the IC-910 with high stability oscillator and is thus a major step backwards if you want to work weak signal digital modes. This is a significant disappointment as the radio has so many other excellent features.

A detailed report on the use of the IC-9700 for weak signal digital modes is on the WIA web site, at the bottom of the page for this magazine issue:

http://www.wia.org.au/members/armag/2019/may/