Product Review Column from *QST* Magazine

February 1993

ICOM IC-728 and IC-729 Transceivers

ICOM AT-160 Automatic Antenna Tuner

A&A Engineering ViewPort VGA Slow-Scan TV System

Conducted By James W. Healy, NJ2L
Senior Assistant Technical Editor

ICOM IC-728 and IC-729 Transceivers

Reviewed by Larry Wolfgang, WR1B, and Rus Healy, NJ2L

Unpacking a new radio is always exciting! There's the anticipation of trying out the latest technology, along with a bit of apprehension over learning how to make the best use of the features. There may even be some concern over finding all the right buttons to make the radio play properly. Mostly, though, the task of setting up a new radio should be *fun*.

ICOM's latest entry-level radios *are* fun. The IC-728 and IC-729 (which join the IC-725 at the low end of ICOM's MF/HF transceiver line) are small, light rigs. We tested an IC-728 and its twin, the IC-729 (an IC-728 with 46.2- to 61.1-MHz receiver coverage and transmit coverage of 50 to 54 MHz). Unless otherwise noted, this review applies to both radios.

Features

As the IC-728 is one of ICOM's entry-level MF/HF platforms, you might expect it to lack features. Although this radio doesn't have all the bells and whistles of the higher-priced rigs, it doesn't lack as much as you might think. The rig receives from 30 kHz to 30 MHz, has a preamplifier and speech processor, flexible memory, VFO and scanning options, an interference-fighting passband-tuning circuit, and several other nice touches. Functions standard on most radios that you won't find in the IC-728 include a VOX circuit, an RF-gain control, a noise-blanker threshold control and complete function metering. In the IC-728, FM transceive operation and AM transmitting are options. (They're standard in the IC-729.)

The uncluttered front panel is ergonomically laid out. There's plenty of room between controls, and most of them are large enough to see and operate easily—even in mobile operation. The exceptions are a few of the push-button controls, which are small, but well-spaced. The adjustable-drag main tuning knob has a very good feel.

In addition to the usual two VFOs, the radio has 26 memories. Each memory stores operating frequency, mode and filter selection. Two pairs of memories also store separate transmit and receive frequencies for split operation. This provides a convenient way to store the operating frequencies you need to chase a DXpedition, for instance, or for storing the input and output frequencies of 10- and 6-meter FM repeaters.

You can easily switch between either VFO or the memories, equalize the VFOs, write a VFO frequency to memory, or put a memory frequency into a VFO—just like high-end radios. The memories are tunable, so you can use one or more as a temporary "scratch pad." You can change the stored modes and frequencies as though the memories were VFOs.

The VFOs use a band-stacking register to store the last-used frequency, mode and filter information for each band. So, when you change bands, you come back to the same frequency, mode and filter you last used on that band. It's nice to see this feature in an entry-level radio.

Pressing the **kHz, MHz** or **BAND** buttons selects the main dial's function. These buttons toggle the functions on and off. A small arrow appears above the appropriate display digit(s) when one of these fast-tuning functions is selected.

Three push buttons select the six combinations of operating modes and filters. The **SSB** button alternately selects upper and lower sideband; the **AM/FM** button toggles between these modes; and the **CW/N** button toggles between the wide and narrow IF filters, if you've installed the optional 500- or 250-Hz CW filter.

Other features include an unadjustable but fairly effective noise blanker; a 20-dB attenuator; an RF preamplifier; fast or slow AGC time constants; and a speech processor. You adjust the processor level with a small front-panel knob. RF output is easily adjusted from about 10 watts to 100+ watts on each band (10 watts on 6 meters—see Tables 1 and 2 for specifics).

The Bottom Line

The IC-728 offers solid basic performance and features for its price. A small, lightweight package, it's well suited to mobile and portable operation. The IC-729, essentially an IC-728 with 6 meters, combines the '728's high points with wider receiver coverage, and performs unusually well on the 50-MHz band.

With the **RIT** control, you can tune ±1.2 kHz from the displayed frequency. Although the displayed frequency doesn't change as you adjust the **RIT** control, you can sum the offset with the VFO frequency by pressing the **FUNC**tion button and then hitting the **RIT** on/off button. So, if you've tuned a station with the RIT and want to set your transmit frequency to the same spot, just poke these two buttons, in that order. Zeroing the RIT requires you to manually center the knob.

One of the IC-728's most useful features is passband tuning (**PBT**). On SSB, the **PBT** control operates like IF shift in other radios. On CW, it varies the IF bandwidth—fully counterclockwise gives minimum bandwidth and fully clockwise gives wide-open selectivity for the selected filter. In both modes the control narrows IF bandwidth, giving interference reduction not available in most rigs in this class.

Because the IC-728 doesn't support FSK operation and thus requires you to use AFSK by feeding audio tones into the mike connector or a rear-panel accessory jack, the **PBT** control is especially useful in RTTY and AMTOR operation. You set the radio for lower-sideband operation for these modes, so you can only use the SSB IF filter. The **PBT** circuit compensates for this limitation by letting you adjust the passband for minimal interference.

In addition to operating frequency, the main display shows which VFO is selected, operating mode, and memory channel that will be selected if you switch from VFO to memory operation. (This is also the memory that will be overwritten if you hit the **MW** button, so be sure to check the memory contents first to ensure this is the channel you want to use.)

The S meter doubles as an output-power meter during transmitting. The scales are

Table 1

ICOM IC-728 MF/HF Transceiver, Serial no. 001683

Manufacturer's Claimed Specifications	***Measured in the ARRL Lab***
Frequency coverage: Receive, 500 kHz-30 MHz; transmit, 1.8-2, 3.5-4, 7-7.3, 10.1-10.15, 14-14.35, 18.068-18.168, 21-21.45, 24.89-24.99 and 28-29.7 MHz.	Receive, 30 kHz to 30 MHz; transmit, as specified.
Modes of operation: AM, CW, FM, LSB, USB.	As specified.
Power requirement: 13.8 V dc ±15%; receive, 1.6 A max; transmit, 20 A max.	At 13.8 V, receive, 0.95 A max; transmit, 15 A max.
Receiver	*Receiver Dynamic Testing*
Receiver sensitivity (10 dB [S+N]/N), bandwidth not specified: SSB and CW, 0.16 μV (–123 dBm).	Minimum discernible signal (noise floor) with 500-Hz IF filter: *Preamp On* / *Preamp Off* 1.0 MHz: –121.5 dBm / –121.5 dBm 3.5 MHz: –137.5 dBm / –128.5 dBm 14.0 MHz: –137 dBm / –128.5 dBm 28.0 MHz: –138.5 dBm / –128.5 dBm
AM (10 dB [S+N]/N, preamp on): 0.5-1.8 MHz, 13 μV (–85 dBm); 1.8-30 MHz, 2 μV (–101 dBm).	Signal 30% modulated with a 1-kHz tone: 1 MHz, –105 dBm; 3.8 MHz, –120.5 dBm.
FM (12 dB SINAD, preamp on): 0.5 μV (–113 dBm).	29 MHz, 15-kHz filter: –119.5 dBm.
Blocking dynamic range: Not specified.	Blocking dynamic range with 500-Hz IF filter:* *Preamp Off* / *Preamp On* 1.0 MHz: 113 dB† / 113 dB† 3.5 MHz: 115.5 dB† / 114.5 dB† 14.0 MHz: 122.5 dB† / 120.5 dB† 28.0 MHz: 118.5 dB† / 117.5 dB†
Two-tone, third-order IMD dynamic range: Not specified.	Two-tone, third-order IMD dynamic range with 500-Hz IF filter:* *Preamp Off* / *Preamp On* 1.0 MHz: 88.5 dB / 88.5 dB 3.5 MHz: 90.5 dB / 88.5 dB 14.0 MHz: 91.5 dB / 90 dB 28.0 MHz: 85.5 dB / 85.5 dB
Third-order input intercept:‡ Not specified.	*Preamp Off* / *Preamp On* 1.0 MHz: 11.25 dBm / 11.25 dBm 3.5 MHz: 7.25 dBm / –4.75 dBm 14.0 MHz: 8.75 dBm / –2.0 dBm 28.0 MHz: –0.25 dBm / –10.25 dBm
S-meter sensitivity (μV for S9 reading): Not specified.	At 14 MHz: Preamp on, 18 μV; preamp off, 48 μV.
FM squelch sensitivity: Not specified.	At 29 MHz, preamp on: –120 dBm.
Receiver audio output: 2.6 W into 8 Ω (distortion not specified).	2.8 W into 8 Ω at 10% total harmonic distortion.
Receiver IF/audio response: Not specified.	At –6 dB, **PBT** centered: SSB IF filter, 182-2277 Hz (2095 Hz); AM IF filter, 64-2200 Hz (2136 Hz); 500-Hz IF filter (**PBT** at 3 o'clock), 638-1221 Hz (583 Hz); 500-Hz IF filter (**PBT** at 9 o'clock), 674-1012 Hz (388 Hz).
Transmitter	*Transmitter Dynamic Testing*
Transmitter power output: Adjustable from 10-100 W on CW, SSB and FM; 4-40 W on AM.	Adjustable from 8 to 103 W (CW, SSB, FM); AM, as specified. Output varies slightly from band to band.
Spurious-signal suppression: >50 dB.	As specified. Meets FCC specifications for equipment in its power-output class and frequency range.
Third-order intermodulation distortion products: Not specified.	See Fig 1.
CW keying characteristics: Not specified.	See Fig 2.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	AGC fast: S1 signal, 160 ms; S9 signal, 17 ms. AGC slow: S1 signal, 17 ms; S9 signal, 17 ms.
Composite transmitted noise: Not specified.	See Fig 3.

Size (height, width, depth): 3.7 × 9.5 × 9.4 inches; weight, 10.1 pounds.

*Blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.
†Noise limited.
‡Third-order input intercept (dBm) = MDS (dBm) + 1.5 × third-order IMD dynamic range (dB).

fairly easy to read, though the meter is on the small side.

Options

As mentioned earlier, the AM transmit/FM transceive unit is an option in the IC-728 and standard in the IC-729. For 10- or 6-meter repeater operation, you may also need the UT-30 programmable tone encoder to access repeaters that require subaudible-tone encoding.

The CT-17 level converter provides the interface between a computer's EIA-232-D serial port and the radio. With this interface (or a similar unit[1]) and the appropriate software, you can select operating band and mode, change frequency and perform other control functions remotely from your computer.

If you plan to use the '728 in a mobile installation (its small size and easy-to-use controls lend themselves nicely to this application), you may want the optional IC-MB5 mobile mounting bracket.

In keeping with the IC-728's budget price, ICOM shaved some extras long con-

[1]Several interfaces compatible with ICOM radios are commercially available. Others you can build include ones described by Nigel Thompson, KG7SG, in "A Low-Cost PC Interface for ICOM Radios," *QST*, Jul 1992, pp 37-38; and Wally Blackburn, AA8DX, in "Everything You Always Wanted to Know about Hardware for Computer-Controlling Modern Radios," elsewhere in this issue.

Table 2
ICOM IC-729 MF/HF/VHF Transceiver, Serial no. 01168

Manufacturer's Claimed Specifications*	***Measured in the ARRL Lab***
Frequency coverage: Receive, 500 kHz-30 MHz and 50-54 MHz; transmit, same as IC-728, plus 50-54 MHz.	Receive, 30 kHz to 33 MHz and 46.2-61.1 MHz; transmit, as specified.
Power requirement: Same as IC-728.	50-MHz transmit, 3.6 A max.
Receiver	*Receiver Dynamic Testing*
Receiver sensitivity (preamp on, 10 dB [S+N]/N, bandwidth not specified): 50-54 MHz, SSB and CW, 0.13 μV (–125 dBm).	Minimum discernible signal (noise floor) at 50 MHz with 500-Hz IF filter: Preamp on, –141 dBm; preamp off, –137 dBm.
FM (12 dB SINAD, preamp on): 0.3 μV (–117 dBm).	50 MHz, 15-kHz filter: –122 dBm.
Blocking dynamic range: Not specified.	Blocking dynamic range at 50 MHz with 500-Hz IF filter:† Preamp on, 111 dB‡; preamp off, 112 dB‡.
Two-tone, third-order IMD dynamic range: Not specified.	Two-tone, third-order IMD dynamic range at 50 MHz with 500-Hz IF filter:† Preamp on, 85 dB; preamp off, 88 dB.
Third-order input intercept:** Not specified.	50 MHz: preamp on, –13.5 dBm; preamp off, –5 dBm.
Transmitter	*Transmitter Dynamic Testing*
Transmitter power output: 50-54 MHz, adjustable from 1-10 W on CW, SSB and FM; 1-4 W on AM.	50 MHz: Adjustable from 1 to 11 W (CW, SSB, FM); AM, as specified.
Spurious-signal suppression: >60 dB.	As specified. Meets FCC specifications for equipment in its power-output class and frequency range.
Third-order intermodulation distortion products: Not specified.	See Fig 4.
Weight: 10.8 pounds.	

*Except where noted, IC-729 specifications are the same as those for the IC-728.
†Blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.
‡Noise limited.
**Third-order input intercept (dBm) = MDS (dBm) + 1.5 × third-order IMD dynamic range (dB).

sidered standard equipment on MF/HF transceivers. The most obvious of these is a carrying handle; it's optional.

The IC-728 is designed for use with ICOM's automatic antenna tuners. For operating in the 100-W range, the AT-160 MF/HF tuner (reviewed separately) is the smallest and least expensive of these. A similar unit, the AT-150, includes an automatic selector for three antennas and a random-wire output. The IC-AT500 is rated for use with up to 500 watts, which makes it suitable for use with ICOM's IC-2KL amplifier. The AT500 includes an automatic selector for four antennas. A separate automatic antenna selector rated at 1 kW PEP, the EX-627, is also available.

ICOM offers several external speakers and three desktop microphone options. The hand-held mike included with the radio is adequate for most operating.

Instruction Manual

The 52-page instruction manual is well written and informative. With few exceptions, the manual answers how-to questions quickly. The front- and rear-panel descriptions cover basic operation. Page references with each control guide you to more detailed operating instructions later in the book.

The "Installation and Connections" section has clear diagrams illustrating the various connections required to integrate the '728 into your station. These diagrams include power connections, wiring for various amplifiers, antenna tuners and the connections for data-mode interfaces.

For the CW-key connector, the manual shows a ¼-inch, three-conductor plug using the tip and shield, with no connection to the ring. It turns out that a two-conductor plug (with the shield grounded) also works.

Unlike most current radios, the IC-728 doesn't come with a set of connectors to match the radio's rear-panel jacks. This is inconvenient because the rig uses three DIN jacks for many of its connections. Fortunately, these jacks use commonly available plugs.

Nearly half the manual is dedicated to detailed operating instructions. These instructions cover basic operating techniques as well as describing memory-channel and scanning operation in detail. Two pages of diagrams, tables and text describe how to use the radio's programmed- and memory-scan functions.

Separate fold-out sheets give a block diagram and a complete schematic diagram. Five manual pages are dedicated to maintenance and adjustment. Large diagrams illustrate disassembly procedures and highlight the various maintenance operations you can perform. These include replacing a fuse on the PA unit, resetting the CPU, and adding or removing diodes to configure the advanced scanning functions. Other internal adjustments you can make include the frequency calibration, CW sidetone level, RIT center position, PA idling current and BFO frequency.

The IC-728 uses a lithium battery for retaining memory information. Claimed battery life is 5 years, and when the battery dies the radio will transmit and receive normally, but loses information stored in the memories when it's powered down.

Under the Hood

You may be in for a surprise when you pop the top cover off an IC-728. All you'll see is heat sink, plus a small speaker in the right front corner. The entire top half of the radio comprises the PA unit, built into this heat sink. A *very* quiet fan in the PA unit runs continually during transmitting. The radio gets only barely warm after several minutes of full-power, key-down operation. The radio is solidly built.

On-the-Air Performance

In many respects, the IC-728 performs surprisingly well for an entry-level transceiver. Its PBT circuit offers selectivity options unavailable in many radios. Its clean synthesizer chain gives you the feeling that you're using a higher-end radio. Operation is intuitive and logical; controls are well-placed and feel right. The backlit display is easily readable from almost any viewing angle and under a wide range of lighting conditions.

You change bands by poking the **BAND** button and rotating the tuning knob. When you select AM or FM, the tuning step is automatically set to 1 kHz. You can also use the **kHz** button for quickly tuning through a band.

The default SSB and CW slow tuning rate is a pleasant 2 kHz per revolution in 10-Hz steps. You can also choose 20- or 50-Hz tuning steps for a 4- or 10-kHz per revolution rate, respectively. If you turn the tuning knob quickly, the tuning rate automatically doubles.

In the receiver's rated 500-kHz to 30-MHz tuning range, it has few receiver spurs ("birdies")—none of which move the S meter. The three loudest ones are at 9.0095, 12.6986 and 26.21465 MHz. None of the audible spurs are in the ham bands.

Projected from the radio's small speaker, receiver audio is acceptably loud and clear. It's plenty loud for unobstructed listening in noisy environs, such as a car.

SSB

Reports indicate that the IC-728 produces high-quality transmitted audio with the stock microphone. The manual suggests setting the **MIC GAIN** and speech-processor **LEVEL** controls at a position between 10 and 12 o'clock for the supplied mike. The meter has no ALC or compression-level scales. Only the red **TX** LED tells you (vaguely) whether you're driving the transmitter appropriately. It should flicker a bit more brightly than normal on voice peaks. Our tests show that this produces good-sounding and clean transmitter audio with the stock microphone, but without a second receiver, it's hard to verify that the transmitter is adjusted properly.

CW

CW operation is generally smooth with the '728. The radio receives CW as LSB, which is somewhat unconventional; the CW offset is fixed at 800 Hz. The sidetone matches the offset. Split-frequency operation is simple and intuitive, as the appropriate controls are closely grouped on the radio's front panel.

Semi-break-in or manual-changeover CW operation is selected with a rear-panel push button. You can adjust the TR delay time with a recessed, rear-panel control. This control placement and type is seriously deficient—*you need a screwdriver to adjust it!* Unless you do all your CW operating in a narrow speed range, you'll find this to be inconvenient. At the shortest selectable TR delay in semi-break-in mode, the transmitter unkeys between dots at 20 WPM. This is close enough to full break-in for most operating. At the longest delay, the transmitter seems to stay keyed for an eternity (actually several seconds) after sending stops.

The receiver's AGC sounds pretty good. Fast AGC is slightly harsh on S9+ CW signals, but even SSB signals sound reasonably good with fast AGC. The rig's slow AGC is quite good.

Both of our review radios include 500-Hz CW filters. The monolithic filter is easy to install (a 5-minute job requiring only a Phillips screwdriver), and provides a useful selectivity improvement that all but the most casual CW operators will appreciate. Even with the narrow filter in line and **PBT** set for minimum bandwidth, however, the rig's selectivity isn't quite good enough for crowded bands. The 250-Hz filter thus seems like a more appropriate choice for serious CW operators.

Under crowded band conditions, the 500-Hz CW filter and the 20-dB attenuator work well against overload and interference. The RF preamp adds needed gain, especially on the high bands with crummy antennas. Otherwise, however, using the preamp makes the receiver *so* sensitive that it overloads rather easily.

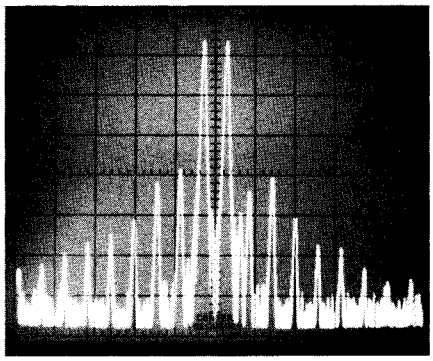


Fig 1—Worst-case spectral display of the IC-728 transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 39 dB below PEP output, and fifth-order products are approximately 40 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 100 W PEP output at 14.25 MHz.

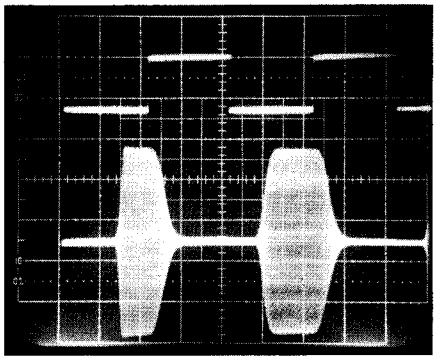


Fig 2—CW-keying waveform for the ICOM IC-728 in the semi-break-in mode. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output at 14 MHz.

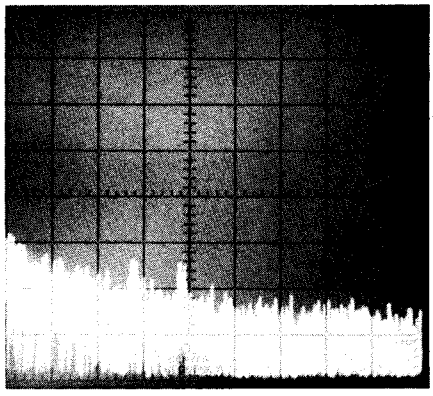


Fig 3—Spectral display of the IC-728 transmitter output during composite-noise testing. Power output is 100 W at 14 MHz. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The scale is calibrated so that the log reference level (the top horizontal line on the scale) represents –60 dBc/Hz and the baseline is –140 dBc/Hz. Composite-noise levels between –60 and –140 dBc/Hz can be read directly from the photographs. The carrier, off the left edge of the photographs, is not shown. This photograph shows composite transmitted noise at frequencies 2 to 20 kHz offset from the carrier.

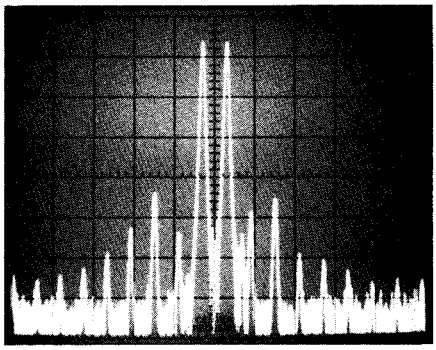


Fig 4—Spectral display of the IC-729 transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 48 dB below PEP output, and fifth-order products are approximately 44 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 10.1 W PEP output at 50 MHz. The IC-729 produces an outstandingly clean transmitted SSB signal at 50 MHz.

Data Modes

Since the '728 has no provision for direct FSK operation, as mentioned earlier, you must use the sideband filters for data modes. Although this works fine for RTTY, the SSB bandwidth is too wide for crowded band conditions. The **PBT** control comes in handy here, though, letting you adjust the passband to minimize interference.

Broadcast and Shortwave Listening

Dave Newkirk, WJ1Z, observes that there's little difference in the rig's sound quality between AM received with the radio in its AM mode and AM received as SSB. This suggests that rather severe high-frequency audio rolloff is built into the radio to suppress hiss in the IF and audio chains. Our frequency-response tests bear this out. Even with this rolloff, audio-amplifier hiss is quite noticeable. The IC-728 also suffers from the same barn-door-wide AM filter used in the IC-725.[2] In short, the IC-728 isn't a high-fidelity AM-broadcast receiver, but casual AM listeners will find it quite acceptable.

The radio's triple-conversion scheme uses a first IF around 70.45 MHz. (The exact frequency depends on the mode.) The second IF is at 9 MHz, and the third is at 455 kHz. In their IC-728 ads, ICOM claims that triple

[2]Product Review, "ICOM IC-725 MF/HF Transceiver," *QST*, Mar 1990, pp 38-41.

conversion offers inherently better performance than dual conversion. There's little evidence to support this claim, however. Some dual-conversion receivers perform better, and other triple-conversion receivers don't perform as well as the IC-728 where it counts: in *basic radio performance*.

Along these lines, the IC-728 performs surprisingly well. Judging a book by its cover, we suspected that the IC-728 was a reskinned and slightly modified IC-725, which suffers from mediocre performance. This wasn't the fault of the radio's RF design, however: It, like the '728, has good sensitivity and dynamic range for a radio in its class. The problem in the '725 is largely the result of an unusually noisy synthesizer.

What we found in the '728's receiver is considerably better basic performance, especially on crowded bands, because of its much quieter synthesizer. More importantly, the IC-728's basic receiver performance numbers are among the best you'll find in the major entry-level market.

The IC-729 and 6 Meters

The IC-729 is presently the least expensive 100-watt MF/HF transceiver with 6 meters. Other than the inclusion of 6-meter coverage and 46-61 MHz reception, it's practically identical to the IC-728 (see Tables 1 and 2). Although the '729 puts out just 10 watts on 6 meters, the radio performs well enough to help you get acquainted with the band. Its sensitivity and dynamic range are adequate for almost all 6-meter operation—in fact, they're better than those of most dedicated 6-meter transceivers! To climb the ladder to higher transmitter power, you can choose from a variety of commercial amplifier alternatives.

Summary

ICOM has solid entry-level performers in the IC-728 and IC-729. If you can do without the bells and whistles and filtering options of higher-end radios, or if you're looking for a radio whose features don't require you to take a full-semester course in operating to learn and use it, take a careful look at the '728. It's a solid, lightweight radio that lends itself well to mobile and portable operation, although it lacks the CW keyer and internal antenna tuner that would qualify it as a station in a box. In ease of use, it's a hands-down winner.

Manufacturer's suggested retail prices: IC-728, $1099; IC-729, $1419; FL-100 500-Hz CW filter, $81; FL-101 250-Hz CW filter, $77; CT-17 computer-control interface, $102; UI-7 AM/FM unit, $75; UT-30 programmable tone encoder, $19; SM-6 desk microphone, $50; MB-5 mobile bracket, $27. Manufacturer: ICOM America, Inc, 2380 116 Ave NE, Bellevue, WA 98004, tel 206-454-7619.

ICOM AT-160 Automatic Antenna Tuner

The matching 100-watt antenna tuner for the IC-728 and IC-729, the AT-160 uses relay-selected inductor taps and motor-driven capacitors to match loads with SWRs up to 3:1 on the 160- through 10-meter ham bands. The tuner uses control signals from the IC-728 to complete its automatic tuning. The AT-160 mounts to a bracket that you can attach to either side of the radio. All necessary hardware is included. The AT-160 also works with the IC-725 and -726 transceivers. Unlike the internal antenna tuners in most radios, the AT-160 gives you the advantage of being in line on transmit *and* receive, thus adding selectivity and its improved antenna-system match on receive.

A piece of coax, a seven-conductor cable and a four-wire power cable interconnect the radio and the tuner. Attach your antenna to the tuner, and the installation is complete. (If you like, you can install an SWR/power meter between the radio and the tuner.) You can also use the AT-160 with an ICOM EX-627 automatic antenna selector. In this case, another seven-pin DIN cable connects the tuner to the antenna selector. The EX-627 automatically selects one of up to six antennas depending on the operating frequency.

The AT-160 is so simple that almost anyone can use it. Simply press the **TUNER** button on the '728 and hold it for about 1 second. **TUNE** appears on the left side of the display, the radio goes into transmit, and the capacitor-drive motors whir briefly. You may also hear the relays (quietly) switching inductor taps. Within a few seconds, this activity stops, the radio goes back into receive, and you're ready to transmit at full power into a matched load.

You need to follow this procedure only once for each band. The next time you switch to this band and select the tuner, it automatically resets the tuner to the settings it has stored for that band. When you begin to transmit, the AT-160 fine tunes the antenna if necessary. Tuning works this way regardless of operating mode.

The instructions and specifications state that the AT-160 is designed to match an antenna with an SWR of 3:1 or less. This means the antenna should have an impedance between about 17 and 150 Ω. If you try to match an antenna that has an impedance outside the tuner's range, it will attempt to match the antenna for about 7 seconds. If the tuner can't achieve a match in this time, it turns itself off and sets the transceiver for tunerless operation, indicated as **THROUGH** on the radio's display.

The tuner worked well with a variety of coax-fed antennas. It matched a 10, 15 and 20-meter Yagi on 12 and 17 meters; a 40-meter dipole on all the higher-frequency bands; and a 3/8-wavelength 160-meter inverted **L** on all but the 14- and 18-MHz bands. It also failed to match the 40-meter dipole on 80 or 160 meters—but it did match an 80-meter dipole on 160 meters.

It turns out that ICOM's SWR-matching specification for the AT-160 is quite conservative. Spot checks showed that it could match loads with indicated SWRs as high as 10:1. Used as it's intended—mainly for "flattening" less-than-optimal, coax-fed antenna systems across ham bands for which they're intended—the AT-160 does the job quickly and quietly.

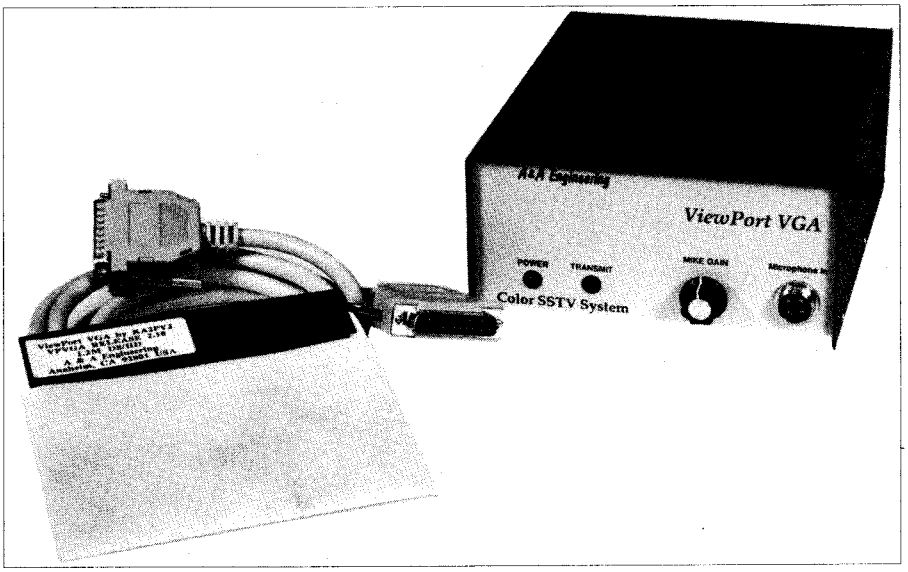
Manufacturer's suggested retail price: $413. Manufacturer: ICOM America, Inc.

A&A Engineering ViewPort VGA Slow-Scan TV System

Reviewed by Ralph Taggart, WB8DQT, ARRL Technical Advisor

Compared to traditional, expensive slow-scan TV hardware such as the Robot Research model 1200C scan converter, personal computers provide an attractive alternative for SSTV operation. A lot of innovative SSTV work was accomplished with Commodores, Ataris and Radio Shack Color Computers. These systems can do an excellent job with high-resolution, gray-scale versions of color images in various formats, but their color capabilities are either absent or flawed. One major exception is the Amiga AVT system, with SSTV hardware and software developed by Ben Williams, AA7AS. With appropriate display hardware, the Amiga system can equal the resolution and color quality of the 1200C—and even exceed it with new AVT color modes.

Since the advent of the VGA graphics standard, IBM PCs and compatible computers have also become realistic players in the SSTV game. A number of hardware and software developers are now devoting serious attention to these computers. A&A Engineering's ViewPort VGA interface is a significant effort in this direction. The ViewPort VGA system uses two components: a hardware interface and software developed by John Montalbano, KA2PYJ.



Hardware Interface

The hardware has four major subsystems: the PC interface; video-demodulation circuits; transmit modulator; and TR-control circuits. Most PC-related projects use either a dedicated bus card, requiring a vacant slot (which essentially leaves all those nice VGA laptop computers out of the picture), or a serial port, which is too slow for serious SSTV work. A&A's ViewPort VGA takes a comparatively little-used approach: interfacing via the computer's *parallel* port.

The PC-compatible parallel port is a mix of input and output lines (it's actually *three* ports in terms of the PC hardware), and it has the advantage of being available on almost every PC in existence.

Receive Demodulator

The demodulator in the A&A interface has a long history. It first appeared in the venerable Robot model 400 scan converter, and was later used with some modification by Clay Abrams, K6AEP, in an SSTV system for the Radio Shack Color Computer.[3] John Langner, WB2OSZ, made still other modifications in adapting the circuit for use with the Atari computer; this is the version used by A&A Engineering.[4]

The ViewPort VGA hardware interface uses eight op-amp stages to implement an audio limiter, discriminator, four post-detection filters and an output buffer. Only two pots need be adjusted. When these pots are properly set, the unit produces an output range of 0 V with a 1200-Hz input to +5 V with a 2300-Hz input. This covers the SSTV luminance (1200 Hz) and chrominance sync frequencies, and the 1500- to 2300-Hz black-to-white gray-scale range.[5] This variable voltage is applied to an A/D converter that drives a multiplexer. The multiplexer permits 8-bit data from the video A/D chip to enter the computer using only four input lines on the parallel port.

Transmit Modulator

SSTV transmit modulators are notorious for their tedious adjustment to obtain the required 1200-Hz sync output and 1500- to 2300-Hz video output. When WB2OSZ designed his interface for the Atari computer, he introduced an all-digital, crystal-controlled modulator that eliminated adjustments. This basic circuit is used in the A&A interface. The 4-MHz subcarrier is generated with a series of programmable dividers, operating from a 4-MHz crystal oscillator. The parallel port's 8 data bits, normally used to send data to the printer, are buffered by a bus-driver chip and used to control the programmable divider chain. The result is a known relationship between the value written to the parallel port and the resulting subcarrier frequency. The subcarrier output doesn't incorporate band-pass filtering, but the signal is clean enough to be applied to the audio input circuit of a typical SSB transceiver.

TR Functions

The A&A interface has four-pin connectors for the microphone input and an output that connects the interface to a transceiver. When the software is about to transmit a picture, it uses two data bits to close a relay in the interface that switches the SSB transceiver's audio input from the microphone to the transmit-modulator output. After the transmission ends, the relay reverses the process. This is a nice feature, since no additional switching is required to go back and forth between microphone audio and transmitted SSTV signals.

Packaging

The wired and tested version of the interface, reviewed here, is packaged in an attractive 2.75×6×7.25-inch (HWD) chassis with a top cover secured by six self-tapping screws. All the active circuits are contained on a high-quality, 4- × 6-inch double-sided PC board. The cabinet also contains a power-supply circuit that provides the needed +12, –12 and +5 V for the main circuit board. The power supply and the main board are available as bare PC boards and complete parts kits.

The interface's rear panel contains a two-wire ac power cord, a push-button power switch, fuse holder, four-pin transmitter connector, **SSTV IN** phono jack, **TAPE OUT** (transmitted SSTV signal) phono jack, and the DB25 female jack for the cable to the computer's parallel port. The front panel is shown in the title photo.

[3]C. Abrams and R. Taggart, "Color Computer SSTV: Part I," *73 Magazine*, Nov 1984, pp 10-13, 16, 18, 20, 21; Part II, Dec 1984, pp 18-22, 24-26, 28-32.

[4]J. Langner, "Color SSTV for the Atari ST—Part I," *73 Amateur Radio*, Dec 1989, pp 38-42; Part II, Jan 1990, pp 41-43.

[5]A detailed account of SSTV standards and operation is J. Langner, "SSTV—Slow-Scan TV—It Isn't Expensive Anymore," *QST*, Jan 1993, pp 20-30.

Software

A&A Engineering ships KA2PYJ's software with complete kits and wired, tested units. The program is *not* copy protected and is distributed as shareware. (You're purchasing the hardware interface, not the software—A&A Engineering throws that in as a courtesy.) John requests a $12 contribution from those who use the software. I feel that this is a modest sum, considering that full-blown imaging software demands hundreds to thousands of hours to develop. The program is fully functional, whether you contribute or not, but registering will get you into the update loop. John actively upgrades the software, so registration is an excellent investment.

The software documentation is contained in a file on the distribution disk. It's quite complete. In addition to program features, the file documents the program's update history and specific problems that users have encountered. Program hardware requirements are highlighted and include 100% IBM compatibility, at least 640 kilobytes of memory, a parallel port and a VGA display capable of handling the 320 × 200 × 256 mode. The documentation cautions against the use of TSRs (terminate-and-stay-resident programs) and notes that the program doesn't run if *Windows* is active.

The program has three principal menus: receive functions, transmit functions and additional functions. The functions available via each menu are listed and any one can be activated by a single keystroke. The menu backgrounds are color coded so that, with a color monitor, you're instantly aware of which menu is active. The menu structure isn't fancy, but it's functional and doesn't require much time to learn.

The receive menu supports real-time display of 8, 12, 24 or 36-second B&W images, 36- and 72-second Robot color, Scottie modes 1 and 2, and Martin modes 1 and 2. The transmit choices are a bit more restrictive, with 8, 12, 24 and 36-second B&W and 36- or 72-second Robot color. Scottie and Martin modes are not supported in transmit because these modes, like fax, require an extremely accurate time base for proper image synchronization. Normally such oscillator accuracy would be required for reception as well, but the program can receive the Martin and Scottie modes because line sync pulses are included in the transmission format (to allow a system to lock up on the signal in mid-frame).

The additional-functions menu is a grab bag of useful items, including:

- Display of gray-scale and color bars
- Image saving
- Delete files
- Load files (.TGA and .PCX formats)
- Load an image with a custom palette
- Call up an image directory
- Parameter setup

Although you can load only Targa (.TGA) and *PC Paintbrush* (.PCX) image files directly, calling the directory function gives you access to .TGA and .PCX images, as well as images created by GEST and HIRES, two popular programs created to support the Robot 1200C.

Calling the Parameter Setup option gives access to another menu with several useful routines:

- *Loopback Test*—When the **TAPE OUT** jack is jumpered to **SSTV IN**, the system can transmit SSTV tones and display the demodulated signal in graphical form. This is a built-in alignment routine that take the guesswork out of the two video-demodulator adjustments.
- *Tuning Indicator*—An accessory routine that lets you optimally tune a station while it is transmitting a picture.
- *Oscilloscope*—A real-time scope simulator that lets you analyze SSTV signals.

In addition to these functions, you can change the active drive and the parallel port, and look at the image luminance, R-Y, and B-Y data.

Installation

The program loads timing data, parallel-port assignment, and whether a high-resolution color card is installed from a configuration file (SSTV.CFG) supplied on the program disk. To install the software, you simply copy it to your hard disk and run the program. If necessary, you can alter entries in SSTV.CFG if you experience timing problems (such as poor color registration). The software documentation describes how to alter the file's various parameters.

A standard DB25 cable (supplied with the interface) connects the interface and computer. A shielded audio cable connects the **SSTV IN** phono jack on the interface to the receiver's audio output. The four-pin **MICROPHONE IN** and **MICROPHONE OUT** jacks were a bit of a hassle to connect since the pinouts aren't defined on the schematic. I had to open the unit and trace the wiring to the connectors to be sure which was which. Depending on your microphone wiring, you may need to make a short adapter and prepare a cable to connect the interface's **MICROPHONE OUT** connector to your rig's microphone-input connector.

On the Air

When I first attempted to place the system into service, I couldn't make the computer and the interface communicate with each other. I checked the interface hardware, to no avail.

The problem turned out to be that the program recognizes parallel port assignments slightly differently between true IBM PCs and clones. The program works fine with clones, but not at all with *real* IBM PCs with the parallel printer port on the motherboard! And, of course, I was using such an IBM computer. This should be easy to fix in software. Until this is implemented, you'll need a plug-in parallel-port card to use the interface with an IBM system.

Picture Display

The A&A unit handles black-and-white images flawlessly. The system saves images to disk only in the 123-kbyte Targa (.TGA) color format. Monochrome images thus acquire a color alias when saved and reloaded. This is out of keeping with the software's otherwise good performance, given the wide range of monochrome receive modes.

Compared to monochrome formats, color SSTV is extremely complex. The ViewPort VGA system does an excellent job of registering color images in all modes. But if you have a standard VGA system, received-image display is hampered by the VGA's 256-color limit. Incoming image data is coded for 32,768 colors. The program supports several 32,768-color boards (which are commonly available for $160-$200). One of these is an excellent investment if you want to take advantage of the maximum color quality the system can deliver.

With the standard 256-color palette, the program tries to optimize the display and generally does a good job. The resulting pictures are satisfactory—especially if you haven't spent a lot of time looking at the output of a Robot 1200C (which uses 262,000 colors!).

Annoyingly, the system hangs if it doesn't receive a sync pulse when you go into a receive mode. You can usually get out by tuning off a bit to get a 1200-Hz beat note; otherwise you must reboot the system.

Image Transmission

Transmitted images retain the full 32,768-color spectrum. Image quality is excellent. A number of color images are provided with the program; you can also retransmit images you've copied on the air. With certain limitations, any images in *PC Paintbrush* (.PCX), Targa (.TGA) and the GEST and HIRES file formats can be loaded for display and transmission. Some variants of these may require reworking with a graphics editor; the documentation suggests suitable software for this task.

Pictures derived from TV frame grabbers, flat-bed and hand-held scanners, and various paint and graphics programs can be imported if you have software that can convert them to a format that the program supports. The ability to add graphics to photos and perform a

The Bottom Line

Whether you're a budding SSTVer or a longtime slow-scan aficionado, the ViewPort VGA interface and the accompanying software offer you excellent performance and a variety of useful features. Although resolution is suboptimal with 256-color VGA systems, high-resolution VGA cards provide very good performance with this system.

wide range of special effects using various paint, drawing and graphics programs means that you're limited only by your own imagination in assembling images for transmission.

The Noise Problem

Computers vary greatly in the amount of RF noise they generate. A noisy computer can play havoc with weak-signal work, since computer hash can mask all but strong signals. The better computers are well-shielded, but noise can be radiated by any high-data-rate cables that connect a computer to external equipment. With the A&A interface, the parallel-port cable and the monitor cable can be significant sources of RF noise. The use of a shielded parallel-port cable is advisable, as is keeping this cable as short as possible. The IBM computers were the quietest of the units I tested (ferrite chokes and other noise-suppression components are installed internally in these computers). The clones and a 386 laptop I used are very noisy. Any computer-noise problem can be tamed with enough time and perseverance, but it helps if the computer is reasonably quiet to begin with. It's a good idea to take a portable shortwave receiver to the store when shopping for a computer for your station.

Summary

The ViewPort VGA hardware interface functioned perfectly throughout the evaluation period and was properly adjusted at the factory. The interface doesn't limit your system's performance, and you can upgrade the color quality at any time with a new VGA card. As the software goes, I'd welcome the following upgrades:

- Support for true IBM PC parallel ports.
- A hot-key exit function for times when a sync pulse is missed in the receive modes.
- A dedicated format for saving monochrome images to disk.

PC-compatible computers are deficient in the area of high-resolution color image display, compared with dedicated systems or the Amiga video system. A&A's ViewPort VGA system does, however, make the best of what VGA offers. The ViewPort VGA interface unit is an excellent platform for serious SSTV experimentation. It and the software A&A Engineering supplies with it provide an affordable option for getting into slow-scan TV. In fact, this system may well satisfy most operators—particularly those who upgrade their VGA display capabilities—as a long-term SSTV system.

Prices: ViewPort VGA kit (part number 189-ENC), $169.95; assembled, tested unit (p/n 189-ASY), $229.95; PC board kit with part overlay and schematic diagram (p/n 189-PCB), $19.95. Shipping charges are extra. Software is included with complete kits and assembled, tested versions.

Options

The ViewPort VGA interface can be used for facsimile operation with only the addition of a 4-MHz clock, described in my article elsewhere in this issue. A wired and tested version of this clock costs $19.95 (plus s/h). If the board is ordered with the ViewPort VGA, shipping is included.

Also available from A&A Engineering is a 20-segment LED tuning indicator with a mounting bezel (part #169). If you purchase this option with an assembled unit, add $40. In kit form (#169-KIT), it costs $35 and requires you to cut a hole in the interface's front panel to accommodate the display.

Manufacturer: A&A Engineering, 2521 W La Palma, Unit K, Anaheim, CA 92801, tel 714-952-2114, fax 714-952-3280.

SOLICITATION FOR PRODUCT REVIEW EQUIPMENT BIDS

[In order to present the most objective reviews, ARRL purchases equipment off the shelf from dealers. ARRL receives no remuneration from anyone involved with the sale or manufacture of items presented in the Product Review or New Products columns.—*Ed.*]

The ARRL-purchased Product Review equipment listed below is for sale to the highest bidder. Prices quoted are minimum acceptable bids, and are discounted from the purchase prices.

Kenwood TS-950SDX MF/HF transceiver (see Product Review, December 1992 *QST*). Minimum bid: $3300.

Yaesu FT-890 MF/HF transceiver with optional YF-100 500-Hz CW filter, YF-101 2.6-kHz SSB filter, ATU-2 internal antenna tuner and FP-800 power supply/speaker (see Product Review, September 1992 *QST*). Sold as a package only. Minimum bid, $1349.

Maldol 28HS2HB 2-element 10-meter beam (see Product Review, December 1992 *QST*). Minimum bid: $70.

HAL PCI-3000 multimode HF data modem, SPT-2 tuning indicator and FIL-1 filter (see Product Review, December 1992 *QST*). Sold as a package only. Minimum bid: $420.

The following 2-meter hand-held transceivers (see Product Review, October 1992 *QST*):

Alinco DJ-F1T. Minimum bid: $198.
Alinco DJ-162TD with optional battery charger. Minimum bid: $177.
ICOM IC-P2AT. Minimum bid: $247.
ICOM IC-2SRA. Minimum bid: $350.
Kenwood TH-28A. Minimum bid: $240.
Kenwood TH-225A. Minimum bid: $233.
Radio Shack HTX-202. Minimum bid: $184.
Standard C168A. Minimum bid: $240.
Yaesu FT-411E. Minimum bid: $212.
Yaesu FT-415. Minimum bid: $198.

Sealed bids must be submitted by mail and must be postmarked on or before February 26, 1993. Bids postmarked after the closing date will not be considered. Bids will be opened seven days after the closing postmark date. In the case of equal high bids, the high bid bearing the earliest postmark will be declared the successful bidder.

In your bid, please clearly identify the item you are bidding on, using the manufacturer's name, model number, or other identification number, if specified. Each item requires a separate bid and envelope. Surface shipping charges (UPS brown label or equivalent) will be paid by ARRL. The successful bidder will be advised by mail. No other notifications will be made, and no information will be given to anyone other than successful bidders regarding final price or identity of the successful bidder. If you include a self-addressed, stamped postcard with your bid and you are not the high bidder on that item, we will return the postcard to you when the unit has been shipped to the successful bidder.

Please send bids to Bob Boucher, Product Review Bids, ARRL, 225 Main St, Newington, CT 06111. QST

New Products

ANTENNA MOBILE MOUNT

◊ Keep your mobile installation neat with a sleek, small-footprint mobile-mount VHF/UHF antenna. The 52-inch, 25°-adjustable 2-meter antenna features the compact 1⅜- × 1-inch RF-1123 mount. The dual-band model is 17 inches tall. Retail price: 2 meters, $51 for fiberglass and $38 for black stainless steel; 144/440 MHz model $49. EUR-AM, PO Box 990, Meredith, NH 03253; fax 603-476-5113.