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Yaesu FT-2600M VHF FM Mobile Transceiver

Kenwood CS-4125 20 MHz Dual Trace Oscilloscope

APRS Engineering's MIM Module

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The Yaesu FT-2600M VHF FM Mobile Transceiver

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From the moment ARRL Lab test engineer Michael Tracy, KC1SX, released Yaesu's FT-2600M into my custody, it became immediately apparent to me that this radio was one tough monkey.

Its rugged-looking textured faceplate, rubberized controls and smallish blank gray screen belied its user-friendly control layout—two knobs, four buttons. A front-firing speaker grill on the right side seemed just a little too eager to bark out some audio.

The chassis—a healthy chunk of unpainted cast aluminum bristling with cooling fins—made up most of the underbelly. A black sheet metal lid concealed the circuitry within.

I couldn't help but recall my past experiences with other members of its family—its grandfather, the FT-2400H, and its father, the FT-2500M (the first of its lineage to earn a military specification rating for toughness)—a couple of formidable, and talented, characters in their own right.

For the average Joe, it would have been difficult to pick this mutt out of a lineup based on model number alone—but it wouldn't for me—I had an encounter with its mother's clan, Yaesu's Vertex commercial arm, a few months back. The resemblance on her side of the family was uncanny.

I shoved the subject back into its box and shut the lid, locked the container in my truck and smugly thanked Mike for the hand-off. I returned to my desk at HQ, secretly hoping that once I got it home that evening, I would be able to muster the guts to haul it into the shack, tether it to an antenna cable, feed it some voltage and begin the interrogation process.

Modus Operandi

The FT-2600M possesses nearly all of the advanced features that we've come to expect in the modern FM mobile transceiver. These include a time-out-timer, automatic power off, automatic repeater shift, priority channel watch, CTCSS encode/decode, DTMF autodial memories and a scan system with programmable limits.

Some of the more notable highlights are a boatload of memories (175), 8-character alphanumeric memory naming, digital code squelch (*DCS*) encode and decode, and CTCSS and DCS scan. In addition, there's four power output settings (with 60 W out on high), 1200/9600 bits/s packet capabilities, a dc voltage readout and direct frequency/memory input (and user programmable soft keys) on the microphone keypad.

Yaesu has also tossed in a couple of the exclusive features that they've packed into all of their recent VHF and VHF/UHF transceivers. The FT-2600M has both the "Smart Search" and "Auto Range Transpond" systems. We'll dish out the skinny on these later.

Sizing Things Up

The width and depth dimensions on this new unit are about equal to those of its forefathers, but the height has been reduced considerably—down to a little over $1\frac{1}{2}$ inches. This transceiver is noticeably wider than most of the other currently available single band mobiles.

The volume control knob is located in the upper left hand corner of the front panel. The power switches on with a snap as you rotate the knob in the clockwise direction. Squelch adjustments are made using a menu setting. There's a 6-pin modular microphone jack just below the volume control.

The display window is offset towards the left side. Beneath the window is a row of four rubberized buttons. Surprisingly, these are the only four buttons on the entire chassis. Each has two labels, one above and the other on the surface of the button. These are **SET**/**MHz**, **LOW**/**REV**, **DW**/**A/N** and **MW**/**D/MR**. These front panel keys are not backlit. While there are some additional control buttons located on the microphone, most of the settings for functions that are not commonly needed for typical operations are contained in a 33-item menu. The menu selections are numbered and titled with up to 5 alphanumeric characters, making identification of their assignments fairly intuitive.

The size of the display window is relatively small, especially in comparison to the oversized screens on the '2400 and '2500, but the digits and alphanumeric character size is still more than adequate for easy viewing. The active LCD segments appear black on an amber field. The display brightness can be set to one of four levels or off.

The earlier units had a large amount of the screen area dedicated to an oversized S/RF meter. The '2600 employs a more conventional 12-segment horizontal bargraph meter that's positioned along the lower edge of the display. A row of icons along the top edge of the window indicates the state of several of the important functions.

The main encoder is located to the right of the display window. This puts it slightly to the right of the centerline of the front panel. Above this knob is a small green/red busy/transmit LED indicator. The area that makes up the remaining portion on the right side of the front panel contains the speaker grill.

The back panel supports three jacks and a dc power pigtail with a common T-type connector and a fuse holder. The supplied dc power cable is about 9 feet long and has ad-

The Bottom Line

The rugged good looks of the Yaesu FT-2600M project the image of simple, tough, no-nonsense communicator. Further investigation reveals a number of hidden talents and a level of performance that will undoubtedly earn it the respect of its peers. This rig's got moxie.

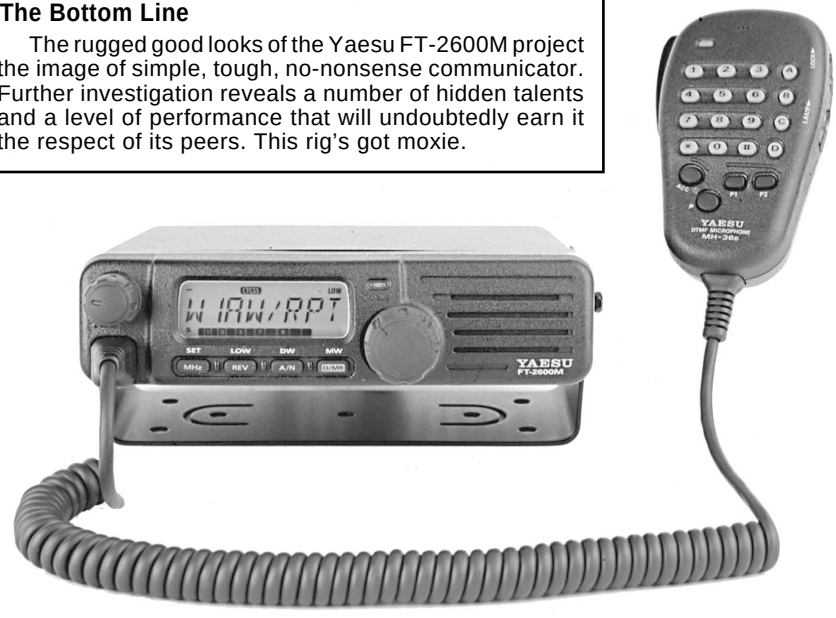


Table 1
Yaesu FT-2600M, serial number 9E010057

Manufacturer's Specifications	*Measured in ARRL Lab*
Frequency Coverage: Receive, 134-174 MHz; transmit, 144-148 MHz.	Receive and transmit, as specified.
Power requirements: 12.4-15.2 V dc; receive, 1.0 A; transmit, 10.0 A (high power).	Receive, 0.6 A (maximum volume, no signal); transmit, 9.2 A, tested at 13.8 V.
Size (hwd): 1.6×6.3×6.3 inches; weight, 2.9 pounds.	
Receiver	*Receiver Dynamic Testing*
Sensitivity: 12 dB SINAD, 0.2 μV.	FM, 12 dB SINAD: 0.12 μV.
Two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset from 146 MHz, 71 dB*, 10 MHz offset from 146 MHz, 101 dB;
Adjacent-channel rejection: Not specified.	20 kHz offset from 146 MHz, 71 dB;
Spurious response: 70 dB.	IF rejection: 112 dB, image rejection: 79 dB.
Squelch sensitivity: Not specified.	At threshold: 0.12 μV.
Audio output: 3.5 W at 10% THD into 4 Ω.	3.8 W at 10% THD into 4Ω.
Transmitter	*Transmitter Dynamic Testing*
Power Output: (H/L1/L2/L3): 60 / 25 / 10 / 5 W.	58 / 22 / 7.9 / 4.2 W.
Spurious signal and harmonic suppression: 60 dB.	75 dB. Meets FCC requirements for spectral purity.
Transmit-receive turnaround time (PTT release to 50% of full audio output): Not specified.	Squelch on, S9 signal: 60 ms.
Receive-transmit turnaround time ("tx delay"): Not specified.	55 ms.
Bit-error rate (BER), 9600-baud: Not specified.	Receiver: BER at 12-dB SINAD, 1.8×10^{-3}; BER at 16 dB SINAD, 6.8×10^{-5}; BER at –50 dBm, $<1.0\times10^{-5}$; transmitter: BER at 12-dB SINAD, 9.3×10^{-3}; BER at 12-dB SINAD + 30 dB, 1.8×10^{-3}.

*Measurement was noise limited at the value indicated.

ditional fusing in both leads at the supply end. The antenna connector is mounted directly on the chassis. The two remaining jacks are a $^1/_8$-inch external speaker jack and a female DB-9 receptacle for data connections.

The microphone provided with the FT-2600M is Yaesu's MH-36B. On the face of the mike is a familiar 16-digit DTMF keypad and four additional buttons labeled **ACC**, **P**, **P1** and **P2**. The assignments for the **ACC**, **P1** and **P2** buttons can be changed in menu settings. In their factory default configurations, they can be used to activate and vary the settings of the CTCSS and DCS systems; to initiate the CTCSS or DCS scan features; to open the squelch or to start the Smart Search. The **P** button allows you to step between the home channel, the VFO and the memory recall modes.

On the top of the microphone are **UP** and **DOWN** keys for moving through the memories and VFO frequencies or for starting a scan. On the right side are two slide switches, one to turn on the DTMF keypad backlighting and another that will disable all microphone buttons except for the PTT.

In addition to the usual DTMF autopatch and control applications, you can also use the buttons on the DTMF keypad to directly input frequencies or memory channel numbers. While not as full-featured as some of the microphone remote control arrangements currently available, the MH-36B offers a good measure of control capabilities and is still fairly easy to operate—even in a mobile environment.

Let's Pull His Jacket

It was time to do a little digging into the paperwork.

The included 6 × 8 inch 55-page *Operating Manual* is well organized and easy to follow. It starts out with a very complete *Contents* section, a general description of the unit's capabilities and a *Specifications* table. Next there's detailed numbered diagrams of the front and rear panel controls and connectors that includes specifics on the microphone and data connector pin outs. A diagram of the display with an explanation of the icons and graphics is also provided.

Seven pages are dedicated to the *Installation* section. This covers everything from coax selection and RF safety considerations to setting up for packet operation. Most of the remaining pages describe the actual transceiver operation. Advanced features are detailed in the later pages of this section. The last few pages have a summary table for the menu selections and an item by item quick reference guide for the various menu settings.

A separate 16 x 11 inch sheet with a complete and very legible schematic is also included.

Alright All Ready, Work Him Over

I twisted the power switch/volume control and fed him the juice. The display lit up and immediately spilled the beans on the voltage of my shack's dc supply—13.8 V. A second or so later this information was replaced by the operating frequency.

Display legibility is good, even from fairly extreme off-angles, but the shiny surface of the window can be subject to glare under the bright lights. You'll want to keep this in mind when choosing a permanent mounting location in your vehicle or shack.

A few calls on some local repeaters resulted in good reports all around. The transmit audio was typically described as "clear and clean." Receive audio from the unit's built in speaker was impressive—remarkably clear when considering the apparent physical speaker size limitations of this front-firing design. Even with the volume cranked up all the way, understanding the other station was not a problem (although that level of audio did ring the ears a bit!). With its ample audio output and the fact that the sound is more likely being directed toward the operating position, many may find it unnecessary to install an external speaker in all but the noisiest of applications.

I did notice that when operating at even 5 W (LOW 3) the heatsink got quite warm. Once I had it mounted in my truck I found that it got even warmer running at slightly higher power settings. Given that the bottom of the rig consists entirely of finned heatsink, the heating will probably be of little consequence. This should be considered when choosing a place to bolt it down. The manual includes a discussion on choosing an appropriate mounting location in the *Installation* section.

If you're pushing the limits of the transceiver's heat handling capabilities, a thermal protection sensor will activate a "TX PRTCT" message in the display. I never managed to reach the point where the '2600 cried "uncle."

As with most FM transceivers on the market today, the FT-2600M offers expanded receive frequency coverage—134 to 174 MHz. While this range allows you to listen in on a good variety of public service and commercial communications (not to mention NOAA weather, MARS, CAPS and the VHF marine frequencies) the AM aircraft band is

not covered. I tuned around a bit and eavesdropped on the radio chatter of some of my gumshoe pals.

Programming in frequencies, memory names and related information is pretty easy. Once you've got the memories loaded a few quick presses of the **D/MR** button lets you cycle between "home" (usually referred to as "call channel"), VFO and memory mode. When the radio is in the "home" channel mode, an "H" will appear on the right side of the display; in the memory mode, an "M" will appear. When the unit is in the VFO mode, no symbol appears.

If you are in the memory mode, a quick press of the **A/N** button will toggle you between a display of the actual operating frequency or the alphanumeric memory name that you have assigned to that particular memory. It's interesting to note that the frequency or memory name tag and the memory channel number are not displayed simultaneousy. You can bring up the memory channel number by pressing and holding the **D/MR** button for about 1 second. Let the radio automatically return you to the initial display though (it takes about 4 seconds). If you are not careful, you'll end up overwriting your memory name.

The FT-2600M comes equipped with CTCSS and DCS (*digital code squelch*) encode and decode. There are four configuration choices. You can set the radio for CTCSS encode; CTCSS encode *and* decode; DCS encode *and* decode; or off. While this shouldn't present any particular limitations for most operators, note that you cannot activate the decode modes independent of the encode modes. There are also no provisions for setting independent tones or codes for encode and decode on a single frequency or repeater pair. A menu setting for inverting the DCS codes is included.

I should warn you that if the menu is set for CTCSS encode only, the **CTCSS** icon will not appear in the display unless the radio is in transmit. This led to a bit of confusion when I was initially learning to program and operate the radio.

Tone and code scan is also included. The **ACC** button on the microphone (in its factory default setting) will initiate a scan for the tone or code. Once the system detects the tone or code in use, it will stop and allow receive audio to pass. Press and hold the **D/MR** button for one second, and the detected access information will be assigned to the appropriate setting in the menu.

The Packet Racket

The '2600M is capable of 1200 and 9600 baud packet. Yaesu has made TNC connection with this transceiver quite convenient. Many of the other rigs on the market today use either a 6-pin mini-DIN or the microphone jack for packet connections. This transceiver uses a standard female DB-9 jack mounted on the back panel. While the 6-pin mini-DIN connector appeared to be making headway as the "industry standard packet data connector," I've got to admit that the DB-9 seems to be an excellent alternative—they sure are easier to wire!

If you intend to use the radio for both data and voice communications, an obvious advantage of having a dedicated data connector is that it eliminates the need to swap between the mike and a TNC interconnect cable when changing between these modes. The microphone circuit is disabled during the packet transmissions, but there is a menu setting that would allow you to keep it available even during packet transmissions. Simultaneous voice and packet transmission, however, will result in interference to the transmitted data.

There is no need to manually toggle between baud rates. Separate pins in the DB-9 connector are assigned to 1200 and 9600 baud operation. The average packet operator should have no trouble setting this rig up for packet use.

I used the radio for a bit of APRS and local DX cluster operation at 1200 bits/s and found it worked quite well. I didn't have the opportunity to put it through its paces on 9600 bits/s. Lab numbers generated during BER testing (see Table 1) turned up numbers that indicate that the 9600 bits/s bit error rate on transmit is high. It's important to note that we've seen shortcomings in the 9600 bits/s operation of the majority of the recently released fm-only transceivers. If 9600 bits/s operation is your bag, see "*9600-Ready" Radios: Ready or Not?* by Jon Bloom, KE3Z, in the May 1995 issue of *QST*.

Special "Talents"

An interesting feature that Yaesu provides in the '2600M—and several of their other recently released VHF and VHF/UHF units—is their automatic range transponder system (*ARTS*). This function can automatically transmit a burst of DCS information that will alert other ARTS equipped operators that they have moved out of communications range. A CW ID can be programmed, and once activated will identify these automatic transmissions at 9-minute intervals. This system could be valuable for search and rescue or public service operations.

Another exclusive highlight is the Smart Search system. Once activated, the radio will sweep the entire band—or search between programmed band-scan limits—and store the active frequencies into a separate bank of 50 memory channels. The transceiver will make a single sweep between the frequency selected at the beginning of the operation and the top of its range or your selected upper band-scan limit. The resulting stored information will take a bit of sorting through though—you'll find several are loaded with various carriers and locally generated birdies, and strong nearby signals may appear wide enough to the system to end up in memories below and above the actual desired frequency. The system is definitely handy and useful though, and the collection of unwanted information is only a very minor annoyance. The collected information will be discarded when you turn off the power. If you find any interesting frequencies, you'll want to load these into the regular memory channels.

A neat characteristic worth mentioning is the distinct sound that is generated when you press any of the four front panel keys. Once you grow accustomed to their individual sound, it can be useful for mobile operation as verification that you've pressed the proper button. They may be helpful to the vision impaired as well. If the tones rattle you, you can deactivate them in a menu setting.

Yaesu offers an optional *Windows*-based programming kit, the ADMS-2E, that can make setting up this radio even easier. If you happen to encounter a second FT-2600M, you can also "clone" the programmed information from one into the other. This operation does not require a computer and is performed via interconnection of the two microphone jacks using a user-constructed cable.

Lab numbers for this transceiver are very good. If you refer back to previous product review columns and compare the measurements with the other single band VHF transceivers covered in recent years, you'll find the FT-2600M stands up to the competition quite well. The 0.12 µV FM sensitivity scores at the top of the class. The 10 MHz offset IMD, usually a good indicator of a unit's ability to fight off interference from strong, nearby VHF commercial communications, measures well above the running average. The IF and image rejection figures are also very respectable. These performance characteristics may be partially attributable to its commercial heritage.

Gripes

The FT-2600M offers very good performance, a good measure of features and durable construction. The only complaints that I can come up with are the lack of front panel button label lighting and a couple of digs that are related to the included microphone.

The fit and finish of the FT-2600M seems top notch. The only exception is the rubber boot that covers the connector on the radio end of the microphone cable. It's a loose slip fit over the plug and cable and makes that connection appear loose and sloppy. Although it probably doesn't accurately reflect the overall durability of the plug's connection, it is a bit annoying. The only other beef I have is with the microphone PTT button. The spring return tension is very light—I found myself accidentally activating the transmitter on a number of occasions.

The Last Words

The FT-2600M is a VHF FM transceiver with a healthy variety of the right stuff—very respectable features, performance, rugged good looks and uncomplicated operation. If you're looking to install a voice or voice and data transceiver in your shack or vehicle, the '2600M is just begging for you to initiate a more thorough private investigation. Let 'im have it.

Manufacturer: Yaesu USA, 17210 Edwards Rd, Cerritos, CA 90703; tel 562-404-2700, **http://www.yaesu.com**. Manufacturer's suggested retail price: FT-2600M, $289. Typical current street price, $240. ADMS-2E Windows programming kit, $38.

The Kenwood CS-4125 20 MHz Dual Trace Oscilloscope

Reviewed by Mike Gruber, W1MG
ARRL Technical Advisor

"An oscilloscope measures voltage with respect to time." Those scholarly words from a lecture by one of my electronics instructors—more years ago than I care to admit—seemed remarkably profound at the time. I didn't fully appreciate their significance until some time later—probably not until the course was over. My instructor's words stayed with me all these years however—which, I suppose, is a testament in itself. Despite modern advances in oscilloscope technology, that basic premise still remains unchanged.

Here is a simple explanation of how an oscilloscope works. A focused beam of electrons strikes the phosphorus coating on the inside of the screen of a cathode ray tube (*CRT*). The phosphorous at the point that the beam strikes glows. Coils located on the neck of the CRT create a variable magnetic field that is used to deflect the beam. One set of coils is used to sweep the beam from left to right across the screen. This movement in the horizontal direction corresponds to the "time" in my instructor's quote. Simultaneously, the level of a particular input signal that you are sampling—an ac or dc voltage for example—is used to control the magnetic fields produced by a second set of coils that varies the deflection in the vertical direction. The greater the voltage, the greater the vertical deflection.

As the changing magnetic fields influence the position where the beam strikes the screen, a glowing phosphorous trace along the path of its motion creates a graphical representation of the voltage over time. Typically, the beam is blanked during its return to the left side of the screen. The process repeats itself when the 'scope's "triggering" circuitry senses the correct point on the waveform (set by the user) and initiates a new horizontal sweep. If properly triggered, the repeating sweeps render a steady image of the input signal's magnitude over a specific time period.

A classic example is the familiar sine wave shape that's formed by a properly sampled alternating current (ac) voltage.

While perhaps not as universal or indispensable as the venerable multi-meter, the 'scope can add some tremendous measurement capabilities to your test bench. As an electronics student, I found that the way information is shown on an oscilloscope's screen can be an invaluable aid in understanding what's actually going on in a circuit.

Should you be adding an oscilloscope to your test bench? Today's typical electronics hobbyist probably considers laboratory grade instruments way beyond his financial means. While there are some inexpensive hobby grade oscilloscopes on the market, they often lack important features, and the surplus units you'll see crowding the tables at the typical hamfest are typically those large, heavy vacuum tube versions of yesteryear.

A high quality dual trace oscilloscope that includes a good variety of the measurement capabilities commonly needed on the test bench is not always easy to find, especially at a price that won't break the budget. Is the Kenwood CS-4125 the exception? Let's take a look!

First Impressions

At first glance, the outward appearance of the CS-4125 reminded me of the laboratory grade oscilloscope in the ARRL lab. Even the color was similar. I was impressed with the quality of construction. I also thought that its size would be an ideal compromise for most hobbyists. The control panel labels; the screen; and the knobs and switches are large enough to easily read and operate—yet the instrument itself is small and light enough to find room on a small workbench or to allow for easy transportability. The unit measures roughly $6^1/_4 \times 13^1/_2 \times 16^3/_4$ inches. The screen is about $3^1/_2 \times 4^1/_4$ inches.

The controls and layout are so similar to other oscilloscopes that I've worked with that I decided to try performing a few simple measurements with the CS-4125 before I read the manual. Much to my surprise, I succeeded in observing numerous waveforms from my signal generator with ease. The waveform traces were clear, easy to read and very stable. While I wouldn't recommend that *you* dive right in without first reading the documentation, this should serve to illustrate the intelligent layout and intuitive operation of this instrument.

Features and Controls

The CS-4125 comes with two 1X/10X probes and a removable power cord. An outer transport case and a control panel cover are not included. There are no user changeable expansion modules or plug-ins either, but Kenwood does offer an optional accessory bag (MC-78). This bag attaches to the top of the oscilloscope and provides storage for the probes and the manual. This is the only available accessory.

The handle deserves mention. It not only serves as a convenient carrying point but also provides an adjustable prop for the unit. It locks in to several different positions, two of which are suitable for tilting the front panel up for easier viewing. You can also store it flush against the underside of the case, much like the bails common on HF transceivers. Four large plastic feet are attached to the bottom of the cabinet for setting it flat on a bench or shelf. The back panel has four projections molded into the corners that serve as legs—allowing you to securely stand the oscilloscope with the front panel facing upward. A recessed area on the back panel includes tabs for winding the power cord for storage.

The most prominent feature on the front panel is—of course—the screen, located on the left side. All front panel controls are positioned to the right of the screen and are grouped in six distinct sections.

In the upper left hand section is a set of four controls that include the **POWER** pushbutton switch (with an LED power-on indicator); **INTENSITY** and **FOCUS** controls; and a screwdriver adjustment control point for **TRACE ROT**ation.

Just to the right is a collection of controls labeled **VERTICAL**. These include a 5-position toggling **MODE** switch that selects which of the channels (or combinations thereof) is displayed, a **CH 2 INV**ert button and an **X-Y** button.

In the upper right hand corner there's a **TRIGGER** control group. You'll find two additional 5-position toggle switches labeled **MODE** and **SOURCE**, a trigger threshold **LEVEL** adjustment knob and a rising or falling signal **SLOPE** trigger push button.

The remaining three sections make up a second row of control groups. There are two identical groups labeled **CH1 or Y** and **CH2 or X**. These each contain a knob marked ↕**POSITION**, a second knob marked **VARIABLE**, a 12-position rotary switch for selecting the **VOLTS/DIV**ision and a 3-posi-

Bottom Line

The Kenwood CS-4125 offers the measurement precision and many of the expanded capabilities found on the high-end oscilloscopes at a price that's attractive to the electronics hobbyist.

Table 2

Kenwood CS-4125, serial number 2090695: accuracy

Frequency		*Voltage*	
Marconi Signal Generator	***CS-4125***	***Precision DC Reference***	***CS-4125***
10.0 kHz	9.93 kHz	10.0 mV	10.2 mV
20.0 kHz	19.9 kHz	20.0 mV	20.2 mV
50.0 kHz	49.8 kHz	50.0 mV	50.1 mV
100 kHz	99.1 kHz	100 mV	101 mV
200 kHz	201 kHz	200 mV	203 mV
500 kHz	506 kHz	500 mV	504 mV
1.00 MHz	1.01 MHz	1.00 V	1.01 V
2.00 MHz	2.02 MHz	2.00 V	2.04 V
5.00 MHz	5.04 MHz	5.00 V	5.04 V
10.0 MHz	10.1 MHz	10.0 V	10.2 V
20.0 MHz	19.9 MHz	20.0 V	20.0 V

Size (hwd): 6.25×13.5×16.75 inches; weight, 15.6 pounds.

tion **AC**/**GND**/**DC** toggle switch.

To the right of these is a section titled **HORIZONTAL**. Here you'll find a 20-position **SWEEP TIME/DIV**ision switch, a **VARIABLE** sweep time control, a ↔**POSITION** control and a **X10 MAG**nification push button. Also located within this group is a **CAL**ibrate output signal test point. The calibrating signal is set for 1 V peak to peak at 1 kHz.

Along the bottom of the faceplate are three BNC connectors. These provide 3 inputs—for channel 1 (or Y), for channel 2 (or X) and an additional input for external triggering. A binding post for a ground connection is also included.

On the back panel of the '4125 there are two additional BNC connectors; a **CH 1 OUTPUT** (5 V RMS maximum) and a **Z-AXIS INPUT** (42 V peak maximum)—more on these later.

The Manual

The *Instruction Manual* is a $6 \times 8^{1}/_{4}$ inch booklet and covers both the CS-4125 (20 MHz) and a CS-4135 (40 MHz) oscilloscope models. Only 32 pages—about half the manual—are in English and pertain directly to oscilloscope operation. The rest consists of instructions in Japanese and several pages of safety warnings in Japanese, German and English.

The manual contains the usual table of contents, explanation of features, control descriptions and initial control settings. In fact, it reminds me somewhat of the typical transceiver manual. The later part also details a handful of sample oscilloscope applications—including measuring the voltage difference between two points on a waveform, measuring times and frequencies, and measuring signals with high and low frequency components. While no doubt helpful, I believe most beginners would benefit from additional and supplemental material, such as that contained in chapter 26 of the new *2000 ARRL Handbook*.

Overall, I'd rate the manual as adequate—but there is some room for improvement. While clear and comprehensive with regard to most of the various functions of the CS-4125, it could be enhanced with a little more detail in some areas. The explanation of the trigger source control, for example, isn't as clear as it could be—it is, however, accurate as presented. There are also a number of typographical errors.

Features

The CS-4125 is equipped with nearly all of the features I would expect to find in a quality dual trace oscilloscope. If you're already familiar with oscilloscope operation, you'll recognize many of them. Some features are particularly notable—especially for a 'scope in this price range. I'll point them out as we take a closer look.

The unit displays two waveforms simultaneously by using either an "alternate" or "chop" process. The alternate setting automatically alternates between the channel 1 and channel 2 traces with each sweep. For two signals with a reasonably high sweep rate, this allows you to clearly view the two input waveforms on the screen at the same time. The chop setting rapidly switches (at about 150 kHz) between the two channels. This setting reduces the flickering that would occur when viewing two inputs that have slow repetition rates or relatively slow sweep rates.

I was very pleased to discover that the CS-4125 also includes an "add" capability. While this has many uses, the manual describes one in step-by-step detail. When used in conjunction with the **CH2 INV**ert feature, it can cancel an undesired signal from a displayed waveform. Simply feed a sample of the undesired signal to channel 2, invert it, then add it in to the desired plus undesired signal that is connected to channel 1. The resulting trace is a representation of the signal fed into channel 1 with the undesired channel 2 signal removed.

Both the vertical (voltage) axis and the sweep time accuracy are specified at ±3%. Variable fine adjustment controls for each axis are also included. These knobs have a slight detent as you rotate them into the **CAL**ibrate position.

The large aperture rectangular screen has a grid with ten horizontal and eight vertical divisions. Each division is 1 cm × 1 cm. Tick marks further divide both the vertical and horizontal lines of the "cross-hairs" into 5 segments per cm.

On the left edge of the screen there are convenient percent markings at 0, 10, 90 and 100% vertical scale—very handy for measuring rise times. The horizontal lines that correspond to the 10 and 90% values are also divided with five tick marks per centimeter.

One particularly nice aspect of the screen and scale arrangement is its "reduced parallax" feature. The lines that make up the measurement grid are etched onto the face of the CRT, significantly reducing the measurement errors that can result from viewing the screen from off angles. The display does not include scale illumination.

Another neat feature is the action of the intensity control. Unlike many oscilloscopes, an automatic focusing system helps maintain proper focus as you vary the trace intensity.

Speaking of intensity, there's a **Z. AXIS INPUT** jack that will vary the intensity of the trace relative to the connected voltage. A positive voltage fed into this input will decrease the intensity of the trace. TTL level intensity modulation is also possible.

Each probe has a **X1/X10** switch that effectively expands the range of the vertical axis. The **X10 MAG**nification button, located in the **HORIZONTAL** control group, can expand the horizontal axis.

An X-Y operating mode provides additional measurement capability. In this mode, the "Y" axis is not swept but rather controlled by the channel 1 input. The "X" axis is controlled by the input to channel 2. Using X-Y operation, you can determine phase differences and frequency relationships between the two signals with Lissajous patterns. A good example of an application for this is the generation of the "twin bananas" display of the "mark" and "space" signals of a properly tuned RTTY signal.

I find the **CH1 OUTPUT** jack, located on the back panel, to be a particularly notable inclusion. With it, a signal fed into the channel 1 input can be easily shared with another measurement instrument—a frequency counter for example. The channel 1 output level supplies 0.1-V for each vertical division of channel 1 trace that's shown on the display. This built-in circuitry affords a couple of advantages. The channel 1 input is high impedance and the channel 1 output is 50 Ω. This allows the oscilloscope to act as a signal buffer. Since the output is proportional to the size of the waveform on the display rather than the actual input voltage, you can use the channel 1 **VOLTS/DIV**ision and **VARIABLE** controls to amplify or attenuate the input signal before you feed it to the other device.

The maximum voltage that's available at the channel 1 output is 5 V. Note that with the 8 vertical divisions available on the display and the fixed 0.1-V/division scaling factor for this feature, a waveform that fills the display from top to bottom would result in an output of only 0.8 V. To get a higher output voltage, you would need to set the 'scope to display the waveform with some (or most) of it expanded beyond the viewing limit of the screen.

I also found some highlights in the CS-4125's triggering functions. Triggering sets the point at which a sweep begins on a waveform, and good triggering is particu-

larly important for display stability. As expected, there are the usual **AUTO**matic and **NORM**al triggering modes. These trigger a new sweep at a certain rising or falling voltage on the waveform. The normal mode initiates a sweep only when triggering occurs, while the automatic mode provides a free running sweep in the absence of a trigger.

While those two modes are pretty common, I was surprised to see three additional triggering options. There's a **FIX**ed setting that provides a fixed trigger level regardless of the trigger **LEVEL** control setting, a **TV-FRAME** setting that triggers on composite video vertical sync pulses and a **TV-LINE** setting that uses composite video horizontal sync pulses for triggering. The later two capabilities—obviously—are exceptionally handy when working with television and video signals.

Performance

We sent the CS-4125 to an independent metrology lab in the Boston area to verify its calibration accuracy "straight out of the box"—it met its accuracy specifications. The level of accuracy of this unit compares favorably in many areas with the analog laboratory grade instrument used in the ARRL lab. The ARRL oscilloscope's frequency response however, extends all the way to 100 MHz, while the CS-4125 is only rated up to 20 MHz. Table 2 shows the results of test measurement comparisons taken in the ARRL lab.

Above 20 MHz, although the waveform image may still be present, the displayed amplitude of the waveform will drop off quickly with rising frequency.

On the test bench, the CS-4125 performs a yeoman's job with a variety of signals from a number of sources. Triggering is easy to set, and once set, traces are stable and jitter-free. Even when I varied the frequency and amplitude, the CS-4125 seemed reluctant to loose trigger. Triggering in the fixed mode is also surprisingly stable over a very wide rage of levels. (Note: The triggering's **LEVEL** control is disabled in this mode.)

In Summary

The CS-4125 is a basic but quality oscilloscope with features not ordinarily expected in an instrument in this price class. It's compact size and light weight makes it a fine choice for both bench-top and portable use. The CS-4125 rates serious consideration by anyone who does not have a need for more advanced features—such as those afforded by a digital or storage scope. Performance-wise, the CS-4125 is ideal for home, shop and hobby uses, and could quite possibly fit the bill in many laboratory applications as well.

Manufacturer: Kenwood TMI Corporation, 16-2, Hakusan 1-chrome, Midori-ku, Yokohama-shi, 226 Japan. *US Importer*: Print Products International, 8931 Brookville Rd, Silver Spring MD 20910; 800-638-2020; fax 800-545-0058; **sales@prodintl.com**; **http://www.prodintl.com**.

Importer's suggested retail price: $595. Typical current street price: $395.

APRS Engineering's MIM Module

Reviewed by Stan Horzepa, WA1LOU
QST Contributing Editor

The MIM Module is a tiny circuit board that serves as a building block for a packet encoder and modulator for APRS position and telemetry reporting applications. It assembles data into APRS/AX.25-compatible packets for transmission at 1200-baud by a suitable transmitter. Note that the MIM Module is a transmit-only device; it cannot be used to demodulate and decode received packets.

It's capable of encoding for packet transmission Global Positioning System (GPS) position reports you provide to it in NMEA 0183 format, any telemetry information you supply to it via analog and digital inputs and beacon text that you have programmed in its EEPROM. It will also generate 20 WPM CW for station identification.

DOS-based software, *MIC107.EXE*, is bundled with the MIM and is used to program your call sign, digipeater paths, beacon text and for setting the unit's various operating parameters.

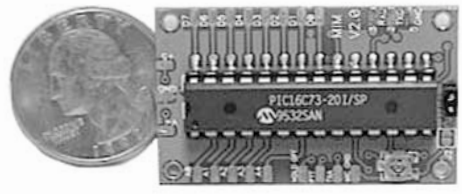
The module will accept power from a regulated 5 V dc source or an unregulated 6.5 to 40 V dc source. An on-board voltage regulator handles unregulated sources and provides a 5 V dc 100 mA output. Since the module requires less than 15 mA, the remaining regulated output may be used for other applications.

The unit is constructed on a 1 × 1.7-inch PC-board that contains surface mount components and a socket-mounted microcontroller (to facilitate firmware upgrades). Solder pads along the perimeter of the board provide the power, programming, telemetry, data and control connection points. These include the unregulated dc input, the regulated dc input/output, 5 analog inputs (0-5 V dc), 8 digital inputs, RS-232 received and transmitted data, TXA hold-off, PTT output, transmit audio, mike ground and chassis ground.

The MIM module is not plug and play. It's intended to be a subassembly for constructing a device for a desired application. Its small size makes it ideal where smaller is better.

Some possible examples for applications for the MIM Module are GPS trackers—where data provided from a connected GPS receiver would be encoded and transmitted, reporting the position of the station.

The telemetry inputs can be used to report the readings of nearly any sensor whose information can be represented by or converted to a voltage between 0 and 5 V dc or a high or low logic state. With a total of 13 inputs, there's a tremendous capacity for instrumentation of any system—this could serve as the interface between the sensors and the radio transmitter of a remote weather station for example. Couple these sensing capabilities with its light weight and compact size, and this makes the MIM Module an ideal subassembly for telemetry and/or position reporting for balloons or rockets.



Building a "Tracker"

I wanted to use the MIM module in a device that would test both its APRS position reporting ability and also touch on its telemetry applications. I decided on a simple battery-powered APRS tracker for connection to the mike jack of an FM transceiver. For tracking, I would feed the MIM position reports that were calculated by my GPS. For telemetry, I used a voltage divider (circuit details are included in the documentation) that allows me to monitor the voltage of the 9-V battery I used to power the module.

To build my device required the purchase of just a handful of parts. These included assorted connectors, resistors, a 9-V battery and snap on battery terminal and a 10-position DIP switch.

In order to build my tracker, I followed the directions for building a "MIC-Lite" that are provided with the MIM Module package. This unit would be very similar to the MIC-E—a TAPR kit that, like the MIM, can encode and transmit GPS position packets.

The MIM can be configured in either of two different modes—the "MIM" or the "MIC-E" mode. In the "MIM" mode, all 13 of the device's input pins are available for use as telemetry inputs. In the "MIC-E" mode, 10 of these pins are assigned to specific control functions that are controlled with external switches. The switches are used to set the digipeater path, to change the GPS position transmit rate, and to select one of the 7 preprogrammed APRS position comments. In this mode, only the remaining 3 inputs are available for telemetry information.

The plans include an internal microphone element and PTT switch, therefore eliminating the need for an external microphone. This makes it especially handy for H-T APRS applications. Since I planned to use my tracker for APRS position and telemetry only, I eliminated the microphone element and PTT switch circuitry from my final design.

I completed the tracker sans enclosure in one evening. Once I decide on what kind of enclosure to use, I imagine I will have to invest another evening in buttoning up the project.

In my verson, the 10-position DIP switch allows me to select one of eight "canned" APRS position comments ("Off Duty," "Enroute," "In Service," "Returning," "Committed," "Special," "Priority," or "Emergency"), that is transmitted with each position packet. The switch set also permits me to choose any digipeater paths and to select how often I want a position packet to be transmitted (typically "often" when my tracker is mobile and "not so often" when it is stationary). There's also a switch that toggles the battery power on and off.

Tracker Programming

With assembly completed, I connected the tracker's serial port connector to the serial port (COM 1) of my computer and started the *MIC107.EXE* software.

MIC107.EXE is simple, bare bones DOS software. When you start the program, it reads the current settings stored in the MIM's memory. It then displays those settings in the DOS window, along with a list of available commands and provides a command prompt for entering them.

Some of the commands are similar to those that you would use to program an AX.25-compatible TNC. MYC, for example, allows you to program your call sign and SSID. Other commands are unique to the MIM. If the function of a command is forgotten or not obvious, the software can provide help. Enter "H," a space, and the unfamiliar command (eg, "H TXDP") and the software will display a brief description of that command. This built-in assistance was a godsend—the documentation provided with the module does not include a description of all the available commands.

I selected the MIC-E mode, then programmed the various timing and identification parameters I would need. As a guideline, here is how I programmed the tracker for my application:

MODE MIC (selects the MIC-E mode)
PER 15 (sets the reference timing period to 15 seconds)
POS 2 (a multiple of PER, POS determines how often a position packet is transmitted)
B 30 (a multiple of POS, B determines how often the beacon is transmitted)
TELE 4 (a multiple of POS, TELE determines how often telemetry is transmitted)
TXD 22 (a multiple of 10 milliseconds, TXD determines the delay between when the transmitter is keyed and the packet data stream begins)
BT Tracker in a Rocket 88 (BT sets the contents of the beacon text)
MYC WA1LOU-8 (MYC sets the call sign and SSID of the tracker)
MYS /p (MYS selects the icon that will appear on APRS maps)

Note that I did not use the VIA command to select a digipeater path—I planned to test the tracker within the coverage area of my home APRS station, which is also an APRS digipeater (WA1LOU-15).

Once I set all the operating parameters, I invoked the PERM command to store my selections in the memory of the module.

Tracker Tracking

With programming completed, I quit *MIC107.EXE*. Then I disconnected the tracker from my computer's serial port and connected my GPS. I also plugged the radio port connector (an 8-pin mike connector in my case) into my mobile FM transceiver, powered everything up, and hit the streets.

I drove around downtown Wolcott, Connecticut for approximately 30 minutes. The only indication that anything was happening was when my FM transmitter's red transmit LED lit briefly every minute or so, presumably transmitting packets generated by my tracker. I returned to the Horzepa Homestead, but instead of powering everything off, I toggled a DIP switch to set the packet transmission rate to the "not-so-often" position, hopped out of the car and headed straight to the ham shack to see what had transpired.

On the computer screen of my home APRS station, I viewed the APRS map for downtown Wolcott. The map showed my tracker's icon in several positions along my route and the included telemetry data reported that my tracker's battery power was hovering around 9 V dc. All seemed to be working according to plans!

I left the tracker running overnight and checked the APRS map again in the morning. As expected, my tracker's icon was still in the same spot on the map and my tracker's battery voltage was still around 9 V dc.

Everything was working as expected. Now all I have to do is go shopping for a suitable enclosure to complete my tiny tracker.

What's Up, Docs?

My only real complaint with the MIM module is its documentation. It consists of seven text files that are stored on the *MIC107.EXE* diskette that accompanies the module and one additional file on their Web site. These files cover various aspects of the MIM.

Some of the information contained in the files is redundant, some of it is lacking and all of it seems a bit disorganized. As a result, I found myself spending an inordinate amount of time switching between files trying to locate needed information. Just when I thought I found a bit of information I was seeking in one file, I would discover related bits of information in a different file. I often found myself wondering, "Is this the information I need or is there more lurking elsewhere in some other file?"

I made things a little easier for myself by using a word processor to combine all the files into one large file. This allows me to use the word processor's search facilities to find information. However, this is only a stopgap solution. The MIM desperately needs a comprehensive, well-organized, indexed manual. As I wrote earlier, the MIM module is not "plug and play."

In Conclusion

Except for the documentation, the MIM module is an excellent product whose time has come. With APRS booming all over the Amateur Radio world, the MIM can be a key ingredient in the designs of tinkerers and experimenters who are trying to cram tracking and telemetry into nooks and crannies everywhere.

Manufacturer: APRS Engineering LLC, 115 Old Farm Ct, Glen Burnie, MD 21060; **wb4apr@amsat.org**; **http://www.toad.net/~wclement/mim2.htm**.

Price: $79 plus $4 shipping and handling.

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