Product Reviews

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Product Reviews:

Ameritron ALS-1306 HF and 6 Meter Power Amplifier

MFJ-939I Automatic Antenna Tuner

Rowetel SM1000 FreeDV Adapter

JYE Tech Ltd DSO138 DIY Oscilloscope Kit

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Ameritron ALS-1306 HF and 6 Meter Power Amplifier

A no-tune solid-state amplifier delivering 1200 W PEP output from 160 to 6 meters

Reviewed by Phil Salas, AD5X
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The ALS-1306 is the next iteration of Ameritron's ALS-1300 solid state, 1200 W amplifier reviewed in the September 2011 issue of *QST*.[1] The ALS-1300 covered 160 – 15 meters (plus 12/10 meters with an optional filter), but the ALS-1306 covers all ham bands from 160 – 6 meters except for 60 meters. While the ALS-1300 required the Ameritron ARI-500 interface for automatic band tracking from the transceiver's band data, the ALS-1306 has auto band tracking built in. The only ALS-1306 options currently available are various transceiver interface cables and the external QSK-5 PIN diode transmit-receive (TR) switch. Some operators who enjoy high-speed, full break-in CW will want to consider the silent-operating QSK-5, which was not included with our amplifier. We'll discuss interface cables later in the review.

Overview

The ALS-1306 consists of a main amplifier RF deck and a separate 50 V dc, 50 A power supply. The power supply cable permits RF deck and power supply separation up to 6 feet. Both units are reasonably compact and lightweight, making this amplifier/power supply combo convenient for home, portable, and DX operations. The amplifier specifications and performance measurements are given in Table 1.

The ALS-1306 power supply (see Figure 1) consists of two identical 50 V, 25 A switchmode power supplies mounted back to back. A single 4-inch fan cools the power supply. The power supply comes wired for 240 V ac operation, and it includes a permanently attached cable with NEMA 6-15P plug, which will mate with either a NEMA 6-15R or 6-20R receptacle. Operation from 120 V ac is possible, but not recommended.

The ALS-1306 RF deck consists of two combined 600 W amplifier modules, each with four MRF-150 FETs (eight MRF-150 FETs total). Four 3-inch temperature-controlled fans cool the amplifier modules by drawing air through the heatsink fins. Figure 2 shows an edge view of the heatsink, underneath the low-pass filter assembly.

> **Bottom Line**
>
> The Ameritron ALS-1306 solid-state amplifier provides 1200 W PEP from 160 – 6 meters. Its size, weight, no-tune capability, and ability to integrate seamlessly with most transceivers make it a good candidate for your ham station.

The ALS-1306 includes effective protection circuitry. An onboard processor monitors for faults including high SWR, amplifier current mismatch, incorrect filter selection, high PA heatsink temperature, transmission from 26 – 28 MHz, and the band switch set to REMOTE but no remote band data sensed. When the amplifier faults, it drops into standby and is bypassed automatically. Normal operation is restored by first clearing the fault and then switching from OPERATE to STANDBY and then back to OPERATE.

Amplifier metering consists of two cross-needle meters with LED backlighting. The left meter simultaneously monitors the FET drain currents of the two 600 W amplifier modules. The right multimeter monitors the following parameters:

REF: Amplifier forward and reflected power, and SWR.

PAB: Power amplifier balance, with a zero reading indicating perfect balance.

ALC: ALC activity between the amplifier and transceiver when ALC is connected.

HV1 and HV2: Drain voltage applied to the two internal power amplifier modules.

Backlit indicators show the band selected, whether it is manually selected by the BAND switch or automatically selected by a connected transceiver. The ALC indicator flickers when ALC is active, and the TX indicator lights when the amplifier is keyed. Finally, the state of the SWR, PA, and TX indicators (steady and blinking) provide detailed fault information as described in the ALS-1306 manual.

Figure 1 — The matching power supply.

Table 1
Ameritron, ALS-1306, serial number 00038

Manufacturer's Specifications	Measured in ARRL Lab
Frequency range: All amateur frequencies in the range of 1.8 to 54 MHz.	160, 80, 40, 30, 20, 17, 15, 12, 10, 6 meters.
Power output: 1200 W PEP typical.	As specified, except 1000 W on 6 meters.
Driving power required: ≤100 W.	60 – 100 W (typical) for 1200 W output.
Input SWR: Less than 1.5:1.	As specified.
Spurious and harmonic suppression: Not specified.	60 dB (typical), except 47 dB on 30 meters (3rd harmonic). Meets FCC requirements.
Third order intermodulation distortion (IMD): Not specified.	3rd/5th/7th/9th: 14 MHz: 37/40/52/56 dB below PEP. 50 MHz: 26/39/46/52 dB below PEP.
TR switching time: Not specified.	Amplifier key to RF output: 12 ms; amplifier un-key to RF power off: 29 ms.
Primary power requirements: 200 – 260 V ac, 50 – 400 Hz, 15 A.	
Size (height, width, depth): amplifier, 7.7 × 10.7 × 18.9 inches; power supply, 7.7 × 10.7 × 14 inches (depth shown with power cord bent reasonably).	
Weight: amplifier, 23.5 lbs; power supply, 12 lbs.	
Price: $3000.	

Amplifier Connections

Figure 3 shows the rear panel of the ALS-1306. The power supply cable connects to the large POWER INPUT connector. Standard UHF RF IN/RF OUT connectors, a ground wire post, and ALC and RELAY (amp key) connectors provide transceiver interfacing. ALC should be used only to prevent accidentally overdriving an amplifier, as you should always adjust your drive level to properly drive any amplifier prior to ALC onset. The REMOTE A/B connectors are for future remote control devices.

The RELAY input has an open circuit voltage of 12 V dc and requires your transceiver's amplifier keying output circuitry to sink < 20 mA. Therefore the ALS-1306 can be keyed from any transceiver without requiring a special interface. Note that the ARRL Lab measured 12 ms for ALS-1306 transmit-receive (TR) relay actuation. Most current transceivers have an amp-key-to-RF-output delay menu setting. Set your transceiver to delay the RF output more than 12 ms to prevent hot switching.

The BAND DATA connector provides for automatic band tracking with most transceivers, as well as an amp key input that is in parallel with the RELAY jack. The BAND DATA interface currently supports Icom band voltage (not CI-V), Elecraft and Yaesu BCD band data, and Kenwood RS-232. No special setup is needed. Just connect the appropriate interface cable between your transceiver and the ALS-1306, and the amplifier will sense the band data information and track your transceiver.

Incidentally, Icom band voltage does not discriminate between 15 and 17 meters, or 12 and 10 meters, so the ALS-1306 band indication may not correspond to the Icom band selected. It depends on whether the previous band is below or above 15/17 or 12/10 meters. The ALS-1306 uses the same filters for 15 and 17 meters, and for 12 and 10 meters, so the amplifier will operate fine even if the indication is wrong on these bands.

Finally, a problem occurs when attempting to simultaneously use the ALS-1306 RS-232 Kenwood interface and other RS-232 devices. For example, you might also want to use the RS-232 band information with a computer logging program or a controller to automatically switch a band pass filter or antenna switch. In these cases, the ALS-1306/Kenwood band tracking interface does not work. MFJ is working on a firmware update to address this.

As I have an Elecraft K3, I acquired the Ameritron DB-DB15HE cable. After receiving the cable, I found that it was not optimum for my application. While the DB-DB15HE provides the Elecraft BCD band data information to the ALS-1306, it also provides direct keying of

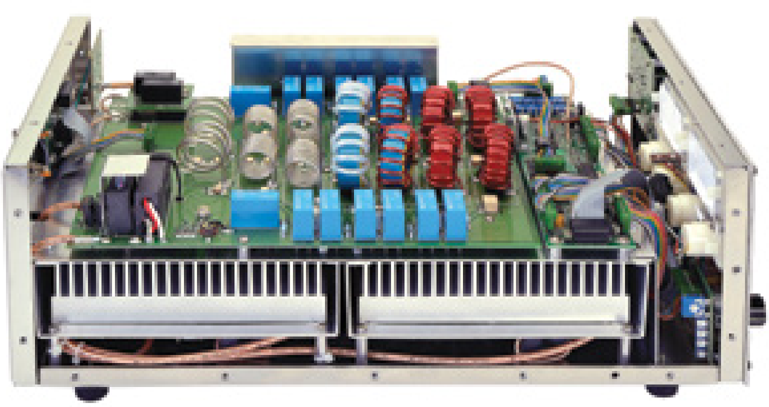

Figure 2 — Inside the ALS-1306. The two individual 600 W amplifier heatsinks are visible below the low-pass filter board.

Figure 3 — Rear panel view of the ALS-1306.

the ALS-1306 via the K3 ACCESSORY connector. The first problem is that the ALS-1306 keying input was measured at 13 mA. This is above the 10 mA maximum keying capability specified by Elecraft for their ACCESSORY connector. Further, my lower-band antenna is a 43-foot vertical, so I use an MFJ-998 auto tuner with this antenna system. The MFJ-998 interrupts the amp key line when the SWR is high or when the MFJ-998 is tuning, a feature found on other auto tuners and high-end SWR meters. For this feature to work, the amp key line cannot connect directly to the ALS-1306 band data amp key input. I built my own version of a K3 interface cable that does not include amp keying, and also brings out the K3 ALC input. Amp keying is provided by a standard phono cable that connects the K3 phono amp key output through the MFJ-998, and then on to the ALS-1306 RELAY input jack. See *QST* in Depth on the ARRL website for details on this cable.[2]

Performance Measurements

FCC compliance and IMD testing was performed in the ARRL Lab, with the results shown in Table 1. I conducted some additional testing at my station, with the results shown in Table 2. My initial tests included measuring amplifier power output and checking the amplifier's internal power meter against an Array Solutions PowerMaster PEP wattmeter (NIST-traceable, specified accuracy ±3%). I adjusted the drive for amplifier output power of 1200 W PEP using a properly spaced string of Morse code dits (this should correspond to about a 25% duty cycle, which is similar to the SSB duty cycle). Then I measured the power after key-down continuous transmission for 5 seconds. The ALS-1306 met its 1200 W PEP specification on all bands except 6 meters, though there is some power sag under key-down conditions. As we went to press, Ameritron indicated that they are revising the input attenuator board to switch out the attenuator on 6 meters. This will allow the amplifier to make 1200 W output on that band with 60 to 70 W of drive. Note the low drive necessary to get to the US limit of 200 W output on 30 meters.

I also found the ALS-1306 peak-reading wattmeter to be quite accurate for an analog meter. Each "tick" on the meter is 100 W, and all ALS-1306 meter readings were within 1 tick of the PowerMaster readings.

Table 2
Typical Amplifier Operating Conditions

Measured by the author (see text).

Band (m)	Input SWR	Drive (W) for 1200 W PEP Output	Output Power (W) Key-Down*
160	1.02:1	50	1100
80	1.08:1	70	1050
40	1.19:1	65	1050
30	1.21:1	12**	200**
20	1.27:1	50	1100
17	1.29:1	60	1080
15	1.57:1	55	1100
12	1.51:1	40	1150
10	1.27:1	42	1050
6	1.16:1	75	950

*Output power after 5 seconds continuous transmission.
**Tested at US legal limit of 200 W.
Bypassed SWR was 1:1 on all bands.

Table 3
SWR Degradation Tests

Band (m)	SWR	Fault Forward Power (W)*
80	17:1	150
40	5.6:1	250
20	2.5:1	650
17	2:1	950
10	1.5:1	No fault

*This is the power level at which the amplifier protection kicked in at the frequency and SWR shown. See text.

Next I looked at SWR protection. The ALS-1306 is designed to protect itself when it senses approximately 150 W reflected power. To test this, I built a "SWR degradation" box consisting of a high-current 220 pF capacitor placed in series with my high-power dummy load. This permitted me to vary SWR by simply changing bands. I applied the full drive required for 1200 W PEP as listed in Table 2 to the SWR degradation box/dummy load. For any SWR of 2:1 or greater, the amplifier immediately faulted with no damage. Then, starting with very low drive, I increased the drive level until the amplifier faulted. Table 3 lists the actual forward power versus SWR that caused the amplifier to fault.

RTTY Operation

At the time of this review, Ameritron had not specified the 100% duty cycle output power necessary for RTTY or other continuous carrier modes. One operator tried using the ALS-1306 during an RTTY contest, which typically requires 5 to 10 second transmissions, followed by a short receiving break, over and over again for an extended period. At 1000 W output, he noticed that after a few minutes of this, the PA balance meter indication crept higher until the PA warning light flashed. Reducing power to 600 – 700 W allowed operation to continue.

We reported this experience to Ameritron, and they decided to try a different core material for the output transformers to help with heat issues. The new core material is used in current production. As we tried to nail down a RTTY power rating, Ameritron indicated that specifying such a rating is complicated and depends on the load impedance, SWR, ambient air temperature, duty cycle, band of operation and other factors such as components heating and cooling at different rates.

Based on the 350 W output/10 minute on-off/50% duty cycle RTTY specification of the Ameritron ALS-600 amplifier, I believe that 700 W for safe RTTY operation is about right, as the ALS-1306 is essentially two combined ALS-600 amplifiers. I transmitted 700 W for the 60 seconds that my dummy load could take this power level without overheating. During that time the

See the Digital Edition of *QST* for a video overview of the Ameritron ALS-1306 HF and 6 Meter Power Amplifier.

ALS-1306 fans did not speed up, and no thermal alarm was given. Of course this is not a perfect test, but does indicate a good starting point. The amplifier's protection circuitry will let you know if you overdo it.

Some Thoughts on an Antenna Tuner

Unless you have a near-perfect antenna system, the ALS-1306 will require an antenna tuner for full-power operation. Since it's a no-tune amplifier, an auto tuner may be your first choice. My MFJ-998 handles 160 – 10 meters nicely, and provides amplifier disabling during tuning and/or high SWR conditions. Since most 6 meter antennas are resonant and well-matched, 6 meter antenna tuner capability usually isn't necessary. However, when my MFJ-998 is bypassed, the SWR at 6 meters is a little high at about 1.5:1. Further, it would be more convenient if the MFJ-998 followed transceiver band changes, as does the ALS-1306.

Conclusion

If you've been considering a high power solid-state amplifier, the Ameritron ALS-1306 may fit your needs. Its well-protected 1200 W PEP output, no-tune operation, and automatic band switching provides simple installation and operation.

Manufacturer: Ameritron, 116 Willow Road, Starkville, MS 39759; tel 662-323-8211; **www.ameritron.com**.

Notes

[1]P. Salas, AD5X, "Ameritron ALS-1300 HF Power Amplifier," Product Review, *QST*, Sep 2011, pp 51 – 52.

[2]The file is available for download from **www.arrl.org/qst-in-depth**.

MFJ-939I Automatic Antenna Tuner

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Those of us who live in urban areas rarely have the space for HF Yagis or other large antennas. My 102-foot-long G5RV wire antenna works on most, but not all, bands from 80 – 10 meters as long as I use an antenna tuner. The antenna tuner in my transceiver does not have enough range to match this antenna on some bands, so an external antenna tuner is required. Some tuners have worked well with my antenna system and others have not. That is why I was interested in testing the new MFJ-939.

MFJ offers several different versions of the MFJ-939. The review unit is the MFJ-939I, which is set up to interface with Icom transceivers and includes a cable to connect the tuner to any Icom transceiver that supports Icom's AH3 or AH4 antenna tuner. The MFJ-939K is compatible with Kenwood transceivers, and the MFJ-939Y is compatible with Yaesu radios (there are several different Yaesu-compatible versions).

The Specs

The MFJ-939I offers lots of functionality in a small package. It fits nicely in a go-kit or backpack because of its small size and light weight. It only needs 2 W of RF to tune, so it works fine with 5 W QRP transceivers. Its maximum power is limited to 200 W SSB or CW. Under the hood, it employs an L-network matching circuit, a frequency counter, and an SWR sensor. A microcontroller drives switching relays that select the appropriate inductors and capacitors for proper tuning. The automatic tuning process uses proprietary tuning algorithms, and there are said to be more than 20,000 nonvolatile memories configured in eight banks of more than 2500 memory locations each.

The ARRL Lab verified the tuner's specified frequency range of 1.8 to 30 MHz and found that it also tuned some loads on 6 meters. Its impedance matching range is 6 to 1600 Ω, as verified by the Lab — see Table 4. ARRL Senior Test Engineer Bob Allison, WB1GCM, noted, "While the tuner matched a 6 Ω load, the user should pay close attention to the efficiency measured below 25 Ω. I would be okay running 100 W, but not the rated 200 W at this impedance. There are no problems with 25 – 1600 Ω matches provided that the reactance is not too high."

Also note that although the tuner will find a match with a 1600 Ω load (32:1 SWR), coaxial cable feed line loss will be high. For example, a 100-foot run of RG-213 will exhibit an additional 6 dB of loss with a 1600 Ω resistive load compared to having a well-matched 50 Ω antenna at the far end. It pays to do what you can to improve the match at the antenna.

The MFJ-939I also found a match on 10 meters with its antenna jack open or shorted. This happens with some automatic tuners and it is a good reason to use an external field strength meter while operating to make sure that you are actually transmitting.

Bottom Line

The compact MFJ-939I is a fine companion for Icom transceivers. It offers a wide tuning range and fast operation. Versions are available for plug-and-play setup with other transceiver brands.

Connecting the Tuner

The MFJ-939I comes with a radio interface cable and a dc power cable. After removing it from the carefully packed shipping box, I connected the tuner between my Icom IC-756PROIII and G5RV antenna feed line using the standard SO-239 connectors on the back panel of the tuner. I also connected the tuner's GROUND connector, a wing nut, to my station's ground bus. Finally, I connected the supplied interface cable between the PROIII's TUNER connector (a four-pin Molex socket) and the tuner's RJ-45 RADIO INTERFACE connector (see Figure 4).

The interface cable carries control signals from the transceiver's front-panel TUNER button and also supplies 13.8 V from the radio to power the tuner. If your radio cannot supply the power, there is a power input jack on the back of the tuner. MFJ includes a cable with a matching power connector on one end to provide power from an external source. The manual contains extensive information on interfacing the tuner with Icom and other transceivers.

On the Air

Then I was ready to try it! There are three buttons on the front panel. The POWER button turns on the tuner, although with the interface cable connected, it powered up when I turned on the rig. Pressing the TUNE button starts the auto tune cycle. The ALT button, among other functions, toggles among memory banks and between automatic and semi-automatic tuning modes. The front panel has a green LED labeled SWR that lights up when the SWR is 1.5 or less, and a red LED labeled TUNE that illuminates when automatic tuning is in progress. There is no SWR/power meter or digital readout.

I put my radio on 40 meters, pushed the TUNER button on the PROIII, and that activated the MFJ-939I tuning cycle, bypassing the radio's internal tuner. It tuned surprisingly quickly and quietly compared to other auto tuners that I have used. The green LED lit up, indicating that the SWR was 1.5 or lower. I tried the tuner on all bands between 80 and 10 meters (except 60 meters). It tuned almost instantaneously and produced an SWR below 1.5:1 on all bands.

The real test for any tuner in my shack is obtaining an acceptable SWR with the G5RV on 30 meters. The MFJ-939I tuned this band quite well. To make sure that I was actually getting out, I made a dozen or so CW and JT65 contacts on 30 meters, a band that I have not operated on for a long time.

When I was operating, the tuner remembered the best match for a given frequency. There were a few occasions, particularly when I changed bands, when I had to push the TUNER button on my rig to retune. I believe that it will require fewer retunes as more frequencies reside in the tuner's memory.

Additional Functions

The MFJ-939I operates in other modes including self-check, calibrate, and reset. You activate these functions by pressing various combinations of the three buttons on the front panel. The MFJ-939I also implements MFJ's "StickyTune" mode, which allows for one-handed tuning operation by starting the tuning process automatically when RF power is applied. This mode is not needed when using the interface cable.

Another useful set of features is that the tuner sends Morse code to indicate problems and then takes actions to protect itself from damage. For example, it sends "QRO"

Table 4
MFJ-939I, serial number n/a

Frequency range: 1.8 to 30 MHz.
Type: Auto L.
Matching range: 6 – 1600 Ω. See below.
Power rating: 200 W maximum for CW/SSB; no rating specified for digital modes.
Minimum power required for tuning: 2 W typical.
Power requirement: 12 – 15 V dc at 400 mA while tuning; 190 – 210 mA (standby); 0 mA (bypass).
Insertion Loss (bypass): ≤0.1 dB (1.8 – 25 MHz), 0.15 dB at 28 MHz.
Size (height, width, depth): 2.1 × 6.8 × 8.1 inches (incl protrusions); weight: 2.3 lb.
Price: MFJ-939I, $160. Kenwood and Yaesu versions also $160.

ARRL Lab Resistive Load and Loss Testing

SWR	Load (Ω)		160 m	80 m	40 m	20 m	10 m
8:1	6.25	Power Loss%	23	18	19	19	20
		SWR	1.9	1.3	1.3	1.8	1.6
4:1	12.5	Power Loss%	15	13	12	15	10
		SWR	1.8	1.4	1.2	1.6	1.8
2:1	25	Power Loss%	5	9	8	10	9
		SWR	1.2	1.4	1.0	1.1	1.4
1:1	50	Power Loss%	1	4	1	3	4
		SWR	1.0	1.4	1.0	1.1	1.4
2:1	100	Power Loss%	2	2	5	7	9
		SWR	1.4	1.2	1.7	1.5	1.7
4:1	200	Power Loss%	1	4	4	9	6
		SWR	1.3	1.5	1.6	1.7	1.4
8:1	400	Power Loss%	1	2	1	11	10
		SWR	1.2	1.1	1.3	1.9	1.4
16:1	800	Power Loss%	1	5	4	7	13
		SWR	1.1	1.5	1.4	1.4	1.7

Frequency	Short	Open
1.8 MHz	NT	NT
3.5 MHz	NT	NT
7.0 MHz	NT	NT
14 MHz	NT	NT
28 MHz	Yes	Yes
50 MHz	Yes	NT

Tuner found a match on 160 – 10 meters with a 1600 Ω resistive load.
Tuner found a match at 6 meters with 25 – 800 Ω resistive loads.
Yes = will tune into open or short circuit.
NT = no tuning solution.

Figure 4 — The MFJ-939I rear panel. The separate POWER jack is not used when a transceiver interface cable is connected.

if insufficient power is applied during tuning. If more than 200 W of power is applied, the tuner will go into bypass mode and send "QRT." It beeped and blinked insistently at me when I tried to transmit without the antenna connected. Since you are not always looking at the tuner while operating, the audible warnings are a good idea.

Documentation

A printed manual is not included in the box, but a 35-page downloadable PDF manual is available on MFJ's website. The manual has a block diagram of the tuner, but there is no schematic. The manual has lots of practical information about using the tuner, including antenna recommendations and a table of the tuner's various modes and settings. I found it helpful, and I recommend reading it before operating the tuner. I did!

Summary

With its many features, this automatic antenna tuner is truly a plug-and-play device. I rarely touched it while operating. Its small footprint, light weight, wide tuning range, and remarkably fast tuning time make it ideal for fixed or portable use. Its only limitation is its power handling capability of 200 W. I found the MFJ-939I to be a terrific little automatic tuner, and I enjoyed using it in my shack.

Manufacturer: MFJ Enterprises, PO Box 494, Mississippi State, MS 39762; tel 800-647-1800; **www.mfjenterprises.com**.

Rowetel SM1000 FreeDV Adapter

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Digital voice on the HF bands isn't a new development. In 2007, for instance, amateurs were experimenting with digital voice applications such as *WinDRM*, *DRMDV*, and *FDMDV*, all written by Cesco Lanza, HB9TLK. With a computer sound card acting as a modem, it was possible to exchange digital voice signals and other data with Lanza's free software.

These applications relied on a voice *codec* (coder/decoder) known as *MELP*, which was developed for the US Department of Defense and NATO. Rights to various forms of the *MELP* codec are held by several companies and were never released for free distribution and use by hams. Few were surprised when a complaint was finally lodged concerning amateur use, and this sent Lanza back to the drawing board to re-work his software with an open-source codec called *Speex*. The revised applications worked, but not as well as they did with the original *MELP* codec. As a result, enthusiasm for software-based HF digital voice ebbed considerably.

At about the same time, the Japanese manufacturer AOR introduced its ARD9800 digital voice and image interface, and it remains available for purchase today. The ARD9800 eliminates the need to run software on a station computer. Instead, you simply connect the ARD9800 to your transceiver's microphone input and audio output. When you speak into the ARD9800's hand mic, the device transforms your analog audio to digital and keys your transceiver. When receiving, it reverses the process and plays the decoded audio. The ARD9800 uses the proprietary *AMBE 2020* vocoder and the on-air results are impressive, but the $659 price tag has hampered widespread adoption.

Bottom Line

The Rowetel SM1000 FreeDV adapter adds digital voice capability to any HF transceiver. Setup and operation are quite easy, just requiring connections to the transceiver's microphone input, receive audio output, and PTT switching.

The software side of HF digital voice technology languished until David Rowe, VK5DGR, created *Codec 2*. At long last, amateurs had a high-performance, open-source codec. *Codec 2* saw one of its first uses in *FreeDV* software. Thanks to *FreeDV*, anyone who is already set up for digital modes such as PSK31 can operate HF digital voice as well.

With the success of the computer-based client, the next logical step in the evolution of *FreeDV* was to follow AOR's lead and ditch the computer entirely.

Introducing the SM1000

The SM1000 FreeDV adapter was developed by David Rowe, VK5DGR, and Rick Barnich, KA8BMA. The design is based around a STM32F4 microcontroller and includes a built-in microphone, speaker, and several transformer-isolated radio ports. Everything is packed into a thin 3 × 4-inch enclosure, which means you can easily hold it in your hand.

Like the ARD9800, the SM1000 allows you to operate digital voice without a computer. And like the ARD9800, you connect the SM1000 to your transceiver's microphone input and audio output. However, the similarities end there.

Unlike the ARD9800, the SM1000 is entirely open source. If you have the software expertise, for example, there is nothing to stop you from loading new firmware to modify the functionality of the SM1000. The open-source aspect extends to the hardware, too. Schematics, circuit board layouts, and more are openly published.

Selling at $195 US, the SM1000 is also substantially less expensive than the ARD9800. The cost differential alone has drawn the attention of amateurs in the United States and elsewhere, so much so that the initial SM1000 production run quickly sold out. Fortunately, the manufacturer has since ramped up production to match the demand.

Getting Connected

The SM1000 arrives ready to go. The only thing you need to do is fashion the cables necessary to connect the unit to your transceiver and a 12 V dc power source. You have the option of bringing all the connections out of an RJ45 port at the rear of the SM1000, or you can use the individual ⅛-inch jacks along the back of the case (see Figure 5).

Figure 5 — The SM1000 can connect to the transceiver via the RJ45 RIG connector, or the individual ⅛-inch phone jacks along the bottom of the case.

To connect the SM1000 to my Kenwood TS-2000 transceiver, I chose to tap the SM1000's jacks for the PTT (push to talk) and audio output lines to the TS-2000's microphone jack. From the TS-2000's external speaker jack, I ran a separate cable to the SM1000's receive audio input. I obtained dc power from my station power supply.

First Contact

As the instructions state, the first thing you must do is set up the audio levels. This is critical to proper operation of the SM1000.

The SM1000 enclosure offers three access holes for these adjustments. I decided to try the built-in microphone so, with the transceiver off, I squeezed the PTT button on the side of the SM1000 and adjusted the MIC GAIN potentiometer while watching the CLIP LED indicator on the front of the unit. Ideally, microphone gain should be set at the point where the LED just flickers sporadically when speaking at a normal level.

Next, I fired up the TS-2000 in upper sideband and took to the airwaves for a test transmission. With a single press of the SELECT button, I switched the SM1000 to DV mode. While pressing the SM1000's PTT button, I watched the TS-2000's ALC meter and carefully tweaked the SM1000's audio output (RIG MIC) level until the meter indicated essentially no ALC activity. Finally, I adjusted the TS-2000's receive audio level to the point where the CLIP indicator on the front of SM1000 barely flickered.

I should note that when you turn on the SM1000 initially, it defaults to its analog "pass through" mode, which means that you'll hear analog audio from your radio. If you key the SM1000 and speak, the microphone will send your transmit audio to your transceiver as analog audio. This allows you to switch between analog and digital operation easily whenever you desire.

When you press the SELECT button and place the SM1000 in DV mode, the adapter responds by falling utterly silent. Unless someone is sending a FreeDV signal, the SM1000 remains quiet. When you transmit, the audio from the built-in microphone is encoded as a FreeDV digital transmission. If your transceiver has a transmit audio monitoring function, all you will hear is a buzzing sound.

Tuning to 14.236 MHz, one of the popular FreeDV frequencies, I soon decoded a transmission from Art Knighton, W4BCX, in Melbourne, Florida. As I've reported in past discussions about HF digital voice, when a signal is decoding well, the effect is rather strange. Instead of the usual noise one is accustomed to hearing on HF, there is nothing but the voice of the operator. It is almost as though you are listening to a voice on a telephone line.

I gave Art a call and he replied with a good signal report, although he said I needed to further reduce the SM1000 MIC GAIN, or at least speak more softly. I was copying Art at about an S-6 signal level and this translated to solid DV decoding. The audio quality wasn't high fidelity, but it was completely intelligible — and all taking place within a 1200 Hz bandwidth.

At times, Art's signal would fade to about S-1. When this occurred, the audio would break up or halt altogether. I noticed that the SM1000 required very little time to resynchronize and resume decoding as his signal strengthened.

Tests with W1AW

We purchased a second SM1000 and installed it at ARRL Headquarters station W1AW. Station Manager Joe Carcia, NJ1Q, and I conducted an informal test at varying power levels on 40 meters between W1AW and my home station. We quickly discovered just how critical the audio adjustments can be. The slightest tweak of a potentiometer could make a drastic difference in intelligibility.

During our tests, we also discovered that while the SM1000 internal microphone renders intelligible audio, we achieved much better fidelity when we connected external microphones. The SM1000 microphone is really designed for portable or mobile use. During my conversation with W4BCX, he mentioned that many SM1000 users connect microphone headsets to their units. The SM1000 provides a set of jacks for this purpose, as well as jacks for an external PTT (such as a footswitch). I connected an inexpensive single-ear microphone headset to the SM1000, and the improvement was instantly obvious.

Conclusion

It will be interesting to see how HF digital voice evolves with the introduction of the SM1000. At the time this review was written, I was hearing FreeDV transmissions at 14.236 MHz with increasing regularity. Taking their cue from meteor scatter operators, some FreeDV enthusiasts are setting up skeds online at websites such as the one established by John Hays, K7VE, at **qso.k7ve.org**.

Although FreeDV transmissions are digital, they take place in the "phone" portions of the bands thanks to the antiquated wording of the Federal Communications Commission's Part 97 rules. As the rules are currently written, it is the *content* of a transmission that dictates where it can take place. Despite being otherwise digital, the FCC regards FreeDV as a phone transmission because the content is voice.

I don't think FreeDV will replace SSB on the HF bands anytime soon. Compared to FreeDV, SSB offers much better performance at lower signal strengths. FreeDV is also inferior to SSB when it comes to dealing with interference. I noticed that moderate interference from nearby signals was sufficient to severely disrupt FreeDV decoding.

Even so, when conditions are favorable, FreeDV with the SM1000 can be a fascinating experience. This is yet another valuable item in the Amateur Radio toolkit and it has the potential to become a platform for additional experimentation.

This review of the SM1000 is a snapshot of the unit as it exists today. Thanks to the open-source nature of the product, you can be reasonably certain of more enhancements to come.

Manufacturer: Rowetel Inc, 9 Nelson Ave, Flinders Park 5025, Australia; **www.rowetel.com**. Customers outside Australia must purchase the SM1000 from the manufacturer in China, Aliexpress, at **www.aliexpress.com** (direct purchase link: **www.aliexpress.com/store/product/SM1000/1390863_32289993270.html**). Price: $195.

See the Digital Edition of *QST* to listen to these samples of FreeDV audio using the Rowetel SM1000.

Decoding 100% with an S6 signal level.

Poor decoding with an S1 signal level.

JYE Tech Ltd DSO138 DIY Oscilloscope Kit

Reviewed by Paul Danzer, N1II
n1ii@arrl.net

One day the mail carrier delivered a 3 × 4 × 5 inch package, direct from China. Inside was an oscilloscope. In this digital age, we are all getting used to the smaller size of equipment. I remember many years ago working with a 70+ pound Tektronix scope, and more recently testing a digital scope that fit in my shirt pocket, but it required an iPad or iPhone for the display.[3]

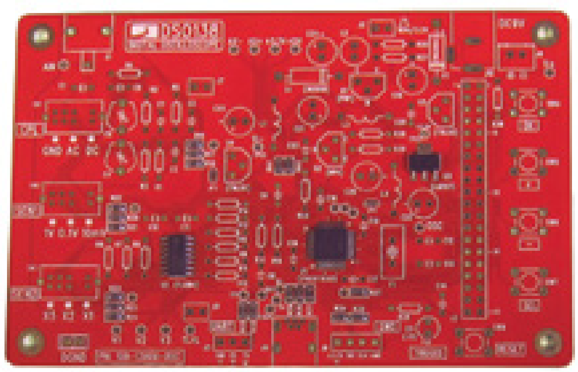
The DSO138 is an oscilloscope kit that includes a 2.4-inch TFT LCD display for — would you believe? — less than $40 plus shipping. This is a fun kit to assemble, and after putting it together you have a fully functional oscilloscope with a 200 kHz bandwidth (Table 5 shows the scope's specifications). The package comes complete with a probe for this single-channel scope as well as a very complete set of troubleshooting instructions. All that you have to supply is a 9 V power source and a lot of patience.

Bottom Line

The patient kit builder is rewarded with a fully functional 200 kHz oscilloscope with some high-end features for a very low price.

What's in the Box

There are two versions of this kit. Part number 13804K comes with only the main IC soldered in place. In addition to the parts with leads, you have to solder a number of surface mount (SMD) parts. Being an OT (Old Timer), I wisely opted for part number 13803K, which has all the SMD parts attached to the two boards shown in Figure 6. The larger board contains the through-hole resistors, capacitors, and other small parts you have to mount in addition to the SMD parts already soldered in place. The board quality is excellent, with a coating to help you avoid solder bridges. Printed part numbers are clear and unmistakable. The display is mounted on the smaller board, and the only thing you have to do on this board is solder three sets of pins on the back of the board to connect



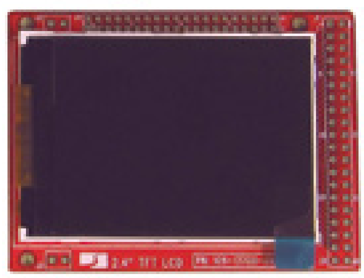


Figure 6 — The larger (4½ × 2⅞ inch) PC board contains the microprocessor, controls, and analog front end parts. The smaller board (2¾ × 2 inches) holds the 2.4-inch TFT LCD screen.

Table 5
Major Characteristics and Specifications

Analog bandwidth: 0 – 200 kHz.
Sampling rate: 1 Msps max.
Sensitivity: 10 mV/division to 5 V/division.
Sensitivity error: <5%.
Vertical resolution: 12-bit.
Time base: 10 µs/division to 500 s/division.
Record length: 1024 points.
Built-in 1 kHz, 3.3 V test signal.
Waveform frozen (hold) function.
Save/recall waveform function.
Price: Model 13804K (only microprocessor installed), $32; Model 13803K (all SMD parts installed), $36.

it to the larger board. In addition to the two boards, the box contains a surprisingly small bag of parts and connectors (see Figure 7).

Exercise Patience

Don't let the word *patience* discourage you. The kit is a fun project, but you will have to solder in some very tight places. As a start, a 20 W soldering iron with a pencil tip is recommended. (Okay, I cheated and used a 40 W iron.) It is also helpful if you can find thin solder corresponding to perhaps AWG #28 or #30 wire diameter. Fortunately the plated through-hole quality is excellent and makes soldering a bit easier.

The resistors are approximately 3⁄64-inch long. Even with a magnifier of some sort, reading the color bands is challenging. Figure 8 shows one way to ensure using the correct resistors. The sheet of paper has the resistor values written on the left. To the right of the listing is a piece of double-sided tape. After measuring each of the 39 resistors (remember the word *patience*), you can place them on the tape near their value. While measuring the resistors you will find three that measure about 3 Ω. These are the three inductors.

A magnifying loupe will also help you place the resistors and check for solder bridges. Harbor Freight Company (**www.harborfreight.com**) sells a set of five loupes, including a 10× unit, for about $4 — an excellent investment for this kit or other close work. The capacitors are clearly marked (I used a magnifier to read the labels), but if you have a capacitance meter you can double check your selections.

Controlling the Scope

Figure 9 shows the main board after assembly. The probe connector is on the top left and two power connectors on the top right. Either power connector feeds the unit. The black connector accepts (tested by trial and error, no information was supplied) a ¼-inch coaxial power connector, available from RadioShack as a 5.5 mm coaxial power connector. A simple circuit for powering the scope from a standard 13.8 V power supply is shown in the accompanying sidebar, "DSO138 Scope Power Supply."

Slide switches on the left side each have three positions. As with most oscilloscopes, the top switch allows you to pick ground reference, ac coupling, or dc coupling. The middle slide switch sets the vertical axis sensitivity in increments of 10 (1 V, 0.1 V or 10 mV per division). The final switch is a multiplier for the sensitivity (×5, ×2, and ×1), so that the 12-bit vertical resolution can be used to measure from 10 mV per division to 5 V per division. The 12-bit resolution means a total of 4096 increments when measuring voltage. The selected voltage scale is displayed on a legend at the bottom left of the screen.

The five pushbutton switches on the right take a bit of learning. The package includes specific instructions in a clear but brief form. These switches control the sweep speed, trigger point, storage, waveform statistics display, and test modes.

Sweep speeds are variable from 10 µs per division to 500 seconds per division, and a total of 1024 points can be stored in memory. In addition to a test square wave signal for general use, a specific set of test instructions are given to check for open and shorted pins on the three board connectors. While J2 and J3 are two-pin connectors and not much of a problem to solder, J1 consists of two rows of 20 closely spaced pins that have to be soldered — so a test routine for this connector is a very good idea.

For many years, analog scopes showed waveforms, but if you wanted to store the waveforms for later examination and analysis you had to buy an expensive storage scope. Digital scopes (digital storage oscilloscopes, or DSOs) throw in a storage mode at no additional cost because the data is stored on its way to being displayed. This little scope is no different. By pressing two pushbuttons simultaneously, you can store a waveform. Pressing another two brings the stored waveform to the screen. While you are looking at the stored waveform, another few button presses bring a set of waveform measurements to the top of the screen (see Figure 10).

Adding Features

The manufacturer describes the package as "partial open source." The embedded code is not made available, but the website lists links to other sites that have directions for making your own or adding other functions if you wish. Jacks are supplied on the bottom of the large board to allow connecting to a PC. I did

Figure 7 — It's hard to believe that this small bag of parts (including the probe) is all you need to make a fully functional oscilloscope.

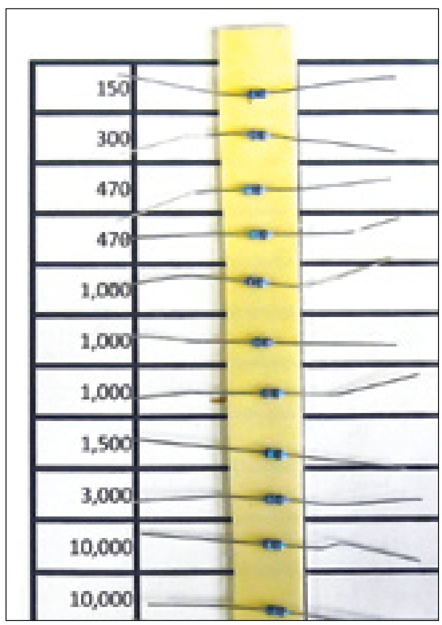


Figure 8 — The task of finding the correct resistor is made much easier by measuring and sorting out the 39 resistors in advance.

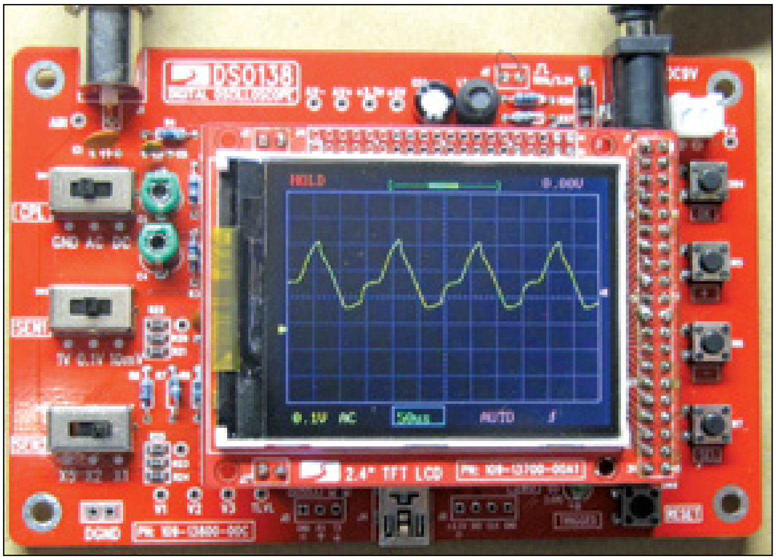


Figure 9 — The scope in action. The waveform shown is the sum of a triangle added to a sine wave. On the bottom, the legend shows a scale of 0.1 V per cm, ac coupling to the probe, and 50-µs per cm sweep speed. Triggering is set to AUTO.

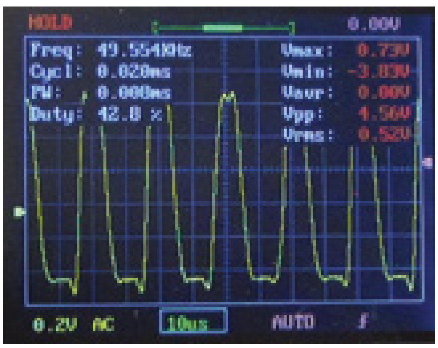


Figure 10 — After freezing the display, a few button presses results in an alphanumeric display of the waveform values — the same as available with big brother scopes!

not try this advanced capability during the review. It is not surprising that other software can be hosted, because the core of the oscilloscope is a STM32F103C8 microprocessor.

End Result

Today, oscilloscopes come in many varieties. Some scopes are self-contained and some are software only.[4] After assembling and testing this oscilloscope, you will have a fully functional scope capable of displaying and automatically measuring signals within its bandwidth capability. The price is such that you can even consider mounting it on the front panel of a piece of homemade equipment in place of an analog meter, allowing you to continuously monitor your audio, transmitting waveform, keying wave shape, or whatever your imagination dreams up — all with a self-contained scope costing less than $40.

Manufacturer: JYE Tech Ltd, Guilin University Science Park, Unit 302, Guilin, Guangxi 541004, China; **accudiy.com** (click on "DIY Kits," then "Oscilloscopes").

Notes

[3]P. Danzer, N1II, "Oscium iMSO-204 Portable Oscilloscope," Product Review, *QST*, Jun 2014, pp 48 – 51.

[4]P. Danzer, N1II, *Oscilloscopes for Radio Amateurs*, ARRL Item no. 0976, available from your ARRL dealer or from the ARRL Store. Telephone toll free in the US 888-277-5289, or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

DSO138 Scope Power Supply

This scope requires 9 V dc and will operate from a transistor battery, but the battery will not have a very long life! Figure A shows a simple circuit that uses a variable voltage regulator and a handful of parts to supply the needed 9 V from a common 13.8 V supply. Before connecting the power supply output terminals to the scope, use a voltmeter to adjust the output voltage by turning R2. Parts are available from RadioShack (part numbers are shown in parentheses). — *Paul Danzer, N1II*

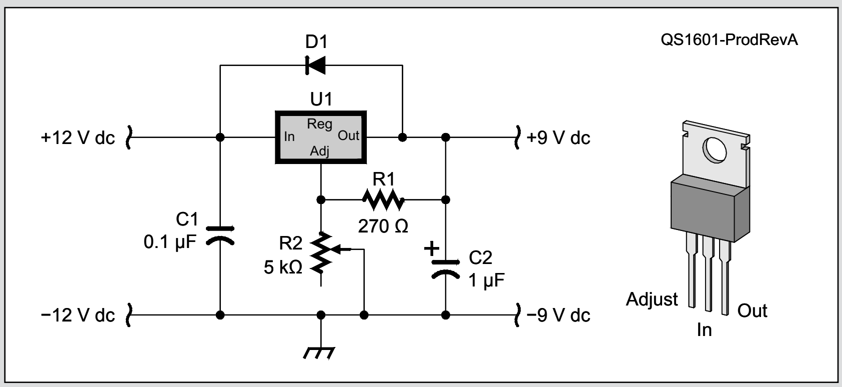


Figure A — Schematic of the 9 V power supply.

C1 — 0.1 µF, 50 V disc ceramic from assortment (272-801)
C2 — 1 µF, 35 V (272-1434)
D1 — 1N4005 (from assortment of 25 diodes, 276-1653). Use any power rectifier diode with a number starting with 1N400 such as 1N4001, 1N4002, and so on
R1 — 270 Ω, ½ W resistor (271-1112)
R2 — 5 kΩ variable resistor (271-1714)
U1 — LM317T adjustable regulator IC (276-1778)