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Product Review

FlexRadio Systems Power Genius XL Amplifier

Reviewed by Terry Glagowski, W1TR
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FlexRadio Systems, best known for pioneering work in the software-defined radio (SDR) field, has added a maximum-legal-power, solid-state linear amplifier to its product line. Solid-state amplifiers have become mainstream as vacuum tubes have become more difficult to acquire and solid-state power capabilities have increased. The costs and safety issues associated with vacuum tubes are a burden, such as high voltages and multiple power supplies for plates, grids, filaments, and other components. Now it is commercially feasible for amateur radio amplifier manufacturers to provide maximum legal output power plus headroom using solid-state devices. Currently, comparable tube amplifiers are still less expensive, but that may not be the case for much longer.

First Impressions

The Power Genius XL (PGXL) is a fairly compact unit. This is especially true considering that it is capable of maximum legal power output and includes an internal power supply. It weighs about 40 pounds and is fairly easy to move around the station. In comparison, my Emtron DX-3 tube amplifier is more than twice as large and weighs 160 pounds. There is a handle built into the PGXL front panel that makes carrying the unit easy, compared to holding it like a box.

The amplifier power switch is *not* on the front panel, but the operate/standby switch is. I prefer to have the power switches on the front panel of equipment, along with the microphone, the headphones, the key, or the

Bottom Line

The Power Genius XL amplifier from FlexRadio Systems effortlessly delivers 1,500 W on 160 through 6 meters. It includes a number of clever features, including built-in support for full single-operator, two-radio (SO2R) operation.

Table 1
FlexRadio Power Genius XL, serial number 1-50/18-0074, firmware v3.4.10, updated to v3.4.16

Manufacturer's Specifications	Measured in ARRL Lab
Frequency range: All amateur frequencies in the range of 1.8 to 29.7 MHz and 50 to 54 MHz.	160, 80, 60, 40, 30, 20, 17, 15, 12, 10, 6 meters.*
Power output: 1,500 W, 2 kW capable.	Tested up to 1,500 W RF output.
Driving power required: 50 W (US version) for 1,500 W RF output.	Drive level needed for 1500 W PEP output: 1.8 MHz, 40 W; 3.5 MHz, 41 W; 7 MHz, 43 W; 14 MHz, 46 W; 18.1 MHz, 42 W; 21 MHz, 57 W; 24.9 MHz, 72 W; 28 MHz, 50 W; 50 MHz, 53 W. See Figure A.
Harmonic and spurious suppression: Not specified.	1.8 MHz, 80 dB; 3.5 MHz, 71 dB; 5.3 MHz, 71 dB; 7 MHz, 67 dB; 10.1 MHz, 61 dB; 14 MHz, 67 dB; 18.1 MHz, 61 dB; 21 MHz, 61 dB; 24.9 MHz, 70 dB; 28 MHz, 64 dB; 50 MHz, 76 dB. Exceeds FCC requirements.
Third order intermodulation distortion (IMD): Not specified.	14 MHz, 3rd/5th/7th/9th order IMD products: At 1,500 W PEP, 34/39/49/56 dB below PEP; At 1,000 W PEP, 36/42/52/61 dB below PEP; At 500 W PEP, 38/43/53/66 dB below PEP.
Keying time: At least 10 ms.	Unkey to key, 13 ms; key to unkey, 17 ms.
Primary power requirements: 90 – 250 V ac.	Tested with 234 V ac. Limited to 700 W with 120 V ac line.

Size (height, width, depth): 6 × 20 × 14 inches; weight, 39.6 pounds.

*Reminder: US amateurs must observe a limit of 200 W PEP output on the 30-meter band, and 100 W PEP relative to a ½-wave dipole on 60 meters.

paddle jacks. Other connections should be on the rear panel.

The amplifier operated as expected without any quirks. It provides pure, powerful RF output on any frequency with about 50 W of drive.

Important Features

The Power Genius XL RF deck and power supply are housed in a single desktop enclosure. It covers all amateur bands from 160 through 6 meters, and Military Auxiliary Radio System (MARS) operation is possible with the standard firmware. The amplifier uses a pair of MRF-1K50H LDMOS power transistors and had no trouble making 1,500 W output on all bands with about 50 W of drive.

Band switching is automatic, controlled via transceiver interface or by sensing the frequency of the RF input signal. Integration with the FLEX-6000 series transceivers is seamless, but the manual includes detailed setup information for integration with transceivers from Elecraft, Kenwood, Icom, and Yaesu. There are appropriate connectors on the rear panel, and transceiver type and communication parameters are set from a menu.

The PGXL can be set up for use with two transceivers and antenna systems for SO2R (single-operator, two-radio) operation. (This includes SO2R operation with the FLEX-6600M and other FLEX transceivers that are capable of SO2R operation with one radio.) Isolation between the two transceiver inputs is about 70 dB.

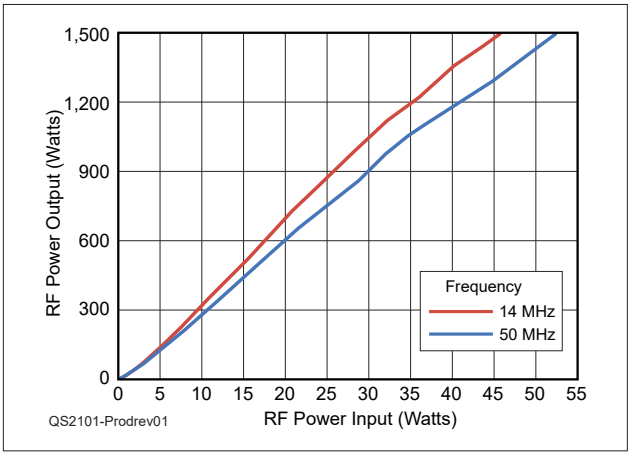

Figure A — FlexRadio Power Genius XL RF input versus RF output.

The operator interacts with the amplifier via a color LCD touchscreen on the front panel (see Figure 1). The LCD provides meters and other information about operating conditions, as well as access to various menus and control buttons. Meter settings include RF power output, SWR, temperature, ac line voltage, and

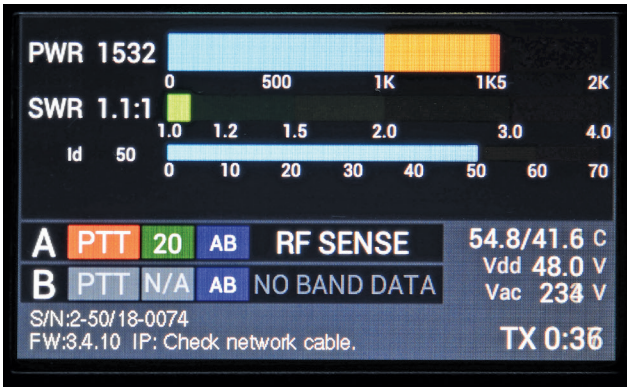

Figure 1 — The colorful PGXL display shows operating conditions at a glance. The amplifier output is 1,532 W into an ARRL Lab dummy load with a 1.1:1 SWR. The lower bar display is drain current. Drain voltage and ac line voltage are shown at the lower right. The lower half of the display indicates that radio A is connected, PTT is engaged, the band is 20 meters determined by RF sensing, and the PGXL is operating in class AB. No radio B is connected. If the PGXL were connected to a LAN, the IP address would be shown at the bottom. Amplifier serial number and firmware version are shown as well.

LDMOS power transistor drain voltage and current. You can also communicate with the amplifier using *Power Genius XL Utility* software. Directions for downloading and installing the software are found in the manual and easy to follow.

The *PGXL Utility* software can also be used for upgrading the amplifier firmware. Download the firmware ZIP file from the FlexRadio website, extract the contents, and then use the *PGXL Utility* to upgrade the firmware. As with other FlexRadio products, new firmware is released periodically to add features, improve operation, or fix bugs. During the review period, we received firmware version 3.4.16, along with a revised manual as a PDF and another PDF with details of what had changed.

Separate bias settings can be used for linear modes and nonlinear modes to increase efficiency when possible. Class AAB (more linear, less efficient) is intended for AM, SSB, and PSK modes, while class AB (less linear, more efficient) is intended for FM, CW, RTTY, and other digital modes. Bias selection is automatic when the amplifier is paired with a FLEX-6000 series transceiver. It can be selected manually from the front panel or using the *PGXL Utility* software.

A maximum efficiency algorithm (MEffA) can be selected for class AB operation to maximize efficiency, while maintaining signal quality. According to the manual, the MEffA adjusts drive voltage and bias settings based on the type of input signal. MEffA operation requires a simple setup procedure to establish the best drive level for the desired RF output.

The PGXL offers excellent harmonic suppression. In addition to the low-pass filters typically found in amateur radio amplifiers, the PGXL uses additional high-pass filters to direct unwanted harmonic energy into an internal 400 W resistive dummy load, called the *harmonic load*. This technique removes unwanted energy from the output stage, improving linearity and thermal management and allowing the transmitter to achieve the same fundamental power output with lower peak drain voltage. The harmonic load is mounted on a dedicated heatsink, with a temperature sensor and fan controller.

The Power Genius XL features a predistortion sampler output for transceivers that can use that signal for predistortion processing to reduce transmitted intermodulation distortion products. There are separate predistortion samplers for the two transceiver inputs.

The PGXL will operate at full power with an antenna system SWR up to about 2:1. Output power folds back between 2:1 and 3:1. Above 3:1, the amplifier stops transmitting. The unit does not include an antenna tuner.

Setup

For this review, I used the Power Genius XL with the FLEX-6600M transceiver reviewed in the February 2020 issue of *QST*. I also used an MFJ-998 automatic antenna tuner for antennas that exceed the amplifier's SWR limits. My antennas include Yagis for 40 through 10 meters and wires for 160, 80, and 60 meters. I am a US Air Force MARS operator, and I used the amplifier with an Icom IC-756PROIII to test operation using RF-sensed band selection on MARS frequencies.

Installation is very easy and straightforward. For best results with the PGXL (or any legal-limit amplifier), plan to use a 240 V ac line capable of 20 A or more. The amplifier includes a detachable power cord, and the user must install the appropriate connector for their station outlet. PGXL firmware version 3.4.16 improved support for operation from 120 V ac. Maximum power output is limited to 700 W, and the power meter scales change to reflect this. Drive power is also attenuated to minimize the possibility of overdriving the amplifier.

Figure 2 shows the PGXL rear-panel connections. A unique feature of the PGXL is the ability to operate with two transceivers in single-operator, two-radio (SO2R) configuration. Two transceivers can share the amplifier using two separate inputs, outputs, and PTT controls (all labeled for radio A or radio B), but only one at a time can transmit. RF input and output connectors are SO-239 types. For non-FlexRadio trans-

Figure 2 — The PGXL rear panel. RF input and output and predistortion sampler connections are in the upper center, with band data/CAT and PTT connections below. [Photo courtesy of FlexRadio Systems]

ceivers, connect the PTT control to the appropriate PTT phono connector. Connect the transceiver CAT cable to the appropriate amplifier DB-9 CAT connector (optional if you plan to use RF sensing). That's it.

Note that the manual indicates that your transceiver should be set to delay RF output for at least 10 milliseconds after PTT output contact closure to allow the PGXL to switch to transmit. This setting is often available in a TX delay or similar menu. (The ARRL Lab measured this keying time at 13 milliseconds for the review unit.) If a TX delay adjustment is not available, you can use a foot switch to key the amplifier, and then key the transceiver from the PGXL's **PTT OUT** jack. The PGXL does not support full-break-in (QSK) CW operation.

Like the FlexRadio transceivers, the PGXL has an RJ-45 ethernet jack for connection to a local area network. If you're using a FLEX-6000 series radio that is also connected to the network, the amplifier will find the radio on the LAN. Of course the ethernet connection means that the amplifier can be used as part of a remote station as well as locally.

I found setup to be relatively simple for the amplifier, just configuring the interface screen for the transceivers I wanted to use. This was my first time using the FLEX-6600M transceiver, and that required some reading of the manual. You can view the contents of the amplifier LCD screen on your computer using the *Power Genius XL Utility*.

Operational Experience

I used the Power Genius XL on all bands from 160 through 6 meters and all modes except digital. I have no doubt that it would work well there, too. Most of the time, I used the FLEX-6600M with the amplifier, and got excellent reports during regional and transglobal contacts. I used the amplifier with my Icom IC-756PROIII on the MARS frequencies from 2.0 to 30 MHz on a dummy load, and it easily produced 1,500 W output. (Note that the 26.0 and 27.9 MHz MARS frequencies are locked out per FCC regulations because of proximity to the citizens band.)

When using the FLEX-6600M, the amplifier tracked the band using the ethernet connection. When using the IC-756PROIII, the amplifier sensed the frequency and selected the proper band. This required a brief pulse of RF from the transceiver, then release of the PTT, VOX, or CW keyer, and then the amplifier would operate normally following a band change. Virtually any transceiver that provides a PTT output to control an amplifier will work with the PGXL. The PTT control is optically isolated and very low voltage and current, so it will work with any transceiver.

The PGXL has fans in the power supply unit, the RF deck, and the filter compartment. The firmware manages the fans independently based on information from sensors in each compartment. As with other solid-state, legal-limit amplifiers, fan noise is higher than with typical comparable tube-type amplifiers. To help manage that, the PGXL offers several user-selectable fan profiles. In standard mode, recommended for casual SSB, CW, and digital operation, the fans run at low speed, increasing speed with temperature, but optimized for lowest fan noise. Contest mode is recommended for contesting or other operating activities with a lot of transmissions. The fans run at a higher initial speed than in standard mode, increasing with temperature and turning off when the amplifier cools down. In broadcast mode, the fans run continuously at high speed, regardless of temperature. This mode is intended for extended high-power RTTY and

digital-mode operation, high-duty-cycle SO2R contesting, or situations in which the amplifier is located away from the operating position.

In standby mode, the PGXL fan is quiet after it cools down. In operational mode and receiving, the fan is only moderately noisy. As with other solid-state, legal-limit amplifiers, after a lengthy full-power transmission, it does get rather loud as it tracks the internal temperature and more cooling is needed. I did some informal testing with a sound pressure level meter and measured 40 dBA in standby mode (but perfectly quiet when the fans are not running), 70 dBA in operating mode with light transmissions, and 85 dBA under full power. My Emtron DX-3 tube amplifier is slightly quieter with the stage 1 fan operating at 66 dBA, although stage 2 is much more.

Summary

The FlexRadio Power Genius XL is a great solid-state, maximum-legal-limit amplifier for 160 through 6 meters. It integrates seamlessly with FLEX-6000 series radios, but it also works well with other transceivers with or without band data connections. It effortlessly produces 1,500 W output on any band with about 50 W drive, something that cannot be said about just any amplifier. MARS operation from 2 to 30 MHz is also available. Although not inexpensive, it has outstanding performance. The manual and other documentation is available from the FlexRadio website.

Manufacturer: FlexRadio Systems, 4616 W. Howard Lane, Suite 1-150, Austin, TX 78728; **www.flexradio.com**. Price: $6,999.

PreciseRF HG3 Stepper Magnetic Loop Antenna

Reviewed by Phil Salas, AD5X
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In the June 2019 issue of *QST*, I reviewed the PreciseRF HG-1, a small magnetic loop antenna that has the option of being tuned remotely. PreciseRF recently released the HG3, a stepper-controlled magnetic loop antenna that includes remote tuning only, as well as additional features. The stepper motor provides an accurate and repeatable tuning system.

Description

The HG3 covers 7 to 30 MHz. Maximum power ratings are between 25 W and 100 W depending on operating mode (duty cycle) and frequency (see Table 2). Optional 80-meter and 60-meter high-voltage/high-current resonating capacitors, or a new 60/80-meter tunable resonating capacitor may be purchased for operation on those bands. However, the maximum power rating on 80 and 60 meters is reduced to 10 W PEP.

Bottom Line

The HG3 is designed for both portable and fixed station operation. The remote-tuned stepper-controlled tuning results in precise, repeatable operation.

Table 2
PreciseRF HG3 Manufacturer's Specifications

Parameter	14 MHz at 10 W Input	29 MHz at 10 W Input
SWR/Return Loss	1.01:1/41.09 dB	1.14:1/23.40 dB
Bandwidth (2:1 SWR)	31.2 kHz	279 kHz
Quality factor (Q)	448	104
Rrad	0.074 W	1.36 W
Rloss	0.093 W	0.134 W
Power radiated	4.44 W	9.10 W
Efficiency	44% (–3.5 dB)	91% (–0.4 dB)
Max Power (with 25-foot RG-8 feed line)		
PEP SSB	55 W (75 W with CMB-300 balun)	
CW 50% duty cycle	35 W	
RTTY (digital) and AM	25 W	
Max Power (with 50-foot RG-8 feed line)		
PEP SSB		75 W (100 W with CMB-300 balun)
CW 50% duty cycle		50 W
RTTY (digital) and AM		35 W

Environmental: 0 – 35 °C, <80% relative humidity. Water resistant, not waterproof.

PreciseRF offers three configurations of the HG3. Most users will purchase either the EXPRESS or PRO configuration. The EXPRESS and PRO configurations include:

- a 38-inch-diameter radiator loop made from LMR 600 coaxial cable;
- a copper tube induction loop at the feed point;
- a tuning capacitor adjusted by a high-resolution, remotely tuned 2,000-position stepper motor;
- a loop tuning controller;
- a three-section PVC mast;
- and a 9 V dc power supply, universal tripod adapter, 25 feet of RG-58 feed line, 25 feet of CAT6 controller cable, and a comprehensive, illustrated user guide.

The PRO version includes a USB key that adds functions to the HG3 controller, with auto-assisted tuning, an integrated SWR bridge, an equivalent radiated power (ERP) display, and the ability to control the optional PreciseRF AR-1 remote 12 V dc antenna rotator.

There is also a LAB version intended for experimental use. It is available in kit form, requiring some assembly and soldering. It supports a NEMA 17 ultra-resolution, 8,000-position stepper motor, as well as the features of the PRO version.

Finally, the manual and website mention a future high-power (QRO) version of the HG3 that is currently in development. No information was available at the time of this review, other than it supports a NEMA 21 ultra-resolution, 8,000-position stepper motor, as well as all PRO version features.

Installing the HG3

If you wish to operate on 80 or 60 meters with the optional resonators, you must open the tuning unit's case and bridge two solder pads to connect the tuning capacitor to the external 60/80-meter banana jacks. This impacts 10-meter tuning, however. The 60/80-meter resonators plug into the top of the tuning unit.

The HG3 is designed to be installed in portable or permanent locations. The included tripod adapter permits the HG3 to be easily mounted on a camera tripod. As with other magnetic loop antennas, if there is any breeze the tripod can fall over. The tripod legs need to be well secured, or the antenna guyed using anchors and cord included in the HG3 package.

As mentioned earlier, the PRO version of the HG3 provides control for the optional AR-1 12 V dc rotator through the HG3 controller. However, the AR-1 rotator is designed for temporary, portable deployment only. Also, the optional aluminum mast is required when the AR-1 is used.

For a more permanent mount, the three-section PVC mast should be replaced with the optional aluminum mast, which can be attached to a more secure mount using U-bolts (not included). For this review, I mounted the HG3 at about the 15-foot level to a mast attached to the side of my house and rotated it with my U105 TV antenna rotator, as shown in Figure 3. Because the HG3 is bidirectional, only a 90-degree rotation capability is required.

The CAT6 stepper control cable and AR-1 rotator control cable are weatherproof. Although 25-foot cables are provided, cable lengths up to 50 feet have been tested by PreciseRF. All RF connections on the HG3 controller and antenna interface are BNC female. The included 25-foot RG-58 cable is terminated with BNC male connectors.

Finally, like all small transmitting loops, the HG3 maximum radiation occurs in the plane of the loop, with deep nulls perpendicular to the loop when vertically mounted. Keep this in mind, and always position yourself perpendicular to the HG3, especially when in close proximity to the antenna when transmitting. PreciseRF recommends that the antenna be placed so that there is at least a 15-foot clearance around it,

Figure 3 — The HG3 mounted on a pole attached to the author's house and turned with a U105 TV antenna rotator.

and that the operator should be at least 20 to 25 feet from the antenna.

Operating the HG3

The HG3 controller is powered by 9 to 13.8 V dc applied through a standard 2.1 × 5.5 millimeter power connector. If you do not use the included 9 V dc power adapter, you will need to provide your own dc cable. This is what I did, because it was convenient for me to power the controller from my 13.8 V dc station power supply.

Figure 4 — The HG3 PRO controller with the startup screen shown. The buttons below the screen change function, depending on the screen selected.

Operation of the HG3 is quite straightforward. When the controller is powered on, it briefly displays the firmware version and configuration as determined by the absence or presence of the USB key. Next, it defaults to the basic operating screen and sets the band to 40 meters. There are four soft keys labeled **F1** through **F4**. The display indicates the function of these keys, and changes when keys are pressed to indicate the functions associated with the current display. The basic startup screen is shown in Figure 4.

Pressing the **BAND** (**F1** key) on the controller changes the display to permit you to decrement (**F1**) or increment (**F2**) the bands (see Figure 5). Once in the desired band, press **OK** (**F4**). When changing bands, the HG3 controller always sets the tuned frequency to just below the lower band edge. So when changing bands, you will always rotate the **TUNE** control clock-

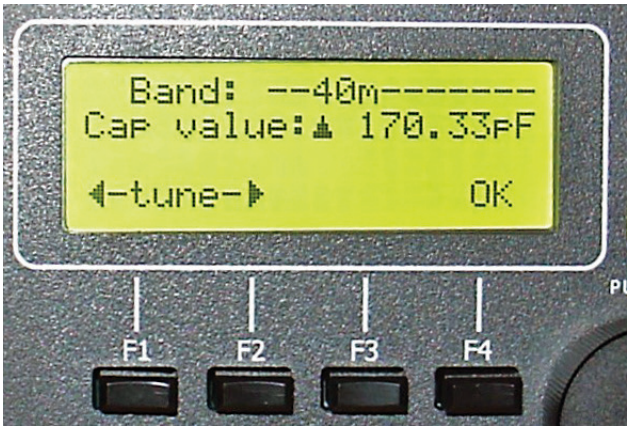

Figure 5 — Pressing **BAND** on the startup screen brings up this screen for changing to a different frequency band by using the arrow buttons (**F1** and **F2**).

wise to find the maximum noise level. I found tuning particularly easy by observing the noise level on my Xiegu G90 transceiver's spectrum display.

I almost always wound up with close to a 1:1 SWR using this tuning method. Whether you look at a transceiver spectrum display or listen to the noise level, once noise is peaked, you can transmit a low-power signal and then fine-tune the HG3 for lowest SWR. Tapping the **TUNE** button changes the stepper tuning increments from coarse to fine, making it easy to tweak the SWR performance. Also, the HG3 controller displays the tuning capacitor value, so I found it easy to return to a favorite frequency by tuning to a previous capacitor setting.

With the PRO version, there is an auto-assisted tuning feature. The controller automatically scans for a low SWR, starting at slightly below the maximum-noise-tuned frequency. To enable autotune, tune the controller for maximum noise on your transceiver. Then press **AUTO** (**F2**). The controller will display "Connect Radio" and "Transmit 1 – 3 Watt CW." Transmit a low-power carrier, and press **OK** (**F3**). If the power is not correct, you will be prompted to increase the power level. The HG3 is automatically tuned in small steps while the controller continuously updates the capacitance value, SWR, ERP, and bar graph displays. Automatic tuning stops when the lowest SWR point is found, and the process can be canceled at any time by pressing **CANCEL** (**F4**).

This entire process takes only a few seconds and works very well. I wound up with a 1:1 SWR on 40 through 12 meters, and a 1.5:1 SWR on 10 meters when using this method. This worked great on 20 through 10 meters with my Xiegu G90 portable transceiver. I had to use my Elecraft K3 transceiver to verify auto-tuning on 40 and 30 meters, as the G90 automatically cuts back power for an SWR of 3.6:1 (maximum protection setting) even when transmitting a low-level signal. Because the HG3 controller starts below the maximum noise tuned frequency, the starting SWR is usually greater than the G90's 3.6:1 SWR-protection point on 40 and 30 meters.

The **MODE** (**F3**) button enables the optional AR-1 rotator control (with the PRO version only), and also displays external 80/60-meter resonator information if it is used. I did not try these optional features. The **HELP** (**F4**) button provides instructions on tuning.

I operated on 40, 30, and 20 meters due to band conditions during the review period. The 17- through 10-meter bands were completely inactive. Transmit power was 20 W with my Xiegu G90. I operated CW (my preferred mode) on 30 meters, but focused on SSB on 40 and 20 meters. I could pretty much work anyone I could hear.

I also made many comparisons between the HG3 and my 43-foot vertical. On average, I found the HG3 to be about two S-units below the 43-foot vertical. This was not unexpected — after all I'm comparing a 3-foot diameter antenna to a 43-foot vertical. However, I did experience a surprising number of occasions where the HG3 actually outperformed the 43-foot vertical on 20 meters. I was also pleasantly surprised by the significantly improved signal-to-noise ratio of the HG3 when compared to the 43-foot vertical. On the 43-foot vertical, all sorts of spurious signals from neighborhood electronics equipment are present, but they were not heard on the HG3.

Conclusion

The PreciseRF HG3 is an effective antenna worth considering for restricted antenna locations and portable operation at power levels up to about 50 W PEP. Because it is remotely tuned, the high-intensity RF field can always be kept well away from the operator. Finally, you can view the HG3 operation manual, the HG3 installation guide, and an informative video on the PreciseRF website.

Manufacturer: PreciseRF, 960 S. Gribble Rd., Canby, OR 97013; **www.preciserf.com**. Price: HG3 EXPRESS, $935; HG3 PRO, $1,195; AR-1 antenna rotator, $275; aluminum antenna mast, $119; 60M-1 resonator, $65; 80M-1 resonator, $65; variable 60 – 80 meter resonator, $75; LAB 8K tuner kit, $275.

Dr.Duino Explorer Edition Arduino Project Kit

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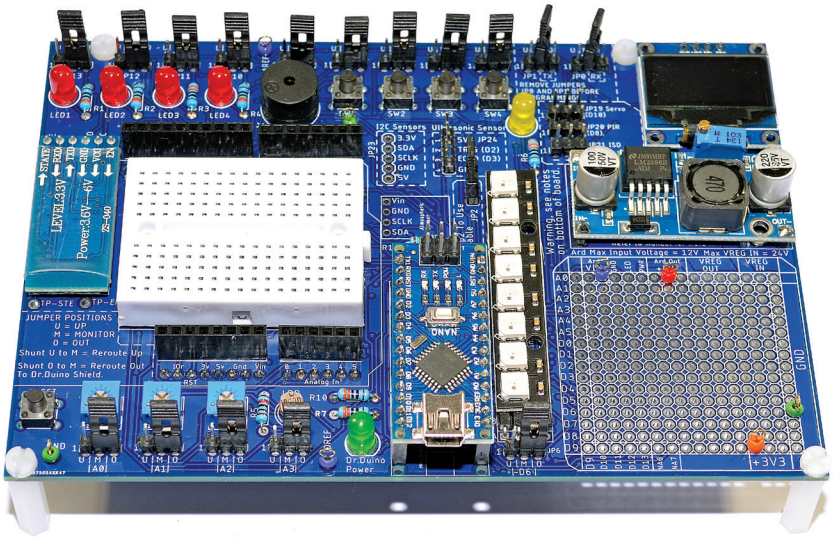

Unless you make your own, I have not been able to find many choices for a good Arduino development and prototyping platform. While I do like using the Phase Dock WorkBench (reviewed in the April 2020 issue of *QST*) for prototyping larger projects, sometimes that platform is overkill for smaller proof-of-concept prototype Arduino projects.

The bigger brother to the Dr.Duino Pioneer (reviewed in the November 2020 issue of *QST*), the Dr.Duino Explorer Edition looks to fill the bill for that "grab-it-and-go" development platform. It has a number of commonly used components integrated on the board and was obviously created with developing and troubleshooting Arduino projects in mind. However, just because it has a few more bells and whistles than the Pioneer Edition doesn't mean that the Explorer can't be used as a learning platform as well. In fact, quite the opposite is true. The Explorer Edition comes with free access to a Facebook group, where Dr.Duino users can ask questions and share ideas. The educational focus is also clear in the inclusion of a postcard-sized "cheat sheet," with resistor color codes printed on one side, and some basic Arduino programming information on the other (see Figure 6).

The Explorer board comes with a practical mix of components mounted on board that you can use in creating your own projects. On the 4 × 6 inch PC board, there are four LEDs, four pushbutton switches, three potentiometers, a light-dependent resistor (LDR), a 128 × 32 organic LED (OLED), a strip of eight red-green-blue (RGB) LEDs, a Bluetooth LE (low-energy) module, and a 3-to-20 V, 3 A dc/dc converter. The board also has a socket for the included Arduino Nano. In addition, there are connectors that allow the Explorer to be used as a shield for an Arduino Uno, as well as providing a mounting point for your own shield assemblies. The Explorer also has two prototyping areas, a 178-pin breadboard area, and a solder-pad area you can use to permanently add components.

Bottom Line

The Dr.Duino Explorer Edition is a well-designed development, prototyping, and troubleshooting platform with a good mix of onboard components for creating a wide variety of Arduino projects.

Building the Kit

The Explorer ships as an easy-to-assemble kit, as shown in Figure 7. I was able to build mine in a single afternoon. The Explorer comes with five demo Arduino projects, along with an automatic test procedure (ATP) sketch that lets you put the board through all of its paces to verify that it is fully functional.

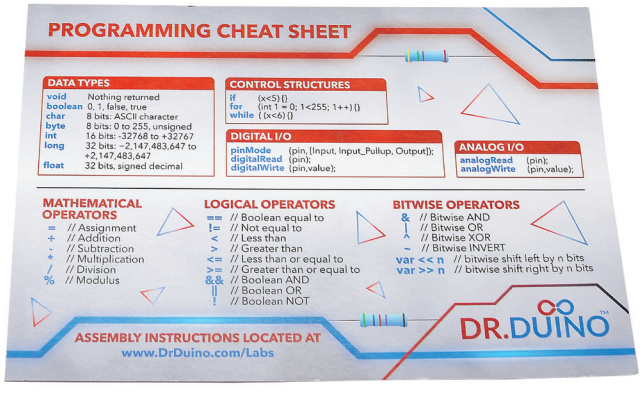

Figure 6 — The included *Programming Cheat Sheet* shows common Arduino programming commands on one side and resistor color codes on the other.

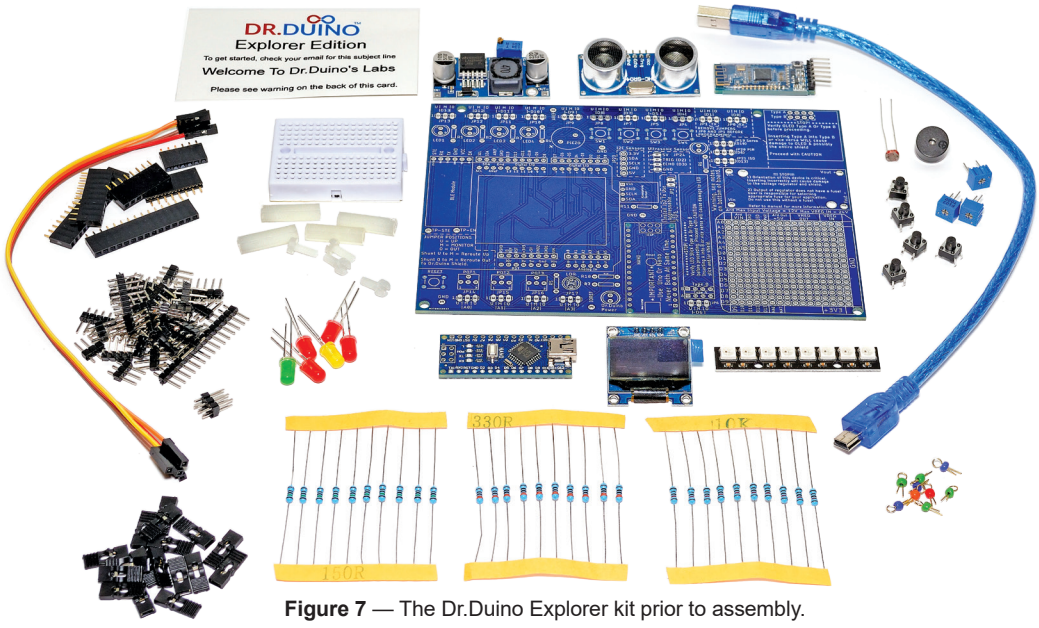

Figure 7 — The Dr.Duino Explorer kit prior to assembly.

The only negative I had about the assembly process is that the 154-page manual is online. I'm old-school and like to work from either hard copy or a PDF. The manual itself is a well-written step-by-step assembly and user guide. One of the most notable things about the assembly manual is the emphasis on support. It's nice to see a company that focuses on their customers as much as they do on their products.

The circuit board itself is well laid out and easy to use. I like that the pulse-width-modulation (PWM) capable pins are stenciled with a tilde (~) on the board. No more trying to remember which pins do PWM and which ones don't. For testing and troubleshooting purposes, there are nine test points on the board. You're even provided with a schematic of the board if you want to dig deep and see how things work.

One key feature of the Explorer board is Dr.Duino's Re-Route It Technology. A series of three-pin headers and jumpers allow you to route signals from the Arduino to the onboard I/O pins and components, or route the signals off-board via the Arduino shield connector.

I have mixed feelings about the solder-pad prototyping area itself. While I like that all of the board's I/O and power pins are brought out to this area, I'm not sure that I would feel comfortable using this semi-permanent prototyping area. If I were to use it, it would most likely be to add some of the components that I use most often in my designs and would want them available permanently.

Expansion Pack

As with the Pioneer Edition, Dr.Duino offers a PLUS version with an expansion pack. The PLUS edition includes an inertial measurement sensor, a micro servo, a voice recorder/player with speaker, an atmospheric sensor, and a passive IR sensor, along with 120 breadboard and header connecting cables. The PLUS edition adds instructions for four more projects designed to demonstrate the use of these components. The projects are practical and fun, and they can be a great way to get your kids involved with the Arduino. Using basic construction techniques with paper and cardboard cutouts, the projects are designed to be housed in the plastic box the Expansion Pack ships in.

As with the Pioneer, an Education Package for the Explorer is offered during the checkout process. This package adds five more projects as well as a PDF of "Arduino Course for Absolute Beginners," by Michael James, which is one of the better Arduino tutorials I have seen.

As a finishing touch, the Explorer board uses four nylon standoffs to raise the board above your work surface. These standoffs are high enough to allow an Uno to be installed underneath without touching the work area.

All in all, the Explorer makes a great addition to my arsenal of Arduino development and prototyping tools.

Manufacturer: Dr.Duino, **www.drduino.com/hamradio**. Price: Dr.Duino Explorer, $159; Explorer PLUS Edition, $199; Education Package, $29.

Pacific Antenna Tracer Injector Kit

Reviewed by Paul Danzer, N1II
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This shirt pocket-size (1.8 × 3.5 inch) device acts as a wide-range resistance/continuity checker, which is useful for troubleshooting circuits on the workbench. Although not obvious from its catalog description, I found that it can be used to detect very low levels of conduction from corrosion. The Tracer Injector is a kit built on a single PC board. Red and black test leads are included, but not an enclosure.

Figure 8 shows the finished PC board. The unit puts out a signal from the lower left-hand (red) jack. To check continuity, the test lead from the upper (black) jack is connected to the other end of the circuit. With its high gain (adjustable), the Tracer Injector can confirm continuity over circuit paths ranging from 0 Ω (a short circuit) to greater than 1 MΩ.

This device can make your bench testing a bit easier. If you have ever tried to see if there was continuity (more than just 0 Ω) with a standard multimeter and a pair of probes, you may have found that you need two sets of eyes. The first set is needed to make sure the probes are on the circuit points you are testing, and the second set is needed to read the meter. The Tracer Injector uses audio to confirm conditions over a circuit path, and the gain adjustment allows you to decide just how high or low the path resistance should be.

Building the Kit

This kit and the accompanying instruction sheets (available as a PDF file from the Pacific Antenna website) are a good choice for the inexperienced builder or as a club project to introduce members to PC board soldering and kit construction. All of the components are through-hole parts.

The instructions start off with a listing of tools that might be required and some hints and brief instructions for board assembly in general. A parts listing follows, with a column to check off as you insert and solder a component. The board has clearly printed part numbers corresponding to the numbers in this list. As usual, a magnifier of some sort will help you confirm values printed or color-coded on the component.

Each instruction for mounting a component or a group of components is accompanied by a set of pictures. Printing the manual in color would be a good idea to make full use of illustrations. Figure 9 shows a typical instruction step. This example is for mounting two electrolytic capacitors and includes pictures of the parts, the section of the board that receives the capacitor, and what this board section should look like after you have mounted and soldered the part.

The final assembly step suggests you mount the supplied rubber feet to prevent shorts if you are not going to place the unit in an enclosure. The unit is powered by a 2032 coin battery, and the board assembly includes an on/off switch. The 2032 battery is com-

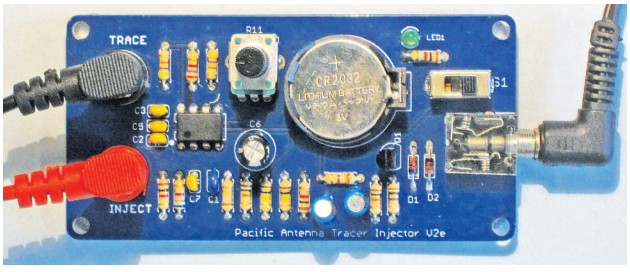


Figure 8 — The kit comes with two 24-inch color-coded test leads. The connector on the right is the headphone jack.

How Does it Work?

The Tracer Injector consists of two individual circuits, powered by the same coin-sized battery and have a ground connection in common. One dual-section TLC27L2CP operational amplifier (op-amp) and one 2N3904 transistor are used.

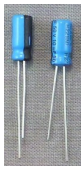
One section of the op-amp is set as an oscillator at about 800 Hz, with a positive and negative symmetrical triangular waveform output connected to the red jack. The waveform is rich in harmonics and puts out approximately 2 V peak-to-peak with an open circuit.

The other half of the IC is configured as a high-gain audio amplifier with a gain control in the feedback leg. It drives the audio amplifier transistor, whose output is connected to the audio output jack.

Bottom Line

The Pacific Antenna Tracer Injector kit worked as expected, and other uses for this very small, self-contained, battery-operated unit will probably occur to you. The excellent instructions would make it a good first project.

Next, install the 10uF electrolytic capacitors in locations C4 and C8



Note that there is a + symbol on the layout.

This is the pad for the longer lead on the capacitor. Usually, the – lead is labeled on the capacitor body as well

Figure 9 — Each component, or group of components, to be installed has a short section in the assembly manual. Written instructions are accompanied by pictures of the component(s), the relevant area of the PC board, and the section of the board with the component(s) soldered in place. Shown here is the step for installing two electrolytic capacitors, also included is information on positioning the leads correctly.

monly used in toys and home electronics, so it is readily available.

A Few Tests

When I finished putting the kit together, I found I had not taken down any notes; I did not find a single error in the instruction sheets, nor was there any difference between the instructions and the hardware. There are two hints I would suggest. First, on the PC board, the outline of the single integrated circuit is shown with a semicircular cut at one end (the Pin 1 end), as well as a dot. Many ICs (including the one with the kit) just have the dot near Pin 1. Second, as usual the LED outline shows a flat side for orientation, but it's not always easy to find the flat side on the part itself. As noted in the instructions, mount the LED with the shorter lead adjacent to the "LED1" label on the printed board.

Using the Tracer Injector

The Tracer Injector is basically an ohmmeter with an audio output that is monitored with a set of stereo headphones or an amplified speaker plugged into the ⅛-inch jack on the PC board. (You will need to provide the headphones or speaker.)

Sensitivity is decreased by turning the volume control on the Tracer Injector PC board clockwise (the opposite of my usual experience with volume controls). The sensitivity is controlled to some extent by the sensitivity of your headphones or speaker.

At maximum volume, with the test leads separated, I could not hear any leakage audio tone with my headphones. The unit is specified to be able to test circuits with resistance of 0 Ω to 1 MΩ, but I could hear a faint tone when connected to a 40 MΩ resistor.

As usual, I had a few other projects under way at my home. One of them was to install two identical CAT5 multiconductor cables. This meant that at each end, there were four pairs of wires to sort out in each cable. I found that I did not have to look at both an ohmmeter and a pair of wires while my wife shorted out pairs at the other end. Using the audio tone to confirm pairs sped up the process.

One additional use of the Tracer Injector might be to detect corrosion conduction. After discovering that an audio tone could be heard with a path resistance of 40 MΩ, I suspect corrosion paths that are past the range of typical ohmmeters might be identifiable.

Manufacturer: Pacific Antenna, P.O. Box 10301, Fayetteville, AR 72703; **www.qrpkits.com**. Price: $25 plus shipping.